Report of the 2024 ICCAT Yellowfin Tuna Stock Assessment Meeting

(hybrid/ Madrid, Spain, 8-12 July 2024)

1. Opening, adoption of agenda and meeting arrangements and assignment of rapporteurs

The hybrid meeting was held in person at the ICCAT Secretariat in Madrid Spain, and online, from 8 to 11 July 2024. Dr Shannon Cass-Calay (U.S.), the Yellowfin Tuna Rapporteur and meeting Chair, opened the meeting and welcomed participants (the "Group"). On behalf of the Executive Secretary, Dr Miguel Neves dos Santos, Assistant 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, 12	M. Ortiz
Item 2a	R. Forselledo,
Item 2b, 2c	F. Fiorelleto, C. Mayor, M. Ortiz, A. Kimoto
Item 2d	S. Sagarese, A. Kimoto
Item 3a, 4a, 5a	M. Lauretta, S. Sagarese, D. Courtney, A. Kimoto
Item 3b, 4b, 5b	R. Sant'Ana, G. Merino, G. Correa, M. Narváez, A. Kimoto
Item 6	S. Cass-Calay, A. Kimoto, M. Ortiz
Item 7a, 7b	R. Sant'Ana
Item 7c	G. Merino, A. Urtizberea
Item 7d	S. Cass-Calay, R. Sant'Ana, G. Merino
Item 8	C. Brown, S. Wright
Items 9, 11	S. Cass-Calay
Item 10	S. Wright

2. Summary of input data for stock assessment

2.1 Biology

Document SCRS/2024/121 presented estimates of natural and fishing mortality rates derived from the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) conventional tagging dataset. Tag recovery data were analyzed using Brownie models as parameterized in terms of instantaneous rates of fishing (F) and natural (M) mortality, with mixing window, tag shedding, and tag reporting rates obtained from previously published work. The total mortality rate (Z) was estimated at 0.44/year, with M estimated at 0.35/year and F estimated at 0.09/year.

The Group acknowledged the value of the results of this study due to the importance of natural mortality for the stock assessment of the species. Also, the Group highlighted that this is a very important research result obtained from the AOTTP, which confirms the importance of the ICCAT research programmes.

There was a question regarding tag-induced mortality, as other studies conducted in other oceans consider much higher values (Hoyle *et al.*, 2015). Phi (Φ) in the model is the probability that an animal survives any initial tag shedding and initial tag-induced mortality. The author noted that the AOTTP does not have information on tag-induced mortality, it was therefore assumed negligible. The tag-shedding rate used in the study (3%), based on Gaertner *et al.* (2022), represents the probability of losing the tag in the short term. A sensitivity run considering a higher value of tag-induced mortality (37%) as observed in other studies was conducted.

The Group commented that other uncertainties exist, including the likely lower reporting rates impacting larger size classes mainly captured with other fishing gears. The author agreed that this was a source of uncertainty and explained that there is probably a lower reporting rate for fishing gears such as longline, and since the AOTTP ended there has been less awareness raising and personnel coverage to encourage tag recapture reporting. However, to account for this, a sensitivity analysis was conducted, considering a lower reporting rate (60%), that did not result in major changes in the resulting M. The study also identified other sources of uncertainty that should be considered.

The author was consulted about the exploration of historical tagging information to estimate time varying M, and expressed that there is available information on tagging. However, that information lacks estimates of reporting rates, and therefore would be very difficult to use or combine with the study's data input. Many assumptions and sensitivity analyses should be done when using historical information. The development of the AOTTP considered many variables to accomplish the objectives of the programme. Despite all this planning, many problems arose associated with unforeseen events.

The Group noted that even though the results presented were not being used as data input in the current stock assessment, the estimated value of M was similar to the assessment M assumptions used and that can be used to confirm or reject the different hypotheses used. A comment was made that this estimate of M was derived from mostly younger fish (ages 1-4) and that it is therefore slightly lower than the estimate of M used in the assessment once Lorenzen scaling was applied. Also, the confidence intervals of M and Z were discussed and explained to be tight due to the strict assumptions of the analysis.

Document SCRS/2024/124 presented a comparison of the age estimates using different hard parts from the same individual, including otoliths, spines, and vertebrae. The study assumed otoliths as the "correct" age estimation source and compared them to estimates from spines and vertebrae. At the level of the spines and vertebrae, only one band is deposited per year as is the case with otoliths. Based on the bias and precision indices and the bias curves, the otolith would be the best structure for the estimation of the age of yellowfin tuna. Results indicated similar age estimates for fish up to 5 years old for the 3 structures used. However, for older/larger fish it was concluded that there is a significant overestimation of age from 5 to 7 years from spine reading (**Figure 1**), while there is an underestimation of age from vertebrae of fish ages 7 and 9 compared to the otolith (**Figure 2**).

The Group welcomed the presentation of this important study. Regarding the use of spines, the authors were consulted if mark readings were corrected considering missing marks due to the reabsorption in the core area of spines. Authors commented that reabsorption was observed starting even in small individuals (40 cm SFL) and that larger individuals have higher reabsorption areas, so readings become more complex. In the study, however, if reabsorption was observed, readings were corrected using an estimated correction factor from fish individuals that showed none or minimal reabsorption.

It was noted that otoliths are commonly the main structure used for age estimation and growth studies. However, given the results of this study for Atlantic yellowfin tuna the use of other structures (vertebrae and spines) could be useful, taking into consideration the size/age ranges for which similar results were observed. This could benefit or be considered in research programmes, since in general, hard structures such as spines and vertebrae samples are easier to obtain on the field compared to otoliths. This study also provided potential correction factors between the different hard structures used for yellowfin tuna. With this information, the Group could recommend the use of these other structures for age and growth studies.

2.2 Catches

The Secretariat reported on the intersessional work done following the data preparatory meeting for the species (SCRS/P/2024/087).

The Group was made aware that Task 1 and Task 2 datasets were updated with information received until 30 June 2024, and that these new data resulted almost exclusively in additional nominal catch and size-frequency records (including catch-at-size (CAS)) for the year 2023, which were still considered preliminary and not included in the assessment.

Therefore, the Group confirmed that modelers could use the Task 1 and Task 2 datasets as provided at the end of the data preparatory meeting in April 2024. **Table 1** reflects the total nominal catches for yellowfin tuna in the period 1950 to 2023.

Document SCRS/2024/039 reviewed catch by fleet and size sampling data of Atlantic yellowfin tuna for its use within the stock evaluation models by the Secretariat. Catch and size data were reviewed and estimated for the fleet structure ID used at the 2019 yellowfin tuna stock assessment.

Document SCRS/2024/119 reviewed catch and effort data for bigeye and skipjack tuna from the Mexican longline fleet in the Gulf of Mexico. The revision of the data submitted to ICCAT is based on the national observer programme data that spans from 1993 to 2021. Significant discrepancies between observed and reported data to ICCAT were noted for years before 2002.

The Group considers the updates better information and recommends them to be included in the ICCAT databases replacing the previous information. It was noted that the update catches of western skipjack were minimal and did not substantially change the catch series input used for the SKJ-W management strategy evaluation (MSE) operating models.

2.3 Size

Document SCRS/2024/120 presented updated catch-at-size (CAS) estimates for the Chinese longline fleet targeting tropical tuna in the Atlantic from 2015 to 2021. This update was in response to the request for CPCs targeting tropical tuna species to enhance their catch-at-size estimation (T2CS) for yellowfin tuna stock assessment.

Presentation SCRS/P/2024/088 provided the Group with the latest yellowfin catch-at-size data from 1960 to 2022. It detailed the calculation methodology and proposed steps toward a more systematic or automated approach.

2.4 Fleet structure

During the development of Stock Synthesis (SCRS/2024/110), the fleet structure was modified slightly from the data preparatory recommendations (ICCAT, 2024) to better align with the tropical tunas multi-stock MSE fleet structure (**Table 2**). Specifically, the purse seine free school and floating object (FOB) associated fleets were revised to single individual fleets with seasonal observations, as opposed to four separate fleets each by season. The Group agreed with the changes to move from 25 to 19 fleets in the Stock Synthesis model.

3. Methods and model settings

3.1 Stock Synthesis

An initial assessment of the Atlantic yellowfin tuna stock using Stock Synthesis 3.30.18 (Methot and Wetzel, 2013) was provided to the Group (SCRS/2024/110) that incorporated the recommendations from the 2024 Yellowfin Tuna Data Preparatory Meeting (ICCAT, 2024). Key changes from the data preparatory meeting recommendations included:

- Increasing the coefficient of variation (CV) of input catch data from 0.01 to 0.02 to get a better model fit.
- Reducing the number of fleets from 25 to 19 to better align with the tropical tunas multi-stock MSE fleet structure (**Table 2**), and to better account for growth across seasons.
- Fitting to the more recent period of 1979-2022 for the joint catch per unit effort (CPUE) longline index for the tropical Atlantic (region 2), upweighting this index by 10.
- Estimating growth within Stock Synthesis in combination with age data input as conditional age-at-length and refining the size at the minimum age parameter (L at A_{MIN})
- Refining selectivity patterns, time blocks, and prior selectivity values for select fleets, including mirroring fewer fleets than recommended.

A seasonal model was constructed covering a timeframe from 1950-2022 (**Figure 3**) with the stock starting in an unfished, virgin condition.

Three abundance indices were modeled (**Table 3** and **4**, **Figure 4**), 1) the joint-CPC region 2 (tropical Atlantic) longline index (1979-2022); 2) the acoustic echosounder buoy index associated with FOBs (2010-2022, seasonally); and 3) the purse seine free school index (1993-2022, seasonally). The joint longline index was assumed to have a selectivity equivalent to the Japan longline fleet in the tropical Atlantic (fleet 11). The acoustic buoy index was assumed to have the same selectivity as the purse seine fleet operating on FOBs (fleet 4), and the purse seine free school index was assumed to have the same selectivity as the purse seine free school fleet (fleet 3). All indices were scaled to a mean of 1, and index CVs for the purse seine free school index and acoustic echosounder buoy index were scaled to an average CV of 0.2 while retaining the interannual variability estimated by the standardization models.

Length data for each fleet, year, and season were provided by the Secretariat after all CPC data updates were completed following the data preparatory meeting (**Figure 5**). Length compositions were input as the number of fish observed per 4 cm size bin. The effective sample sizes were equal to the natural log of the number of observations to reduce the effect of pseudo-replication in sampling and decrease the weight of length data in the overall model likelihood.

The assumption of growth was modified from the 2019 assessment and modeled as a Richards growth curve, consistent with the findings and recommendations of Pacicco *et al.* (2021) (**Table 5**). Growth was estimated within Stock Synthesis without parameter priors using the conditional age-at-length data (**Figure 6**) available for the period 2007-2021 for fleets 13 (Longline North Other) and 17 (RR US). Weight (kg) was estimated from current SCRS straight fork length (cm) conversion factors W = 2.1527x10-5 * SFL^2.976 (Caverivière, 1976).

Maturity and fecundity assumptions remain unchanged from the 2019 assessment. Fecundity was modeled as a direct function of female body weight. The maturity at length was based on Diaha *et al.* (2016), with 50% maturity at 115.1 cm straight fork length (SFL). The sex ratio was assumed to be 50:50 males-females. Birth date was adjusted to the first month of each season (January, April, July, October).

As detailed in the Report of the 2024 Yellowfin Tuna Data Preparatory Meeting (ICCAT, 2024), age-specific M assumptions were modified from the 2019 stock assessment, based on new information on the regression (Hamel and Cope, 2022) used to estimate the scale of M at older ages. A value of natural mortality of 0.3 was assigned to age 7 (baseline M), consistent with the Hamel and Cope (2022) estimator of M, and assuming a maximum age of 18. This treatment differs from the 2019 stock assessment where the baseline M of 0.30 was based on the Then *et al.* (2015) estimator of M (ICCAT, 2019) assuming a maximum age of 18.

Length-based selectivity was estimated for the fleets with some deviations from the recommendations from the data preparatory meeting. Selectivity was estimated directly for 17 out of the 19 fleets, assuming a cubic spline function for fleets 1-5 to model the bimodality of length composition observations. Fleets 6-10, 12-13, and 15-19 were modeled as double normal functions, and fleets 11 and 14 were assumed to have asymptotic logistic selectivity (**Table 2**). Fleets 9 (BB North Azores) and 16 (HL Brazil) were mirrored to fleet 8 (BB Dakar late), since there was limited size composition data for those fleets. Selectivity at age was derived by stock synthesis, based on the model estimated fleet selectivity-at-length.

The stock-recruitment relationship followed a Beverton-Holt function with virgin recruitment (R_0) and mean log-scale recruitment standard deviation (sigmaR) freely estimated. Steepness was fixed at 0.8 for the reference case, but a Monte Carlo analysis included a uniform random distribution between 0.7 and 0.9 to assess alternative values, similar to the analysis conducted on M. Annual recruitment deviations were estimated for the period 1974 to 2021. Prior to 1974, recruitment was derived from the estimated stock-recruitment relationship. The lognormal bias correction ($-0.5\sigma^2$) for the mean of the stock-recruit relationship was applied with a bias correction ramp as recommended by Methot and Taylor (2011). The estimated total annual recruitment was distributed across the four seasons according to seasonal allocations estimated in the model.

The length data component variance adjustments followed the method of Francis (2011). Relative data weighting followed the same assumptions as the 2019 stock assessment (ICCAT, 2019), with a 50% weight (lambda = 0.5) applied to the length composition data, and a 100% weight value (lambda = 1) applied to the indices of abundance. A major deviation from the 2019 stock assessment model and the data preparatory recommendation was to upweight (lambda = 10) the joint LL region 2 index to improve model fit to the long-term abundance series. This decision was reviewed by the Group and was agreed to represent a major improvement to the model.

Overall, the model estimated 173 parameters, consisting of 114 selectivity parameters, 2 stock recruitment parameters, 6 growth parameters, 3 seasonal recruitment allocations, and 48 recruitment deviations. Model parameter standard deviations were derived from the variance-covariance matrix. It was noted that model reported estimates of spawning stock biomass (SSB) refer to the beginning of the year, and fishing mortality refers to the mortality rates over the entire year.

To evaluate the effect of alternative M assumptions, a Monte Carlo resampling analysis was conducted, with 4000 random M values drawn from a lognormal distribution (log(mean)=0.3, Std Dev = 0.31) and the reference case model iterated assuming those alternative M values (**Figure 7**).

A continuity model run was constructed for comparison with the 2019 stock assessment based on the same biological assumptions. Additional sensitivity analyses were provided based on the preliminary reference case including the Age Structured Production Model (ASPM) analysis (SCRS/2024/116), removing indices of abundance one at a time (SCRS/2024/110), removing recruitment deviates, down weighting the EU purse seine (PS) free schools index, and removing the size frequency data from the last 5 years (2018-2022) (SCRS/2024/111).

Document SCRS/2024/111 also explored an uncertainty grid of 9 models with a cross combination of fixed alternative assumptions on natural mortality (M = 0.25, 0.3, and 0.35) and steepness (h = 0.7, 0.8, and 0.9). The natural mortality estimates of 0.25, 0.3, and 0.35 correspond to maximum ages for the population of 21.6, 18, and 15.4 years, respectively. These alternative runs of the proposed uncertainty grid are listed in **Table 6**. Model diagnostics included retrospective analyses, runs tests on CPUEs and length data, and jackknife runs with each abundance index removed, following the approach proposed by Carvalho *et al.* (2021).

The Group received some technical suggestions for the Stock Synthesis implementation, mostly related to selectivity and recruitment settings for the preliminary reference model to improve parameterization:

- For selectivity type 27 (cubic spline), fix one of the node selectivity parameter values as recommended in the Stock Synthesis manual (Methot *et al.*, 2024).
- Allow for time-varying recruitment deviations between seasons, which are currently held constant across time in the reference model (i.e., the relative proportion of recruitment between seasons is constant which assumes no variation in the spawning season over time).
- Additional changes were recommended based on best practices including the use of the natural cubic spline, the Dirichlet-Multinomial approach for data weighting, estimating recruitment deviations without the explicit constraint to sum to zero, and using the fleet-specific parameter/hybrid F method.
- Refinements to selectivity estimation by including time-varying selectivity for the fleets with conditional age-at-length and random walks instead of blocks.

The Group welcomed and considered the recommendations and after further evaluation, it decided that the reference model would estimate all five node selectivity parameter values for each fleet to allow flexibility in model estimation (e.g., growth) for both the Monte Carlo analysis and the grid approach.

Analyses of alternative models based on these recommendations were conducted during the meeting, and it was determined that the alternative treatments did not substantially improve model information content or have significant effects on the model estimates. It was also noted that for selectivity type 27 (cubic spline), one of the parameters has a prior with a CV of 10% (i.e. highly informative prior) in the reference case model to facilitate the convergence when the parameters are modified in the grid approach or the Monte Carlo runs while the rest of the selectivity parameters are estimated freely. Therefore, it was recommended to retain the proposed reference case model presented for use in estimating the stock status and stock projections.
The Group briefly discussed the outcome of the alternative models of the step-by-step changes to the reference model:

- Use Stock Synthesis version 3.30.22.1.
- Holding one of the node selectivity parameter values constant for each fleet.

– Time-varying recruitment distribution between seasons.
– Recruitment deviations not constrained to sum to zero.
– Fleet-specific parameter/hybrid F method.

While these exploratory runs did provide additional insights into parameters causing the retrospective patterns (e.g., spline parameters causing issues), they did not substantially improve model diagnostics or have a large impact on assessment results. As a result, the Group agreed to move forward with the reference model described in Document SCRS/2024/110.

3.2 Surplus production models

3.2.1 mpb

The stock assessment model *mpb* (Kell, 2016) in Document SCRS/2024/113 was configured with total catch and two indices of abundance: the CPUEs from the Joint Longline in Region 2 (SCRS/2024/036) and the EU purse seine index operating on free schools (Kaplan *et al.*, 2024). The *mpb* package has methods for plotting, examining goodness of fit, deriving quantities used to provide management advice, estimating uncertainty, and other statistical diagnostics to evaluate model performance.

The Group noted that this model was used as part of the ensemble of models used to develop management advice in the 2019 yellowfin tuna stock assessment (ICCAT, 2019). The model was configured with the initial values used in 2019 with a narrower constraint on the intrinsic growth rate parameter (r) (**Table 7**).

3.2.2 JABBA

The most recent version of JABBA (v2.3.0, Winker *et al.*, 2018) Bayesian surplus production was applied to the time series of catches and indices to assess the yellowfin tuna stock of the Atlantic until 2022. Document SCRS/2024/114 presented all priors settings, results, and model formulation of the JABBA models. JABBA was implemented in R (R Development Core Team) with Just Another Gibbs Sampler (JAGS) interface (Plummer, 2003) to estimate the Bayesian posterior distributions of all quantities of interest using a Markov Chains Monte Carlo (MCMC) simulation. In this study, four MCMC chains were used. The models were run for 50,000 iterations, and sampled with a burn-in period of 5,000 for each chain.

Document SCRS/2024/114 included the continuity run (S05) of the 2019 stock assessment and the preliminary reference case (S06) with several sensitivity analyses. Both models applied the total catch series of Atlantic yellowfin tuna between 1950 and 2022 (**Figure 3**) and 2 indices (**Tables 3** and **4**, **Figure 4**): the joint CPUE longline index for Region 2 (tropical area) and the EU Purse Seine fleet targeting free-swimming schools of adult yellowfin tuna. The continuity run S05 assumed the *r* prior as the 2019 JABBA stock assessment posterior distributions, which resulted in a *r* prior of $\log(r) \sim N(\log(0.154), 0.200)$ with a fixed input value of $B_{MSY}/K = 0.342$. The *r* prior for the preliminary reference case S06 was derived from the age-structured equilibrium model (ASEM, Winker *et al.*, 2019) using the reference point estimates in the 2024 Stock Synthesis preliminary reference case. This assumed an *r* prior of $\log(r) \sim N(\log(0.3740), 0.374)$ with a fixed input value of $B_{MSY}/K = 0.270$.

The Group pointed out that the Stock Synthesis preliminary reference case up weighted the joint longline index in Region 2 by a factor of 10. This decision was made after the 2024 Yellowfin Tuna Data Preparatory Meeting (ICCAT, 2024), and the Group agreed with the change (section 3.1). However, the Group decided not to investigate this change during the meeting in the JABBA models.

4. Model diagnostics

4.1 Stock Synthesis

Stock Synthesis converged to a stable solution, with a negative log-likelihood consistent across the jittered parameter starting values (**Figure 8**). The final model gradient was 0.000089, lower than a target of 0.0001, and was considered acceptable for model convergence, particularly since the solution was stable across different starting parameter values.

The model showed a general lack-of-fit to the purse seine free school index, but relatively better fits to the acoustic buoy and joint-CPUE longline indices (**Figure 9**). The residual errors of the indices showed consistent centralized distributions, evidenced by the diagnostic runs test (**Figure 10**). A conflict in recent trend between the purse seine free school and all three regions joint-CPC longline indices was apparent (**Figure 9**), with a decline in the purse seine and an increase in the longline observed since 2019. Applying a 10-times likelihood weight to the joint CPUE longline index, which represents the most informative dataset on long-term spawner biomass across space and time, greatly improved the model fit to the time series, especially in the more recent years (SCRS/2024/110). Only the acoustic buoy index exhibited good predictive skill according to the hindcast analysis (MASE < 1; **Figure 11**).

Fits to the aggregated length composition (**Figure 12**) provided a primary diagnostic of model selectivity estimation. Overall, the reference case demonstrated an acceptable fit to the aggregated length composition data of all fleets. The annual residual patterns appeared mostly randomly distributed and deemed adequate for the major harvesting fleets, while the fleets with relatively smaller removals showed some non-random patterns in residuals (**Figure 13**). This was, in part, a result of shifting length composition over time not accounted for in time varied estimates and was particularly observed in fleets with multi-modal length compositions. Time blocks were not considered for fleets with sparse data (i.e. low sample size) because of concerns that the model may chase noise. Predictive skill of mean length was acceptable for Fleets 5, 11, 13-14, 17, and 19 (MASE < 1; **Figure 14**).

A list of model parameters is presented in **Table 8**, including estimated values, standard deviation, and prior distribution assumptions where necessary. Selectivity parameters were estimated with good precision, with select priors added to the spline (GradeLo and Val1) and double-normal (top-logit) parameters to improve model stability (**Table 8**). Growth parameters were well estimated without priors (**Figure 15**) and resulted in a growth curve very similar to the size-modified Richards curve published by Pacicco *et al.* (2021) and presented at the data preparatory meeting (**Figure 16**). Estimation of growth was possible due to the inclusion of conditional age-at-length, which was not modeled directly in the 2019 yellowfin tuna stock assessment (ICCAT, 2019).

Estimated recruitment deviates indicated high variability from year-to-year, with periods of lower than average predicted recruitments (prior to 1980 and 2003-2007) and periods where recruitment deviations were relatively high, including the most recent years (**Figure 17**).

Since the steepness (h) of the Beverton-Holt curve was fixed, the main productivity parameters estimated in Stock Synthesis were the average level of age-0 recruitment at unfished equilibrium spawning biomass (R0) and sigmaR. The likelihood profile of R0 from the reference case indicated a maximum likelihood estimate near 11 (natural log scale), equivalent to approximately 60 million age 0 recruits, with slightly lower values supported by the length (10.6) and index (10.8) data (**Figure 18**). The likelihood profile of sigmaR indicated a maximum likelihood estimate near 0.24, although the index and length data supported larger values while the age data supported lower values (**Figure 18**). Almost all data series supported estimates of steepness near the upper bound (**Figure 18**).

In the reference case for the current assessment, the spawning stock biomass was estimated to decline throughout the time series until the most recent three years (**Figure 19**). The scale of biomass estimates was very sensitive to the alternative data and parameter assumptions, which was also apparent in an age-structured production model sensitivity run (**Figure 20**; SCRS/2024/116). The recent spawning stock biomass trend was greatly influenced by the different indices as evidenced by the jackknife analysis because of conflicts in the most recent years, particularly between the purse seine free school and joint CPUE longline indices. Recent period biomass estimates increased when the PS free school index was removed, while it declined considerably when the joint CPUE LL index was removed (**Figure 21**).
Fishing mortality (reported as an exploitation rate in biomass) increased sharply between 1965 and 1982, and further increased between 2005 to 2015, with peak fishing mortality estimated in 2020 at a 13% exploitation rate (**Figure 22**). Since 2015, exploitation rate has remained between 10-13% of the stock biomass removed by fishing annually (**Table 9**, **Figure 22**).

Results from the retrospective analysis indicated strong directional patterns (**Figure 23**). Mohn's rho, which measures the severity of retrospective patterns, was equal to –0.139 and 0.21 for the SSB and F time series, respectively, which were just within and outside the acceptable range, respectively (-0.15 to +0.20; see Hurtado-Ferro *et al.*, 2015). As the last few years of data are removed, the model estimates of SSB are much lower, while estimates of F increase, although they appear to remain within the confidence interval of the model with data through 2022. It was noted that retrospective diagnostics were substantially better for the ratio reference of biomass and fishing mortality (to -0.062 and 0.230 for the SSB/SSB_{MSY} and F/F_{MSY} time series) compared to the absolute values (**Figure 23**).

The Group reviewed the proposed 9-model uncertainty grid (SCRS/2024/111) suggested by the technical team that included three natural mortality vectors and three values of steepness. All models achieved similar levels of likelihood without parameters hitting bounds. Overall, there are no major differences regarding the statistical performance, although the high M and low steepness scenarios did not converge in all the retrospective diagnostic peels. Retrospective patterns were less pronounced for lower M values, while recruitment deviate trends and convergence suggest higher values of M.

4.2 Surplus production models

4.2.1 mpb

A suite of diagnostics was used to evaluate the performance of the biomass dynamic model *mpb* to fit total catch and CPUE data. Overall, the model showed an acceptable distribution of residuals (**Figure 24**) and reasonable retrospective trends (**Figure 25**). However, a likelihood exploration showed that the model is converging to estimate biological parameters (*r* and *K* (carrying capacity)) that show a poorer likelihood than other options (lower penalty function, residual sum of squares), i.e. larger and darker points in **Figures 26** to **30**. Furthermore, the model shows the lowest penalty function at implausible biological values of *r* (<0.001). This was confirmed by the likelihood exploration for the estimated reference points and stock status.

The Group discussed options to improve these diagnostics but acknowledged that most of the options had already been explored. Overall, the Group noted that it is difficult for biomass dynamic models to fit the conflicting trends of the two abundance indices, probably because this model cannot use process error to improve the fit to the data. The Group decided to stop exploring this model and not use it for developing the management advice.

4.2.2 JABBA

The diagnostics included the JABBA-residual plot (Winker *et al.*, 2018), the Root-Mean-Squared-Error (RMSE) fit to the loess smoother of all residuals CPUE indices combined and the runs test to detect non-randomness in CPUE residuals (Carvalho *et al.*, 2017). The runs test diagnostic was applied to residuals of the CPUE fit on log-scale using the function "runs.test" in the R package tseries (Trapletti, 2011), considering the 2-sided *p*-value of the Wald-Wolfowitz runs test. A retrospective analysis (n = 5 years) and jackknife analysis on CPUEs were also provided.

The visual inspection of trace plots (Figure 3 in SCRS/2024/114) of the key model parameters showed good mixing of the four chains (i.e. moving around the parameter space). This also indicates convergence in the MCMC chains, and that the posterior distribution of the model parameters was adequately sampled with the MCMC simulations. A summary of posterior quantiles for parameters and management quantities of interest is presented in **Table 10**.

JABBA residual plots showed that distributions of residuals were similar between the preliminary reference case S06 and the continuity run S05 with RMSE values around 14%, which indicates a good fit to CPUE data (**Figures 31** and **32**). However, the two indices (Joint_LL_R2 and EU_PS_FS) showed an opposite trend in fitting for the most recent 4 years. Only the Joint_LL_R2 passed the runs test diagnostic for the preliminary JABBA reference case (S06) (**Figure 33**).

Plots of process error (**Figure 34**) deviates by year indicate that the models presented a similar stochastic pattern, with a pronounced negative trend after 2008, which stabilizes towards the end of the time series when observing the central tendency (e.g. median signal). The 95% Bayesian credibility interval (CI) always included zero, which might be considered statistical evidence for a non-significant effect of this trend.

The medians of the marginal posterior for *r* in S05 and S06 were 0.138 and 0.181, respectively (**Table 10**, **Figure 35**). The posterior distributions for *K* indicate that the input data were very informative about *K* (**Figure 35**) and the medians of the marginal posterior for *K* in S05 and S06 were 2,299,725 and 1,649,524 metric tons (**Table 10, Figure 35**). The shape of the production curve function for S06 (preliminary reference case) was skewed to the left indicating a more productive stock with a smaller carrying capacity compared to the ones for S05 (continuity run) (**Figure 35**).

Retrospective analyses were conducted over eight sequential years for S05 and S06 (**Figures 36** and **37**) did not show any systematic patterns, and the estimated Mohn's rho (**Table 11**) fell within the acceptable range of -0.15 and 0.20 proposed by Hurtado-Ferro *et al.* (2015). However, the hindcasting cross-validation results suggest that none of the indices presented mean absolute scaled error (MASE) scores around one or less, which suggests these indices did not have good prediction skills (**Figure 38**).

The Jackknife analyses for S05 and S06 showed that removing the EU_PS Free school index (i.e. use only Joint_LL_R2) affected the stock status after 2010, resulting in less fishing mortality and stable biomass (**Figures 39** and **40**). While removing the Joint_LL_R2 affected the stock status in the recent 3 years resulting in lower B/B_{MSY} and higher F/F_{MSY} in S05 (**Figure 39**). In S06, the removal completely changed the fitting and stock status, however, the estimates were highly uncertain (**Figure 40**).

5. Model results

5.1 Stock Synthesis

All recommendations made by the Group at the data preparatory meeting were implemented in Stock Synthesis as stepwise, iterative model revisions from the continuity to a proposed reference case model (SCRS/2024/110). The effect of each revision on spawning stock biomass estimates is highlighted in **Figure 41**. Overall, the range of biomass scale estimates across the 2024 model revisions was notably larger than those observed in the 2019 uncertainty grid (**Figure 42**), highlighting the influence of alternative data and parameter assumptions on spawning stock biomass estimates.

While reviewing the step-by-step approach used to develop the reference model, a few questions were raised by the Group. First, the Group noted a large change in SSB trajectories, specifically a large reduction in SSB in the mid-1970s (**Figure 41**). This change resulted from removing the estimation of early recruitment deviations with estimation solely from 1974-2021 when length compositions and indices were available. Other technical questions centered around refinements to selectivity, in particular the declining slope parameter for the West purse seine fleet, where initial model runs were showing a clear misfit in the length compositions.

The Group questioned whether the Stock Synthesis model was more appropriate for feeding into the tropical tunas multi-stock MSE as opposed to providing management advice. The technical team responded that the model was thoroughly vetted and carefully developed considering the recommendations from the data preparatory meeting. The Group supported this observation by highlighting the major improvements over the 2019 Stock Synthesis model regarding improved diagnostic performance and better methodology for addressing uncertainty.

Much of the Group discussions focused on the application of the Monte Carlo analysis for the 2024 yellowfin tuna assessment. Given the nature of the uncertainty being considered in the assessment (e.g., natural mortality and steepness) it was noted that the Monte Carlo approach is an improvement over a structural uncertainty grid.

This additional analysis was considered a very useful addition to the process and the Group decided to prioritize the Monte Carlo analysis for estimating stock status and projected stock. In the case of the 2024 yellowfin tuna assessment, the Monte Carlo approach better encompasses uncertainty in key fixed parameters (namely natural mortality and steepness), and was considered an improvement over the 2019 assessment uncertainty grid. The Group recognized that this approach requires an established process, specifically decisions regarding which parameters to focus on and how to specify informative priors. The parameters chosen for yellowfin were M and h, which are often correlated. As a result, runs from the Monte Carlo analysis will require screening for inclusion in the final results (e.g., excluding models with poor convergence criteria and retaining only those with biologically plausible time series estimates). The Group noted that in cases where the uncertainty includes changes to the data and or data weighting (removals, indices, etc.) the uncertainty grid approach may better capture structural uncertainty.

The Group expressed interest in comparing the results of both the Monte Carlo analysis and the uncertainty grid approach but recognized this was a longer-term scientific exploration. Additional efforts are needed to set appropriate upper and lower limits for M for the uncertainty grid, especially in light of the independent M estimates discussed (SCRS/2024/121). Applying the Hamel and Cope (2022) approach for estimating M for use in an uncertainty grid could also help specify an appropriate distribution for M.

While discussing the grid approach, the Group considered the importance of weighting model runs and recommended further exploring this as a research recommendation for the Group and the SCRS.

5.2 Surplus production models

5.2.1 mpb

Noting the problems with the diagnostics, the Group decided not to include the results of the *mpb* model for developing the management advice.

5.2.2 JABBA

The trajectories of B/B_{MSY} in scenarios S05 and S06 showed continuous decreasing trends (**Figure 43**). F/F_{MSY} trajectories showed an increasing trend from the beginning of the time series, with some decreases around the late 2000s.

In the JABBA preliminary reference case S06, fishing mortality has been mostly below F_{MSY} and biomass has been above B_{MSY} during the stock assessment period. At the beginning of 2022, the median of B/B_{MSY} was 1.036 with a 95% credibility interval between 0.597 and 1.898 (**Table 10**), and the median of F/F_{MSY} was 1.052 (95% credibility interval: 0.381-1.97). The continuity run scenario (S05) showed slightly more pessimistic results for the same estimated benchmarks, the median of B/B_{MSY} was 0.781 with a 95% credibility interval between 0.493 and 1.224 (**Table 10**), and the median of F/F_{MSY} was 1.539 (95% credibility interval: 0.82-2.491).

The Group noted that even with the structuring of the process error, the state-space surplus production model adjusted using JABBA could not directly respond to the upward trend observed in the joint longline abundance index. The authors explained that this was caused by the strong conflict observed between the two abundance indices (Join_LL_R02 and EUPSFS) used in scenarios S05 and S06, mainly at the end of the time series.

6. Stock status and projections

6.1 Synthesis of stock assessment results

The Group reviewed and discussed the results by three stock assessment platforms: Stock Synthesis, *mpb*, and JABBA for the Atlantic yellowfin stock in 2024.

Although the models fitted using *mpb* showed relatively acceptable residual distributions and retrospective patterns, a more detailed exploration of the likelihood patterns in relation to the minimization of the likelihood function showed that the r and K parameters converged to biologically implausible values. In addition, it was difficult for the model to capture the change in trends observed in the most recent period of the relative abundance joint index. For these reasons, the Group chose not to utilize the *mpb* framework for the management advice.

The Bayesian surplus production models (JABBA) showed full convergence of the models and acceptable diagnostics. It was noted that the preliminary JABBA reference case showed an opposite trend in index fits for the most recent 4 years given equal weighting on the indices. The authors could investigate more JABBA scenarios by upweighting the index deemed better informed and with greater spatial-temporal coverage (i.e. the Joint LL index) to improve model fit to the long-term spawner abundance index. However, the Group considered the Monte Carlo framework applied in the Stock Synthesis models allowed for a fuller exploration of parameter uncertainty, the Group decided to only use Stock Synthesis for the management advice of the 2024 yellowfin tuna stock assessment.

6.2 Methodology to incorporate stock assessment model uncertainty

The Group discussed alternative methodological approaches (see section 5.1) to incorporate uncertainty in the influential fixed parameters of M and steepness (*h*) from the Stock Synthesis reference case. The Monte Carlo approach considers uncertainty around the main fixed parameters within the reference case model, and the results obtained from the Monte Carlo approach are weighted based on the probability distributions of the resampling method. The grid approach accompanied by multi-variate log-normal approximation has been used in the 2019 yellowfin tuna stock assessment and several other ICCAT stock assessments, e.g. Atlantic bigeye tuna, and Atlantic blue marlin.

The Group concluded that the Monte Carlo approach better encompasses uncertainty in the most influential fixed parameters (namely natural mortality and steepness) for the 2024 yellowfin tuna stock assessment, and it was considered an improvement over the 2019 assessment uncertainty grid. The Group recommended adopting this method for estimating stock status and projected yields.

Alternative values of M were randomly drawn (7,200 iterations) from a lognormal distribution (log mean = 0.3, stdev = 0.31) and values of h were drawn from a uniform distribution between 0.7 and 0.9. The Group agreed to filter to 4000 combinations of M and h (**Figure 44**) from the total iterations by excluding biologically implausible assumptions and non-converged runs.

The results of the Monte Carlo analysis showed a very broad range of stock status outcomes, depending on the values of M and *h* (**Figure 44**). The Group discussed the need to more appropriately characterize the confidence intervals of the management references. To identify plausible parameter combinations, the Group evaluated the proportion of random draws at each combination of M and h that produced acceptable diagnostics (with a non-significant trend in recruitment deviations over the time series) (**Figure 45**). The best performing models were encompassed within a confidence interval narrower than 95%. Therefore, an 80% confidence interval was selected to define the uncertainty in stock status.

6.3 2024 YFT Stock Assessment results

The 2024 yellowfin tuna stock assessment results were provided based on the Stock Synthesis model applying a Monte Carlo approach for the basis of the management advice. The trend in the spawning stock biomass (SSB) relative to the level that would produce MSY (SSB_{MSY}) shows a general continuous decline over time (**Figure 46**). The results indicated that spawning stock biomass has remained above SSB_{MSY} over the entire time series. The SSB/SSB_{MSY} in the last few years showed a slightly increasing trend.

Estimates of fishing mortality relative to F_{MSY} increased steadily until the early 1980s, and it varied at around 0.8 (F/F_{MSY}) until the early 2010s (**Figure 46**). The fishing mortality since the mid-2010s increased to F_{MSY}, but dropped in the recent 2 years (2021 and 2022). The median estimate of SSB_{2022}/SSB_{MSY} was 1.37 (80% confidence interval: 0.91 - 2.15), indicating the stock was not overfished in 2022. The median estimate of F_{2022}/F_{MSY} was 0.89 (0.40 - 1.46), indicating that overfishing was not occurring in 2022. The median MSY estimated is 121,661 t with 80% confidence intervals of 107,485 and 188,456 t (**Table 12**). The probability of the stock being in each quadrant of the Kobe plot in 2022 is provided in **Figure 47**. The corresponding probabilities are 58% of the 4000 trials occurred in the green (not being overfished not subject to overfishing), 23% were in the orange (subject to overfishing but not being overfished), and 18% in the red (being overfished and subject to overfishing).

6.4 Projections

The Group requested to conduct stock projections by applying the Monte Carlo approach assuming constant catch (i.e. landings plus dead discards) scenarios for the basis of the proposal on management advice on Atlantic yellowfin tuna.

The Group agreed to the following specifications for the projections:

- 2023 and 2024 catches set equal to the average of the last 3 years (2020-2022) at 141,805 t.
- Projections with different constant catch (landings and dead discards) scenarios started in 2025 and were run for 10 years and end year 2034.

- 14 different constant catch (landing + dead discards) scenarios, 0 catch and from 100,000 to 160,000 t with an interval of 5,000 t.
- For the projected constant catch scenarios (2025-2034) the proportions of catch by fleet and season used the average percentages between 2020 and 2022 estimated by the model.
- Projected annual recruitment is estimated from the Stock Synthesis reference case stock-recruitment curve (with recruitment deviations equal to zero). The relative proportions of annual recruitment by season were obtained from the Synthesis reference case model (2020-2021) and held constant for the projection period.
- Fleet selectivities for the projection period were equivalent to the average of the terminal 3 years (2020-2022) from the Stock Synthesis reference case.

Because this Monte Carlo projection method is time-consuming, the Group reviewed the deterministic projection results from the reference case Stock Synthesis model during the meeting (**Figure 48**). These provisional projections indicated that a catch greater than 130,000 t would result in overfishing by the end of the year 2034. The Group agreed to finalize the stochastic projections intersessionally and the final projection results, including the Kobe 2 strategy matrix, will be submitted as an SCRS document to the 2024 September Species Groups meeting.

7. Tropical tunas MSE process

7.1 Western skipjack (SKJ-W) MSE

Document SCRS/2024/115 document presented an update on the development and status of the Western Atlantic Skipjack Management Strategy Evaluation (W-SKJ MSE) process including the revisions in the operating models, in terms of dealing with multiple relative abundance indices, and management procedures, like tunning process and rules to lead with symmetric and/or asymmetric variations on TAC inter management periods were present. Operating models are now using a combined relative abundance index. This index is created from the distinct indices available (BB Brazil, PS Venezuela, LL USA GOM) and the empirical index-based (free-model based). The indices are weighted based on the inverse variance of each index. It was informed also that all candidate management procedures (CMPs) include now a tuning parameter that could allow the maximization of the yields at a desired level (e.g. as defined in the operational management objectives). It has also implemented a symmetrical and/or asymmetrical decision rule for both classes of MPs. The Group agreed and welcomed the advances presented in the W-SKJ MSE process.

Document SCRS/2024/122 described the Brazilian baitboat standardized index update and review. The authors highlighted that this index is associated with a major harvesting fleet that accounts for a high proportion of western skipjack landings and covers a relatively long period. Catch and effort data from the Brazilian baitboat fishery in the southwestern Atlantic Ocean, from 2000 to 2023, were included in this updated index. The standardization used a similar model structure as the last standardization work, a Bayesian Spatial-Temporal Hierarchical model using Integrated Nested Laplace Approximations with a Lognormal distribution. The estimated model showed an interesting poleward movements of the abundance of the stock over time. No change in the historical index trend was observed, and the updated recent years shown an increased trend in the relative abundance of western skipjack.

Once again, the Group highlighted the importance of the spatio-temporal model applications that make it possible to understand the movements of the stocks studied. This structuring makes it possible to understand possible responses to changes in the habitats of these species linked to the influences of climate change.

Document SCRS/2024/117 presented an update on the standardized index of relative abundance for skipjack tuna estimated from logbook data (1987-2023) using a delta lognormal generalized linear model (GLM) approach. Factors considered for the analysis were year, season, area, association with whales, association with whale sharks, seiner capacity, and help by baitboat. Diagnostic plots showed no significant departure from expected distributions. The standardized skipjack tuna catch rate index shows a declining trend since 2015, with a sharp drop for the last two years of the series (2022 and 2023).

This last point was of concern for the Group as it would indicate a substantial reduction in the stock size in a short period. It was noted that such a drop is not reflected in the other indices. The Group also pointed out that the estimated CVs are particularly high for those two years and considered the possibility of excluding those years or the complete index. For this reason, the Group requested the authors to present additional maps and plots during the meeting to check whether the drop in the last two years could be caused by a reduction in the coverage of the sampling area or a decrease of operations of the Venezuelan purse seiners in the area.

The new figures requested by the Group were presented by the authors and discussed during the meeting. **Figures 49** and **50** showed that in general, purse seine fleet spatial coverage of fishing sets in the Caribbean for the last 10 years has not changed considerably. There was a decrease in the total number of sets per year after 2017, and the spatial coverage of the fleet has been reduced only when compared with its fishing activities from 20 years ago. However, this does not explain the sharp decrease in the CPUE standardized index in the last 2 years (2022 and 2023). Also, skipjack total annual catches remained relatively stable during the period 2018-2023, as well as the number of total fishing sets. Furthermore, the coverage of the sampling area does not appear to be particularly different for 2022 and 2023. These matters require more detailed research about the factors influencing fleet dynamics. Considering this new information, the Group recommended that this issue be explored further in the future, particularly to include a deeper more comprehensive analysis of the Venezuelan purse seine fleet, to explore possible changes in fishing power. The Group did not find evidence to exclude the last two years of the standardized index from the Venezuela purse seine fleet.

Presentation SCRS/P/2024/095 provided a strict update of the US pelagic longline index, including three additional years of data (2021-2023) for western skipjack. The frequency of occurrence in recent years was close to 10% of observed sets, similar to the long-term average. No change in the historical index trend was observed with the updated data, and the most recent years indicated an increase in skipjack relative abundance since the last update.

7.2 Tropical tunas multi-stock MSE

The Group agreed to follow the empirical approach proposed in Document SCRS/2024/118 to characterize the impacts of climate change with both a linear change to growth and recruitment and changes in the form of regime shifts. In this regard, the development of sudden changes that are generally evaluated in robustness tests may not be appropriate for tunas, as these may be less affected by sudden changes in the environment, compared for example with the small pelagic stocks in the Pacific Ocean in the years when the El Niño-Southern Oscillation (ENSO) produces drastic changes in the environment. However, there are studies (e.g. Báez *et al.*, 2011) that predict that tunas may be also affected by short-term environmental events like ENSO. The Group also noted the difficulties that the MP could have in reacting under a regime shift on recruitment due to the general lack of indices for young fish on most tuna stocks.

Document SCRS/P/2024/081 presented simulations that assumed that the total selectivity of the stocks does not vary when the fishing efforts of the different gears are modulated under the alternative harvest control rules. It was emphasized that the CMPs tested so far would provide catch limits for the three tropical tuna stocks assuming that catch proportions between fleets are held constant, but the model allows changes in catch proportions to be explored. However, the Group noted the potential to investigate different management options for mixed fisheries under different conditions, for example, changes in selectivity as well as to evaluate the estimated impact of hypothetical changes in fishing effort between free school and fish aggregating device (FAD)/FOB fishing mode within the PS fleets. It is acknowledged that the current MSE is not evaluating the feasibility and/or social-economic impacts of such changes to fishing effort.
The Group noted that the Commission has reiteratively requested scientific advice to reduce the fishing pressure on bigeye and yellowfin juveniles. The Group still needs to decide how to use this MSE (or other tools) to respond to these requests, and this requires a dialogue with the Commission to define management objectives.

7.3 Update MSE Roadmap

The Group reviewed and updated the roadmap of the two tropical tunas MSEs in light of the advances and new information presented at the meeting. In general, the updates rearrange existing tasks within a time frame that aligns better with the results recently presented and the remaining tasks (**Appendix 5**).

8. Workplan to prepare the Responses to the Commission

During the 2024 Yellowfin Tuna Data Preparatory Meeting (ICCAT, 2024), the Group reviewed the spreadsheet of Active Responses maintained by the Secretariat and considered the comprehensive list of questions from Panel 1 listed in Appendix 4 of the Report of the Third Intersessional Meeting of Panel 1 in 2023. At that Yellowfin Tuna Data Preparatory Meeting (ICCAT, 2024), the Group developed an intersessional workplan for 2024 to address the three pending requests for responses to the Commission contained in active ICCAT Recommendations, as well as actions to take with respect to the questions from Panel 1. The following subsections reflect the progress accomplished at the Yellowfin Tuna Stock Assessment Meeting and any updates to this 2024 intersessional workplan.

8.1 SKJ-W MSE (Res. 22-02, paragraph 4)

As part of the process for the development and adoption of a Management Procedure for SKJ-W, the SCRS should provide input to the Commission as referenced in the *Resolution by ICCAT on development of initial conceptual management objectives for western Atlantic skipjack* (Res. 22-02), para 4: "…Panel 1 will provide its recommendations for final management objectives for western Atlantic skipjack tuna, considering the SCRS input, to the Commission for consideration as part of the selection of a management procedure at its 2023 Annual Meeting or as soon as possible thereafter…".

As described in section 7.1 of this report, the Group reviewed the progress to date of the SKJ-W MSE and the plan for the completion of this work. The Group will prepare a response describing the progress of the SKJ-W MSE before the 2024 SCRS Plenary meeting. The workplan for the SKJ-W MSE has the objective of providing suitable CMPs to the Commission in 2024.

8.2 An update of the MSE Roadmap (Rec. 22-01, paragraph 62)

The Commission has requested, in the *Recommendation by ICCAT replacing Recommendation 21-01 on a multi-annual conservation and management programme for tropical tunas* (Rec. 22-01), para 62, that "…The SCRS shall refine the MSE process in line with the SCRS roadmap and continue testing the candidate management procedures…".

As described in section 7.3 of this report, the Group updated the MSE Roadmap. Updates to the MSE roadmap will be finalized at the September 2024 Tropical Tunas Species Group meeting and SCRS Plenary taking into consideration all ICCAT MSE processes.

8.3 Regarding advice on the maximum number of FAD sets (Rec. 22-01, paragraph 31)

The Commission has requested, in Rec. 22-01 para 31, that: "…With a view to establishing FAD set limits to keep the catches of juvenile tropical tunas at sustainable levels, in (2023) SCRS should inform the Commission about the maximum number of FAD sets which should be established per vessel or per CPC…".

The Group discussed alternative options to respond to the Commission request, concluding that one alternative would be addressed through analyses requiring high resolution fisheries statistics from each purse seine vessel fishing operation, with the estimates of catch composition, size distribution, and total catch, as well as the associated factors that may potentially affect catch rates (such as fishing mode, time, area, buoy type, associated biomass from echosounder signals, and or oceanographic variables). This information would permit estimating the average catch rate of an FAD set with confidence bounds and the associated factors that may explain the variability observed. These analyses would potentially allow to estimate the catch capacity per vessel type on a FAD/FOB for a given spatial-temporal structure model and optimize for example a given total catch, or the number of sets to reach a given catch, etc. It would also provide information on the relative fishing capacity of a given vessel/FAD to a selected "reference FAD fishing operation" and follow up on potential changes in fleet structure or FAD/FOB structures through a given period of time.

It would be important to ensure that each fishing operation is well monitored so that, to the extent feasible, estimates of catch composition, size distribution, and total catch reflect a single set and records whether the set is on a monitored FAD (i.e. active buoy), FAD/FOB random encounter, or other vessel associated operation.

The data that are available at the ICCAT Secretariat and provided by the CPCs is at best in 1x1 Lat-Lon spatial resolution and by month, and thus generally represent aggregated information from more than one FAD/FOBs fishing set operation. Also, the Catch and Effort (task 2CE) usually do not cover the total catch (Task 1 NC), and the size distribution of the catch (Task 2SZ, 2CAS) is not associated with a particular set. Therefore, with the data available in the Secretariat databases, it is not feasible to achieve these analyses.

Other options were discussed by the Group, which might still provide useful advice on this topic to the Commission. Such options included requesting CPC scientists to collect high-resolution data on the FAD/FOB operations of their CPC's PS fleet and carry out a similar analysis as described above. Another suggestion was that, if the required information is available in the Secretariat databases, the average catch per FAD/FOB set (without accounting for the various factors that might influence the catch rate) could be calculated from a subset of data, where FAD/FOB catches could be associated with a specific number of FAD/FOB sets.

The Group agreed to consider these alternatives and to develop a draft response in advance of the September 2024 Tropical Tunas Species Group meeting.

8.4 Panel 1 questions

With regard to the extensive list of questions from Panel 1 in Appendix 4 of the Report of the Third Intersessional Meeting of Panel 1 in 2023, the Group noted the number and complexity of the questions, as well as the fact that some questions may require further clarification from Panel 1. The SCRS Chair commented that, although there is a general intent to improve communication and collaboration between the SCRS and Commission, including being responsive to questions raised at intersessional meetings of ICCAT Panels when possible, the process by which these questions were developed (through correspondence over an extended period following the conclusion of the Panel 1 meeting) proved problematic. It may be advisable that future questions for the SCRS be raised and agreed to during the meetings of the Commission or its subsidiary bodies.

The Group noted that the Panel 1 questions could be roughly divided into three general categories: 1) questions related to numbers/limits of FADs or FAD/FOB sets (see section 8.3 above for the plan to address that topic); 2) proportion of juveniles in the catch and the impact of the FAD set moratorium; and 3) implications of changing overall selectivity (e.g. shifting catch proportions between fleets). The Group agreed that the best way to address these questions would be through the application of stock assessment models. In this way, the population numbers and stock dynamics could be considered.

The analyses to be carried out would include:

- Calculating relative fishing mortality by fleet/ fishing mode for all gears using Stock Synthesis model results.
- Describing the structure of the catch in age/size from the Stock Synthesis results.
- Comparing the results above with an analysis of the CAS.
- Examining the relative impact on the potential reproductive capacity of the stock (i.e. potential spawning stock biomass from each major gear).

The Group agreed to carry out these analyses for yellowfin tuna, using results of the stock assessment, during 2024 in advance of the September 2024 Tropical Tunas Species Group meeting. For bigeye tuna, these analyses would be carried out in 2025, following the planned BET stock assessment. To facilitate the 2025 analyses, the submission of CAS for bigeye, yellowfin and skipjack before the bigeye tuna data preparatory meeting will be noted in the 2025 Tropical Tunas Workplan and requested in the 2025 Statistical Call for fisheries data.

The Group agreed to form an Ad Hoc Sub-group (hereafter referred to as the Tropical Tunas Sub-group on Responses) to draft responses to the Commission. This Sub-group, open to all interested SCRS Scientists (as well as observers, as approved by the Yellowfin Tuna Rapporteur and supported by the SCRS Chair), would work intersessionally through correspondence or online meetings as appropriate. During this meeting, 19 meeting attendees agreed to participate in this Tropical Tunas Responses Sub-group.

9. Recommendations

9.1 Research and statistics

The Group recommended that resources be identified to develop a more systematic and reproducible approach for the estimation of catch-at-size (CAS), and noting the limitations of the current approach, also recommended that alternative methodologies be considered to address Commission requests that may currently require a CAS matrix.

The Group noted that available size frequency data are not fully representative of the dynamics of the ICCAT fleets and fisheries and that this could bias the results of the stock assessment models used to develop management advice. The Group recommended the development of a standard methodology to statistically reweight raw size frequency data to ensure they are as representative of fleet/fishery operations as possible. For this purpose, a dedicated SCRS workshop would be helpful.

The Group recommended that national scientists associated with the main tropical tunas purse seine fisheries address the research proposals proposed for responding to the Commission request on the maximum number of FAD sets or FAD deployments, providing SCRS documents for reviewing by the Tropical Tunas Species Group.

9.2 Management advice (YFT Executive Summary)

The Group recommended continued research into the approaches used in constant catch scenarios in projections, in particular: 1) time periods for stock projections that balance management needs, the biology of the species, and current stock status (including age structure of the population); 2) how to conduct projections when recent recruitment conditions are considered to be significantly different from an average or equilibrium conditions; and 3) screening criteria for the exclusion of runs under either the multivariate-lognormal (MVLN) or Monte Carlo simulations approaches.

The Group strongly supported efforts to identify and better incorporate the impacts of climate change on fish populations, and the continued evaluation of the robustness of management advice to the effects of climate change.

The Group continued to support and recommended capacity building initiatives to increase the number of scientists and managers who are able to participate and contribute to the development and implementation of Management Strategy Evaluations.

The Group recommended continued efforts to solicit specific input from the Commission on management objectives for the multi-stock MSE, including probabilities and timelines.
The Group noted that many Commission requests (e.g. impacts of past/potential regulatory actions) are most appropriately considered in a multi-stock context. Therefore, the Group strongly supported the continued development of the tropical tunas multi-stock MSE framework, and the communication of the capabilities of that framework to address important management questions.

10. Tropical Tuna Research and Data Collection Program (TTRaD)

10.1 Tropical Tuna Research and Data Collection Program update

Presentation SCRS/P/2024/094 provided an update on the workplan for the review of the Tropical Tuna Research and Data Collection Program (TTRaD). The plan is to pursue a comprehensive multi-year research programme. The Group agreed to continue to develop this plan in 2024 according to the following steps: 1) continuing to populate the template with the Group and species leads; 2) adding detail about what the work will entail including the outputs in the short, medium and long-term; 3) factoring in outputs and work plans for other relevant projects; 4) developing relevant ToRs for 2025 work; and 5) finalizing the plan at the Tropical Tunas Species Group meeting in September 2024. A request was made to the Group for any new contributors to contact the Tropical Tunas Species Group Coordinator to help with intersessional developments of the plan.

Linked to discussions about tropical tunas research activities under the ICCAT TTRaD and other relevant programmes, a presentation was provided to the Group from the ITUNNES project (Improving tropical TuNa biological knowledge for eNd-usErS). Some of the research objectives of the ITUNNES project are closely related to the ICCAT identified research needs for Atlantic tropical tunas and the Group highlighted the potential for coordination of respective research needs and sampling programmes. The Group noted the potential scientific benefits for both programmes with the active participation and collaboration of ICCAT CPCs that are not currently part of the ITUNNES consortium, in particular for sampling and observations from the western Atlantic region. It was highlighted especially the research activities on tropical tuna age and growth of tropical tunas, noting that there are ongoing research projects in the ICCAT TTRaD and the need to avoid potential duplication of efforts/funding in both programmes.

10.2 Ongoing activities and future planning

An update was provided to the Group on ongoing tropical tunas data collection and routine ageing of samples by the Oceanographic Research Center of Dakar-Thiaroye (CRODT). Since 2019, hard part processing and reading has been undertaken by CRODT, including samples from fish marked with oxytetracycline (OTC). Recent processing of historical and new tropical tuna samples (including yellowfin and bigeye tuna < 40 cm SFL) has meant that over 135 hard parts have been processed by CRODT to date. Preliminary results were highlighted. The research team involved in this work agreed to provide an update to the Tropical Tunas Species Group at the September 2024 meeting.

The Group noted that there are a number of outstanding Terms of Reference (ToRs) which need drafting and circulating in the coming weeks, including the extension of age and growth sampling, and the coordination of an MSE workshop for managers and scientists. The Group provided feedback on the ToRs, with revisions made to the age and growth ToRs to reflect a focus on bigeye tuna data collection and analyses ahead of the bigeye tuna stock assessment proposed for 2025. The ToRs for the MSE workshop(s) were discussed, with updates requested to ensure that the next MSE workshop focuses on a more applied approach to training with practical tropical tunas MSE examples rather than theory. The tropical tuna officers agreed to update and draft the ToRs in line with the advice provided by the Group.

With regard to the 2025 ToRs to be presented at the September 2024 Species Group meeting, the Group reflected on the funding approved by the Commission in 2023 for 2024/2025 ICCAT Research Activities (Appendix 2 to Annex 7 to the *Report for Biennial Period, 2022-23 Part II (2023), Vol. 1*). The Group recommended further discussions about the funding constraints applied to species group data collection and research programmes and requested the Commission consider further flexibility to maximize utilization of funds for the multi-year research programmes required to address priorities for highly migratory species, including tropical tunas.

The Group maintains the recommendation from 2023 for the Ghana capacity building on fisheries statistics. The Secretariat noted that for this request that has financial implications, there have been identified additional funding sources that can support the proposal. Initial contacts with the Institut de Recherche pour le Développement (IRD) (the French National Research Institute for Sustainable Development) and Ghana scientists are ongoing for this workshop to take place by the end of 2024.

11. Other matters

There were no other matters discussed during the meeting.

12. Adoption of the report and closure

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

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Table 1. YFT Task 1 nominal catch (T1NC, t) by region, major gear, flag and year, as of June 30, 2024. Note that 2023 data are preliminary.

			1950
TOTAL			1190
Landings		Baitboat	1176
		Longline	0
		Other surf.	14
		Purse seine	0
Landings(FP)		Baitboat	0
		Purse seine	0
Discards		Baitboat	0
		Longline	0
		Other surf.	0
		Purse seine	0
Landings	CP	Angola	1190
		Barbados	0
		Belize	0
		Brazil	0
		Canada	0
		Cape Verde	0
		China PR	0
		Curaçao	0
		Côte d'Ivoire	0
		EU-Denmark	0
		EU-España	0
		EU-Estonia	0
		EU-France	0
		EU-Ireland	0
		EU-Italy	0
		EU-Latvia	0
		EU-Lithuania	0
		EU-Malta	0
		EU-Netherlands	0
		EU-Poland	0
		EU-Portugal	0
		El Salvador	0
		FR-St Pierre et Miquelon	0
		Gabon	0
		Gambia	0
		Ghana	0
		Great Britain	0
		Grenada	0
		Guatemala	0
		Guinea Ecuatorial	0
		Guinée Rep	0
		Honduras	0
		Japan	0
		Korea Rep	0
		Liberia	0
		Libya	0
		Maroc	0
		Mauritania	0
		Mexico	0
		Namibia	0
		Nigeria	0
		Norway	0
		Panama	0
		Philippines	0
		Russian Federation	0
		S Tomé e Príncipe	0
		Senegal	0
		South Africa	0
		St Vincent and Grenadines	0
		Trinidad and Tobago	0
		UK-Bermuda	0
		UK-British Virgin Islands	0
		UK-Sta Helena	0
		UK-Turks and Caicos	0
		USA	0
		USSR	0
		Uruguay	0
		Venezuela	0
	NCC	Chinese Taipei	0
		Costa Rica	0
		Guyana	0
	NCO	Argentina	0
		Benin	0
		Cambodia	0
		Cayman Islands	0
		Colombia	0
		Congo	0
		Cuba	0
		Dominica	0
		Dominican Republic	0
		Faroe Islands	0
		Georgia	0
		Jamaica	0
		NEI (ETRO)	0
		NEI (Flag related)	0
		Saint Kitts and Nevis	0
		Seychelles	0
		St Lucia	0
		Ukraine	0
		Vanuatu	0
Landings(FP)	CP	Belize	0
		Cape Verde	0
		Curaçao	0
		Côte d'Ivoire	0
		EU-España	0
		EU-France	0
		El Salvador	0
		Guatemala	0
		Guinée Rep	0
		Panama	0
		St Vincent and Grenadines	0
	NCO	Mixed flags (EU tropical)	0
Discards	CP	Canada	0
		EU-France	0
		EU-Portugal	0
		Japan	0
		Korea Rep	0
		Mexico	0
		South Africa	0
		UK-Bermuda	0
		UK-British Virgin Islands	0
		UK-Sta Helena	0
		USA	0
	NCC	Chinese Taipei	0

Table 1. Continued.

		1985–2023
TOTAL		[illegible]
Landings	Bait boat	[illegible]
	Longline	[illegible]
	Other surf	[illegible]
	Purse seine	[illegible]
Landings(FP)	Bait boat	[illegible]
	Purse seine	[illegible]
Discards	Bait boat	[illegible]
	Longline	[illegible]
	Other surf	[illegible]
	Purse seine	[illegible]
Landings CP	Angola	[illegible]
	Barbados	[illegible]
	Belize	[illegible]
	Brazil	[illegible]
	Canada	[illegible]
	Cape Verde	[illegible]
	China PR	[illegible]
	Curaçao	[illegible]
[illegible]	[illegible]	[illegible]

Table 2. Definition of fleet structure for Stock Synthesis (SCRS/2024/110). Purse seine (PS), baitboat (BB), longline (LL), rod and reel (RR), and handline (HL).

N	*Name*	*Years*	*Selectivity*
1	PS early	1965-1985	cubic spline
2	PS transition	1986-1990	cubic spline
3	PS Free School	1991-2022	cubic spline
4	PS FOB	1991-2022	cubic spline, time-varying
5	BB+PS Ghana	1965-2022	cubic spline, time-varying
6	BB-South Dakar	1950-2022	double-normal
7	BB-North Dakar early	1962-1980	double-normal
8	BB-North Dakar late	1981-2022	double-normal
9	BB_North_Azores	1962-2022	mirrored to fleet 8
10	LL North Japan	1957-2022	double-normal
11	LL Tropical Japan	1956-2022	logistic, time-varying
12	LL South Japan	1959-2022	double-normal
13	LL North Other	1959-2022	double-normal
14	LL Tropical Other	1957-2022	logistic, time-varying
15	LL South other	1962-2022	double-normal
16	HL Brazil	1985-2022	mirrored to fleet 8
17	RR West Atlantic	1979-2022	double-normal
18	PS West Atlantic	1979-2022	double-normal
19	Other	1950-2022	double-normal

Table 3. Available indices of Atlantic yellowfin tuna relative abundance from the Joint CPUE longline (SCRS/2024/036). Joint CPUE longline CV = 0.2 (all years). The Stock Synthesis reference model used only Region 2.

series	Joint LL Region1	Joint LL Region2	Joint LL Region3
units	Number	Number	Number
reference	SCRS/2024/036	SCRS/2024/036	SCRS/2024/036
Year	**CPUE**	**CPUE**	**CPUE**
1979	1.44	1.35	0.93
1980	0.59	1.46	0.55
1981	0.64	1.25	0.57
1982	0.83	1.38	0.71
1983	0.66	1.19	0.49
1984	1.08	1.46	0.89
1985	0.8	1.26	0.74
1986	0.9	1.45	0.84
1987	0.82	1.72	0.82
1988	1.44	1.62	1.44
1989	0.95	1.43	0.91
1990	0.89	1.45	0.87
1991	1.16	1.18	1.1
1992	0.96	0.92	0.95
1993	0.82	1.11	0.86
1994	0.9	1.17	0.96
1995	1.21	1.22	1.16
1996	1.11	1.05	1.1
1997	0.74	0.84	0.81
1998	1.2	0.9	1.07
1999	0.96	0.99	0.91
2000	1	0.91	1.08
2001	1.02	0.81	1.01
2002	1.19	0.76	1.19
2003	1.1	0.83	1.34
2004	1.09	0.9	1.16
2005	1.25	0.86	1.23
2006	1.05	0.97	1.21
2007	0.96	0.95	1.4
2008	0.79	0.74	0.8
2009	0.82	0.75	0.87
2010	0.83	0.64	0.73
2011	0.99	0.68	0.99
2012	1.21	0.65	1.35
2013	1.21	0.73	1.22
2014	0.87	0.66	0.88
2015	0.99	0.71	0.96
2016	0.95	0.64	1.17
2017	1.02	0.68	0.84
2018	1.11	0.65	0.92
2019	1.19	0.68	1.49
2020	1.09	0.75	1.23
2021	1.04	0.81	1.06
2022	1.09	0.85	1.54

Table 4. Indices of Atlantic yellowfin tuna relative biomass from the purse seine (PS) free school, and acoustic echosounder buoys. CV columns represent the estimated reweighted CV as indicated in section 3.1 of this report.

EU_PS_FreeSchool												Acoustic Buoy Index							
Year	Qtr	CPUE	CV	Year	Qtr	CPUE	CV	Year	Qtr	CPUE	CV	Year	Qtr	CPUE	CV	Year	Qtr	CPUE	CV
1993	1	2.09	0.3	2003	1	1.67	0.1	2013	1	1.04	0.2	2010	1	1.43	0.2	2020	1	0.88	0.2
1993	2	1.93	0.2	2003	2	1.21	0.2	2013	2	0.62	0.2	2010	2	1.41	0.2	2020	2	1.17	0.2
1993	3	1.11	0.2	2003	3	1.12	0.2	2013	3	0.59	0.2	2010	3	1.28	0.2	2020	3	0.94	0.2
1993	4	0.47	0.2	2003	4	0.55	0.2	2013	4	0.44	0.2	2010	4	1.71	0.2	2020	4	0.94	0.2
1994	1	1.77	0.3	2004	1	1.57	0.3	2014	1	1.24	0.2	2011	1	1.31	0.2	2021	1	1.23	0.2
1994	2	1.27	0.2	2004	2	1.39	0.1	2014	2	0.6	0.2	2011	2	1.29	0.2	2021	2	1.05	0.2
1994	3	1.04	0.2	2004	3	0.92	0.2	2014	3	0.74	0.2	2011	3	0.85	0.2	2021	3	1.48	0.2
1994	4	0.33	0.3	2004	4	0.55	0.2	2014	4	0.47	0.2	2011	4	0.8	0.2	2021	4	1	0.2
1995	1	1.72	0.2	2005	1	1.59	0.2	2015	1	1.41	0.1	2012	1	0.58	0.2	2022	1	1.06	0.2
1995	2	0.95	0.2	2005	2	1.59	0.1	2015	2	0.72	0.2	2012	2	1.01	0.2	2022	2	1.52	0.2
1995	3	1	0.2	2005	3	0.77	0.2	2015	3	0.89	0.2	2012	3	0.8	0.2	2022	3	2.57	0.2
1995	4	0.3	0.3	2005	4	0.6	0.3	2015	4	0.5	0.2	2012	4	0.58	0.2	2022	4	1.17	0.2
1996	1	1.98	0.4	2006	1	1.72	0.1	2016	1	1.29	0.5	2013	1	0.58	0.2				
1996	2	0.89	0.2	2006	2	1.64	0.2	2016	2	0.87	0.2	2013	2	0.72	0.2				
1996	3	0.99	0.2	2006	3	0.89	0.2	2016	3	0.94	0.2	2013	3	0.69	0.2				
1996	4	0.28	0.3	2006	4	0.77	0.2	2016	4	0.54	0.2	2013	4	1	0.2				
1997	1	2.51	0.2	2007	1	1.93	0.1	2017	1	1.11	0.2	2014	1	0.68	0.2				
1997	2	1	0.2	2007	2	1.54	0.2	2017	2	0.95	0.2	2014	2	0.75	0.2				
1997	3	0.95	0.2	2007	3	1.16	0.2	2017	3	0.72	0.2	2014	3	1.01	0.2				
1997	4	0.3	0.3	2007	4	0.89	0.2	2017	4	0.5	0.2	2014	4	0.94	0.2				
1998	1	2.98	0.2	2008	1	2.19	0.1	2018	1	1.07	0.2	2015	1	0.74	0.2				
1998	2	1.17	0.2	2008	2	1.42	0.2	2018	2	1	0.2	2015	2	0.72	0.2				
1998	3	0.87	0.2	2008	3	1.19	0.2	2018	3	0.42	0.3	2015	3	0.88	0.2				
1998	4	0.33	0.2	2008	4	0.82	0.2	2018	4	0.39	0.2	2015	4	0.8	0.1				
1999	1	2.75	0.2	2009	1	2.28	0.3	2019	1	1.16	0.2	2016	1	0.58	0.2				
1999	2	1.21	0.2	2009	2	1.29	0.2	2019	2	1.04	0.2	2016	2	0.74	0.2				
1999	3	0.7	0.2	2009	3	0.94	0.2	2019	3	0.27	0.3	2016	3	0.97	0.2				
1999	4	0.37	0.2	2009	4	0.62	0.2	2019	4	0.3	0.2	2016	4	0.77	0.2				
2000	1	2.24	0.1	2010	1	1.89	0.2	2020	1	1.17	0.3	2017	1	0.55	0.2				
2000	2	1.19	0.2	2010	2	1.12	0.2	2020	2	0.85	0.2	2017	2	0.71	0.2				
2000	3	0.64	0.3	2010	3	0.65	0.2	2020	3	0.25	0.3	2017	3	1.01	0.2				
2000	4	0.37	0.2	2010	4	0.5	0.2	2020	4	0.27	0.2	2017	4	0.98	0.2				
2001	1	1.91	0.2	2011	1	1.32	0.2	2021	1	1.04	0.2	2018	1	0.78	0.2				
2001	2	1.14	0.2	2011	2	0.92	0.2	2021	2	0.6	0.2	2018	2	1.12	0.2				
2001	3	0.75	0.2	2011	3	0.5	0.2	2021	3	0.33	0.2	2018	3	1.23	0.2				
2001	4	0.42	0.2	2011	4	0.45	0.2	2021	4	0.27	0.2	2018	4	1.03	0.2				
2002	1	1.76	0.2	2012	1	1.04	0.2	2022	1	0.84	0.2	2019	1	0.97	0.2				
2002	2	1.12	0.2	2012	2	0.74	0.2	2022	2	0.49	0.2	2019	2	0.94	0.2				
2002	3	1.02	0.2	2012	3	0.49	0.2	2022	3	0.55	0.2	2019	3	1.08	0.2				
2002	4	0.5	0.2	2012	4	0.44	0.2	2022	4	0.3	0.2	2019	4	0.98	0.2				

Table 5. Parameters of the yellowfin tuna Richards growth model as estimated by the Stock Synthesis reference model.

Parameter	Value	Parameter	Value
L_at_Age min	45.506	Richards	-0.172
L_at_Age max	153.019	CV_young fish	0.122
K	0.643	CV_old fish	0.074

Table 6. Proposed uncertainty grid (SCRS/2024/111) alternative assumptions of natural mortality (M) and steepness (h). Bolded values correspond to the Stock Synthesis reference case.

Parameter	Value 1	Value 2	Value 3
M	0.25	**0.3**	0.35
h	0.7	**0.8**	0.9

Table 7. Starting values and fixed parameters used for the *mpb* stock assessment of Atlantic yellowfin tuna.

Parameter	Starting value and range
r (intrinsic growth rate, yr^{-1})	0.16 [0.1, 0.5]
K (carrying capacity, tons)	2.155×10^6 [2.155×10^5, 2.155×10^7]
B_0 (biomass in 1950, tons)	1 [fixed]
Shape parameter (*phi*)	0.001 [fixed]

Table 8. Stock Synthesis reference case parameter estimates, standard deviation, and prior types where necessary.

Parameter	Estimate	Parm_StDev	Pr_type
L_at_Amin_Fem_GP_1	45.5056	7.91E-01	No_prior
L_at_Amax_Fem_GP_1	153.019	9.97E-01	No_prior
VonBert_K_Fem_GP_1	0.64325	5.88E-02	No_prior
Richards_Fem_GP_1	-0.171626	2.64E-01	No_prior
CV_young_Fem_GP_1	0.12213	8.25E-03	No_prior
CV_old_Fem_GP_1	0.0742397	3.04E-03	No_prior
RecrDist_GP_1_area_1_month_4	0.232069	1.42E-01	No_prior
RecrDist_GP_1_area_1_month_7	0.410536	1.11E-01	No_prior
RecrDist_GP_1_area_1_month_10	-0.077513	1.93E-01	No_prior
SR_LN(R0)	11.0391	8.01E-02	No_prior
SR_sigmaR	0.259195	4.03E-02	No_prior
SizeSpline_GradLo_1_PS_ESFR_6585(1)	0.472372	4.70E-02	Normal
SizeSpline_GradHi_1_PS_ESFR_6585(1)	0.0324919	2.75E-02	No_prior
SizeSpline_Val_1_1_PS_ESFR_6585(1)	-6.43057	6.43E-01	Normal
SizeSpline_Val_2_1_PS_ESFR_6585(1)	-0.329257	1.39E+00	No_prior
SizeSpline_Val_3_1_PS_ESFR_6585(1)	-0.423899	1.38E+00	No_prior
SizeSpline_Val_4_1_PS_ESFR_6585(1)	-0.746456	1.34E+00	No_prior
SizeSpline_Val_5_1_PS_ESFR_6585(1)	-0.258433	1.31E+00	No_prior
SizeSpline_GradLo_2_PS_ESFR_8690(2)	0.979357	9.76E-02	Normal
SizeSpline_GradHi_2_PS_ESFR_8690(2)	0.0548566	3.39E-02	No_prior
SizeSpline_Val_1_2_PS_ESFR_8690(2)	-4.12552	4.13E-01	Normal
SizeSpline_Val_2_2_PS_ESFR_8690(2)	2.99565	1.50E+00	No_prior
SizeSpline_Val_3_2_PS_ESFR_8690(2)	2.82896	1.47E+00	No_prior
SizeSpline_Val_4_2_PS_ESFR_8690(2)	1.81557	1.43E+00	No_prior
SizeSpline_Val_5_2_PS_ESFR_8690(2)	3.81162	1.35E+00	No_prior
SizeSpline_GradLo_3_PS_ESFR_FS_9122(3)	0.677614	6.76E-02	Normal
SizeSpline_GradHi_3_PS_ESFR_FS_9122(3)	0.0722519	2.26E-02	No_prior
SizeSpline_Val_1_3_PS_ESFR_FS_9122(3)	-7.9354	7.93E-01	Normal
SizeSpline_Val_2_3_PS_ESFR_FS_9122(3)	-2.92088	1.22E+00	No_prior
SizeSpline_Val_3_3_PS_ESFR_FS_9122(3)	-3.14613	1.19E+00	No_prior
SizeSpline_Val_4_3_PS_ESFR_FS_9122(3)	-3.89433	1.17E+00	No_prior
SizeSpline_Val_5_3_PS_ESFR_FS_9122(3)	-1.40977	1.12E+00	No_prior
SizeSpline_GradLo_4_PS_ESFR_FOB_9122(4)	0.433234	3.56E-02	Normal
SizeSpline_GradHi_4_PS_ESFR_FOB_9122(4)	-0.139655	6.53E-02	No_prior
SizeSpline_Val_1_4_PS_ESFR_FOB_9122(4)	-5.10059	4.27E-01	Normal
SizeSpline_Val_2_4_PS_ESFR_FOB_9122(4)	0.543581	4.82E-01	No_prior
SizeSpline_Val_3_4_PS_ESFR_FOB_9122(4)	0.109072	4.72E-01	No_prior
SizeSpline_Val_4_4_PS_ESFR_FOB_9122(4)	-1.97987	5.70E-01	No_prior
SizeSpline_Val_5_4_PS_ESFR_FOB_9122(4)	-3.19052	7.06E-01	No_prior
SizeSpline_GradLo_5_BB_PS_Ghana_6522(5)	0.624252	4.90E-02	Normal
SizeSpline_GradHi_5_BB_PS_Ghana_6522(5)	0.0023039	5.97E-02	No_prior

Table 8. Continued.

Parameter	Estimate	Parm_StDev	Pr_type
SizeSpline_Val_1_5_BB_PS_Ghana_6522(5)	0.702263	7.02E-02	Normal
SizeSpline_Val_2_5_BB_PS_Ghana_6522(5)	7.56558	1.14E+00	No_prior
SizeSpline_Val_3_5_BB_PS_Ghana_6522(5)	7.33513	1.11E+00	No_prior
SizeSpline_Val_4_5_BB_PS_Ghana_6522(5)	1.92936	1.60E+00	No_prior
SizeSpline_Val_5_5_BB_PS_Ghana_6522(5)	1.2635	2.13E+00	No_prior
Size_DblN_peak_6_BB_area2_Sdak(6)	42.3668	1.80E+00	No_prior
Size_DblN_top_logit_6_BB_area2_Sdak(6)	-17.9589	1.80E+00	Normal
Size_DblN_ascend_se_6_BB_area2_Sdak(6)	3.12461	6.24E-01	No_prior
Size_DblN_descend_se_6_BB_area2_Sdak(6)	7.59863	1.56E-01	No_prior
Size_DblN_peak_7_BB_DAKAR_6280(7)	58.9449	1.78E+00	No_prior
Size_DblN_top_logit_7_BB_DAKAR_6280(7)	-17.3026	1.73E+00	Normal
Size_DblN_ascend_se_7_BB_DAKAR_6280(7)	4.46451	3.45E-01	No_prior
Size_DblN_descend_se_7_BB_DAKAR_6280(7)	7.34664	1.33E-01	No_prior
Size_DblN_peak_8_BB_DAKAR_8122(8)	48.5013	2.02E+00	No_prior
Size_DblN_top_logit_8_BB_DAKAR_8122(8)	-17.0568	1.71E+00	Normal
Size_DblN_ascend_se_8_BB_DAKAR_8122(8)	3.92768	4.35E-01	No_prior
Size_DblN_descend_se_8_BB_DAKAR_8122(8)	8.38034	1.23E-01	No_prior
Size_DblN_peak_10_Japan_LL_N(10)	118.267	2.82E+00	No_prior
Size_DblN_top_logit_10_Japan_LL_N(10)	-16.2792	1.63E+00	Normal
Size_DblN_ascend_se_10_Japan_LL_N(10)	6.28703	2.01E-01	No_prior
Size_DblN_descend_se_10_Japan_LL_N(10)	5.42449	4.90E-01	No_prior
Size_DblN_end_logit_10_Japan_LL_N(10)	-2.13552	4.76E-01	No_prior
Size_inflection_11_Japan_LL_TRO(11)	119.419	3.85E+00	No_prior
Size_95%width_11_Japan_LL_TRO(11)	30.5867	4.40E+00	No_prior
Size_DblN_peak_12_Japan_LL_S(12)	117.74	4.33E+00	No_prior
Size_DblN_top_logit_12_Japan_LL_S(12)	-16.0905	1.61E+00	Normal
Size_DblN_ascend_se_12_Japan_LL_S(12)	6.38164	2.92E-01	No_prior
Size_DblN_descend_se_12_Japan_LL_S(12)	5.54669	8.48E-01	No_prior
Size_DblN_end_logit_12_Japan_LL_S(12)	-1.70147	7.17E-01	No_prior
Size_DblN_peak_13_Other_LL_N(13)	127.18	1.59E+00	No_prior
Size_DblN_top_logit_13_Other_LL_N(13)	-16.9022	1.69E+00	Normal
Size_DblN_ascend_se_13_Other_LL_N(13)	6.89541	7.34E-02	No_prior
Size_DblN_descend_se_13_Other_LL_N(13)	5.46109	2.46E-01	No_prior
Size_DblN_end_logit_13_Other_LL_N(13)	-2.51009	3.87E-01	No_prior
Size_inflection_14_Other_LL_TRO(14)	84.369	2.28E+00	No_prior
Size_95%width_14_Other_LL_TRO(14)	12.9993	2.92E+00	No_prior
Size_DblN_peak_15_Other_LL_S(15)	123.799	4.86E+00	No_prior
Size_DblN_top_logit_15_Other_LL_S(15)	-16.4333	1.64E+00	Normal
Size_DblN_ascend_se_15_Other_LL_S(15)	6.95151	2.23E-01	No_prior
Size_DblN_descend_se_15_Other_LL_S(15)	5.64788	1.00E+00	No_prior
Size_DblN_end_logit_15_Other_LL_S(15)	-0.375587	5.65E-01	No_prior

Table 9. Estimated fishing mortality, recruitment, and spawning stock biomass (t) at the beginning of the year from the Stock Synthesis reference case.

	Reported Catch (t)	Fishing mortality		Recruitment (1000s fish)		Spawning Biomass (t)	
Year	Value	Value	Std Dev	Value	Std Dev	Value	Std Dev
1950	1200	0	0	62260	4985	2240000	170000
1951	1358	0	0	62260	4985	2240000	170000
1952	2787	0	0	62260	4985	2240000	170000
1953	3600	0	0	62259	4985	2240000	170000
1954	3407	0	0	62251	4985	2230000	170000
1955	4300	0	0	62241	4985	2230000	170000
1956	6597	0	0	62231	4985	2220000	170000
1957	23698	0.01	0.001	62218	4985	2210000	170000
1958	40581	0.01	0.001	62180	4985	2190000	170000
1959	57769	0.02	0.002	62116	4984	2160000	170000
1960	68493	0.03	0.002	62025	4984	2110000	170000
1961	58803	0.02	0.002	61936	4983	2070000	170000
1962	57523	0.02	0.002	61875	4983	2040000	170000
1963	64598	0.02	0.002	61823	4983	2010000	170000
1964	68928	0.03	0.002	61774	4983	1990000	170000
1965	67721	0.03	0.002	61716	4984	1960000	170000
1966	58736	0.02	0.002	61649	4984	1930000	169000
1967	60225	0.02	0.002	61604	4985	1910000	169000
1968	84323	0.03	0.003	61568	4985	1900000	169000
1969	94591	0.04	0.003	61498	4986	1870000	169000
1970	74720	0.03	0.003	61399	4988	1830000	169000
1971	74746	0.03	0.003	61348	4989	1810000	169000
1972	95462	0.04	0.004	61328	4989	1800000	170000
1973	95935	0.04	0.004	61284	4990	1780000	170000
1974	107232	0.05	0.004	46338	9312	1770000	170000
1975	124515	0.05	0.005	57250	10518	1740000	170000
1976	124942	0.06	0.006	43961	8650	1700000	170000
1977	131335	0.06	0.007	44980	8588	1620000	173000
1978	134017	0.07	0.008	49740	8846	1540000	182000
1979	127568	0.07	0.009	59235	9731	1450000	192000
1980	130769	0.07	0.01	47660	8982	1360000	194000
1981	156031	0.09	0.012	71959	10902	1280000	193000
1982	165291	0.1	0.014	46292	9042	1240000	192000
1983	165419	0.1	0.014	100875	13931	1210000	191000
1984	114491	0.07	0.01	49823	9175	1210000	193000
1985	156827	0.08	0.012	71485	10363	1250000	196000
1986	146827	0.08	0.011	47730	7853	1320000	205000
1987	145698	0.07	0.011	68150	9332	1400000	217000
1988	136076	0.07	0.01	38700	6931	1430000	222000
1989	162465	0.08	0.012	73000	10898	1450000	222000
1990	193584	0.1	0.015	70136	10784	1420000	219000
1991	167528	0.09	0.013	60771	9286	1330000	211000
1992	163687	0.09	0.013	74004	9458	1290000	203000
1993	162844	0.09	0.013	63920	8311	1300000	202000
1994	172763	0.1	0.014	54554	7371	1310000	203000
1995	154552	0.09	0.013	57772	7754	1300000	203000
1996	148697	0.09	0.013	55616	7892	1290000	203000
1997	136653	0.08	0.012	58035	8201	1250000	199000
1998	144076	0.09	0.013	63203	8823	1220000	193000
1999	134165	0.08	0.012	57789	8667	1190000	190000
2000	131964	0.08	0.012	63370	9358	1180000	188000
2001	152905	0.09	0.014	72359	10065	1180000	189000
2002	136464	0.08	0.012	67739	9041	1170000	189000
2003	123236	0.07	0.011	45140	6759	1180000	190000
2004	119573	0.07	0.01	55606	7380	1220000	194000
2005	105091	0.06	0.009	41127	5846	1270000	198000
2006	105911	0.06	0.009	35465	5115	1280000	196000
2007	102844	0.07	0.009	37876	5562	1230000	188000
2008	111874	0.08	0.011	54007	6733	1170000	178000
2009	117915	0.09	0.013	53526	6649	1070000	166000
2010	118281	0.09	0.013	62507	7270	968000	153000
2011	112499	0.09	0.013	51319	5983	913000	146000
2012	113726	0.09	0.013	51751	5864	907000	144000
2013	106333	0.08	0.012	46404	5632	926000	145000
2014	115023	0.09	0.013	61307	6400	947000	146000
2015	130691	0.1	0.015	57139	6057	936000	144000
2016	150311	0.12	0.017	53459	6102	904000	140000
2017	136863	0.11	0.016	68573	7849	873000	136000
2018	135906	0.12	0.016	74121	8840	856000	134000
2019	136189	0.11	0.016	65510	9113	829000	130000
2020	155282	0.13	0.018	86109	11534	827000	130000
2021	121002	0.1	0.014	84922	13672	855000	134000
2022	148785	0.11	0.015	57059	5130	911000	141000
2023	-	-	-	-	-	970000	151000

Table 10. JABBA summary of posterior quantiles presented in the form of marginal posterior medians and associated 95% credibility intervals of parameters for scenarios S05 (continuity) and S06 (preliminary reference case) for the Atlantic yellowfin tuna. The biomass (B) estimates refer to the beginning of the year.

Estimates	**S05**			**S06**		
	Median	***2.50%***	***97.50%***	***Median***	***2.50%***	***97.50%***
***K* (t)**	2,299,725	1,631,078	3,296,738	1,649,524	976,031	2,985,051
r	0.138	0.096	0.200	0.181	0.103	0.309
φ	0.995	0.820	1.199	0.994	0.822	1.194
σ_{proc}	0.065	0.033	0.114	0.093	0.051	0.151
F_{MSY}	0.16	0.11	0.231	0.318	0.182	0.544
B_{MSY}	786,419	557,767	1,127,360	445,369	263,527	805,960
MSY	124,752	108,202	156,023	137,426	117,507	212,465
B_{1950}/K	0.992	0.782	1.239	0.989	0.759	1.256
B_{2022}/B_{MSY}	0.781	0.493	1.224	1.036	0.597	1.898
F_{2022}/F_{MSY}	1.539	0.82	2.491	1.052	0.381	1.97

Table 11. JABBA summary Mohn's rho statistic for scenarios S05 (continuity) and S06 (preliminary reference case) for the Atlantic yellowfin tuna, computed for a retrospective evaluation period of five years.

	Stock Quantity					
Scenario	B	F	B/B_{MSY}	F/F_{MSY}	B/K	**MSY**
S05	-0.096	0.119	-0.064	0.082	0.000	-0.009
S06	-0.049	0.072	-0.038	0.06	0.006	-0.007

Table 12. Stock status and benchmarks (median and 80% confidence intervals of 4000 iterations) from the Stock Synthesis Reference Case for Atlantic yellowfin tuna.

Estimates	B/B_{MSY}	F/F_{MSY}	MSY
Median	1.37	0.89	121661
80%LCI	0.91	0.40	107485
80%UCI	2.15	1.46	188456

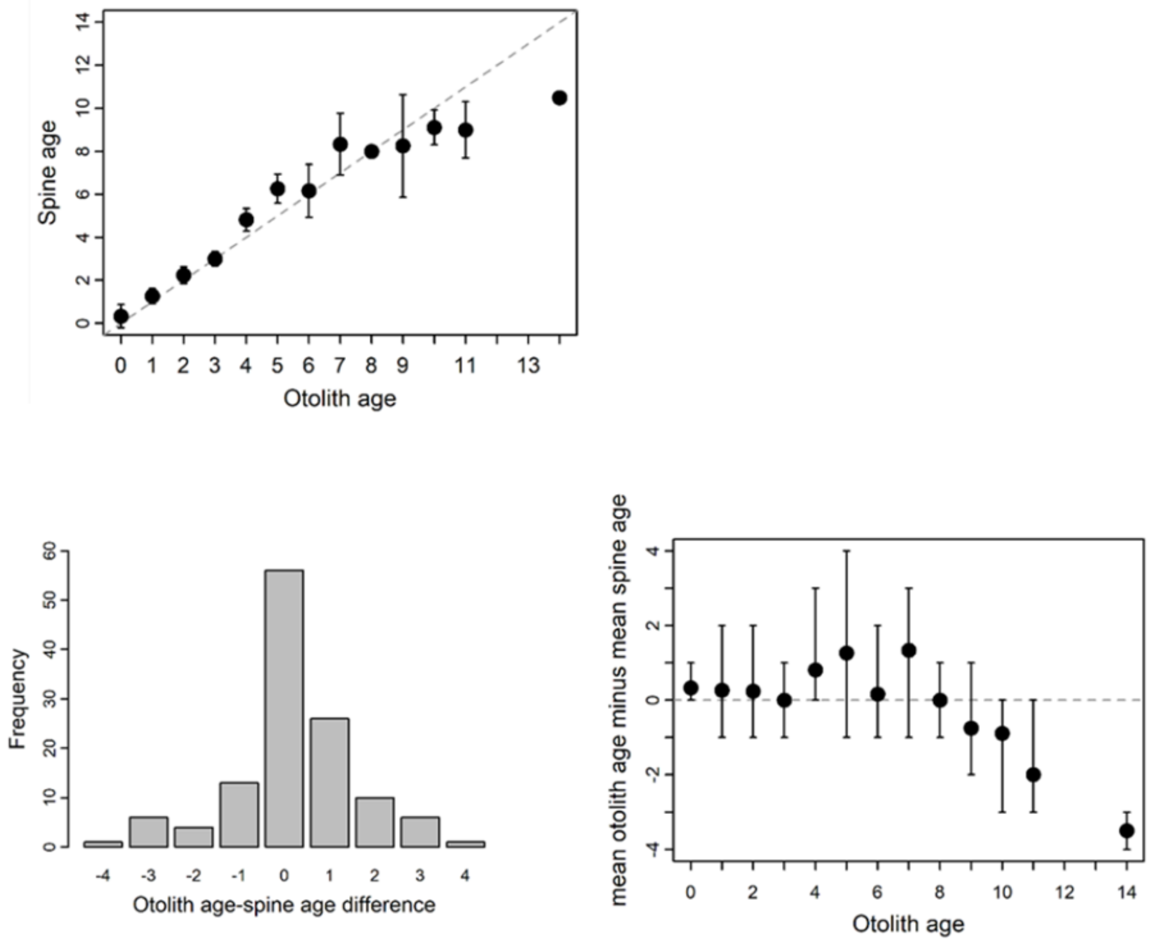


Figure 1. Top left: Comparisons of yellowfin tuna age estimations between otoliths and spines. Observed bias, with confidence interval and 1:1 equivalence line. Points (with 95% confidence interval) above the line indicate ages overestimated by the spine relative to the otolith, and those (with 95% confidence interval) below the line indicate an underestimation of age by the spine. Bottom left: Frequency of observed differences in age estimates. Bottom right: Difference between age estimates as a function of age. The horizontal dotted line shows no difference.

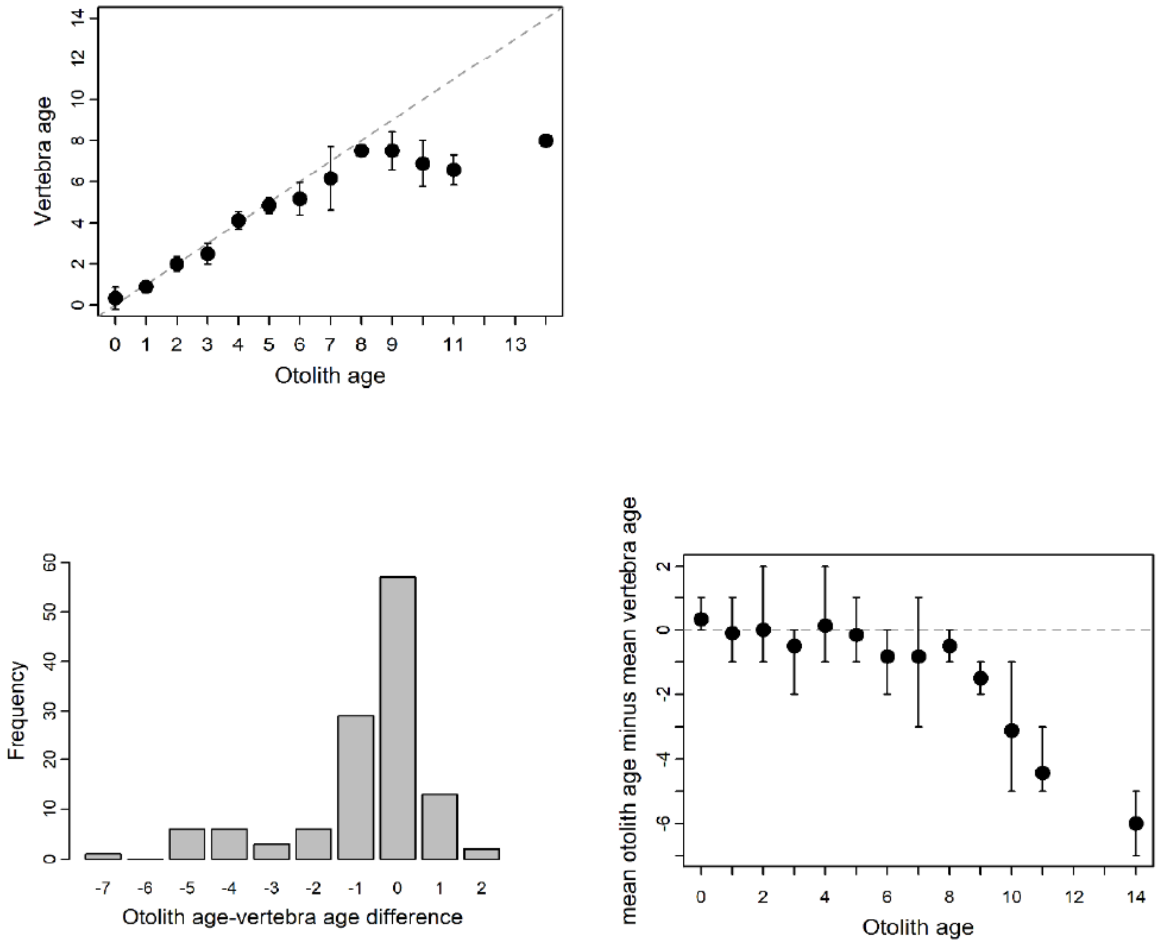


Figure 2. Comparisons of yellowfin tuna age estimations between otoliths and vertebrae. Observed bias, with confidence interval and 1:1 equivalence line. Points (with 95% confidence interval) above the line indicate ages overestimated by the vertebrae relative to the otolith, and those (with 95% confidence interval) below the line indicate an underestimation of age by the vertebrae. Bottom left: Frequency of observed differences in age estimates. Bottom right: Difference between age estimates as a function of age. The horizontal dotted line shows no difference.

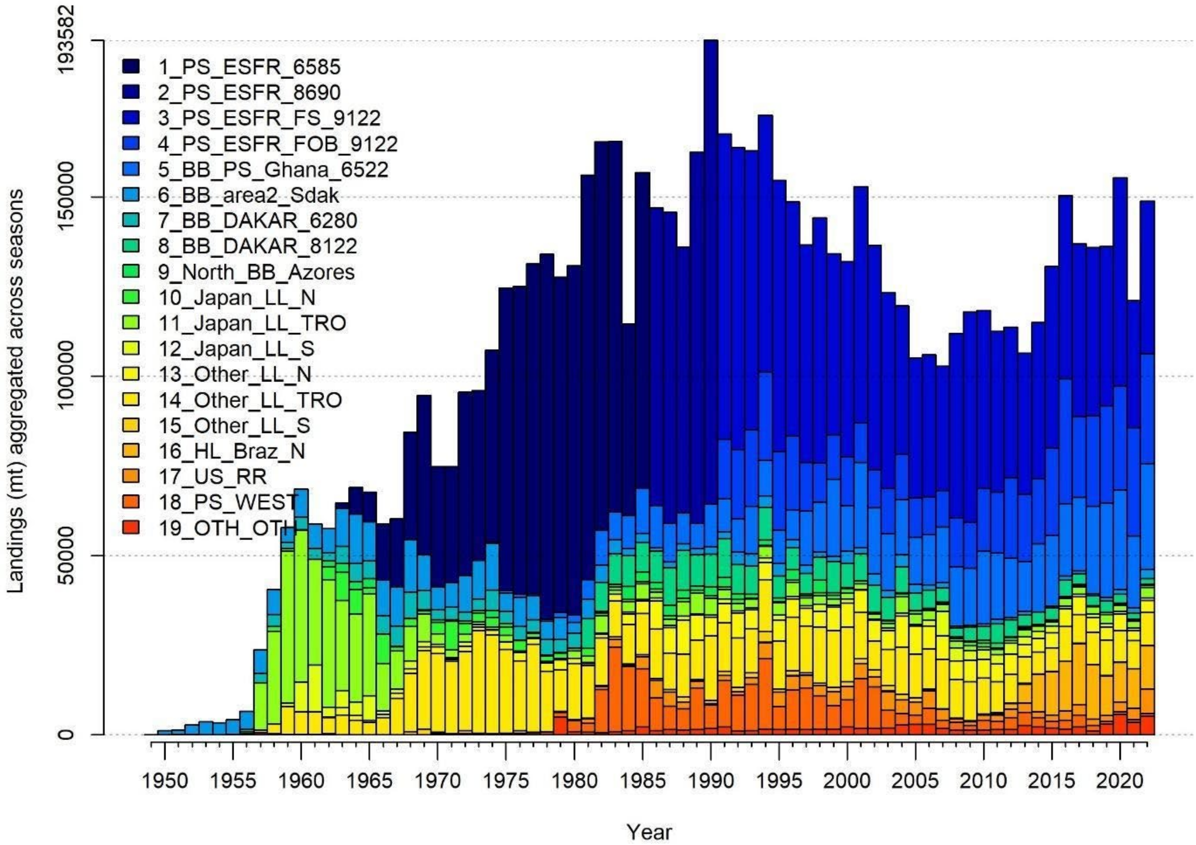
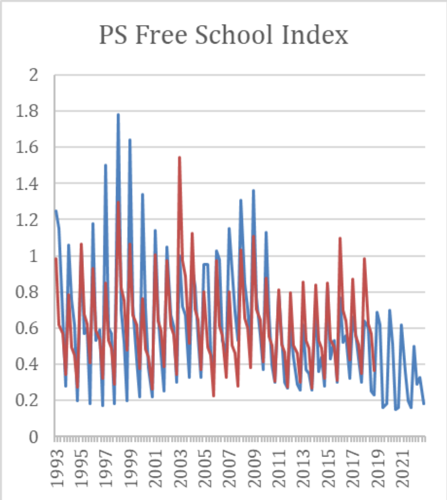
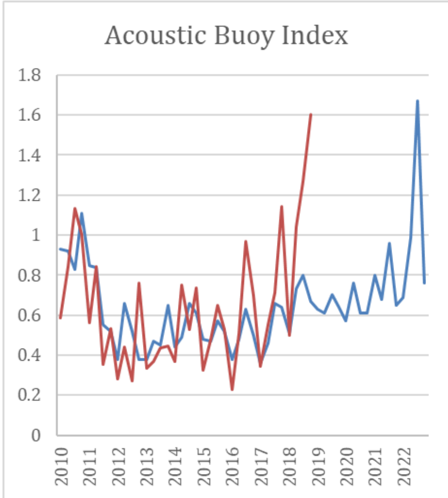


Figure 3. Landings (mt) for each of the fleets (**Table 2**) defined in the stock synthesis models.





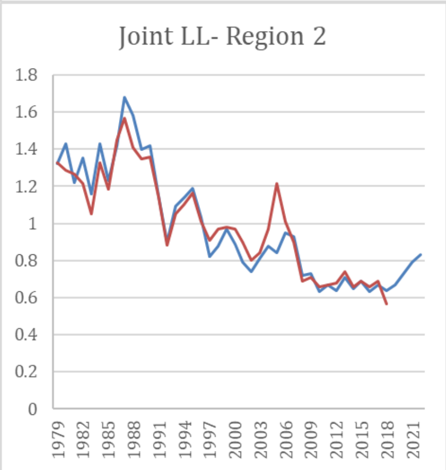


Figure 4. Standardized indices of Atlantic yellowfin tuna relative abundance fit within Stock Synthesis. The red line shows the index used in 2019, and the blue line shows the updated index provided for the 2024 assessment.

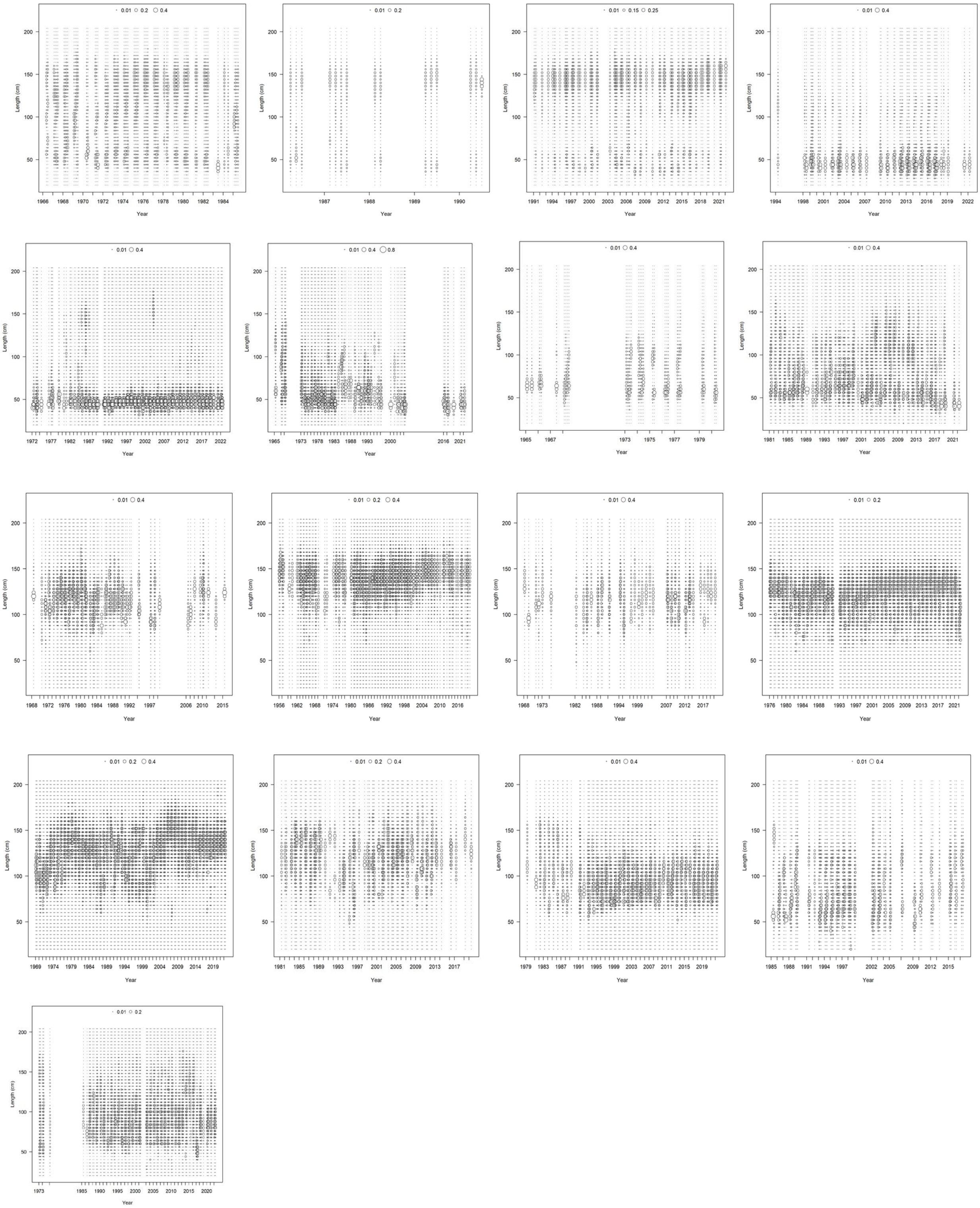


Figure 5. Annual length frequency bubble plots for fleets considered in Stock Synthesis models. (**Table 2** contains details of fleet definitions). The size of the circle is proportional to the number of observations, scaled within each fleet plot.

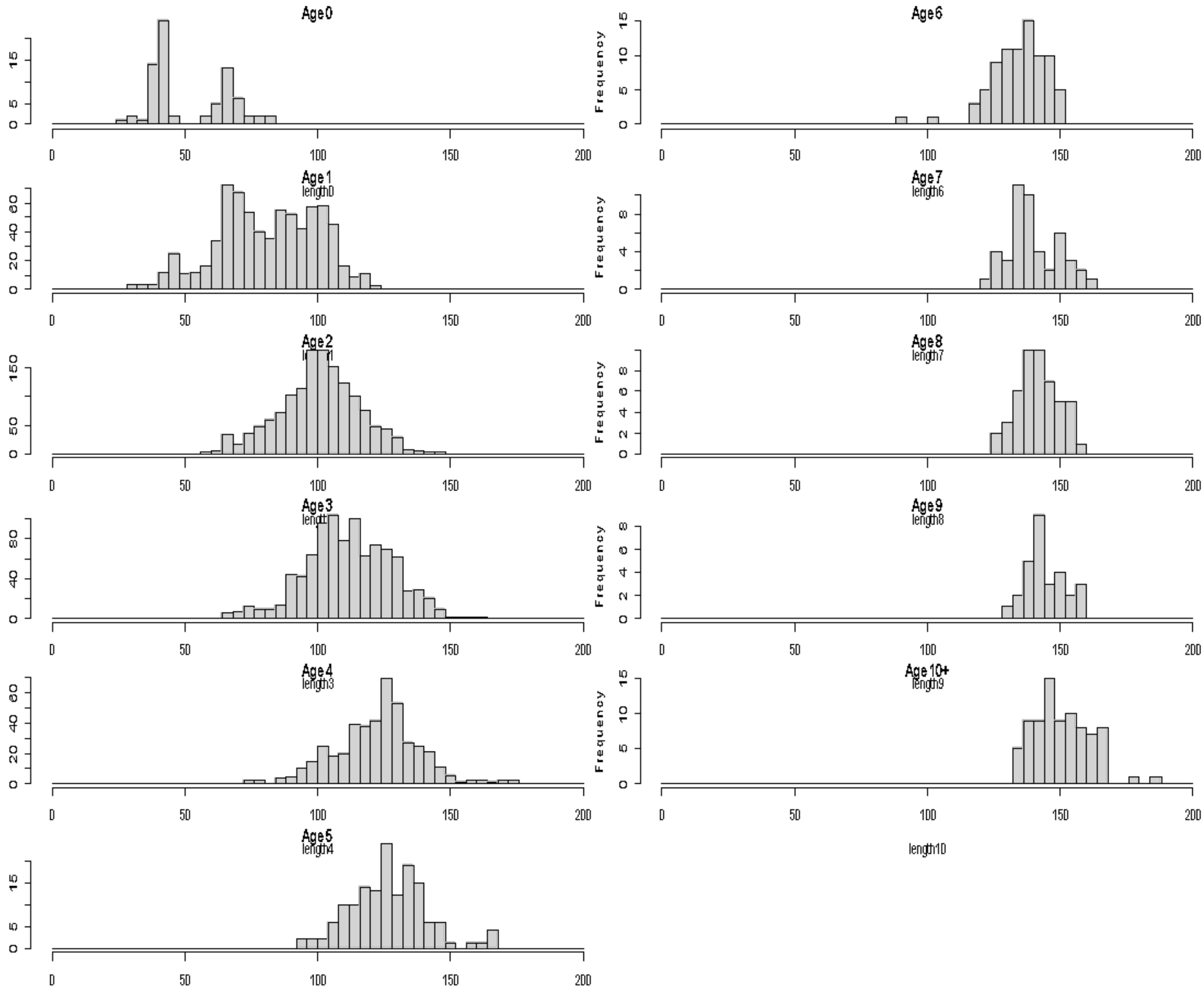


Figure 6. Conditional age-length data of Atlantic yellowfin tuna modeled in Stock Synthesis.

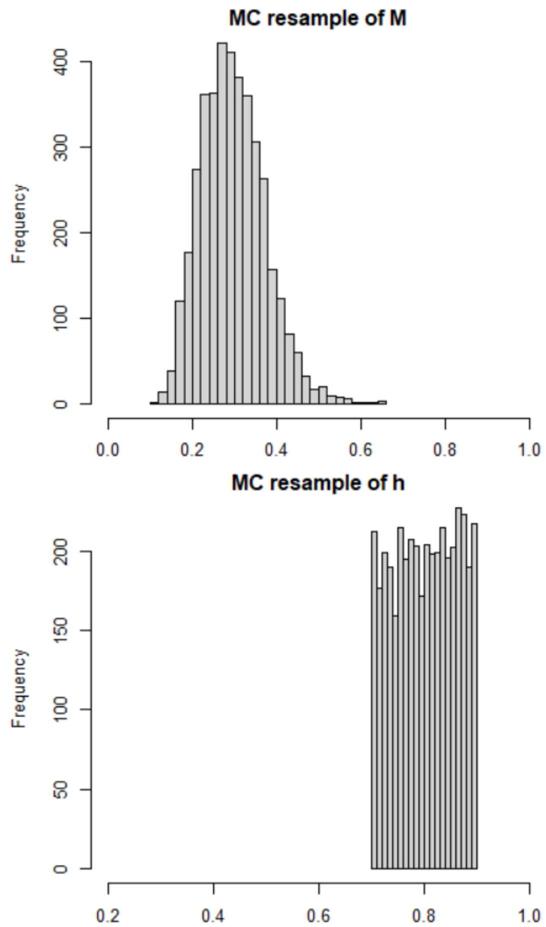


Figure 7. Monte Carlo resampling (4000 iterations) of natural mortality (M) parameter fixed inputs to the Stock Synthesis model trials.

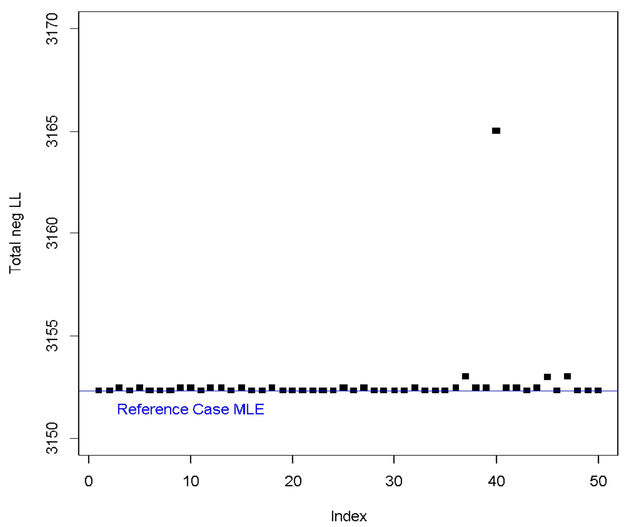
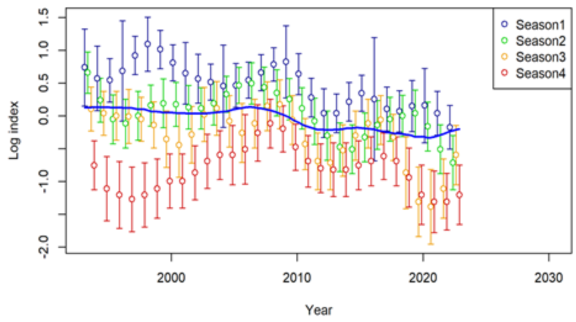
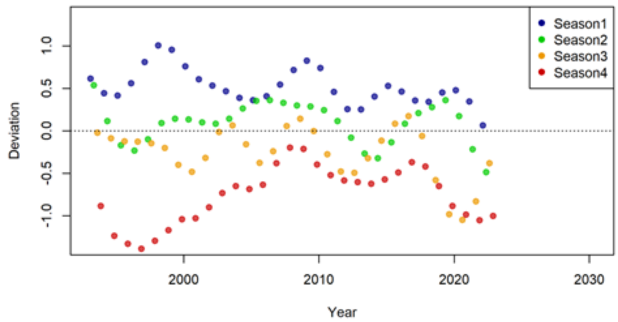


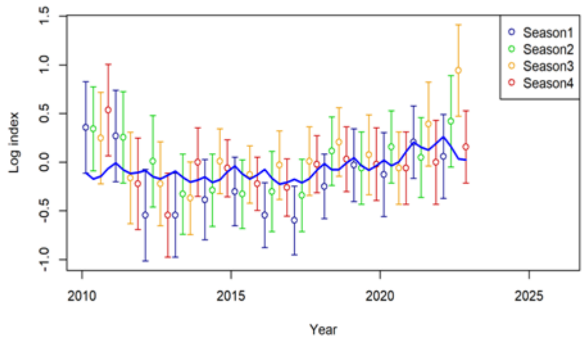
Figure 8. Final objective function (Total negative loglikelihood units) for the Stock Synthesis reference case across jittered starting parameter values.

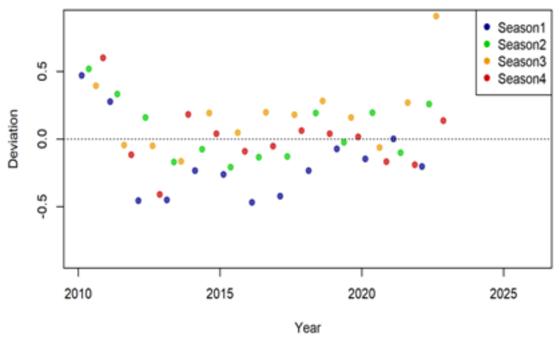
Purse seine free school



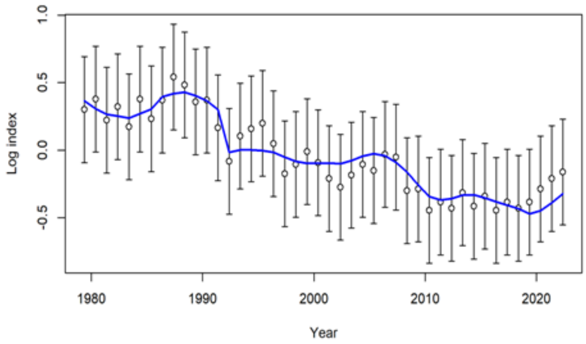


Acoustic buoy index





Joint longline (Region 2)



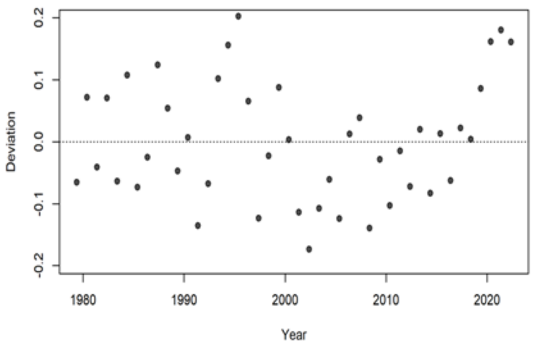


Figure 9. Stock Synthesis reference case fits (left panels) and residuals (right panels) to the Atlantic yellowfin tuna indices of relative abundance. Solid blue lines represent predictions and bars represent observations (open circles) with their CVs.

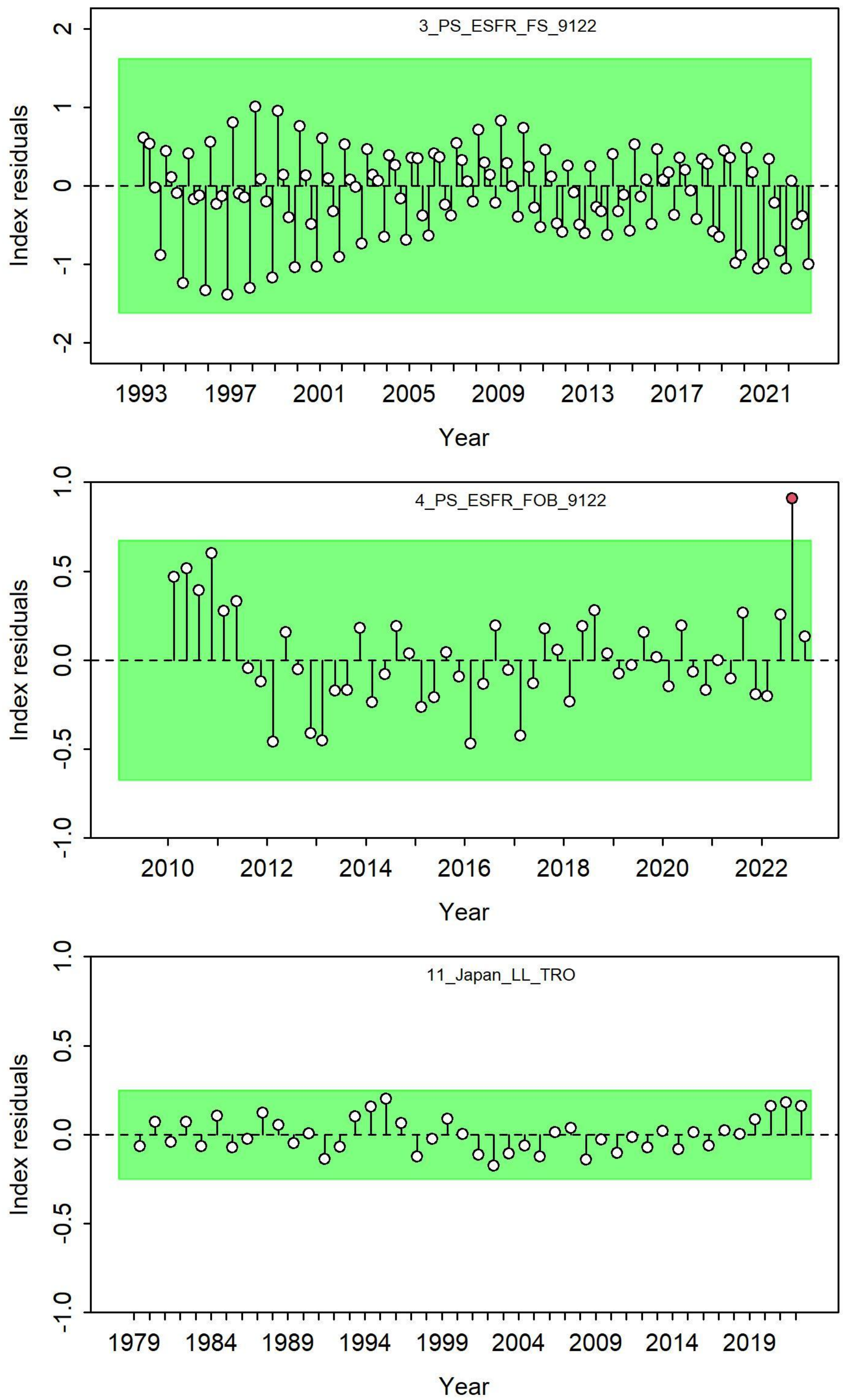


Figure 10. Diagnostic runs test on residual fits to indices of abundance of Atlantic yellowfin tuna for the Stock Synthesis reference case. Red circles represent outliers.

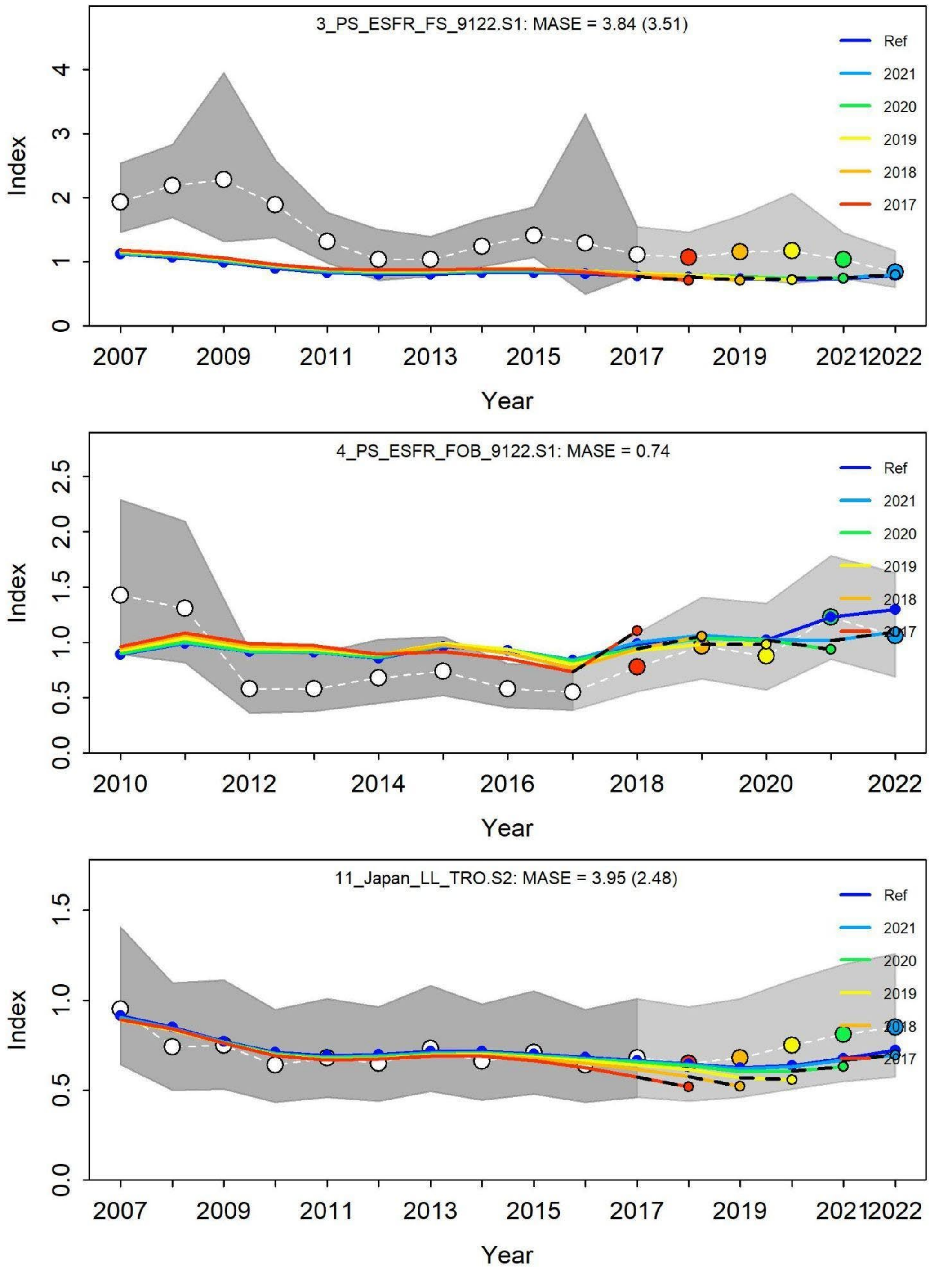


Figure 11. Predicted yellowfin tuna abundance index hindcast analysis of the Stock Synthesis reference case.

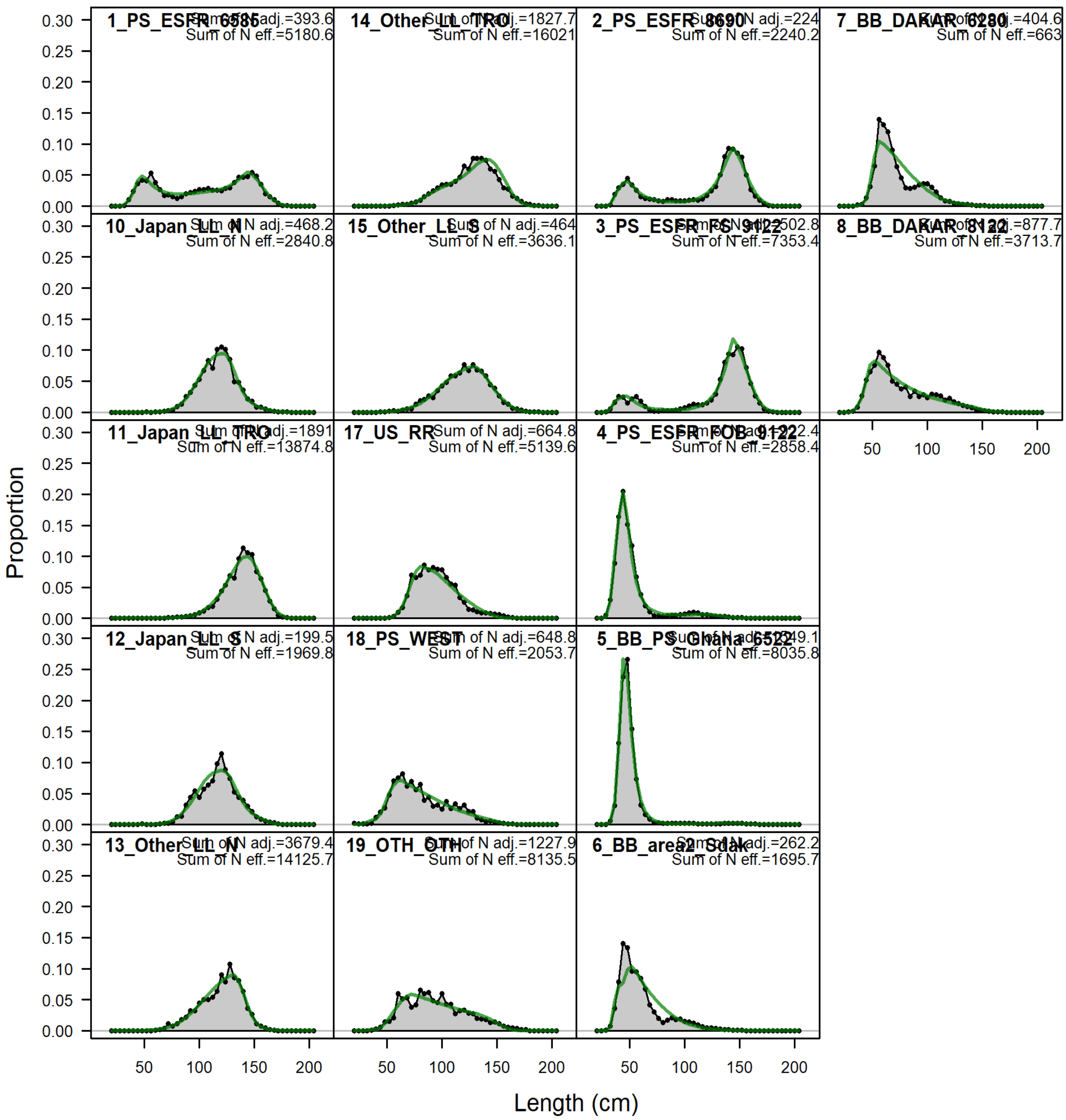


Figure 12. Fits to the fleet aggregated length compositions for Atlantic yellowfin tuna for the Stock Synthesis reference case. Black dots and shade areas represent the observed length data aggregated for all years. Green lines represent model predictions.

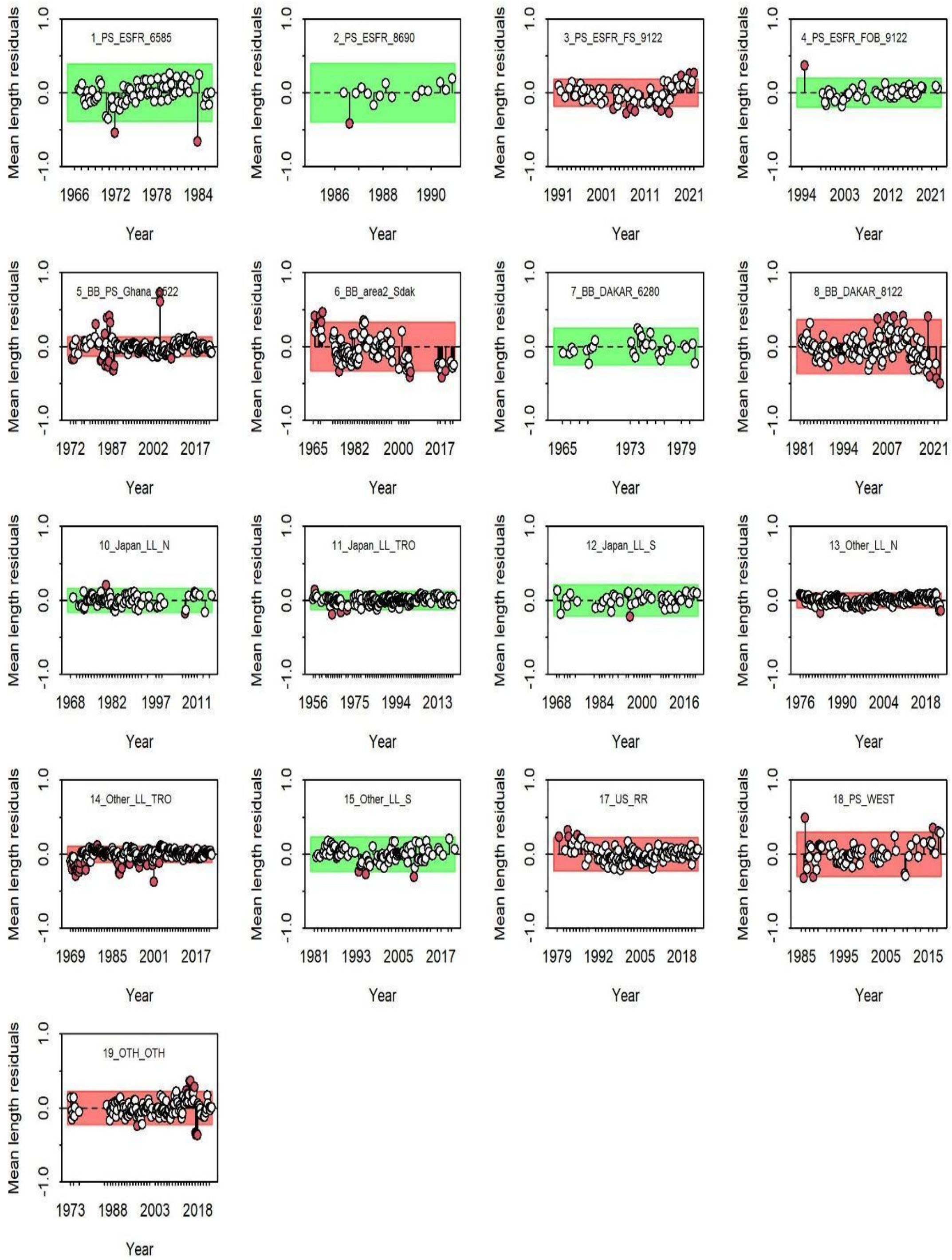


Figure 13. Diagnostic runs test on residual fits to length composition data of Atlantic yellowfin tuna for the Stock Synthesis reference case. Red circles represent outliers and the red box indicates a non-random residual pattern across the time series (i.e. failed runs test).

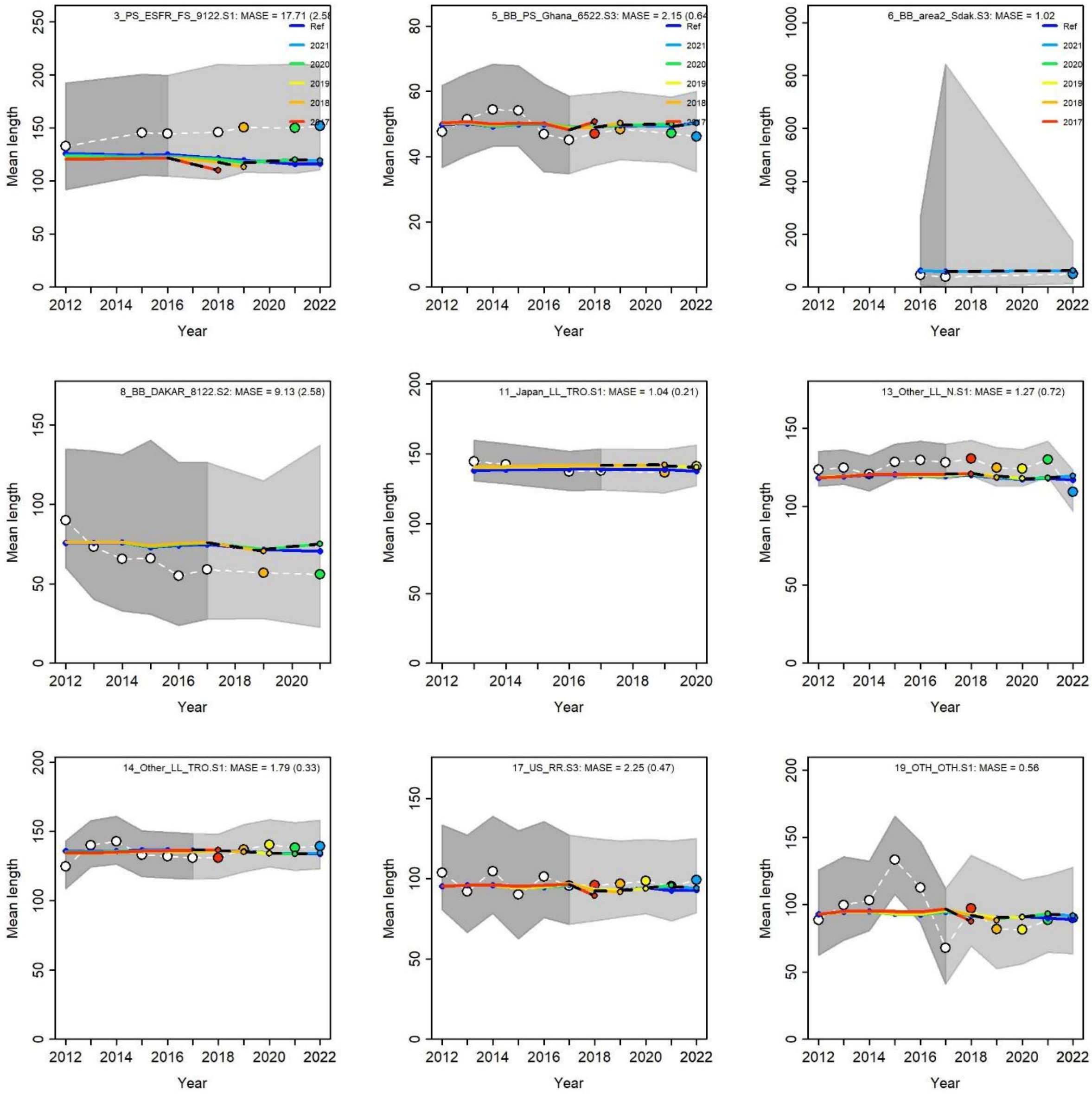


Figure 14. Predicted yellowfin tuna length composition hindcast analysis of the Stock Synthesis reference case.

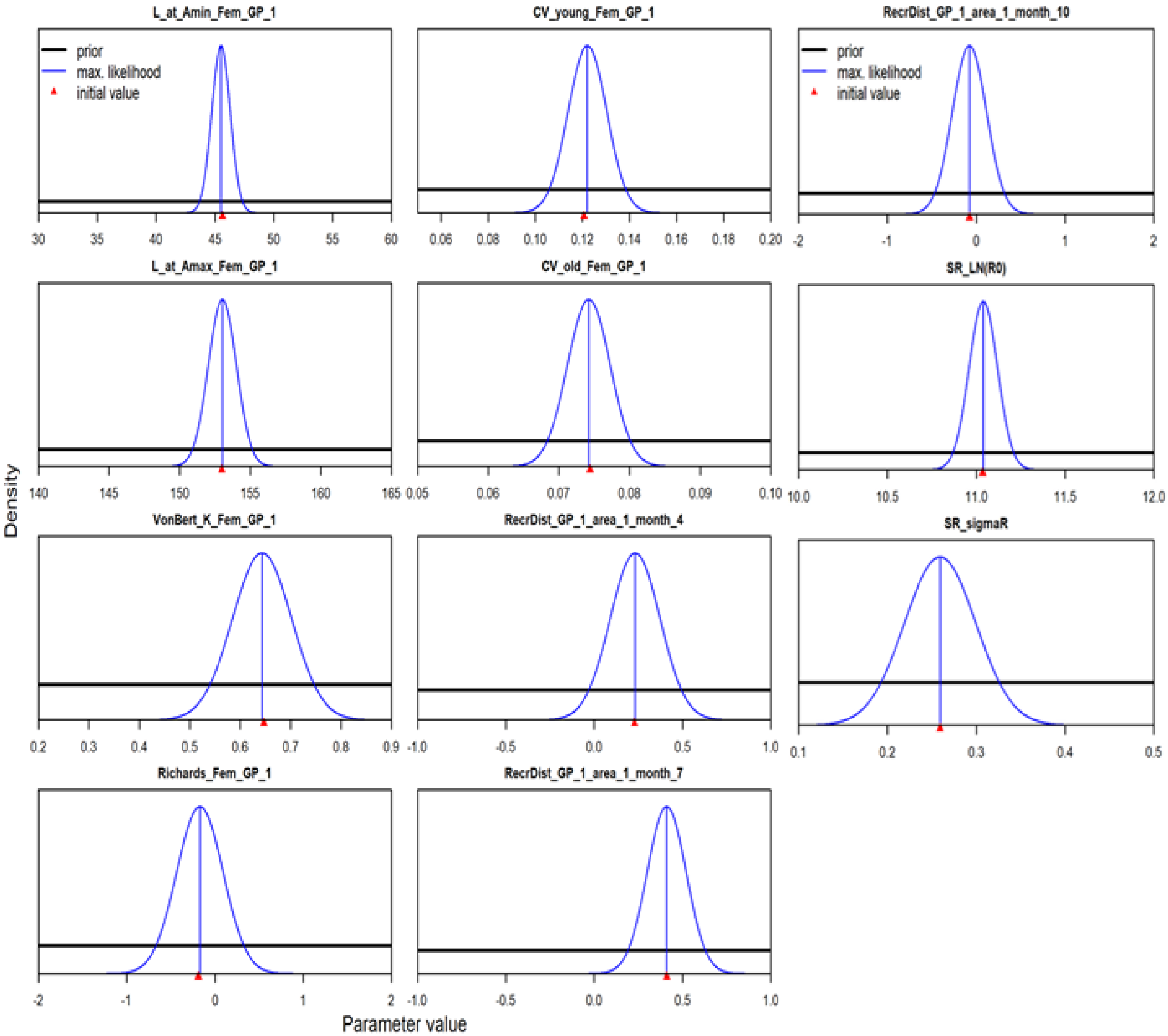


Figure 15. Stock Synthesis reference case model prior and posterior distributions of Atlantic yellowfin tuna growth and stock-recruitment parameters.

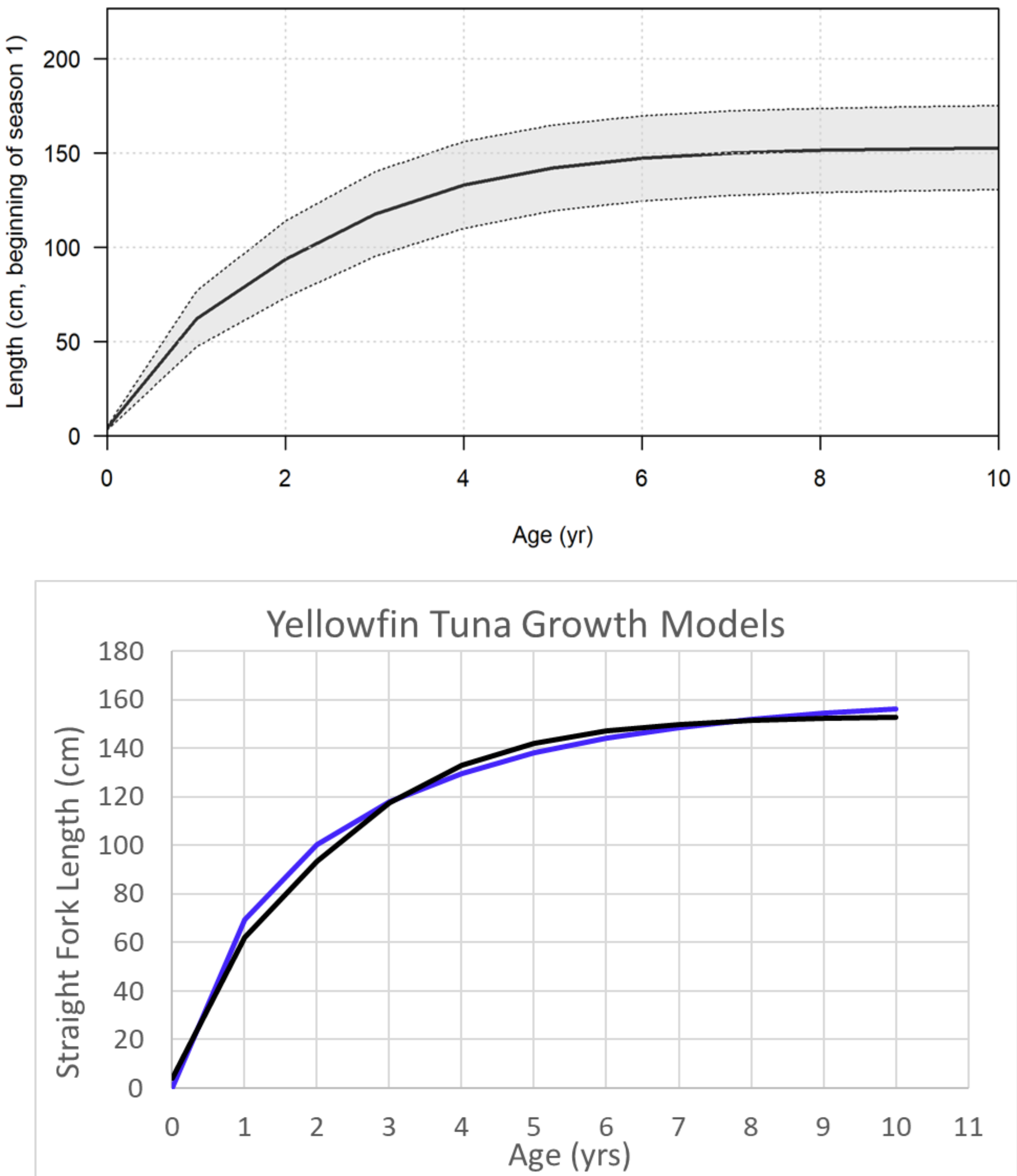
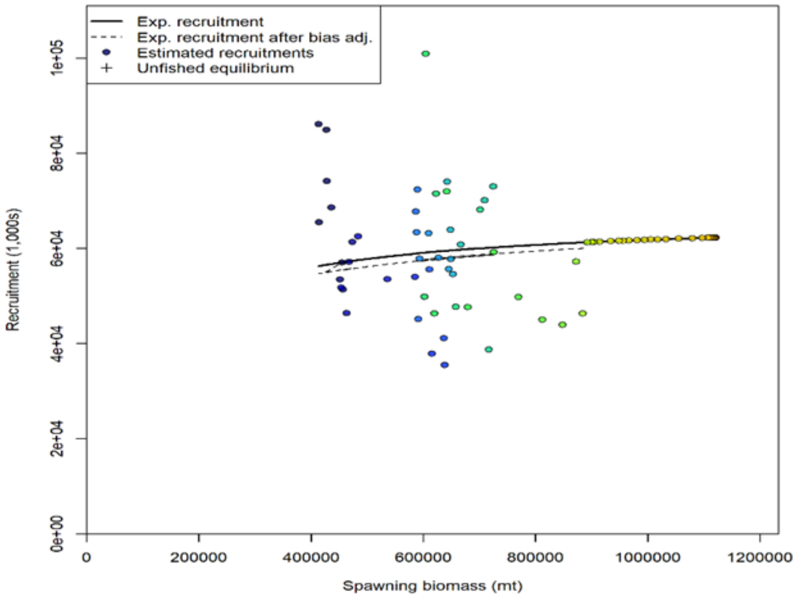


Figure 16. Stock Synthesis estimated growth of Atlantic yellowfin tuna. Top panel shows the plot of estimated Richards growth with 95% confidence intervals and the bottom panel shows the estimated growth model comparison between Stock Synthesis (blue line) and the published size-modified Richards curve estimated by Pacicco *et al.*, 2021 (black line).



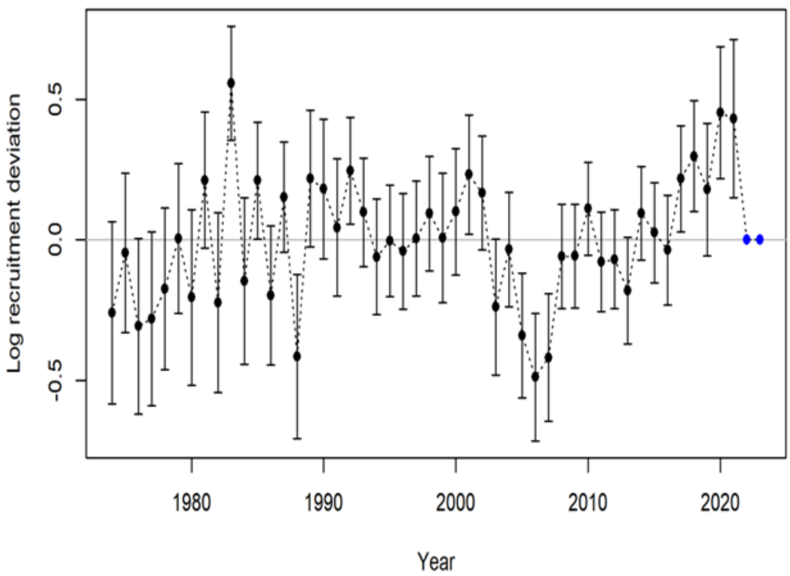
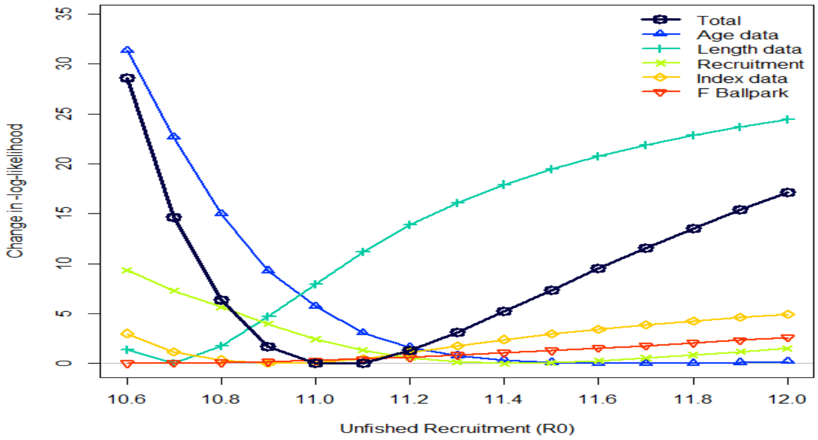
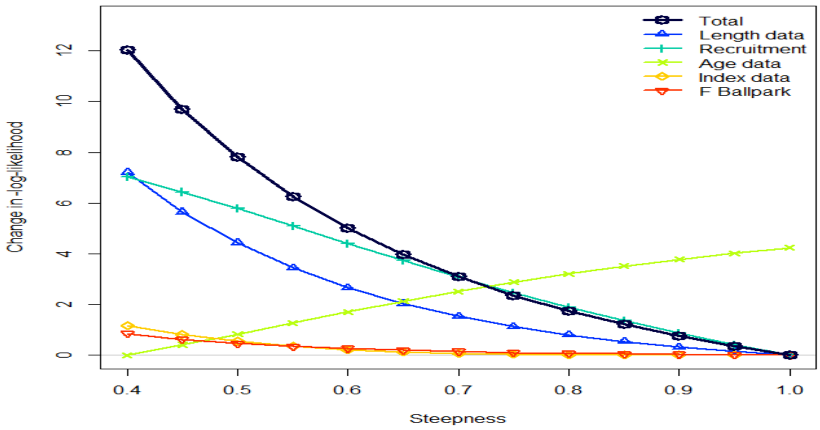


Figure 17. Stock Synthesis estimated Beverton-Holt stock recruitment curve (upper panel) and recruitment deviations (1974-2021; lower panel).





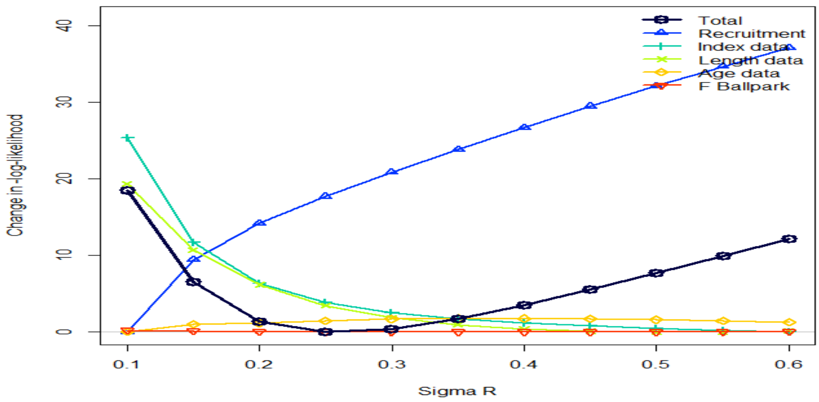


Figure 18. Likelihood profile analysis of stock-recruitment parameters in the Stock Synthesis reference case model.

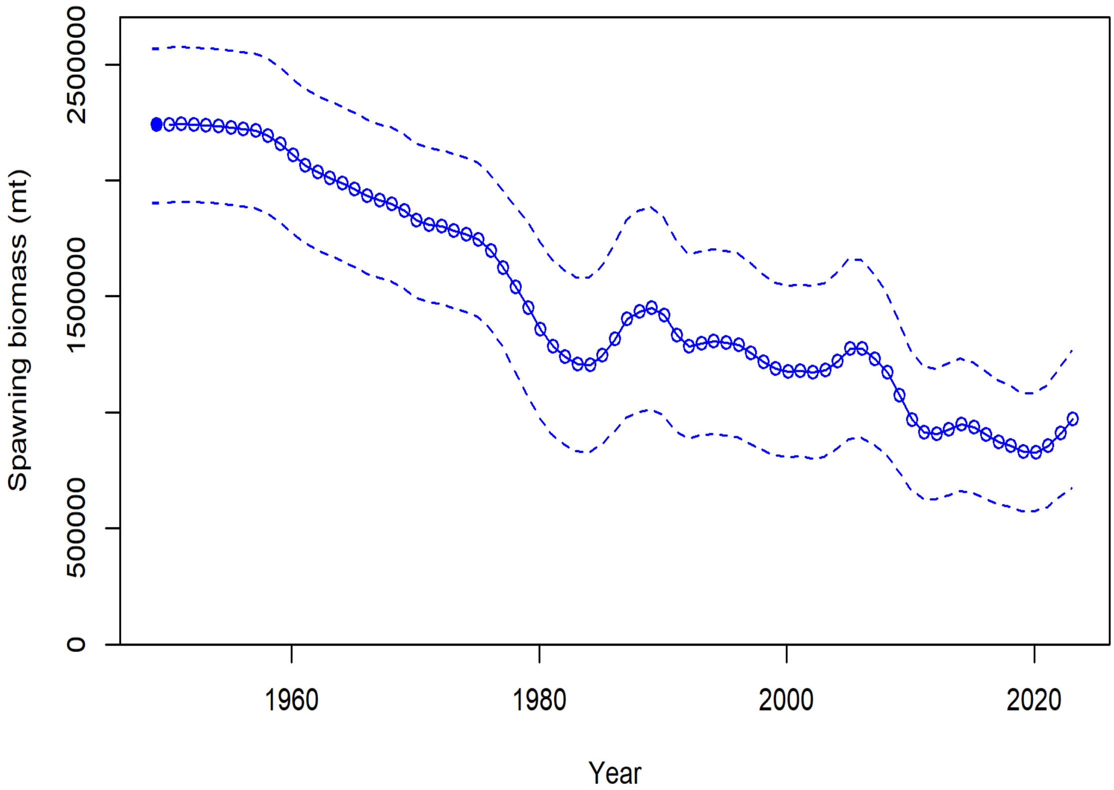
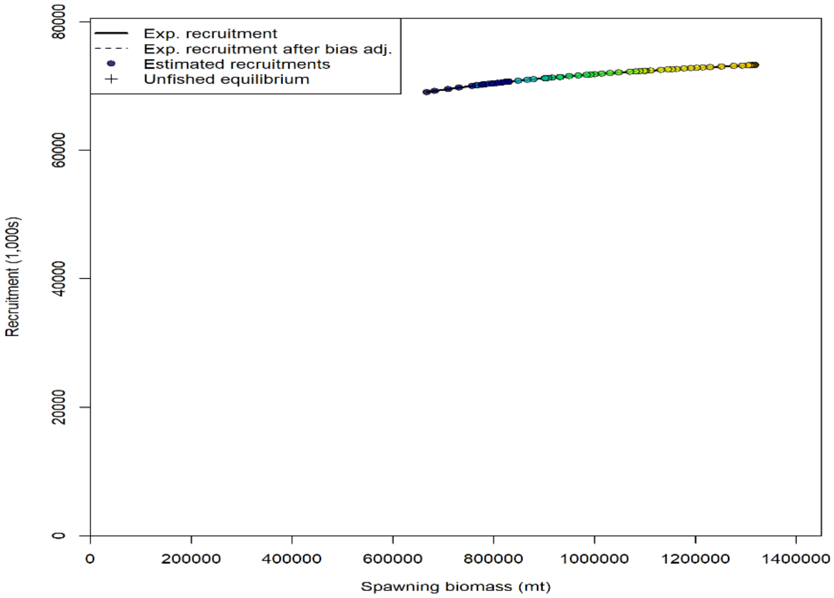


Figure 19. Stock Synthesis reference case model estimated spawning stock biomass (t) of Atlantic yellowfin tuna.



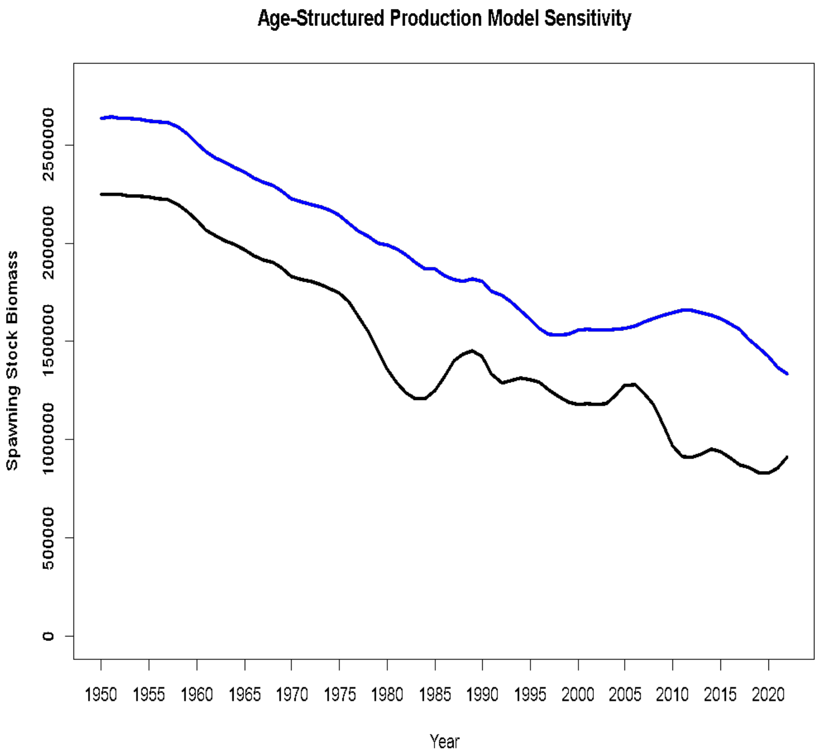


Figure 20. Age-structured production model (ASPM) sensitivity of the Stock Synthesis reference case model for yellowfin tuna. The top panel shows the ASPM stock-recruitment assumption without recruitment deviations, and the bottom panel shows the estimated spawning stock biomass from the ASPM (blue line) compared to the reference case (black line).

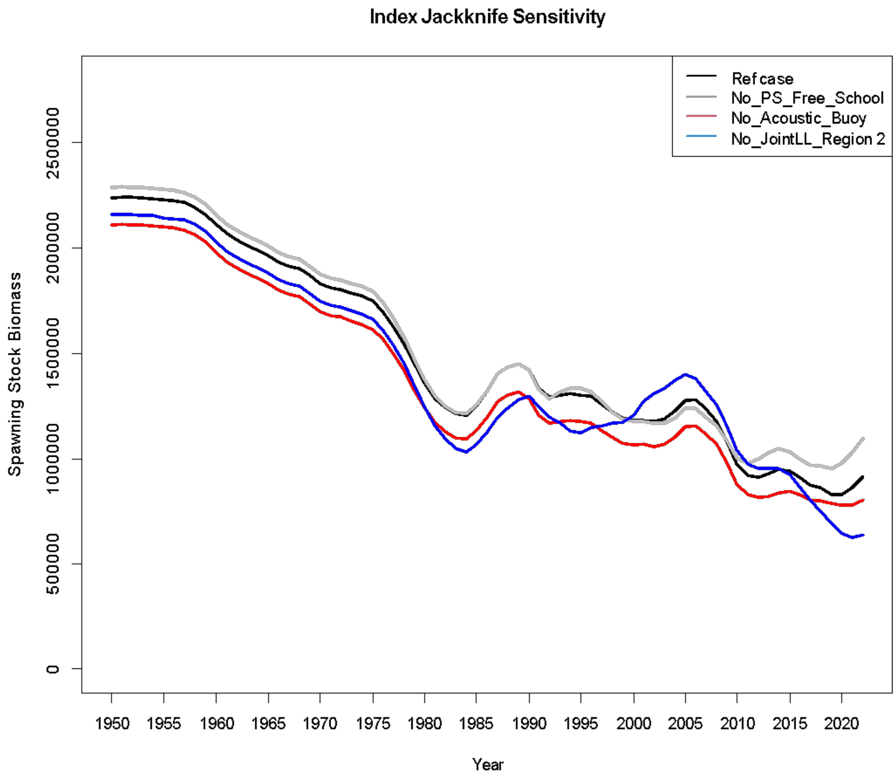


Figure 21. Index jackknife sensitivity analysis of the Stock Synthesis reference case model for Atlantic yellowfin tuna.

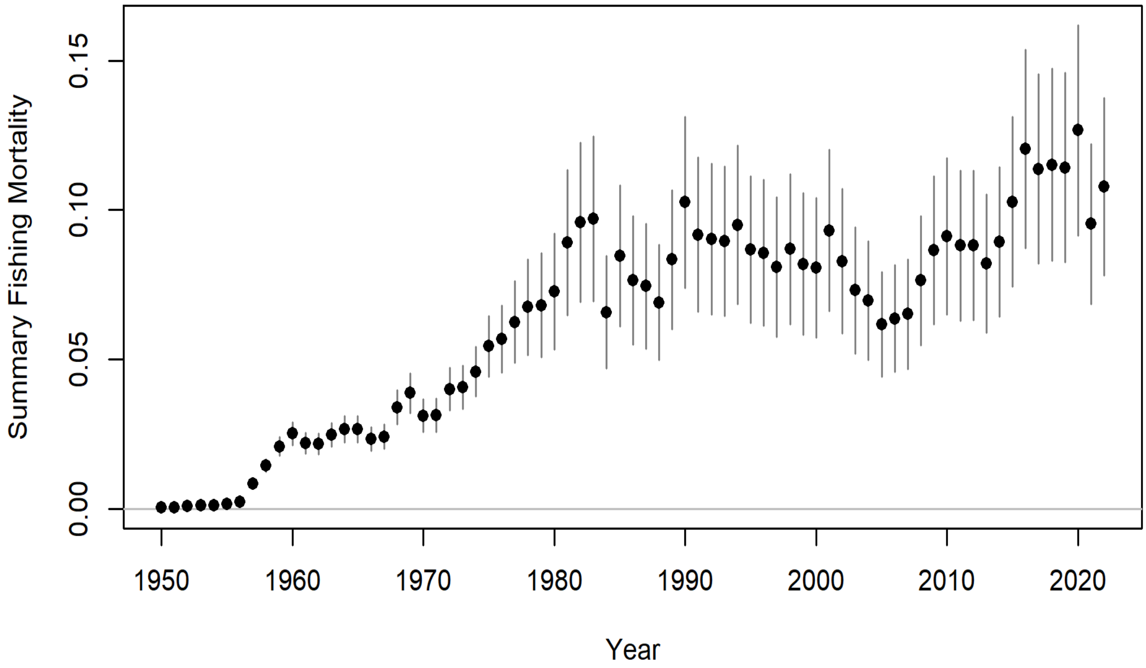


Figure 22. Exploitation rate (biomass) estimates from the reference case Stock Synthesis model.

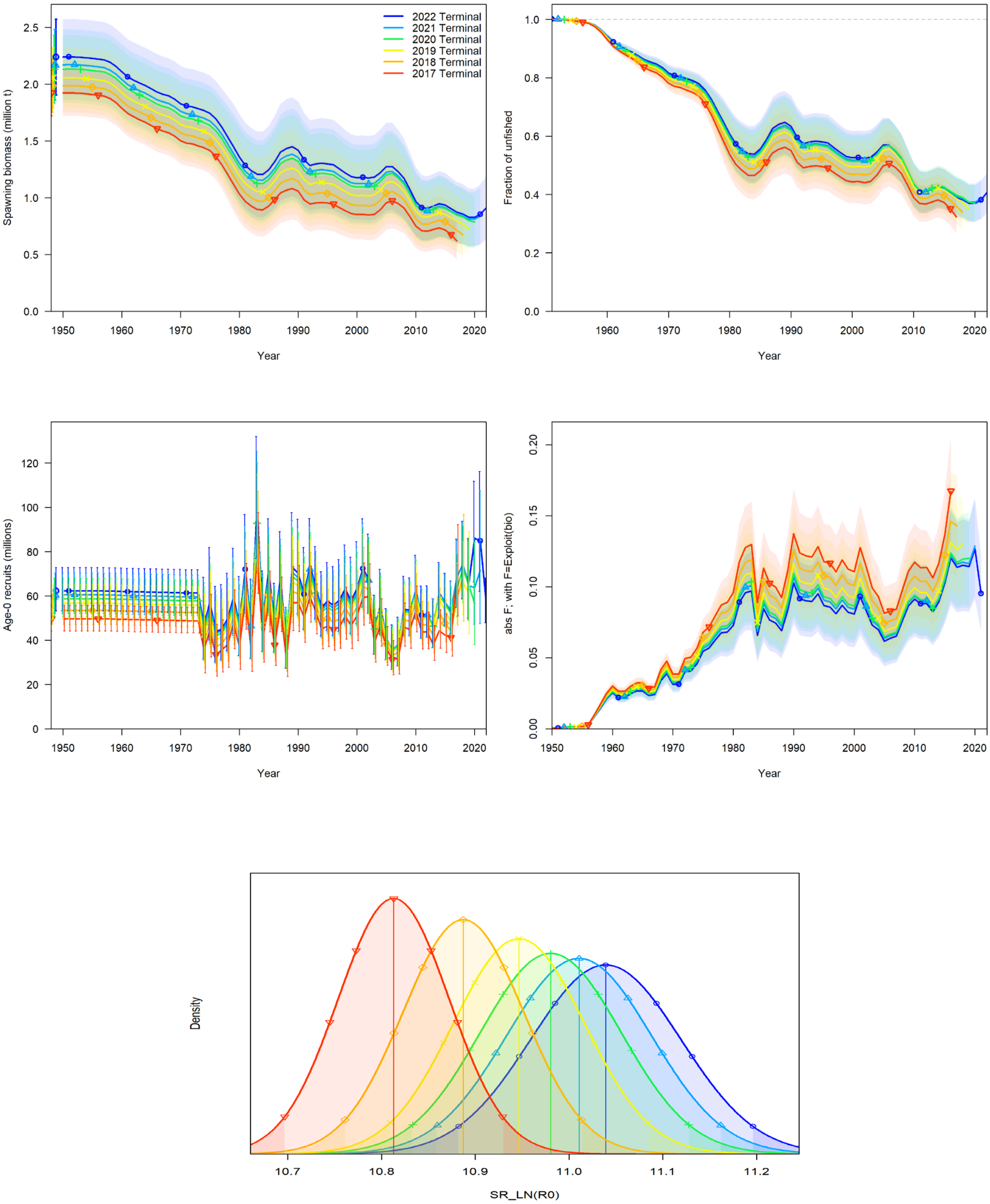


Figure 23. Retrospective analysis with 1 to 5 years of data removed of the Stock Synthesis reference case model for Atlantic yellowfin tuna, for spawning stock biomass, estimated R0, SSB/SSB$_{MSY}$, F/F$_{MSY}$.

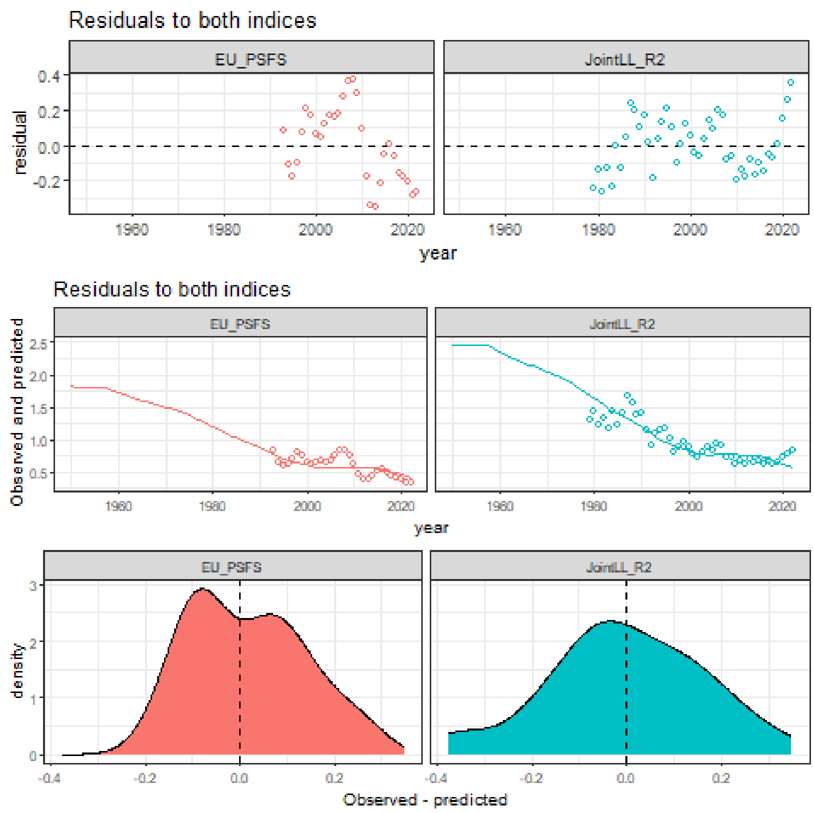


Figure 24. Residuals of fit in the preliminary *mpb* reference case.

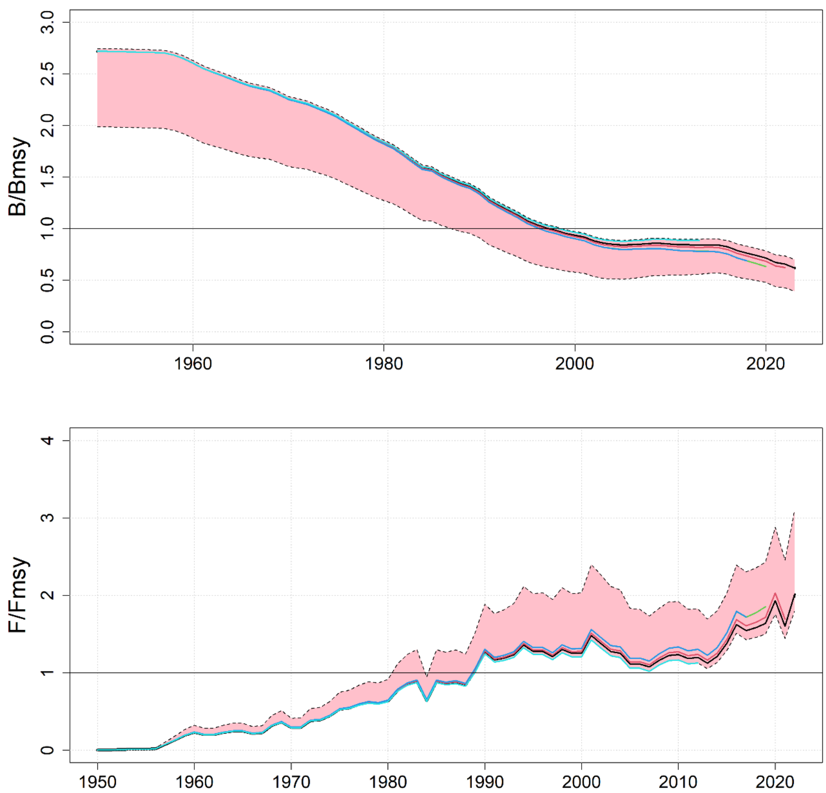


Figure 25. Retrospective analysis of the preliminary *mpb* reference case.

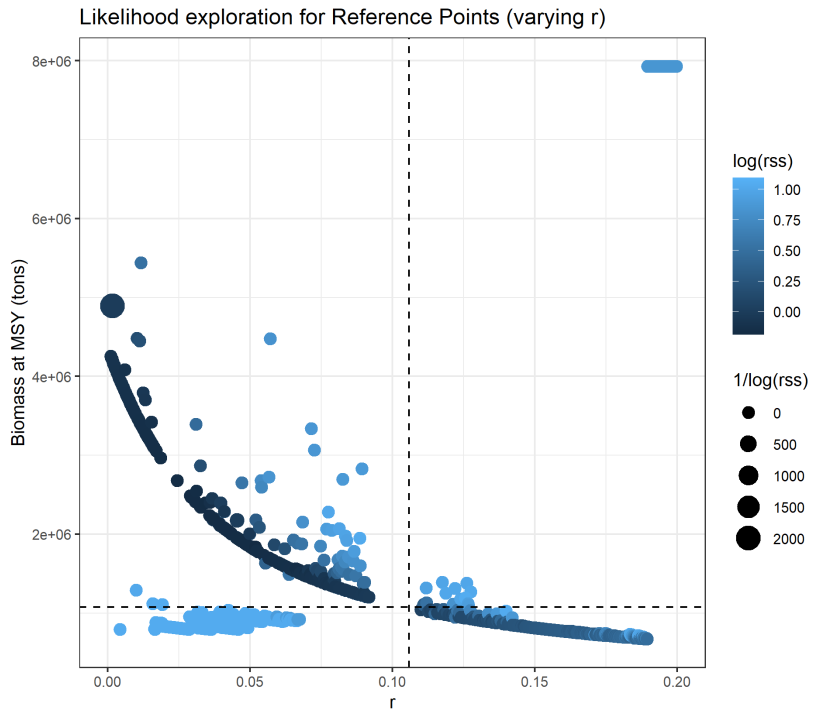


Figure 26. Likelihood exploration for *mpb* models with fixed *r* (penalty function) and estimated biomass at MSY.

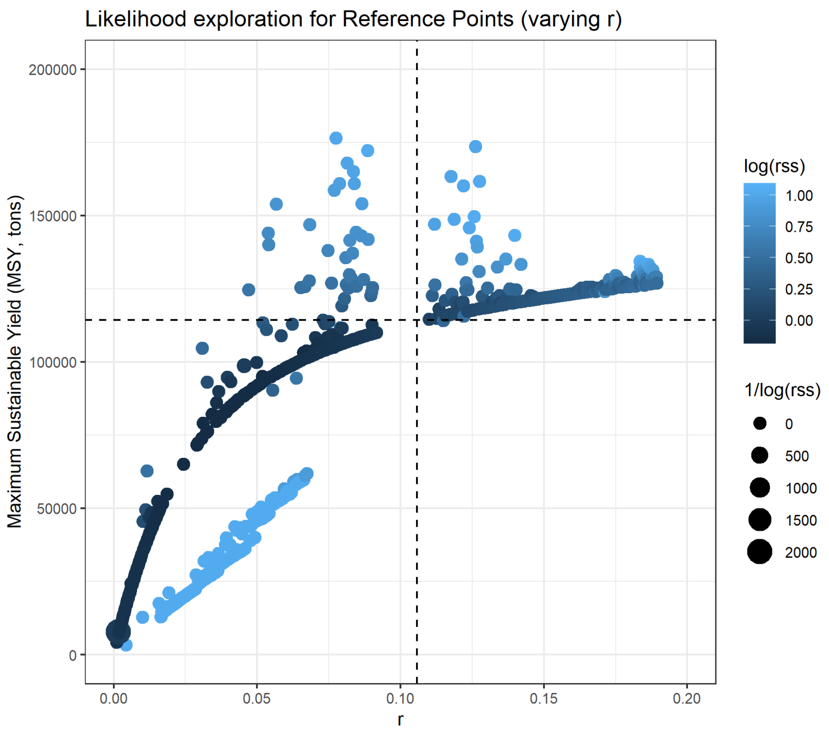


Figure 27. Likelihood exploration for *mpb* models with fixed r (penalty function) and estimated MSY.

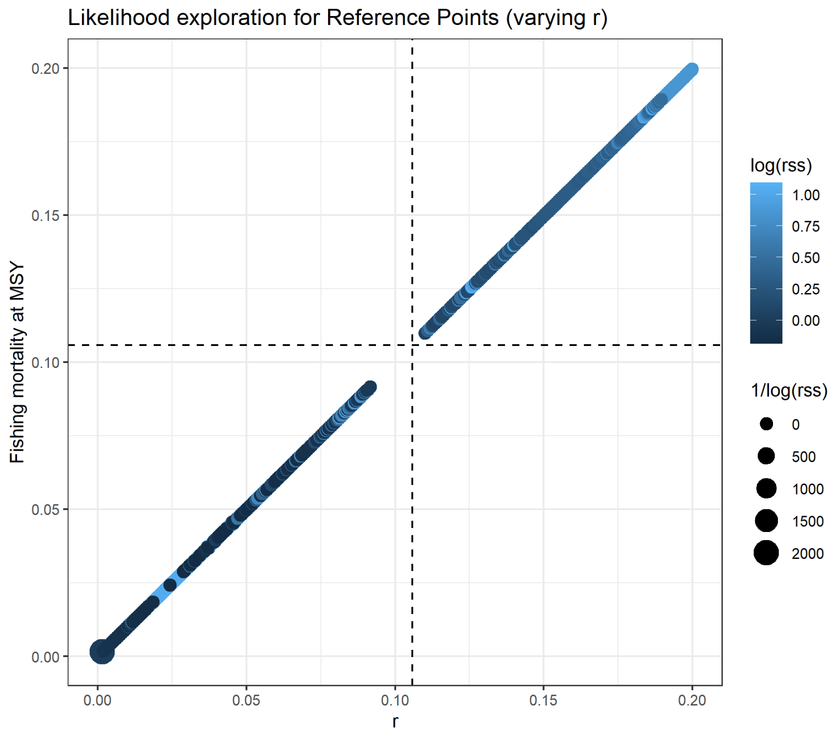


Figure 28. Likelihood exploration for *mpb* models with fixed *r* (penalty function) and estimated fishing mortality at MSY.

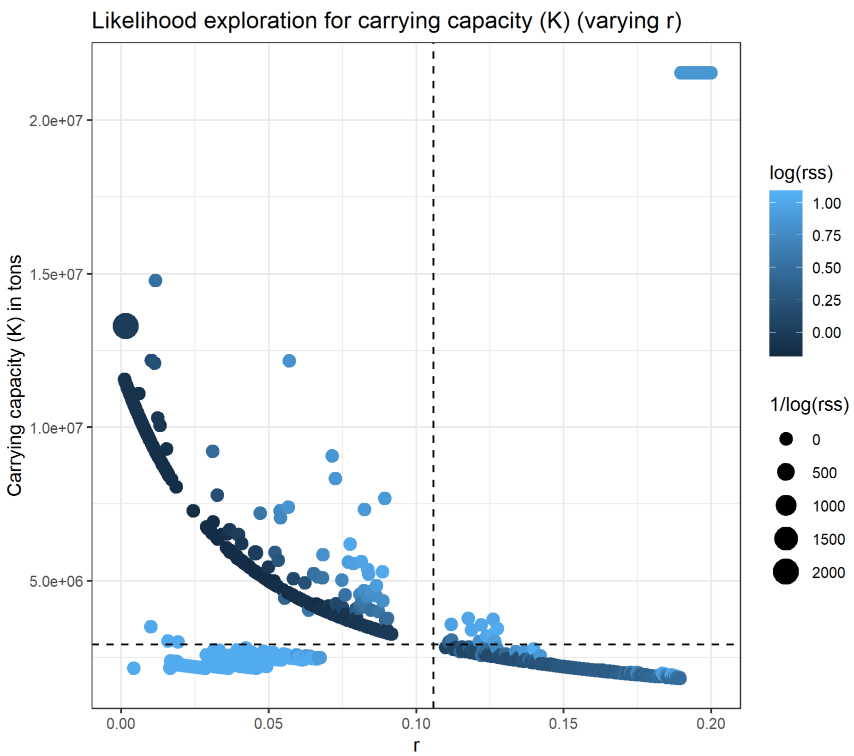


Figure 29. Likelihood exploration for *mpb* models with fixed *r* (penalty function) and estimated carrying capacity (K).

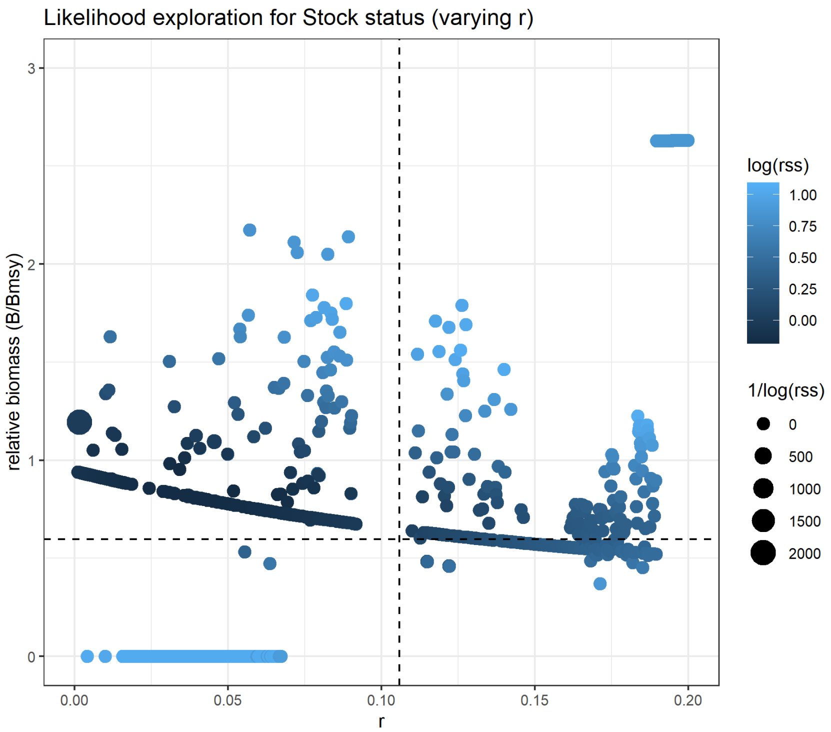


Figure 30. Likelihood exploration for *mpb* models with fixed *r* (penalty function) and estimated stock status at terminal year.

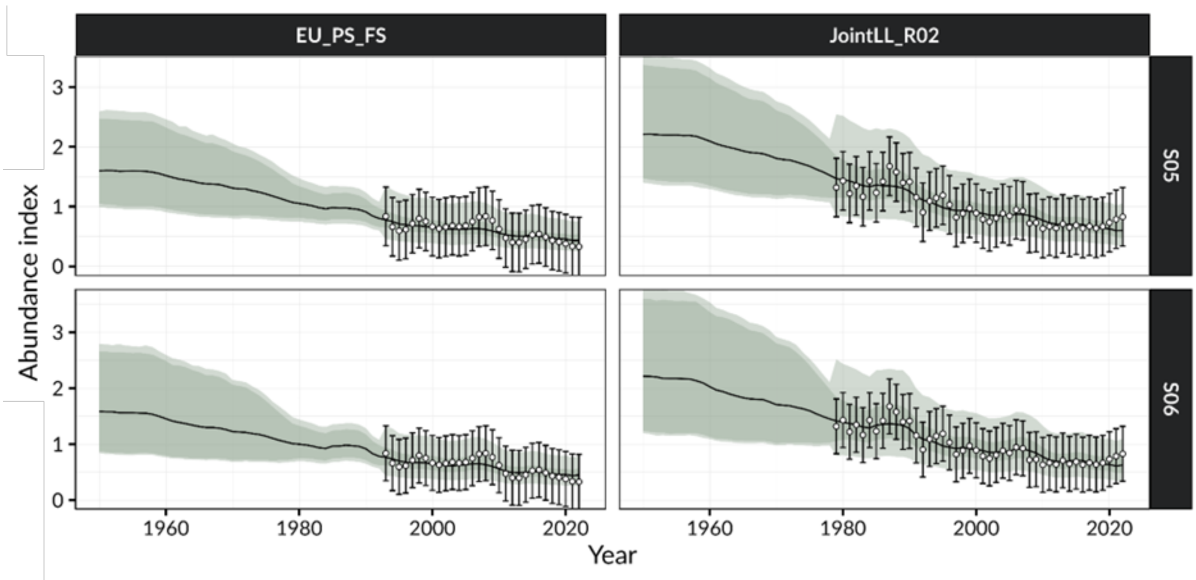


Figure 31. JABBA time-series of observed (circle and SE error bars) and predicted (solid line) CPUE for scenarios S05 and S06 for the Atlantic yellowfin tuna. Shaded grey area indicates 95% credibility intervals. S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

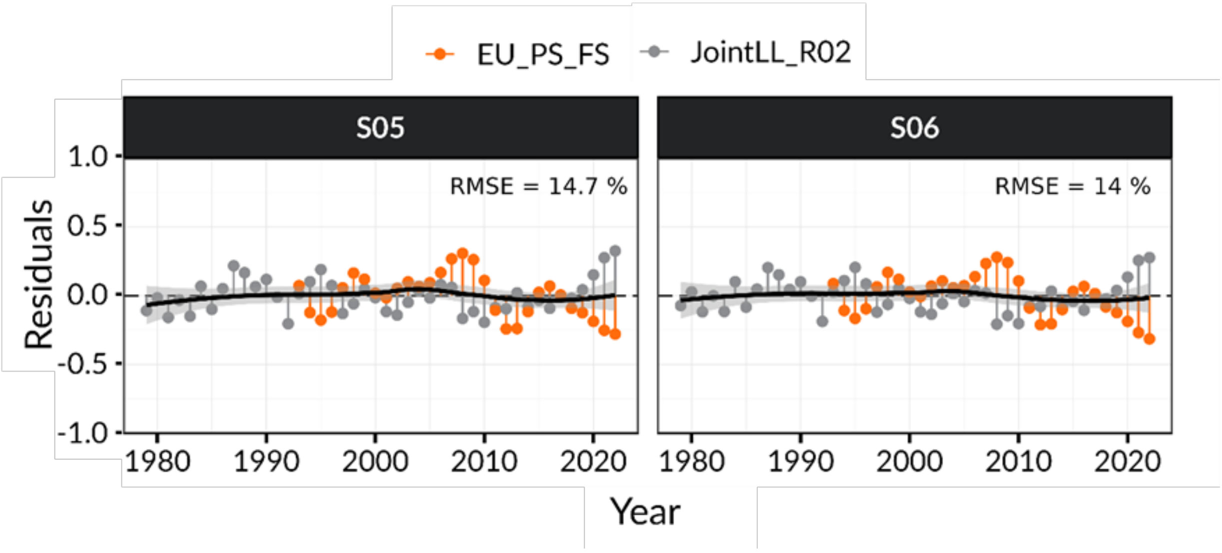


Figure 32. JABBA residual diagnostic plots for alternative sets of CPUE indices (dark gray: JointLL_R02, orange: EU_PS_FS) examined for scenarios S05 and S06 for the Atlantic yellowfin tuna. Influence plots indicate the residuals available for any given year, and solid black lines indicate a loess smoother through all residuals and the shaded grey area indicates standard error of the smoother. S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

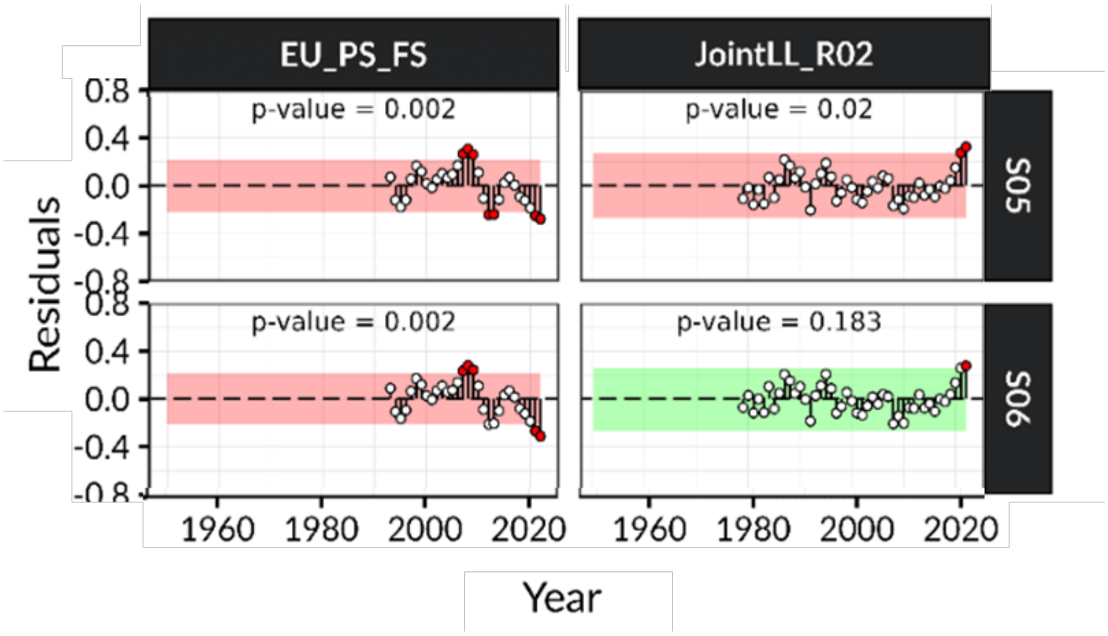


Figure 33. JABBA runs tests to quantitatively evaluate the randomness of the time series of CPUE residuals by fleet for scenarios S05 and S06 for the Atlantic yellowfin tuna. Green panels indicate no evidence of lack of randomness of time-series residuals (p>0.05) while red panels indicate the opposite. 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). S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

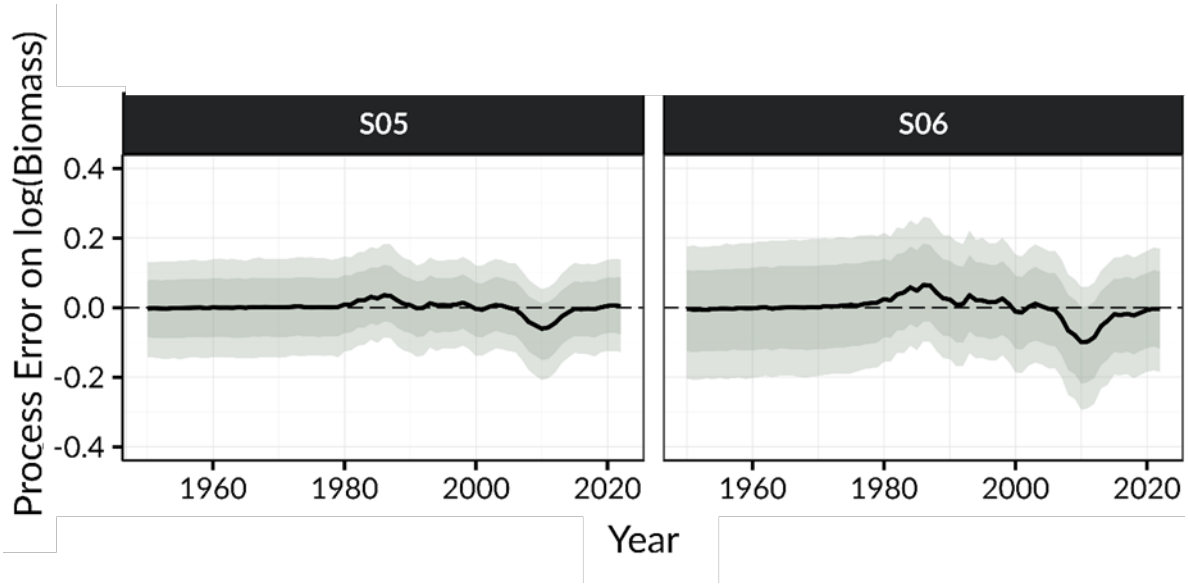


Figure 34. JABBA process error deviates between the deterministic expectation and the stochastic realizations of the predicted log biomass (median: solid line) for scenarios S05 and S06 for the Atlantic yellowfin tuna. The shaded grey area indicates the 80% and the 95% credibility intervals. S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

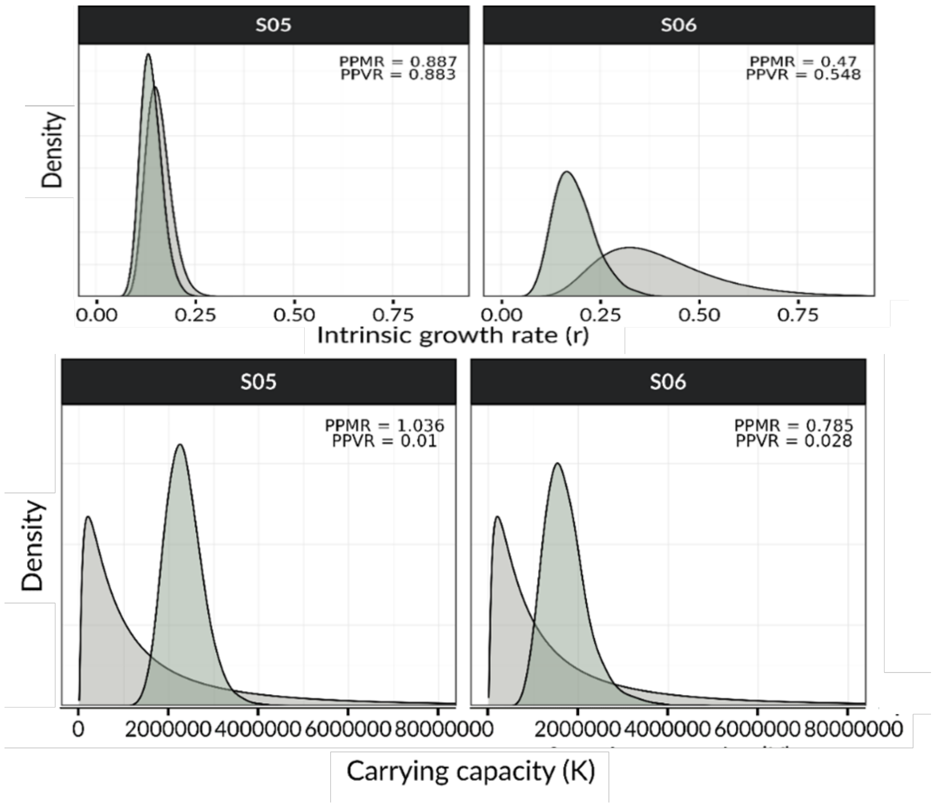


Figure 35. JABBA prior and posterior distributions of r (upper panels) and K (bottom panels) parameters for scenarios S05 and S06 for the Atlantic yellowfin tuna. PPMR: Posterior -Prior Mean Ratio; PPVR: Posterior-Prior Variance Ratio. S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

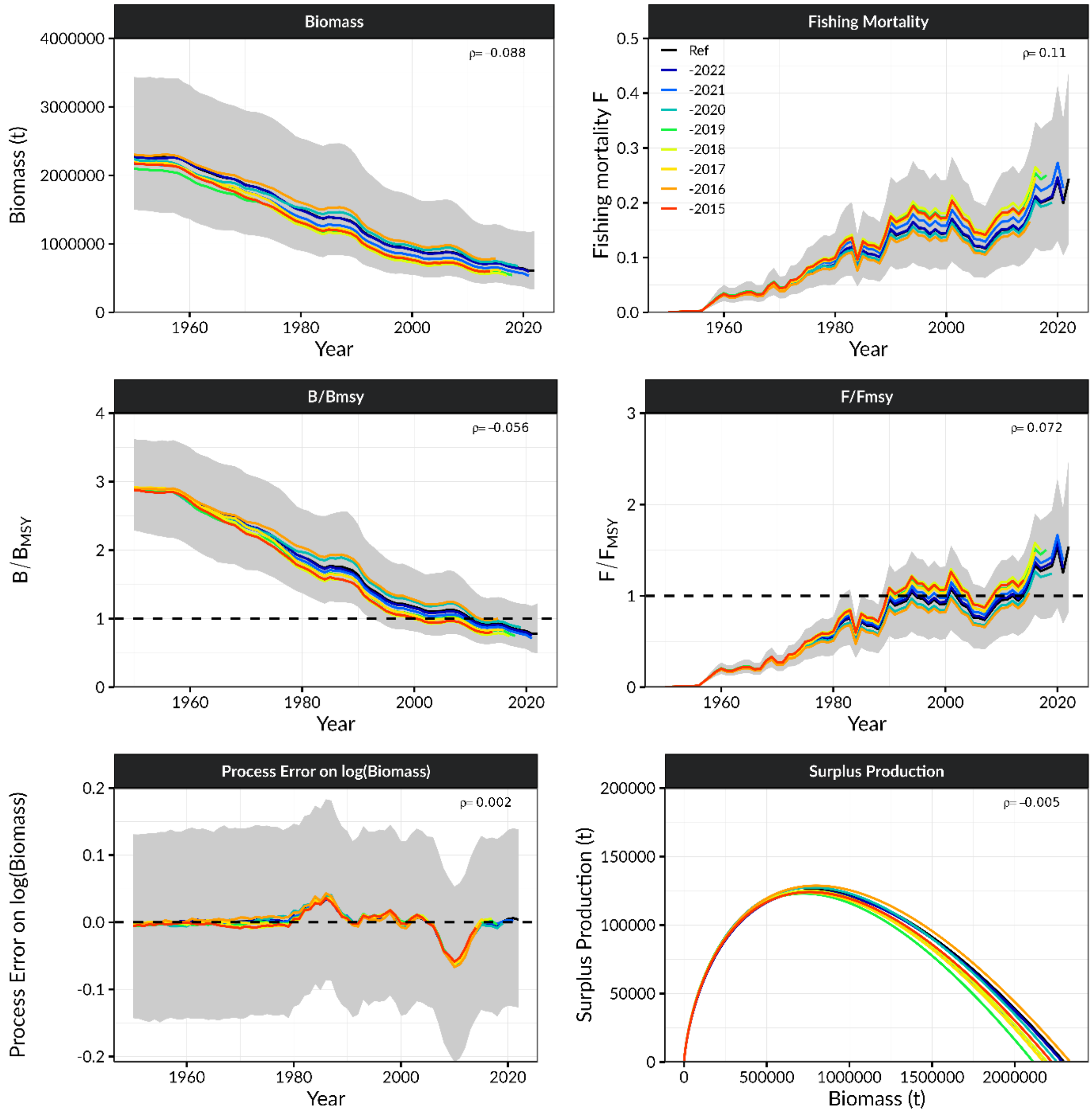


Figure 36. JABBA retrospective analysis of S05, a continuity run, for stock biomass (t), surplus production function (maximum = MSY), B/B_{MSY}, and F/F_{MSY} for the Bayesian state-space surplus production model JABBA for Atlantic yellowfin tuna. The label "Ref" indicates the S05 fits to the entire time series 1950-2022. The numeric year label indicates the retrospective results from the retrospective 'peel', sequentially excluding CPUE data back to 2015.

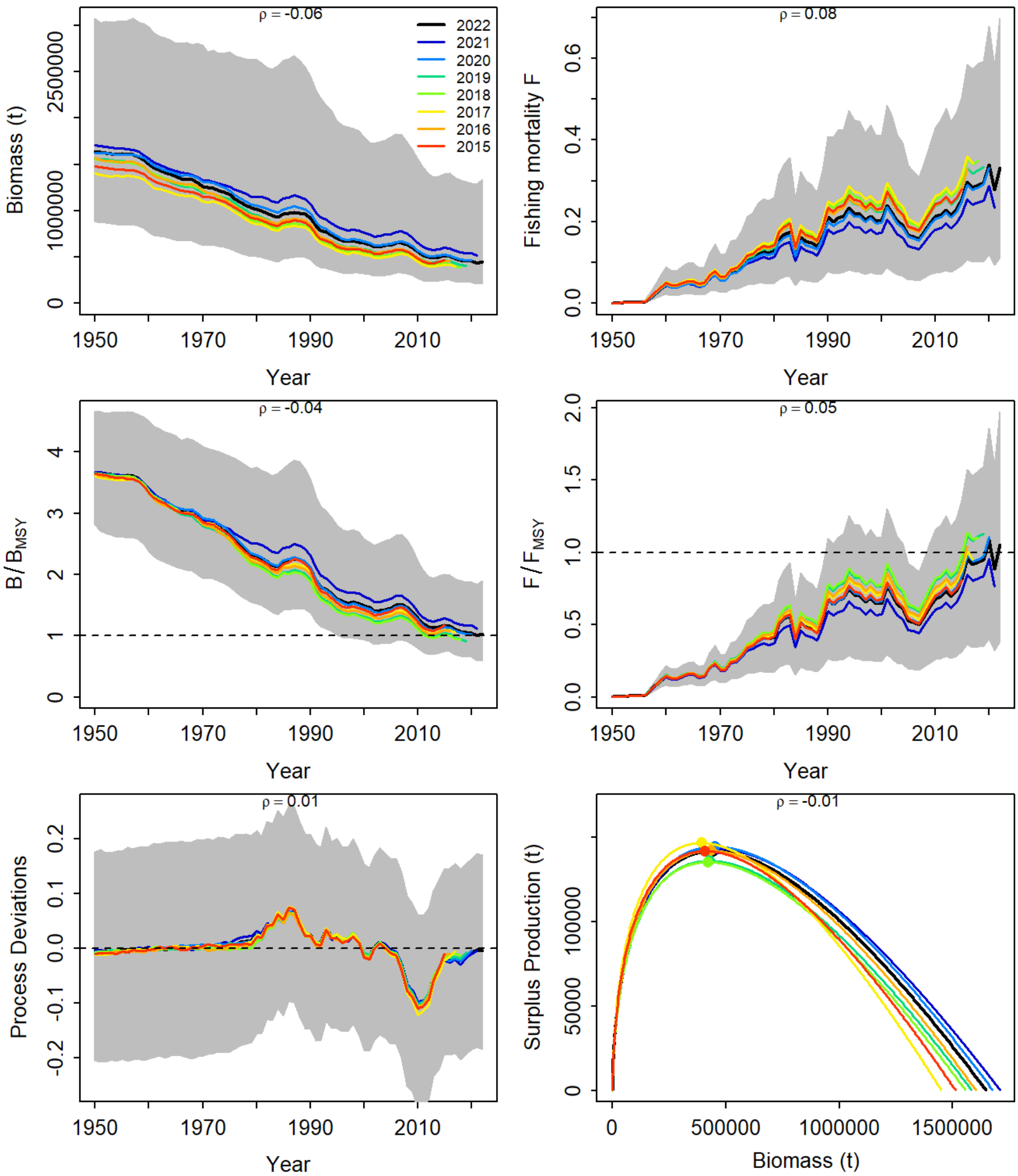
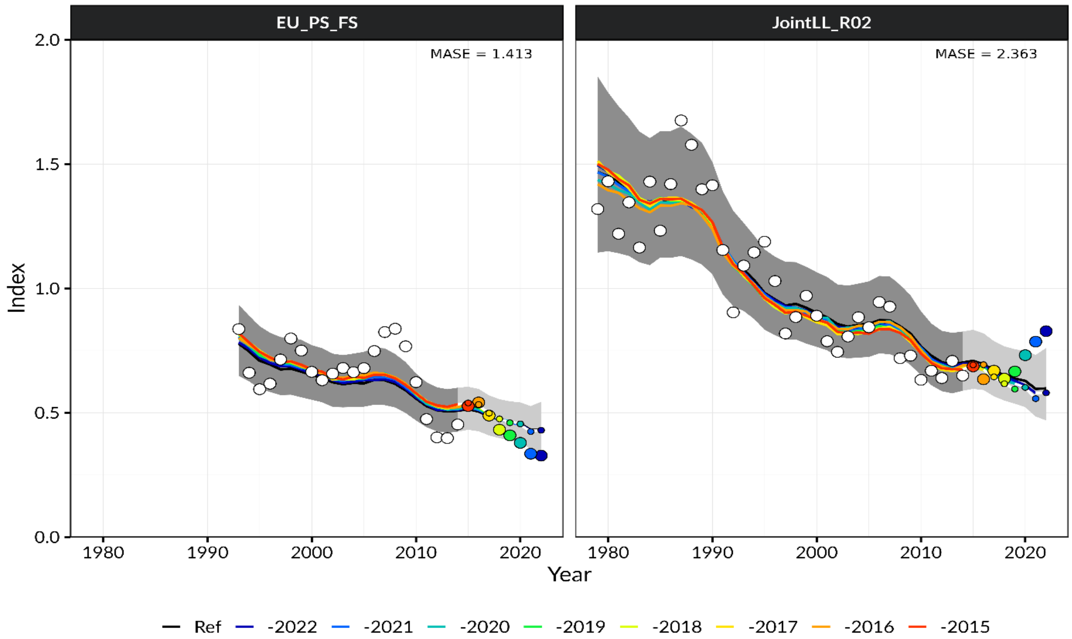


Figure 37. JABBA retrospective analysis of the preliminary reference case (S06) for stock biomass (t), surplus production function (maximum = MSY), B/B_{MSY}, and F/F_{MSY} for the Bayesian state-space surplus production model JABBA for Atlantic yellowfin tuna. The label "2022" indicates the S06 fits to the entire time series 1950-2022. The numeric year label indicates the retrospective results from the retrospective 'peel', sequentially excluding CPUE data back to 2015.

S05



S06

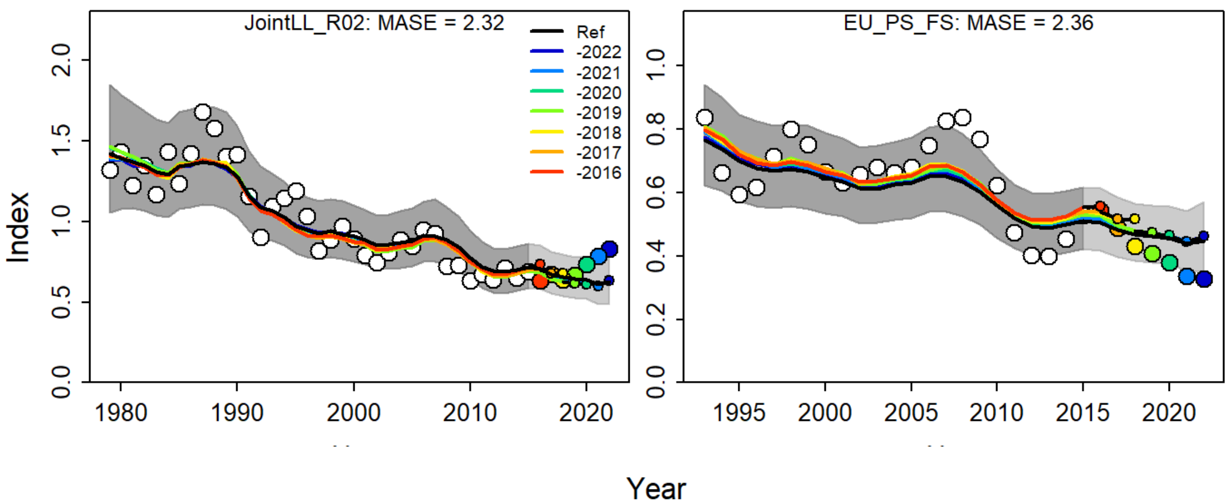


Figure 38. JABBA hindcasting cross-validation results for scenarios S05 (upper panels) and S06 (bottom panels) for the Atlantic yellowfin tuna, showing one-year-ahead forecasts of CPUE values (2015-2022), performed with eight hindcast model runs relative to the expected CPUE. The CPUE observations, used 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).

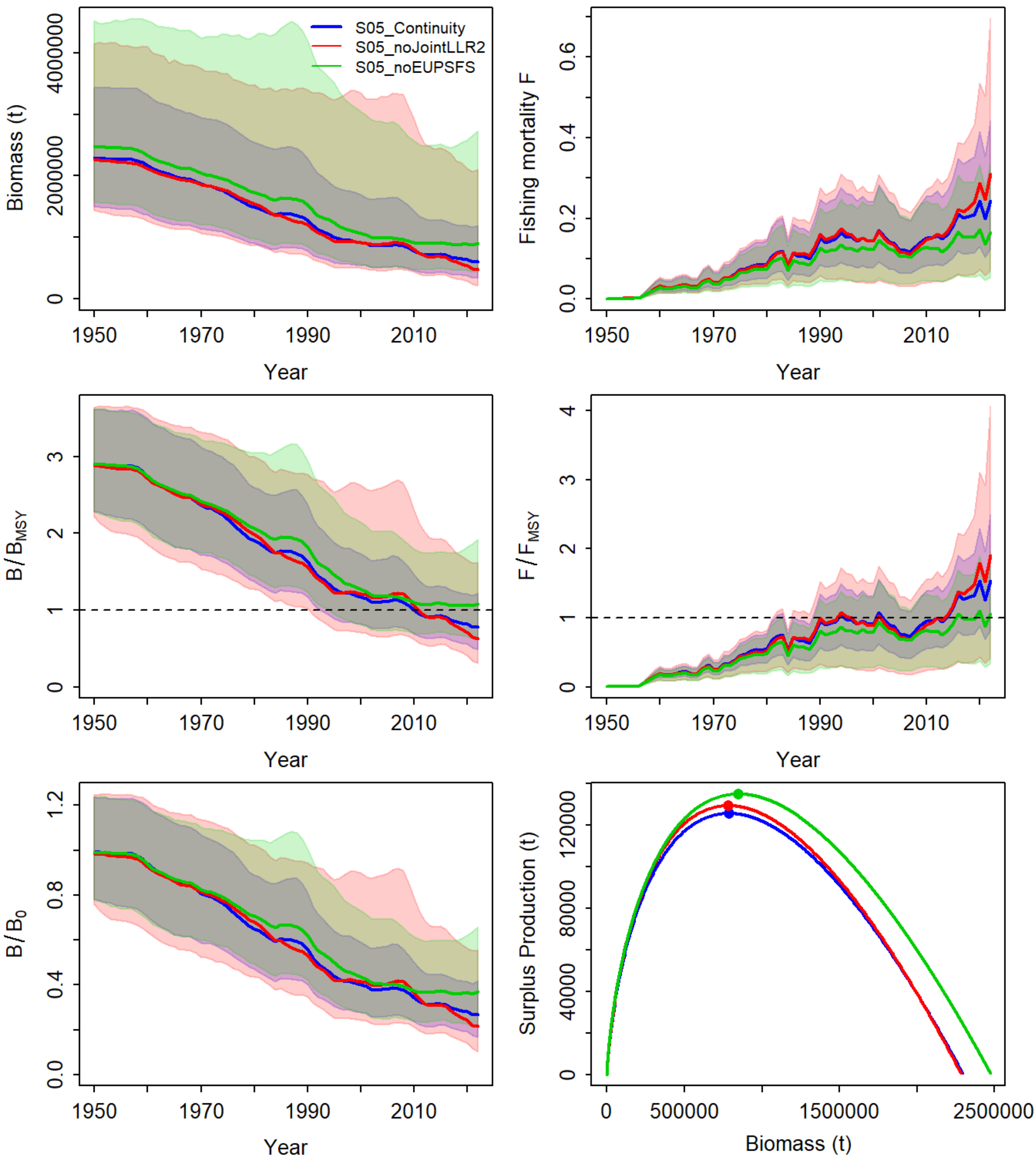


Figure 39. Jackknife index analysis performed on S05, a continuity run, by removing one index at a time and predicting the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and biomass relative to K (B/K) and surplus production curve (bottom panels).

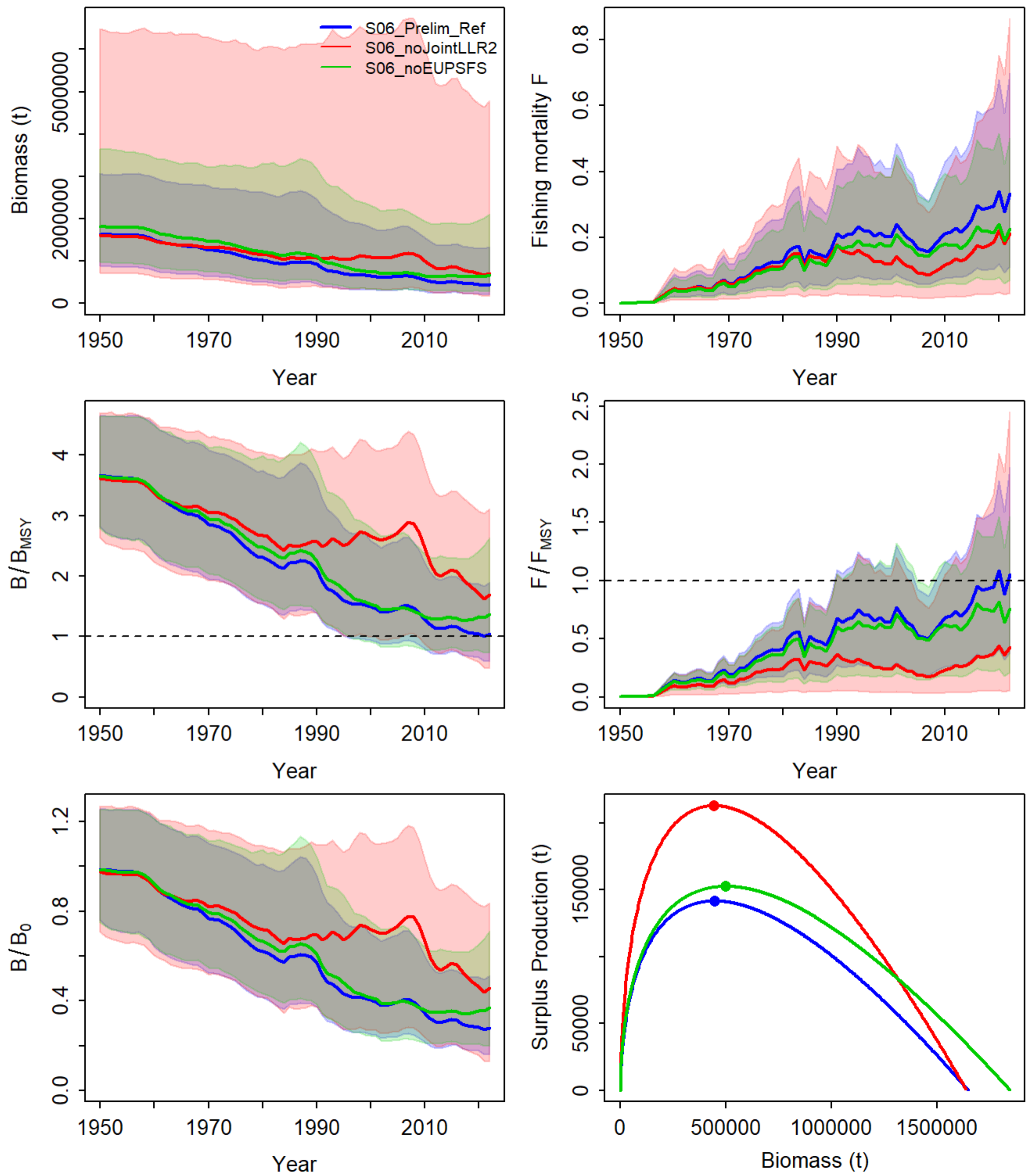


Figure 40. JABBA jackknife index analysis performed on S06, the preliminary reference case, by removing one index at a time and predicting the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and biomass relative to K (B/K) and surplus production curve (bottom panels).

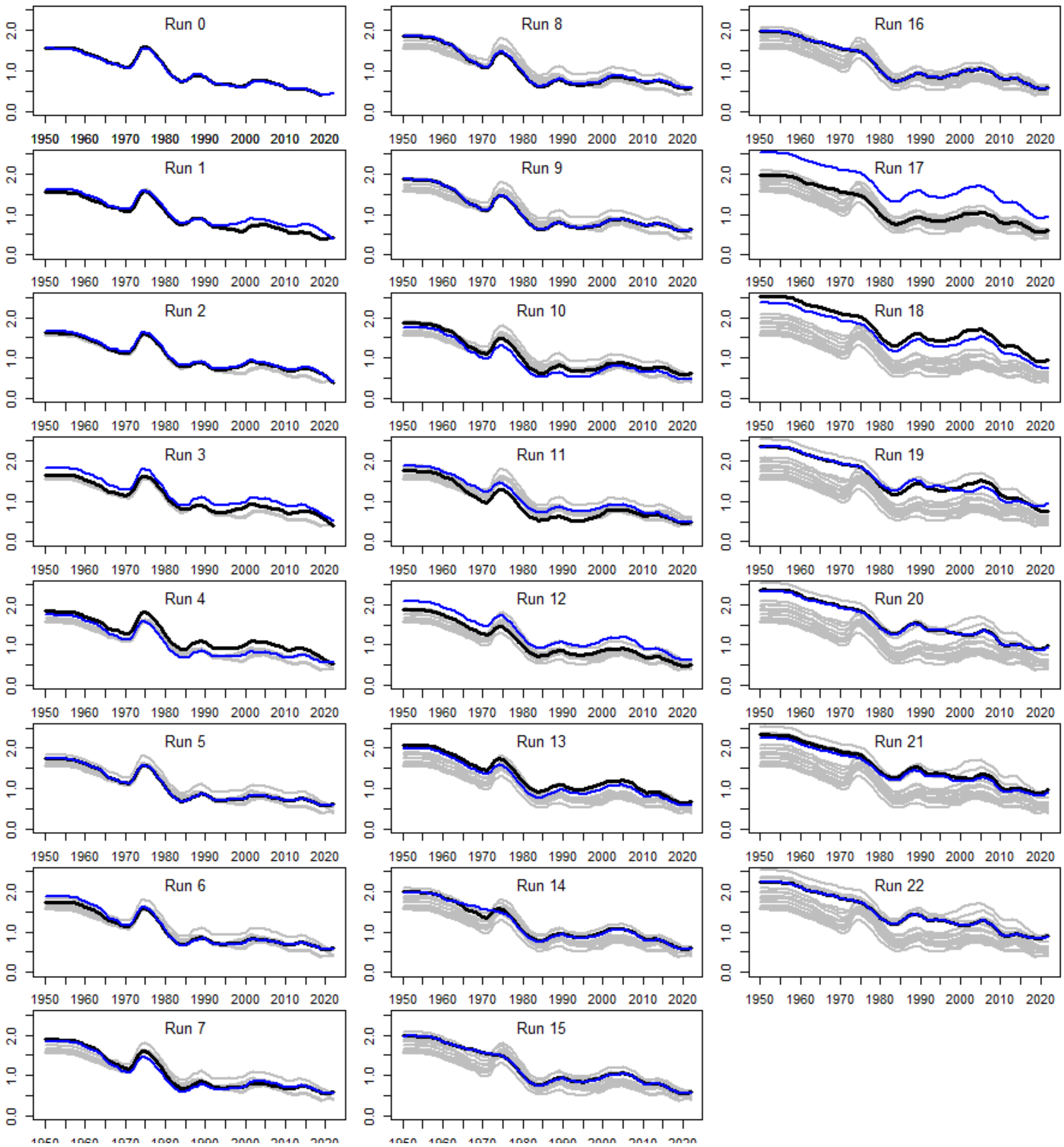
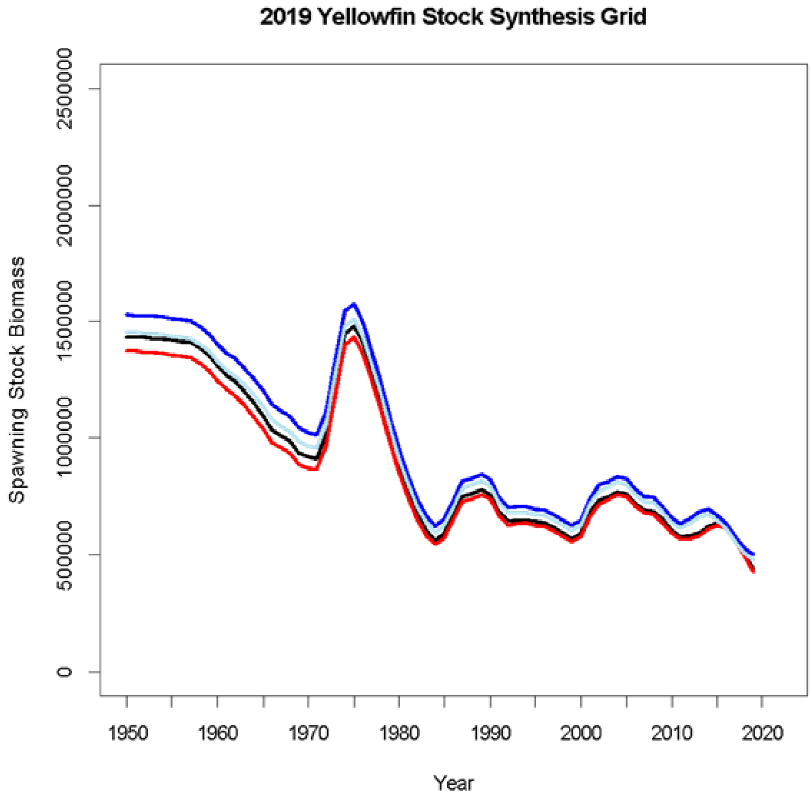


Figure 41. Plots of Atlantic yellowfin tuna spawning stock biomass across iterative Stock Synthesis model runs. The blue line shows the estimates from the current model run listed, the black line shows the estimates from the prior run, and the gray lines show the estimates from all previous runs in the step-wise build of the reference case model.



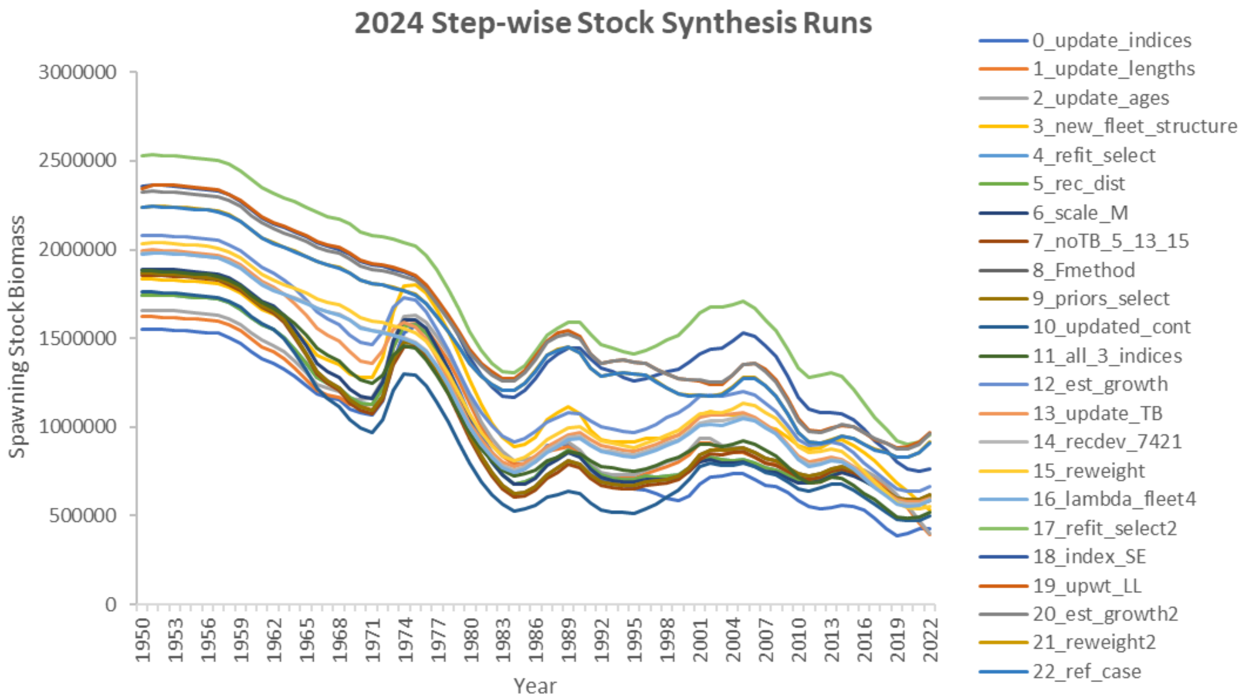


Figure 42. Comparison of spawning stock biomass trajectories from the 2019 Stock Synthesis uncertainty grid (upper panel) versus the alternative step-wise model runs conducted in 2024.

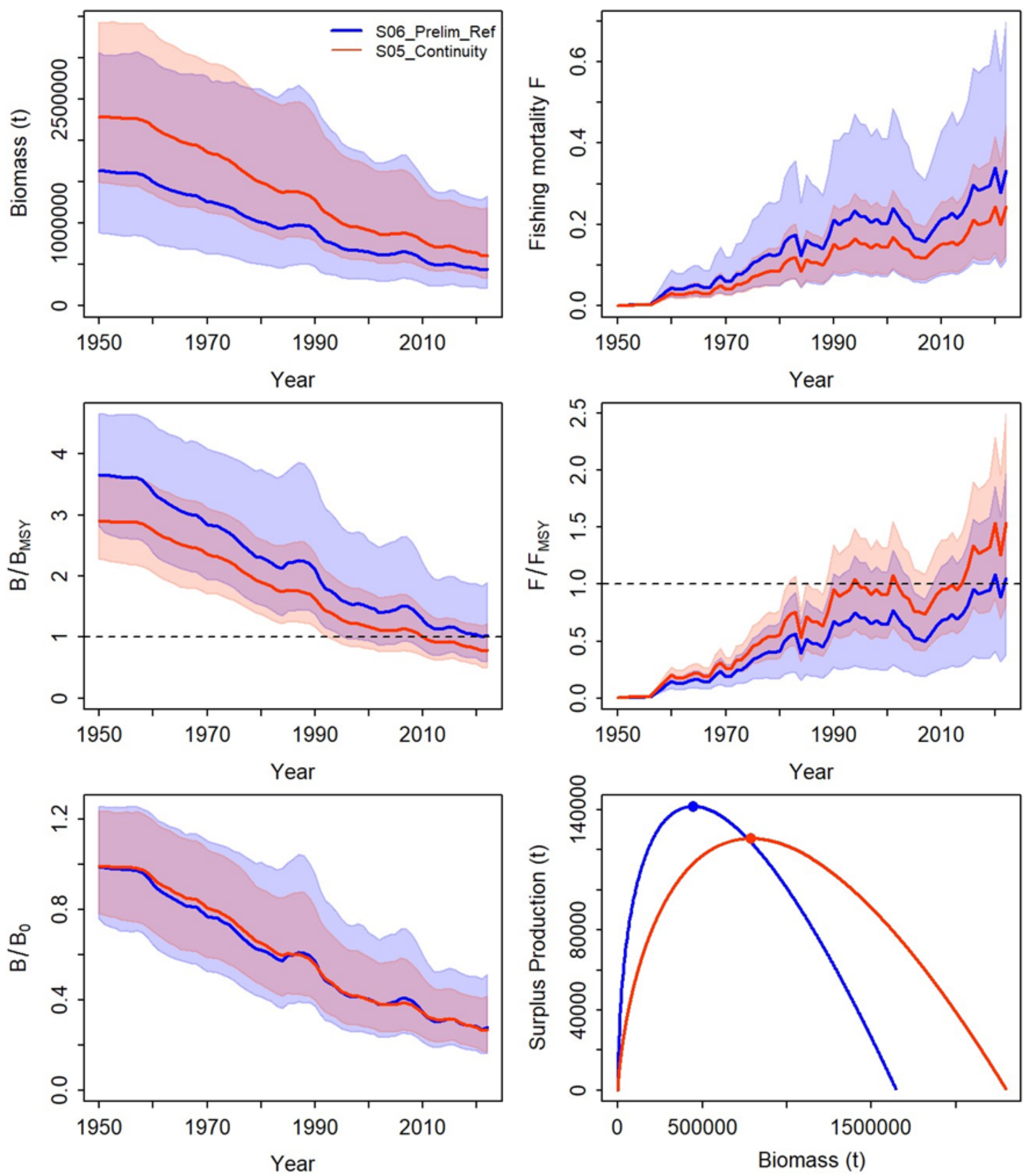


Figure 43. Comparison of JABBA stock assessment estimates for the Atlantic yellowfin tuna in scenarios S05 (red) and S06 (blue), showing trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and biomass relative to K (B/K) and surplus production curve (bottom panels). S05 is the continuity run of the 2019 JABBA final model and S06 is the preliminary JABBA reference case.

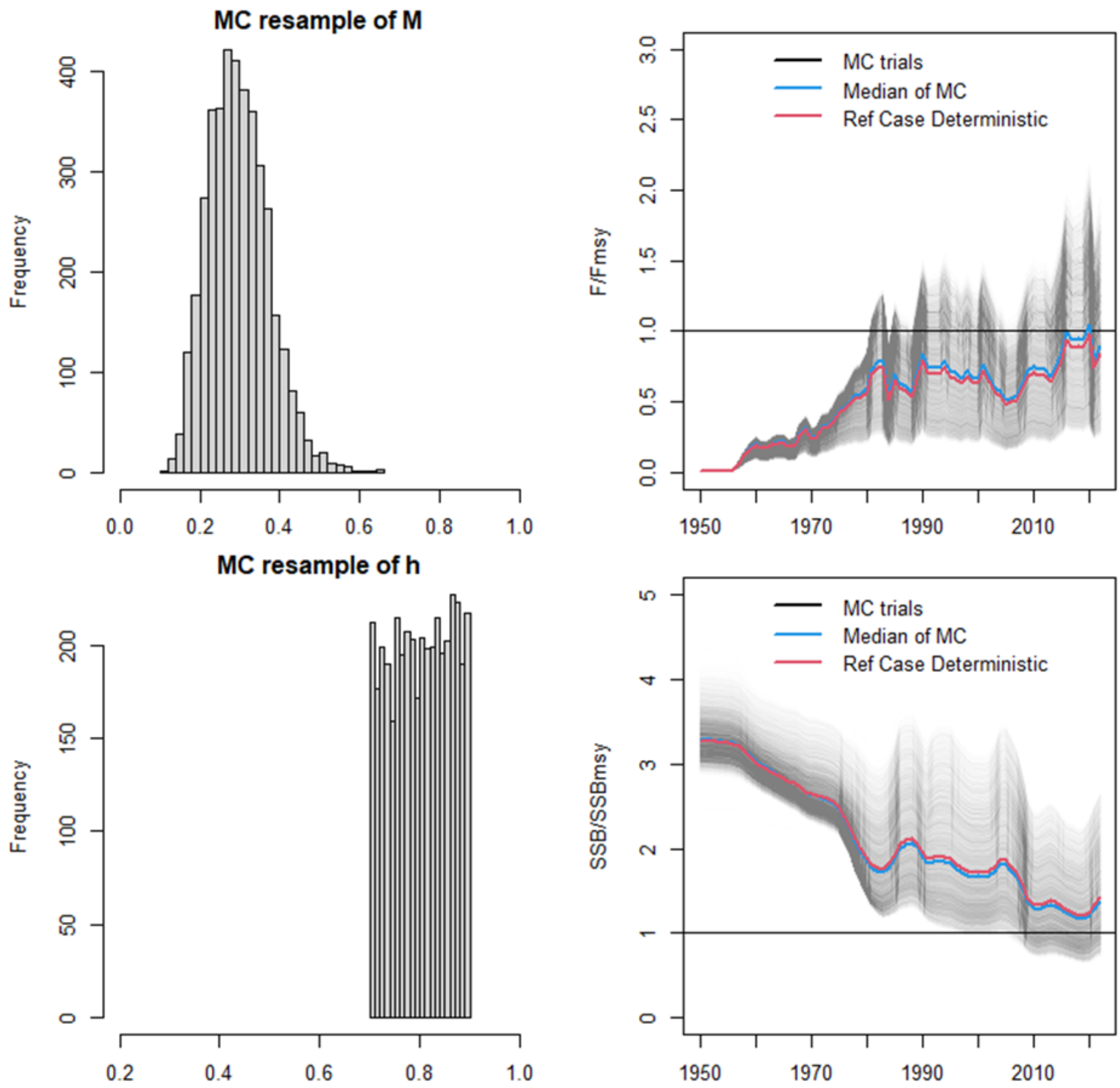


Figure 44. Monte Carlo analysis on the Stock Synthesis reference case. Monte Carlo resamples (left panels) of natural mortality (M) parameter from a lognormal distribution (mean =0.3, sd = 0.31) and of steepness (h) parameter from a uniform distribution between 0.7 and 0.9. F/F_{MSY} and SSB/SSB_{MSY} trajectories (right panels) across 4000 iterations (grey lines) of the Stock Synthesis reference case with alternative M input based on Monte Carlo resampling. The median of 4000 iterations and the deterministic result are shown in blue and red, respectively.

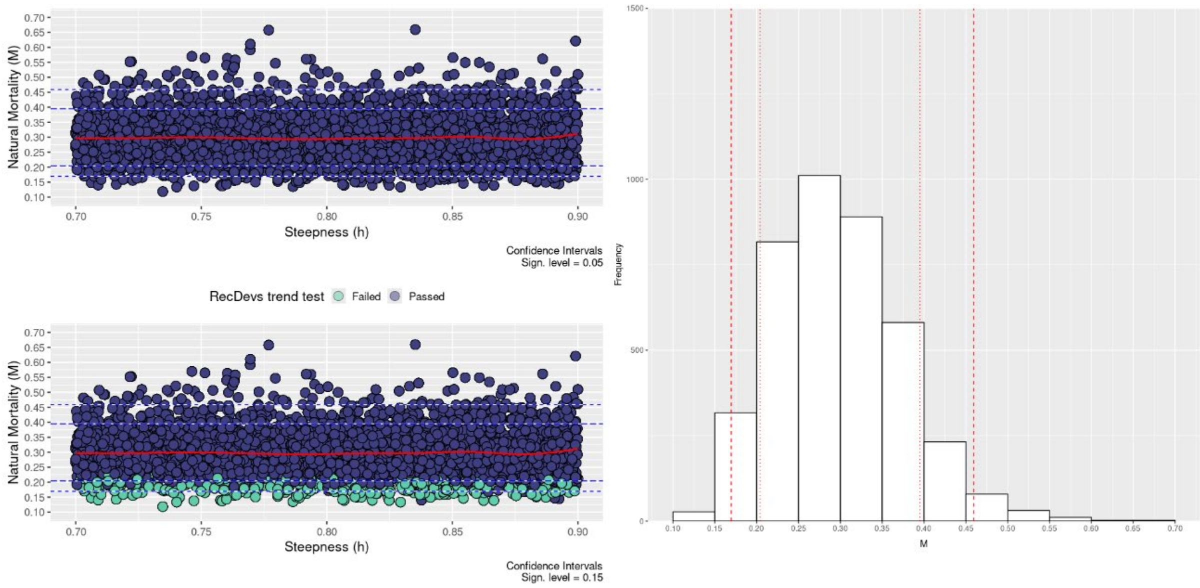


Figure 45. Monte Carlo models hypothesis test of having recruitment deviates without a trend in the combinations of steepness and natural mortality used in the 4000 MC runs. Significant levels for the hypothesis test are 0.05 (upper left panel) and 0.15 (bottom left panel) with 80% and 95% confidence intervals (blue dashed horizontal lines). The blue points mean runs pass the test, while the green points show the opposite. The red lines show a loess smoother through all residuals. The right panel shows the sampling distribution for the M values from 4000 MC iterations with 80% and 95% confidence intervals (red dashed vertical lines).

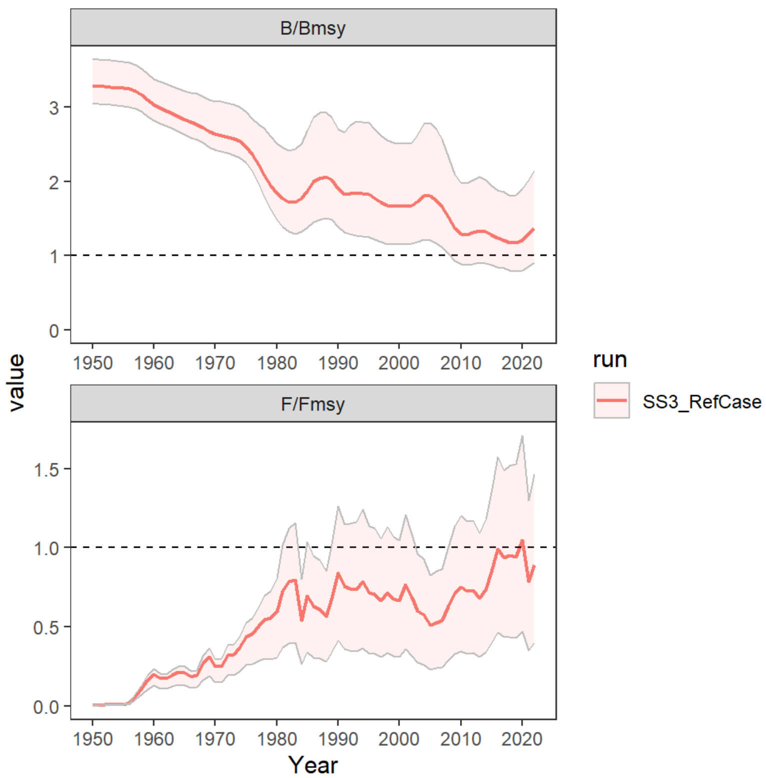


Figure 46. Annual trends of relative biomass (B/B_{MSY}) and fishing mortality (F/F_{MSY}) from the Stock Synthesis reference case for Atlantic yellowfin tuna. The dark line indicates the median of 4000 iterations and the shaded area is the overall 80% confidence bounds of the results.

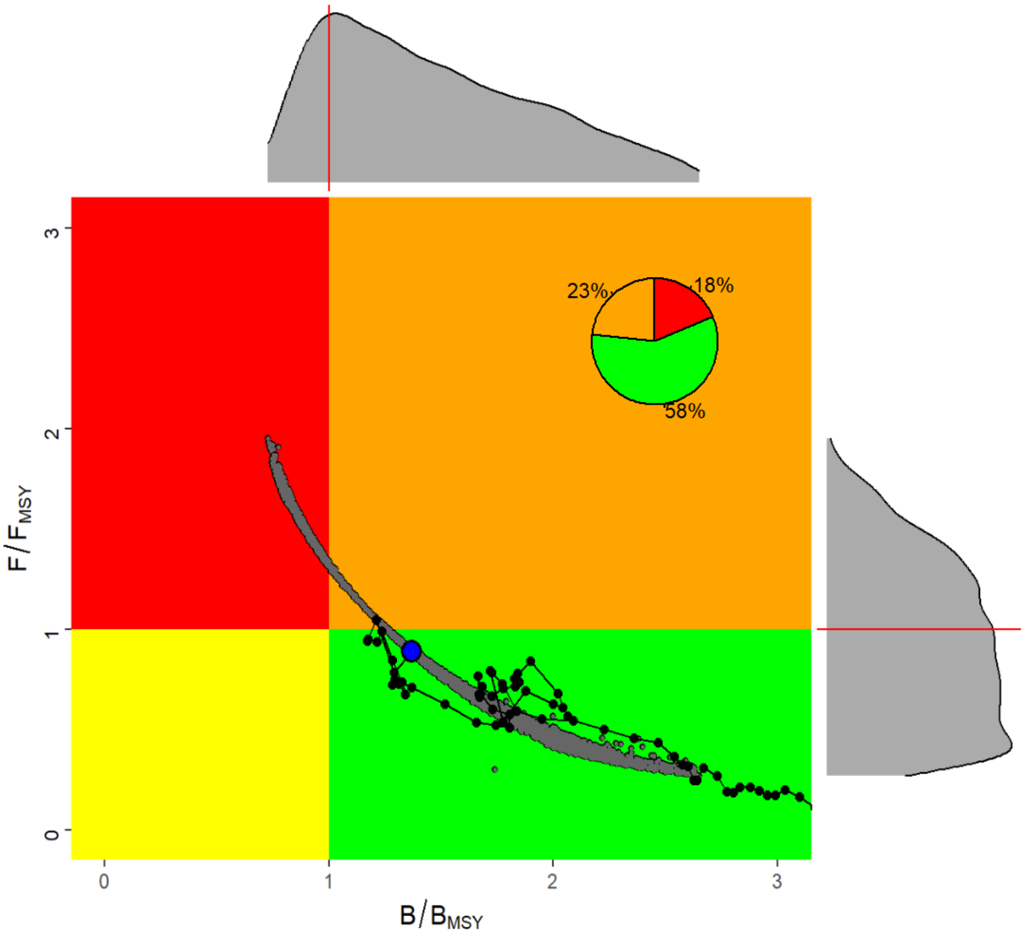


Figure 47. Kobe plot for the 2024 Atlantic yellowfin tuna Stock Synthesis reference case Monte Carlo (4,000 iterations). The line indicates the stock status trajectory starting in 1958. The inserted pie indicates the proportion of MC trials within each Kobe color quadrant, 58% in the green quadrant, 23% in the orange quadrant, and 18% in the red quadrant.

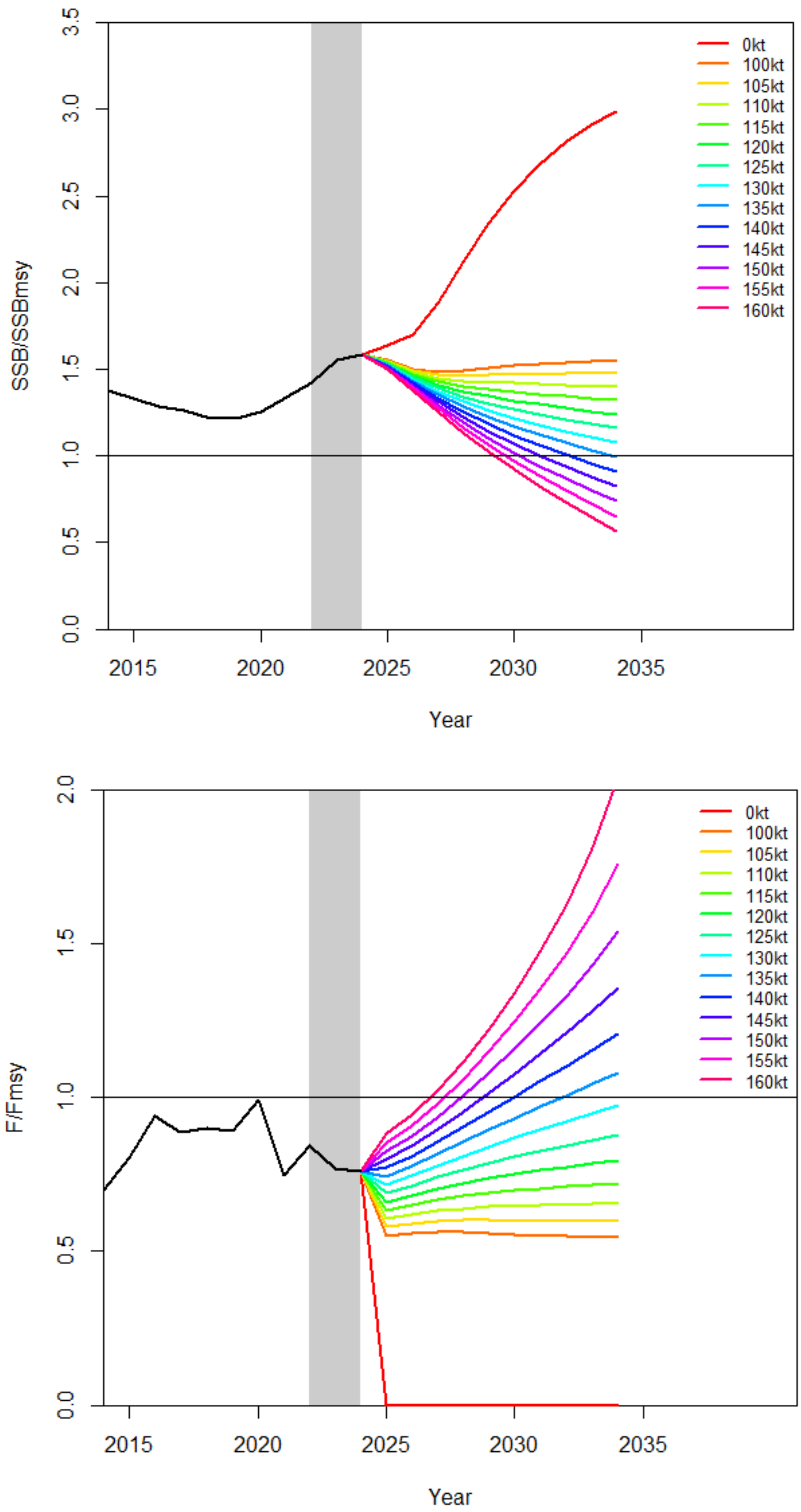


Figure 48. Trends of relative biomass (SSB/SSB_{MSY}, top panel) and fishing mortality (F/F_{MSY}, bottom panel) from preliminary projections (deterministic) of Atlantic yellowfin tuna under different TAC scenarios from the Stock Synthesis reference case. Stock biomass showed the value at the end of the year.

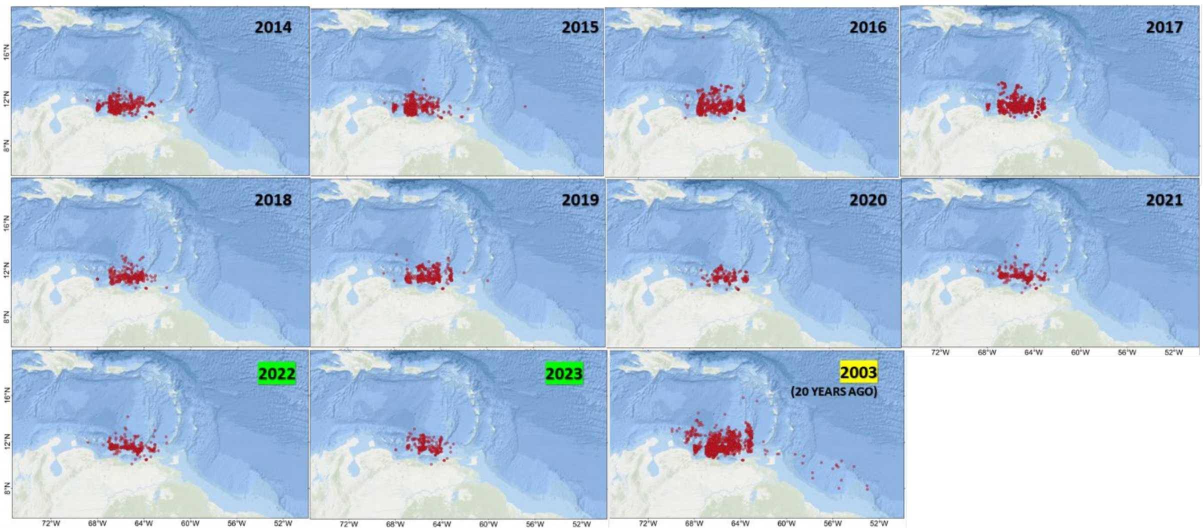


Figure 49. Spatial distribution of Venezuelan purse seine total fishing sets for the last 10 years (2014-2023) compared with the distribution of 20 years ago (2003).

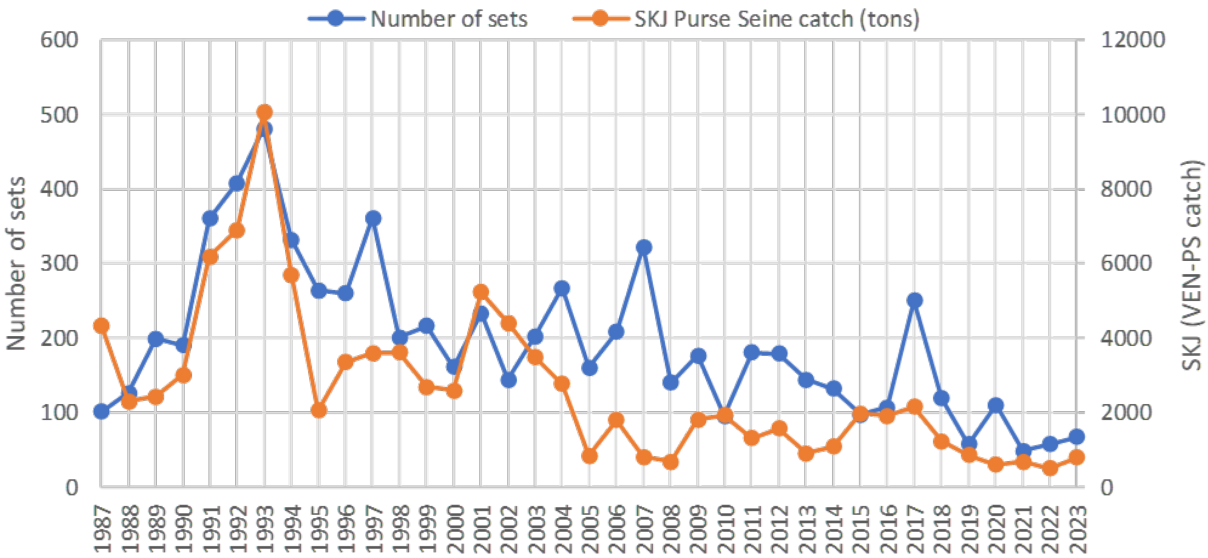


Figure 50. Number of total sets by year of Venezuelan purse seiners and their skipjack tuna total catch (tons).

Appendix 1

Agenda

1. Opening, adoption of agenda, meeting arrangements and assignment of rapporteurs

2. Summary of input data for stock assessment

    2.1 Biology
    2.2 Catches
    2.3 Size
    2.4 Fleet structure

3. Methods and model settings

    3.1 Stock Synthesis
    3.2 Surplus production models

4. Model diagnostics

    4.1 Stock Synthesis
    4.2 Surplus production models

5. Model results

    5.1 Stock Synthesis
    5.2 Surplus production models

6. Stock Status and projections

7. Tropical tunas MSE process

    7.1 Western skipjack MSE
    7.2 Tropical tunas multi-stock MSE
    7.3 Update MSE roadmap

8. Workplan to prepare the Responses to the Commission

    8.1 SKJ-W MSE
    8.2 Update MSE roadmap
    8.3 Regarding advice on the maximum number of FAD sets
    8.4 Panel 1 questions

9. Recommendations

    9.1 Research and statistics
    9.2 Management Advice (YFT Executive Summary)

10. Tropical Tuna Research and Data Collection Program (TTRaD)

11. Other matters

12. Adoption of the report and closure

Appendix 2

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Appendix 3

List of documents and presentations

Reference	Title	Authors
SCRS/2024/039	Review and preliminary analyses of catch and size samples of Atlantic yellowfin tuna (*Thunnus albacares*)	Ortiz M., and Kimoto A.
SCRS/2024/110	Atlantic yellowfin tuna stock synthesis population analyses	Lauretta M., Ortiz M., Kimoto A., Sagarese S., Urtizberea A.O., Moron G., Merino M., and Cass-Calay S.
SCRS/2024/111	Atlantic yellowfin tuna stock synthesis population analyses: sensitivity exploration and proposal for a reference grid with diagnostics	Merino G., Lauretta M., Ortiz M., Kimoto A., Sagarese S., Urtizberea A., Morón-Correa G., and Cass-Calay S.
SCRS/2024/113	Atlantic Yellowfin tuna stock assessment using a Biomass Dynamic Model	Merino G., Urtizberea A., Moron-Correa G., and Santiago J.
SCRS/2024/114	Preliminary Atlantic Yellowfin tuna stock assessment in 2024: An implementation of Bayesian state-space Surplus Production Model using JABBA	Sant'Ana R., Kimoto A., Kikuchi E., Cardoso L.G., Mourato B., and Ortiz M.
SCRS/2024/115	Development State of the Western Atlantic Skipjack tuna MSE Process in June 2024	Sant'Ana R., Mourato B.
SCRS/2024/116	Potential improvements to the Atlantic Yellowfin tuna stock assessment model from Age Structured Production Model (ASPM) analysis	Ijima H.
SCRS/2024/117	Update on standardized catch rates for skipjack tuna (*Katsuwonus pelamis*) from the Venezuelan purse seine fishery in the Caribbean Sea and adjacent waters of the western Central Atlantic for the period of 1987-2023	Narváez M., Evaristo E., Marcano J.H., Gutiérrez X., and Arocha F.
SCRS/2024/118	Incorporating Climate Change effects in the management strategy evaluation for Atlantic Tropical tunas	Correa G.M., Urtizberea A., Merino G., Erauskin-Extramiana M., and Arrizabalaga H.
SCRS/2024/119	Revision of historical catch statistics of bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*) caught by the Mexican fishing fleet in the Gulf of Mexico	Ramirez-Lopez K., Rojas-Gonzales R.I., and Mayor C.
SCRS/2024/120	Updated Catch at Size estimates for the Chinese Tropical Tunas longline fishery in 2015 - 2021	Ji F., Fan Z., Jiangfeng Z., and Feng W.
SCRS/2024/121	Preliminary estimates of natural mortality using the AOTTP conventional tagging data	Ailloud L.
SCRS/2024/122	Update relative abundance index of Western Atlantic skipjack tuna caught by Brazilian baitboat fleet in Southwestern Atlantic Ocean	Sant'Ana R., Mourato B.L., Kikuchi E., Cardoso L.G., and Travassos P.
SCRS/2024/124	Etude comparée de l'âge déterminé à partir de l'otolithe, l'épine dorsale et la vertèbre de *Thunnus albacares*	Agnissan A. R., Diaha N.C., Ailloud L., Coulibaly D., Doffou Y. C., and N'da K.
SCRS/P/2024/081	Harvest control rule options for multi-stock tropical tuna MSE: Demersal fisheries Bay of Biscay case study	Urtizberea A., Garcia D., Correa G.M., Laborda A., Arrizabalaga H., and Merino G.

SCRS/P/2024/087	Yellowfin tuna - Overview of statistical data updates (1950 - 2023)	Fiorellato F.
SCRS/P/2024/088	Updated yellowfin tuna catch-at-size (CAS YFT 1960-2022), with guidance on a systematic (automatic) approach	Palma C., Mayor C., Ortiz M., and Fiorellato F.
SCRS/P/2024/094	Tropical Tuna Research and Data Collection Plan (update)	Wright S.
SCRS/P/2024/095	Strict update of the US Pelagic Longline index for West Atlantic skipjack	Lauretta M.

Appendix 4

SCRS Document Abstracts as provided by the authors

SCRS/2024/039 - Catch and size sampling data of Atlantic yellowfin tuna were reviewed, and preliminary analyses were performed for its use within the stock evaluation models. Catch and size data is normally submitted to the Secretariat by CPCs under the Fishery Statistics requirements. Catch data were reviewed and estimated for the fleet structure ID used at the 2019 yellowfin stock assessment. The size samples data was revised, standardized, and aggregated to size frequency samples by main fishery/gear type, year, and quarter. Preliminary analyses indicated a minimum number of 50 fish measured per size frequency sample, with size information since 1970 for the purse seine, baitboat, and longline fishing gears. For Atlantic yellowfin tuna, the size sampling proportion among the major fishing gears is consistent with the proportion of the catch.

SCRS/2024/110 - We present the Stock Synthesis population assessment results of Atlantic yellowfin tuna for the period 1950 to 2022. The recommendations outlined by the SCRS tropical tuna work group at the data preparatory meeting were implemented sequentially as iterative model runs to observe the effect of each change of the continuity model on exploitation rate and biomass estimates. A provisional reference case is presented with a suite of diagnostics. The reference case model structure is fully compatible with the Atlantic bigeye and East Atlantic skipjack Stock Synthesis models for integration into the multi-stock management strategy evaluation. The influence of key fixed parameters (steepness and natural mortality) were evaluated using Monte Carlo resampling, for comparison with the uncertainty grid approach.

SCRS/2024/111 - Following the presentation of the Stock Synthesis population assessment results of Atlantic yellowfin tuna for the period 1950 to 2022, we develop additional exploratory analyses and a proposal for a reference grid. We propose a 9 models reference grid including three options for steepness (0.7, 0.8 and 0.9) and three options for the natural mortality vector (0.25, 0.3 and 0.35), assuming maximum ages for the population of 21.6, 18 and 15.4 years respectively. We show a summary of the diagnostic tests applied to each model and a full table in the appendix. We propose that models with reasonable diagnostics are accepted for the reference grid developed for management advice. The diagnostics shown in this document could potentially be the basis for a model weighting scheme to assign higher weights to models that perform better than others. In addition, we show additional sensitivity analyses to help understand the reference model proposed for this assessment.

SCRS/2024/113 - We present a preliminary stock assessment using the biomass dynamic model (mpb). We show the estimated trends and reference point with a series of diagnostics of fit and additional likelihood exploratory analyses. Our analysis suggests that sudden short-term changes in abundance indices are difficult to fit and explain. These results are a start point for the stock assessment of yellowfin and will be further explored during the stock assessment session in July 2024. The reference model proposed here estimates that the stock is overfished and subject to overfishing with very high probability.

SCRS/2024/114 - Bayesian State-Space Surplus Production Models were fitted to yellowfin tuna catch and standardized catch-per-unit-effort (CPUE) data using the open-source stock assessment tool JABBA. Following the recommendations at the yellowfin data preparatory meeting in April 2024, we present a continuity run based on the 2019 final JABBA model and the preliminary reference JABBA model results applying the joint longline index in Region 2 and EU PS free school index, with some other sensitivity runs. In the preliminary reference case, r prior was calculated using the preliminary reference point estimates from the 2024 Stock Synthesis preliminary model using steepness 0.8. The continuity run and the preliminary reference JABBA model showed similar stock status trajectories that resembled the typical characteristics of a one-way downhill trip. The preliminary reference model showed that the most recent fishing mortality and biomass were estimated at around MSY levels. The stock status estimates of these scenarios were associated with very high uncertainty, which may be partially explained by the lack of contrast in the continuously declining biomass trend containing limited information about productivity.

SCRS/2024/115 - This document describes proposed updates to the western Atlantic Skipjack tuna Management Strategy Evaluation process including the revisions to operating models and management procedures. Operating models are now using a relative abundance index based on the inverse-variance average weighting across the distinct indices available and, the index-based and model-based management procedures includes a tune parameter that could allow the maximization of the yields until a desired level. It also implemented asymmetrical decision rules also for both classes of MPs. Due to the dependence on updated data to adjust the final simulations, this exercise also used past data and, therefore, these results cannot be interpreted as possible final results.

SCRS/2024/116 - This study used the Stock Synthesis 3 model (Model 22) for Atlantic yellowfin tuna and organized the Age Structured Production Model (ASPM) analysis results. The ASPM analysis showed a large discrepancy between the ASPM-estimated CPUE and the input CPUE, especially in the late period (2005-2022). On the other hand, ASPM-R, which estimated recruitment deviation, showed a relatively good fit. These results suggest that the selectivity settings of the SS3 model and the input data, such as CPUE and size composition, need to be improved. Additionally, a standardized CPUE based on fish size and the fleet definition could be reexamined in the future.

SCRS/2024/117 - An update on the standardized index of relative abundance for skipjack tuna (*Katsuwonus pelamis*) was estimated using Generalized Linear Models approach assuming a delta lognormal model distribution. For this, logbook registers were used (1987-2023), considering as categorical variables year, season/quarter, area, association with whales, association with whale shark, seiner capacity, and help (help by bait boat, without help) during the fishing set. As indicators of overall model fitting, diagnostic plots were evaluated. The standardized skipjack tuna catch rate index shows a declining trend since 2015.

SCRS/2024/118 - Climate change will impact fish and shellfish, their fisheries, and fishery-dependent communities through a complex suite of linked processes. In this document, we summarize the current practices to include climate information in management strategy evaluations, the available evidence regarding the potential impacts of climate change on tuna stocks, and the plan to implement the hypothetical impacts of climate change in the multi-stock management strategy evaluation for tropical tunas in the Atlantic Ocean.

SCRS/2024/119 - Through the use of the Information System on the Longline Tuna Fishery in the Gulf of Mexico (SIA) a review of catch and effort records of fishing activities for the capture of yellowfin tuna has been carried out. This has facilitated compliance with management and conservation commitments in collaboration with IMIPAS, PNAAPD and other interested parties. The review of the ICCAT database for bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*) was completed for the period 1993-2021. Updated historical series for bigeye and skipjack are submitted to ICCAT for consideration and adoption.

SCRS/2024/120 - During the yellowfin tuna data preparatory meeting in April 2024, the Secretariat requested that CPCs targeting tropical tuna species update their catch at size estimation information (T2CS) for the purpose of yellowfin tuna stock assessment. This document presents the updated catch at size estimation for the Chinese longline fleet targeting the Atlantic tropical tuna for the period 2015-2021.

SCRS/2024/121 - This paper presents estimates of natural and fishing mortality rates derived from the Atlantic Ocean tropical Tuna Tagging Programme (AOTTP) conventional tagging dataset. Tag recovery data were analyzed using Brownie models as parameterized in terms of instantaneous rates of fishing (F) and natural (M) mortality. Estimates of the tag mixing window (9 months), tag-reporting rate ($\lambda\lambda$=85%), and tag-shedding rate ($\varphi\varphi$=97%) necessary for the analysis were obtained from previously published work. Yearly time steps were used, with F and M assumed constant across years and continuous throughout each year. The total mortality rate was estimated at 0.44 $yyyy{-}1$, with M estimated at 0.35 $yyyy{-}1$and F estimated at 0.09 $yyyy{-}1$. The estimate of M matches the value currently used in the stock assessment (i.e. obtained using the Then *et al*., 2015 estimator and a maximum age of 18). More conservative assumptions regarding reporting rate and tag-induced mortality resulted in lower estimates of M (0.31-0.34 $yyyy{-}1$) and higher estimates of F (0.10-0.13 $yyyy{-}1$). Though this analysis is very valuable for gaining insight on M independently from the stock assessment and regression approach, many (potentially useful) records had to be removed to adhere to the assumptions of the Brownie model. In order to truly maximize the information content extracted from the AOTTP conventional tagging dataset, a more detailed analysis, perhaps exploring more flexible modeling approaches that are better able to handle the various data subtleties would be greatly beneficial.

SCRS/2024/122 - Catch and effort data from the Brazilian baitboat fishery in the southwestern Atlantic Ocean, from 2000 to 2023, were analyzed in this working paper. The effort was distributed between 19º S and 35º S. Bayesian Spatial-Temporal Hierarchical models using Integrated Nested Laplace Approximations with a Lognormal distribution were used to standardise CPUE series for the stock assessment of the West skipjack stock. The covariates used in the models were: year, quarter, vessels and lat-long squares of 0.5º x 0.5º. The estimated Bayesian Spatial-Temporal lognormal model showed interesting movements of the abundance of the stock. The estimated lognormal index showed three distinct periods. The first one between 2000 and 2012, in general marked by a stable trend over the years, with a pike in the last year of this period. A second period, between 2012 and 2019, marked by a steep one-way downward trend with a small stabilization trend in the last years of this period. And a third period showing a soft increase trend in the recent years.

SCRS/2024/124 - Le but de cette étude est de comparer l'âge de l'albacore (*Thunnus albacares*) déterminé à partir de différentes pièces calcifiées. Ainsi, les structures osseuses notamment les otolithes, les épines et les vertèbres ont été collectées de janvier à décembre 2019, sur des spécimens échantillonnés lors des débarquements de senneurs au port d'Abidjan, mais également des individus marqués à l'oxytetracyline récupérés dans le cadre du projet AOTTP. Après traitement, des lames ont été effectuées pour les différentes structures puis l'âge déterminé à partir des marques annuelles observées. La périodicité des zones translucides de l'épine et de la vertèbre a été estimée par l'analyse des incréments marginaux et par une expérience de marquage-recapture à l'oxytétracycline. La comparaison a été faite à partir des indices de biais et de précisions, des courbes de biais. Les deux méthodes de validation utilisées ont confirmé une formation annuelle de la zone translucide d'Août à Octobre. Les meilleurs indices ont été observés avec l'otolithe, suivi de l'épine dorsale et de la vertèbre. Les estimations d'âge ont été similaires pour les trois structures osseuses seulement pour les individus âgés de 0 à 3 ans. Cependant, il a été surestimé par l'épine dorsale pour les individus âgés de 4 à 5 ans, et sous-estimé à partir de 9 ans. La comparaison de l'âge entre l'otolithe et la vertèbre a montré qu'il n'y avait aucune différence jusqu'à l'âge de 5ans. Les âges dérivés des vertèbres ont été similaires pour des individus de moins de 5ans et sous-estimés chez les poissons de plus 5ans par rapport aux âges déterminés à partir des otolithes.

SCRS/P/2022/081 - This presentation explains the complexity of giving advice to fleets fishing different species based on advice for single species. Two different HCRs were presented: one based on advice for single species following the MSY approach and the other based on multi-stock HCR, using the "pretty good yield" approach. The performance of both HCRs was shown based on demersal fisheries in the Bay of Biscay and Celtic Sea. To understand the impact of these HCRs in the tropical tuna MSE context, a short-cut MSE was developed (without observation error model and without assessment in the MP) with the reference model for each of the species. The results of both simulations were shown with the FLBEIA shiny app.

SCRS/P/2022/087 - The Secretariat reported on the intersessional work done following the data preparatory meeting for the species. It was noted that Task 1 and Task 2 datasets were updated with information received until June 30, 2024, and that these new data resulted almost exclusively in additional nominal catch and size-frequency records (including catch-at-size) for the year 2023, which are still considered preliminary and not included in the assessment.

SCRS/P/2022/088 – The Secretariat presented an update on the yellowfin tuna catch-at-size (CAS) 1960 – 2022 estimation with guidance for a more systematic and automatic approach. It provided a summary of the data input provided by CPCs and the rules and priority for substitutions when missing CAS data.

SCRS/P/2022/094 - This presentation provides an update on developments for the 6-year Tropical Tuna Research and Data Collection plan (TTRaD), including preliminary short-term (2025-2027) priorities. The main developments include an update to deliverable time frames, costs, and context, with a plan to continue developments intersessionally ahead of the SCRS species group meeting in September.

SCRS/P/2022/095 – This presentation provides a strict update of the US longline index of West Atlantic skipjack abundance for the period between 1993 and 2023.

Appendix 5

Revised Roadmap for the tropical tunas MSE processes

During the meeting the Group revised the roadmap for the tropical tunas MSE processes adopted by the Commission in 2023. However, the Group agreed to revisit this subject at the September 2024 Tropical Tunas Species Group and SCRS Plenary meetings.

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
2023*	Commission intersessionally	COMM (PA1) dialogue with SCRS on management objectives and performance indicators to be used for tropical tunas MSE.	COMM (PA1) met intersessionally (May and October, with SCRS participation, to: - recommend final operational management objectives and identify performance indicators - consider final CMPs.
	SCRS development	SCRS to list major sources of uncertainty to be considered in the MSE for multi-stock tropical tuna MSEs. Developing operating and observational error models. Capacity building workshops held.	SCRS advanced work on the SKJ-W MSE, incorporating feedback from COMM through PA1.
	SCRS implementation		

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
2023* **2023***	Commission at Annual Meeting		COMM reviewed updated results on performance of CMPs.
	Commission intersessionally		SCRS will present recommendation on CMPs to the COMM (PA1), to: - consider final CMPs - -.

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
2024*	SCRS development	SCRS to conduct yellowfin assessment. Meetings of Technical MSE Group. SCRS to start the development of educational material to explain how the 3 species interact in the proposed MSE, and what information the SCRS needs from PA1 in order to begin constructing and testing the operating models, including capacity building workshops.	The following abundance indices should be updated using data through 2023, if possible, maintaining the model structure of these indices as used in the 2022 SKJ-W stock assessment: Baitboat Brazil Present, Handline Brazil, Purse Seine Venezuela, and Longline United States of America. SCRS to develop climate change scenarios to test robustness of MPs. SCRS to develop and propose a time schedule for WSKJ-MSE updates and revisions
2024*	SCRS implementation	External peer review of Observation and Operating models. Initial development of candidate MPs and testing of MPs. SCRS to develop clear educational material to explain how the 3 species interact in the proposed MSE and what information the SCRS needs from PA1 in order to begin constructing and testing the operating models, including capacity building workshops.	

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
	Commission at Annual Meeting		COMM to consider final evaluation of CMPs and adopt an MP at the Annual Meeting.
2025 **2025**	Commission intersessionally	COMM (PA1) to develop initial operational MOs for the multi-stock TRO MSE. PA1 also to provide guidance to the SCRS on how to handle: trade-offs in species yields; changes in effort over time; changes in gear use over time; changes in closure periods over time; and, variable allocations over time (and therefore changes in geospatial effort and gear type over time). COMM (PA1) to meet intersessionally, with SCRS participation, to: - discuss CMPs, operational management objectives, and performance indicators - refine CMP(s) - recommend final operational management objectives and identify performance indicators Ambassadors' meetings to be held.	SCRS to develop an exceptional circumstances protocol through an iterative consultation process that provides, inter alia, guidance on a range of appropriate management responses should exceptional circumstances be found to occur
	SCRS develop-ment	SCRS to finalize MSE results, incorporating feedback from COMM through PA1.	SCRS to develop an exceptional circumstances protocol

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
	SCRS implementation		SCRS to evaluate existence of exceptional circumstances in accordance with the EC protocol.
	Commission at Annual Meeting	COMM to adopt an MP, including the TACs.	
2026 and beyond*	Commission intersessionally		
	SCRS development	SCRS to provide final advice to COMM (PA1) on criteria for determining exceptional circumstances and inclusion in the exceptional circumstances protocol to be developed by Panel 1 in consultation with the SCRS.	

		Tropical Tunas (BET, YFT, Eastern SKJ)	*Western Skipjack*
	SCRS implementation	SCRS to develop an exceptional circumstances protocol through an iterative consultation process that provides, inter alia, guidance on range of appropriate management responses should exceptional circumstances be found to occur. SCRS to evaluate existence of exceptional circumstances in accordance with the EC protocol. (2027) SCRS to conduct periodic assessments to ensure that the conditions considered in MP testing are still applicable to the stocks.	SCRS to evaluate the existence of exceptional circumstances in accordance with the EC protocol. SCRS to conduct periodic assessments to ensure that the conditions considered in MP testing are still applicable to the stock.
	Commission at Annual Meeting	COMM to adopt exceptional circumstances protocol in 2027 as a new Annex in MP. COMM to continue use of the MP to set TACs on the predetermined timescale for MP setting.	COMM to continue use of the MP to set TAC on the predetermined timescale for MP setting.