Report of the ICCAT 2024 Atlantic Blue Marlin Stock Assessment Meeting
(hybrid, Madrid, Spain, 17-21 June 2024)

The results, conclusions and recommendations contained in this report only reflect the view of the Billfish Species Group (BIL SG). Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission revises 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 hybrid meeting was held in person at the ICCAT Secretariat in Madrid, Spain, and online, from 17 to 21 June 2024. Ms. Fambaye Ngom Sow (Senegal), the Species Group ("the Group") rapporteur and meeting Chair, opened the meeting and welcomed participants. Mr. Camille Manel, ICCAT Executive Secretary, welcomed the participants and wished them success in their meeting.

The Chair proceeded to review the Agenda which was adopted with some changes (**Appendix 1**). The List of Participants is included in **Appendix 2**. The List of papers and presentations presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents and presentations presented at the meeting are included in **Appendix 4**. The following participants served as rapporteurs:

Sections	*Rapporteur*
Items 1 and 11	M. Ortiz and A. Kimoto
Item 2	C. Mayor, M. Ortiz, J. Garcia
Item 3	C. Fernandez, B. Mourato, E. Kikuchi, K. Ba
Item 4	C. Fernandez, B. Mourato, E. Kikuchi
Item 5	E. Kikuchi, M. Narvaez, M. Ortiz, A. Kimoto
Item 6	A. Kimoto, M. Ortiz
Item 7	C. Brown, F. Sow, D. Die
Item 8	F. Sow, D. Angueko, M. Ortiz
Item 9	F. Sow, K. Ramirez, D. Die
Item 10	M. N. Santos, F. Sow

2. Summary of input data for stock assessment

Inputs and model settings for the Atlantic blue marlin stock assessment were amply discussed and agreed upon during the Blue Marlin Data Preparatory Meeting (Anon., 2024a). Following the Group's intersessional workplan, the Secretariat and the modelers' team provided all the inputs for the different model platforms including catch series, size frequency data, fleet structure, indices of abundance, and age at size data. Complete details of the Group's decisions and recommendations are provided in the Report of the Data Preparatory Meeting (Anon., 2024a).

This section summarizes any updates or changes on data inputs that were reported and departed from the Group's intersessional workplan and recommendations.

2.1 Biology

Document SCRS/2024/108 presented a summary of the informal meeting held by the blue marlin stock assessment modeling team to share their progress and discuss especially the treatment of growth models. The recommendations made on the growth models differed from the decisions at the Blue Marlin Data Preparatory meeting.

Following the workplan agreed during the Blue marlin Data Preparatory Meeting (Anon., 2024a), the modeling team evaluated the two alternative data inputs of age at size (spine or otolith data) and estimated within the Stock Synthesis the growth model of Atlantic blue marlin. Initial results found that the Stock Synthesis model estimating a growth curve internally with the spine-based age at size data (Hoolihan *et al*., 2019) resulted in a completely different growth pattern and overall population dynamics compared to the otolith-based growth curve. Results indicated huge initial biomass with low productivity and stock with large uncertainty that has never been overexploited or subject to overfishing.

Similar results were obtained with the surplus production model (SPM) JABBA runs where the priors for *r* were estimated using the growth parameters estimated within Stock Synthesis. The modelers concluded that the two data sources of Atlantic blue marlin growth were not compatible, and it was not possible to follow the suggestions to apply spine data to estimate the growth curve inside of the model as proposed during the Data Preparatory meeting.

The Group discussed that age estimated for a given fish size using spines results in consistently higher estimates of age for a same-size fish compared to the otolith-based age estimates (**Figure 1**), where the differences are noticeably greater for females. It was indicated that age readings from spines are highly affected by the reabsorption and vascularization of the spine, and there is a need for further age validation to resolve these apparent discrepancies in age readings. It was further suggested that alternative aging techniques including epigenetic aging be explored for blue marlin before alternative growth models are considered for the next evaluation.

The Group accepted the recommendations by the modeling team that the Stock Synthesis models use only the otolith-based data (age at size input) in conjunction with the 2018 Stock Assessment growth model of Goodyear *et al*. (2002) as expected mean size at age input. It was reminded that the Group was made aware of the differences in the size-at-age data from otolith versus spine datasets at the data preparatory meeting and recommended evaluating the age-at-size data separately rather than combining the information into a single model (Table 12**,** Anon., 2024a). It was noted that in the 2018 Stock Assessment, the input was the expected mean size at age from Goodyear *et al*. (2002) and the expected mean size at age from Shimose *et al*. (2015) from Pacific blue marlin.

For the 2024 assessment, it was recommended by the modeler's team to use in the case of Stock Synthesis the expected mean size at age from Goodyear *et al*., 2002 and include the additional otolith age at size observations (Krusic *et al*. 2024) from the Atlantic blue marlin. For the SPM JABBA in the estimation of the *r* prior for the final models, the growth parameters used were those estimated from the otolith samples (Krusic *et al*., 2024) only. A summary of the biological input parameters considered in the assessment models is shown in **Table 1**.

However, the Group considered that it is important to include in the report the results of the initial runs with the spine-based growth model as a sensitivity run in this report because it was requested at the Data Preparatory meeting (**Figure 2**).

2.2. Catches

The Secretariat presented the Group with an updated dataset containing the most current information on Task 1 and Task 2 for blue marlin (BUM, *Makaira nigricans*). This dataset included the SCRS catalogues for all billfishes, nominal catches of blue marlin (landings and dead discards), live discards, a catch and effort catalogue, data series on size sampling and catch-at-size data, catch distribution estimates (CatDIS), and tagging information. All these files were posted in the nextCloud folder created for this meeting.

Regarding the Task 1 and Task 2 datasets, the Secretariat reported that no additional information had been received since the 2024 Data Preparatory meeting. Therefore, all input files prepared and adopted intersessionally after the Data Preparatory meeting remain unchanged. The total blue marlin nominal catches for the entire Atlantic (single stock) by fleet and year are presented in **Table 2.**

Concerning the tagging data, the Secretariat informed the group that a significant review of the data is underway. Specifically, the collaboration between USA scientists and the ICCAT Secretariat was mentioned, aiming to clarify and improve the existing information.

2.3 Size

The Secretariat informed the Group that no new size information was submitted after the blue marlin data preparatory meeting. Therefore, the input size frequency file provided to the modeler's teams represents the latest size information available for blue marlin.

2.4. Indices of abundance

The Secretariat informed the Group that no new or updates of indices of abundance were submitted after the blue marlin data preparatory meeting.

2.5. Fleet structure

During the 2024 Blue Marlin Data Preparatory Meeting, the Group agreed to use the 2018 Fleet structure for disaggregating catch and size frequency input data, which was provided to the modeler's team.

3. Methods and Model Settings

3.1 Stock Synthesis

Document SCRS/2024/107 was presented, providing a description of the explorations conducted with Stock Synthesis (SS3) after the Blue Marlin Data Preparatory meeting held in March 2024.

As in the 2018 Stock Assessment, the SS3 model was configured with 2 sexes (females and males), so that differences in biological parameters between sexes could be taken into account. All catch-per-unit effort (CPUE) and length composition data were for combined sexes.

The explorations for this year's assessment started reviewing the final SS3 configuration of the 2018 Stock Assessment, which was updated using catch until the year 2022 and with modifications applied in several steps:

1. CPUE series were updated;
2. CPUE series were updated (Step 1) and length composition data were also updated;
3. CPUE series and length data as in Step 2 and fitting growth to new otolith data (Krusic *et al*., 2024);
4. CPUE series and length data as in Step 2, and fitting growth to spines data (Hoolihan *et al*., 2019).

Figure 3 shows the 2018 stock assessment and the results of these four initial exploratory runs. As already noted, the growth estimated from the spine data was rather different from that estimated from the other sources of growth data and resulted in unrealistic stock trajectories. The Group agreed to estimate sex-specific growth curves within the SS3 model based on the age-at-length otolith data and the Goodyear growth model (used as "data" on mean size-at-age in SS3). A Richards growth model was estimated, as it is more flexible than a Von-Bertalanffy model and was considered better suited to fit an extremely rapid growth in the first one to two years with a significant slowing thereafter. The modeler, however, explained that the model estimated was very close to a Von-Bertalanffy model.

Sensitivity to catch assumptions using the four scenarios (i.e. base catch series, and 3 alternative scenarios of live discards mortality) agreed upon at the Data Preparatory meeting was examined (**Table 3**). The different catch scenarios made no difference to the estimated SSB trajectories, except for the fourth scenario (the one that included discards from the recreational fleet separately, modelling those discards and their mortality separately in SS3) which led to some differences, although the trends over time were similar (**Figure 4**). This fourth scenario implicitly assumed that the USA recreational data represented the entire Atlantic recreational fleet, which may be unrealistic. The Group agreed to consider the Catch scenario 1, where landings plus reported dead discards are treated as the total catch in the stock assessment, as the baseline one, as agreed at the Blue Marlin Data Preparatory meeting (where it was identified as the one to be used for management advice), and to conduct all future SS3 runs based on it.

The fleets' selectivities (for the five fishing fleets agreed at the Blue Marlin Data Preparatory meeting) were assumed to be the same for both sexes. They were either assumed to be asymptotic (longline fleet and recreational fleet) or had selectivity at the largest length estimated within the SS3 model (for the artisanal fleet). The selectivities of the other two fleets ("others" and "mFAD") were taken to be equal to that of the artisanal fleet. As in the 2018 stock assessment, a time-varying retention curve was included for the recreational fleet to accommodate changes in regulations (minimum legal size).

The 11 CPUE series agreed at the Blue marlin Data Preparatory meeting were used in the model runs. The catchability of the early Japanese and early Chinese Taipei CPUE series was allowed to be time-varying (until 1979), using the YFT/(YFT+BET) yearly ratios in those fleets as a potential covariate, as had already been done in previous SS3 assessments for this stock in the case of the early Japanese CPUE series.

Initial model runs (with the 11 CPUE series) were conducted, using as CVs the reported annual values for each CPUE series, except for those series where the minimum reported CV value was less than 0.3. In the latter case, the CVs of the series were increased by a constant to all values so that the minimum CV value was 0.3 while maintaining the same reported trend on the CVs over the time series. These initial runs showed retrospective patterns, suggesting conflicts in data. To reduce the retrospective pattern, added variance parameters for the CPUE series were included and estimated within SS3, and this model configuration became the new baseline.

Initially, detailed diagnostics were presented for the run with fixed natural mortality M=0.148, on both males and females and fixed steepness h=0.5 (see Section 4.a).

Following the agreed settings at the Blue Marlin Data Preparatory meeting, eight alternative scenarios were examined during the meeting, consisting of combinations of two values of natural mortality of females (either fixed M = 0.148 or M estimated within stock synthesis) and four alternatives for steepness (fixed values of *h* = 0.4, 0.5, 0.7, and *h* estimated within stock synthesis). As in the 2018 assessment, M was fixed at 0.148 for males. It was subsequently realized that the runs with M estimated had used a very wide prior on M (so that M was in effect being freely estimated), whereas at the Blue Marlin Data Preparatory meeting, it had been agreed to use a prior on M with mean=0.148 and standard deviation=0.018. Consequently, the runs with estimated M were conducted again using the latter prior on M (i.e. mean=0.148, std=0.018). The results of these explorations are shown in **Figure 5** and **Table4**.

The Group then had a lengthy discussion on whether estimating M and/or *h* (steepness) in stock synthesis resulted in reliable estimates of these parameters. Generally, the estimates obtained for female M were considered low (around 0.095 to 0.117 depending on the run) compared to the M=0.148 used for the males. The results from the conducted 12 runs (**Table 4**) also indicated a strong negative correlation between the estimates of M and *h* and the Group concluded that there was not sufficient information in the stock assessment data to estimate these parameters.

The Group also discussed whether it would be more appropriate to present (for stock status and management advice) a single stock assessment model, based on a "best" model configuration, or a grid of models reflecting the main structural uncertainties that could not be resolved from the stock assessment data. Major sources of uncertainty identified at the Blue marlin Data Preparatory Meeting were growth and steepness. On growth, the Group had earlier made the decision not to use the spine data in this year's assessment, but steepness remained a main source of uncertainty.

Based on these discussions, the Group concluded that, for this year's assessment, the most appropriate option would be to consider a fixed value of M=0.148 for both males and females and to treat steepness as the main source of structural uncertainty, applying a grid approach with four fixed values of h (0.4, 0.5, 0.6 and 0.7).

The diagnostics for all 4 final grid configurations are shown in Section 4.a.

3.2 Surplus Production Model JABBA

The most recent version of the JABBA (v2.3.0) Bayesian surplus production model was applied to the time series of catches and indices to assess the Atlantic blue marlin stock until 2022. Document SCRS/2024/106 presented all priors settings, results, and model formulation of the preliminary JABBA models.

Based on the preliminary JABBA model results presented, the Group noted substantial differences between the trajectories estimated by the updated model compared to the trajectories of the 2018 assessment that used an earlier version of JABBA (v1.1). Hence, the Group requested a set of sensitivity analyses to evaluate whether the differences between the 2018 and 2024 JABBA assessments were caused by the different software model versions, model settings, or by the new data and/or changes in historical data.

The Group discussed the results and concluded that differences in priors, model settings, and the CPUEs used were the major factors accounting for the different trends of biomass and fishing mortality between the 2018 and 2024 assessments (**Figure 6**). In addition to the different assumptions of B_{MSY}/K, priors of *K* and *r*, and the CPUEs used, the 2018 assessment assumed a fixed process error deviation, no error on the catch data input, and a log-normal distribution for the *psi* prior. In contrast, the 2024 assessment estimated annual process error deviations, assumed a CV of 0.01 for the catch data and used a beta distribution for the *psi* prior. The sensitivity analyses also indicated that the exclusion of the Brazil recreational index (BR_rec) and the inclusion of Japan (JPN_LL_late) and Chinese-Taipei (CTP_LL_late) late longline series of relative abundance in the 2024 assessment also contributed to the substantial changes in the trends of the trajectories since the mid-2000s. Therefore, the Group concluded that given the series of changes between the JABBA 2018 and 2024 assessments, it was not unexpected to see differences in the estimated trends of biomass and fishing mortality.

The Group also discussed the issues concerning the potential changes in the catchability of blue marlin from the Japanese and Chinese Taipei longline fleets in the initial years of each respective fishery, indicating that this is likely related to changes in the target species of these fleets. Both fleets initially caught yellowfin tuna and then modified their fishing operations towards bigeye tuna as the main target species. In the SS3 model (SCRS/2024/107), a flag-specific ratio vectors were used "as data" to modulate the catchability of these two fleets by estimating a parameter to report the relationship between the catchability and the ratio. Since within the JABBA model, it is not possible to include a time-varying catchability parameter, the Group requested during the Blue Marlin Data Preparatory meeting sensitivity analyses to account for potential changes in catchability for the CPUE series of JPN_LL_early and CTP_early outside the model. For this, two alternative scenarios were developed, the first considering a "correction factor" of the CPUEs by using a ratio of the yellowfin and bigeye tuna annual catches for each fleet, and a second scenario using the estimates of catchability ("*q*") from the SS3 model for these indices as the "correction factor" (**Table 5**). The Group recommended using the square root for the catch ratio correction factor as is not expected a strict linear relationship between catchability and the catch ratios.

The results of this sensitivity run compared to the JABBA proposed base model are shown in **Figure 7.** The Group noted that if changes in catchability are not fully accounted for in the standardization of the CPUE series they can change the overall estimates of the blue marlin stock productivity, initial biomass, relative stock trends as well as the current stock status. Despite the changes that this analysis indicated, the Group decided not to include these catchability "corrections" to the indices for the JABBA models as part of the changes in targeting and catchability may have already been included (e.g. by using hooks per basket, depth of set, or target factors) in the standardization of the CPUE series. The Group, however, did recommend that national scientists who are familiar with these fisheries review and attempt to account for potential changes in the catchability for these early-time CPUE series for future assessment evaluations.

For this assessment, the total catch of Atlantic blue marlin spanning the period 1956-2022 included 11 standardized CPUE series from Japan (historical and current longline), Chinese Taipei (longline with three split series), USA (longline), Venezuela (longline, gillnet, and rod & reel), Brazil (longline) and Ghana (gillnet), as follows:

- Japanese historical longline: 1959 - 1993
- Japanese longline: 1994 - 2022
- Chinese Taipei longline: 1968 - 1989
- Chinese Taipei longline: 1990 - 1997
- Chinese Taipei longline: 1998 - 2022
- USA pelagic longline: 1993 - 2022
- Venezuelan longline: 1991 - 2018
- Venezuelan artisanal drift-gillnet: 1991 - 2022
- Venezuelan rod and reel recreational: 1961 - 2001
- Brazilian longline: 1978 - 2005
- Ghanaian gillnet: 2000 - 2009

After the Group discussions on the preliminary 2024 runs from both the JABBA and Stock Synthesis platforms, it was agreed that the main source of uncertainty is associated with the assumptions of steepness in the models. In the case of the surplus production model (JABBA), the steepness parameter is associated

with the estimation of the *r* (productivity) parameter. Therefore, the Group agreed to use a grid approach with a set of equally plausible values of steepness (*h*) of 0.4, 0.5, 0.6, and 0.7 for estimating the JABBA *r* priors. Based on that, the JABBA model considered four specifications of the Pella-Tomlinson model type with different sets of *r* priors and fixed input values of B_{MSY}/K (**Table 6**). The input *r* priors for these four scenarios were derived from age-structured model simulations (Winker *et al*., 2020) using the growth parameters provided by Krusic-Golub *et al*. (2024), each steepness value of the grid proposed, and other life-history parameter described in **Table 7**.

Table 8 depicts the main settings and priors used in all JABBA scenarios for the 2024 assessment. For the unfished equilibrium biomass *K,* it was used the default settings of the JABBA R package in the form of vaguely informative lognormal prior with a large CV of 100% and a central value that corresponds to eight times the maximum total catch and is consistent with other platforms such as Catch-MSY (Martell and Froese, 2013). Initial depletion was input as a "beta" prior ($\varphi = B_{1956}/K$) with mean = 0.99 and CV of 1%. All catchability parameters were formulated as uninformative uniform priors, while additional observation variances were estimated for the indices by assuming inverse-gamma priors to enable model internal variance weighting. Instead, the process error of log (B_y) in year *y* was estimated "freely" by the model using an uninformative inverse-gamma distribution with both scaling parameters set at 0.001. The observation error for CPUE estimates was fixed at 0.05. All model runs used a random catch error uncertainty with a CV of 0.01.

4. Model diagnostics

4.1 Stock Synthesis

Detailed diagnostics were initially presented for the run with fixed M=0.148 and fixed h=0.5, so this section starts with a discussion of the diagnostics for that model configuration. Fits to the CPUE log(indices) were examined visually and considered acceptable (**Figure 8**). Fits to the length compositions of the fleets, aggregated over the years, were also reasonable (**Figure 9**). The estimated annual recruitment deviations did not show any significant trend over time, (**Figure 10**). Overall, the joint-index residual (**Figure 11**) plot indicated only a "fair" fit, with the root mean squared error (RMSE) equal to 52.6% for the CPUE data. A better fit was obtained to the mean lengths, which had an RMSE of 5.1%.

Runs tests (for independence of residuals over time) failed for 8 of the 11 CPUE series (**Figure 12, panel (b)**). The Group, however, considered that failures can occur for a variety of reasons and that a runs test should not be seen as a definite test of the quality or usefulness of input data for the stock assessment model. A likelihood profile on R_0 showed some conflicts in the data, nevertheless, a minimum of the likelihood for R_0 could be found, indicating the ability of the model to estimate this parameter (**Figure 13, panel (b)**).

A retrospective analysis indicated some pattern of overestimation of SSB and underestimation of F, but the Mohn's rho (ρM) values were within the limits considered acceptable (**Figure 14, panel (b)**). A "rule of thumb", proposed by Hurtado-Ferro *et al*. (2015), suggests that values of ρM SSB outside -0.15 to 0.20 for long-lived species would indicate an undesirable retrospective pattern. Hindcast cross-validation results for CPUE observations were in general acceptable, with the exception of the Chinese Taipei index (**Figure 15, panel (b)**). A jitter analysis reached a stable solution (**Figure 16, panel (b)**).

Removing one CPUE series at a time (jackknife) did not change results (**Figure 17**). In order to understand what datasets had more impact on the results, in particular, on the SSB increase detected by the assessment in recent years, runs were conducted excluding groups of data at a time. Specifically, a run was performed including only CPUE data, another run with only length composition data, and another run with only growth data. The run with only length composition data resulted in the biggest SSB increase in recent years. Further runs including or excluding length composition data for different fleets indicated that the length data of the longline fleet had the most influence in the estimated recent increase in SSB. The Group discussed this finding, but found no particular explanation for it, as no remarkable change in the length composition data of this fleet was apparent (see e.g. Ortiz *et al*., 2024, SCRS/2024/025, Figure 10).

The Group then examined diagnostics for the runs corresponding to the models agreed for the final grid, i.e. fixed M=0.148 and h= 0.4, 0.5, 0.6, 0.7. The diagnostics for these 4 runs are shown in **Figures 12** through **16**. Although the retrospective and hindcast cross-validation diagnostics were better for the lower values of *h* in the grid, the Group considered all scenarios were acceptable to conform the 4-model final SS3 grid.

4.2. Surplus Production models

JABBA model diagnostics followed the Carvalho *et al*. (2021) guidelines and included examination of patterns within and among CPUE residuals via residual plots and run tests. Goodness-of-fit was evaluated using root mean squared error (RMSE). Model convergence was evaluated by visual evaluation of the Markov chain Monte Carlo (MCMC) trace plots. In the four scenarios described in section 3.b, MCMC trace plots indicated model convergence (**Figures 18** and **19**).

The models fit poorly each standardized CPUE indices, with RMSE estimates of about 51% in all cases (**Figure 20**). The CPUE residual plots showed some patterns indicating data conflicts caused by CPUE indices' conflicting trends. These patterns and the CPUE data-conflicting situation have been already noted in the previous assessment of the blue marlin stock with high RMSE values (e.g. greater than 50%). Run tests conducted on the log-residuals indicated that the CPUE residuals may not be randomly distributed on seven out of the eleven indices when considering all scenarios. Run tests diagnostic fail for the Japan_LL_hist, Japan_LL, CTP_LL_early, CTP_LL_late, US_LL, VEN_GIL and VEN_Rec indices (**Figure 21** and **22)**.

The process error deviates plots of each model in the grid indicated a random stochastic pattern along the time series with a central tendency (median) fluctuating around zero (**Figure 23**). The 95% Bayesian credibility intervals (CIs) always included zero in all scenarios, which can be considered statistical evidence of a non-significant trend.

The marginal posterior distributions, along with prior densities for the models, are shown in **Figures 24** and **25**. The posterior-to-prior median ratio (PPMR) for *r* was close to 1 in all scenarios, indicating that the posterior is heavily influenced by the prior. This was expected, given the low CVs that were estimated in the development of the priors. On the other hand, the resulting small posterior to prior variance ratio (PPVRs) observed for the *K* parameter indicated that the input data was informative about *K*, which was expected since the high CVs were applied in the development of these priors. The marginal posteriors for initial depletion *phi* (φ) parameter presented both a PPMR and PPVR close to 1, which suggests that this parameter was also largely informed by the priors.

Figures 26 and **27** present the retrospective analysis diagnostics, which showed minimal retrospective deviations from the full models. **Table 9** provides Mohn's *rho* statistic computed for each grid model on the five-year retrospective evaluation period. The Mohn's *rho* in all models fell within the acceptable range of -0.15 and 0.20 for all parameters (B_{MSY}, F_{MSY}, MSY, and (procB) process error), indicating a negligible retrospective pattern overall (Hurtado-Ferro *et al*., 2015; Carvalho *et al*., 2017). The hindcasting cross-validation test results indicated that the JPN_LL, US_LL, and VEN_GIL CPUE indices had mean absolute scaled error (MASE) scores around one or less in all scenarios, which suggested these indices have good prediction skills **(Figure 28** and **29)**. On the contrary, the CTP_LL_late index presented values above 1.4 in all scenarios, which indicates a low to no predictivity skill.

5. Model Results

5.1 Stock Synthesis models

The Group agreed to express the uncertainty of the Stock synthesis assessment with 4 different levels of steepness values (*h* = 0.4, 0.5, 0.6, and 0.7) from the grid model approach. Summaries of the estimates of benchmarks are presented in **Table 10**. The trends of spawning biomass, relative fishing mortality, recruits, and SSB/SSB_{MSY} were similar among the scenarios (**Figure 30**), although absolute biomass values differ among scenarios, with higher initial biomass (1956) at the low steepness.

The trajectories of SSB/SSB_{MSY} showed a decrease at the beginning of the time series until the middle of the 1980s with a short increase at the beginning of the 1990s, followed by a decreasing trend until 2015. Since the early 2000s, the relative biomass has remained below SSB_{MSY} until 2022, after 2015 the trend shifted and shows an increase in recent years in all scenarios. The F/F_{MSY} trajectory showed a sharp increase in the mid-1960s, followed by a decrease and oscillating trend until the 1990s when fishing mortality drastically increased well above F_{MSY} reaching a peak in the early 2000s, since then the trend changed and has been decreasing until 2022. By 2022 median fishing mortality of the stock synthesis scenarios was around F_{MSY}.

Kobe plot from the combined scenarios of the stock synthesis grid showed an anti-clockwise trend pattern with the stock status moving from underexploited through a period of unsustainable fishing to the overexploited phase since the middle 1990s (**Figure 31**). In 2022 three out of four scenarios, the biomass remained below SSB_{MSY}, with a fishing mortality rate remaining close to or above F_{MSY} levels. The stock status for 2022 in the stock synthesis grid showed a 15% posterior probability of being both subject to overfishing and overfished, a 54% posterior probability of being overfished but not subject to overfishing, and 31% of the stock being in the green quadrant of the Kobe plot, i.e. not overfishing and not overfished.

5.2 Surplus Production models

The Group agreed to express the uncertainty of the JABBA stock assessment with four different *r* priors based on steepness values (*h* = 0.4, 0.5, 0.6, and 0.7) from the grid model approach. Summaries of posterior quantiles for parameters and management quantities of interest are presented in **Table 11.**

The trajectories of biomass, fishing mortality, B/B_{MSY}, F/F_{MSY} and B/B_0 were similar among the scenarios (**Figure 32**). The trajectories of B/B_{MSY} showed a sharp decrease at the beginning of the time series until the middle of the 1970s to an overfished status, followed by a decreasing trend until 2000. Since the early 2000s, the relative biomass has remained stable at levels below B_{MSY} until 2022. The F/F_{MSY} trajectory showed an increasing trend since the beginning of the time series, crossing F_{MSY} in the middle of the 1980s, followed by a decreasing trend after the 2000s, but always higher than F_{MSY} until 2022.

Kobe plot from the combined scenarios in the JABBA grid showed a relatively anti-clockwise trend pattern with the stock status moving from underexploited through a period of unsustainable fishing to the overexploited phase since the middle 1980s (**Figure 33**). Under all scenarios, biomass remained below B_{MSY} in 2022, with a fishing mortality rate remaining close to or above F_{MSY} levels. The stock status for 2022 in the JABBA grid showed a 62% posterior probability of being both subject to overfishing and overfished (Kobe plot red quadrant), 37% posterior probability of being overfished but not subject to overfishing (Kobe plot yellow quadrant), and only 1% of the stock being not overfishing and not overfished (Kobe plot green quadrant).

5.3 Synthesis of assessment results

A full stock assessment was conducted for blue marlin in 2024, applying to the available data through 2022, using a grid approach for both surplus production and age-structured models to capture uncertainty around biological parameters.

Following the discussions during the meeting, the Group concluded that the 2024 Atlantic blue marlin stock status evaluation is better represented by the joint grid results from the four Stock Synthesis scenarios and four JABBA scenarios. Therefore, it was recommended that the management advice be constructed from the combined results from the two model platforms of the grid approach that considers four scenarios of steepness (0.4, 0.5, 0.6, and 0.7) as the main axis of uncertainty in the evaluation and gives equal weight to each scenario and platform.

The Group recognized that not all potential sources of uncertainty were fully reflected in the assessment results, raising special concerns about the limited information available on discards and the associated mortality. It was also noted that there were differences between the assessment model platforms. In addition, the Group concluded that there is still a need for better biological information on Atlantic blue marlin and the current data precludes the estimation of steepness in stock synthesis.

The main difference between the stock synthesis model and the surplus production model (JABBA) is that stock synthesis takes into account the stock's age structure. This alone accounts for some of the differences in the stock assessment results between the two platforms, however, there are also other assumptions and data differences that need to be considered when comparing the results from each platform, including:

- In stock synthesis the size distribution of the catch is used to inform both the fisheries selectivity and the age structure dynamics of the population;
- Stock synthesis accounts for lags in recruitment which may directly translate into the rate of stock projection changes;
- In JABBA growth parameters (von Bertalanffy model from Krusic *et al*., 2024) are used in the estimation of the *r* prior while in stock synthesis growth is estimated internally in the model by sex, although catch or size data was not provided by sex. Further, SS3 used two sources of age information, the mean length at age from Goodyear (2002) and the age-at-size observations from the Krusic *et al*. (2024) study;
- And, in stock synthesis there were implemented assumptions regarding changes in catchability for the early longline CPUE series, which were explored in JABBA as sensitivity analysis but were not included in the final JABBA runs.

The Group further discussed other sources of uncertainty that were not accounted for in the present evaluation, highlighting particularly the limited number of dead discard reports in the official Task 1NC.

The Group noted that in the time series of the relative biomass and fishing mortality, there are different trends between JABBA and Stock Synthesis (**Figure 34**) particularly from the mid-1960s to early 1990s, when SS3 indicated that the stock was above B_{MSY} while JABBA showed a stock already overfished. This difference is correlated with the assumptions of changes in catchability for the early-time CPUE series from longline fleets (Japan and Chinese Taipei) that were included in stock synthesis but not considered in the JABBA model.

After 2000, both models agreed better on the trends of relative biomass and fishing mortality, indicating that the blue marlin stock has been overexploited and experiencing overfishing in the recent period. By the end of the assessment period 2022, the stock relative biomass is below B_{MSY} and fishing mortality is below F_{MSY} (**Figure 35**). However, the 95% confidence bounds are wide and expand both above and below the relative benchmarks of biomass and fishing mortality, respectively.

Nonetheless, the Group concluded that the combination of the results from both assessment platforms reflects better the overall uncertainty of the assessment evaluation.

5.4 Stock Status

The results of the 2024 Stock Assessment indicated that the current stock status is overfished but not subject to overfishing (**Figure 36**). By the end of 2022, the blue marlin stock was determined to be at relative biomass (B/B_{MSY}) of 0.667 (0.301, 1.353 95% confidence bounds) and relative fishing mortality (F/F_{MSY}) of 0.906 (0.401, 1.640 95% confidence bounds).

The estimated MSY was determined to be 3,331 t with approximate 95% confidence limits of 2,323 to 4, 659 t. The current status of the blue marlin stock is presented in **Figure 36**. The probability of the stock being in the red quadrant of the Kobe plot was estimated to be 39% by 2022. The probability of being in the yellow quadrants of the Kobe plot was estimated to be 46% and of being in the green quadrant 16%.

6. Stock Projections

The Group requested to run stock projections from the final models of the Bayesian Surplus Production model JABBA and the Age structure Stock Synthesis model assuming constant catch (i.e. landings plus dead discards) scenarios. The Group agreed to consider the combined stock status results and projections from both platforms as the basis for the proposal on the management advice on Atlantic blue marlin.

The specifications for the projections were:

i) Catches (landings and dead discards) for 2023 and 2024 were assumed to be the average of the previous three years (2020-2022) used in the Stock Assessment, which corresponds to landings, dead discards, estimated blue marlin catch from the "BIL unclassified" catch and missing reports as agreed during the Blue Marlin Data Preparatory Meeting (Anon., 2024a);

ii) Projections with different catch (landings and dead discards) scenarios will start in 2025 and run for 10 years, ending year 2034;

iii) 12 different catch (landing + dead discards) scenarios, 0 catch and from 1,000 to 4,000 t;

iv) 10,000 stochastic iterations for each scenario of the grid model and platform;

v) Catches by fleet for the Stock Synthesis models were calculated by using the average percentage of catch by fleet between 2020 and 2022;

vi) Projections will assume an equal weight for each scenario and platform.

The preliminary results were provided to the Group (**Figure 37**). After reviewing the preliminary projection results by JABBA, Stock Synthesis, and both methods, the Group decided to modify the catch scenarios shown above for the Species Group meeting in September. The Group emphasized that the "catch" in the projection contains both landings and dead discards in both assessment model platforms.

The Group recommended changes in the projected catch scenarios which will be finalized intersessionally. The final projections will be submitted as an SCRS document to the September 2024 Species Group meeting.

The preliminary projection results indicate that a constant catch at 2,250 t in the next 9 years would recover the stock biomass above B_{MSY} and fishing mortality below F_{MSY}. However, the Group noted that current projections should be considered with caution as part of the projections assumed a recent positive trend of recruitment, for which there is no information or indices of abundance to confirm this trend.

The Group recommends close monitoring of this stock, including the reported landings and dead discards, and if available requesting regular updates of indices of abundance to confirm the recent trends indicated in the assessment evaluation.

7. Responses to the Commission

7.1 Estimation of live and dead discards

A workshop for beta testing of the Bycatch Estimation Tool (BEYT) was conducted in 2023 and a training workshop on the use and application of the tool will happen later this year. The tool is primarily designed to help estimation of discards for fleets that have on-board observers and estimates of total effort.

The Group discussed whether this tool would enhance the capacity of CPCs to improve the reporting of catches of billfish. It is yet too early to see whether scientists will use it, but it is hoped that in the future CPCs scientists will prepare SCRS documents reporting the use of this tool for the estimation of discards. This will improve the chances of continued financial support for further development of the tool and of any future capacity building activities. Currently, workshops for this tool are held in English, the tool's documentation is only available in English and participants are required to be proficient in R to use the tool.

The Group agreed that the most promising initiatives to facilitate learning and use of this methodology will be:

- translating documentation and tool output to other ICCAT languages,
- having language-specific workshops in each of the ICCAT languages, with instructors speaking in the language of each workshop, and

- developing an interface that minimizes the need to be proficient in R.

The Group noted that CPCs are required to report total landings, dead and live discards for all ICCAT species.

It was noted that the BEYT is not the only way for CPCs to estimate and report live and dead discards and that the lack of familiarity with this particular tool should not preclude CPCs from complying with their reporting requirements.

The Group discussed whether workshops on capacity building for small-scale fleets conducted in West Africa in 2023 and the Caribbean in 2024 provided information on discards or their monitoring by CPCs. The information presented during the workshop on discards of billfish was limited, as small-scale fleets seldom have on-board scientific observers. The workshops, however, provided extensive information on monitoring of catch and effort by these fleets. Synthesis documents of the Annual Reports presented at those workshops are being prepared and will be presented at the September 2024 Subcommittee on Statistics and bycatch meeting.

The Group recommended that follow-up activities to these workshops are designed to improve information on any live and dead discards by small-scale fleets in the Caribbean and Western African areas.

7.2 Fishing mortality estimates by main fleet/gears

In its 2023 response to the Commission to this request, the SCRS agreed to provide estimates of fishing mortality by gear for each of the two sailfish stocks in 2024, as this analysis was not completed in 2023 during the sailfish assessments. The Group intends to provide a response in the case of blue marlin based on the 2024 assessment as well.

The Group discussed the Commission request and the type of information that would be most appropriate to fulfill this request. The response should also describe how the relative uncertainty of catch data by fishing gear (including lack of reporting on discards), may affect estimates of fishing mortality by gear. In particular, the Group noted that discard reporting may have different levels of uncertainty depending on the fleet and gear.

Stock Synthesis provides fleet-specific, yearly estimates of exploitation rate, in numbers and biomass. The Group agreed to report, if appropriate, both as any differences between the corresponding trends may reveal the effects of the selectivity of different gears. Jabba provides yearly estimates of the total harvest rate. Estimates of yearly harvest rate by gear can be calculated by using the proportion of yearly catch (in biomass) of each gear as a relative measure of harvest rate. This calculation is consistent with the JABBA assumption that the relative catch of each gear is proportional to fishing mortality.

The Group agreed to work intersessionally to prepare this response for the September 2024 Species Groups meeting. It was agreed that an *ad-hoc* subgroup open to any member of the Group would work intersessionally to develop a working draft of the response to the Commission, to be reviewed by the Billfish Species Group during its September 2024 meeting. The response should provide for the stocks of Eastern sailfish, Western sailfish, and blue marlin:

- information on the relative uncertainty in the reported catch by gear group,
- annual harvest rates by gear group used in the assessments for JABBA and Stock Synthesis,
- if appropriate, estimates for stock synthesis should be for biomass and number,
- ideally, estimates of annual harvest rates will include estimates of uncertainty consistent with how uncertainty was summarized during the stock assessment (i.e. describing overall uncertainty across and within model platforms).
- a summary of the historical management measures imposed by the Commission on the stocks and the gear group affected by each measure.

8. Recommendations

8.1 Research and statistics

The Group recommended that tools and resources like the BEYT be made available in all three languages for the benefit and wider participation of all ICCAT national CPC scientists. It was proposed that workshops be conducted in the three official languages when necessary and consider the translation of manuals, guidelines, and presentations in all three ICCAT languages.

It was further indicated that the SCRS Strategic Plan should include alternatives for multilanguage options within their objectives of capacity building, enhanced scientific participation, and outreach activities.

The Group recommended that the digital images of blue marlin spines be consolidated into a digital library for further analysis and evaluation.

The Group recommended that the studies on blue marlin reproductive biology be conducted in the Gulf of Mexico and be expanded to the Caribbean region and other fisheries.

The Group recommended that national scientists pay particular attention to the potential variation in catchability for all billfish species within the standardization of catch per unit of effort (CPUE) data for assessment purposes.

The Group recommended that the stock status on a given year (yr) be expressed as the "fishing mortality experienced in the given year (F_{yr})" and the stock biomass at the beginning of the given plus one year (B_{yr+1})". It was further suggested that the Working Group on Assessment Methods (WGSAM) could review and provide general guidelines for consistency in the reporting of stock status across all ICCAT species.

The Group recommended that a small group work intersessionally to prepare a draft response to the Commission's request about fishing mortality by main fleet/gears for blue marlin and sailfish, using the latest stock assessment results. This draft response will be reviewed by the Group during the next 2024 SCRS Species Group meeting.

The Group recommended that follow-up activities to capacity building workshops are designed to improve information on any live and dead discards of billfish by small-scale fleets in the Caribbean and Western African areas.

The Group recommends a capacity-building training course on stock assessment methods, with a focus on Bayesian Surplus production (BSP) models. The course should focus on data inputs, model settings, model assumptions, diagnostics, model results interpretation, and stock projections.

8.2 Management Recommendations

Given that some additional work on projections will be carried out intersessionally, and therefore final Kobe strategy matrices were not available for review at this meeting, management advice discussions were deferred to the September 2024 Species Group meeting. The resulting consensus management advice will be reflected in the blue marlin Executive Summary.

9. Enhance Billfish Research Program update on ongoing activities and future planning.

9.1 Reproductive Biology

The coordinator for the West has been asked to complete Terms of Reference (ToRs) for Gulf of Mexico activities for the Enhanced Programme for Billfish Research (EPBR). The Western coordinator presented the draft ToRs for discussion by the Group. The Group agreed with the research activities described in the ToRs and recommended sending it to the ICCAT Secretariat for revision on administrative matters.

A new contract has been signed with a consortium led by Senegal to continue the collection of samples of small and adult sizes for age and growth studies on all three species of marlins, blue marlin, sailfish and white marlin in the north-eastern Atlantic. The team reported that obtaining the samples requested by the Group has been difficult. It is easier to get the spines rather than the otoliths. The ICCAT Secretariat reported that contacts have been made with the scientists working on the EU purse seine fleet to help obtain such samples.

It was also noted that an inter-sessional meeting this year (SCRS/2024/108) recommended considering other aging methods such as epigenetics to overcome some of the limitations of otolith or spine aging.

9.2 Others

As part of a tagging cruise aimed at sharks a single large blue marlin was tagged, but it died shortly after release. Another tagging survey started in June 2024 and attempts are to be made to tag billfish if they are caught during the survey.

10. Other matters

10.1 Research funding

The SCRS Chair reminded the Group that all Working Groups and Sub-Committees have been requested to develop long-term (6-year) research plans, to facilitate strategic research planning, inform on the timing and likely duration of research projects and sequencing, and aid in coordinated planning across the SCRS. In addition, specific research funding requests should be developed for 2-year periods to coincide with the Commission's primary budgeting cycle, to be reviewed at the SCRS Plenary for inclusion in the Annual SCRS Report.

The ICCAT Secretariat informed the Group that the Science budget for 2024 must be used strictly in line with the approved budget by the Commission, which is detailed in Table 1 of document "SCRS research activities requiring funding for 2024 and 2025" [STF-208B/2023]. No extensions and no changes between budget line items will be permitted.

The ICCAT Secretariat emphasized the importance of receiving all ToRs for Science funding soon after the SCRS Plenary. As such, the Secretariat would have more time to complete its administrative processes for issuing contracts. In this way, Calls for Tenders or Quotation Requests could be issued earlier. The SCRS Chair pointed out that these guidelines, and particularly the deadline for developing ToRs, were consistent with both the development of longer-term research plans and detailed 2-year budget requests. This will also facilitate the discussion of proposed science budget requests for submission to the SCRS Plenary meeting. Having all the ToRs prepared before the annual Commission meeting should help the Commission consider science funding requests and should also help projects start sooner. Given the new guidelines on the use of funds, this efficiency is critical.

The SCRS Chair pointed out that the optimal process for developing ToRs would be for draft ToRs to be brought to meetings of the Group, having been developed in collaboration with the Group by correspondence to the extent possible. The long-term research plan can serve as guidance in developing such draft ToRs. This allows the Group to finalize the review and adoption of the ToRs within the limited time available at the meeting, however, it is acknowledged that some new research proposals may emerge during the meeting, with no time to develop ToRs during the meeting. In circumstances where this process cannot be followed, the ToRs could be developed by the Billfish Rapporteur and/or the SCRS Chair, or an identified Sub-Group. The development of ToRs in this manner is a common, established process within the SCRS.

The Group acknowledged the new guidelines and the importance of providing the ToRs in advance of the Commission annual meeting.

10.2 Workplan

The Group discussed the 2025 Billfish Workplan that will be finalized during the September 2024 Species Group meeting.

11. Adoption of the report and closure

The report was adopted during the meeting. The Chair of the Group thanked all the participants for their efforts, as well as the Secretariat and the interpreters for their work. The meeting was adjourned.

References

Anon. 2018. Report of the 2018 ICCAT Blue Marlin Stock Assessment (Miami, United States 18-22 June 2018). Col. Vol. Sci. Pap. ICCAT 75(5): 813-888.

Anon. 2018a. Report of the 2018 ICCAT Blue Marlin Data Preparatory Meeting (Madrid, Spain 12-16 March 2018). Col. Vol. Sci. Pap. ICCAT 75(5): 743-812.

Anon. 2024. Report of the 2024 ICCAT Blue Marlin Data Preparatory Meeting (Miami, United States, 11-15 March 2024). Col. Vol. Sci. Pap. ICCAT 81(1): 1-86.

Carvalho, F., Punt, A.E., Chang, Y.J., Maunder, M.N., Piner, K.R., 2017. Can diagnostic tests help identify model misspecification in integrated stock assessments? Fish. Res. 192, 28–40.

Carvalho, F., Winker, H., Courtney, D., Kapur, M., Kell, L., Cardinale, M., Schirripa, M., Kitakado, T., Yemane, D., Piner, K. R., Maunder, M. N., Taylor, I., Wetzel, C. R., Doering, K., Johnson, K. F., Methot, R. D. 2021. A cookbook for using model diagnostics in integrated stock assessments. Fisheries Research, 240: 105959.

Goodyear, C.P. 2002. Simulated responses of the size distribution of blue marlin to fishing mortality. Col. Vol. Sci. Pap. ICCAT, 54 (3): 869-881.

Hoolihan J.P., Luo J., and Arocha F. 2019. Age and growth of blue marlin Makaira nigricans from the central western Atlantic Ocean. Fisheries Research, Vol. 220, 105346. https://doi.org/10.1016/j.fishres.2019.105346

Hurtado-Ferro F., Szuwalski C.S., Valero J.L., Anderson S.C., Cunningham C.J., Johnson K.F., Licandeo R., McGilliard C.R., Monnahan C.C., Muradian M.L, Ono K., Vert-Pre K.A, Whitten A.R., and Punt A.E. 2015. Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES Journal of Marine Science, Volume 72, Issue 1, January 2015, Pages 99–110, https://doi.org/10.1093/icesjms/fsu198.

ICCAT. 2024. Statistical Bulletin Vol. 49 (1950-2022).

Krusic-Golub K., Sutrovic A., Rosa D., Ngom F., Andrews A., and Coelho R. 2024. Update on Age Estimation from Atlantic Blue Marlin otoliths. SCRS/P/2024/007

Martell, S., Froese, R., 2013. A simple method for estimating MSY from catch and resilience 504–514. https://doi.org/10.1111/j.1467-2979.2012.00485.x

Shimose, T., Yokawa, K. and Tachihara, K., 2015. Age determination and growth estimation from otolith micro-increments and fin spine sections of blue marlin (*Makaira nigricans*) in the western North Pacific. Marine and Freshwater Research, 66(12), pp.1116-1127

Winker, H., Mourato, B., Chang, Y., 2020. Unifying parameterizations between age-structured and surplus production models: An application to Atlantic white marlin (*Kajika albida*) with simulation testing. Col. Vol. Sci. Pap. ICCAT 76, 219–234.

Table 1. Biological parameters of Atlantic blue marlin considered for the stock assessment inputs.

	Growth -Otolith based (Krusic et al. 2024)		**Growth -Spine based (Hoolihan et al. 2019)**	
Gender	*Female*	*Male*	*Female*	*Male*
L_{inf} (cm)	279.99		302.20	209.60
k	0.427		0.052	0.222
t_0	-1.78		-15.10	-6.50
L_{50} (cm)	206		206	
M	0.148		0.148	
t_{max} (y)	42		42	
LW parameter a	1.90e-06	2.47e-06	1.90e-06	2.47e-06
LW parameter b	3.2842	3.2243	3.2842	3.2243

Table 2. Estimated catches (landings + dead discards, t) of Atlantic blue marlin (*Makaira nigricans*) 1984 – 2023[1] by main gear and flag (source T1NC).

			1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TOTAL	A+M		2888	3399	2100	2276	2867	4323	4591	4196	3077	3135	4216	4187	5366	5670	5637	5326	5395	4376	3807	4316	3106	3470	3070	4263	3602	3121	3005	2750	2758	2143	2769	2075	2128	2694	2075	2098	2158	2184	1732	568
Landings		Longline	1915	2606	1431	1454	2097	3090	3682	3537	2407	2306	3115	3000	3835	4302	3721	3513	3253	2595	1924	2227	1824	1963	1940	2369	2479	2069	1977	1438	1339	991	1300	1268	1207	1539	1262	1400	1206	990	935	555
		Other surf.	766	622	453	503	458	895	698	453	433	588	870	956	1267	1098	1734	1658	2014	1635	1618	1765	1073	1430	989	1672	815	839	832	1019	1055	951	1212	584	636	780	489	495	743	984	558	0
		Sport (HL+RR)	207	170	215	181	187	148	51	63	90	114	120	77	68	132	130	72	69	123	216	305	174	51	103	179	269	152	177	237	289	142	200	112	220	276	255	134	136	152	156	0
Landings(FP)		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0
Discards		Longline	0	0	0	138	124	191	159	142	146	127	111	153	197	139	51	83	60	22	37	19	34	24	38	42	37	40	19	56	70	55	54	106	52	73	44	55	58	45	38	13
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	11	0	1	1	0	0	1	21	1	0	5	4	3	5	13	27	23	15	16	12	15	0
Landings	CP	Angola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0
		Barbados	126	10	14	13	46	3	18	12	18	21	19	31	25	30	25	19	19	18	11	11	0	0	25	0	0	0	9	13	14	11	12	34	11	24	21	13	22	12	9	0
		Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	3	7	47	19	8	5	13	1	6	0	2	0	0	0
		Brazil	32	33	46	51	74	60	52	61	125	147	81	180	331	193	486	509	467	780	387	577	195	612	298	262	182	150	130	63	48	114	105	89	79	64	37	20	13	2	3	0
		Canada	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
		China PR	0	0	0	0	0	0	0	0	0	62	73	62	78	120	201	23	92	88	89	58	96	99	65	13	77	100	99	61	45	40	44	50	40	42	46	37	4	10	0
		Curaçao	50	50	50	50	50	50	50	40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	2	20	15	2	6	0
		Côte d'Ivoire	100	100	100	100	87	45	67	76	56	104	151	134	113	157	66	189	288	208	111	171	115	21	8	132	66	72	54	17	48	48	87	15	72	44	32	163	41	148	6	0
		EU-España	3	4	1	0	8	23	6	14	47	44	55	40	158	122	195	125	140	94	28	12	51	24	91	38	55	160	257	131	190	147	209	287	225	321	293	272	250	226	203	0
		EU-France	0	11	11	36	36	46	64	74	88	139	149	154	197	232	257	285	305	329	340	340	345	360	361	358	395	265	281	284	263	162	303	190	167	209	152	170	282	131	170	0
		EU-Portugal	1	8	12	8	2	5	1	4	2	15	11	10	7	3	61	20	22	18	8	32	27	48	105	135	158	106	140	54	55	25	23	46	50	57	74	18	28	37	36	0
		El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		FR-St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Gabon	0	0	0	0	0	0	0	0	0	1	2	0	304	5	0	0	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ghana	166	150	16	5	7	430	324	126	123	236	441	471	422	491	447	624	639	795	999	415	470	759	405	683	191	140	116	332	234	163	236	88	44	162	60	44	53	278	121	0
		Great Britain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Grenada	8	11	36	33	21	23	30	36	30	33	52	50	26	47	60	100	87	104	69	72	45	42	33	49	54	32	69	53	32	63	63	56	53	54	62	69	49	30	30	0
		Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	23	23	0	15	0	0	0
		Japan	833	1100	509	440	823	1555	1217	900	1017	926	1523	1409	1679	1349	1185	790	883	335	267	442	540	442	490	920	1028	822	731	402	430	189	280	293	296	430	287	357	293	284	333	476
		Korea Rep	344	416	96	152	375	689	324	537	24	13	56	56	144	56	2	3	1	1	0	0	1	6	33	64	91	36	85	57	34	24	10	3	26	25	25	13	20	12	10	0
		Liberia	0	0	0	0	0	0	0	0	0	0	0	87	148	148	701	420	712	235	158	115	188	304	162	274	76	56	46	133	94	178	293	35	127	65	24	18	21	119	25	0
		Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	4	7	82	64	46	27	46	39	0
		Mexico	0	0	0	0	0	0	0	0	0	3	13	13	13	13	27	35	68	37	50	70	90	86	64	91	81	93	89	68	106	86	67	72	66	60	68	51	39	43	29	0
		Namibia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	9	57	0	50	2	23	10	0	8	36	8	32	57	84	53	51	70	8	0
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	21	0	14	12	0	0
		Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	71	38	0	0	0	0	0	0	0	8	0	3	4	1	2	2	0	0	0	0	0	0	0	0	0
		Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		S Tomé e Príncipe	0	0	0	0	28	19	17	18	21	25	28	33	36	35	33	30	32	32	32	32	9	21	26	66	68	70	72	74	76	78	81	11	10	13	5	88	34	109	75	0
		Senegal	0	0	0	0	0	1	1	4	8	0	9	0	2	5	0	0	0	11	24	32	11	1	5	91	114	61	41	64	164	45	72	10	82	39	25	21	358	73	38	0
		South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	2	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0
		St Vincent and Grenadines	0	0	0	0	0	1	0	0	1	2	2	2	1	1	0	1	0	0	20	0	0	0	0	1	3	2	1	0	0	2	0	0	0	2	2	1	2	2	0	0
		Trinidad and Tobago	20	3	43	93	45	13	11	6	1	2	16	28	14	50	16	20	51	17	16	9	11	7	14	16	34	26	22	25	46	48	48	35	19	0	0	0	1	0	0	0
		UK-Bermuda	8	9	11	6	8	15	17	18	19	11	15	15	15	3	5	1	2	2	2	2	2	2	2	2	0	1	2	2	3	3	3	2	1	2	1	1	1	1	0	0
		UK-British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK-Sta Helena	0	0	0	0	0	0	0	0	0	0	0	2	2	1	2	4	4	3	4	1	1	2	2	3	4	2	2	2	12	2	1	1	0	0	0	0	0	0	0	0
		UK-Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		USA	280	295	273	291	221	124	29	33	51	80	88	43	43	46	50	37	24	16	17	19	26	16	17	9	13	6	4	6	14	9	1	9	19	13	20	17	17	22	22	0
		USSR	0	7	23	45	32	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uruguay	0	0	0	0	0	0	0	1	0	0	3	1	1	26	23	0	0	0	1	5	3	2	8	5	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Venezuela	117	219	221	63	81	155	75	56	67	86	122	117	148	142	226	240	125	84	88	120	101	160	172	222	130	120	155	122	161	123	158	144	180	197	132	116	73	96	123	0
	NCC	Chinese Taipei	172	313	215	317	292	473	1704	1672	824	685	663	467	660	1478	578	486	485	240	294	319	315	151	99	233	148	195	153	199	133	78	62	61	75	73	74	40	70	76	40	70
		Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	2	0	0	2	1	3	2	11	9	12	19	14	19	34	53	48	74	35	27	15	24	11	8
		Guyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128	39	75	81	0
	NCO	Benin	9	10	7	4	12	0	6	6	6	6	5	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cuba	373	451	214	205	285	151	202	189	204	69	39	85	43	53	12	38	55	56	34	3	4	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Dominica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	69	75	36	44	55	58	106	76	76	60	0	0	85	62	49	74	52	45	64	54	54	0
		Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	41	71	29	23	23	115	207	142	30	38	47	67	60	65	100	98	99	96	73	170	183	176	87	58	72	72	0
		Jamaica	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mixed flags (FR+ES)	118	122	135	132	137	144	199	137	116	146	133	126	96	82	80	83	147	151	131	148	171	150	136	135	139	164	178	186	181	191	173	176	0	0	0	0	0	0	0	0
		NEI (BIL)	128	78	68	94	74	103	18	20	38	0	0	0	0	0	0	0	53	184	258	167	89	7	160	209	205	177	0	34	0	0	0	0	0	0	0	0	0	0	0	0
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	174	326	362	435	548	803	761	492	274	17	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Saint Kitts and Nevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	8	12	0	2	5	4	0
		Sta Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	10	5	9	18	17	21	53	46	70	72	58	64	119	99	111	53	91	134	93	82	78	61	85	0
		Togo	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	73	53	141	103	775	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ukraine	0	0	0	0	0	0	0	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	7	8	6	3	2	0	0	0	0	0	0	0	0	0
Landings(FP)	CP	EU-España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
		EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
Discards	CP	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
		Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0
		EU-España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	1	4	3	5	7	6	6	7	6	7	0	0
		EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	6	11	12	9	5	5	8	0
		Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	0	0	0	0
		Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	8	16	8	4	0	0
		Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	1	0	0	0	0	0	0	0	0
		Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	2	0	0	0
		UK-Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		USA	0	0	0	138	124	191	159	142	146	127	111	153	197	139	52	83	60	25	49	19	35	25	36	42	38	42	19	50	39	55	53	81	25	47	22	24	20	9	16	0
	NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	24	27	26	16	22	21	20	18	13

[1] 2023 values are provisional and partial, as reported until June 17, 2024.

Table 3. Annual blue marlin total catch removals (landing, dead discards) by fleet ID and catch sensitivity scenarios (1-3) based three different assumptions of mortality of reported live discards.

Blue marlin Catch						
Landings + dead discards, PLUS included BUM from the BIL unclassified split, allocated among fleet according to annual proportions						
Catch t	FleetSS3					JABBA
YearC	ART	LL	mFAD	OTH	SPT	Grand Total
1956	-	39	-	-	-	39
1957	-	764	-	-	-	764
1958	-	772	-	-	-	772
1959	-	841	-	-	-	841
1960	-	2,712	-	-	103	2,815
1961	-	3,961	-	-	122	4,083
1962	-	7,187	-	-	121	7,308
1963	-	8,906	-	1	131	9,038
1964	-	7,846	-	1	164	8,011
1965	-	5,990	-	1	165	6,156
1966	-	3,703	-	4	156	3,863
1967	-	2,037	-	6	203	2,246
1968	-	2,341	-	12	174	2,527
1969	-	2,877	-	15	214	3,106
1970	-	2,653	-	22	211	2,886
1971	-	3,184	-	31	183	3,398
1972	-	2,173	-	48	193	2,414
1973	-	2,967	-	49	210	3,226
1974	-	2,597	-	262	236	3,095
1975	-	2,792	-	236	243	3,271
1976	-	1,911	-	240	268	2,419
1977	-	1,615	-	267	299	2,181
1978	-	1,079	-	260	303	1,642
1979	-	970	-	257	300	1,527
1980	119	1,142	-	283	303	1,848
1981	140	1,268	-	386	313	2,107
1982	60	1,996	-	351	301	2,708
1983	216	1,360	-	367	199	2,142
1984	403	1,915	-	363	207	2,888
1985	337	2,595	11	285	170	3,399
1986	193	1,420	11	260	215	2,100
1987	202	1,558	36	301	181	2,279
1988	201	2,186	36	229	215	2,868
1989	677	3,236	46	198	168	4,324
1990	429	3,778	64	252	68	4,592
1991	240	3,605	74	195	82	4,196
1992	244	2,465	88	168	111	3,077
1993	374	2,309	140	192	140	3,156
1994	658	3,077	149	176	157	4,216
1995	746	2,999	154	177	110	4,187
1996	1,084	3,835	197	145	105	5,366
1997	916	4,209	232	147	167	5,670
1998	1,394	3,515	257	308	164	5,637
1999	1,501	3,311	285	127	102	5,326
2000	1,790	3,028	307	206	102	5,432
2001	1,443	2,300	331	165	160	4,398
2002	1,421	1,622	340	143	282	3,808
2003	1,536	1,909	341	150	388	4,324
2004	837	1,525	348	175	246	3,130
2005	1,224	1,668	369	154	141	3,556
2006	693	1,618	360	197	202	3,070
2007	1,275	2,064	353	248	332	4,272
2008	440	2,141	383	217	433	3,613
2009	317	1,864	259	376	326	3,143
2010	307	1,772	241	400	311	3,031
2011	572	1,285	270	341	391	2,859
2012	495	1,231	231	400	498	2,855
2013	456	903	146	323	321	2,148
2014	734	1,082	273	287	393	2,770
2015	222	1,218	158	295	184	2,077
2016	344	1,167	119	158	381	2,169
2017	376	1,501	166	286	458	2,788
2018	180	1,224	121	222	387	2,134
2019	145	1,329	141	264	240	2,118
2020	457	1,010	265	211	229	2,172
2021	640	981	102	284	240	2,247
2022	230	859	135	265	254	1,743

SENSITVITY 1						
Catch t	FleetSS3					JABBA
YearC	ART	LL	mFAD	OTH	SPT	Grand Tota
1956	-	39	-	-	-	39
1957	-	764	-	-	-	764
1958	-	772	-	-	-	772
1959	-	841	-	-	-	841
1960	-	2,712	-	-	103	2,815
1961	-	3,961	-	-	122	4,083
1962	-	7,187	-	-	121	7,308
1963	-	8,906	-	1	131	9,038
1964	-	7,846	-	1	164	8,011
1965	-	5,990	-	1	165	6,156
1966	-	3,703	-	4	156	3,863
1967	-	2,037	-	6	203	2,246
1968	-	2,341	-	12	174	2,527
1969	-	2,877	-	15	214	3,106
1970	-	2,653	-	22	211	2,886
1971	-	3,184	-	31	183	3,398
1972	-	2,173	-	48	193	2,414
1973	-	2,967	-	49	210	3,226
1974	-	2,597	-	262	236	3,095
1975	-	2,792	-	236	243	3,271
1976	-	1,911	-	240	268	2,419
1977	-	1,615	-	267	299	2,181
1978	-	1,079	-	260	303	1,642
1979	-	970	-	257	300	1,527
1980	119	1,142	-	283	303	1,848
1981	140	1,268	-	386	313	2,107
1982	60	1,996	-	351	301	2,708
1983	216	1,360	-	367	199	2,142
1984	403	1,915	-	363	207	2,888
1985	337	2,595	11	285	170	3,399
1986	193	1,420	11	260	215	2,100
1987	202	1,558	36	301	181	2,279
1988	201	2,186	36	229	215	2,868
1989	677	3,236	46	198	168	4,324
1990	429	3,778	64	252	68	4,592
1991	240	3,605	74	195	82	4,196
1992	244	2,465	88	168	111	3,077
1993	374	2,309	140	192	140	3,156
1994	658	3,077	149	176	157	4,216
1995	746	2,999	154	177	110	4,187
1996	1,084	3,835	197	145	105	5,366
1997	916	4,209	232	147	167	5,670
1998	1,394	3,515	257	308	164	5,637
1999	1,501	3,311	285	127	102	5,326
2000	1,790	3,028	307	206	102	5,432
2001	1,443	2,300	331	165	160	4,398
2002	1,421	1,622	340	143	282	3,808
2003	1,536	1,909	341	150	388	4,324
2004	837	1,525	348	175	246	3,130
2005	1,224	1,668	369	154	141	3,556
2006	693	1,622	360	197	202	3,075
2007	1,275	2,070	353	248	332	4,278
2008	440	2,143	383	217	433	3,615
2009	317	1,870	259	376	326	3,149
2010	307	1,775	241	400	311	3,034
2011	572	1,296	270	341	391	2,870
2012	495	1,242	231	400	498	2,866
2013	456	917	146	323	321	2,162
2014	734	1,092	273	287	393	2,779
2015	222	1,232	158	295	184	2,092
2016	344	1,174	119	158	381	2,176
2017	376	1,511	166	286	458	2,797
2018	180	1,231	121	222	387	2,140
2019	145	1,336	141	264	240	2,125
2020	457	1,013	265	211	229	2,175
2021	640	984	102	284	240	2,249
2022	230	862	135	265	254	1,746

Table 3. Continuation…

SENSITIVITY 2						
Catch t	FleetSS3					JABBA
YearC	ART	LL	mFAD	OTH	SPT	Grand Total
1956	-	39	-	-	-	39
1957	-	764	-	-	-	764
1958	-	772	-	-	-	772
1959	-	841	-	-	-	841
1960	-	2,712	-	-	103	2,815
1961	-	3,961	-	-	122	4,083
1962	-	7,187	-	-	121	7,308
1963	-	8,906	-	1	131	9,038
1964	-	7,846	-	1	164	8,011
1965	-	5,990	-	1	165	6,156
1966	-	3,703	-	4	156	3,863
1967	-	2,037	-	6	203	2,246
1968	-	2,341	-	12	174	2,527
1969	-	2,877	-	15	214	3,106
1970	-	2,653	-	22	211	2,886
1971	-	3,184	-	31	183	3,398
1972	-	2,173	-	48	193	2,414
1973	-	2,967	-	49	210	3,226
1974	-	2,597	-	262	236	3,095
1975	-	2,792	-	236	243	3,271
1976	-	1,911	-	240	268	2,419
1977	-	1,615	-	267	299	2,181
1978	-	1,079	-	260	303	1,642
1979	-	970	-	257	300	1,527
1980	119	1,142	-	283	303	1,848
1981	140	1,268	-	386	313	2,107
1982	60	1,996	-	351	301	2,708
1983	216	1,360	-	367	199	2,142
1984	403	1,915	-	363	207	2,888
1985	337	2,595	11	285	170	3,399
1986	193	1,420	11	260	215	2,100
1987	202	1,558	36	301	181	2,279
1988	201	2,186	36	229	215	2,868
1989	677	3,236	46	198	168	4,324
1990	429	3,778	64	252	68	4,592
1991	240	3,605	74	195	82	4,196
1992	244	2,465	88	168	111	3,077
1993	374	2,309	140	192	140	3,156
1994	658	3,077	149	176	157	4,216
1995	746	2,999	154	177	110	4,187
1996	1,084	3,835	197	145	105	5,366
1997	916	4,209	232	147	167	5,670
1998	1,394	3,515	257	308	164	5,637
1999	1,501	3,311	285	127	102	5,326
2000	1,790	3,028	307	206	102	5,432
2001	1,443	2,300	331	165	160	4,398
2002	1,421	1,622	340	143	282	3,808
2003	1,536	1,909	341	150	388	4,324
2004	837	1,525	348	175	246	3,130
2005	1,224	1,668	369	154	141	3,556
2006	693	1,625	360	197	202	3,078
2007	1,275	2,074	353	248	332	4,282
2008	440	2,144	383	217	433	3,616
2009	317	1,874	259	376	326	3,153
2010	307	1,777	241	400	311	3,036
2011	572	1,303	270	341	391	2,877
2012	495	1,250	231	400	498	2,873
2013	456	926	146	323	321	2,172
2014	734	1,098	273	287	393	2,785
2015	222	1,242	158	295	184	2,101
2016	344	1,179	119	158	381	2,181
2017	376	1,517	166	286	458	2,803
2018	180	1,235	121	222	387	2,145
2019	145	1,340	141	264	240	2,129
2020	457	1,015	265	211	229	2,177
2021	640	985	102	284	240	2,251
2022	230	863	135	265	254	1,748

SENSITIVITY 3						
Catch t	FleetSS3					JABBA
YearC	ART	LL	mFAD	OTH	SPT	Grand Tota
1956	-	39	-	-	-	39
1957	-	764	-	-	-	764
1958	-	772	-	-	-	772
1959	-	841	-	-	-	841
1960	-	2,712	-	-	103	2,815
1961	-	3,961	-	-	122	4,083
1962	-	7,187	-	-	121	7,308
1963	-	8,906	-	1	131	9,038
1964	-	7,846	-	1	164	8,011
1965	-	5,990	-	1	165	6,156
1966	-	3,703	-	4	156	3,863
1967	-	2,037	-	6	203	2,246
1968	-	2,341	-	12	174	2,527
1969	-	2,877	-	15	214	3,106
1970	-	2,653	-	22	211	2,886
1971	-	3,184	-	31	183	3,398
1972	-	2,173	-	48	193	2,414
1973	-	2,967	-	49	210	3,226
1974	-	2,597	-	262	236	3,095
1975	-	2,792	-	236	243	3,271
1976	-	1,911	-	240	268	2,419
1977	-	1,615	-	267	299	2,181
1978	-	1,079	-	260	303	1,642
1979	-	970	-	257	300	1,527
1980	119	1,142	-	283	303	1,848
1981	140	1,268	-	386	313	2,107
1982	60	1,996	-	351	301	2,708
1983	216	1,360	-	367	199	2,142
1984	403	1,915	-	363	207	2,888
1985	337	2,595	11	285	170	3,399
1986	193	1,420	11	260	215	2,100
1987	202	1,558	36	301	181	2,279
1988	201	2,186	36	229	215	2,868
1989	677	3,236	46	198	168	4,324
1990	429	3,778	64	252	68	4,592
1991	240	3,605	74	195	82	4,196
1992	244	2,465	88	168	111	3,077
1993	374	2,309	140	192	140	3,156
1994	658	3,077	149	176	157	4,216
1995	746	2,999	154	177	110	4,187
1996	1,084	3,835	197	145	105	5,366
1997	916	4,209	232	147	167	5,670
1998	1,394	3,515	257	308	164	5,637
1999	1,501	3,311	285	127	102	5,326
2000	1,790	3,028	307	206	102	5,432
2001	1,443	2,300	331	165	160	4,398
2002	1,421	1,622	340	143	282	3,808
2003	1,536	1,909	341	150	388	4,324
2004	837	1,525	348	175	247	3,130
2005	1,224	1,668	369	154	141	3,556
2006	693	1,618	360	197	202	3,070
2007	1,275	2,064	353	248	332	4,272
2008	440	2,141	383	217	433	3,613
2009	317	1,864	259	376	326	3,143
2010	307	1,772	241	400	311	3,031
2011	572	1,285	270	341	391	2,859
2012	495	1,231	231	400	498	2,855
2013	456	903	146	323	321	2,148
2014	734	1,082	273	287	393	2,770
2015	222	1,218	158	295	184	2,077
2016	344	1,167	119	158	381	2,169
2017	376	1,501	166	286	459	2,789
2018	180	1,224	121	222	390	2,137
2019	145	1,329	141	264	240	2,118
2020	457	1,010	265	211	230	2,173
2021	640	981	102	284	240	2,247
2022	230	859	135	265	255	1,744

Table 4. Results of exploratory SS3 runs, estimating natural mortality (M) and/or steepness (*h*). Models are labelled as in **Figure 5**.

Model	**M**	***h***	**M result**	***h* result**
4	0.148	Estimated	0.148	*0.43*
5 (top)	Estimated freely	0.4	*0.115*	0.4
6 (top)	Estimated freely	0.5	*0.107*	0.5
7 (top)	Estimated freely	0.7	*0.095*	0.7
8 (top)	Estimated freely	Estimated	*0.098*	*0.63*
5 (bottom)	Estimated (prior mean=0.148, SD=0.018)	0.5	*0.117*	0.5
6 (bottom)	Estimated (prior mean=0.148, SD=0.018)	0.4	*0.109*	0.4
7 (bottom)	Estimated (prior mean=0.148, SD=0.018)	0.7	*0.095*	0.7
8 (bottom)	Estimated (prior mean=0.148, SD=0.018)	Estimated	*0.101*	*0.60*

Table 5. Original index of abundance from Japan (1959-1993) and Chinese Taipei (1968-1989) longline historical series and the estimated "corrected CPUE" series using the YFT/BET ratio (CPUE corrected 2) or the estimated catchability *q* from Stock synthesis model (CPUE corrected 3).

Use in 2024	Use 1959-1993			JPN LL catch ratio YFT/(BET+YFT)						
Name	JPN_LL_hist									
Fleet	Japan									
Gear	LL						exponent			
Docs	SCRS/2000/081						0.5			
Catch definition	Retained									
Year	Index Number	CV		YearC	%YFT	proxy	proxy2	CPUE corrected 2	q SS3 scaled	CPUE corrected 3
1956				1956	0.98388645					
1957				1957	0.9667448					
1958				1958	0.98359409					
1959	2.221	0.125		1959	0.96755143	2.649	1.628	2.649	1.80E+00	1.232
1960	1.964	0.125		1960	0.94594796	2.590	1.609	2.590	1.77E+00	1.111
1961	3.820	0.125		1961	0.79415876	2.174	1.475	2.174	1.54E+00	2.478
1962	3.456	0.125		1962	0.73258835	2.006	1.416	2.006	1.46E+00	2.371
1963	2.777	0.125		1963	0.72683101	1.990	1.411	1.990	1.45E+00	1.917
1964	1.776	0.125		1964	0.68417415	1.873	1.369	1.873	1.40E+00	1.273
1965	1.216	0.125		1965	0.5784481	1.584	1.258	1.584	1.26E+00	0.963
1966	1.005	0.125		1966	0.61130398	1.674	1.294	1.674	1.30E+00	0.772
1967	0.974	0.125		1967	0.6822621	1.868	1.367	1.868	1.39E+00	0.700
1968	1.176	0.125		1968	0.67466735	1.847	1.359	1.847	1.38E+00	0.851
1969	1.299	0.125		1969	0.57082499	1.563	1.250	1.563	1.25E+00	1.036
1970	1.048	0.125		1970	0.47889023	1.311	1.145	1.311	1.15E+00	0.910
1971	0.652	0.125		1971	0.40576961	1.111	1.054	1.111	1.08E+00	0.606
1972	0.747	0.125		1972	0.38805041	1.062	1.031	1.062	1.05E+00	0.708
1973	0.579	0.125		1973	0.34433358	0.943	0.971	0.943	1.01E+00	0.571
1974	0.966	0.125		1974	0.35261257	0.965	0.983	0.965	1.02E+00	0.944
1975	0.699	0.125		1975	0.24767417	0.678	0.823	0.678	9.26E-01	0.755
1976	0.485	0.125		1976	0.50415731	1.380	1.175	1.380	1.18E+00	0.412
1977	0.558	0.125		1977	0.28558349	0.782	0.884	0.782	9.57E-01	0.583
1978	0.590	0.125		1978	0.25461004	0.697	0.835	0.697	9.30E-01	0.634
1979	0.601	0.125		1979	0.19525765	0.535	0.731	0.535	8.77E-01	0.685
1980	0.733	0.125		1980	0.13745053	0.376	0.613	0.376	7.27E-01	1.009
1981	0.651	0.125		1981	0.20925654	0.573	0.757	0.573	7.27E-01	0.896
1982	0.827	0.125		1982	0.19470877	0.533	0.730	0.533	7.27E-01	1.138
1983	0.741	0.125		1983	0.21957726	0.601	0.775	0.601	7.27E-01	1.020
1984	0.828	0.125		1984	0.17768814	0.486	0.697	0.486	7.27E-01	1.140
1985	0.873	0.125		1985	0.1981667	0.543	0.737	0.543	7.27E-01	1.202
1986	0.605	0.125		1986	0.19907697	0.545	0.738	0.545	7.27E-01	0.833
1987	0.663	0.125		1987	0.24545346	0.672	0.820	0.672	7.27E-01	0.913
1988	0.640	0.125		1988	0.2037152	0.558	0.747	0.558	7.27E-01	0.881
1989	0.674	0.125		1989	0.18641975	0.510	0.714	0.510	7.27E-01	0.928
1990	0.524	0.125		1990	0.17784467	0.487	0.698	0.487	7.27E-01	0.721
1991	0.358	0.125		1991	0.16880699	0.462	0.680	0.462	7.27E-01	0.493
1992	0.366	0.125		1992	0.11590365	0.317	0.563	0.317	7.27E-01	0.504
1993	0.479	0.125		1993	0.08115547	0.222	0.471	0.222	7.27E-01	0.659
1994	0.503	0.125		1994	0.11049762	0.303	0.550	0.303	7.27E-01	0.692
1995	0.472	0.125		1995	0.1284149	0.352	0.593	0.352	7.27E-01	0.650
1996	0.513	0.125		1996	0.13664402	0.374	0.612	0.374	7.27E-01	0.706
1997	0.459	0.125		1997	0.11785274	0.323	0.568	0.323	7.27E-01	0.632
1998	0.475	0.125		1998	0.1753381	0.480	0.693	0.480	7.27E-01	0.654

Table 5. Contunued.

	Use 1968-1989			CTP LL catch ratio							
	CTP_LL_early										
	Chinese Taipei										
	LL						exponent				
	SCRS/2024/030						0.5				
	Retained										
Year	Num.	CV		YearC	%YFT	proxy	proxy2	CPUE corrected	CPUE corrected 2	q SS3 scaled	CPUE corrected 3
1956											
1957											
1958											
1959											
1960											
1961											
1962				1962	0.933						
1963				1963	0.895						
1964				1964	0.880						
1965				1965	1.000						
1966				1966	0.649						
1967				1967	0.545						
1968	0.304	0.095		1968	0.595	1.545	1.243	0.197	0.245	2.46	0.123
1969	0.334	0.083		1969	0.591	1.533	1.238	0.218	0.270	2.43	0.137
1970	0.231	0.080		1970	0.483	1.255	1.120	0.184	0.206	1.80	0.128
1971	0.185	0.087		1971	0.444	1.152	1.073	0.161	0.172	1.61	0.115
1972	0.149	0.102		1972	0.485	1.260	1.122	0.118	0.133	1.81	0.082
1973	0.159	0.122		1973	0.410	1.065	1.032	0.149	0.154	1.46	0.109
1974	0.115	0.100		1974	0.429	1.114	1.055	0.103	0.109	1.54	0.075
1975	0.065	0.111		1975	0.374	0.971	0.986	0.067	0.066	1.31	0.049
1976	0.120	0.127		1976	0.346	0.899	0.948	0.133	0.127	1.21	0.099
1977	0.032	0.130		1977	0.100	0.258	0.508	0.124	0.063	0.57	0.056
1978	0.029	0.134		1978	0.114	0.297	0.545	0.098	0.053	0.60	0.049
1979	0.044	0.142		1979	0.295	0.765	0.874	0.058	0.050	1.04	0.042
1980	0.057	0.100		1980	0.212	0.549	0.741	0.104	0.077	0.41	0.138
1981	0.049	0.096		1981	0.315	0.817	0.904	0.060	0.054	0.41	0.118
1982	0.042	0.094		1982	0.221	0.574	0.758	0.073	0.055	0.41	0.101
1983	0.029	0.111		1983	0.249	0.647	0.804	0.045	0.036	0.41	0.070
1984	0.033	0.102		1984	0.411	1.067	1.033	0.031	0.032	0.41	0.080
1985	0.025	0.101		1985	0.432	1.120	1.058	0.022	0.024	0.41	0.060
1986	0.034	0.102		1986	0.556	1.444	1.202	0.024	0.028	0.41	0.082
1987	0.059	0.114		1987	0.377	0.980	0.990	0.060	0.060	0.41	0.142
1988	0.088	0.162		1988	0.557	1.446	1.203	0.061	0.073	0.41	0.212
1989	0.083	0.154		1989	0.477	1.239	1.113	0.067	0.075	0.41	0.200

Table 6. Results for *r* prior distributions and median shape parameter with corresponding B_{MSY}/K values generated from the Age-Structured Equilibrium Model (ASEM) based on the steepness uncertainty grid levels.

Steepness	***0.4***	***0.5***	***0.6***	***0.7***
MEAN R	0.076	0.092	0.105	0.112
SD OF LOG (R)	0.217	0.222	0.231	0.228
B_{MSY}/K	0.42	0.38	0.36	0.33

Table 7. Life history parameters used to estimate *r* prior distributions and median shape parameter with corresponding B_{MSY}/K values of the Atlantic blue marlin assessment. The priors are generated using an Age-Structured Equilibrium Model (ASEM). Growth parameters are from the Krusic *et al*. (2024) von Bertalanffy model.

SEX	Female	Male
L_{INF} ***(CM)***	279.99	
K	0.427	
T_0	-1.78	
L_{50} ***(CM)***	206	
M	0.148	
T_{MAX} ***(Y)***	42	
A (LENGTH-WEIGHT)	1.90e-06	2.47e-06
B (LENGTH-WEIGHT)	3.2842	3.2243

Table 8. Settings used in the 2024 JABBA settings for all scenarios.

Settings	***2024 assessment***
PERIOD	1956-2022
MODEL TYPE	Pella
CATCH CV	0.01
CATCH ERROR	Random
***PSI*.PRIOR**	C(0.99,0.01)
***PSI*.DIST**	Beta
INVERSE GAMMA	(0.001,0.001)
FIXED OBSERVATION ERROR MODEL	0.05
K (T)	Ln(72303,1)

Table 9. Summary of models Mohn's rho statistic from the retrospective evaluation period of five years for each scenario based on the steepness (*h*) uncertainty grid.

Steepness (h) scenario	***B***	***F***	***B_{MSY}***	***F_{MSY}***	***process error***	***MSY***
0.4	-0.040	0.04	-0.07	0.08	-0.01	0.001
0.5	-0.004	0.005	0.006	0.003	-0.005	-0.011
0.6	-0.01	0.01	-0.03	0.02	0.001	0.02
0.7	0.02	-0.01	0.01	-0.02	0.01	0.01

Table 10. Estimates of benchmark by Stock Synthesis with 4 steepness (*h*) scenarios in the grid, including the mean and the 95% confidence intervals.

Estimates	***Mean***	***2.50%***	***97.50%***	***Mean***	***2.50%***	***97.50%***
Steepness (h)=0.4				**h=0.5**		
Unfished SSB t	70,808	64,372	77,244	59,796	54,966	64,626
F_{MSY}	0.052	0.052	0.053	0.078	0.078	0.079
SSB_{MSY} t	27,416	24,896	29,937	20,674	18,963	22,384
MSY t	2,519	2,323	2,715	2,900	2,706	3,094
SSB_{MSY}/K	0.387	0.386	0.389	0.346	0.344	0.348
h=0.6				**h=0.7**		
Unfished SSB t	52,521	48,484	56,558	47,590	43,733	51,447
F_{MSY}	0.106	0.106	0.107	0.139	0.138	0.140
SSB_{MSY} t	16,170	14,874	17,465	12,885	11,779	13,990
MSY t	3,150	2,959	3,341	3,365	3,162	3,568
SSB_{MSY}/K	0.308	0.305	0.310	0.271	0.268	0.274

Table 11. Summary of posterior quantiles presented in the form of marginal posterior medians and associated 95% credibility intervals of parameters for the 2024 Atlantic blue marlin final JABBA grid (steepness h = 0.4, 0.5, 0.6, and 0.7).

Estimates	**Median**	**2.50%**	**97.50%**	**Median**	**2.50%**	**97.50%**
h 04				**h_05**		
(*r* prior based on steepness 0.4)				(*r* prior based on steepness 0.5)		
K	100,895	69,279	165,154	83,602	57,878	133,430
r	0.102	0.067	0.148	0.115	0.079	0.165
ψ (psi)	0.993	0.964	1.000	0.993	0.965	1.000
σ_{proc}	0.126	0.084	0.185	0.130	0.087	0.188
m	1.32	1.32	1.32	1.068	1.068	1.068
F_{MSY}	0.077	0.051	0.112	0.108	0.074	0.155
B_{MSY}	42,371	29,094.	69,357	31,772	21,996	50,709
MSY	3,297	2,346	4,659	3,422	2,653	4,648
B_{MSY}/K	0.420	0.420	0.420	0.380	0.380	0.380
h 06				**h 07**		
(*r* prior based on steepness 0.6)				(*r* prior based on steepness 0.7)		
K	70,845	50,030	106,834	66,562	47,020	98,674
r	0.127	0.088	0.181	0.125	0.088	0.176
ψ (psi)	0.993	0.963	1.000	0.993	0.964	1.000
σ_{proc}	0.131	0.088	0.187	0.135	0.090	0.191
m	0.958	0.958	0.958	0.811	0.811	0.811
F_{MSY}	0.133	0.091	0.189	0.155	0.108	0.217
B_{MSY}	25,505	18,012	38,462	21,971	15,521	32,571
MSY	3,408	2,744	4,243	3,407	2,813	4,159
B_{MSY}/K	0.360	0.360	0.360	0.330	0.330	0.330

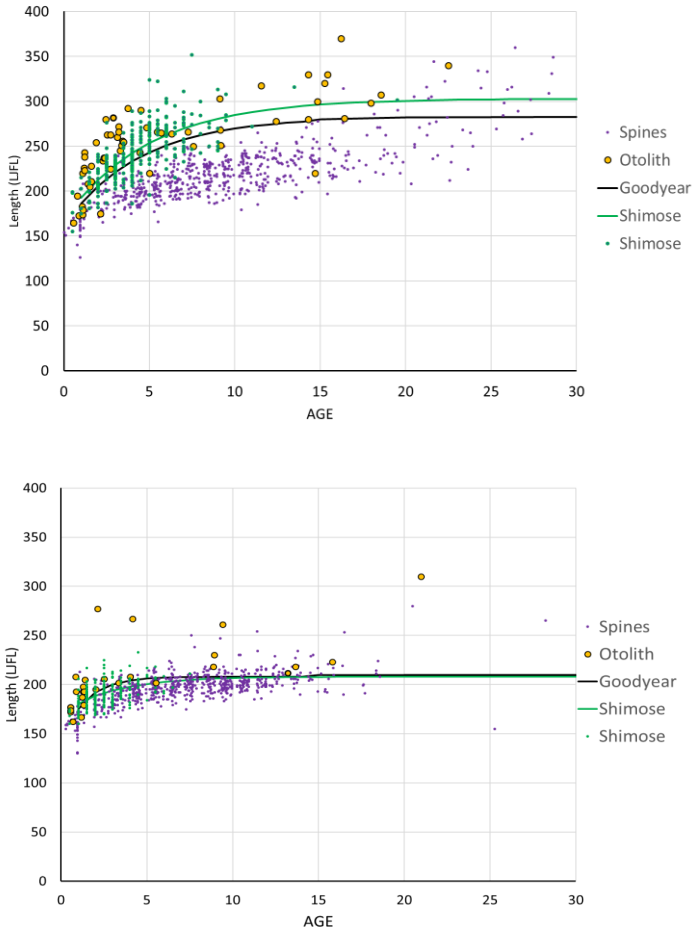


Figure 1. Plots of size at age observations for blue marlin for females (top) and males (bottom) from Atlantic spine samples (purple small dots), Atlantic otolith samples (yellow dots), and Pacific otolith samples (green dots). The solid lines represent the estimated von Bertalanffy growth models. The size at age samples or estimated growth model from the Pacific (Shimose *et al.* 2015) were not used in the 2024 blue marlin stock assessment.

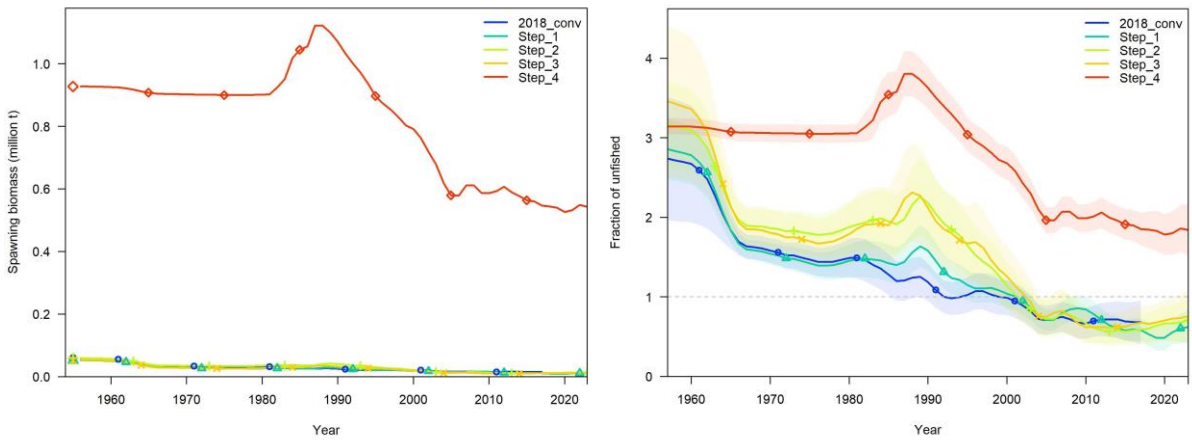


Figure 2. Annual blue marlin spawning biomass t (top) and SSB/SSB_{MSY} (bottom) from the Stock Synthesis models in which growth parameters were estimated from a) the mean size at age Goodyear 2002 (2015) and Atlantic otolith samples (lines 2018_conv, Step_1, Step_2, Step_3) versus b) the growth parameters estimated using only the Atlantic spine samples (Holligan *et al.*, 2019) (Step_4 red line).

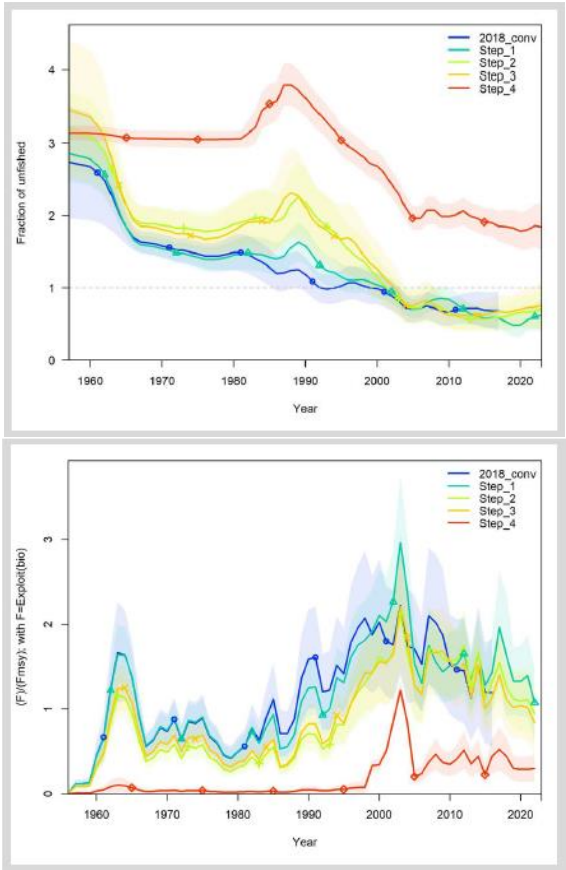


Figure 3. 2018 stock assessment with SS3 and four initial exploratory runs with catch until 2022: Step 1 updating only CPUE data, Step 2 updating both CPUE and length composition data, Step 3 as Step 2 and estimating growth from otolith data, Step 4 as Step 2 and estimating growth from spine data.

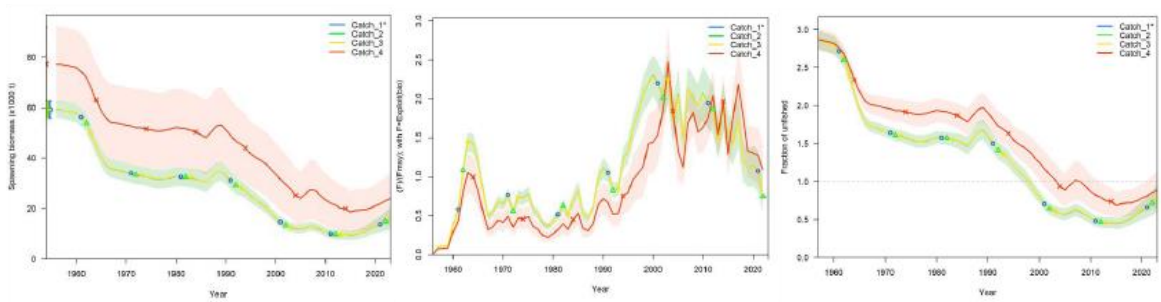


Figure 4. Results of initial SS3 runs with the 4 catch scenarios agreed at the Blue marlin Data Preparatory meeting.

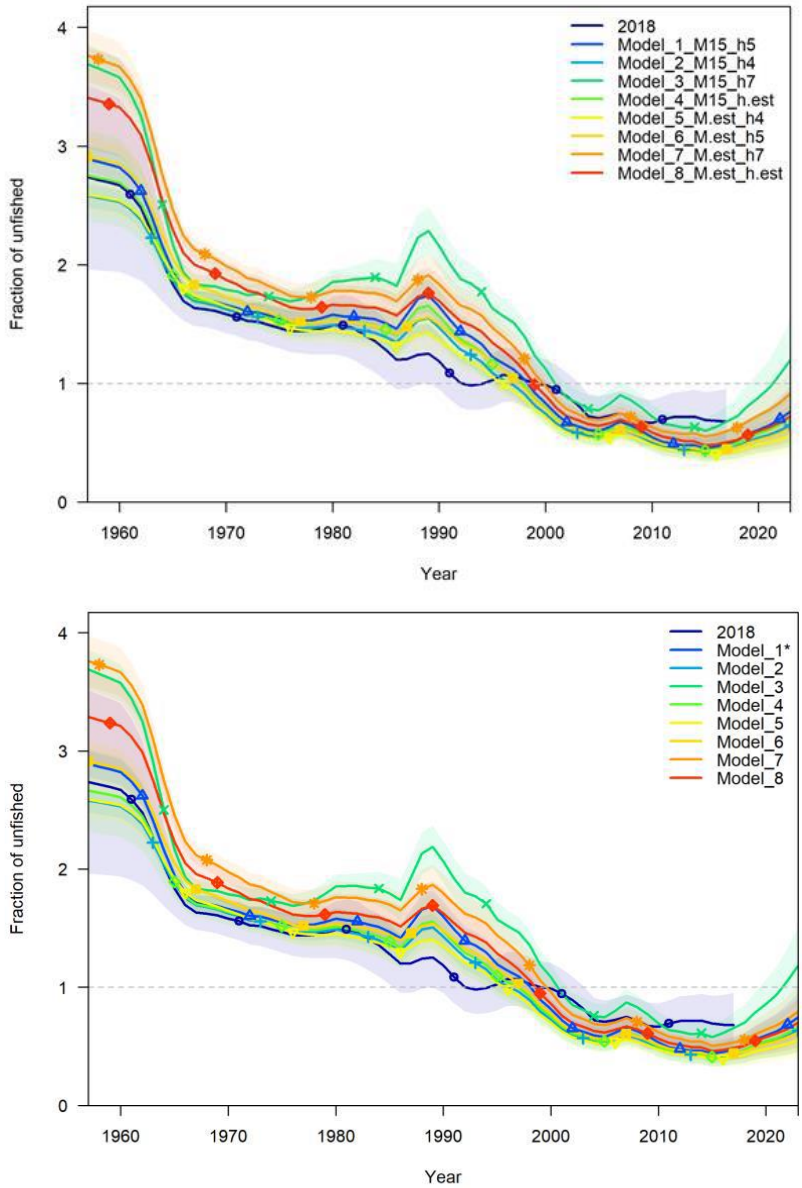


Figure 5. Results of exploratory SS3 runs. In both panels, Models 1-4 have fixed M=0.148 and *h* fixed at 0.5 (Model 1), 0.4 (Model 2), 0.7 (Model 3), and *h* estimated (Model 4). In top panel, Models 5-8 estimate M freely, whereas and *h* is fixed at 0.4 (Model 5), 0.5 (Model 6), or 0.7 (Model 7), *h* estimated (Model 8). Models 5-8 in the bottom panel are configured as in the top panel, with the only difference that M is estimated applying a prior mean of 0.148 and a standard deviation of 0.018.

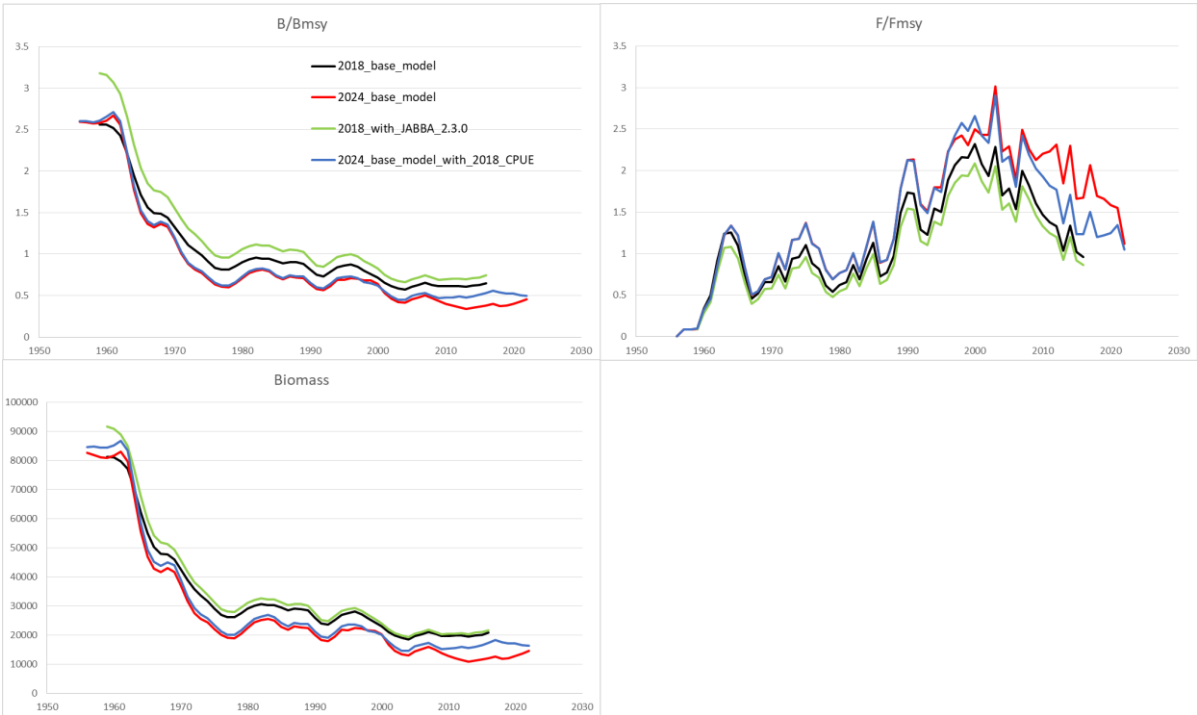


Figure 6. Trajectories derived from a sensitivity analysis comparing the 2018 and 2024 JABBA base models (see text for further details).

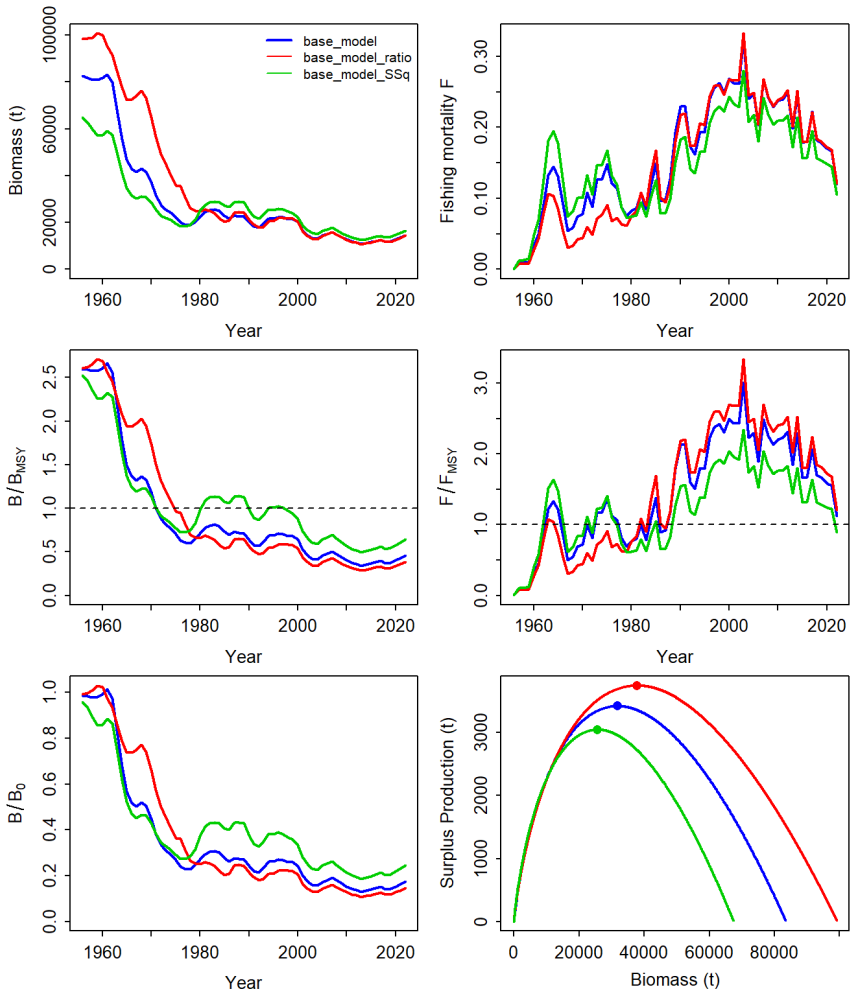
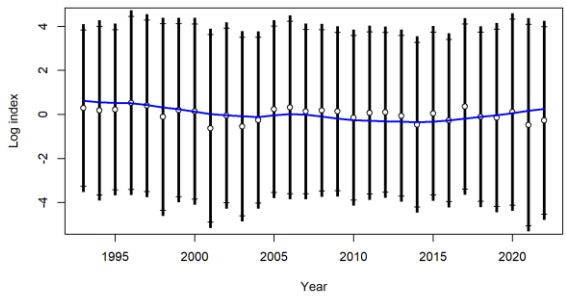
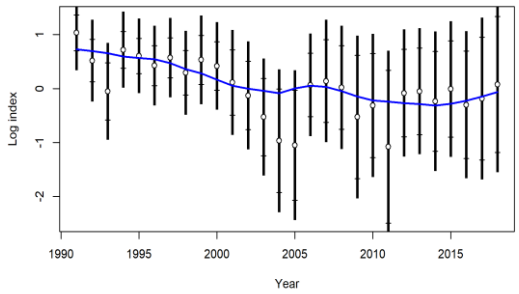
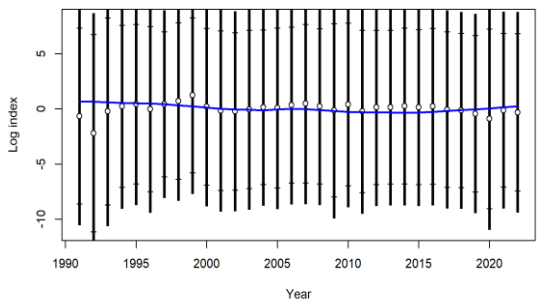
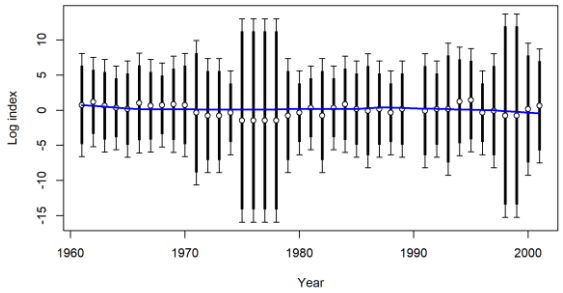


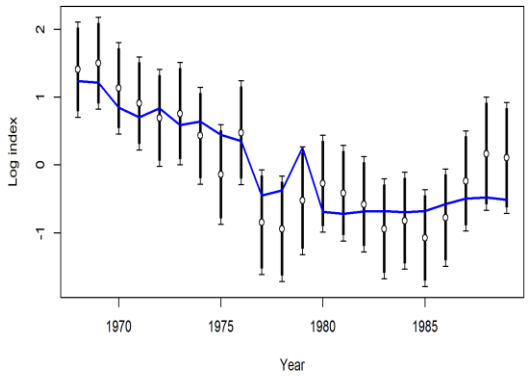
Figure 7. Sensitivity analysis of "corrections" in the catchability of JPN_LL_early and CTP_early CPUEs. "base_model" represents the trajectories of the SCRS/2024/106 preliminary reference model.

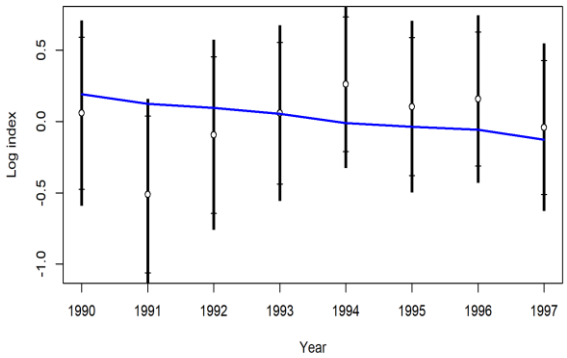

Log index
4
2
0
-2
-4
1995
2000
2005
2010
2015
2020
Year

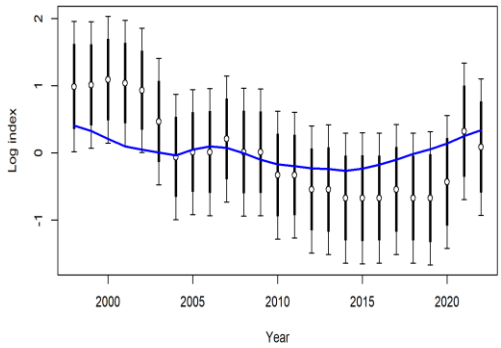

Log index
1
0
-1
-2
1990
1995
2000
2005
2010
2015
Year

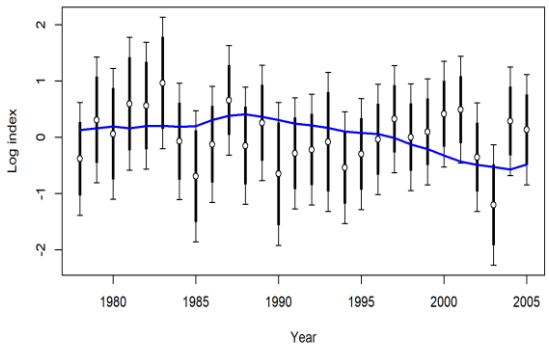

Log index
5
0
-5
-10
1990
1995
2000
2005
2010
2015
2020
Year


Log index
10
5
0
-5
-10
-15
1960
1970
1980
1990
2000
Year


Log index
2
1
0
-1
1970
1975
1980
1985
Year


Log index
0.5
0.0
-0.5
-1.0
1990
1991
1992
1993
1994
1995
1996
1997
Year


Log index
2
1
0
-1
2000
2005
2010
2015
2020
Year


Log index
2
1
0
-1
-2
1980
1985
1990
1995
2000
2005
Year

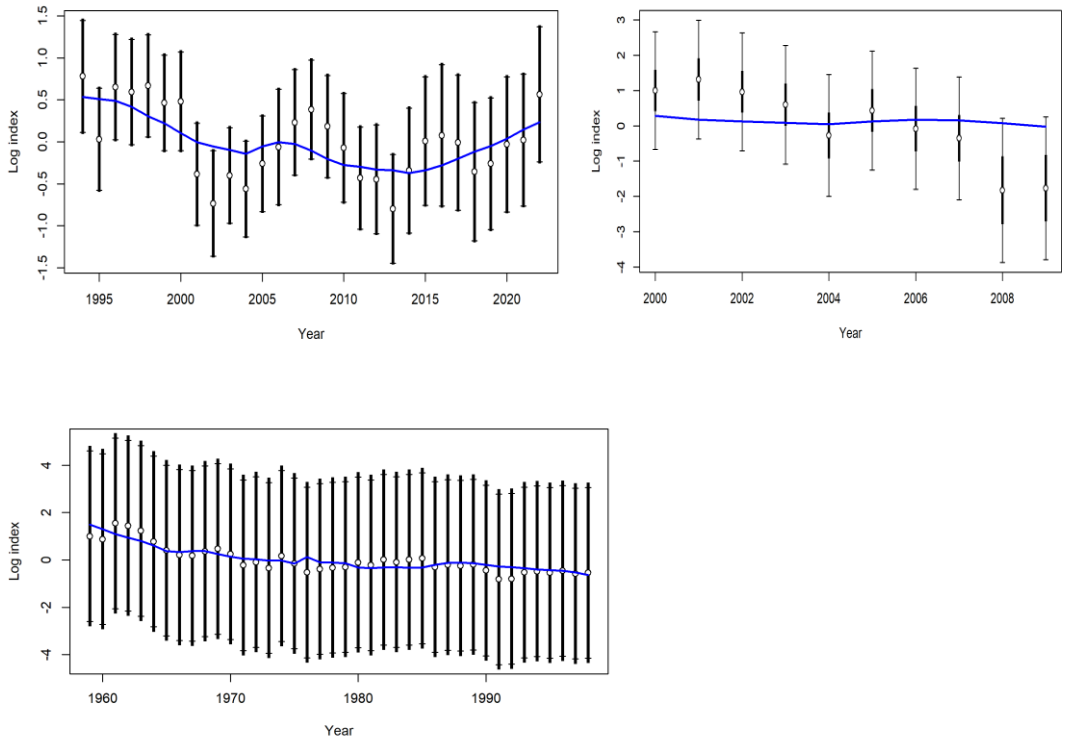


Figure 8. Diagnostics for SS3 run with fixed M=0.148 and h=0.5. Fits to log CPUE indices. USA LL, Ven LL, Ven Art, Ven RR, CTP early, CTP mid, CTP late, Brazil LL, JPN late, Ghana Gillnet, JPN early.

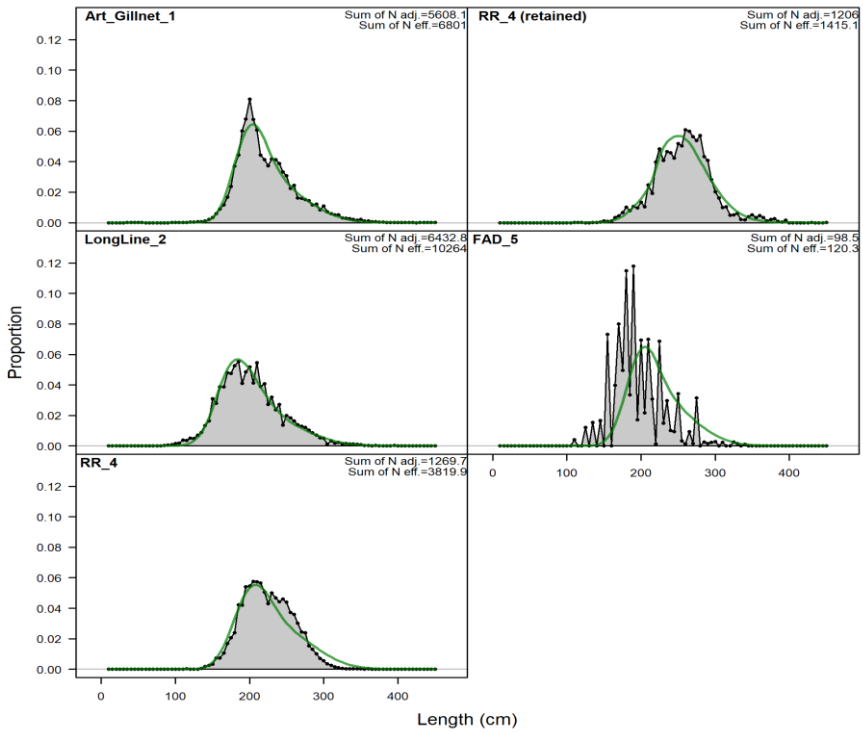


Figure 9. Diagnostics for SS3 run with fixed M=0.148 and h=0.5. Fits to the length compositions of the fleets, aggregated over the years. Note: length composition data of Fleet 5 ("FAD") was not used to fit the model.

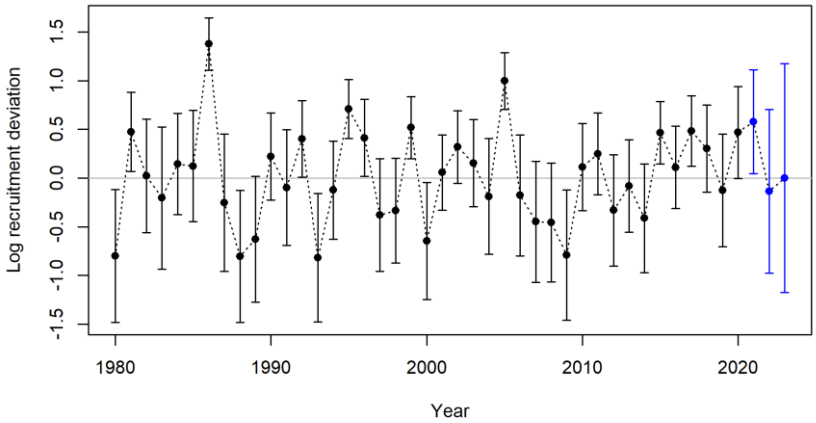


Figure 10. Diagnostics for SS3 run with fixed M=0.148 and h=0.5. Estimated log recruitment deviations.

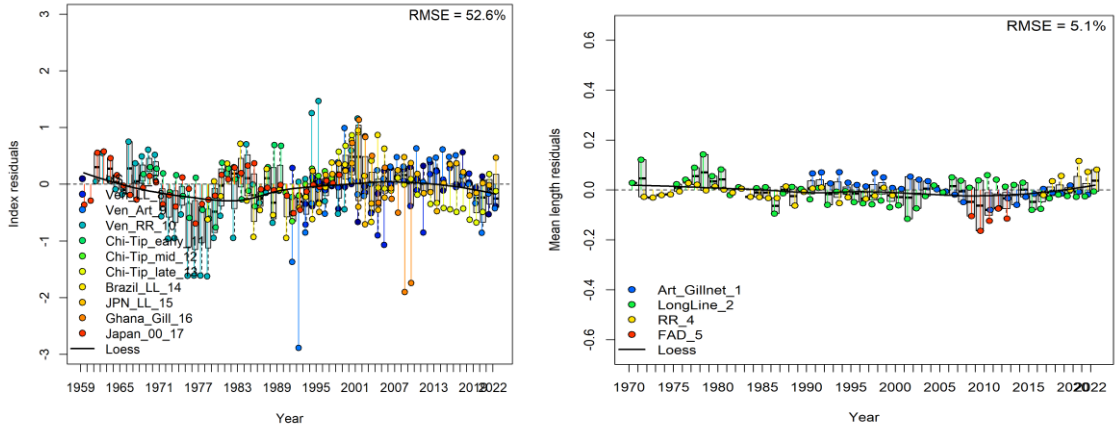
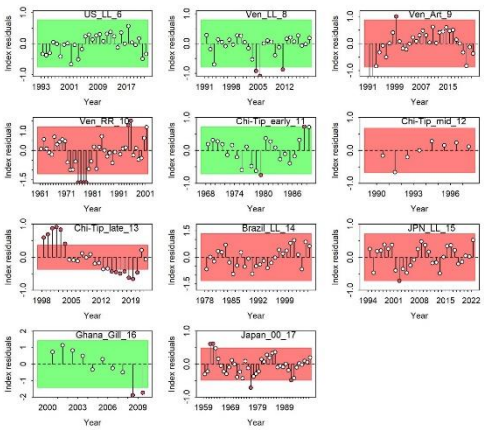
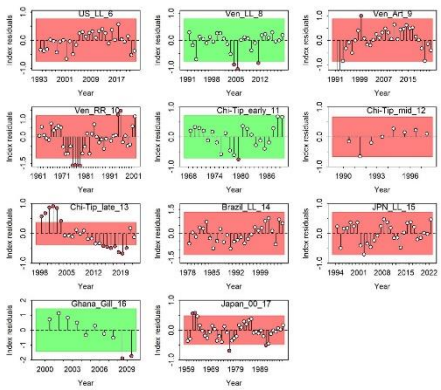


Figure 11. Diagnostics for SS3 run with fixed M=0.148 and h=0.5. Joint residual plot for indices and mean length of the different fleets. Note: length composition data of Fleet 5 ("mFAD") was not used to fit the model.

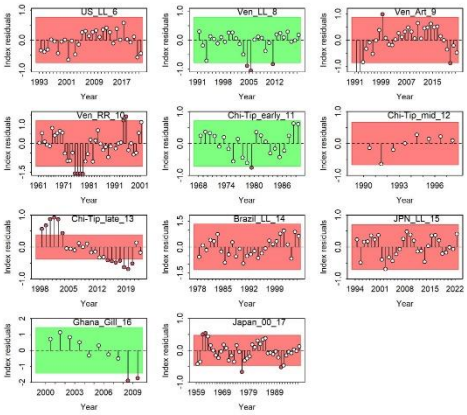
(a) h=0.4



(b) h=0.5



(c) h=0.6



(d) h=0.5

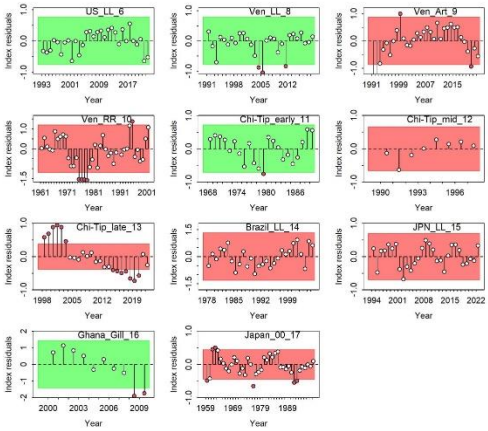
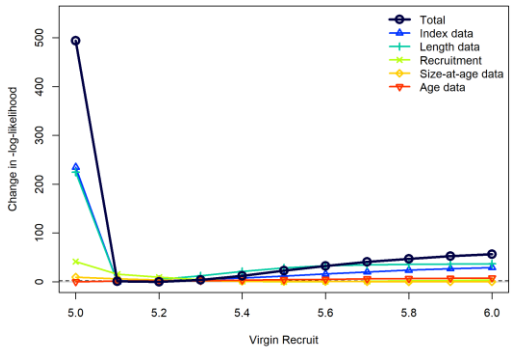
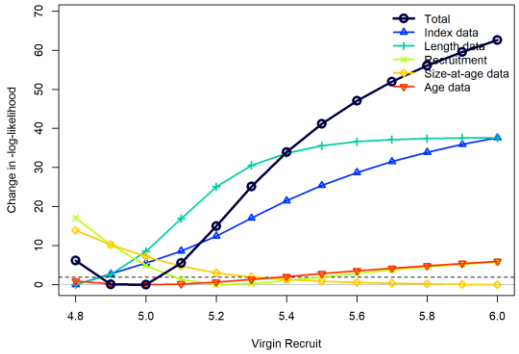


Figure 12. Diagnostics for SS3 run with fixed M=0.148 and h=0.4,0.5,0.6,0.7. Runs test on CPUEs.

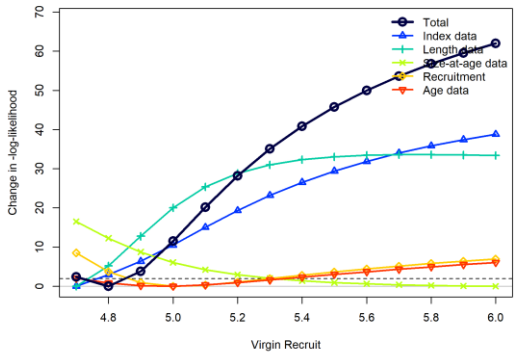
(a) h=0.4



(b) h=0.5



(c) h=0.6



(d) h=0.5

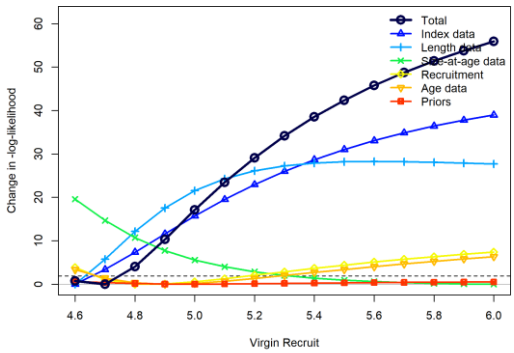
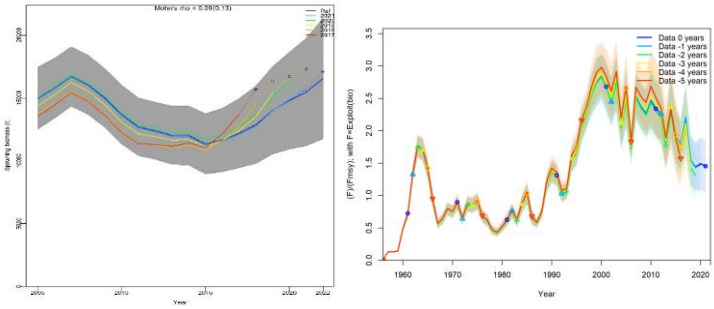
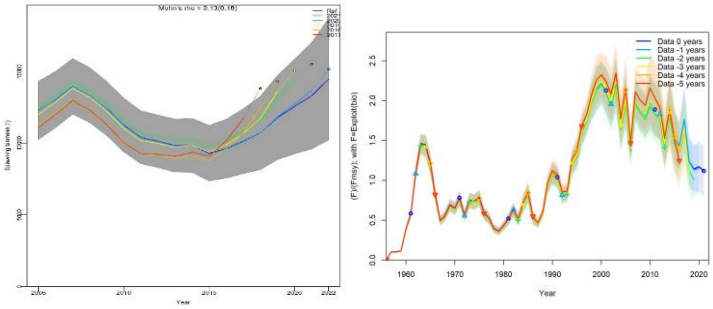


Figure 13. Diagnostics for SS3 run with fixed M=0.148 and h=0.4,0.5,0.6,0.7. Likelihood profile on R0.

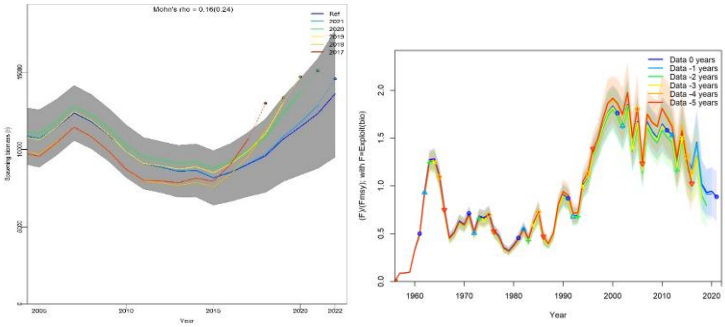
(a) h=0.4 (Mohn's rho on SSB = 0.09 (0.13), final assessment year and hindcast rho)



(b) h=0.5 (Mohn's rho on SSB = 0.13(0.18), final assessment year and hindcast rho)



(c) h=0.6 (Mohn's rho on SSB = 0.16(0.24), final assessment year and hindcast rho)



(d) h=0.7 (Mohn's rho on SSB = 0.19(0.28), final assessment year and hindcast rho)

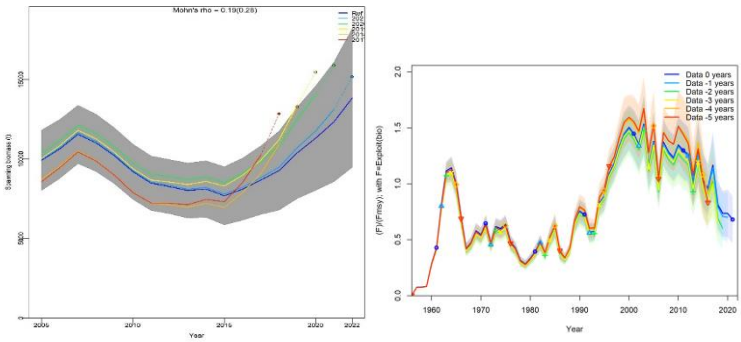
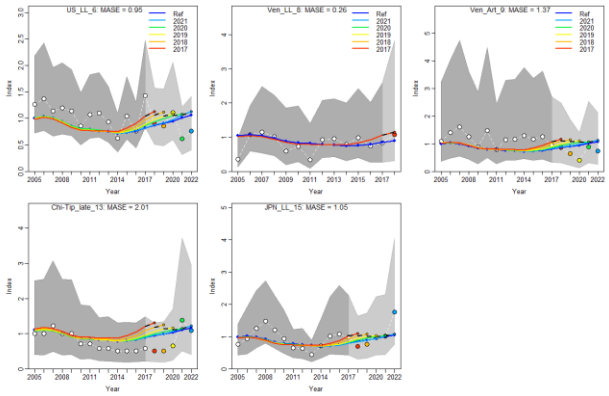
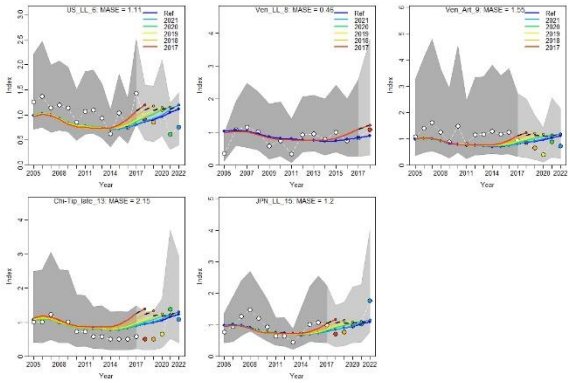


Figure 14. Diagnostics for SS3 run with fixed M=0.148 and h=0.4,0.5,0.6,0.7. Results from retrospective analysis, removing up to 5 years of data from the end of the time series.

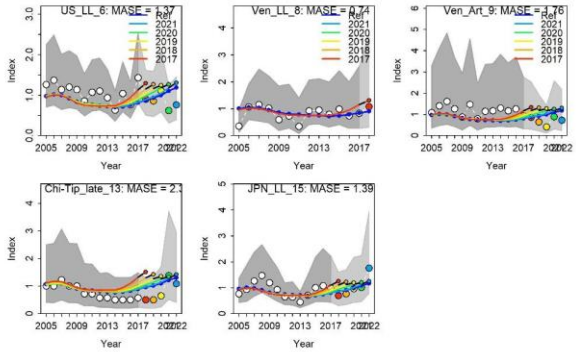
(a) h=0.4 (MASE for US LL=0.95, Ven LL=0.26, Ven Art=1.37, CTP late=2.01, JPN late=1.05)



(b) h=0.5 (MASE for US LL=1.11, Ven LL=0.46, Ven Art=1.55, CTP late=2.15, JPN late=1.2)



(c) h=0.6 (MASE for US LL=1.37, Ven LL=0.74, Ven Art=1.76, CTP late=2.30, JPN late=1.39)



(d) h=0.7 (MASE for US LL=1.66, Ven LL=1.06, Ven Art=2.02, CTP late=2.60, JPN late=1.61)

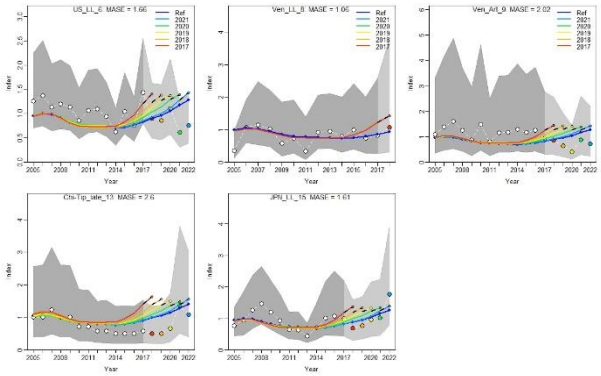
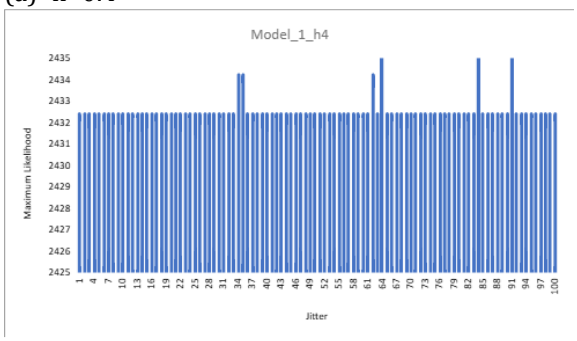


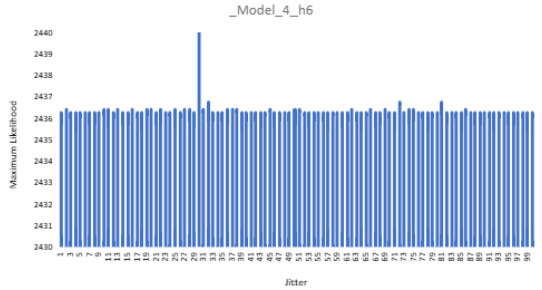
Figure 15. Diagnostics for SS3 run with fixed M=0.148 and h=0.4,0.5,0.6,0.7. Hindcast cross-validation results for CPUE observations, removing up to 5 years of data from the end of the time series.

(a) h=0.4



(b) h=0.5

(c) h=0.6



(d) h=0.7

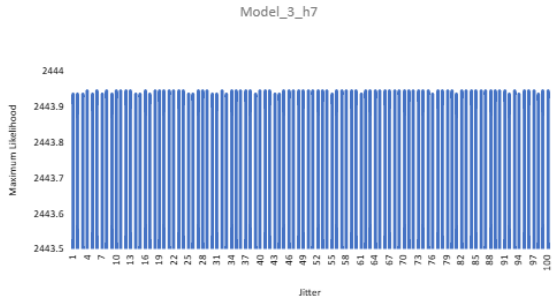
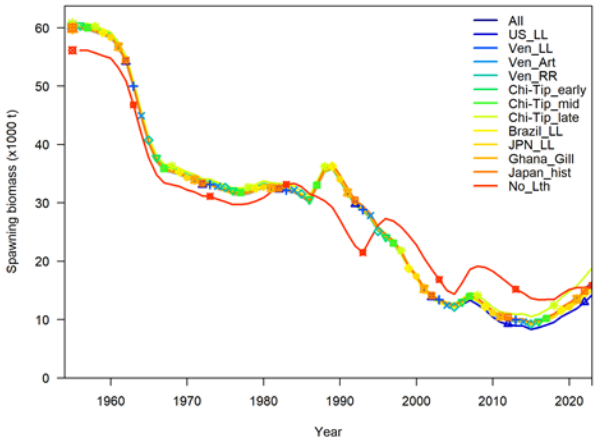
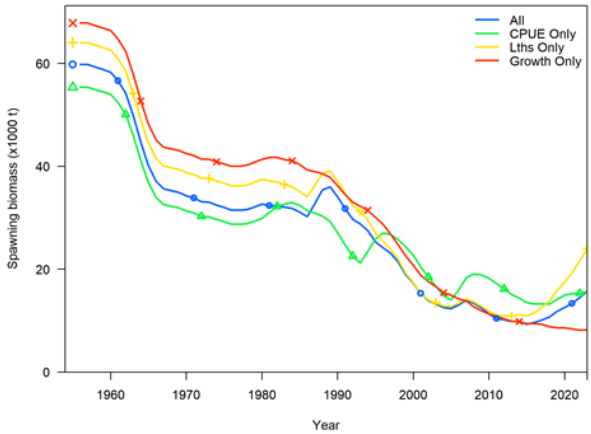


Figure 16. Diagnostics for SS3 run with fixed M=0.148 and h=0.4,0.5,0.6,0.7. Jitter with 100 iterations.

(a) Results of runs excluding 1 CPUE series at a time, and a run excluding all the length composition data (but including all CPUE series).



(b) Results of runs including only 1 type of data (CPUE only, length composition data only, growth data only).



(c) Excluding the length composition data from one fleet at a time

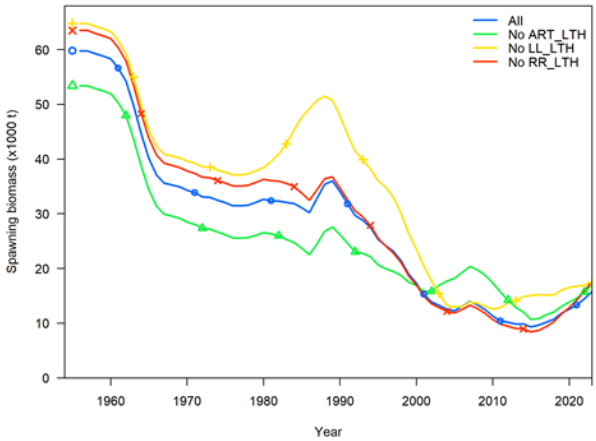


Figure 17. Diagnostics for SS3 run with fixed M=0.148 and h=0.5. Jackknife sensitivity of results to the exclusion of certain datasets. In all panels (a)-(c), the label "All" refers to the run including all data, i.e. all CPUE series and the length composition data of all fleets and the data used to estimate growth within SS3.

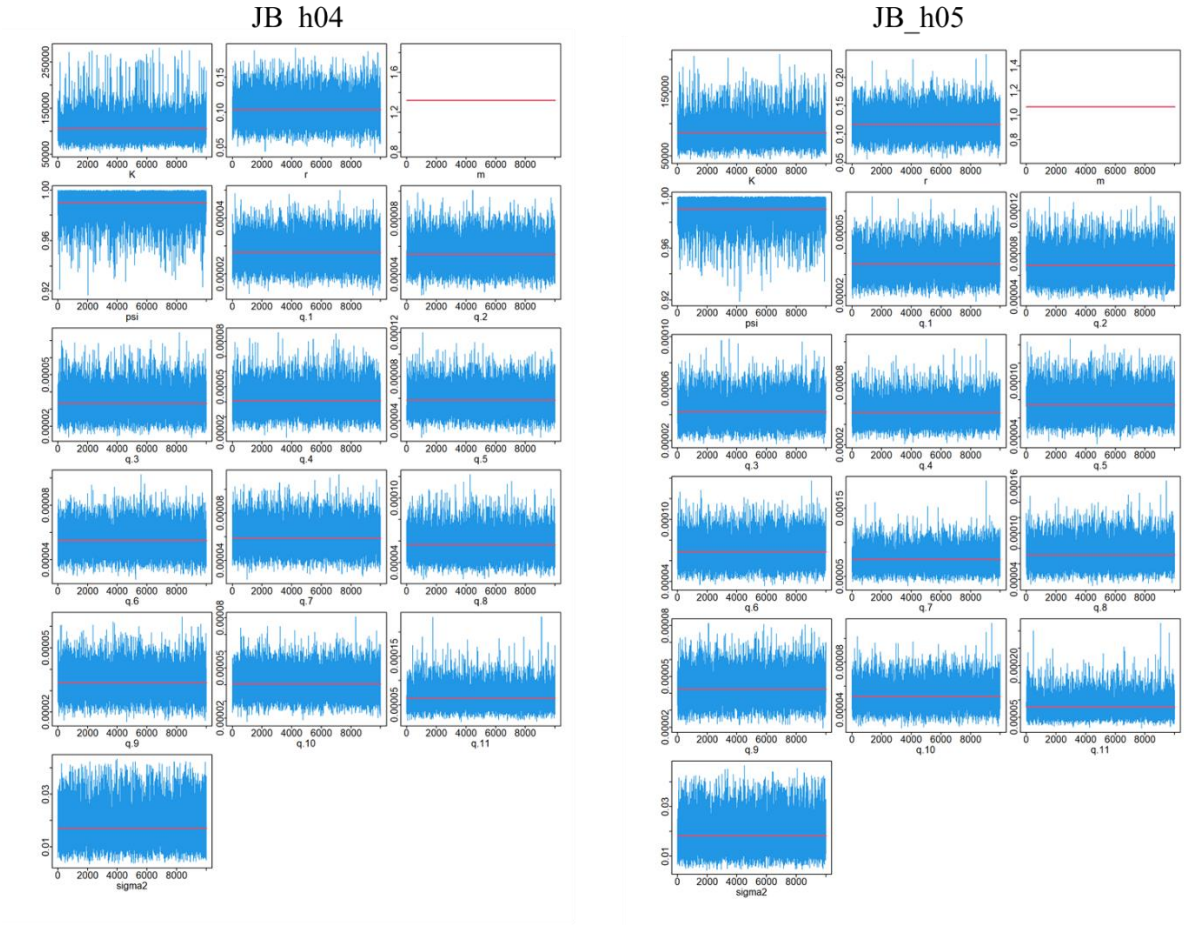


Figure 18. MCMC trace plots for the Atlantic blue marlin JABBA models scenarios with steepness in 0.4 and 0.5.

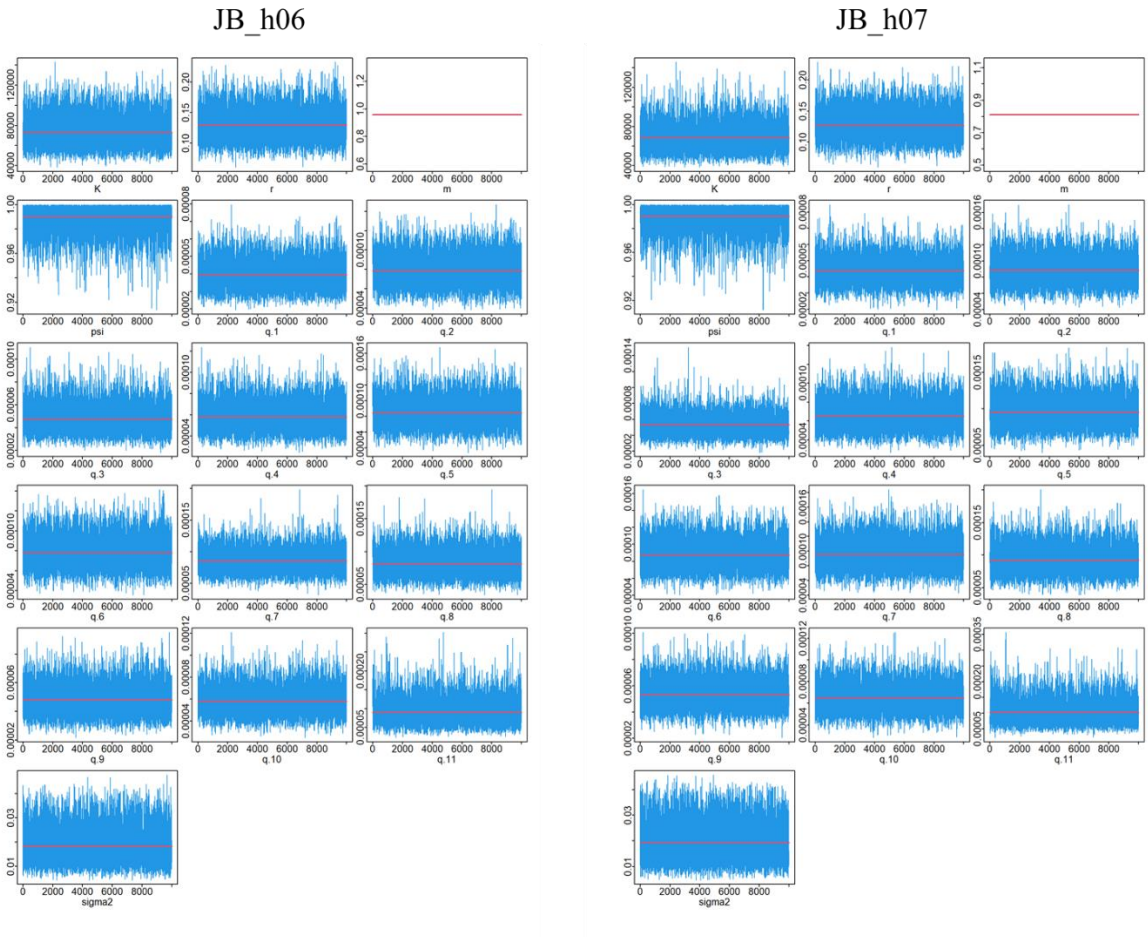


Figure 19. MCMC trace plots for the Atlantic blue marlin JABBA models scenarios with steepness in 0.6 and 0.7.

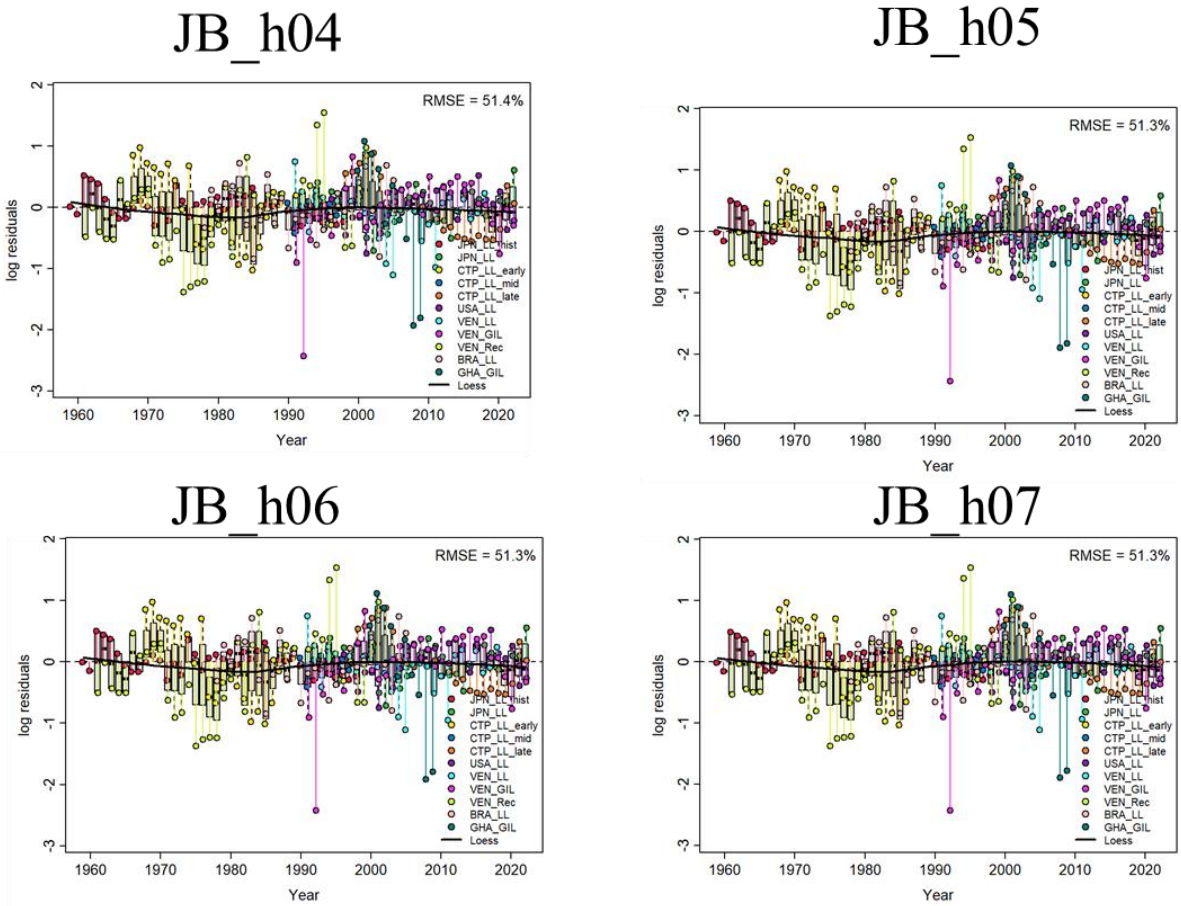


Figure 20. JABBA residual diagnostic plots for the CPUE indices used in the Atlantic blue marlin for each scenario based on the steepness uncertainty grid. Boxplots indicate the median and quantiles of all residuals available for any given year, and solid black lines indicate loess smoother through all residuals.

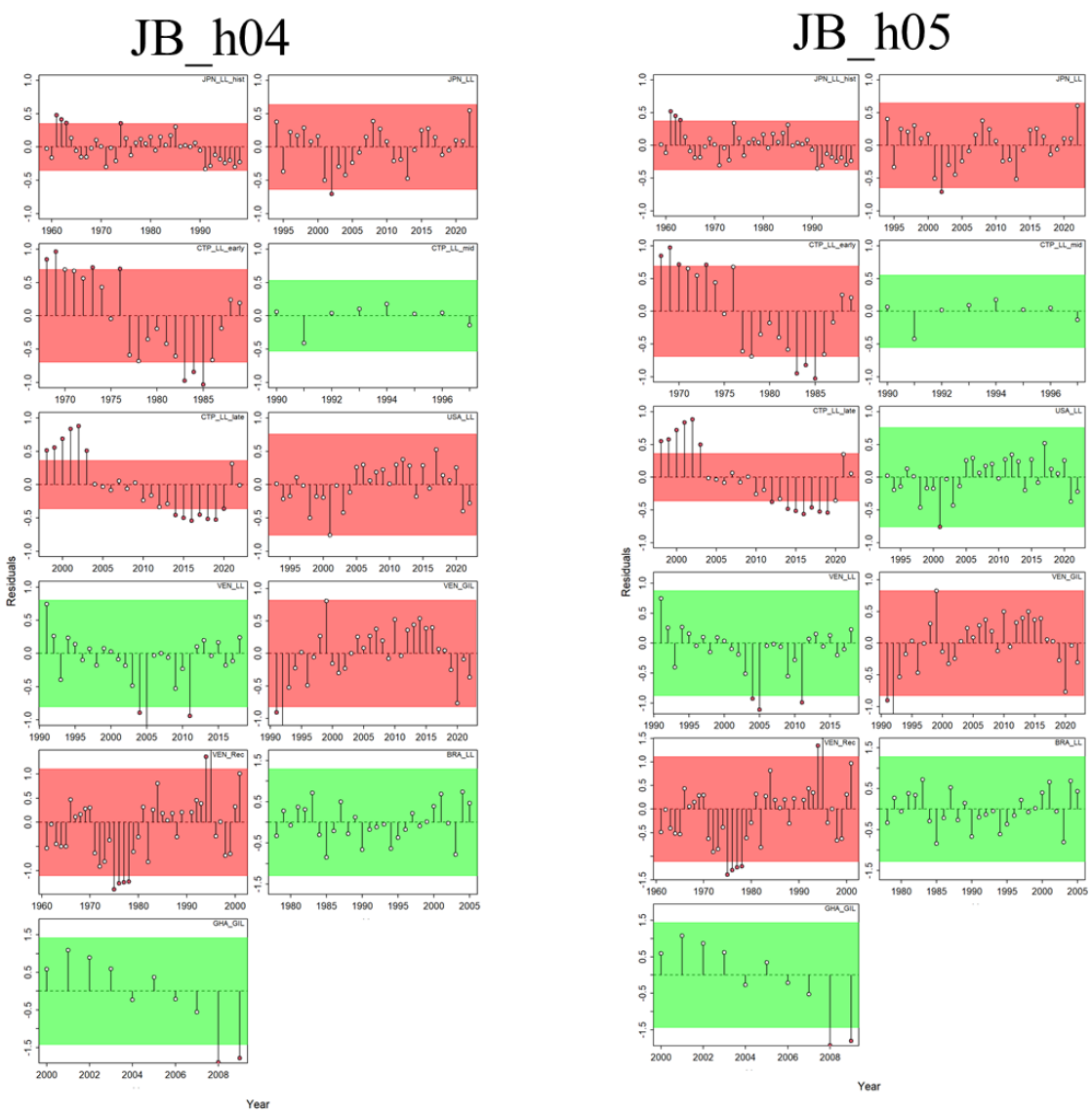


Figure 21. Runs tests to evaluate the randomness of the time series of CPUE residuals by fleet for scenarios with steepness in 0.4 and 0.5. Green panels indicate no evidence of lack of randomness of time-series residuals (p>0.05), while red panels indicate possible autocorrelation. The inner shaded area shows three standard errors from the overall mean, and red circles identify a specific year with residuals greater than this threshold value (3x sigma rule).

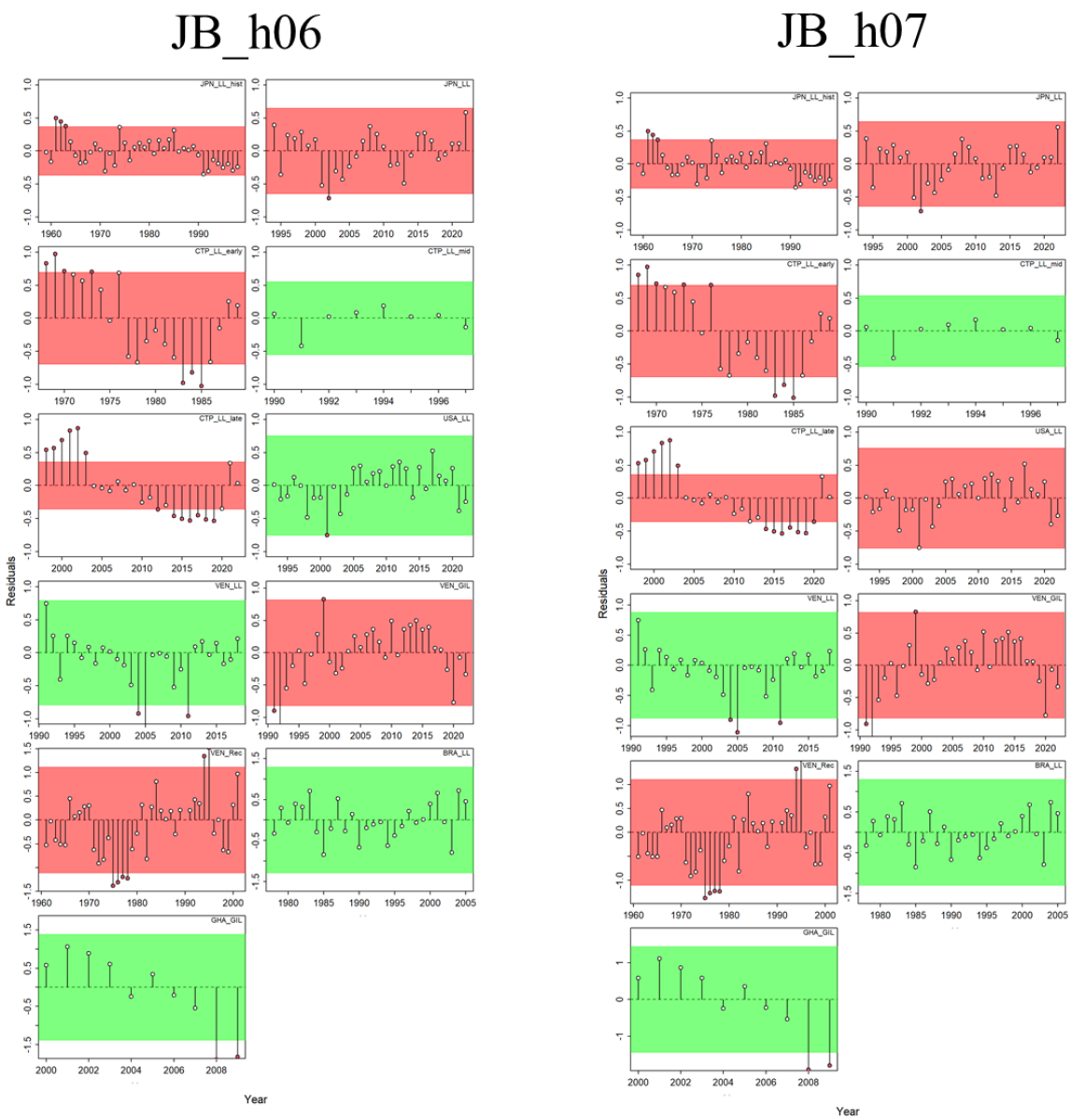


Figure 22. Runs tests to evaluate the randomness of the time series of CPUE residuals by fleet for scenarios with steepness in 0.6 and 0.7. Green panels indicate no evidence of lack of randomness of time-series residuals (p>0.05), while red panels indicate possible autocorrelation. The inner shaded area shows three standard errors from the overall mean, and red circles identify a specific year with residuals greater than this threshold value (3x sigma rule).

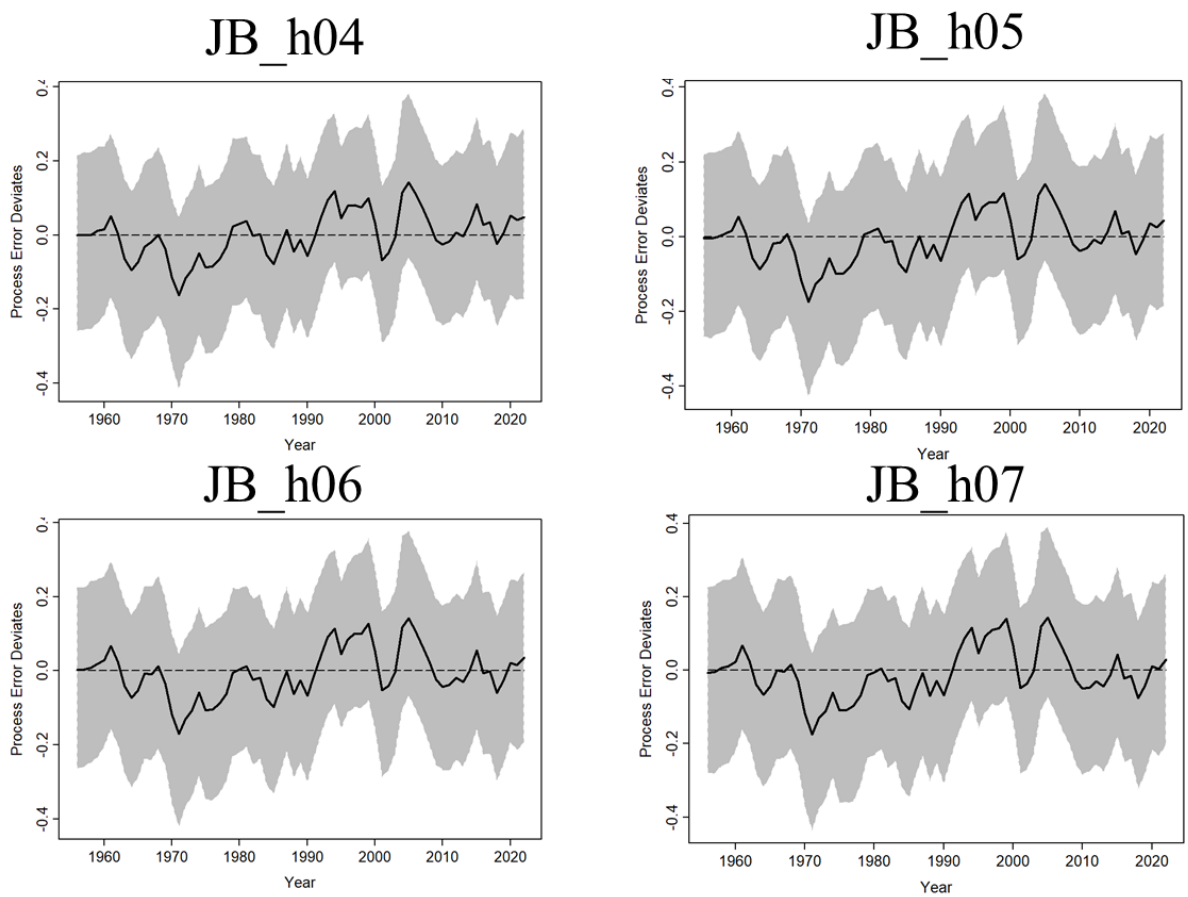


Figure 23. Process error deviates (median: solid line) for the Atlantic blue marlin for each scenario based on the steepness uncertainty grid using the Bayesian state-space surplus production model JABBA. The shaded grey area indicates 95% credibility intervals.

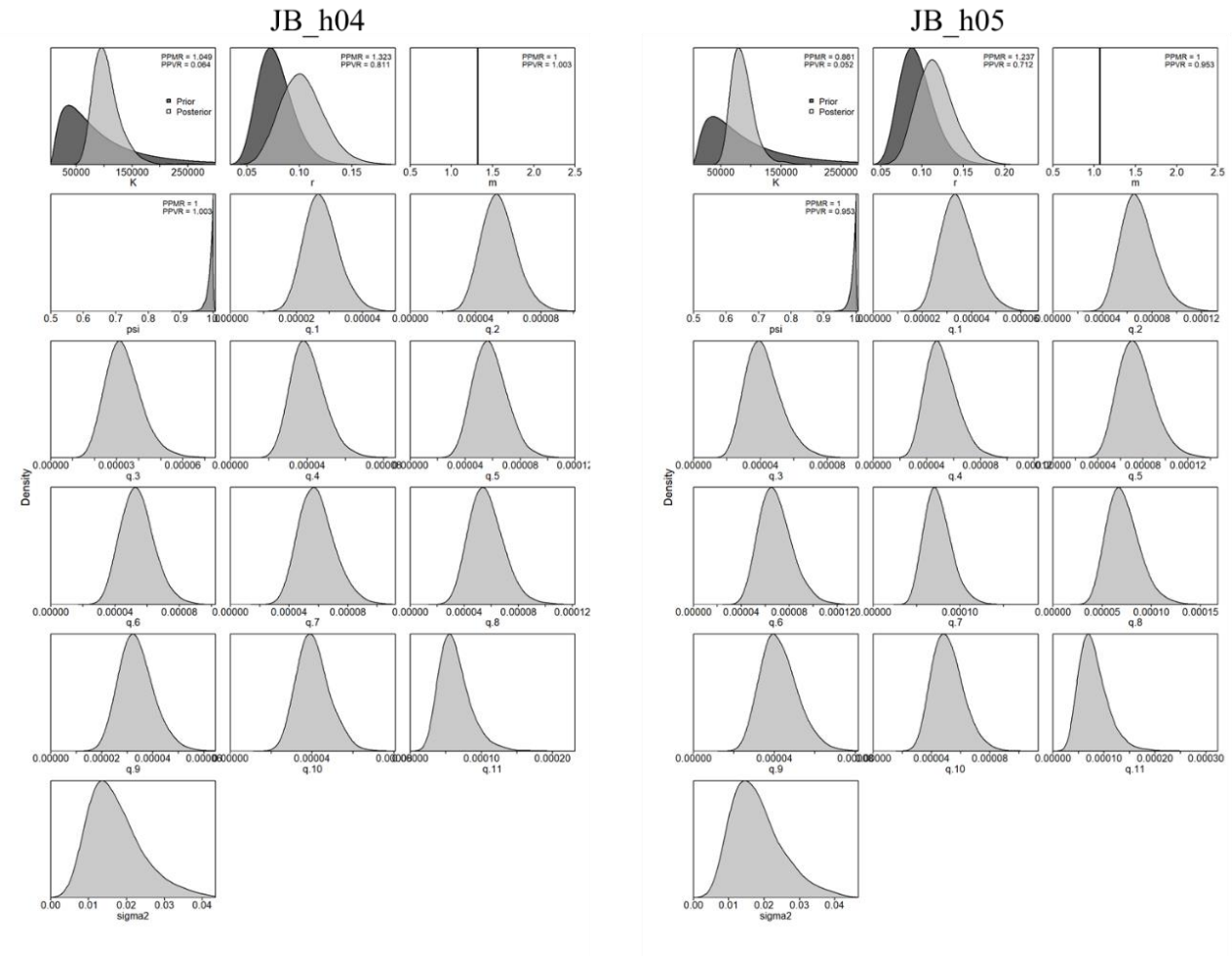


Figure 24. Posterior to prior distributions of various model and management parameters for the Bayesian state-space surplus production model (JABBA) for the Atlantic blue marlin scenarios with steepness in 0.4 and 0.5. PPMR: Posterior to Prior Ratio of Median; PPVRM: Posterior to Prior Ratio of Variances.

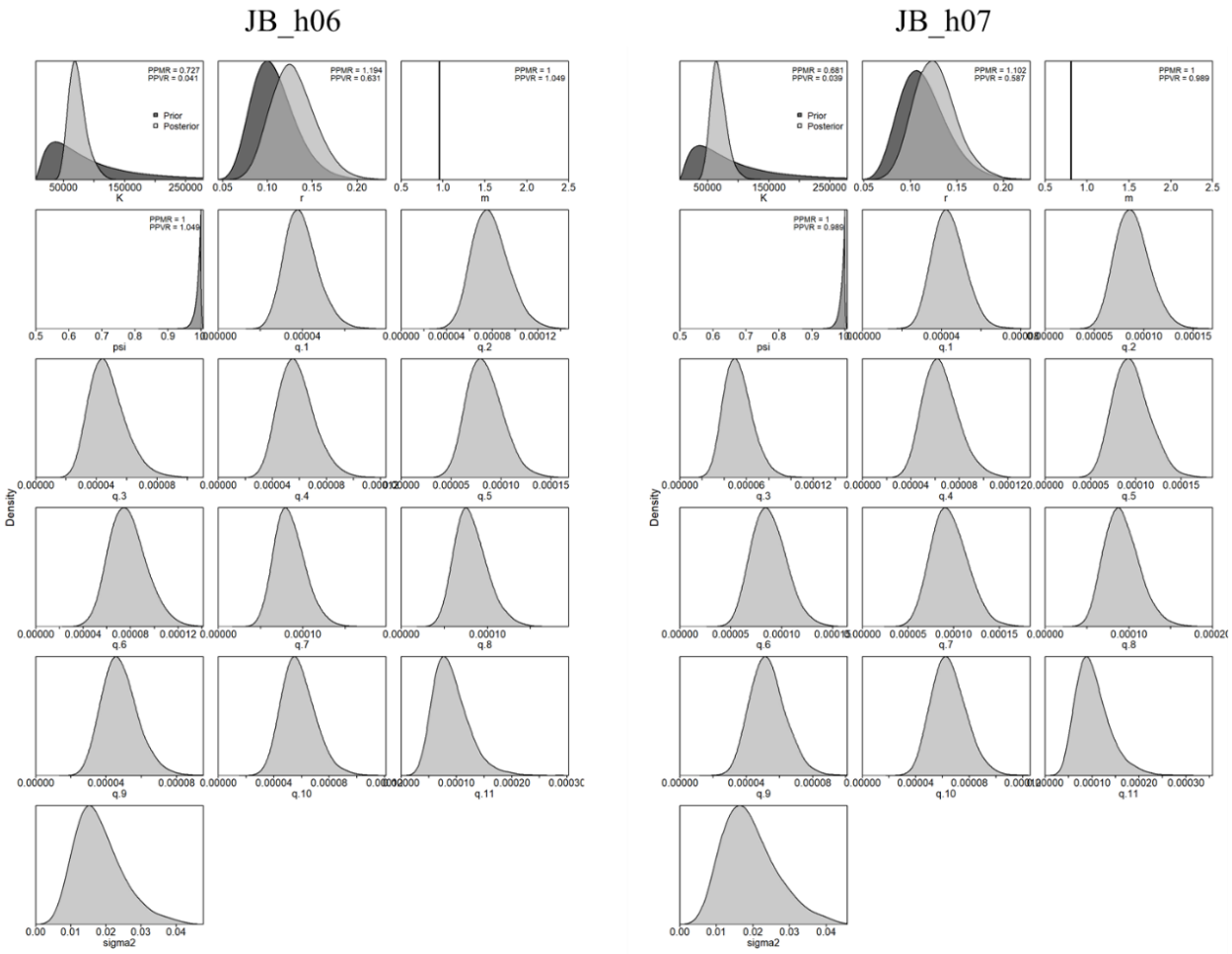


Figure 25. Posterior to prior distributions of various model and management parameters for the Bayesian state-space surplus production model (JABBA) for the Atlantic blue marlin scenarios with steepness in 0.6 and 0.7. PPMR: Posterior to Prior Ratio of Medians; PPVR: Posterior to Prior Ratio of Variances.

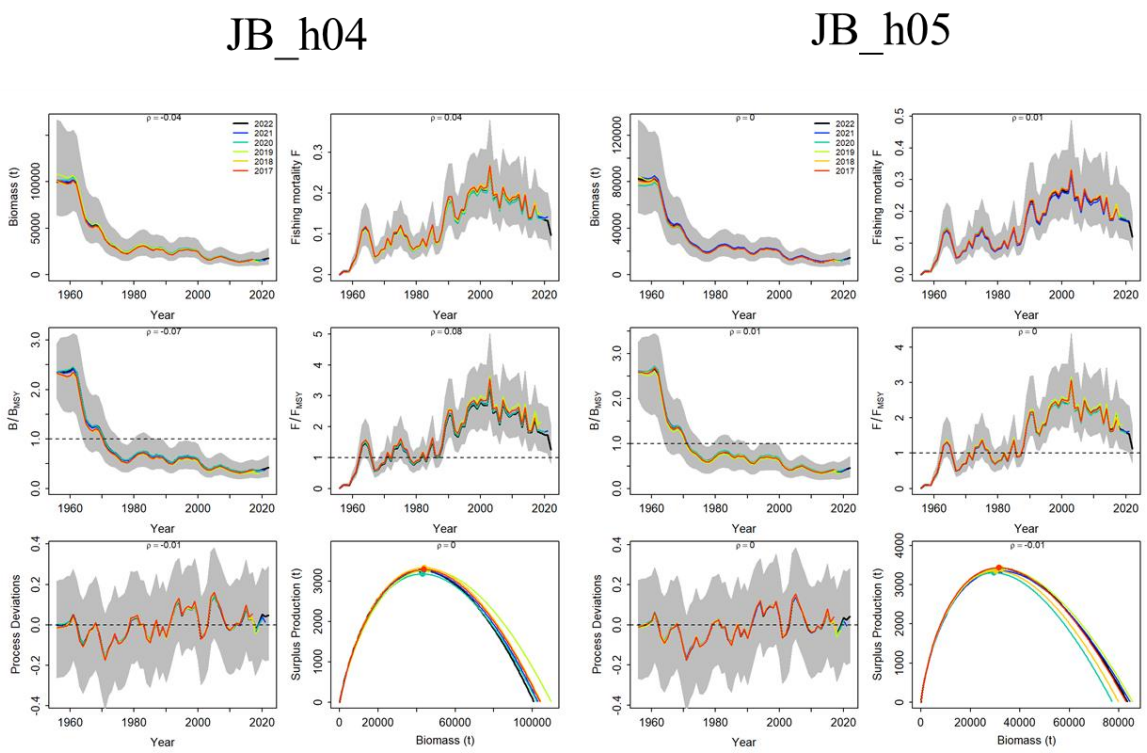


Figure 26. Retrospective analysis performed on the JABBA scenarios with steepness 0.4 and 0.5 for the Atlantic blue marlin by removing one year at a time sequentially (n=5) and predicting the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}), fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels), and process error deviations and surplus production curve (bottom panels).

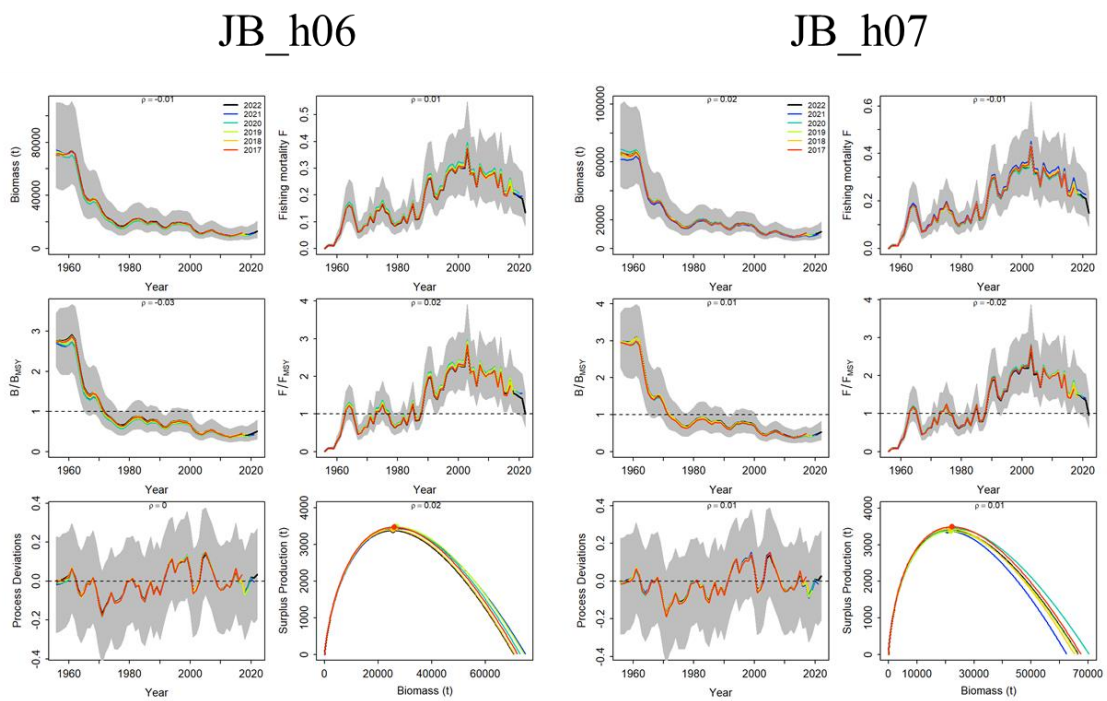


Figure 27. Retrospective analysis performed on the JABBA scenarios with steepness 0.6 and 0.7 for the Atlantic blue marlin by removing one year at a time sequentially (n=5) and predicting the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}), fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and process error deviations and surplus production curve (bottom panels).

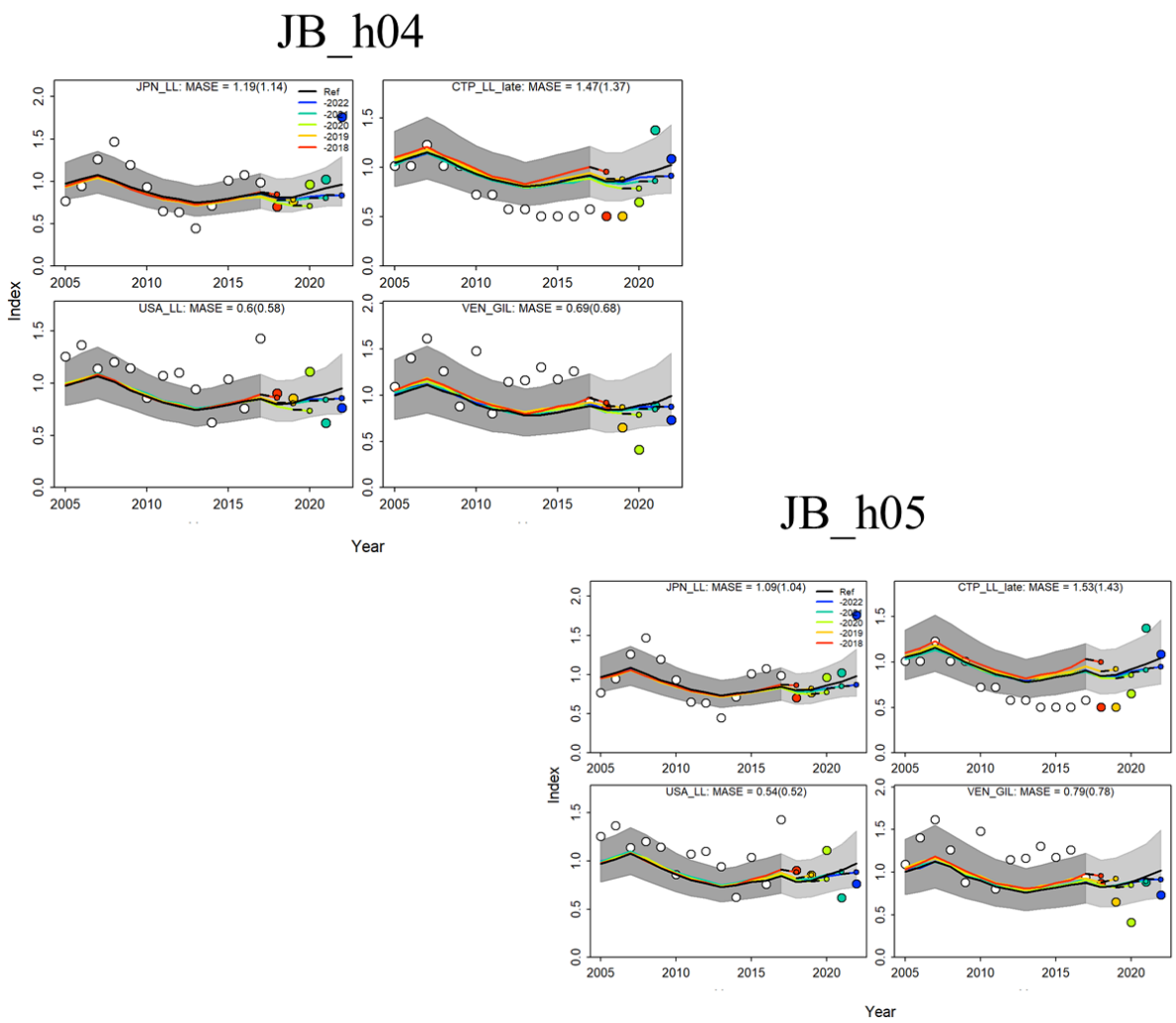


Figure 28. Hindcasting cross-validation results for the JABBA models scenarios with steepness 0.4 and 0.5 for the Atlantic blue marlin, showing one-year-ahead forecasts of CPUE values (2018-2022), performed with five hindcast model runs relative to the expected CPUE. The CPUE observations, used for cross-validation, are highlighted as color-coded solid circles with associated light-grey shaded 95% confidence interval. The model reference year refers to the endpoints of each one-year-ahead forecast and the corresponding observation (i.e., year of peel + 1).

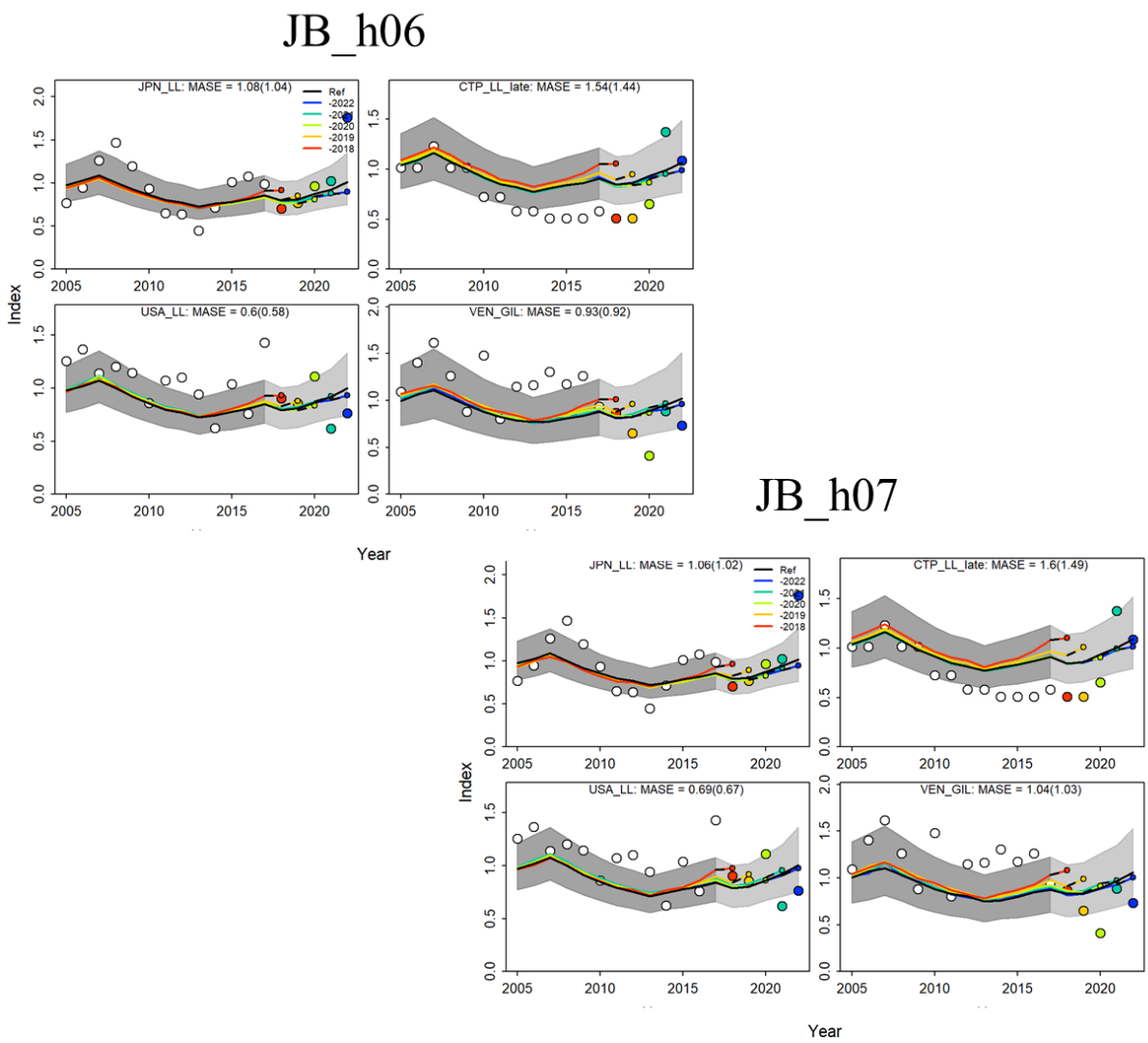


Figure 29. Hindcasting cross-validation results for the JABBA models scenarios with steepness 0.6 and 0.7 for the Atlantic blue marlin, showing one-year-ahead forecasts of CPUE values (2018-2022), performed with five hindcast model runs relative to the expected CPUE. The CPUE observations, used for cross-validation, are highlighted as color-coded solid circles with associated light-grey shaded 95% confidence interval. The model reference year refers to the endpoints of each one-year-ahead forecast and the corresponding observation (i.e., year of peel + 1).

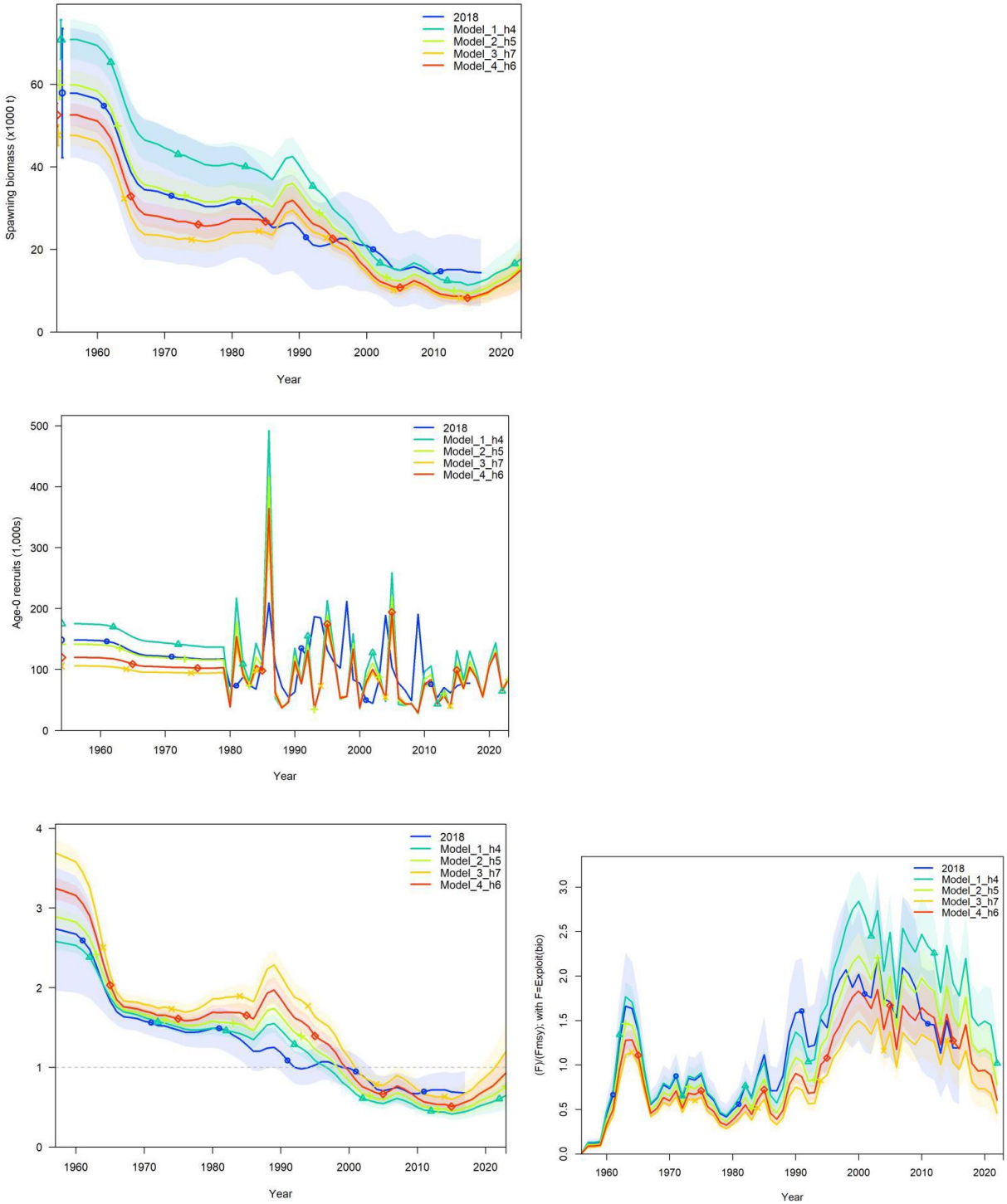


Figure 30. Spawning biomass (t), SSB/SSB$_{MSY,}$ recruits (age 0), and relative fishing mortality (F/F$_{MSY}$) for the 2024 Atlantic blue marlin final Stock Synthesis grid with steepness h = 0.4 (Model_1_h4), 0.5 (Model_2_h5), 0.6 (Model_4_h6), and 0.7 (Model_3_h7).

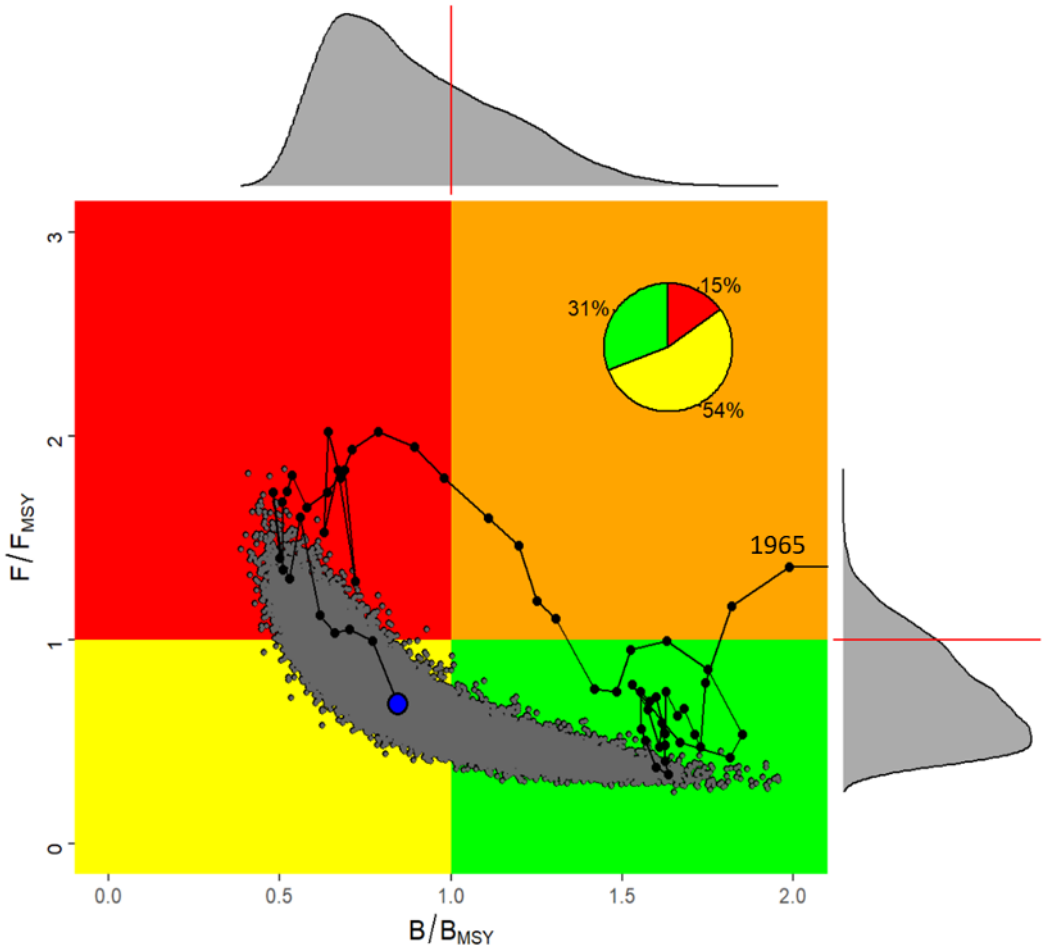


Figure 31. Joint Kobe plot for the 2024 Atlantic blue marlin final Stock Synthesis grid model (steepness *h* = 0.4, 0.5, 0.6, and 0.7). The inserted pie indicates the proportion of stochastic results within each Kobe color quadrant, 15% in the red quadrant, 54% in the yellow quadrant, and 31% in the green quadrant.

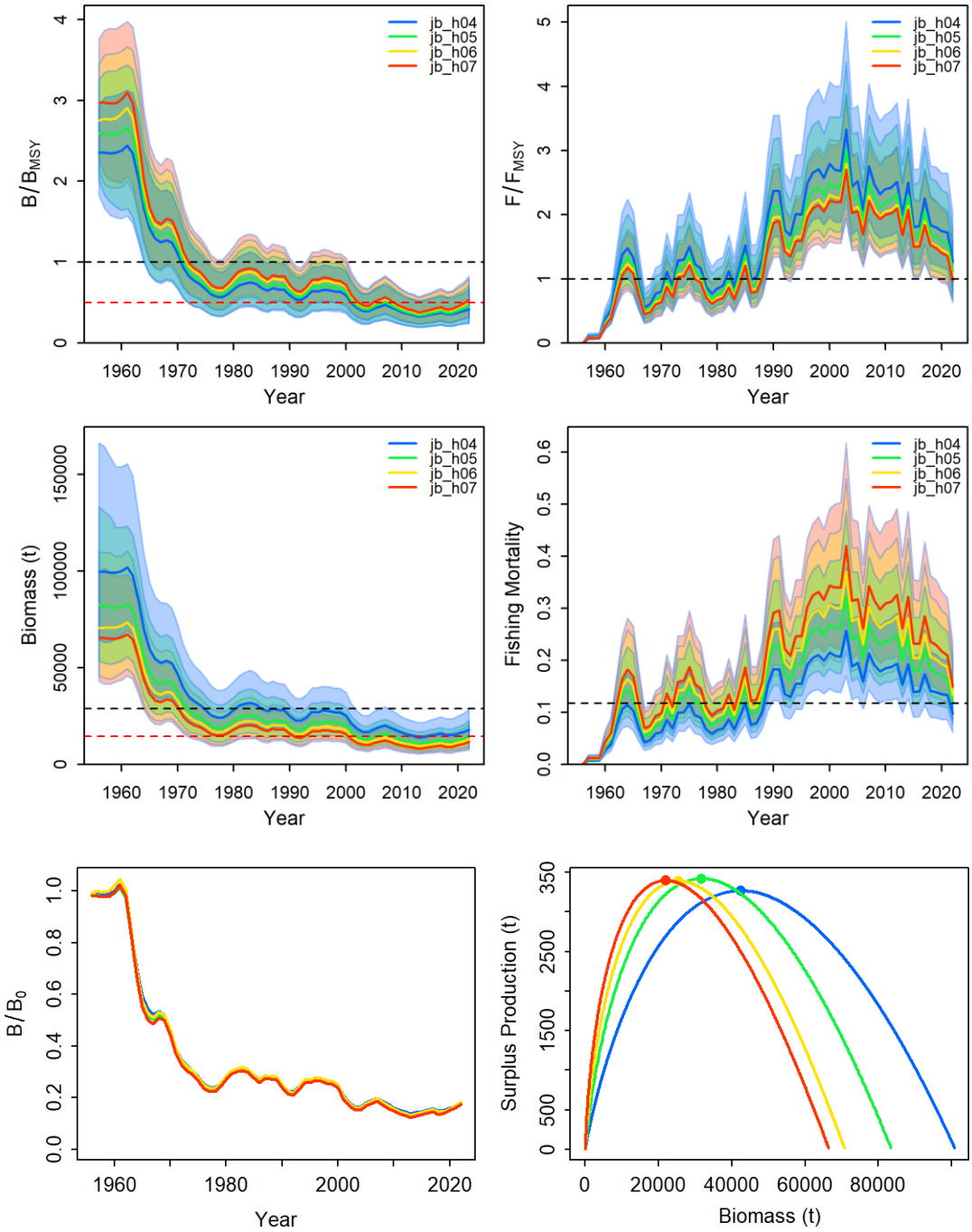


Figure 32. Biomass relative to B_{MSY} (B/B_{MSY}), fishing mortality relative to F_{MSY} (F/F_{MSY}), biomass, fishing mortality (upper panels), biomass relative to K (B/B_0) and surplus production curve for the 2024 Atlantic blue marlin final JABBA grid (steepness h = 0.4, 0.5, 0.6, and 0.7). The dashed red line indicates the 50% B_{MSY}, and the shade areas in color indicate the 95% credibility intervals from the Bayesian SPM.

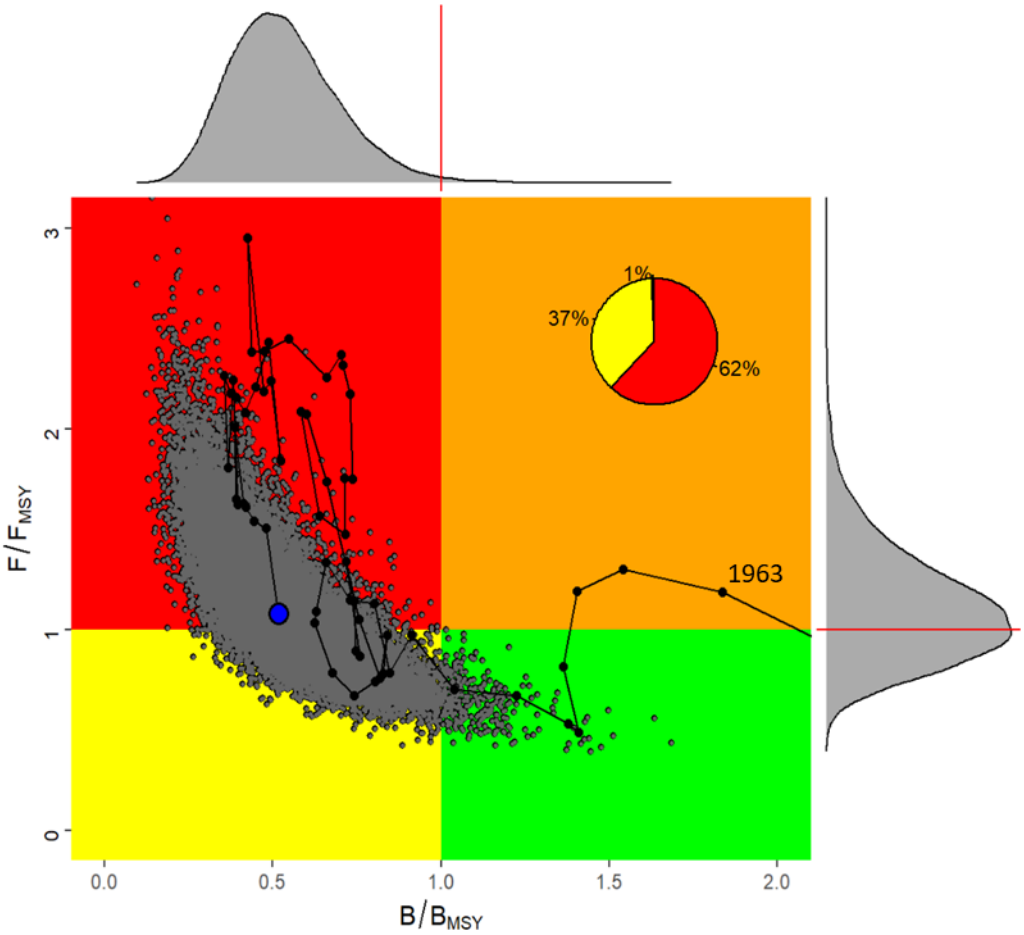


Figure 33. Joint Kobe plot for the 2024 Atlantic blue marlin final JABBA grid models (*r* priors based on steepness h = 0.4, 0.5, 0.6, and 0.7). The inserted pie indicates the proportion of stochastic results within each Kobe color quadrant, 62% in the red quadrant, 37% in the yellow quadrant, and 1% in the green quadrant.

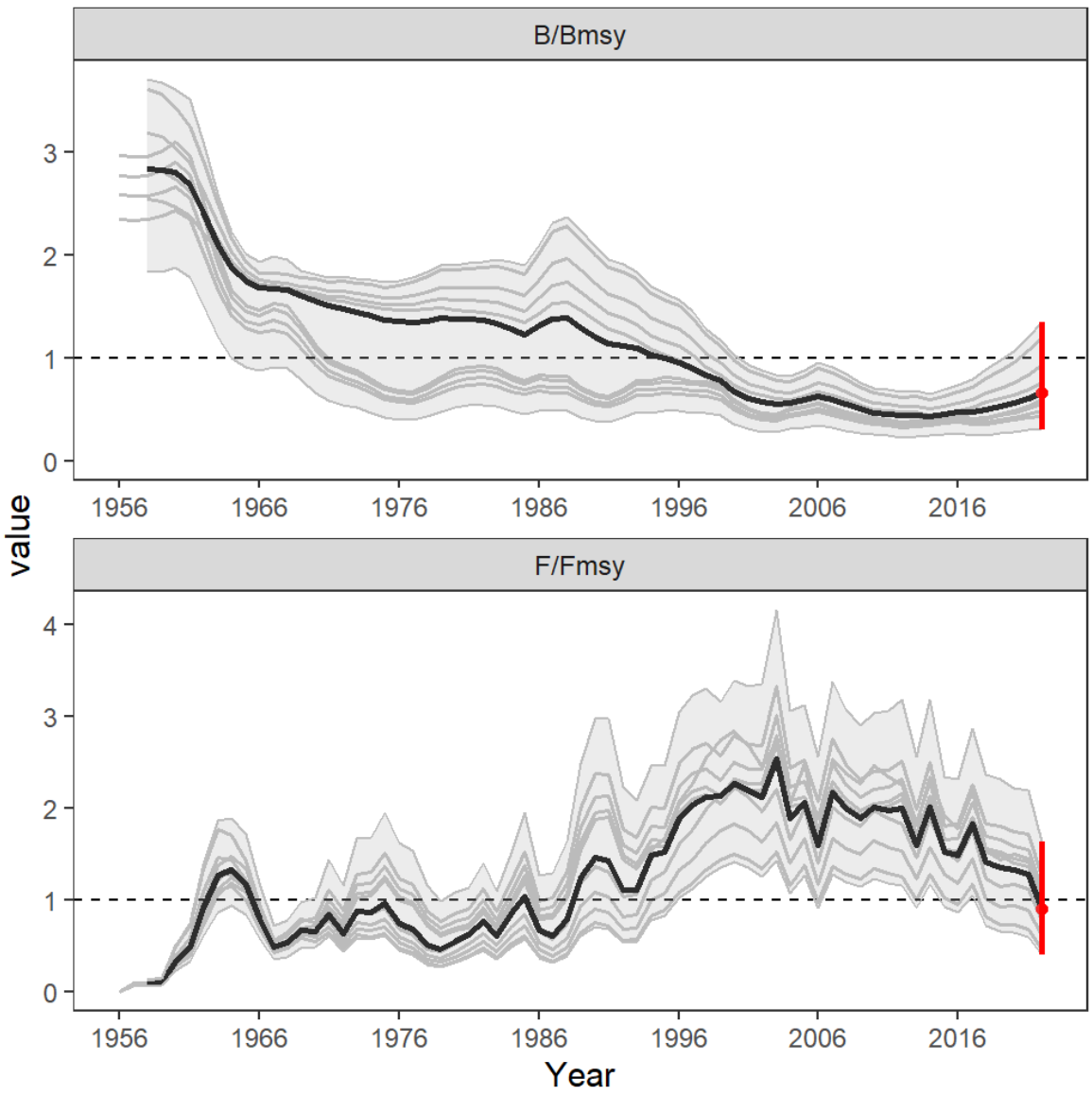


Figure 34. Annual trends of relative biomass (B/B_{MSY}) and fishing mortality (F/F_{MSY}) from the final combined grid model scenarios for Atlantic blue marlin. The dark line indicates the mean of all scenarios, lighter color lines indicate the individual scenario trends, and the shaded area is the overall 95% confidence bounds of the results. The results from the JABBA models started in 1956, while the ones for Stock Synthesis in 1958.

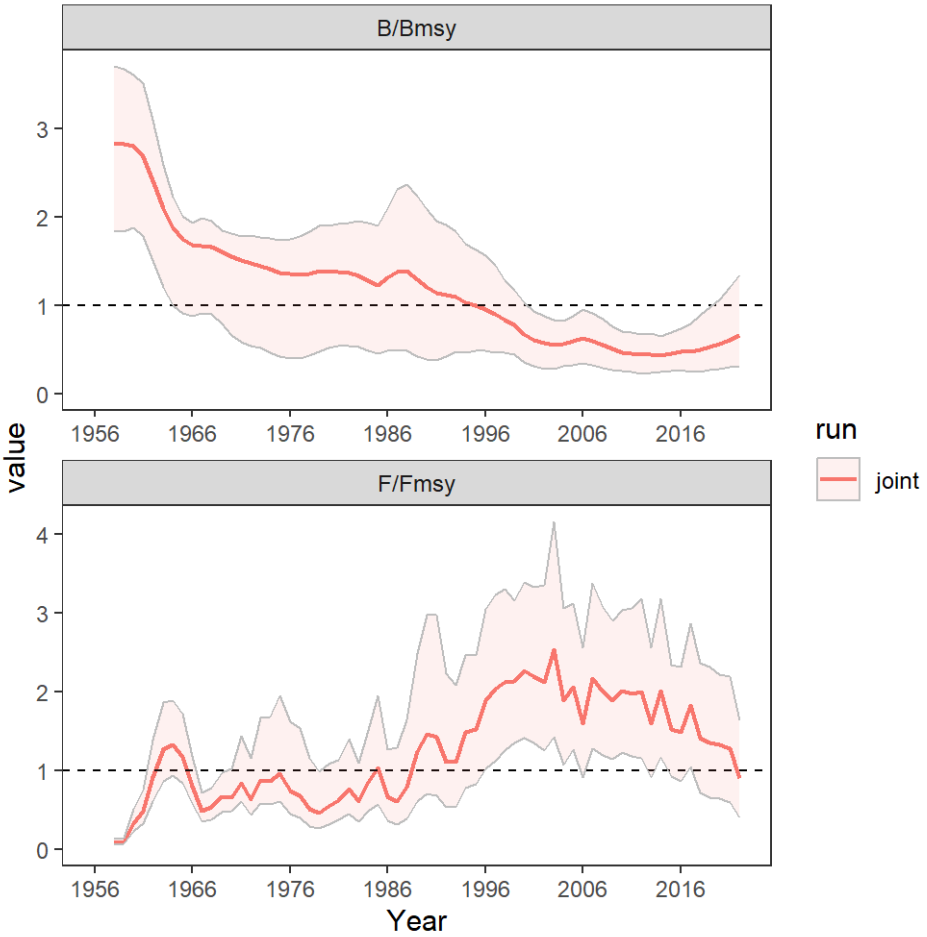


Figure 35. Annual trends of relative biomass (B/B_{MSY}) and fishing mortality (F/F_{MSY}) from the final combined grid model scenarios for Atlantic blue marlin. The dark line indicates the mean of all scenarios, lighter color lines indicate the individual scenarios trends, and the shaded area the overall 95% confidence bounds of the results

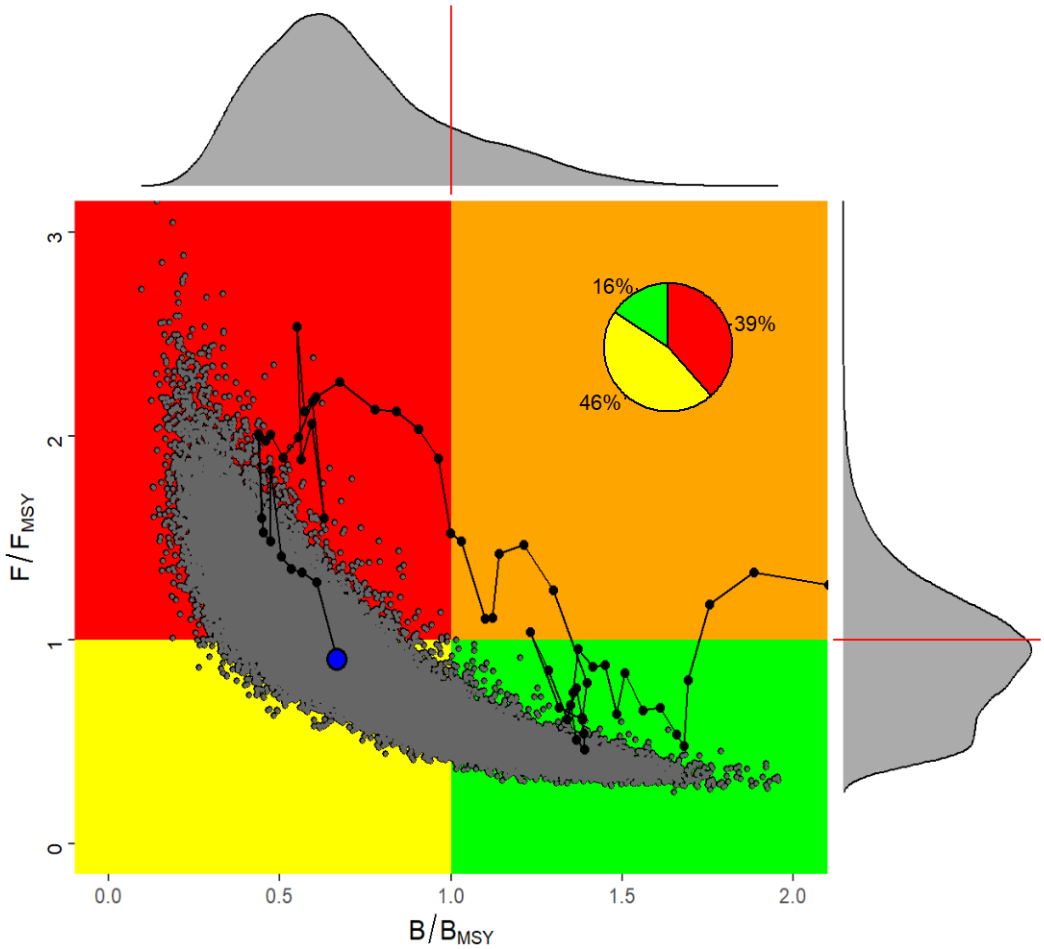


Figure 36. Kobe plot for the 2024 Atlantic blue marlin stock status (as of the end of 2022 fishing year) estimated from the combined grid models. The line indicates the stock status trajectory starting in 1965, the large blue dot indicates the stock status in 2022.

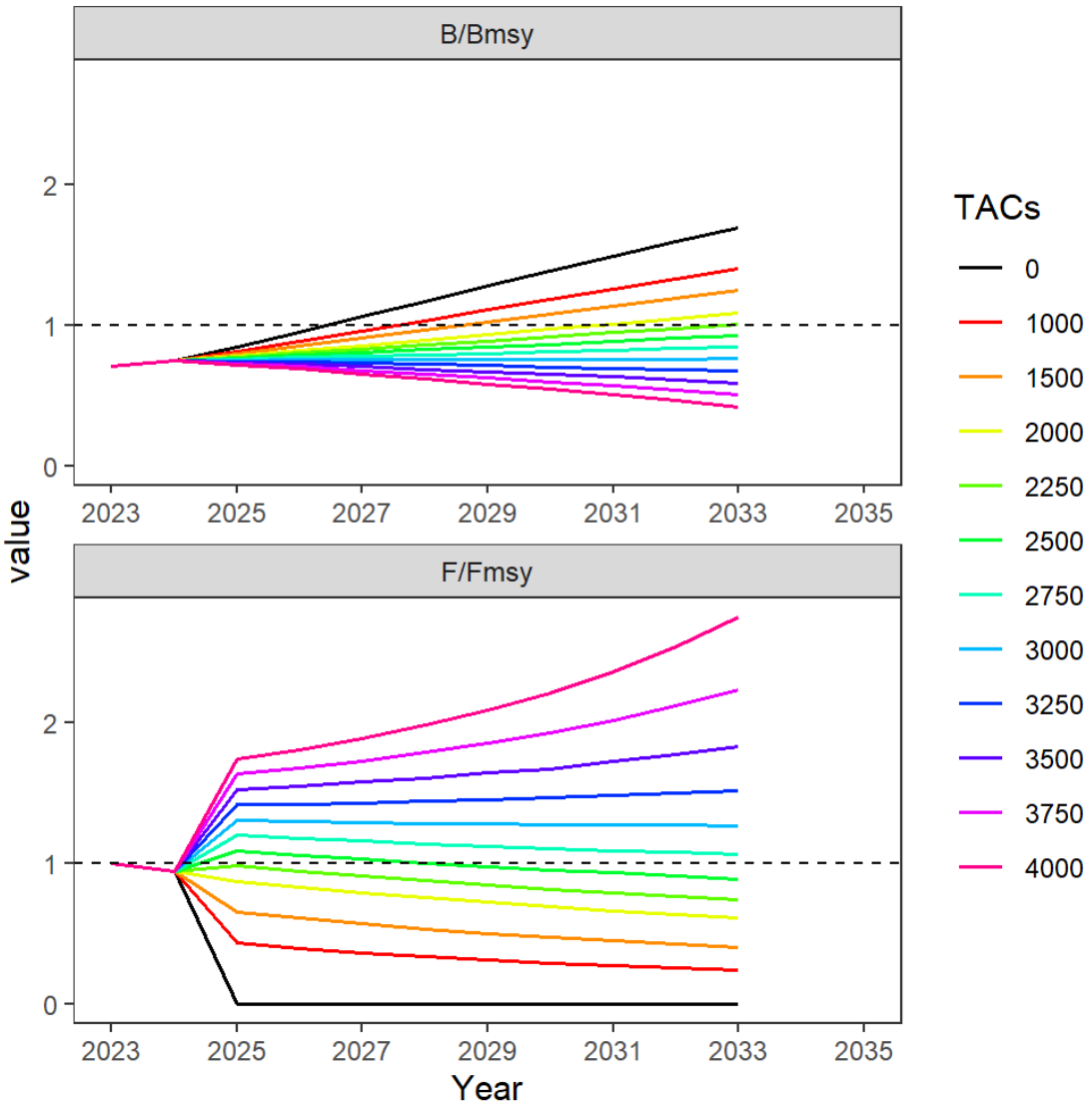


Figure 37. Preliminary projection results. Trends of projected relative stock biomass (upper panel, B/B_{MSY}) and fishing mortality (bottom panel, F/F_{MSY}) for Atlantic blue marlin under different fixed catch scenarios of 0–4,000 t, based upon the projections of both JABBA and Stock Synthesis grids. Each line represents the median of 80,000 iterations of each grid scenario and platform stock projections starting in 2025.

Appendix 1

Agenda Blue Marlin Stock Assessment

3. Opening, adoption of agenda and meeting arrangements
4. Summary of input data for stock assessment
    a. Biology
    b. Catches
    c. Size
    d. Indices of abundance
    e. Fleet structure
5. Methods and Model Settings
    a. Stock Synthesis
    b. Surplus Production models
6. Model diagnostics
    a. Stock Synthesis
    b. Surplus Production models
7. Model results
    a. Stock Synthesis
    b. Surplus Production models
    c. Synthesis of assessment results
8. Stock projections
9. Responses to the Commission:
    a. Estimation of live and dead discards
    b. Fishing mortality estimates by main fleet/gears
10. Recommendations
    a. Research and statistics
    b. Management
11. Enhance Billfish Research Program update on ongoing activities and future planning.
    a. Reproductive biology
    b. Others
12. Other matters
    a. Research Funding
    b. Workplan BIL Group
13. Adoption of the report and closure

Appendix 2

List of participants[2] *

CONTRACTING PARTIES

BRAZIL

Leite Mourato, Bruno
Profesor Adjunto, Laboratório de Ciências da Pesca - LabPesca Instituto do Mar - IMar, Universidade Federal de São Paulo - UNIFESP, Rua Carvalho de Mendoça, 144, Encruzilhada, 11070-100 Santos, São Paulo
Tel: +55 1196 765 2711, Fax: +55 11 3714 6273, E-Mail: bruno.mourato@unifesp.br; bruno.pesca@gmail.com; mourato.br@gmail.com

Kikuchi Santos, Eidi
Federal University of Rio Grande - Institute of Oceanography, 96201-900 Rio Grande
Tel: +55 53 991 641 561, E-Mail: eidikikuchi@hotmail.com

CHINA, (P. R.)

Feng, Ji
Shanghai Ocean University, 999 Hucheng Huan Rd, 201306 Shanghai
Tel: +86 159 215 36810, E-Mail: fengji_shou@163.com; fji13_shou@yeah.net; 276828719@qq.com; f52e@qq.com

CÔTE D'IVOIRE

Konan, Kouadio Justin
Chercheur Hidrobiologiste, Centre de Recherches Océanologiques (CRO), 29 Rue des Pêcheurs, BP V 18, Abidjan 01
Tel: +225 07 625 271, Fax: +225 21 351155, E-Mail: konankouadjustin@yahoo.fr

EUROPEAN UNION

Báez Barrionuevo, José Carlos
Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Puerto Pesquero de Fuengirola s/n, 29640, España
Tel: +34 669 498 227, E-Mail: josecarlos.baez@ieo.csic.es

Fernández Costa, Jose Ramón
Instituto Español de Oceanografía, Ministerio de Ciencia e Innovación - CSIC, Centro Costero de A Coruña, Paseo Marítimo Alcalde Francisco Vázquez, 10 - P.O. Box 130, 15001 A Coruña, España
Tel: +34 981 218 151, Fax: +34 981 229 077, E-Mail: jose.costa@ieo.csic.es

Fernández Llana, Carmen
Instituto Español de Oceanografía (IEO), Consejo Superior de Investigaciones Científicas, C/ Corazón de María, 8, 28002 Madrid, España
Tel: +34 91 342 11 32, E-Mail: carmen.fernandez@ieo.csic.es

Liniers Terry, Gonzalo
Instituto Español de Oceanografía (IEO, CSIC), Calle Corazón de María 8, 28002 Madrid, España
Tel: +34 915 107 540, E-Mail: gonzalo.liniers@ieo.csic.es; g7linierst@gmail.com

GABON

Angueko, Davy
Chargé d'Etudes du Directeur Général des Pêches, Direction Générale des Pêche et de l'Aquaculture, BP 9498, Libreville Estuaire
Tel: +241 6653 4886, E-Mail: davyangueko83@gmail.com; davyangueko@yahoo.fr

GHANA

Kwame Dovlo, Emmanuel
Director, Fisheries Scientific Survey Division, Fisheries Commission, P.O. Box GP 630, Accra, Tema
Tel: +233 243 368 091, E-Mail: emmanuel.dovlo@fishcom.gov.gh

---

* Head Delegate

[1] Some delegate contact details have not been included following their request for data protection.

Addi, Ebenezer Adinortey
Research Manager, Fisheries Scientific Survey Division, P.O. Box BT 62, Tema
Tel: +233 573 542 608; +233 245 538 962, E-Mail: ebenezer.addi@fishcom.gov.gh; addiebenezer@yahoo.com

Baah Essel, Peter
Assitant Research Manager, Accra, Tema
Tel: +233 501 588 024, E-Mail: Peter.essel@fishcom.gov.gh

Tigyimah, Benedicta
Assistant Fisheries Manager, Fisheries Commission, Post Office Box BT 62, Tema, Accra
Tel: +233 550 035 728, E-Mail: benedicta.tigyimah@fishcom.gov.gh

GUINEA REP.
Kolié, Lansana
Chef de Division Aménagement, Ministère de la Pêche et de l'Economie maritime, 234, Avenue KA 042 - Commune de Kaloum BP: 307, Conakry
Tel: +224 624 901 068, E-Mail: klansana74@gmail.com

Soumah, Mohamed
Centre National des Sciences Halieutiques de Boussoura (CNSHB), 814, Rue MA 500, Corniche Sud Madina, Boussoura, 3738 Conakry
Tel: +224 622 01 70 85, E-Mail: soumahmohamed2009@gmail.com

JAPAN
Kawano, Masataka
Technical Official, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries, International Affairs Division, Tokyo Kasumigaseki, Chiyoda-ku 100-8907
Tel: +81 335 028 460, Fax: +81 335 042 649, E-Mail: masataka_kawano320@maff.go.jp

Uozumi, Yuji
Advisor, Japan Tuna Fisheries Co-operation Association, Japan Fisheries Research and Education Agency, Tokyo Koutou ku Eitai 135-0034

MEXICO
Ramírez López, Karina
Instituto Mexicano de Pesca y Acuacultura Sustentables (IMIPAS), Centro Regional de Investigación Acuícola y Pesquera - Veracruz, Av. Ejército Mexicano No.106 - Colonia Exhacienda, Ylang Ylang, C.P. 94298 Boca de Río, Veracruz
Tel: +52 5538719500, Ext. 55756, E-Mail: karina.ramirez@imipas.gob.mx; kramirez_inp@yahoo.com

PANAMA
Molina, Laura
Autoridad de los Recursos Acuáticos de Panamá - ARAP, Dirección General de Investigación y Desarrollo, Edificio Riviera, Ave. Justo Arosemena, Calle 45 Bella Vista, 0819-05850
Tel: +507 511 6036, E-Mail: lmolina@arap.gob.pa

SÃO TOMÉ E PRÍNCIPE
Da Conceiçao, Ilair
Director das Pescas, Ministério da Agricultura, Desenvolvimento Rural e Pescas, Bairro 3 de Fevereiro - PB 59, Sao Tomé
Tel: +239 990 9315, Fax: +239 12 22 414, E-Mail: ilair1984@gmail.com

SENEGAL
Ba, Kamarel
Docteur en Sciences halieutiques et modélisation, Ministère de l'Agriculture et de l'Equipment Rural, Institut Senegalais de Recherches Agricoles (ISRA), Centre de Recherches Oceanographiques de Dakar Thiaroye (CRODT), Pôle de Recherches de Hann, Route du Front de Terre, 2241 Dakar
Tel: +221 76 164 8128; +221 766 055 999, Fax: +221 338 328 262, E-Mail: bakamarel@gmail.com; kamarel2@hotmail.com

Sow, Fambaye Ngom
Chercheur Biologiste des Pêches, Centre de Recherches Océanographiques de Dakar Thiaroye, CRODT/ISRA, LNERV - Route du Front de Terre - BP 2241, Dakar
Tel: +221 3 0108 1104; +221 77 502 67 79, Fax: +221 33 832 8262, E-Mail: ngomfambaye2015@gmail.com; famngom@yahoo.com

UNITED STATES
Cass-Calay, Shannon
Director, Sustainable Fisheries Division, Southeast Fisheries Science Center, NOAA, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 305 361 4231, Fax: +1 305 361 4562, E-Mail: shannon.calay@noaa.gov

Díaz, Guillermo
NOAA-Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 305 361 4227; +1 305 898 4035, E-Mail: guillermo.diaz@noaa.gov

Die, David
Research Associate Professor, Cooperative Institute of Marine and Atmospheric Studies, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149
Tel: +1 305 421 4607, E-Mail: ddie@earth.miami.edu; dddejean@kutaii.com; ddie@rsmas.miami.edu

Fernández, Michelle
4600 Rickenbacker Causeway, Key Biscayne, FL 33149
Tel: +1 305 582 9112, E-Mail: maf45257@miami.edu

Schirripa, Michael
Research Fisheries Biologist, NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 305 445 3130; +1 786 400 0649, Fax: +1 305 361 4562, E-Mail: michael.schirripa@noaa.gov

Zhang, Xinsheng
NOAA/NMFS/SEFSC, 3500 Delwood Beach Rd., Florida 32408
Tel: +1 850 234 6541 ext. 264, Fax: +1 850 235 3559, E-Mail: Xinsheng.Zhang@noaa.gov; Xinsheng.Zhang0115@gmail.com

URUGUAY
Domingo, Andrés *
Dirección Nacional de Recursos Acuáticos - DINARA, Laboratorio de Recursos Pelágicos, Constituyente 1497, 11200 Montevideo
Tel: +5982 400 46 89, Fax: +5982 401 32 16, E-Mail: dimanchester@gmail.com

VENEZUELA
Narváez Ruiz, Mariela del Valle
Lab. 34, Edif. Instituto Oceanográfico de Venezuela, Universidad de Oriente, Departamento de Biología Pesquera, Av. Universidad, Cerro Colorado, DBP-31 Laboratory, 6101 Cumaná Estado Sucré
Tel: +58 412 085 1602, E-Mail: mnarvaezruiz@gmail.com

Arocha, Freddy
Asesor Científico, Instituto Oceanográfico de Venezuela, Universidad de Oriente, A.P. 204, 6101 Cumaná Estado Sucre
Tel: +58 424 823 1698; +58 412 692 8089, E-Mail: farochap@gmail.com

Rodríguez Rosales, Arvin Alejandro
Analista de Multilaterales de la Oficina de Integración y Asuntos Internacionales, Ministerio del Poder Popular de Pesca y Acuicultura, Parque Central. Piso 17, 1040 Caracas
Tel: +58 424 175 6221, E-Mail: arvinalejandror@gmail.com; oai.minpesca@gmail.com

Vásquez, Ruth
Ministerio del Poder Popular de Pesca y Acuicultura Torre Este. Piso 17. Oficina de Integración y Asuntos Internacionales, Oficina de Integración y Asuntos Internacionales, Torre Este. Piso 17. Parque Central. Caracas
E-Mail: conocimientocenipa@gmail.com

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

CHINESE TAIPEI
Su, Nan-Jay
Associate Professor, Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, No. 2 Beining Rd., Zhongzheng Dist., 202301 Keelung City
Tel: +886 2 2462 2192 #5046, Fax: +886-2-24622192, E-Mail: nanjay@ntou.edu.tw

COSTA RICA
Pacheco Chaves, Bernald
Instituto Costarricense de Pesca y Acuicultura, INCOPESCA, Departamento de Investigación, Cantón de Montes de Oro, Puntarenas, 333-5400
Tel: +506 899 22693, E-Mail: bpacheco@incopesca.go.cr

OBSERVERS FROM NON-GOVERNMENTAL ORGANIZATIONS

FISHERY IMPROVEMENT PLAN - FIP
Martinez de Lagos Guevara, Estíbaliz
FIP, Gran vía 45, 2º, 36204 Vigo, Pontevedra, España
Tel: +34 604 077 868, E-Mail: emartinez@datafishts.com

Oihenarte Zubiaga, Aintzina
FIP, Bizkaiko Jaurerria, 2 1ºizq, 48370 Bermeo, Bizkaia, España
Tel: +34 944 000 660, E-Mail: aoihenarte@datafishts.com

OTHER PARTICIPANTS

SCRS CHAIRMAN
Brown, Craig A.
SCRS Chairman, Sustainable Fisheries Division, Southeast Fisheries Science Center, NOAA, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149, United States
Tel: +1 305 586 6589, E-Mail: craig.brown@noaa.gov

EXTERNAL EXPERT
Palma, Carlos
ICCAT Secretariat, C/ Corazón de María, 8 - 6 Planta, 28002 Madrid, España
Tel: + 34 91 416 5600, Fax: +34 91 415 2612, E-Mail: carlos.palma@iccat.int

ICCAT Secretariat

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

Manel, Camille Jean Pierre
Neves dos Santos, Miguel
Ortiz, Mauricio
Kimoto, Ai
Taylor, Nathan
Mayor, Carlos
Fiorellato, Fabio
De Andrés, Marisa
García, Jesús

ICCAT INTERPRETERS
Baena Jiménez, Eva J.
Calmels, Ellie
Godfrey, Claire
Liberas, Christine
Linaae, Cristina
Pinzon, Aurélie

Appendix 3

List of papers provided during the meeting

Doc. Ref.	Title	Authors
SCRS/2024/106	Assessment of Atlantic blue marlin (*Makaira nigricans*) using JABBA model (1956-2022)	Mourato B., Kikuchi E., Sant'Ana R., Cardoso L.G., Ngom F.; Narvaez Ruiz M., Arocha F., Kimoto A., and Ortiz M.
SCRS/2024/107	Current status of the blue marlin (*Makaira nigricans*) stock in the Atlantic Ocean 2024: Pre-decisional stock assessment model.	Schirripa M.
SCRS/2024/108	Summary report of the informal intersessional online meeting modeling team BUM stock assessment 2024.	Anon

Appendix 4

SCRS documents and presentations abstracts as provided by the authors

SCRS/2024/106 - We applied the JABBA model for the Atlantic blue marlin (*Makaira nigricans*) with the best available data through 2022. Preliminary JABBA stock assessment results suggest reasonably robust fits to the data as judged by the presented model diagnostic results. The resulting stock status for 2022 was generally consistent and predicted with high probabilities that current fishing levels are generating overfishing (F2022> F_{MSY}), whereas biomass is below the sustainable levels that can produce MSY (B2022<B_{MSY}). As such, our models conclusively estimate that stock is overfished and subject to overfishing, with probability of 69.4% for the red quadrant of Kobe.

SCRS/2024/107 - This document describes the pre-decisional base case model configured to estimate the status of the blue marlin (Makaira nigricans) stock for the June 2024 stock assessment meeting. The model configuration is based on the 2018 model used to provide management advice. Uncertainties specifically accounted for were growth, stock-recruitment steepness, natural mortality and conflicting CPUE trends. Uncertainties not accounted for where, inter alia, seasonal and/or aerial differences in life history traits and illegal, unreported and unregulated (IUU) landings. Several assumptions were investigated via different model configurations, namely four steepness values (0.40, 0.50, 0.70 and model estimated) and two natural mortality values (0.148 and model estimated for females).

SCRS/2024/108 -The modeling team for the 2024 Atlantic blue marlin stock assessment met intersessionally on May 9, 2024, to present progress on the assessment models following the recommendations and workplan agreed upon by the Billfish Species Group at the data preparatory meeting. A review of the growth information provided by the two sources of size at age observations otoliths versus spines suggested different growth model patterns, particularly for females. The group recommended that further exploration and validation of spine-derived age estimates were needed before integrating both age-at-size data into the assessment models. Hence it was recommended to use only otolith data for the 2024 assessment models.