REPORT OF THE 2022 SKIPJACK STOCK ASSESSMENT MEETING

(Online, 23 - 27 May 2022)

1. Opening, adoption of agenda, and meeting arrangements

The meeting was held online. Dr David J. Die (USA), the Tropical Tunas Species Group ("the Group") coordinator, and the West Skipjack tuna rapporteur, MSc. Rodrigo Sant'Ana, opened the meeting and welcomed participants. Camille Manel, ICCAT Executive Secretary, welcomed the participants and thanked the efforts made by all participants to attend the meeting remotely.

The Chair reviewed the Agenda, which was adopted (**Appendix 1**). The List of Participants is included in **Appendix 2.** The List of Documents and Presentations provided to the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents and presentations provided at the meeting are included in **Appendix 4**. The following participants served as rapporteurs:

Sections	*Rapporteur*
Items 1, 9	M. Ortiz
Item 2	C. Palma, S. Wright, M. Narvaez, M. Ortiz
Item 3	M. Lauretta, D. Gaertner, E. Kikuchi, R. Sant'Ana
Item 4	G. Cardoso, H. Murua, J. Santiago, N. Fisch, S. Cass-Calay, G. Merino, A. Urtizberea
Item 5	A. Kimoto, M. Lauretta
Item 6	A. Maufroy, K. Bradley
Item 7	G. Diaz
Item 8	D. Die

2. Summary of available data for assessment and updates since the Data Preparatory meeting

1.1Fisheries statistics, size, and CAS estimates

The Secretariat informed the Group that no updates were made to the skipjack (SKJ, *Katsuwonus pelamis*) statistics (Task 1 and Task 2 datasets) after the 2022 Data Preparatory meeting. Therefore, all the input files prepared and adopted intersessionally after the Data Preparatory meeting remain unchanged, as reflected in document SCRS/2022/093. The total SKJ catches of each stock (SKJ-E: eastern Atlantic; SKJ-W: western Atlantic stock) by fleet and year are presented in **Table 1** and **Table 2**, respectively.

In relation to the preliminary estimates of "*faux poissons*", Task 1 catch series of several purse seine flags (2015-2020) obtained by the Group during the Data Preparatory meeting (details in Anon., 2022), the Secretariat contacted all the involved CPCs in order to officially adopt those estimations. Only Cape Verde, EU-Spain and EU-France acknowledged those complementary catches. The remaining ICCAT CPCs with tropical purse seine fleets (Belize, Côte d'Ivoire, Curaçao, El Salvador, Guatemala, Guineé Republic, Panama, and Senegal) did not adopt the complementary "*faux poissons*" catch series, and they indicated that total catches were already included in the official Task 1 data provided. The Group agreed that the "*faux poissons*" estimates provided during the SKJ Data Preparatory meeting represented the best scientific estimates of additional removals and agreed to maintain the total "*faux poissons*" catches of these 8 fleets under the flag code "NEI-Mixed flags", as presented in **Table 3**. This merge did not change any of the purse seine catch series previously agreed for the fleet structure of both stocks.

As described in Ortiz and Kimoto (2022), Task 2 size information (T2SZ) of SKJ also remained unchanged. The T2SZ data prepared for Stock Synthesis (SS3) input files already incorporate a preliminary version of the Brazilian BB fisheries (presented in Cardoso et al., 2022).

The Secretariat updated the SKJ catch-at-size (CAS) during the meeting to estimate the mean weight series by major fishery for both stocks, using the most recent information on T1NC, T2SZ and T2CS (Task 2 catch-at-size estimated/reported by ICCAT CPCs). The 1969-2013 period was revised to accommodate changes in T1NC and some revisions to T2SZ and T2CS datasets made by ICCAT CPCs after the 2014 SKJ stock assessment (Anon., 2015). The CAS for the 2014- 2020 period was estimated for the first time, using the same methodology (substitution rules, assumptions, raising method, etc.) as for the 2014 stock assessment.

The CAS matrices for SKJ-E and SKJ-W are presented in **Tables 4** and **5**, respectively. The mean weights by major fishery and year are presented in **Figure 1** (SKJ-E) and **Figure 2** (SKJ-W).

The overall mean weight of SKJ-E steadily decreased from about 2.6 kg in 1969 to 1.9 kg in 2010, followed by an increase (2.5 kg in 2015) and another decrease between 2013 (2.5 kg) and 2020 (1.9 kg). This oscillation was also observed in purse seine fisheries (major gear) and to a lesser degree in baitboat fisheries. SKJ-W estimated mean weights had oscillated between 2.5 kg and 4.0 kg across all the time series (1969-2020), with a slight decrease in the last decade (3.4 kg in 2010 to 3.0 kg in 2019/2020). The high mean weight of 2020 for the "oth" series (a combination of the remaining gears) may have some inconsistency in the associated size datasets used for the CAS estimation. These size datasets must be fully revised in the future. On average (all years, 1969-2020), the estimated mean weight of SKJ-E is about 2.1 kg and about 3.4 kg for SKJ-W, indicating that fish caught from eastern stock are smaller than those from the western stock.

During the meeting it was noted that the spatial distribution of catches and fishing effort of the PS tropical fleets has expanded in tropical areas, particularly towards the West, North, and South of the main traditional fishing area in the Gulf of Guinea (**Figure 3**). The Secretariat provided a summary of the catches in 5x5 (CATDIS) and 1x1 (T2CE) degree squares for recent years based on the CATDIS, which allocates catch geographically using Catch-Effort (T2CE) reports from CPCs. The plots show the median SKJ-E catch (in log10 scale) by 5x5 degree square for periods of 5 years since 2000 (**Figure 4**). A similar plot is shown by year since 2015 in 1x1 resolution for the tropical PS fleets (**Figure 5**). It was noted that mean catches had increased closer to the West stock boundary in the tropical area, but also towards the south, with mean SKJ catches in the 2020s comparable to those observed in the Gulf of Guinea. Other additional information corroborated the spatial expansion of the tropical tunas PS fleets including; i) the number of 1x1 cells that have reported catches of tropical species (SKJ, YFT, BET) (**Figure 6**), ii) the estimated spatial coverage from the standardized EU PS CPUE of E-SKJ caught under non-owned dFADs using the VAST methodology (**Figure 7**) (SCRS/2022/028), and iii) the fishing effort trends of PS fleets fishing on FOB/FADs or free schools (FSC) (**Figure 8**).

The Group was informed that, on average, the PS Task 2 CE reports account for over 60% of the total E-SKJ Task 1 NC reported since 2000 (**Figure 9**), therefore the Group concluded that these indicators were robust and that expansion of PS fleet catches and fishing effort coincided with the increasing trend of SKJ catches from about 160,000 t in 2010 to their peak at 283,000 t in 2018. However, in the last 2 years, 2019 and 2020 reported catches of SKJ had decreased to about 217 thousand t. It was suggested that the recent catch reductions were mostly related to management restrictions on the BET and YFT fisheries.

1.2 Biological parameters and fleet structure

SCRS/2022/044 provided a summary of the development and current composition of the Canary Island baitboat fleet between 2000 and 2021, including the number of vessels and species composition of landings.

SCRS/2022/045 provided the biological parameters of the skipjack caught by the Canary Island baitboat fleet, including length-weight relationships and sex-ratios by size.

Following the recommendations and intersessional work plan agreed by the Group during the 2022 SKJ Data Preparatory meeting (Anon., 2022), document SCRS/2022/093 was presented as a summary of the biological and fisheries inputs for the assessment models for both the East and West Atlantic stocks. The report provided updates to the fleet structure, growth parameters, and natural mortality (**Tables 7** and **8**). The fleet structures were updated in line with the latest BET and YFT stock assessments with the aim of allowing for future integration with the tropical tuna MSE process. Fleets with similar fishing operation patterns and available data were combined, resulting in 10 distinct fleets for SKJ-E and 5 fleets for SKJ-W. In terms of growth and natural mortality, the growth parameters for the uncertainty grid were defined as the 25th, 50th and 75th percentiles of the simulated distributions in length at age, with natural mortality generated using the approach outlined by Gaertner (2015). Regarding "*Faux Poisson*" estimates for other PS fleets, the Group agreed to include aggregated estimates associated with a given CPC's flag if the CPC agreed with the estimates and methodology, or "NEI other fleets" if the CPC did not agree with the estimates or methodology. There was no change in the length-weight relationship, maximum age, and maturity assumptions compared to the 2014 SKJ stock assessment. A full summary of life-history parameters used in the 2022 assessment is provided in **Table 9**.

1.3 Relative indices of abundance

Relative indices of abundance for the eastern and western stocks to be used in stock assessment were presented in Anon. (2022) and no updates were presented in the current meeting (**Tables 10** and **11).** A new abundance index for the Venezuelan baitboat fleet was presented (SCRS/2022/089). However, the Group agreed not to include it in the 2022 stock assessment models.

SCRS/2022/089 describes a standardized index of relative abundance for the Venezuelan baitboat fishery during the 1987-2022 period. The index was estimated using generalized linear models with a delta lognormal approach. Logbook data was used for this model and size length composition was analysed from port sampling. Nominal and standardized CPUEs show similar overall trends (**Figure 10**, **Table 11**). Standardized catch rates declined from1988 to 1990. From that point on, the trend shows relative stability, which increased variability since 2005, decreasing for the most recent year of the time series (2020). The size composition median length of sampled skipjacks increased (>58 cm) for the last two years (2019 and 2020), with the lowest standard deviation for the same years.

The Group discussed some technical aspects of the standardization, including recommendations such as grouping observations to avoid fitted probabilities of 0 and 1 in the binomial model, using tools for detecting and understanding factors that drive the standardization, and excluding observations in which baitboats were collaborating with PS vessels by providing bait to the fish schools to keep them at the surface. The authors mentioned that this latest advice was already taken into account in the development of the index. The Group also noted that the standardized CPUE is expected to diverge from the nominal one when properly accounting for factors that change over time, something that occurred with this standardized index.

3. Stock Assessment Models and other data relevant to the assessment

3.1Eastern Stock

3.1.1 Statistically integrated models (Stock Synthesis 3)

SCRS/2022/095 provided a detailed summary of the preliminary configuration, reference case diagnostics, and results for the Stock Synthesis (SS, ver 3.30.18) model of eastern skipjack. The model is a single-stock, combined-sex, one-area model and quarterly for the East Atlantic. The lead analyst presented an overview of model inputs and assumptions and provided a comprehensive set of model diagnostics. The Group made several recommendations for revision, many of which were integrated and evaluated during the meeting. Changes to the data inputs included the addition of the Canary Island baitboat index and separate runs that fitted the two recent period indices separately (the acoustic buoy and VAST purse seine CPUEs). The Group agreed to continue the development of the SS model intersessionally, with particular attention given to how trends in recruitment deviations are influenced by alternative data assumptions/weighting and, in turn, how those changes influence stock biomass, recruitment, and stock status estimates. A summary of the Stock Synthesis data inputs and parameterization is provided below.

Fleet structure and CPUE

- Fleet structure: 10 fleets (**Table 7**):
  1. Historic purse seine 1963-1985
  2. Purse seines 1986-90
  3. Free school purse seines 1991-2020
  4. FOB/FAD associated purse seines 1991-2020
  5. Ghana purse seines/baitboats
  6. South Dakar purse seines/baitboats
  7. Dakar purse seines/baitboats 1962-1980
  8. Dakar purse seines/baitboats 1981-2020
  9. Bait boats North (>25 Lat)
  10. East Atlantic Longlines

- Indices of abundance: 3 indices (**Table 9**)
  1. Canary Island baitboat (1980-2013)
  2. Acoustic buoy (2010-2020 seasonally)
  3. EU purse seine non-owned FOB/FADs (2010-2019 seasonally).

The baitboat index was associated with fleet 9, the VAST purse seine index was associated with fleet 4, and the acoustic buoy was included as a survey with selectivity mirrored to fleet 4. The index CV of the echosounder buoys was estimated in log scale by using the equation in the SS manual, the values available were used for the standardized CPUE, and a CV of 0.3 was assumed for the Canary Island baitboat in the all-time series due to the very high SE values.

Fleet length compositions and selectivity

Length data for each fleet, year, and season were provided by the Secretariat after all CPC data updates were completed following the 2022 Data Preparatory meeting (Anon., 2022). Length compositions were input as the number of fish observed per 2 cm lower limit size bin. The effective sample sizes were equal to the natural logarithm LN (total number of fish measured) to reduce the effect of pseudo-replication in sampling and decrease weighting in the overall model likelihood. The length composition of the longlines fleets after 2003 showed catches of the largest fish and was assumed to have asymptotic selectivity. A double-normal selectivity pattern was assumed for all other fleets. Once solved to a stable minimum solution, a normal prior with a CV of 0.1 was added to some selectivity parameters that showed large standard errors before running sensitivities.

Growth, natural mortality, maturity, and fecundity

The three alternative growth scenarios outlined in SCRS/2022/093 were included as one of the uncertainty grid (**Table 12**) axes. Linear growth was assumed from birth (Age 0 length = 6 cm) to age 1, after which von Bertalanffy growth was assumed. Each growth model scenario had a corresponding mean length-at-age 1, asymptotic mean growth (L_{inf}), growth k parameter, and CV of length-at-age of 0.2 for all ages (**Table 13**). The base natural mortality rate at age 6 for each growth scenario was estimated using the approach of Gaertner (2015). The natural mortality rate of other ages was modelled in SS with a Lorenzen function. Fecundity was modelled as a direct function of female body weight and maturity was modelled with a logistic function with slope -0.22 and 50% of being mature at 42 cm in size. Recruitment was assumed to occur quarterly throughout the year. The relative distribution of spawning by quarter was estimated directly in the model based on the size-structure data.

Stock recruitment

Stock recruitment followed a Beverton-Holt function with virgin recruitment (R0) freely estimated across a range of fixed steepness (*h* = 0.7, 0.8, and 0.9). For the reference case, steepness was fixed at 0.8 and sigma-r was fixed at 0.5. Annual recruitment deviations were estimated for the period 1990 to 2020 in the reference case model. The lognormal bias correction (-0.5σ2) for the mean of the stock-recruitment relationship was applied to the period 1961 to 1997 with a bias correction ramp applied as recommended by Methot and Taylor (2011). An alternative run was presented with recruitment deviations estimated for the 1968- 2019 period. Another alternative run was also presented including the Canary Island bait boat survey with recruitment deviates starting in 1980.

Data weighting, model parameterization, and model diagnostics

The initial reference case model used default/equal weighting of data series. Sensitivity analyses were conducted using the Dirichlet and Francis weighting methods. The Group recommended exploring data reweighting options intersessionally, including an alternative weighting of the CPUE and length composition data, as well as the relative weighting of the length compositions across fleets.

For each of the model runs, the estimated parameters included 38 selectivity parameters, R0, quarterly recruitment allocations, and annual recruitment deviations. Model parameter standard deviations were derived from the variance-covariance matrix. Standard model diagnostics included jitters of starting parameters, fits to data inputs and model residuals, retrospective analyses, profiling of key estimated parameters (R0 and standard deviation of recruitment i.e., sigmaR), data input residual run tests, and hindcasting of abundance indices. Analyses were conducted using SS3 built-in diagnostics and the ss3diags R package (Carvalho *et al.,* 2021).

The Group proposed an uncertainty grid that consisted of 18 models across the combinations of two index treatments (VAST PS and acoustic buoy modelled separately), the three alternative scenarios of growth/natural mortality, and three levels of steepness (fixed at h = 0.7, 0.8 and 0.9).

3.1.2 Surplus Production models (JABBA and MPB)

A preliminary run for the assessment of eastern Atlantic Ocean skipjack using a biomass dynamic model (MPB) was provided in document SCRS/2022/102. The preliminary diagnostics showed problems with model convergence when using the five indices available for the assessment.

The Group discussed the reasons why MBP did not provide consistent results. Potential explanations for this issue are the different trends in CPUE observed for the different fishing fleets. For example, it was suggested that the increase over time in the CPUE of the baitboats operating off Senegal was likely due to an increase in fishing efficiency related to the implementation of new fishing modes (e.g., fishing the school associated with the vessel, use of dFAD, etc.). In contrast, the development of the purse seine FOB/FAD fishery in the Mauritania-Senegal area could have had a negative impact on the baitboat CPUE around the Canary Islands. In addition, the fact that the total eastern Atlantic skipjack catch was continuously increasing over the time series may also create a conflict for the model fit. The Group recommended additional scenarios: starting the time series in 1990, assessing the impact of VAST and BAI indices separately, and adding a run with the catch ratio index. It was also suggested to check again how the model behaves with the inclusion of the Canary Island baitboat CPUE (and excluding Azorean baitboats to be comparable with SS3 results).

Document SCRS/2022/100 provided the results of Bayesian State-Space Surplus Production Models(JABBA) applied to the E-SKJ stock. The models based on the JABBA framework used total fishery catch data from 1950 to 2020 provided by the ICCAT Secretariat. CPUE time series of 5 fishing fleets were used and a total of 9 distinct scenarios, based on 3 input values in growth parameters (SCRS/2022/093) and 3 variations in steepness (0.7, 0.8, and 0.9) were presented. All models were implemented using a Pella and Tomlinson production function (**Table 14**). The priors of K were kept uninformative similar to those used Anon. (2015). For K, a lognormal distribution was implemented using the JABBA "range" option. Lower and upper values ranged from 290,000 t to 1,500,000 t, which resulted in an approximate mean value of 717,622 t and a CV of 43%. For r, priors distributions were developed with an associated shape parameter of a Pella-Tomlinson production function from an Age-Structured Equilibrium Model (ASEM) approach with Monte-Carlo simulations (Winker *et al.,* 2019). The stock parameters used as inputs for the ASEM models included the uncertainty grid configuration cited previously and presented in **Table 14**. For all scenarios, the same initial depletion prior ($\varphi = B_{1950}/K$) was defined by a beta distribution with a mean = 0.93 and a CV of 5%. All catchability parameters were formulated as uninformative uniform priors. The process error of $\log(B_y)$ in year y for all scenarios was defined by an inverse-gamma distribution with a shape parameter equal to 0.01 and a rate parameter equal to 0.01.

JABBA is implemented in R (R Development Core Team, https://www.r-project.org/) with the JAGS interface (Plummer, 2003) to estimate the Bayesian posterior distributions of all quantities of interest using a Markov Chains Monte Carlo (MCMC) simulation. The JAGS model is executed in R using the wrapper function jags from the library r2jags (Su and Yajima, 2012), which depends on the rjags R package. In this study, three MCMC chains were used. Each model was run for 30,000 iterations, sampled with a burn-in period of 5,000 for each chain and thinning rate of five iterations. Basic diagnostics of model convergence included visualization of the MCMC chains using MCMC trace-plots as well as Heidelberger and Welch (1992), Geweke (1992), and Gelman and Rubin (1992) diagnostics as implemented in the coda package (Plummer *et al.,* 2006).

Model diagnostics were provided to evaluate the model fits, residual runs tests, retrospective patterns, and hindcast prediction skills. To check for systematic bias in the stock status estimates, a retrospective analysis was also performed by systematically removing one year of data at a time sequentially over eight years (n = 8), then refitting the model after each data removal and comparing the resulting estimates of biomass, fishing mortality, B/B_{MSY}, F/F_{MSY}, B/B_0, and MSY to the reference model that is fitted to the full data time series. To compare retrospective bias among models, Mohn's rho (ρ) statistic was computed by using the formulation defined by Hurtado-Ferro *et al.* (2014). A model-free hindcasting cross-validation (HCXval) technique by Kell *et al*. (2016) was applied, where observations are compared to their predicted future values of CPUE by calculating the Mean Absolute Scaled Error (MASE) proposed by Hyndman and Koehler (2006), which scales the mean absolute error of prediction residuals to a naïve baseline prediction, where a 'prediction' is said to have 'skill' if it improves the model forecast when compared to the naïve baseline.

Finally, a sensitivity analysis based on the interactive stepwise addition of the inclusion of the CPUE series one-by-one was implemented, taking the EU PS VAST index as the base index (**Table 15**).

It was shown that for all scenarios, the behaviour of the model's fits appeared to be mostly influenced by the pattern observed in the past CPUE series of the baitboats operating off Senegal and by the non-owned dFAD CPUE from the European Purse seiner (fitted using the VAST method). The Group recommended additional scenarios, such as starting the time series in 1990 and conducting a sensitivity analysis without the Canary Island baitboats index.

3.2 Western Stock

3.2.1 Statistically integrated models (Stock Synthesis 3)

SCRS/2022/098 presented a provisional version of the stock assessment model using Stock Synthesis (SS) for the western skipjack stock, including the initial model setup, fleet definitions, selectivity, and parameterization. A one-area, combined-sex, and annual model was constructed for western Atlantic skipjack covering a timeframe from 1952 to 2020. Initial stock biomass in 1952 was assumed to be in an unfished, virgin stock condition. The fleet structure comprised 5 fleets and 5 abundance indices were modelled (**Table 8**).

Indices were available for 4 of the 5 fleets (PS_West, BB_West, LL_USMX, LL_OTH, and HL_RR). Two indices were available for the baitboat fleet, one from 1981 to 1999 (BRA_BB_hist) and the other from 2000 to 2020 (BB_West). The BRA_BB_hist index was set as a survey, and its selectivity mirrored BB_West selectivity. Selectivity was parameterized as length-based for all fleets, with the selectivity parameters being freely estimated by the model. A dome-shaped was assumed for the fleets PS_West, BB_West, and HL_RR and an asymptotic shape for LL_USMX and LL_OTH, as proposed by the stock assessment team. A time block for the selectivity of PS_West was imposed (2015-2020).

Length compositions were input as the number of fish per 2 cm size bin. The effective sample sizes were equal to the ln (number of observations) to reduce the effect of pseudo-replication in sampling and decrease the weight of length data in the overall model likelihood. Weight in kilograms was estimated by the conversion of length (cm) composition assuming the relationship: Wt = (7.48e-06* length^ 3.253). Fecundity was modelled as a direct function of female body weight. Growth was modelled as for the E-SKJ stock with a von Bertalanffy formulation assuming the same parameters as shown in **Table 13**, noting that size at age 0 was assumed to be 2 cm. (**Table 9**). Each growth model scenario had a corresponding mean length-at-age 1, asymptotic mean growth (L_{inf}), growth *k* parameter, and CV of length-at-age of 0.2 for all ages.

Age-specific M assumptions were modified from what was suggested in Anon. (2022). During this meeting the use of Gaertner (2015) scaling was proposed (SCRS/2022/093), however, the initial runs resulted in unrealistic high values of M for the youngest ages and low numbers at older ones (SCRS/2022/098). Thus, an alternative parameterization within SS was applied using the Lorenzen function with the same assumed asymptotic natural mortality-at-age recommended in Anon. (2022) for each growth curve scenario (SCRS/2022/093). The length data component variance adjustments followed the method of Francis (2011).

The stock-recruitment relationship followed a Beverton-Holt function with virgin recruitment (R0) freely estimated across a range of fixed steepness and annual recruitment deviation (sigmaR = 0.4). The initial steepness values defined by the Group (*h*= 0.7, 0.8, and 0.9) were used. Runs were conducted for the nine scenarios in the uncertainty grid, as a result of 3 steepness values and 3 cases of Growth/Natural mortality at age (**Table 13**). However, based on diagnostics and model fits, the steepness axis of 0.9 was dropped from the uncertainty grid, and a steepness value of 0.6 was added in its place. Examination of model diagnostics was done by following Carvalho *et al*. (2021).

3.2.2 Surplus Production models (JABBA)

The models based on the JABBA framework used total fishery catch data from 1952 to 2020 provided by the ICCAT Secretariat. Relative abundance indices were made available during the Skipjack 2022 Data Preparatory Meeting (Anon., 2022) in a form of standardized CPUE time series. These indices cover various periods and represent distinct fishing gears and fleets that operate on the W-SKJ stock. The indices used were BRA BB Past, BRA BB Present, BRA HL, USA LL, and VEN PS. The CVs for all indices were scaled to a 0.25 average.

The model specifications were based on the uncertainty grid defined in Anon. (2022), which resulted in nine distinct scenarios. These scenarios incorporate three variations in growth parameters, as provided in SCRS/2022/093and three values of steepness (0.7, 0.8, and 0.9). All models were implemented using a Pella and Tomlinson production function (**Table 14**). The priors of *K* were kept uninformative similar to those used in Anon. (2015). For *K*, a lognormal distribution was implemented using JABBA "range" option. Lower and upper values ranged from 50,000 to 200,000 t, which resulted in an approximate mean value of 106,190 t and a CV of 36%. The *r* prior distributions were developed with an Age-Structured Equilibrium Model (ASEM) approach that uses Monte-Carlo simulations and the corresponding associated shape parameter of a Pella-Tomlinson production function (Winker *et al*., 2019). The stock parameters used as inputs for the ASEM models included the uncertainty grid configuration cited previously and presented in **Table 15**. For all scenarios, the same initial depletion prior ($\varphi = B_{1952}/K$) was defined by a beta distribution with a mean = 0.93 and a CV of 5%. All catchability parameters were formulated as uninformative uniform priors. The process error of $\log(B_y)$ in year *y* for all scenarios was defined by an inverse-gamma distribution with a shape parameter equal to 0.01 and a rate parameter equal to 0.01.

JABBA is implemented in R (R Development Core Team, https://www.r-project.org/) with the JAGS interface (Plummer, 2003) to estimate the Bayesian posterior distributions of all quantities of interest utilizing a Markov Chains Monte Carlo (MCMC) simulation. The JAGS model is executed in R using the wrapper function *jags* from the r2jags R library (Su and Yajima, 2012), which depends on the rjags R package. In this study, three MCMC chains were used. Each model was run for 30,000 iterations and sampled with a burn-in period of 5,000 for each chain and a thinning rate of five iterations. Basic diagnostics of the model convergence included visualization of the MCMC chains using MCMC trace-plots as well as the Heidelberger and Welch (1992), Geweke (1992), and Gelman and Rubin (1992) diagnostic tests as implemented in the coda R package (Plummer *et al.,* 2006).

Model diagnostics were provided to evaluate the model fits, including residual run tests, retrospective patterns, and the hindcast prediction skill test. To check for systematic bias in the stock status estimates, a retrospective analysis was also performed by systematically removing one year of data at a time sequentially over eight years (n = 8), and then refitting the model after each data removal and comparing the biomass, fishing mortality, B/B_{MSY}, F/F_{MSY}, B/B_0 and MSY estimates to the reference model that was fitted to the full data time series. To compare retrospective bias among models, the Mohn's rho (ρ) statistic was computed by using the formulation defined by Hurtado-Ferro *et al.* (2014). A model-free hindcasting cross-validation (HCXval) technique by Kell *et al.* (2016) was applied, where observations are compared to their predicted future values of CPUE by calculating the Mean Absolute Scaled Error (MASE) proposed by Hyndman and Koehler (2006), which scales the mean absolute error of prediction residuals to a naïve baseline prediction, where a 'prediction' is said to have 'skill' if it improves the model forecast when compared to the naïve baseline.

Finally, sensitivity analyses based on the interactive stepwise addition of the inclusion of the CPUE series one-by-one were implemented, taking the BRA BB Past and BRA BB Present indices as base indices (**Table 17**). Based on these sensitivity analyses, a new model run was presented during the meeting using the scenario S05 (h=0.8 and $r \sim$ lognormal [0.44, 0.184]) as a Reference Case that included a weighted measure between abundance indices assuming each respective representativeness over the total catches.

4. Stock status results

4.1 Eastern stock

4.1.1 Statistically integrated model, Stocks Synthesis

Stock Synthesis model convergence and fit diagnostics

The preliminary reference case developed for East Atlantic skipjack tuna showed instability in some of the diagnostic analyses. The model showed an acceptable convergence 2.7e-05, lower than a target of 0.0001. However, the jitter analysis showed that the model converges to local minima when the starting values are changed.

The preliminary reference case included both the echosounder buoy index and the standardized PS FAD CPUE fishing on non-owned FADs, as agreed during the 2022 Data Preparatory meeting (Anon., 2022). However, these two indices show a different trend: the echosounder buoy index increases while the PS FAD CPUE does not. None of the runs test diagnostics applied to the indices showed a random pattern in the residuals. Therefore, the Group agreed to consider both indices separately and to include these indices as one axis of the final uncertainty grid.

In the preliminary reference model, the recruitment deviates were estimated from 1990 onwards when the PS FOB/FAD fishery fleet officially starts its operations and most of the length composition data are available. However, the preliminary reference model only has indices data from 2010 onwards and, therefore, the Group decided to add the Canarian baitboat index from 1980 to 2013. However, at the 2022 Data Preparatory meeting, the Group agreed to use the BB historic indices (including the Canary Island BB CPUE) only for a continuity case. Nonetheless, the inclusion of the Canarian BB index showed a more plausible trend in the effect of removals on the SSB. The Canary Island BB index passed the random residual test and also improved the overall retrospective pattern of the model. However, the model was still not able to predict any of the recent indices (the echosounder buoy and Vast indices) in the hindcast diagnostic analyses (MASE>1), even when considering them separately. The Group agreed to use the Canary Island BB index in the model.

The results of the preliminary model showed a positive recruitment deviate from 2010 when landings start to increase until the highest historical landings observed in 2018. This occurred even when only the PS FOB/FAD CPUE was included, which does not show an increasing trend. In addition, the retrospective pattern also shows instability of the estimate of R0. As a result, the estimated values of R0 increase each year when new data are available. These trends in the recruitment deviates and the estimates of R0 could be explained by, for example, the spatial expansion of the fishing effort and/or by changes in the productivity of the stock that are not accounted for in the current model configuration. An age structure production model (ASPM) analysis was implemented in SS3 and the results show that the trend of the biomass is mainly driven by the recruitment deviates within the current model structure.

The longline fleet is the only fleet with a logistic asymptotic selectivity, the time series of the length composition showed an increasing trend in the mean size of the catch. Therefore, only data from the relatively stable period of 2003 onwards were considered. However, these changes in the size distribution affect estimates of selectivity and could be causing some of the instability in the model. Therefore, the Group agreed to fix the selectivity of the longline fleet.

The Group also explored the option of estimating recruitment deviates only after 2010 in order to avoid positive recruitment deviates at the end of the time series. This option led to a very unstable estimate of model parameters.

Although none of the preliminary runs or additional runs attempted during the meeting were accepted as a reference case, the diagnostic results of these attempts are reported in SCRS/2022/095. The Group agreed that more work is needed to get a more robust and stable model(s).

4.1.2 Surplus Production models, JABBA and MPB

JABBA results, convergence and model diagnostics

The model fits to each of the five standardized CPUE indices are shown in **Figure 11** for each of the nine uncertainty grid scenarios. For all scenarios, the behaviour of the model fits appeared to be driven by the pattern observed in the DAK BB Past and EU PS VAST indices. The variability observed in the other indices, as well as the poor signal of long and relatively flat time-series indices, are not fitted well by the models.

The results of the log-residuals run tests for each CPUE and each scenario are shown in **Figure 12.** Green panels indicate CPUE indices that passed the runs test with no evidence of a non-random residual pattern ($p > 0.05$) and red panels indicate a failed test. In addition, the inner shaded area shows 3-sigma limits around the overall mean as proposed by Anhøj and Olesen (2014) and the red circles identify each specific year where the residuals are larger than the threshold limit. In all scenarios, the same patterns were observed with a failed behaviour in the runs test diagnostic procedure for almost all indices, with the exception of the AZO BB Past index in all scenarios and the EU PS VAST index in scenario S03 (**Figure 12**). In general, the goodness-of-fits were comparable among all scenarios with the RMSE statistics ranging from 83.1% to 85.6% (**Figure 13**). This pattern shows some of the conflicting trends between indices.

The medians of the marginal posteriors for K ranged between 1,080,736 t (S03) and 1,699,609 t (S07) (**Table 18**). The values for the posterior to the prior median ratio (PPMR) and the variance (PPVR) ratios estimated for the K parameter indicated that this parameter was informed by the input data in the model in all scenarios. However, there were no observed reductions in the precision (e.g., standard error) of the posteriors compared to the priors defined for this parameter. For r, the medians of the marginal posteriors ranged between 0.397 (S07) and 1.014 (S03). In general, the values of PPMR and PPVR estimated for r show that the input priors defined the behaviour of the posteriors as expected. This pattern was less evident for the scenarios S01, S02, and S03 (**Figure 14**).

The results of an eight-year retrospective analysis applied to scenario S05 showed a negligible retrospective pattern (**Figure 15**). The estimated Mohn's rho for all stock quantities fell within the acceptable range of -0.15 and 0.20 (Hurtado-Ferro *et al.*, 2014; Carvalho *et al.,* 2017), which confirmed the lack of an undesirable retrospective pattern in the model. The hindcasting cross-validation results for all updated indices show predictions within the 95% CI, suggesting good prediction skills for the S05 scenario (**Figure 16**), except for the EU Echosounder index that presented some predictions outside of the 95% CI. The mean absolute scaled error (MASE) estimated was above the reference level (MASE > 1) for both indices evaluated, which indicates that the average model forecasts are not better than a naïve baseline prediction like a random walk process (Carvalho *et al.,* 2021).

The results of the sensitivity analysis based on the inclusion of forward stepwise indices in the model are shown in **Figure 17.** These results showed some distinct behaviours over the general trajectories estimated with the addition of another index. The general trend and the pattern observed at the beginning of the series were similar among all models, the most significant change can be observed at the end of the time series for all quantities (Biomass, B/B0, B/B_{MSY}, and F/F_{MSY}). The model with only the EU PS VAST index showed the most pessimistic trend, while the gradual inclusion of the other indices in the model tended to make the results more optimistic with each interaction.

However, even though the model showed statistical convergence in all the adjusted scenarios, the conflict in the trends observed among the relative abundance series, as well as the process error deviates (**Figure 15**), led the Group to recommend continuing the development of the JABBA assessment model(s) for the E-SKJ stock according to the workplan, as described in Section 8.

MPB results, convergence, and model diagnostics

The Group discussed a potential reference case using total catch and abundance indices from the Azores baitboat, EU purse seine (VAST), and the Echosounder index, with the model starting in 1990 from an initial state of 85% of B0. The reference case showed relatively poor fits to the available indices (**Figure 18**) and stability in the retrospective analysis for 1 to 3-year peels, but it was unstable when 4 or more years were removed (**Figure 19**). Additional diagnostics were presented to the Group including the production function (**Figure 20**) and the likelihood profile for the intrinsic growth rate (**Figure 21**). Additional runs were evaluated to explore i) the inclusion of the ratio YFT/SKJ index (Abascal *et al.,* 2022), ii) the separation of the VAST and Echosounder indices in different runs, and iii) a different starting point for the biomass in 1990 (**Figure 22**). The new runs suggest that the VAST index is necessary to ensure convergence and estimate realistic values of MSY (**Table 24**).

Overall, the lack of stability of the model raised concerns and the Group noted that the contradictory signals of increased catch and stable or increasing indices in the last years may be difficult to reconcile within the MPB model. Therefore, the Group agreed not to use the results of the MPB to provide stock status and management advice.

4.1.3 Synthesis of assessment results

As the Group was unable to develop a reference model for the eastern SKJ stock at the meeting, it was agreed to continue working intersessionally, as described in Section 8.

4.2 Western stock

4.2.1 Statistically integrated model, Stocks Synthesis

After the provisional model configuration (described in Section 3.2.1) was presented, the Group decided to maintain the growth/M-at-age of the uncertainty grid. However, because the yield curve was not well determined at a steepness level of 0.9, the Group agreed to modify the steepness level values in the uncertainty grid to h = 0.6, 0.7, and 0.8 for the W-SKJ stock. It was noted that this is consistent with a hypothesis that the overall productivity of the western SKJ stock is lower in comparison with the eastern SKJ stock, at least based on historical catches (Evans *et al.*, 1981). Some alternatives of different years for estimating the recruitment deviations were tested and the Group agreed to restrict the estimations of recruitment deviations starting in 1993 (originally estimated from 1980 onwards), when size compositions for all the major fishing fleets are available. The restriction of estimating the recruitment deviations between 1993 and 2018 resulted in a less steep decline in the spawning biomass in early 1980, which addressed a concern raised by the Group in the original model configuration. The Group agreed on a reference model case using the growth/M-at-age level of the 0.5 quantile, steepness 0.7, and the recruitment deviations estimated from 1993 to 2018.

The reference case of the Stock Synthesis model shows stability in the log-likelihood with different starting values (**Figure 23**). The final model gradient was 4.7e-05, lower than a target of 0.0001, and considered acceptable for model convergence, particularly since the solution was stable across different starting parameter values. All 50 jittered model runs converged, with 47 of the model runs resulting in the same total negative likelihood estimate value as the base run (365 likelihood units), and 3 model runs had larger total negative likelihood values. The jittered model was robust to the initial values of the parameters and gave no evidence that the model converged to local minima of the objective function instead of the global minimum.

The model showed a generally good fit to the indices and showed acceptable fits to the length composition for all fishing fleets, except for the years between 2010 and 2016 for the BB_West fishing fleet (**Figure 24**). The residual patterns of the indices and the length fits were good overall. Estimated deviations from the stock-recruitment curve (i.e., recruitment deviates) indicated high variability in year-to-year recruitment (**Figure 25**), with positive deviations from 1994 to 1999, a dynamic increase and decrease from 2000 to 2013, followed by a significant decrease in 2014 and 2015, and then negative but closer to the mean in 2016 and 2017.

In general, the joint residual plots for the reference case showed a random pattern for the residuals of the fits to the indices for all fleets with some outliers for the HL_RR and LL_USMX fleets (>1 or < -1), but without a significant impact on the overall pattern (**Figure 16**). A negative trend in the residuals was observed at the beginning of the BRA_BB_hist index time series. The residuals of the length composition fits also showed a random pattern for all fleets with no evident outliers (**Figure 26**).

The retrospective analysis for the reference model performed relatively well (**Figure 27**), all falling within the confidence intervals of the different runs and showing no discernible trend. The scale of SSB increased, but the overall trend remained when 4- and 5-year data were removed (**Figure 27**). The Mohn's rho values estimated for SSB (0.01) and F (0.06) fell within the acceptable range of -0.15 and 0.20 (Hurtado-Ferro *et al.*, 2014; Carvalho *et al.,* 2017), which confirmed the lack of an undesirable retrospective pattern in the model.

The prediction skill analysis for the reference case showed that all recent CPUE indices and length compositions included at least one observation that fell within the hindcast evaluation period 2015–2019 (**Figures 28** and **29**). The MASE scores > 1 for the index of the two main fleets PS_West and BB_West indicated lower prediction skills. In general, the length compositions have better prediction skills than the indices.

A list of model parameters is provided in **Table 19**, including estimated values and their associated asymptotic standard errors, initial parameter values, minimum and maximum values, priors if used, and whether the parameter was fixed or estimated. Since steepness (*h*) and the sigmaR of the Beverton-Holt curve were fixed, the main productivity parameter estimated in Stock Synthesis was the average level of age-0 recruitment at unfished equilibrium spawning biomass (R0).

The estimated time series of SSB for the reference case indicated that stock decreased from the late 1970s to the early 1980s and remained at relatively low levels during the mid-1980s and mid-1990s. After some immediate increase in the mid-1990s, the stock remained at around 100,000 to 130,000 t until 2015. A steep decrease was observed in SSB since 2015 to the historical lowest level in 2019 and 2020 (**Figure 30**).

Based on the reference case, the Group examined the results of the 9 models from the uncertainty grid. Overall, throughout the uncertainty grid results, the higher growth/M (G/M) vectors quantiles (0.75) estimated the most drastic spawning biomass declines since the early years of the time series (warmer colours in **Figure 31**) and the lowest spawning biomass in the recent periods. In contrast, the smaller G/M quantiles (0.25) estimated the lower SSB declines and the larger spawning biomass in recent periods. Inside each G/M quantile, the larger the steepness values, the lower the spawning biomass scales (**Figure 31**). Regarding recruits at age 0 (**Figure 32**), the larger G/M quantile estimated lower recruit numbers and a more minor variation across the time series. The larger G/M quantile estimated larger numbers of age 0 recruits (almost double) and larger variation across the time series.

When considering only the 0.75th quantile level of growth/M vector of the uncertainty grid, the stock reached an overfished status (SSB/SSB_{MSY} <1) for the three steepness values (**Figure 33**), driven in part by estimates of recent low recruitments. For the other axes of the uncertainty grid, the stock was never overfished. On the other hand, the stock did not have ongoing overfishing across the uncertainty grid (**Figure 14**). The highest values of F/F_{MSY} were estimated for the 0.75th quantile of the growth/M vector.

4.2.2 Surplus Production models, JABBA

SCRS/2022/099 presented a Bayesian State-Space surplus production model for the western skipjack stock based on nine distinct scenarios derived from the uncertainty grid proposed in Anon. (2022). Diagnostics indicated that the model converged according to Heidelberger and Welch (1992), Geweke (1992), and Gelman and Rubin (1992) convergence diagnostics. For the run tests applied to the indices, all scenarios failed for the BRA BB Present, BRA HL, and VEN PS indices, and all scenarios passed the runs test for fits to the BRA BB Past and USA LL indices. Goodness-of-fit statistics were comparable among all scenarios, as RMSE statistics ranged from 42.1% to 42.7%. In addition, the annual process error deviations estimated for all scenarios showed a similar stochastic pattern with no clear trend, tending around the zero and 95% credibility intervals covering the zero value, suggesting no evidence of structural model misspecifications. Retrospective analyses indicated no severe retrospective patterns according to the range proposed by Hurtado-Ferro *et al.* (2014). Finally, MASE scores for the hindcasted models based on S05 indicated that predictions were worse than the naïve prediction (MASE>1) for the BRA_BB_Present, VEN PS, and BB HL indices.

Results of the models indicated that the medians of the marginal posteriors for *K* ranged between 121,544 t (S03) and 208,597 t (S07), and for *r* ranged between 0.443 (S07) and 1.054 (S03). The range of MSY median estimates was narrow between all nine scenarios, reaching the lower value in the S07 scenario (32,716 t) and the higher value in the S03 scenario (40,152 t) (**Table 20**). Furthermore, the marginal posterior medians for B_{MSY} varied between 50,945 t (S02) and 79,276 t (S07) and estimates of F_{MSY} showed a small variation between the nine scenarios, with median values varying from 0.414 (S07) to 0.799 (S03) (**Table 20**).

In general, all scenarios showed a similar trend for the trajectories of B/B_{MSY} and F/F_{MSY} over time (**Figures 35** and **36**). The trajectory of B/B_{MSY} showed a sharp decrease after 1980 and a subsequent stable trend from 1984 to 2020. The Group discussed that one explanation for this stability between 1984 and 2020 could be linked to the flat pattern observed in the more extended index used in the model (VEN PS index). The F/F_{MSY} trajectory showed a sharply increasing trend in the same year that a decrease was observed in the B/B_{MSY} trajectory, and a slight decrease from that period onwards to the end of the time series (**Figures 35** and **36**). The Group discussed that the abrupt increase in F/F_{MSY} after 1980 coincided with the beginning of operations of the Brazilian baitboat fleet as regards this stock.

The sensitivity analysis based on the interactive stepwise addition of each CPUE series showed that the trajectory of the model at the end of the time series was sensitive to the inclusion of the VEN PS CPUE (**Figure 38**). In light of this, a revised model was developed during the meeting based on S05 (h=0.8 and r ~ lognormal[0.44, 0.184]), which weighted abundance indices according to the respective representativeness of each fleet as regards the total catch. The Group decided to move forward with the revised model formulation of JABBA.

This new weighted model produced biomass point estimates above B_{MSY} (median estimate 62,965 t, 95% CI: [45,341 t- 93,770 t]) for almost the entire time series, concluding in 2020 with a median point estimate of B/B_{MSY} =1.2 (95% CI: [0.495 – 2.187]; **Figure 39**). The lower values for the 95% credible intervals of B/B_{MSY} were less than 1 for most years between 1980-2020. Fishing mortality median point estimates were also consistently below F_{MSY} (median estimate 0.503 [0.356 - 0.722]; **Figure 40**). In 2020, F/F_{MSY} was estimated at 0.448 [0.191 - 1.389]. When considering the 95% credible intervals for the entire time series, there was some probability that $F/F_{MSY} > 1$ in the latter portion of the time series. The estimate of MSY from this model was 31,353 t [24,848 t - 46,494 t].

The Group noted that the stock status estimates from the JABBA model do agree with the estimated stock status estimated using the Stock Synthesis model. However, the Group decided not to use the results of the surplus production model to provide management advice.

4.2.3 Synthesis of assessment results

Given the limited time available at the stock assessment meeting, the Group emphasizes that the results included in this section are considered near final, but still require a final review before they are adopted. However, the Group does not expect substantial changes to occur prior to the final adoption at the September Tropical Tuna Species Group meeting.

The Group compared the results for the two assessment models considered for the western Atlantic stock (Stock Synthesis, and JABBA). The annual trends in total biomass (B), B/B_{MSY}, and F/F_{MSY} produced by the models suggested similar population dynamics (**Figure 41**). This is expected when the data are informative and the models are specified similarly. All models suggested a steep decline in stock biomass as fishing mortality (F) increased in the late 1970s and 1980s. The Group considered whether the increase in the catch that occurred during that time (a 7-fold increase from roughly 5,000 t to 35,000 t) was sufficient to produce this precipitous decline and agreed that it was. The Group also noted that the stock status in recent years was similar for all model runs considered. In the reference case assumptions regarding M and steepness, all models indicated that western skipjack is not currently experiencing overfishing ($F < F_{MSY}$) and is not overfished ($B > B_{MSY}$).

The most significant difference among the models was the initial unfished biomass (B_0). The surplus production model (JABBA) is not age-structured and estimated a lower B_0 and a higher stock size, relative to B_0, needed to support maximum sustainable yield (MSY). The age-structured model (Stock Synthesis) suggests a higher B_0 and produces MSY at a higher level of depletion (i.e., B_{MSY} is less than 25% of B_0). The Group agreed that this result is expected considering that JABBA is a surplus production model that does not include age-specific life history dynamics. Stock synthesis is an age-structured model that includes age-specific life history functions. The life history of skipjack tuna suggests a highly productive stock with full maturity at age-1.

Given the similarity of the JABBA and Stock Synthesis model results, and the advantages of age-structured model configurations (e.g., inclusion of age-specific life history functions, facilitating the multi-species MSE, ability to explore the impacts of time varying selectivity and/or fleet allocation), the Group decided to use only Stock Synthesis model results in the development of management advice from the uncertainty grid used to quantify the major sources of scientific uncertainty. Nine Stock Synthesis runs were included in the grid, exploring uncertainty in growth parameters resulting in growth/natural mortality (M) and stock productivity (steepness, *h*=0.7, 0.8, and 0.9).

Parameter	**Value 1**	**Value 2**	**Value 3**	**Value 4**	**Value 5**	**Value 6**	**Value 7**	**Value 8**	**Value 9**
Steepness	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9
Growth param quantile	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75

The annual patterns in the median SSB, Recruitment, SSB/SSB$_{MSY}$, and F/F$_{MSY}$ were similar for all nine models, although the absolute magnitude of the estimates varied considerably (**Figure 42**). The current stock status was dependent on the assumed natural mortality and steepness. The three models run at the lowest M (at the 75th percentile of the growth parameters distribution) indicated the highest depletion (SSB near or below SSB$_{MSY}$), but none of the models considered suggested that overfishing has recently occurred (F<F$_{MSY}$). All models indicated that recruitment of the western stock has been below average since about 2015.

The uncertainty in current stock status was quantified using the Monte-Carlo multivariate lognormal (MVLN) with 20000 iterations (Walter and Winker, 2019) for each of the uncertainty grid cases (**Figure 43** and **Table 21**). The Group discussed if the number of axes in the uncertainty grid is sufficient to estimate the probability distribution of the stock status. A visual inspection of the "banana shape" of the Kobe plot, as well as the deterministic projections, reflected the expected correlation between relative biomass and relative fishing mortality (see section 5.2).

The resulting Kobe plot indicates that the stock is likely to be in a healthy condition (green quadrant; 81.1% probability) and is not overfished (SSB/SSB$_{MSY}$ = 1.38) nor undergoing overfishing (F/F$_{MSY}$ = 0.48). There is a small, but not insignificant, probability that the stock is either overfished (yellow quadrant; 13.4%) or both overfished and undergoing overfishing (red quadrant; 5.5%). The three models with the lowest assumed M at age (Qnt75) were the least optimistic with regards to stock condition and produced median SSB estimates below the level that supports MSY (SSB/SSB$_{MSY}$ ranging from 0.78-0.90). The models with a lower M produced SSB estimates above SSB$_{MSY}$ (SSB/SSB$_{MSY}$ ranging from 1.25-2.25). No model indicated that the median F in 2020 was above F$_{MSY}$ (median F/F$_{MSY}$ ranged from 0.22-0.81 of F$_{MSY}$). The overall average MSY estimate produced from the uncertainty grid was 35,277 t. Individual model estimates ranged from 28,444 t to 46,340 t.

5. Projections Kobe Matrix for skipjack tuna stocks

5.1 Eastern Stock

The group agreed to finalize stock assessment results for the eastern skipjack stock and also agreed to discuss projection settings at the informal intersessional meeting in July (see the workplan in Section 8), if the stock assessment results are deemed suitable for projections. The projections and resulting Kobe 2 strategy matrices will be reviewed at the September Species Group meeting and considered as a basis for the management advice. To facilitate the intersessional projection exercises in advance, the group agreed on the assumption of 2021 and 2022 catch to fix at 217,199 t that is the 2020 reported catch, while purse seine catch might be decreased, especially in 2022 due to the lower number of active vessels.

5.2 Western stock

The Group recommended that final management advice be developed from the distribution of the projections for the 9 Stock Synthesis runs (combination of *h* [0.6, 0.7, or 0.8] and Qnt [25, 50, or 75]) of the uncertainty grid. The Group agreed to conduct these projections using the following specifications.

- Projection interval: the Group agreed to develop projections for the period 2021-2040, and to produce management recommendations based on the projection results for the 2021-2032 period.
- For projection purposes, 2021 and 2022 catches are fixed at 18,859 t (the 2020 reported catch) even though the Group was informed on a recent decrease in fishing effort for the main SKJ western fisheries (BB Brazil).
- Catch scenarios: projection at constant F_{MSY}, constant catch projections at 0 t, and from 16,000 t to 40,000 t in 2,000 t intervals. Additional constant catch projections of 33,000 t and 35,000 t should be carried out in order to have finer scale intervals at levels near, but not exceeding, MSY.
- Recruitment: based on the estimated stock recruitment relationship with no recruitment deviations.
- Selectivity and relative contribution of fleets to catches: The estimated selectivities in recent years (2018 – 2020) in the model were used for projections. The proportions of the catch for each fleet were calculated using the average of the last three years (2018-2020) and used for the projections (**Table 22**).
- Projections were conducted using the Monte-Carlo multivariate lognormal (MVLN) described in Walter and Winker (2019) with 10,000 iterations.

During the meeting, the preliminary results of projections using MVLN 200000 iterations were presented to the Group (SCRS/P/2022/031), and it was agreed that the assessment team will provide final results at the informal intersessional meeting in July and an SCRS document will be presented at the September SCRS Species Group meeting.

Projections of spawning stock biomass and fishing mortality relative to SSB_{MSY} and F_{MSY} benchmarks were calculated for each of the 9 Stock Synthesis uncertainty grid runs for the western skipjack stock (**Figure 44** for SSB). The mean of the 9 runs was then calculated for each projection year (**Figure 45**).

As a result of the assumptions made for 2021 and 2022 catches and the gradual decrease in catch after 2017, the SSB/SSB_{MSY} increases and F/F_{MSY} decreases in the 2021-2022 period. Beginning in 2023, catches of 30,000 t or more lead to a decline in the spawning stock biomass. In this projection, the median of SSB/SSB_{MSY} remains above 1.0 at the range of the considered catch scenarios by 2032. However, the Group reiterated that the uncertainty of the projections increases substantially as time increases and that long-term projections (e.g., 5+ years) are highly uncertain.

The Group observed some unexpected SSB/SSB_{MSY} trajectories, and this could be the same case for BET and YFT projections. Stock Synthesis returned implausible values for F/F_{MSY} or SSB/SSB_{MSY} that consisted in some instances of extremely large fishing mortality rates associated with very small levels of biomass. To prevent this undesirable projection behaviour, a ceiling of 9 on F/F_{MSY} and a floor of 0.1 on SSB/SSB_{MSY} could be used to effectively prevent the stock from complete collapse during projection runs.

A tentative Kobe 2 strategy matrix was also examined. The Group discussed the possibility of using finer catch intervals for the projections. The SCRS sometimes provides projections with fine catch intervals to better assist the Commission in its deliberations to adopt TACs. However, the Group expressed its concerns regarding using finer TAC intervals because it will significantly increase the amount of work for the modellers and would make difficult for the Group to review the new results in the limited time available. The Group suggested that the SCRS could provide the Commission with a simple methodology to interpolate results between the available catch scenarios. Finally, the Group further requested that the modellers conduct the projection with the MSY level (35,277 t on average across 9 runs, **Table 21**), which is closer to 35,000 t. This will be provided to the Group intersessionally.

There were a few probabilities of SSB falling below 10% SSB_{MSY} in the projections, which corresponds to 1.8 – 2.8 % of virgin biomass for the 9 grid runs. The Group requested that the probabilities of SSB falling below 20% SSB_{MSY} also be provided.

6. Recommendations

6.1 Management

6.1.1 Eastern Stock

The Group agreed that management recommendations for the eastern Stock will be developed based on the results that will be presented at the scheduled intersessional meeting.

6.1.2 Western Stock

The Group points out that recent catches have been below previous catches and below MSY, and that such a decline is mostly due to lower catches by the Brazilian fleets. The Group noted that the stock assessment results showed lower recruitments at the end of the time series, which might be partially responsible for the lower catch levels.

Despite the lower recent catch levels, the Group indicated that the W-SKJ stock has a high probability of being in the green quadrant of the Kobe plot (i.e., not overfished and not undergoing overfishing).

The Group noted that the preliminary results of the projections indicate that recent catch levels are sustainable and are predicted to increase the stock size if recruitment is at the levels predicted by the stock-recruitment relationship. The Group recommends that catches should not be allowed to exceed MSY.

6.2 Research and statistics – including those with financial implications

These recommendations are in addition to those included in Anon. (2022).

- The uncertainty in age validation remains an important data gap for SKJ, the stock assessments used three scenarios of growth to account for this lack of information, which also affected natural mortality estimates. To reduce this uncertainty, the Group recommended that a validated reference age collection and standardized age key for input in stock assessment be produced. Noting that further analysis of AOTTP size samples could contribute to assessing the most appropriate growth parameters, a better understanding of the current status for the ageing of SKJ is needed. Continued capacity building of age and growth lab techniques that began as part of AOTTP may also help to resolve this data gap, noting that fulfilling this research need may have financial implications.
- In the 2014 SKJ stock assessment (Anon., 2015), the Canarian' baitboat index was used as part of the reference case. Therefore, the Group recommends updating and standardising this index for future use in stock assessments.
- Considering the inherent difficulties of eastern skipjack stock assessment to ensemble a grid to provide stock status and management advice, the Group recommends that the activities of the AOTTP funded by the Commission consider AOTTP data analysis to inform skipjack stock assessments (e.g., exploitation rates, movement and mixing rates, etc.).
- During the 2022 preparatory meeting (Anon., 2022), the Group recommended exploring the potential migration of SKJ across stock boundaries. Research to better understand SKJ stock structure could be achieved through analysis of returned AOTTP SKJ tags, or deployment of more conventional tags in places where movement details remain unknown (e.g., Venezuela to Equator and northern migrations of the western stock). Fine-scale movements and vertical migrations of SKJ could be assessed using electronic tags on large individuals, which may help to clarify whether there are movements across stock boundaries.
- Outputs of some of the stock assessment model runs highlighted potential issues with stock-recruitment curve steepness. Although similar values (0.7-0.9) are used across other oceans for SKJ, the Group recommends that research be conducted into factors that can influence steepness.
- The Group discussed that the fleet structure and characteristics used in the stock assessment align with those used in other tropical tuna stock assessments. However, the SKJ purse seine fishery has added variability due to the changes in areas fished and operational methods over several past years. The Group recommends further evaluating the changes in SKJ PS fisheries and exploring how to incorporate those changes into future stock assessments.

- At present, the stock assessment is not independently reviewed. Hence, the Group recommends an independent review of the future SKJ stock assessment.
- The Group noted the expansion of the eastern tropical tuna purse seine fleet to the North and the West and discussed the potential reasons for the expansion of the PS fishing grounds that may include / combine the following factors : (1) a change in the spatial scale of Task 2 data (from 1°x1° to 5°x5°), (2) the increased use of FOBs and related changes in fishing practices (its consequences in terms of fishers behaviour) (sharing information among vessels) (3) changes in the access to fishing grounds with the different configurations of the FOB moratorium and fishing agreements, and (4) increasing stock size or a change in the spatial distribution of the E-SKJ stock (in relation to the use of dFADs and/or in relation to other factors such as climate change). The Group, therefore, recommends that these hypotheses be examined in the near future.
- The Group recommends continuing research on the W-SKJ stock and its relation and response to changes in the climate and/or oceanographic conditions.

7. Responses to the Commission

The Group reviewed the requests from the Commission that were not addressed or not fully addressed by the SCRS in 2021 (ICCAT, 2021). The intention was to review the requests and the responses provided so far and discuss how the remaining questions are going to be addressed between now and the SCRS meeting in September:

21.1 Discards in purse seine fisheries, Rec. 17-01, paragraph 4. The Group noted that this can be addressed using information from observers. However, it was noted that this information was already available at the ICCAT Secretariat and could be used by the SCRS to inform the Commission.

The Secretariat will provide a summary of the available information at the next meeting. The Secretariat informed the Group that it is planning to summarize the observer data for tropical tunas caught in PS gear submitted through the ST09-DomObPrg statistical form and the information will be presented to the Group during the Species Group meeting in September. The Group agreed to prepare a response to the Commission based on the information that will be provided by the Secretariat.

21.4 Fishing prohibited with FADs, Rec. 21-01, para 28. The Group was informed that the analysis proposed by the SCRS in 2021 is in progress and results will be presented to the Group by September 2022. It was suggested to incorporate 2021 in the analysis if data are available in time. The idea is to have a projection matrix to evaluate the impact of the moratoria on FADs.

The Group noted that, in order to evaluate the efficacy of historical closures, appropriate indicators of fishing mortality for one-year old for the major surface fleets could be evaluated based on recent stock assessment results from BET and YFT.

The Group noted that for this analysis, historical FOB/FAD set data is required and that the reporting of this information is mandatory as per Rec 21-01. The Group requested that the SCRS report which CPCs have provided the required historical FOB/FAD set data by 31 July 2022, as per paragraph 31 of Rec. 21-01.

The Group noted that this analysis could investigate potential SKJ yield lost due to the FAD closure.

21.8 The SCRS shall refine the MSE process in line with the SCRS roadmap and continue testing the candidate management procedures. Rec. 21-01, para 62. It was noted that the roadmap will be discussed in the Meeting of the Tropical Tunas MSE Technical SubGroup (19-20 May, 2022)

The Group discussed that the development of successful reference models for both SKJ stocks is an important step to advance the Tropical Tunas MSE. MSE work for W-SKJ can be advanced by taking into consideration the results of the current stock assessment. The MSE team has already conducted preliminary conditioning of the OMs for the western stock and it is confident that the results of the stock assessment will be successfully incorporated into the conditioning of the OMs that will be discussed in September.

In the case of the eastern stock, the Group discussed that the MSE could use an assessment model in a different state without needing to define stock status and use it within that framework. It was indicated that there might be a need to develop a wider set of OMs than initially thought to include some additional hypotheses discussed during the meeting. For example, potential changes in productivity that could have resulted from the spatial expansion of the E-SKJ fishery and/or the use of FADs. Another hypothesis to include is the effect of different climate change scenarios on, for example, stock recruitment. The Group was informed that the MSE team has already discussed this last issue.

In general, the Group agreed that the OMs should include a wide number of scenarios, but all the scenarios should be plausible.

The Group indicated that the highest priority for the MSE team should be setting additional OMs that incorporate some of the findings of the current assessment instead of developing CMPs.

21.9 Efficacy that full fishery closures along the lines of those proposed in PA1_505A/2019, Rec. 21- 01, para 66a. The Group noted that a tool to evaluate the impact of the closure was presented in the past (Herrera et al., 2020) but that the SCRS could not address this question. However, this question is linked to Rec. 21-01 paragraph 28 and will be at least partially addressed in the response to the request.

The Group agreed that the results of the current stock assessment does not change the perception of the analysis done by Herrera *et al*. (2020). It was discussed that the calculations of the proportion of recruitment by quarter is new information that could affect the setting of the closures, for example, closing quarter 1 could reduce the mortality of recruits. However, there is still a need to develop a stable assessment model for E-SKJ to test this hypothesis. It was pointed out that the previous work by Herrera *et al.* (2020) used monthly catches which might capture the recruitment dynamics of the eastern stock. The Group also indicated that the closure was an alternative management tool for managing by controlling catches.

21.11 The SCRS and the Secretariat shall prepare TORs to carry out an evaluation of the monitoring, control and surveillance mechanisms in place in ICCAT CPCs. Rec. 21-01, para 66c. No action was agreed by the Group.

The Group and the Secretariat discussed the best approach to advance this work. Evaluation of data collection and processing programs is within the purview of SCRS. However, the Group discussed if this task should be conducted by the Subcommittee on Statistics. There was a general agreement that SCRS should focus on the monitoring portion of this task.

The Group discussed that the TORs should not only focus on the collection and processing of catch data but that it should also focus on fishing effort data including changes in fishing capacity. In other words, the TORs are to be developed to include assessment of data collection and processing of Task1 and Task2 data.

The Group also discussed if the TORs should be developed to conduct the analysis for all CPCs or just for major contributors to the total catch. For example, the Group agreed that one approach could be to conduct the analysis for those fleets that catch 90% of the tropical tuna complex in the eastern Atlantic. However, the Group also acknowledged the need to include other gears (e.g., longline, baitboats) in the analysis instead of just focusing on PS gear. It was agreed that besides the amount of catch, the importance of the information provided by the different fleets to the stock assessments should also be taken into consideration and that identifying data gaps that can reduce the uncertainty of stock assessment results is another important step.

One Commission request missing (paragraph 66 b) in Rec. 21-01. In 2021 the SCRS provided a table with the annual evolution of only large-scale PS vessels operating in ICCAT. The information was incomplete and should be updated including also the capacity and number of other fleet components (e.g., support vessels, BB, LL). The Group emphasized the importance of providing this information by September 2022 and requested national scientists to collaborate with this task.

The Group acknowledged that no update of fishing capacity estimates had been performed in the past few years. ISSF informed the Group that they can update this work for large PS vessels. The Group and the Secretariat discussed if the information submitted by CPCs through the ST01-T1FC statistical form (fleet characteristics) could be used to update fishing capacity estimates. However, the ST01-T1FC form only includes individual vessel information for vessels that are > 20 m LOA. Information for vessels < 20 m LOA is reported in a summarized form. Another limitation of the ST01 form is the lack of information on the amount of fishing conducted by each vessel. The Secretariat informed the Group that they can conduct a fishing capacity analysis using the ST01-T1FC form taking into consideration the caveats discussed by the Group.

8. Other matters

Due to time limitations, the Group was unable to complete all the tasks planned for the meeting. Thus, the Group discussed and agreed on a workplan for the intersessional period between this meeting and the Species Group meeting in September. The agreement is as follows:

- Continue to work on improving the SS3 and JABBA assessment models for the East-SKJ stock by considering the following suggestions for improvement. Add an axis of uncertainty representing the relative abundance indices used (2 levels: i Canary Islands' BB + PS Vast and ii Canary Islands' BB + Echosounder buoy) to the grid of uncertainty.
    - SS3
        - Alternative weighting of length composition data
        - Inclusion of AOTTP tagging data for the purposes of survival estimation (will require analysis and preparation of tagging data sets prior to 15 June).
        - Analysis of the recruitment deviates trend and time period
        - Analysis of the introduction of length composition with bin of 1 cm.
        - Analysis of starting the model in a different period, for example, at the same time as the Canarian BB 1990.

    - JABBA
        - Alternative M vectors scaled in new runs from SS3
        - Sensitivity analysis regarding Process Error Deviations
        - Alternative production functions and Abundance Indices

- Have an informal Tropical Tuna Species Group webinar on the 15July 2022 (11:00 – 16:30 CET) open to all participants of the current meeting.
    - Finalize West-SKJ Projection and confirm the results adopted in the stock assessment meeting report
    - Present and discuss new runs for SS3 and JABBA for the East-SKJ
    - Decide whether such runs are appropriate to agree on a reference case and uncertainty grid for East-SKJ. If appropriate, develop a Kobe plot
    - If feasible, develop projections and a Kobe matrix for East-SKJ

- Between 15 July and the Species Group meeting
    - Prepare drafts of the Executive summary for SKJ
    - Prepare drafts of responses to the Commission
    - Prepare SCRS paper(s) describing intersessional work conducted on East-SKJ assessments for presentation during the Species Group meeting.

9. Adoption of the report and closure

The report was adopted partially during the stock assessment meeting (sections 3, 4 and 8) and partially by correspondence (sections 1, 2, 5, 6, 7 and 9).

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Table 1. Task 1 catch (t) by year and fleet ID for the skipjack east stock unit 1950 – 2020.

Catch t	FleetID	FleetName									
	1	2	3	4	5	6	7	8	9	10	
YearC	PS EU 63-85	PS EU 86-90	PS EU FSC 91+	PS EU FAD 91+	PSBB Ghana	BB South Dakar	BB Dakar 62-80	BB Dakar 81+	BB North 25 lat	LL E-SKJ	Total
1950									704.00		704.00
1951									459.00		459.00
1952									581.00		581.00
1953									786.00		786.00
1954									720.00		720.00
1955									1,192.00		1,192.00
1956					1.00	149.00			1,002.00		1,152.00
1957					3.00	15.00			155.00	3.00	176.00
1958						58.00			400.00		458.00
1959						89.00			337.00		426.00
1960						529.00			619.00	23.00	1,171.00
1961					1.00	1,566.42	180.58		825.00	4.00	2,577.00
1962					8.00	4,436.27	852.73		3,975.00		9,272.00
1963	384.00				2.00	7,909.63	1,053.37		6,720.00		16,069.00
1964	1,346.00				520.00	4,816.75	702.25		6,345.00	19.00	13,749.00
1965	3,316.00				80.00	8,985.67	1,354.33		8,778.00	22.00	22,536.00
1966	6,148.00					8,762.71	1,655.29		4,444.00	32.00	21,042.00
1967	7,465.00				490.00	7,559.02	1,870.98		4,170.00	13.93	21,568.93
1968	20,978.00				3,186.00	15,113.26	3,671.74		2,747.00	34.85	45,730.85
1969	9,687.00				4,836.00	8,543.14	1,830.86		2,713.00	8.77	27,618.77
1970	18,226.00				12,004.00	10,060.13	3,789.87		3,918.00	11.61	48,009.61
1971	32,856.00				16,556.00	16,005.80	4,299.20		7,033.00	38.89	76,788.89
1972	38,012.60				12,435.00	13,625.19	3,907.81		7,794.00	51.54	75,826.14
1973	28,994.00				22,052.10	15,661.17	4,388.83		4,914.00	31.70	76,041.80
1974	54,444.00				21,266.00	25,329.88	5,592.48		7,270.65	107.74	114,010.74
1975	28,266.00				9,316.00	10,643.36	2,913.64		1,609.00	115.79	52,863.79
1976	31,339.00				7,742.00	20,980.67	2,952.33		2,675.00	23.05	65,712.05
1977	51,978.00				16,411.00	28,202.00	3,402.00		7,303.00	93.23	107,389.23
1978	53,805.00				10,503.00	28,965.00	5,586.00		4,937.00	25.07	103,821.08
1979	35,698.00				7,599.00	32,241.32	4,494.68		4,288.00	6.55	84,327.55
1980	53,842.00				11,556.00	24,628.27	4,889.93		3,881.00	6.84	98,804.04
1981	63,595.00				12,931.00	24,050.75		2,981.35	6,847.00	49.08	110,454.18
1982	72,406.31				21,244.00	16,534.49		5,562.51	8,117.00	16.31	123,880.62
1983	65,155.53				26,588.00	8,256.79		3,750.83	2,283.39	416.53	106,451.06
1984	61,271.80				25,599.07	1,242.13		4,806.87	5,905.00	22.00	98,846.87
1985	46,449.41				21,116.00	304.40		5,218.60	8,064.00	6.00	81,158.41
1986		57,503.78			22,815.00	61.64		2,774.36	7,936.00	19.00	91,109.78
1987		54,497.13			24,723.00	80.00		4,042.00	11,779.00	6.00	95,127.13
1988		71,173.53			27,476.00	85.78		4,455.22	17,335.00	4.00	120,529.53
1989		52,537.27			23,705.00	305.39		5,588.61	12,876.00	9.00	95,021.27
1990		80,842.19			24,661.00	377.56		5,073.81	7,982.33		118,936.89
1991			55,219.03	93,296.94	26,321.30	99.34		3,333.45	13,758.08	5.00	192,033.13
1992			27,798.21	77,284.45	19,793.00	120.61		2,623.71	14,540.00	3.03	142,163.02
1993			53,069.66	91,197.59	20,590.00	105.40		3,550.58	8,437.00	2.00	176,952.23
1994			44,431.75	78,880.46	21,572.20	622.67		3,656.22	12,282.00	10.21	161,455.52
1995			32,710.93	86,007.54	18,919.00	866.34		4,348.37	10,129.00	3.10	152,984.29
1996			14,444.89	74,778.26	24,529.00	543.06		2,540.08	12,748.00	7.03	129,590.32
1997			28,524.91	45,173.21	26,516.72	725.81		5,961.84	10,279.00	47.40	117,228.89
1998			34,126.02	32,663.05	44,544.09	432.13		10,514.67	9,960.00	85.30	132,325.27
1999			43,020.46	43,720.74	54,377.76	136.97		7,723.53	5,919.00	41.62	154,940.08
2000			22,989.62	53,553.46	38,858.21	252.74		8,187.15	2,404.10	48.25	126,293.53
2001			15,778.05	45,607.41	58,238.02	485.42		8,096.44	3,650.67	52.80	131,908.80
2002			11,628.56	33,047.87	43,141.02	187.61		9,234.38	3,290.19	55.60	100,585.22
2003			30,469.34	47,008.39	36,137.85	508.16		10,309.81	5,692.69	66.05	130,192.29
2004			26,943.42	57,781.36	48,876.95	620.37		9,185.38	10,551.60	46.57	154,005.66
2005			12,506.68	52,175.87	56,671.25	780.96		14,206.89	7,569.18	71.48	143,982.32
2006			8,082.77	42,330.93	37,118.31	348.47		9,835.25	14,006.78	200.93	111,923.44
2007			5,506.37	53,924.47	38,806.43	168.97		11,849.73	9,561.60	405.33	120,222.89
2008			11,783.03	50,672.59	42,448.14	88.76		8,647.69	9,278.60	171.95	123,090.75
2009			8,456.51	64,892.54	49,049.08	110.31		12,766.14	2,496.28	58.16	137,829.02
2010			13,330.05	75,163.32	50,590.93	83.87		10,474.93	14,340.59	41.68	164,025.38
2011			14,915.00	100,017.33	49,694.50	454.11		16,649.08	5,335.06	29.40	187,094.48
2012			21,880.96	107,605.77	61,055.35	35.43		17,956.16	10,107.89	21.36	218,662.92
2013			19,300.83	129,947.92	55,401.21	11.68		12,167.72	7,226.49	17.70	224,073.55
2014			12,829.71	124,679.87	52,358.65	26.45		9,515.89	6,053.30	39.02	205,502.90
2015			18,989.94	126,298.01	64,648.92	66.74		8,644.32	2,766.29	10.13	221,424.34
2016			14,202.80	150,988.58	57,447.11	576.78		11,463.34	3,541.13	479.21	238,698.94
2017			17,081.20	146,694.67	62,679.66	486.78		10,740.92	5,107.63	418.58	243,209.44
2018			25,611.69	162,624.52	74,578.78	246.37		10,958.53	11,141.28	8.74	285,169.91
2019			11,773.91	162,426.90	69,110.54	228.22		10,744.03	5,054.91	210.73	259,549.25
2020			32,879.08	111,517.09	64,640.00	120.49		5,278.78	3,428.69	10.07	217,874.19

Table 2. Task 1 catch (t) by year and fleet ID for the skipjack west stock unit 1952 – 2020.

Catch t	FleetID	FleetName				
	1	2	3	4	5	
YearC	PS West	BB West	LL USMX	LL OTH	HL RR	Total
1952		1,229.00				1,229.00
1953		1,281.00				1,281.00
1954		1,370.00				1,370.00
1955		1,396.00				1,396.00
1956		1,503.00				1,503.00
1957		1,955.00				1,955.00
1958		1,650.00				1,650.00
1959		1,830.00				1,830.00
1960		3,263.00				3,263.00
1961		3,295.00				3,295.00
1962	463.00	1,549.00				2,012.00
1963	2,995.00	968.00				3,963.00
1964	3,980.00	1,071.00				5,051.00
1965	64.00	1,481.00				1,545.00
1966	40.00	1,651.00		100.00		1,791.00
1967	32.00	2,655.00		103.07		2,790.07
1968	135.00	2,407.00		102.15		2,644.15
1969	102.00	1,655.00		101.23		1,858.23
1970		2,200.00		277.39		2,477.39
1971		1,700.00	16.90	273.21		1,990.11
1972	245.00	1,400.00	16.18	279.28		1,940.46
1973	29.00	1,921.00	42.00	575.30		2,567.30
1974	28.00	2,972.00	41.71	389.55		3,431.26
1975	196.00	2,836.00	91.49	258.72	2.00	3,384.21
1976	700.00	2,883.00	13.38	177.57		3,773.95
1977	334.00	2,588.00	7.77	141.00	19.00	3,089.77
1978	1,722.00	2,464.00	26.24	209.69	63.00	4,484.93
1979	737.00	4,225.00	2.11	176.33	292.00	5,432.45
1980	2,887.00	9,351.00	3.22	149.95	1.10	12,392.26
1981	4,654.00	17,999.00	23.02	236.00	180.00	23,092.02
1982	9,705.00	22,402.00	11.79	386.00	22.00	32,526.79
1983	9,845.00	20,057.00	202.57	525.00	109.07	30,738.64
1984	10,924.93	16,810.00	49.00	743.00	36.00	28,562.93
1985	9,270.00	28,506.00	69.18	444.00	62.13	38,351.31
1986	4,954.00	25,885.00	18.18	897.00	143.06	31,897.24
1987	4,964.00	18,805.00	17.31	280.00	97.24	24,163.55
1988	2,315.01	21,146.00	12.00	212.00	51.31	23,736.32
1989	2,466.00	23,492.00	19.56	373.00	31.82	26,382.38
1990	3,241.00	22,350.00	27.42	416.00	75.87	26,110.29
1991	6,935.00	24,096.00	10.36	662.79	107.74	31,811.88
1992	7,389.00	21,112.00	11.23	459.30	63.03	29,034.56
1993	12,397.00	19,902.00	11.71	421.00	92.09	32,823.80
1994	5,712.00	22,855.00	8.57	1,296.00	77.52	29,949.09
1995	2,059.00	17,744.00	33.71	1,941.90	81.00	21,859.61
1996	3,349.00	23,741.00	11.31	374.79	85.50	27,561.60
1997	4,347.00	27,045.00	6.15	232.31	81.31	31,711.76
1998	3,826.00	24,727.00	18.80	411.71	103.53	29,087.04
1999	2,936.00	23,881.00	56.59	331.88	150.06	27,355.53
2000	3,063.35	25,641.00	22.28	424.50	42.28	29,193.41
2001	5,297.10	25,142.30	59.45	886.63	65.28	31,450.76
2002	2,116.05	18,736.88	318.01	344.09	84.49	21,599.52
2003	2,296.30	21,990.30	81.16	303.21	77.56	24,748.53
2004	2,769.12	24,081.60	179.40	329.53	101.84	27,461.48
2005	1,966.57	26,027.60	178.84	314.12	29.45	28,516.57
2006	2,045.01	23,766.12	256.36	324.22	60.81	26,452.51
2007	1,209.25	23,897.94	50.52	210.47	71.33	25,439.51
2008	901.28	20,701.94	40.66	303.70	65.57	22,013.16
2009	2,034.57	23,518.10	19.58	78.83	123.21	25,774.29
2010	1,943.16	22,803.47	851.88	210.34	97.78	25,906.62
2011	1,859.49	29,468.12	351.71	227.05	481.31	32,387.68
2012	1,582.03	30,692.80	49.87	167.45	342.58	32,834.73
2013	907.74	32,187.12	639.95	245.93	547.54	34,528.28
2014	1,081.25	24,813.95	433.61	287.75	551.52	27,168.09
2015	2,243.09	17,537.76	187.41	190.32	558.57	20,717.15
2016	1,912.29	16,810.42	788.61	203.45	1,347.31	21,062.09
2017	2,150.27	14,646.53	258.65	244.67	5,490.89	22,791.00
2018	1,226.30	14,926.46	290.31	209.61	4,618.91	21,271.59
2019	876.46	15,409.55	388.69	181.71	2,240.82	19,097.22
2020	1,008.94	14,593.47	174.36	61.39	2,344.38	18,182.56

Table 3. Merge of the “faux poisson” SKJ catch series (shaded in yellow).

[1] T1NC as of 2022-05-23 (SKJ-SA)

Stock	PartyStatus	FlagName	CatchTypeCode	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remarks
ATE	**CP**	Belize	LF	395	368	179	636	301							not adopted
		Cape Verde	LF	726	411	230	428	1362	1485	1046	327	512	355	410	adopted
		Côte d'Ivoire	LF		42	562	544	202							not adopted
		Curaçao	LF	415	441	545	520	351							not adopted
		EU-España	LF	1394	1842	983	998	1623	3028	3658	2788	1943	2396	1809	adopted
		EU-France	LF	743	1480	1646	463	440	1716	1920	893	2169	1616	1681	adopted
		Guatemala	LF	136	51	102	72	93							not adopted
		Guinée Rep	LF	614	1778	2379	1670	2146							not adopted
		Panama	LF	354	609	284	962	400							not adopted
	NCO	Mixed flags (EU tropical)	LF	3427	2372				4484	8603	4618	6499	5396	6710	merged (not adopted series)
ATW	**CP**	Cape Verde	LF						2	2		9		9	adopted
		EU-España	LF						8	67	35	7	13	9	adopted
	NCO	Mixed flags (EU tropical)	LF						58	37	21	29	6	17	merged (not adopted series)
TOTAL				**8205**	**9395**	**6909**	**6293**	**6918**	**10779**	**15334**	**8682**	**11169**	**9781**	**10645**	

[2] T1NC as of 2022-02-25 (SKJ-DP)

Stock	PartyStatus	FlagName	CatchTypeCode	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remarks
ATE	**CP**	Belize	LF	395	368	179	636	301	399	876	478				
		Cape Verde	LF	726	411	230	428	1362	1485	1046	327	512	355	410	
		Côte d'Ivoire	LF		42	562	544	202							
		Curaçao	LF	415	441	545	520	351	1644	2296	1128	1742	1249	1289	
		El Salvador	LF						683	1920	765	1359	1286	1600	
		EU-España	LF	1394	1842	983	998	1623	3028	3658	2788	1943	2396	1809	
		EU-France	LF	743	1480	1646	463	440	1716	1920	893	2169	1616	1681	
		Guatemala	LF	136	51	102	72	93	735	663	500	713	575	655	
		Guinée Rep	LF	614	1778	2379	1670	2146							
		Panama	LF	354	609	284	962	400	713	1279	525	647		826	Group estimates (2015-2020)
		Senegal	LF						309	1569	1223	2037	2285	2340	
	NCO	Mixed flags (EU tropical)	LF	3427	2372										
ATW	**CP**	Belize	LF							4					
		Cape Verde	LF						2	2		9		9	
		Curaçao	LF						4	11	8	14	3	4	
		El Salvador	LF						5	13	8	3		8	
		EU-España	LF						8	67	35	7	13	9	
		Guatemala	LF							1	5	5	4	1	
		Panama	LF						49	8				5	
		Senegal	LF									8			
TOTAL				**8205**	**9395**	**6909**	**6293**	**6918**	**10779**	**15334**	**8682**	**11169**	**9781**	**10645**	
	Difference (t) in TOTAL: [1]-[2]			0	0	0	0	0	0	0	0	0	0	0	NO change in TOTAL

Table 4. CAS (catch-at-size) matrix estimated for SKJ-E (Eastern stock) in thousands of fish caught, by year and 2 cm size classes.

	Year												
Li (2cm)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
20	0	0	1	0	0	0	0	66	0	0	0	0	0
22	0	1	6	0	0	0	0	2	0	0	0	3	1
24	0	6	34	4	0	0	0	0	0	1	0	14	0
26	1	13	45	4	0	0	0	0	0	3	0	7	37
28	2	20	98	40	1	14	1	2	0	4	3	10	207
30	3	18	25	4	6	40	11	59	7	49	30	69	195
32	3	16	28	18	10	63	15	73	67	58	211	221	315
34	31	57	88	93	131	279	54	169	200	197	314	543	664
36	73	112	161	167	358	744	246	386	493	632	895	1950	1008
38	240	377	707	904	1013	2078	644	1318	1345	1514	1718	3110	2914
40	466	834	1771	1850	2584	5500	1396	3105	2984	3467	2818	4613	5792
42	870	1685	3268	3123	4836	8551	2181	4038	4286	5124	3817	6139	8555
44	1555	3301	5077	4843	7418	9364	2744	4676	5359	6572	5133	6514	9817
46	1299	3188	4128	3953	5969	8204	2764	3994	6284	7182	6053	6165	8229
48	1070	2590	3555	3821	3685	6076	2129	3357	6648	5961	4708	5337	5538
50	981	1776	3289	3385	2159	4020	1977	2823	5797	4095	3339	3774	3842
52	1150	1783	3229	3129	1952	2564	1798	1836	3838	2692	2055	2821	2725
54	1138	1627	2775	2693	1915	1760	1470	1529	2528	2046	1420	1875	1767
56	797	1122	1681	1702	1343	1086	1168	1073	1697	1616	967	1110	1005
58	498	606	927	853	770	651	579	635	1130	1169	632	639	595
60	275	317	458	354	294	611	535	385	760	613	565	532	375
62	115	135	198	194	165	303	236	177	393	445	491	370	315
64	29	63	111	89	80	105	205	93	238	203	343	223	144
66	8	24	37	42	52	127	222	45	122	149	201	153	111
68	8	8	24	19	36	41	106	21	93	107	177	121	66
70	1	0	0	6	8	27	71	22	37	75	61	69	35
72	1	0	0	1	1	3	34	6	5	34	29	34	28
74	4	7	10	12	8	3	23	3	2	9	12	4	8
76	0	0	0	0	0	2	7	0	6	2	1	2	2
78	0	0	0	0	0	5	2	1	11	5	0	0	1
80	0	0	0	0	0	0	7	1	5	0	0	1	0
82	0	0	0	0	0	0	0	0	9	0	0	0	0
84	0	0	0	0	0	0	0	0	3	4	13	0	0
86	0	0	0	0	0	0	0	0	6	9	26	0	0
88	0	1	0	0	0	0	0	0	9	9	26	0	0
90	0	1	0	0	0	232	0	0	6	0	0	0	0
TOTAL	10619	19687	31734	31305	34796	52451	20627	29895	44370	44045	36061	46425	54290

	Year													
Li (2cm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	1	1	1	1	2	1	2	2	1
26	1	1	1	1	0	5	5	5	6	16	13	19	17	17
28	28	8	4	4	2	29	28	31	35	92	78	109	97	81
30	82	63	30	22	13	139	145	154	186	462	379	549	471	390
32	180	175	90	53	40	436	463	492	587	1430	1189	1645	1521	1261
34	489	460	262	206	145	935	975	1064	1188	2765	2283	3192	3004	2456
36	1194	1037	652	603	573	1475	1638	1634	1860	4149	3373	4643	4385	3768
38	2512	2115	1264	1301	1183	1788	2595	2452	2874	5454	4087	5796	5489	5337
40	5083	4161	2828	3003	1923	2873	4772	3890	4250	7835	6102	8632	6798	8127
42	7530	7647	5279	5163	3688	5155	8087	5912	6321	12267	9322	12041	10183	12771
44	9390	9033	6635	5633	6784	6801	11022	7190	8355	15072	11687	14621	13058	14890
46	11027	9690	6104	4738	8674	7537	10436	7591	9682	15780	12262	16248	14204	13457
48	7235	6943	5245	3954	7097	5951	7628	5988	8055	12395	8430	11789	11042	9206
50	4527	3898	4579	3110	4439	4213	4525	4220	5286	8042	4824	5781	5622	4329
52	3131	2459	3467	2431	2847	3113	2746	2605	3173	4461	2687	2954	3549	2251
54	2110	1420	2119	1756	1617	1648	1592	1396	1965	2516	1507	1815	1647	1053
56	1648	771	1056	1145	898	943	976	777	1081	1388	887	1132	1009	681
58	942	445	469	740	468	521	600	411	569	868	595	700	626	583
60	516	319	232	494	219	394	401	271	404	469	472	501	441	474
62	217	192	199	347	137	248	269	205	288	308	388	336	267	359
64	114	135	160	203	74	149	144	117	223	189	330	157	194	220
66	91	61	122	104	37	91	51	41	142	137	251	96	129	133
68	35	32	75	56	10	30	16	19	78	81	166	95	98	78
70	21	7	35	22	2	8	4	32	25	35	99	38	39	37
72	9	12	8	7	1	3	4	27	10	13	26	9	25	23
74	5	1	6	3	0	1	6	10	1	1	13	7	8	7
76	1	0	1	0	0	1	7	1	0	0	4	3	1	1
78	1	1	1	0	0	1	9	1	0	0	3	0	0	0
80	1	0	1	0	0	1	3	0	0	0	0	0	0	0
82	2	0	0	0	0	1	1	0	0	0	0	0	0	0
84	0	0	0	0	0	2	1	0	0	0	0	0	0	0
86	0	0	0	0	0	1	0	0	0	0	0	0	0	0
88	0	0	0	0	0	1	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTAL	58121	51087	40924	35098	40871	44495	59151	46536	56644	96228	71456	92910	83925	81992

	Year													
Li (2cm)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
20	0	0	0	0	0	0	0	0	0	0	1	0	2	0
22	0	0	0	0	0	0	0	0	1	0	0	0	0	0
24	0	1	1	1	2	0	0	1	6	1	3	1	7	10
26	4	8	8	11	11	7	2	7	10	11	6	8	41	25
28	27	61	63	60	70	33	26	41	67	35	34	48	95	67
30	145	330	311	342	366	138	142	293	523	230	183	288	382	269
32	520	1028	920	1118	1168	483	378	1005	1791	706	584	1081	1045	1054
34	1316	2085	1716	2414	2336	953	811	2030	3453	1973	1172	2523	2423	2818
36	2731	3422	2592	3665	3723	2160	1633	3284	4677	3304	1866	4639	3792	5386
38	3556	4249	3244	4565	4638	3721	2716	4526	5178	4478	2954	6275	4740	6189
40	5582	5415	4409	7059	6654	6391	4148	6205	6422	6544	4683	8124	5773	6455
42	9548	7912	6743	10726	8182	9074	5832	8788	8143	9041	6848	8711	7685	7242
44	11521	8926	9530	13306	8473	10222	7138	10306	9769	10159	8166	8429	8521	8344
46	12145	10178	11360	12818	8123	9029	7592	9235	10458	9695	7986	7391	7671	8264
48	8467	7895	9350	8939	6779	7583	6667	7057	9988	7959	6498	5397	6207	6472
50	3815	4210	5722	6353	4950	5544	4486	4954	6982	6023	4470	3551	4249	4631
52	2247	2642	3894	3452	2971	3504	2709	2865	4050	3681	2958	2531	3143	3226
54	1365	1129	1829	2042	2243	2052	1574	1675	2209	2202	2008	1774	2117	2476
56	948	691	1014	1060	1304	1104	938	1091	1433	1552	1408	1148	1388	1750
58	645	489	701	652	900	797	609	776	826	955	800	779	908	1393
60	468	345	441	403	563	552	398	576	580	642	435	637	696	924
62	305	246	239	220	335	346	227	364	405	460	267	418	412	644
64	176	129	150	171	152	216	116	224	280	297	137	187	335	472
66	111	47	75	107	79	112	54	184	134	155	79	103	126	145
68	75	38	24	40	38	77	31	91	68	99	61	33	46	75
70	30	12	20	19	52	20	16	46	28	24	28	17	17	35
72	5	5	8	11	20	7	12	27	14	15	11	18	11	37
74	1	0	2	1	3	2	10	12	7	7	5	20	16	11
76	0	3	2	3	3	2	4	2	3	5	9	12	8	1
78	0	0	0	0	1	3	3	4	1	3	4	3	1	1
80	0	0	1	1	0	0	1	2	0	1	3	2	2	0
82	0	3	1	0	0	0	1	1	18	1	0	1	1	0
84	0	0	1	0	0	0	0	0	0	0	0	1	0	0
86	0	3	0	0	0	0	0	0	0	0	0	0	0	0
88	0	3	0	0	0	0	0	0	0	0	0	0	0	0
90	0	4	2	0	0	1	0	1	1	2	5	0	0	0
TOTAL	65756	61508	64371	79561	64138	64134	48273	65674	77527	70263	53671	64151	61860	68417

	Year										
Li (2cm)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
20	0	1	0	0	0	0	4145	0	0	1	0
22	2	0	0	0	3	0	1	15	3	0	5
24	21	1	0	0	8	6	13	24	11	5	4
26	55	5	5	4	20	20	30	27	57	30	28
28	118	22	55	29	80	60	117	134	123	89	116
30	324	252	383	246	349	455	811	779	719	516	515
32	1046	1108	1326	843	1009	1451	2568	2318	2392	1796	1976
34	3055	3499	4131	2045	2472	3529	5516	5277	5913	4051	4521
36	5557	7082	7362	3363	4997	5964	7583	9332	10659	7674	7431
38	7031	9873	9477	4466	6209	5823	9489	14112	15679	10985	10105
40	9679	11951	11654	6108	8236	8495	14280	19006	22065	17171	15242
42	10924	13469	12299	7297	9701	13151	16993	20404	25817	19362	16646
44	11115	13559	12459	9324	11775	16208	16143	19485	24687	19420	15613
46	10545	11421	13222	10319	12328	13482	12622	16231	20569	17256	13770
48	9279	8567	10897	9866	10236	9728	10546	11076	13409	12417	9867
50	6480	5888	7511	7909	6708	6814	7857	6535	7502	7507	5843
52	4293	4268	5302	6903	5023	5597	5315	3923	4229	4857	4062
54	2347	2925	3574	6114	3868	3969	3880	2328	2500	3042	2598
56	1525	1942	2645	4544	2919	2828	2601	1664	1534	2528	1996
58	918	1373	1866	3474	2147	2038	1943	1070	1154	1785	1547
60	556	780	1583	2560	1681	1398	1291	866	926	1559	1253
62	373	504	1144	1969	1233	956	826	621	565	946	811
64	181	262	637	1322	875	571	584	400	275	614	542
66	68	134	300	706	584	474	348	169	96	334	362
68	47	53	139	239	329	378	220	99	48	158	154
70	9	29	18	85	170	337	104	39	22	44	38
72	9	9	19	31	50	161	84	33	2	11	7
74	0	4	4	10	5	88	33	13	1	4	1
76	1	3	1	2	1	4	8	4	0	0	0
78	1	3	0	0	1	1	0	2	0	1	0
80	1	1	0	0	0	0	1	1	0	1	0
82	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	1	0	0	0	0	0	0
88	0	0	0	0	1	0	0	0	0	0	0
90	1	2	1	0	2	0	1	0	0	0	0
TOTAL	85562	98989	108017	89778	93021	103985	125952	135986	160957	134165	115056

Table 5. CAS (catch-at-size) matrix estimated for SKJ-W (Western stock) in thousands of fish caught, by year and 2 cm size classes.

	Year																																																			
Li (2cm)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	18	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
24	0	1	1	1	1	1	0	0	0	1	0	2	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	1	0	0	0	0
26	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	1	0	3	0	0
28	1	2	2	2	2	2	1	1	1	1	0	1	0	0	1	0	0	0	2	1	2	1	3	0	1	5	1	0	0	0	0	0	0	0	0	1	3	0	1	0	1	0	0	0	14	33	0	4	2	2	1	2
30	2	3	2	2	2	3	2	2	1	4	1	8	1	2	1	1	12	15	3	1	2	1	4	0	17	10	2	1	2	0	2	0	4	0	2	10	6	3	2	1	2	1	1	1	36	0	1	16	10	8	4	4
32	5	7	6	6	6	7	7	8	7	10	5	14	1	1	1	2	15	33	4	4	4	2	13	1	56	31	4	2	3	1	3	8	11	2	4	16	9	0	9	1	10	5	2	0	12	1	4	39	24	59	30	11
34	5	7	6	6	6	7	26	30	27	16	11	18	2	1	3	10	14	24	5	5	6	3	30	22	127	35	11	8	11	5	11	29	52	8	10	34	16	0	23	3	23	13	6	0	15	33	29	109	87	62	48	48
36	7	10	9	8	9	13	39	45	40	23	22	23	4	3	17	29	74	62	16	15	35	33	49	77	305	58	32	27	34	10	27	32	86	16	12	24	34	2	39	12	40	28	21	11	8	1	14	300	271	242	214	207
38	23	34	30	30	30	46	66	70	64	44	49	44	8	6	27	57	59	121	75	36	76	48	129	68	512	148	79	65	75	48	75	92	144	29	30	47	45	9	78	13	69	47	30	12	10	136	74	453	435	398	378	350
40	25	38	34	36	35	78	107	117	106	83	84	91	30	34	56	166	694	305	105	63	86	67	202	121	586	281	114	152	174	119	147	144	294	45	84	67	102	30	94	25	76	70	35	26	187	75	141	244	335	248	160	149
42	33	50	45	49	47	116	110	110	104	113	95	186	119	342	385	706	1047	383	93	108	121	101	393	221	687	326	146	173	167	140	125	150	350	74	175	128	247	105	133	190	160	278	242	309	93	150	185	265	571	295	226	165
44	50	75	67	75	73	161	161	147	140	160	127	273	211	556	600	1016	1100	407	311	229	235	147	518	357	894	512	204	208	187	177	132	201	425	103	319	382	458	338	223	362	288	479	475	596	295	61	512	396	843	439	350	277
46	59	87	78	81	89	175	159	149	140	210	153	266	231	253	373	547	945	551	385	389	419	357	764	530	855	716	283	320	302	296	185	187	413	188	473	901	634	477	316	442	615	634	735	742	524	994	571	636	988	769	592	489
48	55	82	72	72	89	166	152	154	148	219	154	274	300	289	380	475	1041	710	648	647	583	756	1070	707	793	837	434	510	466	400	344	312	577	329	567	1228	909	899	411	908	847	850	1035	996	507	1622	842	894	1096	1097	894	694
50	54	79	69	68	93	129	127	130	123	198	188	241	461	436	588	582	1637	922	729	919	958	1258	1204	741	833	981	531	579	732	522	517	519	801	526	614	1316	1337	1207	696	979	963	900	1163	995	2050	2410	486	1004	1061	1140	975	816
52	43	56	48	52	63	84	107	120	95	165	131	192	792	847	877	986	1448	1111	701	929	1183	1473	1291	821	885	1020	621	690	1000	826	697	735	935	689	675	904	1486	1306	775	704	1053	807	1154	981	3063	1783	494	972	980	1025	918	783
54	30	39	32	34	43	61	83	87	69	139	106	197	710	1025	933	1122	1437	1288	795	778	1129	1437	1214	863	1213	914	607	739	1180	963	821	895	1013	725	740	809	1426	1327	587	501	898	686	1026	919	1536	807	439	616	632	834	711	486
56	29	36	27	27	31	41	64	72	58	116	119	215	684	932	811	824	1300	1323	854	743	952	1067	1093	851	991	899	566	775	1206	935	898	959	952	714	745	726	1091	955	478	391	758	570	841	784	667	420	429	758	689	599	616	562
58	31	34	22	25	27	30	41	56	49	98	123	278	467	676	643	638	1054	1003	792	682	830	565	855	790	898	798	626	850	1063	1004	985	1066	817	620	684	568	543	723	418	388	611	484	692	701	843	341	550	663	661	603	601	562
60	37	41	27	31	37	33	43	62	52	76	113	289	496	550	529	527	681	691	528	509	424	287	588	595	553	647	538	743	782	880	861	916	551	407	457	471	334	356	404	302	493	396	547	584	526	107	389	218	205	200	184	256
62	21	25	16	16	27	19	19	26	25	55	85	241	400	580	491	592	390	369	251	326	265	187	373	399	362	420	436	584	509	569	556	602	449	321	371	372	175	188	368	217	322	277	375	416	287	203	446	116	100	79	70	108
64	21	24	17	18	25	21	16	23	20	51	73	187	313	461	359	422	184	168	155	189	121	68	182	282	271	219	256	340	292	297	291	321	327	230	256	265	107	102	405	113	147	123	170	190	20	68	215	64	46	67	37	48
66	11	10	6	9	10	7	12	22	18	49	46	136	253	420	354	419	95	86	103	97	83	49	119	159	97	86	114	157	193	194	190	208	268	196	214	109	39	49	322	123	113	129	145	168	2	69	156	35	11	9	5	35
68	8	11	7	7	10	9	5	6	7	38	34	89	121	280	269	255	54	42	90	40	51	19	49	127	41	43	64	85	99	103	104	104	197	136	149	37	19	11	270	136	78	150	151	186	1	38	96	19	9	9	3	12
70	16	23	21	19	24	27	8	5	5	26	21	64	83	211	229	238	33	34	51	19	56	9	19	81	66	35	57	73	41	47	46	41	57	48	47	17	21	0	146	117	47	128	121	157	0	2	22	14	5	5	1	27
72	10	15	14	12	17	17	5	3	3	13	12	25	50	79	102	79	30	21	53	16	14	5	31	85	18	28	49	54	13	10	12	10	50	40	41	14	19	0	75	56	27	72	61	76	1	0	22	12	3	3	3	24
74	2	4	4	3	6	6	4	2	2	7	7	16	36	26	48	22	11	10	29	19	14	13	15	39	21	27	26	26	11	9	9	7	31	25	26	7	8	6	50	70	10	76	65	91	19	5	24	4	3	3	1	0
76	0	1	1	1	2	1	1	0	0	4	4	12	24	18	41	12	2	4	10	7	5	5	15	34	30	13	12	8	4	5	2	3	25	16	16	8	4	9	31	41	10	46	38	52	1	1	3	4	2	5	1	22
78	0	0	0	0	1	1	0	0	0	6	7	3	10	6	16	7	2	2	3	15	11	11	13	38	8	10	16	13	8	5	5	5	2	2	2	6	5	7	5	27	1	29	24	34	20	0	12	1	1	54	28	0
80	0	0	0	0	1	0	0	0	0	4	8	0	0	1	4	5	1	1	1	1	0	0	5	3	4	1	3	5	0	0	0	0	4	3	6	5	3	6	6	22	5	24	19	26	0	0	0	0	1	10	13	21
82	0	0	0	0	0	0	0	0	0	9	4	0	0	1	2	11	0	1	1	0	11	7	16	11	2	1	1	2	0	1	0	0	2	2	2	0	0	0	3	7	1	7	6	9	2	0	6	0	1	6	5	21
84	0	0	0	0	1	0	0	0	0	6	4	0	0	0	0	2	1	0	0	0	0	0	1	6	2	7	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	6	0	0	1	1	0	0
86	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	1	0	0	1	1	0	0	0	0	0	2	3	4	0	0	0	0	0	0	0	0	0	0	0	7	1	7	6	9	0	6	3	0	4	0	0	21
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	7	1	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	28	1	1	1	0	0	1	0	0	0	8	1	3	0	0	1	0	0	1	0	0	24	11	0	14	6	0	1	0
TOTAL	578	796	665	693	808	1263	1369	1449	1303	1944	1792	3385	5808	8036	8141	9750	13363	9691	6797	6786	7677	7979	10258	8057	11131	9116	5838	7193	8555	7567	7046	7548	8837	5500	6722	8478	9085	8116	6369	6161	7670	7332	9187	9072	10781	9382	6165	7881	9085	8272	7072	6201

Table 6. Fleet structure for the East Atlantic Skipjack stock.

Fleet	Fleet Name	Description	Time Period	Gear	Area	Catch (Flagname or fleet code ICCAT)	Size Fleet code	Abundance indices
1	PS EU 63-85	Purse seine ETRO EU (Spain France)	1963 - 1985	PS	East ATL	CAN, CYM, CIV, CUB, EU(SPA, FRA, POR), JPN, MAR, PAN, SEN, ZAF, USSR	EU (SPA,FRA,POR), FIS, NIE Etro, Maroc, CIV, PAN, SEN, ZAF, CAN, JPN)	
2	PS EU 86-90	Purse seine ETRO EU (Spain France)	1986 -1990	PS	East ATL	CUB, EU(SPA, FRA, POR), JPN, MAR, NOR, PAN, SEN, ZAF	EU (SPA,FRA,POR), FIS, NIE Etro, Maroc, CIV, PAN, SEN, JPN, VUN)	
3	PS EU FSC 91+	Purse seine ETRO Free-school (FSC)	1991 - 2020	PS-FSC	East ATL	ANG, BLZ, CPV, COG, CIV, CUB, CUW, SLV, EU(SPA, FRA, POR), GTM, GNQ, JPN, KOR, LIB, MAR, NEI, NOR, PAN, RUS, SEN	EU (SPA,FRA), FIS, NIE Etro, BLZ, MAR, CPV, CUW, SLV, GTM, PAN, SEN, RUS, SVT, VUN)	Catch Ratio 1990-2018 ONLY as Sensitivity Analysis
4	PS EU FAD 91+	Purse seine ETRO FOB/FAD	1991 - 2020	PS-FAD	East ATL	BLZ, CPV, CIV, CUB, CUW, SLV, EU(SPA, FRA), GMT, MAR, NEI, NOR, PAN, SEN, STV, VUT	EU (SPA,FRA), NIE Etro, BLZ, CPV, CUW, SLV, GTM, MAR, PAN, SEN, SVT)	EchoSounder 2010-2020 as Whole ESKJ Population PS FAD VAST 2010-2020 (yearly or new quartely)
5	PSBB Ghana	Ghana purse seine and baitboat	All	PS + BB	East ATL	GHA Add catch E-SJK PS VEN, USA **Add catch other gears**	GHA	
6	BB South Dakar	Baitboat south Dakar	All	BB	South of 10° N	ANG, CPV, CUW, EU(SPA, FRA, POR), GAB, JPN, KOR, MAR, NAM, PAN, SEN, STV, UK-STH	ANG, CPV, CUW, EU (SPA, FRA, POR), JPN, KOR, FIS, NAM, PAN, SEN, SVT, UK-STH, VEN	
7	BB Dakar 62-80	Baitboat Dakar 62-80	1962 - 1980	BB	10° N to 25 N° Lat	CPV, EU(SPA,FRA), SEN	EU FRA, FIS	Dakar BB 1969-(1980)
8	BB Dakar 81+	Baitboat Dakar 81+	1981 - 2020	BB	10° N to 25 N° Lat	CPV, CUW, EU(SPA, FRA, POR), PAN, SEN, STV	CPV, CUW, EU (SPA, FRA), PAN, SEN, STV, VEN	Dakar BB (1981)-2012
9	BB North 25 lat	Baitboat North 25	All	BB	North of 25 N° Lat	CPV, EU(SPA,FRA), MAR	CPV, EU (SPA, POR)	Canary BB 1980-2013 Azores BB 1963-2013
10	LL fleets	All longline fleets	All	LL	East ATL	JPN, CHN, CIV, EU-SPA, EU-POR,KOR, PAN, STV, CTP, MAR	JPN, CIV, CUB, CTP	

Table 7. Fleet structure for the West Atlantic Skipjack stock.

Fleet	Fleet Name	Description	Time Period	Gear	Area	Catch (Flagname or fleet code ICCAT)	Size Fleet code	CPUE available
1	PS West Atl	Purse seine	All	PS	West ATL	VEN, USA	USA, VEN	PS Venezuela: 1987-2020
2	BB West	Baitboat	All	BB	West ATL	BRA, VEN, CUB, JPN, PAN,	BRA, VEN, CUB, JPN, VEN	Brazil BB: 2000-2021 Historic Brazil BB: 1981 -1999
3	LL USMXCA	Longline USA, Mexico and Canada	All	LL	West ATL	BRB, CAN, EU-SPA, EU-FRA, EU-POR, KOR, MEX, STV, USA, GRD, DMA	MEX	USA LL: 1993-2020
4	LL JPNCTP	Longline Japan and Chinese-Taipei	All	LL	West ATL	JPN, CTP **Add catch other gears**	JPN, CTP	GOM larvae: sensitivity only
5	HL_RR	Handline Brazil Rod & Reel USA	All	HL+RR+ SP	West ATL	BRA, USA	BRA, USA	Brazil HL: 2010-**2016**

Table 8. List of decisions made regarding life history assumptions for the 2014 and 2022 skipjack stock assessment models.

	2014	**2022 (PROPOSAL)**	
	SAME ASSUMPTIONS E & W	**SAME ASSUMPTIONS E & W**	
	surplus production models	*surplus production models*	*SS*
Growth parameters	Paired values of *K*, L_{inf}, and *t0* were chosen from published von Bertalanffy growth curves[1]. For each iteration, a set of von Bertalanffy parameters was randomly selected and the mean size-at-age was calculated.	Generate dummy age-length pairs based on selection of growth curves + some level of variability in size at age. Fit VB to resulting set of predicted values and extract median and percentiles to use as the 3 growth assumptions for the uncertainty grid. Compare results from using Atlantic-only models vs. all models.	Generate dummy age-length pairs based on selection of growth curves + some level of variability in size at age. Fit VB to resulting set of predicted values and extract median and percentiles to use as the 3 (fixed) growth assumptions for the uncertainty grid. Compare results from using Atlantic-only models vs. all models. Specify CV based on upper limit of CI reaching the largest fish observed in the catch (~120cm)
Natural mortality	Normal prior (μi, 0.04) where μi is the mortality at age i. L < 15 cm: 12.01*exp((-0.08*L) + (0.0005*L^2)) + 1.77 L >= 15 cm: 12.01*exp((-0.08*L) + (0.0005*L^2)) (Gaertner 2015 approach) and size at age is derived from the various growth models chosen	Use Lorenzen's model for a vector of M at age and adjust the M of age 6 to the expected …. For each of the growth models.	
Maximum age	6 years	Same as 2014	
Length-weight relationship	W(kg) = 7.480 x 10-6 * FL (cm)^3.253 (Entire Atlantic)	Same as 2014	

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[1] Chu Vien Tinh, 2000; Tanabe et al., 2003; Chur and Zharov, 1983; Yao 1981 in Wild and Hampton, 1994; Uchiyama and Strushaker, 1981; Chi and Yang 1973 IN Wild and Hampton, 1994; Joseph and Calkins, 1969.

Table 8 (Continued). List of decisions made regarding life history assumptions for the 2014 and 2022 skipjack stock assessment models.

	2014	**2022 (PROPOSAL)**	
	SAME ASSUMPTIONS E & W	**SAME ASSUMPTIONS E & W**	
	surplus production models	*surplus production models*	*SS*
Maturity	Size at 50% maturity = 42cm (approx. 9.5 months old) and fully mature at 55cm. A 3-line model, fixed at zero for ages 0 to 6 months, linear increasing at a rate of 0.125 (1/8) from 6 to 14 months, and fixed at one for 14+ months	Same as 2014	
Fecundity		NA	Female SSB
Spawner-Recruit relationship	Beverton-Holt, steepness beta prior with mode of 0.9[2]	Fixed values of *h*: 0.7, 0.8, 0.9 based on 10th, 50th and 90th percentile of Beta (18,4) distribution.	Fixed values of *h*: 0.7, 0.8, 0.9 based on 10th, 50th and 90th percentile of Beta (18,4) distribution. Sigma R: attempt estimation. If needed fix it.

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[2] This is based upon examination of the prior distribution for h used in the Western Pacific skipjack and yellowfin tuna assessments (Beta (18, 4) distribution) but allowing a greater density towards lower values of steepness

Table 9. Available E-SKJ abundance indices for the 2022 stock assessment.

Name		EU Echosounder		Catch Ratio YFT/SKJ	
SCRS Doc		SCRS/2022/026		SCRS/2022/031	
Use in 2022 Assessment		Yes		only sensitivity	
Year	Quarter	Scaled index	SE	Scaled index	SE
1990	1				
1990	2			0.314	0.347
1990	3			0.229	0.358
1990	4			0.404	0.344
1991	1			0.552	0.298
1991	2			0.713	0.344
1991	3			0.155	0.327
1991	4			0.193	0.301
1992	1			0.408	0.301
1992	2			0.248	0.314
1992	3			0.040	0.331
1992	4			0.073	0.321
1993	1			0.195	0.300
1993	2			0.148	0.305
1993	3			0.077	0.344
1993	4			0.133	0.303
1994	1			0.134	0.319
1994	2			0.182	0.305
1994	3			0.040	0.321
1994	4			0.055	0.294
1995	1			0.131	0.297
1995	2			0.112	0.297
1995	3			0.090	0.331
1995	4			0.107	0.284
1996	1			0.143	0.296
1996	2			0.090	0.308
1996	3			0.059	0.312
1996	4			0.142	0.293
1997	1			0.266	0.294
1997	2			0.092	0.311
1997	3			0.072	0.343
1997	4			0.115	0.345
1998	1			0.446	0.564
1998	2			0.109	0.540
1998	3			0.413	0.487
1998	4			0.118	0.447
1999	1			1.039	0.486
1999	2			0.388	0.399
1999	3			0.241	0.378
1999	4			0.225	0.583
2000	1			0.436	0.377
2000	2			0.280	0.353
2000	3			0.213	0.411
2000	4			0.322	0.331
2001	1			0.469	0.363
2001	2			0.181	0.385
2001	3			0.493	0.377
2001	4			0.399	0.396
2002	1			0.940	0.368
2002	2			0.421	0.358
2002	3			0.230	0.371
2002	4			0.402	0.350
2003	1			0.507	0.354
2003	2			0.589	0.359
2003	3			0.299	0.371
2003	4			0.468	0.387
2004	1			0.398	0.369
2004	2			0.251	0.342
2004	3			0.452	0.372
2004	4			0.528	0.339
2005	1			0.279	0.368
2005	2			0.423	0.371
2005	3			0.329	0.320
2005	4			0.484	0.328
2006	1			0.3865	0.3218
2006	2			0.3617	0.3381
2006	3			0.7208	0.3466
2006	4			0.4665	0.315
2007	1			0.6143	0.3697
2007	2			0.3334	0.3408
2007	3			0.5454	0.3532
2007	4			0.5654	0.3285
2008	1			0.4799	0.3289
2008	2			0.2163	0.3728
2008	3			0.2173	0.3643
2008	4			0.2233	0.3594
2009	1			0.2189	0.3751
2009	2			0.2831	0.3754
2009	3			0.4846	0.3342
2009	4			0.6264	0.3314
2010	1	1.624	0.249	0.5983	0.3523
2010	2	1.377	0.208	0.4617	0.3462
2010	3	1.033	0.161	0.337	0.3397
2010	4	1.952	0.304	0.5075	0.3392
2011	1	1.357	0.218	0.7778	0.4255
2011	2	1.446	0.223	0.7168	0.3324
2011	3	0.663	0.103	0.9154	0.3224
2011	4	0.825	0.125	0.6885	0.3226
2012	1	0.631	0.098	0.663	0.3504
2012	2	1.082	0.167	0.8068	0.3616
2012	3	0.561	0.087	0.7687	0.3688
2012	4	0.517	0.078	0.3507	0.3908
2013	1	0.669	0.1	0.7045	0.3743
2013	2	0.737	0.103	0.6877	0.3791
2013	3	0.57	0.072	0.7993	0.374
2013	4	0.954	0.115	0.6679	0.3235
2014	1	0.828	0.108	0.3253	0.4103
2014	2	0.745	0.093	0.3799	0.3765
2014	3	0.79	0.091	0.4798	0.3395
2014	4	0.86	0.089	0.3794	0.3425
2015	1	0.758	0.089	0.4911	0.4038
2015	2	0.762	0.091	0.3392	0.3535
2015	3	0.81	0.081	0.4627	0.3215
2015	4	0.944	0.083	0.3772	0.3363
2016	1	0.761	0.084	0.5161	0.4521
2016	2	0.863	0.118	0.2837	0.3675
2016	3	0.846	0.097	0.4267	0.3825
2016	4	0.903	0.09	0.2724	0.3481
2017	1	0.768	0.088	0.1954	0.4519
2017	2	0.996	0.123	0.6455	0.4036
2017	3	1.097	0.135	0.5454	0.3747
2017	4	1.493	0.151	0.4403	0.3574
2018	1	1.434	0.161	0.4936	0.3882
2018	2	1.979	0.244	0.8801	0.4113
2018	3	1.485	0.175	0.4466	0.4381
2018	4	1.585	0.174	0.8618	0.3742
2019	1	1.749	0.232		
2019	2	1.524	0.202		
2019	3	1.418	0.196		
2019	4	1.577	0.2		
2020	1	1.341	0.196		
2020	2	1.838	0.235		
2020	3	1.122	0.148		
2020	4	1.471	0.185		

Table 9. Continued.

Name	EU PS VAST		W-Med RR		Azores BB		Canary BB		Dakar BB	
SCRS Doc	SCRS/2022/028		SCRS/2019/169		Assessment 2014		Assessment 2014		Assessment 2014	
Use in 2022 Assessment	Yes		No		Continuity runs		Continuity runs		Continuity runs	
Year	Scaled index	SE	Scaled index	SE	index	SE	index	SE	index	SE
1960										
1961										
1962										
1963					0.135	0.391				
1964					0.983	1.342				
1965					0.321	0.544				
1966					1.436	1.215				
1967					0.215	0.403				
1968					0.553	1.079				
1969					0.051	0.133			0.743	0.595
1970					0.007	0.021			0.788	1.039
1971					1.171	1.728			0.808	1.043
1972					0.466	0.910			0.792	1.043
1973					0.091	0.205			0.790	1.039
1974					0.035	0.086			0.831	1.039
1975					0.010	0.030			0.755	1.038
1976					0.294	0.645			0.792	1.040
1977					1.612	1.306			0.752	1.038
1978					1.328	1.511			0.930	1.099
1979					0.733	1.048			0.909	1.100
1980					0.715	0.717	0.959	0.729	0.667	1.038
1981					1.079	0.970	1.225	1.161	1.009	1.038
1982					1.549	1.254	1.443	1.369	0.954	1.039
1983					0.386	0.586	0.677	0.692	0.876	1.037
1984					1.480	1.507	0.901	0.898	1.023	1.100
1985					0.222	0.399	1.839	1.796	0.791	1.040
1986					0.721	0.999	0.867	0.869	0.897	1.039
1987					1.181	1.386	0.938	0.953	1.051	1.039
1988					2.682	1.853	1.146	1.150	1.075	1.037
1989					1.844	1.661	1.483	1.416	1.143	1.100
1990					0.068	0.131	1.558	1.515	1.142	1.037
1991					1.818	1.745	1.192	1.163	0.953	0.972
1992					0.864	1.317	1.137	1.136	0.975	1.007
1993					0.760	1.006	0.707	0.739	1.166	0.984
1994					1.377	1.487	1.169	1.138	1.047	0.974
1995					0.279	0.439	1.042	1.000	0.954	0.977
1996					0.808	1.078	1.026	1.051	1.066	0.974
1997					0.424	0.709	1.046	1.096	1.008	0.965
1998					0.586	0.734	2.241	2.229	1.207	0.966
1999					1.047	0.835	0.702	0.721	1.172	0.961
2000					0.838	0.785	0.705	0.746	0.994	0.961
2001					1.019	0.818	0.641	0.678	1.104	0.963
2002					1.303	1.324	0.226	0.242	1.128	0.964
2003					2.069	1.475	0.745	0.792	1.087	0.964
2004					1.490	1.105	0.750	0.794	1.044	0.965
2005					1.266	1.028	0.855	0.907	1.158	0.968
2006			0.160	0.072	2.062	1.737	0.893	0.928	1.088	0.967
2007			0.253	0.060	2.651	1.876	0.565	0.593	1.178	0.969
2008			0.220	0.068	2.779	1.850	0.946	0.969	1.072	0.973
2009					0.232	0.389	0.751	0.798	1.156	0.968
2010	0.838	0.325	0.320	0.227	3.604	2.544	0.771	0.811	1.192	0.966
2011	0.991	0.328	0.224	0.130	1.572	1.350	0.669	0.723	1.344	0.968
2012	1.016	0.336	0.228	0.042	0.243	0.396	1.381	1.361	1.391	0.972
2013	1.006	0.346	0.339	0.073	0.538	0.913	0.801	0.839		
2014	0.987	0.353	0.443	0.043						
2015	1.030	0.365	0.371	0.043						
2016	1.208	0.371	0.248	0.030						
2017	0.693	0.383	0.237	0.033						
2018	0.747	0.392	0.209	0.032						
2019	0.859	0.403								

Table 10. Available W-SKJ abundance indices for the 2022 stock assessment.

Name	BRA BB		BRA HL schools		USA GOM		USA LL observer		VEN PS	
SCRS Doc	SCRS/2022/029		SCRS/2022/036		SCRS/2022/040		SCRS/2022/037		SCRS/2022/039	
Use in 2022 Assessment	Yes + use early period of BRA BB 1981 1999 (2014 SA)		Yes for West up to 2016 only, re-estimate w/o 2017-2020		only sensitivity		Yes		Yes	
Year	Scaled index	SE	Scaled index	SE	Scaled index	CV	Scaled index	CV	Scaled index	CV
1981										
1982					1.795	0.164				
1983					0.512	0.279				
1984					0.524	0.230				
1985					0.031	1.449				
1986					0.337	0.356				
1987					0.142	0.368			0.906	0.300
1988					0.176	0.361			0.780	0.280
1989					0.833	0.209			0.887	0.280
1990					0.663	0.148			0.925	0.390
1991					0.664	0.273			1.132	0.270
1992					0.464	0.280			0.992	0.230
1993					0.997	0.150	0.390	0.230	1.059	0.300
1994					0.838	0.193	0.650	0.230	0.944	0.320
1995					0.644	0.132	0.350	0.220	0.720	0.340
1996					0.503	0.255	1.360	0.260	1.003	0.500
1997					0.451	0.193	0.510	0.260	1.409	0.240
1998					0.748	0.194	2.170	0.230	1.454	0.310
1999					0.637	0.192	0.820	0.210	0.866	0.320
2000	1.214	0.124			0.815	0.173	0.870	0.240	1.172	0.220
2001	1.073	0.101			0.976	0.203	1.250	0.230	1.108	0.300
2002	1.020	0.100			0.755	0.172	0.300	0.410	1.325	0.220
2003	0.768	0.101			1.179	0.223	1.120	0.220	0.957	0.270
2004	0.935	0.100			1.618	0.277	1.430	0.180	0.914	0.190
2005	1.029	0.105			0.687	0.197	1.370	0.170	0.855	0.180
2006	1.310	0.107			0.886	0.176	1.980	0.180	0.653	0.250
2007	1.355	0.101			0.947	0.178	1.080	0.170	0.438	0.200
2008	1.300	0.101			0.958	0.127	0.940	0.160	0.610	0.190
2009	1.303	0.104			1.195	0.220	1.110	0.150	0.731	0.230
2010	1.076	0.102	0.095	0.296	1.618	0.246	0.660	0.170	0.903	0.280
2011	1.525	0.098	0.290	0.113	1.803	0.151	2.050	0.160	0.780	0.360
2012	1.854	0.098	0.239	0.115	0.985	0.167	1.460	0.160	0.796	0.220
2013	1.167	0.105	0.403	0.211	2.249	0.138	0.610	0.160	1.059	0.220
2014	0.917	0.110	1.063	0.370	1.648	0.129	0.580	0.160	1.078	0.180
2015	0.819	0.124	0.645	0.027	1.900	0.098	0.830	0.170	1.613	0.340
2016	0.620	0.197	0.456	0.065	1.927	0.114	1.340	0.160	1.390	0.290
2017	0.442	0.108	2.112	0.086	2.369	0.127	0.870	0.180	1.210	0.250
2018	0.488	0.109	1.842	0.023	1.344	0.148	0.620	0.190	1.065	0.290
2019	0.520	0.112	2.148	0.042	1.183	0.120	0.840	0.210	1.210	0.210
2020	0.679	0.103	1.707	0.077			0.430	0.280	1.057	0.820
2021	0.585	0.108								

Table 11. Nominal and standardized (Delta lognormal mixed model) CPUE series (t/fishing operation) for the Venezuelan baitboat fleet (1987-2020) estimated from logbooks. UCI: Upper confidence interval, LCI: Lower confidence interval, CV: Coefficient of variation, SD: Standard deviation.

Year	n	Nominal CPUE	Standardized CPUE	UCI	LCI	CV	SD
1987	521	1.05	1.52	1.57	0.43	0.37	0.57
1988	891	1.47	1.40	1.80	0.04	0.63	0.88
1989	565	0.88	0.90	0.98	0.20	0.44	0.39
1990	1029	0.29	0.54	0.61	0.09	0.48	0.26
1991	1117	0.46	0.60	0.64	0.14	0.42	0.25
1992	740	0.40	0.58	0.69	0.07	0.54	0.31
1993	850	0.28	0.55	0.69	0.03	0.60	0.33
1994	602	0.48	0.57	0.70	0.05	0.57	0.32
1995	621	0.54	0.69	0.67	0.24	0.32	0.22
1996	813	0.48	0.77	1.14	0.13	0.83	0.64
1997	685	0.49	0.55	0.68	0.05	0.57	0.32
1998	981	0.87	0.80	1.17	0.12	0.81	0.65
1999	944	0.43	0.69	0.90	0.00	0.65	0.45
2000	1181	0.72	1.01	0.97	0.36	0.30	0.31
2001	1068	0.64	0.71	0.83	0.10	0.52	0.37
2002	816	0.53	0.63	0.75	0.07	0.54	0.34
2003	758	0.72	0.75	0.93	0.06	0.57	0.43
2004	686	0.97	1.14	1.35	0.14	0.53	0.61
2005	480	0.63	0.69	0.83	0.07	0.55	0.38
2006	345	0.23	0.32	0.38	0.03	0.56	0.18
2007	277	1.15	0.99	1.11	0.19	0.47	0.46
2008	139	0.36	0.66	0.80	0.07	0.55	0.36
2009	238	0.25	0.29	0.48	0.11	1.02	0.29
2010	173	0.25	0.29	0.50	0.12	1.09	0.31
2011	322	0.63	0.76	0.86	0.14	0.47	0.36
2012	206	0.30	0.52	0.51	0.17	0.33	0.17
2013	265	0.57	0.84	1.10	0.01	0.65	0.55
2014	151	0.32	0.80	0.98	0.06	0.58	0.46
2015	119	0.12	0.29	0.37	0.01	0.62	0.18
2016	370	0.58	1.06	1.20	0.20	0.47	0.50
2017	668	0.32	0.64	0.74	0.11	0.49	0.31
2018	275	0.29	0.64	0.67	0.16	0.40	0.25
2019	214	0.21	0.74	0.62	0.35	0.18	0.13
2020	23	0.16	0.42	0.49	0.07	0.82	0.21

Table 12. The uncertainty grid for the assessment models for West and East SKJ, based on assumptions of i) steepness (3 levels), and ii) the growth/natural mortality at age (corresponding 0.25, 0.5, and 0.75 quantiles of the SKJ growth model estimated at the Data Preparatory meeting and equivalent vectors of M at age (SCRS/2022/093)).

Axis of uncertainty \ levels			
Steepness *h*	0.7	0.8	0.9
Growth + M-at-age See below for details	A	B	C

Table 13. Natural mortality at age rescaled inside SS3 using Lorenzen function applied to the uncertainty grid proposed during the SKJ Data Preparatory meeting and presented in SCRS Document SCRS/2022/093.

West SKJ		**von Bertalanffy growth parameters**			**Natural mortality at age estimates**						
Steepness *h*	**quantile**	**L_{inf}**	***K***	***t0***	**M_0**	**M_1**	**M_2**	**M_3**	**M_4**	**M_5**	**M_6**
0.6	**0.25**	67	0.54	-0.09	1.3967	0.81126	0.671222	0.610485	0.580039	0.563692	0.55
	0.5	76	0.53	-0.31	1.20679	0.70558	0.59886	0.55030	0.52532	0.51168	0.5
	0.75	86	0.49	-0.49	1.18466	0.689097	0.590272	0.542923	0.517574	0.503206	0.49
0.7	**0.25**	67	0.54	-0.09	1.3967	0.81126	0.671222	0.610485	0.580039	0.563692	0.55
	0.5	76	0.53	-0.31	1.20679	0.70558	0.59886	0.55030	0.52532	0.51168	0.5
	0.75	86	0.49	-0.49	1.18466	0.689097	0.590272	0.542923	0.517574	0.503206	0.49
0.8	**0.25**	67	0.54	-0.09	1.3967	0.81126	0.671222	0.610485	0.580039	0.563692	0.55
	0.5	76	0.53	-0.31	1.20679	0.70558	0.59886	0.55030	0.52532	0.51168	0.5
	0.75	86	0.49	-0.49	1.18466	0.689097	0.590272	0.542923	0.517574	0.503206	0.49

East SKJ	**von Bertalanffy growth parameters**			**L at age 1**	**Recruitment Quarter**	**M at season**	**Natural mortality at age estimates**						
quantile	**L_{inf}**	***K***	**t0**				**M_0**	**M_1**	**M_2**	***M_3***	**M_4**	**M_5**	**M_6**
0.25	**67**	**0.54**	**-0.09**	**29.81**	1	1	1.84987	0.912655	0.707103	0.626263	0.587373	0.566916	0.55
					1	2	1.44007	0.83818	0.680436	0.613943	0.581023	0.563458	0.548804
					1	3	1.19462	0.782861	0.658787	0.603581	0.575589	0.560473	0.547764
					1	4	1.02652	0.740432	0.641006	0.594818	0.570926	0.557891	0.546858
					2	1	1.84526	1.02396	0.738585	0.639407	0.593334	0.569502	0.55
					2	2	1.84526	0.910379	0.705339	0.624701	0.585907	0.565502	0.548628

					2	3	1.43648	0.83609	0.678738	0.612412	0.579573	0.562053	0.547435
					2	4	1.19164	0.780908	0.657144	0.602075	0.574153	0.559075	0.546397
					3	1	1.83998	1.18823	0.778673	0.655263	0.600352	0.57251	0.55
					3	2	1.83998	1.02103	0.736471	0.637577	0.591636	0.567872	0.548426
					3	3	1.83998	0.907773	0.70332	0.622913	0.58423	0.563883	0.547058
					3	4	1.43237	0.833696	0.676796	0.610659	0.577914	0.560444	0.545868
					4	1	1.83393	1.42766	0.830957	0.674572	0.608652	0.576015	0.55
					4	2	1.83393	1.18433	0.776114	0.653109	0.598379	0.570629	0.548193
					4	3	1.83393	1.01767	0.734051	0.635482	0.589692	0.566006	0.546624
					4	4	1.83393	0.90479	0.701009	0.620866	0.582311	0.56203	0.54526
0.5	**76**	**0.53**	**-0.31**	**38**	1	1	1.71007	0.778567	0.626788	0.563015	0.531357	0.514375	0.5
					1	2	1.27527	0.725203	0.606028	0.553064	0.526114	0.511475	0.498983
					1	3	1.03291	0.684384	0.588978	0.54464	0.521609	0.508963	0.498096
					1	4	0.873318	0.652374	0.574838	0.537475	0.517727	0.506783	0.497322
					2	1	1.7061	0.871286	0.650856	0.5735	0.536225	0.516522	0.5
					2	2	1.7061	0.776756	0.62533	0.561705	0.530121	0.513178	0.498837
					2	3	1.27231	0.723516	0.604618	0.551777	0.52489	0.510285	0.497822
					2	4	1.0305	0.682792	0.587608	0.543373	0.520395	0.507779	0.496937
					3	1	1.70155	1.02776	0.680973	0.586043	0.541926	0.519009	0.5
					3	2	1.70155	0.868966	0.649123	0.571973	0.534797	0.515147	0.498669
					3	3	1.70155	0.774687	0.623665	0.560209	0.528709	0.511812	0.497508

					3	4	1.26892	0.721589	0.603008	0.550307	0.523492	0.508927	0.496497
					4	1	1.69636	1.26505	0.719389	0.601169	0.54863	0.521897	0.5
					4	2	1.69636	1.02463	0.678897	0.584256	0.540274	0.517427	0.498476
					4	3	1.69636	0.866316	0.647144	0.570229	0.533166	0.513576	0.497148
					4	4	1.69636	0.772326	0.621763	0.558501	0.527097	0.510251	0.495992
0.75	**86**	**0.49**	**-0.49**	**44.55**	1	1	1.76119	0.753617	0.616612	0.555402	0.523695	0.506036	0.49
					1	2	1.27176	0.706615	0.596987	0.54556	0.518308	0.502947	0.488881
					1	3	1.01203	0.669841	0.580666	0.537147	0.513637	0.500245	0.487895
					1	4	0.845547	0.640466	0.566974	0.529922	0.509575	0.49788	0.487026
					2	1	1.75663	0.843359	0.638808	0.565507	0.528551	0.508256	0.49
					2	2	1.75663	0.751667	0.615016	0.553964	0.522339	0.504726	0.488732
					2	3	1.26847	0.704786	0.595442	0.544148	0.516967	0.501645	0.487616
					2	4	1.00941	0.668108	0.579163	0.535757	0.512308	0.498951	0.486632
					3	1	1.75148	1.00645	0.666148	0.577465	0.534186	0.510805	0.49
					3	2	1.75148	0.840885	0.636934	0.563848	0.527001	0.506766	0.488563
					3	3	1.75148	0.749462	0.613212	0.552339	0.520807	0.503246	0.487298
					3	4	1.26475	0.702719	0.593695	0.542552	0.515451	0.500174	0.486185
					4	1	1.74565	1.26054	0.700382	0.591721	0.540748	0.513737	0.49
					4	2	1.74565	1.0031	0.663933	0.575544	0.532409	0.509106	0.48837
					4	3	1.74565	0.838089	0.634816	0.561973	0.525248	0.50508	0.486938
					4	4	1.74565	0.74697	0.611173	0.550503	0.519075	0.501572	0.485678

Table 14. Summary of the uncertainty grid scenarios for East Atlantic skipjack tuna. B_{MSY}/K are input parameters derived from the ASEM model as priors.

Scenario	Model	r	B_{MSY}/K (m)
S01	ASEM h = 0.7 Pella m	Lognormal (0.545, 0.284)	0.40
S02	ASEM h = 0.8 Pella m	Lognormal (0.607, 0.318)	0.41
S03	ASEM h = 0.9 Pella m	Lognormal (0.668, 0.330)	0.42
S04	ASEM h = 0.7 Pella m	Lognormal (0.416, 0.148)	0.38
S05	ASEM h = 0.8 Pella m	Lognormal (0.440, 0.184)	0.37
S06	ASEM h = 0.9 Pella m	Lognormal (0.466, 0.219)	0.36
S07	ASEM h = 0.7 Pella m	Lognormal (0.366, 0.142)	0.38
S08	ASEM h = 0.8 Pella m	Lognormal (0.385, 0.172)	0.36
S09	ASEM h = 0.9 Pella m	Lognormal (0.402, 0.206)	0.35

Table 15. Summary of sensitivity analysis runs for East Atlantic skipjack tuna.

Scenario	Model	Type	Indices
S05	Pella m	ASEM h = 0.8	+ EU PS VAST
S05	Pella m	ASEM h = 0.8	+ EU PS VAST + EU Echosounder
S05	Pella m	ASEM h = 0.8	+ EU PS VAST + EU Echosounder + AZO BB Past
S05	Pella m	ASEM h = 0.8	+ EU PS VAST + EU Echosounder + AZO BB Past + CAN BB Past
S05	Pella m	ASEM h = 0.8	+ EU PS VAST + EU Echosounder + AZO BB Past + CAN BB Past + DAK BB Past

Table 16. Summary of the uncertainty grid scenarios for West Atlantic skipjack tuna. B_{MSY}/K are input parameters derived from the ASEM model as priors.

Scenario	Model	r	B_{MSY}/K (m)
S01	ASEM h = 0.7 Pella m	Lognormal (0.545, 0.284)	0.40
S02	ASEM h = 0.8 Pella m	Lognormal (0.607, 0.318)	0.41
S03	ASEM h = 0.9 Pella m	Lognormal (0.668, 0.330)	0.42
S04	ASEM h = 0.7 Pella m	Lognormal (0.416, 0.148)	0.38
S05	ASEM h = 0.8 Pella m	Lognormal (0.440, 0.184)	0.37
S06	ASEM h = 0.9 Pella m	Lognormal (0.466, 0.219)	0.36
S07	ASEM h = 0.7 Pella m	Lognormal (0.366, 0.142)	0.38
S08	ASEM h = 0.8 Pella m	Lognormal (0.385, 0.172)	0.36
S09	ASEM h = 0.9 Pella m	Lognormal (0.402, 0.206)	0.35

Table 17. Summary of sensitivity analysis runs for JABBA West Atlantic skipjack tuna.

Scenario	Model	Type	Indices
S05	Pella m	ASEM h = 0.8	+ BRA BB Past + BRA BB Present
S05	Pella m	ASEM h = 0.8	+ BRA BB Past + BRA BB Present + USA LL
S05	Pella m	ASEM h = 0.8	+ BRA BB Past + BRA BB Present + USA LL + BRA HL
S05	Pella m	ASEM h = 0.8	+ BRA BB Past + BRA BB Present + USA LL + BRA HL + VEN PS

Table 18. Summary of posterior quantiles presented in the form of marginal posterior medians and associated 95% credibility intervals of parameters for the Bayesian state-space surplus production models for East Atlantic skipjack tuna.

S01				**S02**			
Estimates	**Median**	**LCI (2.50%)**	**UCI (97.50%)**	**Estimates**	**Median**	**LCI (2.50%)**	**UCI (97.50%)**
K	1.268.825	774.129	2.230.156	K	1.127.863	692.823	1.805.619
r	0,756	0,435	1,273	r	0,915	0,507	1,496
ψ(psi)	0,940	0,815	0,991	ψ(psi)	0,940	0,813	0,991
σ_{proc}	0,104	0,056	0,171	σ_{proc}	0,099	0,054	0,171
S03				**S04**			
Estimates	**Median**	**LCI (2.50%)**	**UCI (97.50%)**	**Estimates**	**Median**	**LCI (2.50%)**	**UCI (97.50%)**
K	1.080.736	663.238	1.832.490	K	1.577.513	1.121.595	2.328.869
r	1,014	0,564	1,667	r	0,453	0,340	0,605
ψ(psi)	0,940	0,816	0,991	ψ(psi)	0,940	0,810	0,990
σ_{proc}	0,095	0,052	0,164	σ_{proc}	0,122	0,071	0,185
S05				**S06**			
Estimates	**Median**	**LCI (2.50%)**	**UCI (97.50%)**	**Estimates**	**Median**	**LCI (2.50%)**	**UCI (97.50%)**
K	1.509.670	1.036.906	2.405.568	K	1.414.773	966.329	2.266.726
r	0,507	0,355	0,732	r	0,566	0,367	0,868
ψ(psi)	0,939	0,816	0,991	ψ(psi)	0,939	0,816	0,991
σ_{proc}	0,116	0,065	0,180	σ_{proc}	0,113	0,061	0,179
S07				**S08**			
Estimates	**Median**	**LCI (2.50%)**	**UCI (97.50%)**	**Estimates**	**Median**	**LCI (2.50%)**	**UCI (97.50%)**
K	1.699.609	1.205.711	2.590.927	K	1.616.704	1.097.909	2.496.304
r	0,397	0,301	0,523	r	0,429	0,304	0,605
$\psi(psi)$	0,940	0,814	0,991	ψ(psi)	0,939	0,816	0,990
$\sigma proc$	0,122	0,074	0,185	σ_{proc}	0,120	0,070	0,185
S09							
Estimates	**Median**	**LCI (2.50%)**	**UCI (97.50%)**				
K	1.585.391	1.065.949	2.469.064				
r	0,472	0,314	0,715				
ψ(psi)	0,938	0,813	0,990				
σ_{proc}	0,116	0,065	0,181				

Table 19. A list of model parameters for the W-SKJ reference case of the stock synthesis model. No priors were used in this model, and no parameter was estimated at the bounds.

Label	Value	Phase	Min	Max	Init	SD	Type
SR_LN(R0)	11.4604	1	0.0001	20	11.13	0.09	SRR
Size_DblN_peak_PS_West(1)	48.6286	2	20	90	49.16	0.94	Sel
Size_DblN_top_logit_PS_West(1)	-12.1995	2	-15	15	-	47.55	Sel
Size_DblN_ascend_se_PS_West(1)	4.37675	3	-4	12	4.43	0.18	Sel
Size_DblN_descend_se_PS_West(1)	4.79913	3	-10	6	4.78	0.3	Sel
Size_DblN_end_logit_PS_West(1)	-2.69686	3	-20	20	-2.28	0.5	Sel
Size_DblN_peak_BB_West(2)	55.3124	2	20	90	55.94	1.08	Sel
Size_DblN_top_logit_BB_West(2)	-11.9822	2	-15	15	-	50.66	Sel
Size_DblN_ascend_se_BB_West(2)	4.87641	3	-4	12	4.9	0.18	Sel
Size_DblN_descend_se_BB_West(2)	4.67589	3	-10	6	4.73	0.32	Sel
Size_DblN_end_logit_BB_West(2)	-4.15657	3	-20	20	-4.59	4.2	Sel
Size_inflection_LL_USMX(3)	47.35	2	20	126	48.8	1.75	Sel
Size_95%width_LL_USMX(3)	8.46853	3	0.01	100	9.3	2.53	Sel
Size_inflection_LL_OTH(4)	76.1612	2	20	126	77.85	9.37	Sel
Size_95%width_LL_OTH(4)	13.601	3	0.01	100	13.43	7.28	Sel
Size_DblN_peak_HL_RR(5)	52.676	2	20	90	53.2	2.01	Sel
Size_DblN_top_logit_HL_RR(5)	-10.932	2	-15	15	-10.8	62.28	Sel
Size_DblN_ascend_se_HL_RR(5)	4.93594	3	-10	15	4.95	0.32	Sel
Size_DblN_descend_se_HL_RR(5)	3.26863	3	-10	15	2.98	1.45	Sel
Size_DblN_end_logit_HL_RR(5)	-	3	-20	20	-0.6	0.5	Sel
Size_DblN_peak_PS_West(1)_BLK1repl_2015	57.6126	2	20	90	57.63	1.7	Sel
Size_DblN_top_logit_PS_West(1)_BLK1repl_2015	-3.2507	2	-15	15	-2.98	1.07	Sel
Size_DblN_ascend_se_PS_West(1)_BLK1repl_2015	4.40235	3	-4	12	4.37	0.36	Sel
Size_DblN_descend_se_PS_West(1)_BLK1repl_2015	3.63638	3	-10	6	3.62	1.55	Sel
Size_DblN_end_logit_PS_West(1)_BLK1repl_2015	-1.39099	3	-20	20	-0.9	0.91	Sel

Table 20. Summary of posterior quantiles presented in the form of marginal posterior medians and the associated 95% credibility intervals of parameters for the Bayesian state-space surplus production models for West Atlantic skipjack tuna (uncertainty grid scenario).

		S01				**S02**	
Estimates	**Median**	**LCI**	**UCI**	**Estimates**	**Median**	**LCI**	**UCI**
K	135,554	89,686	223,440	K	124,239	81,155	190,556
r	0.861	0.552	1.321	r	0.980	0.618	1.551
ψ(psi)	0.940	0.815	0.991	ψ(psi)	0.939	0.816	0.991
σ_{proc}	0.103	0.056	0.166	σ_{proc}	0.101	0.056	0.164
F_{MSY}	0.724	0.465	1.112	F_{MSY}	0.782	0.493	1.238
B_{MSY}	54,219	35,872	89,372	B_{MSY}	50,945	33,278	78,138
MSY	38,457	29,754	59,238	MSY	39,119	30,300	59,165
B_{1952}/K	0.931	0.726	1.164	B_{1952}/K	0.930	0.724	1.166
B_{2020}/K	0.734	0.532	0.922	B_{2020}/K	0.752	0.546	0.931
B_{2020}/B_{MSY}	1.836	1.330	2.306	B_{2020}/B_{MSY}	1.834	1.330	2.271
F_{2020}/F_{MSY}	0.257	0.143	0.440	F_{2020}/F_{MSY}	0.253	0.145	0.427
		S03				**S04**	
Estimates	**Median**	**LCI**	**UCI**	**Estimates**	**Median**	**LCI**	**UCI**
K	121,544	79,093	194,144	K	188,042	140,788	269,550
r	1.054	0.651	1.654	r	0.506	0.384	0.662
ψ(psi)	0.940	0.815	0.991	ψ(psi)	0.940	0.817	0.991
σ_{proc}	0.098	0.054	0.162	σ_{proc}	0.106	0.061	0.169
F_{MSY}	0.799	0.493	1.253	F_{MSY}	0.474	0.360	0.620
B_{MSY}	51,043	33,216	81,532	B_{MSY}	71,464	53,506	102,441
MSY	40,152	30,630	61,185	MSY	33,621	27,008	47,088
B_{1952}/K	0.932	0.730	1.166	B_{1952}/K	0.931	0.722	1.162
B_{2020}/K	0.769	0.566	0.943	B_{2020}/K	0.641	0.438	0.847
B_{2020}/B_{MSY}	1.832	1.347	2.245	B_{2020}/B_{MSY}	1.687	1.153	2.229
F_{2020}/F_{MSY}	0.246	0.142	0.417	F_{2020}/F_{MSY}	0.319	0.185	0.556
		S05				**S06**	
Estimates	**Median**	**LCI**	**UCI**	**Estimates**	**Median**	**LCI**	**UCI**
K	172,595	122,341	261,704	K	155,467	107,402	238,505
r	0.575	0.408	0.800	r	0.651	0.447	0.936
ψ(psi)	0.939	0.815	0.990	ψ(psi)	0.939	0.819	0.991
σ_{proc}	0.104	0.059	0.167	σ_{proc}	0.105	0.059	0.167
F_{MSY}	0.568	0.403	0.790	F_{MSY}	0.680	0.467	0.977
B_{MSY}	63,873	45,275	96,850	B_{MSY}	55,971	38,667	85,865
MSY	36,040	28,110	51,995	MSY	37,617	29,019	55,466
B_{1952}/K	0.929	0.724	1.171	B_{1952}/K	0.931	0.721	1.169
B_{2020}/K	0.673	0.463	0.871	B_{2020}/K	0.689	0.477	0.885
B_{2020}/B_{MSY}	1.819	1.252	2.353	B_{2020}/B_{MSY}	1.914	1.324	2.458
F_{2020}/F_{MSY}	0.276	0.161	0.496	F_{2020}/F_{MSY}	0.251	0.143	0.453

Table 20. Continued.

	S07				S08		
Estimates	**Median**	**LCI**	**UCI**	**Estimates**	**Median**	**LCI**	**UCI**
K	208,597	156,839	303,053	K	185,436	134,087	270,092
r	0.443	0.339	0.581	r	0.500	0.362	0.682
ψ(psi)	0.939	0.814	0.991	ψ(psi)	0.939	0.817	0.991
σ_{proc}	0.106	0.062	0.168	σ_{proc}	0.107	0.062	0.171
F_{MSY}	0.414	0.317	0.544	F_{MSY}	0.522	0.378	0.712
B_{MSY}	79,276	59,606	115,174	B_{MSY}	66,760	48,273	97,237
MSY	32,716	26,300	45,689	MSY	34,376	27,248	49,174
B_{1952}/K	0.927	0.720	1.163	B_{1952}/K	0.931	0.719	1.172
B_{2020}/K	0.628	0.432	0.833	B_{2020}/K	0.637	0.433	0.847
B_{2020}/B_{MSY}	1.651	1.136	2.192	B_{2020}/B_{MSY}	1.770	1.203	2.354
F_{2020}/F_{MSY}	0.335	0.195	0.576	F_{2020}/F_{MSY}	0.296	0.169	0.527
	S09						
Estimates	**Median**	**LCI**	**UCI**				
K	172,008	119,107	263,847				
r	0.561	0.386	0.806				
ψ(psi)	0.940	0.814	0.990				
σ_{proc}	0.104	0.059	0.167				
F_{MSY}	0.618	0.426	0.888				
B_{MSY}	60,216	41,697	92,367				
MSY	36,731	28,686	54,241				
B_{1952}/K	0.930	0.728	1.167				
B_{2020}/K	0.668	0.465	0.871				
B_{2020}/B_{MSY}	1.909	1.327	2.489				
F_{2020}/F_{MSY}	0.259	0.145	0.455				

Table 21. Estimates of MSY, F_{MSY}, Virgin SSB, SSB_{MSY}, 10%SSB_{MSY} and 20%SSB_{MSY} for the deterministic 9 grid runs for the W-SKJ stock

Quantile	h	MSY	F_{MSY}	Virgin SSB	SSB_{MSY}	10%SSB_{MSY}	%SSB_{MSY}	20%SSB_{MSY}
25	0.6	41003	0.500	199582	54466	2.7%	10893	5.5%
25	0.7	42401	0.701	166437	37316	2.2%	7463	4.5%
25	0.8	46340	1.002	148743	25599	1.7%	5120	3.4%
50	0.6	32342	0.377	250229	69702	2.8%	13940	5.6%
50	0.7	33497	0.536	210495	48736	2.3%	9747	4.6%
50	0.8	35906	0.787	185962	33293	1.8%	6659	3.6%
75	0.6	28313	0.310	294861	82172	2.8%	16434	5.6%
75	0.7	28444	0.451	238811	55306	2.3%	11061	4.6%
75	0.8	29244	0.697	200524	35381	1.8%	7076	3.5%

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Table 22. Constant catch scenarios by fleet used for projections for the western skipjack stock.

		FL1	FL2	FL3	FL4	FL5
Years	catch	PS_West	BB_West	LL_USMX	LL_OTH	HL_RR
2021 - 2022	18859	1000	14529	266	151	2913
2023 - 2040	0	0	0	0	0	0
2023 - 2040	14000	742	10786	198	112	2163
2023 - 2040	16000	848	12326	226	128	2472
2023 - 2040	18000	954	13867	254	144	2780
2023 - 2040	20000	1060	15408	282	160	3089
2023 - 2040	22000	1166	16949	310	176	3398
2023 - 2040	24000	1272	18490	339	192	3707
2023 - 2040	26000	1378	20031	367	208	4016
2023 - 2040	28000	1484	21571	395	224	4325
2023 - 2040	30000	1590	23112	423	240	4634
2023 - 2040	32000	1696	24653	452	256	4943
2023 - 2040	34000	1802	26194	480	272	5252
2023 - 2040	36000	1908	27735	508	288	5561
2023 - 2040	38000	2014	29275	536	304	5870
2023 - 2040	40000	2120	30816	564	320	6179

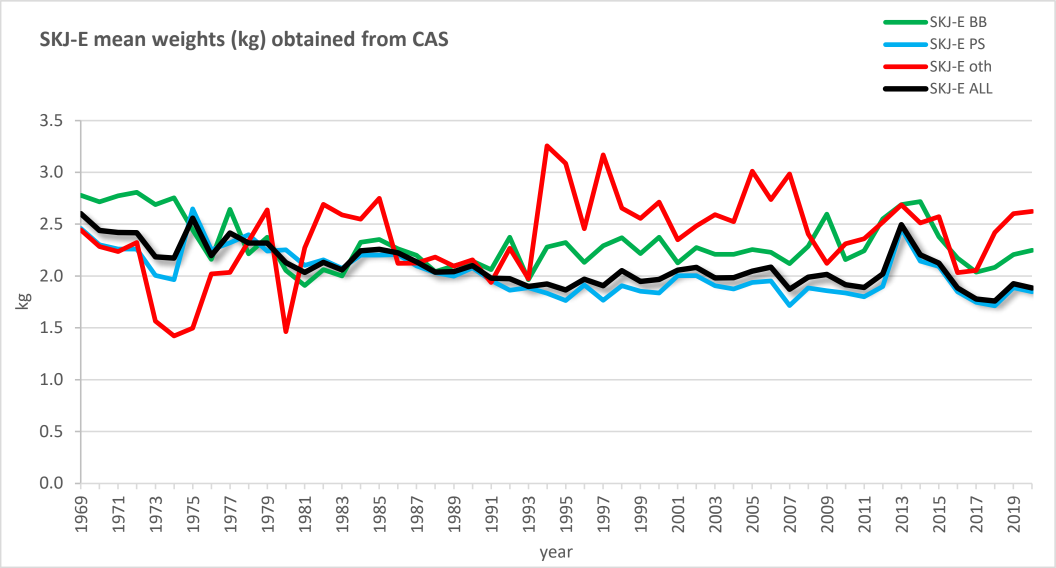


Figure 1. SKJ-E weighted mean weights (kg) estimated from the overall CAS estimations.

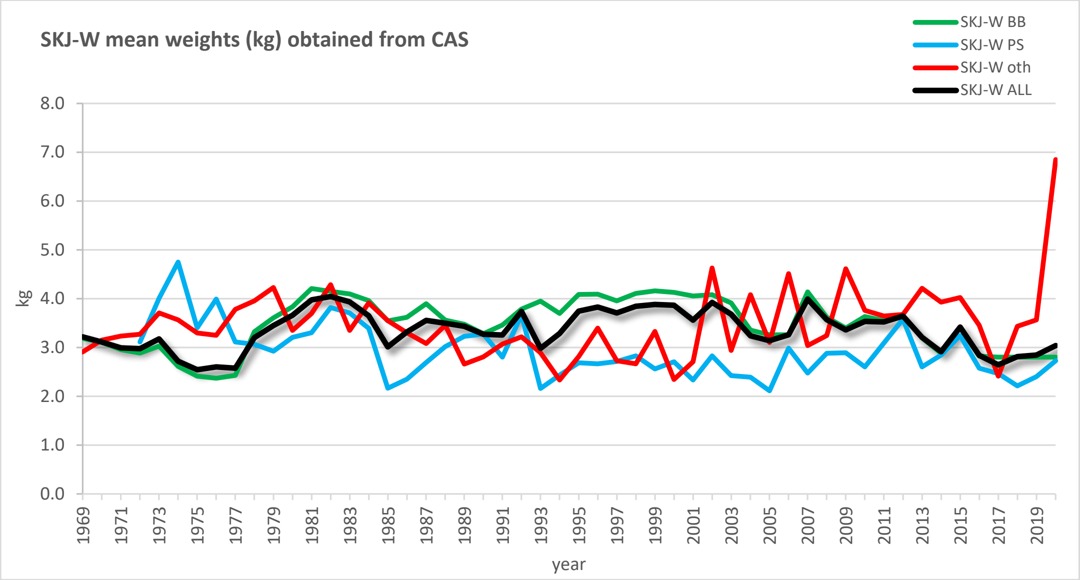


Figure 2. SKJ-W weighted mean weights (kg) estimated from the overall CAS estimations. The high value of the mean weight in other gears (oth) in 2020 may be due to some errors/inconsistencies in the associated size information available.

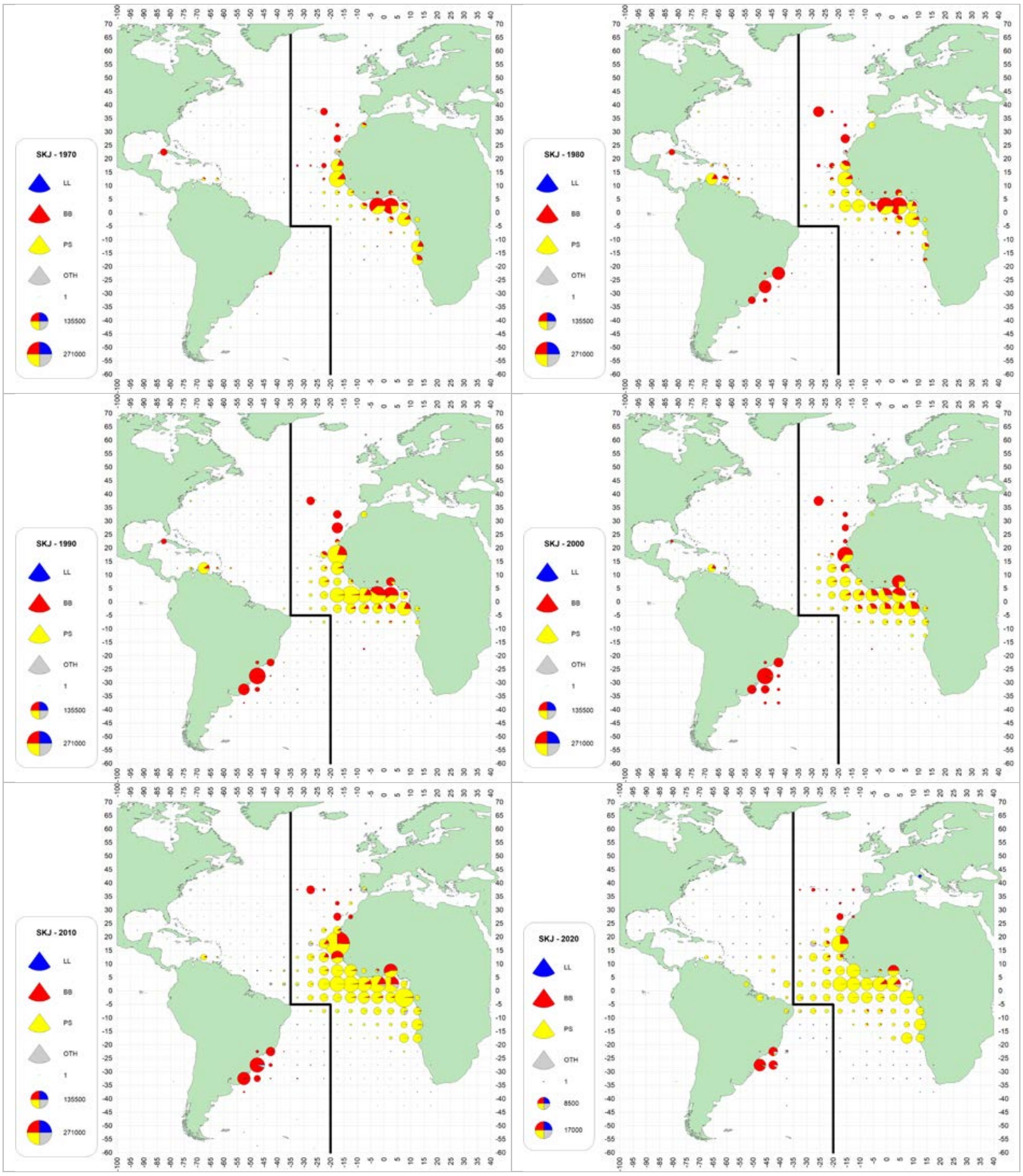


Figure 3. SKJ total catches (t) in 5x5 degree squares (source: CATDIS) by major gear and decade (1970-2020). The last decade only contains 1 year.

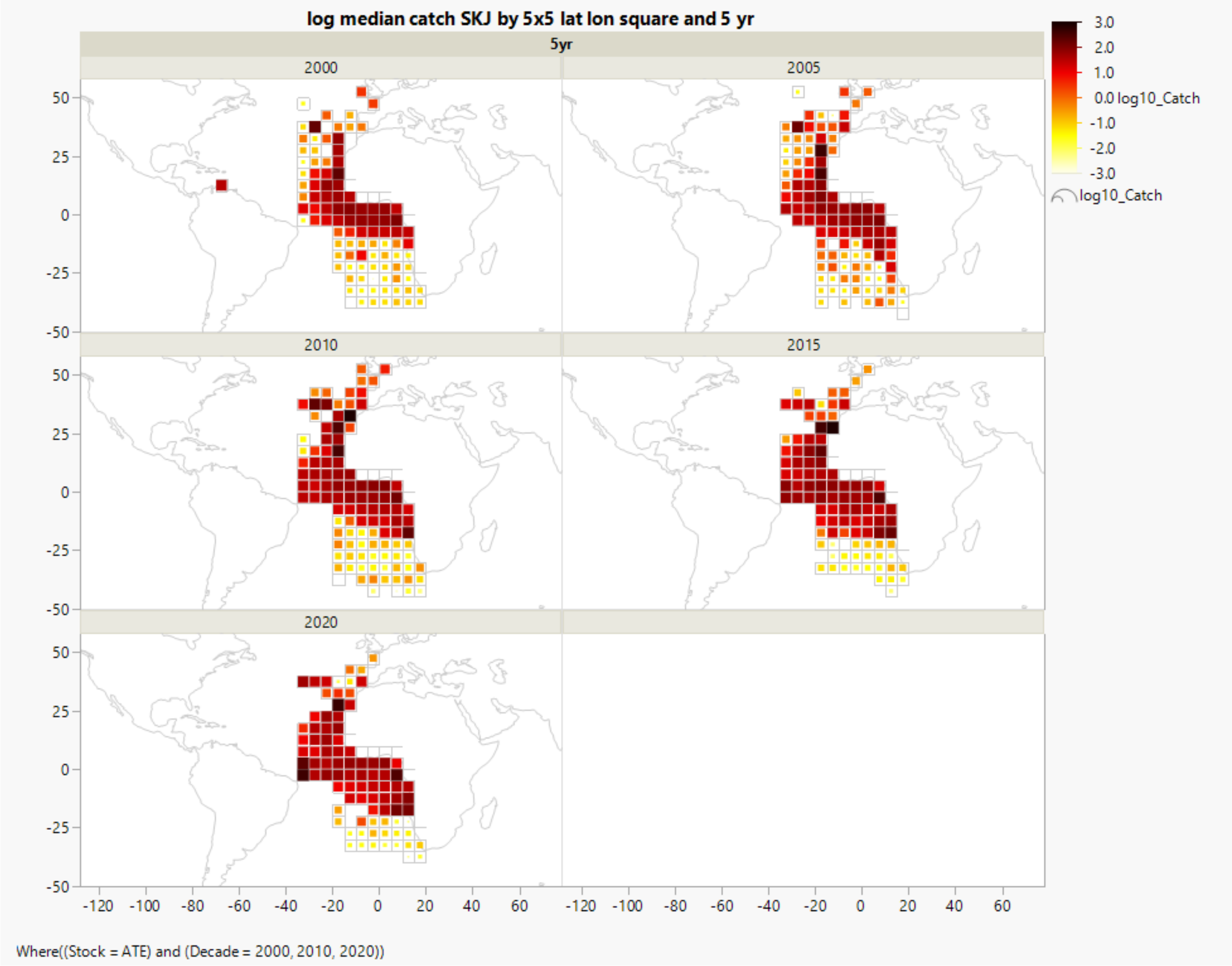


Figure 4. Spatial distribution (5x5 degree square) of SKJ median catch (t) since 2000 grouped in 5-year periods. Colour shades indicate the log10 of the median catch overall. Estimates based on the SKJ CATDIS database*.*

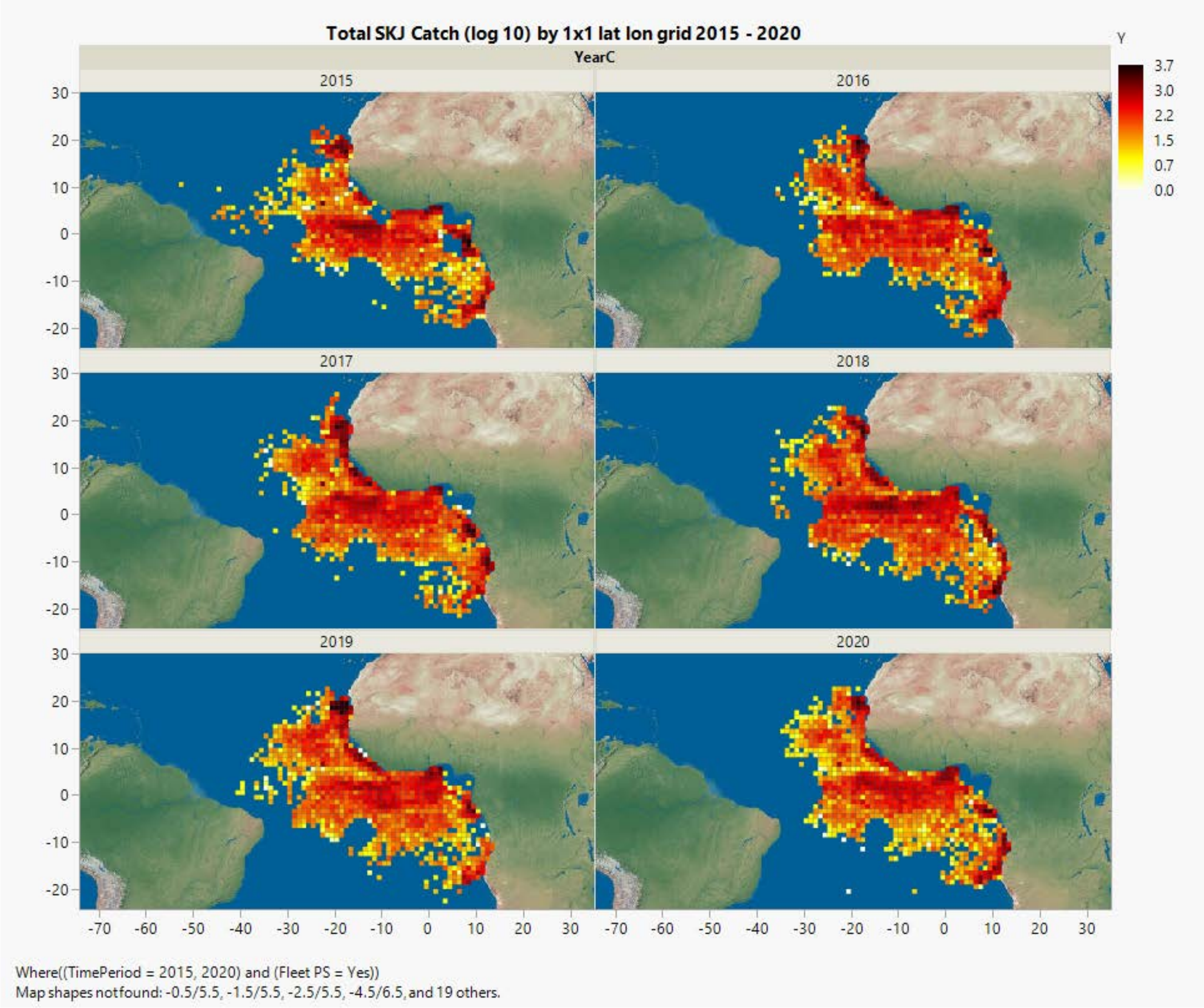


Figure 5. Total annual catch of SKJ (log 10 t) by 1x1 degree squares from 2015 to 2020 based on T2CE data reported by CPCs. Darker shades indicate larger catches.

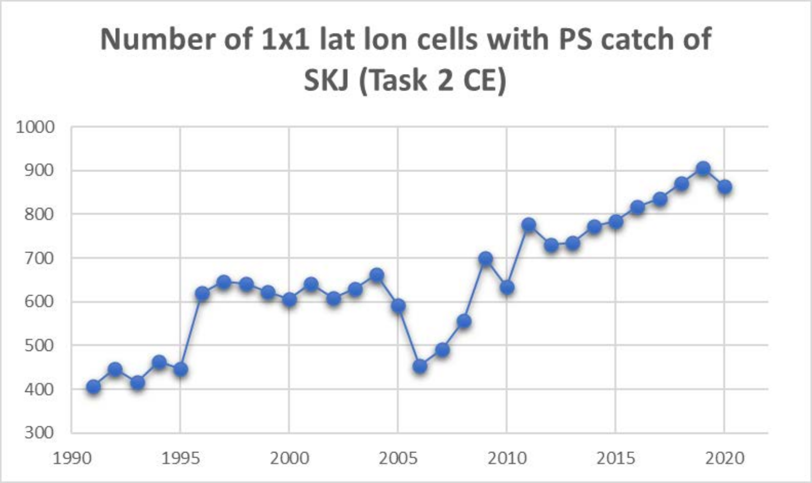


Figure 6. Number of 1x1 degree squares that have reported catches of tropical tunas (SKJ, YFT, BET) by year from the T2CE ICCAT dbase. Note that the period 1990-2009 may be incomplete as not all fleets with reported catches (Task 1 NC) had reported the Task 2 CE in the spatio-temporal resolution indicated.

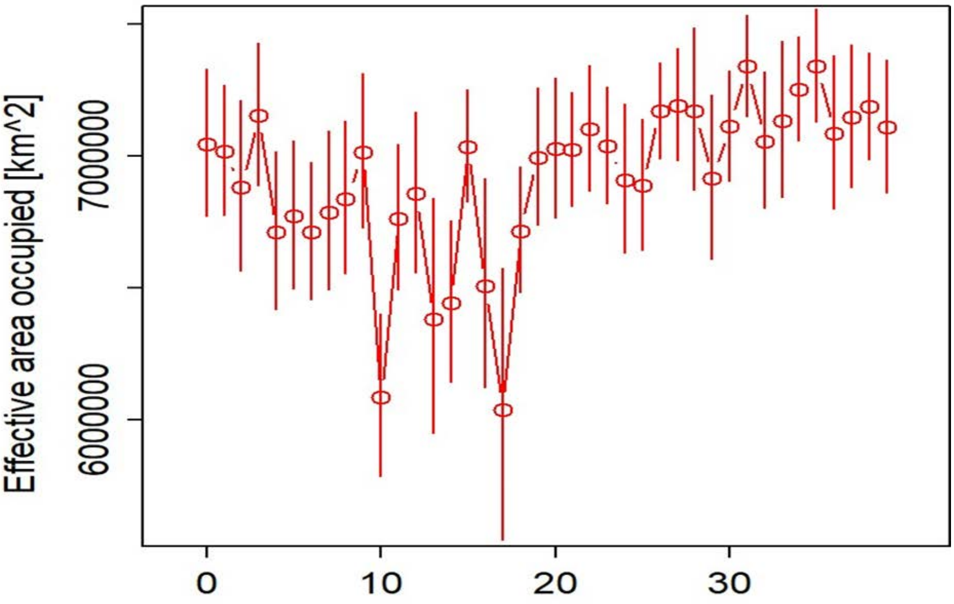


Figure 7. Estimated effective area occupied (in square km) required to contain a population given its average population density (kg km−2)] of the eastern Atlantic skipjack caught by the European purse seiner for fishing operations on drifting FADs not owned by the vessel. The plot shows the estimate (circle) and confidence interval (±1 se) by year-quarter (*x*-axis), from Q1-2010 to Q4-2019 (SCRS/2022/028).

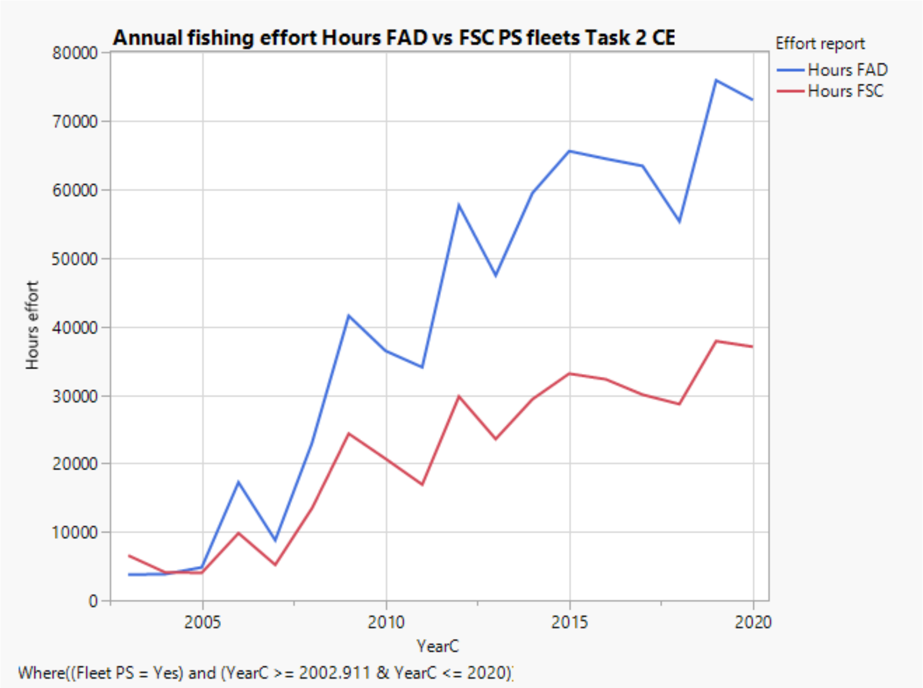


Figure 8. Reported fishing effort (hours fishing) for the tropical tuna PS fleets (Task 2 CE) by fishing mode on floating objects (FOB/FAD) and free schools (FSC) 2005 - 2020.

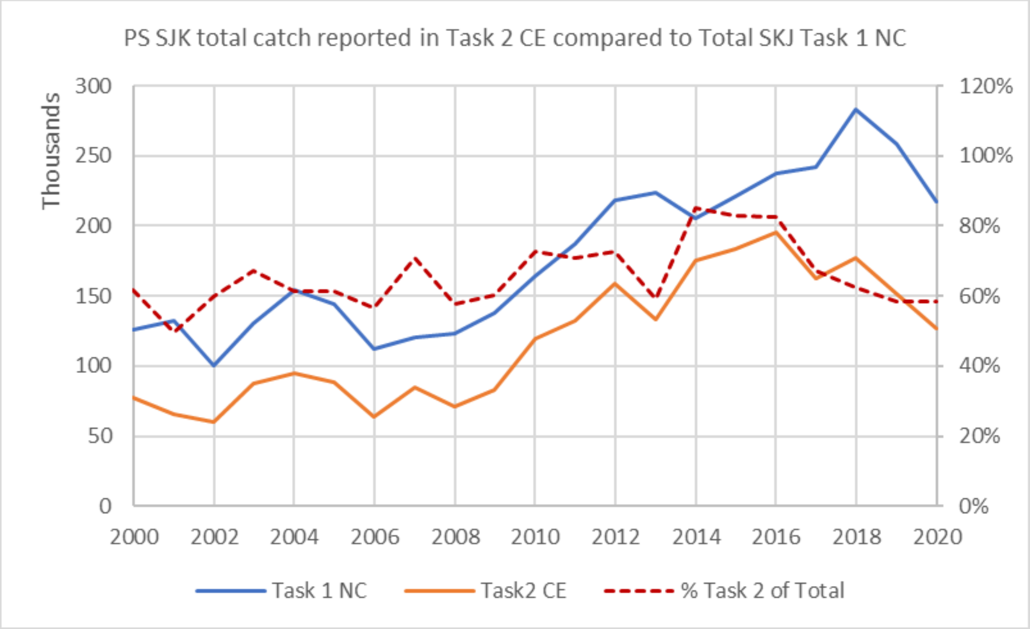


Figure 9. Annual trends of the E-SKJ total catch (Task 1 NC) compared to the purse seine (PS) SKJ catch reported in Task 2 CE (Task 2 CE). The dashed line indicates the annual percent values on the right *y*-axis.

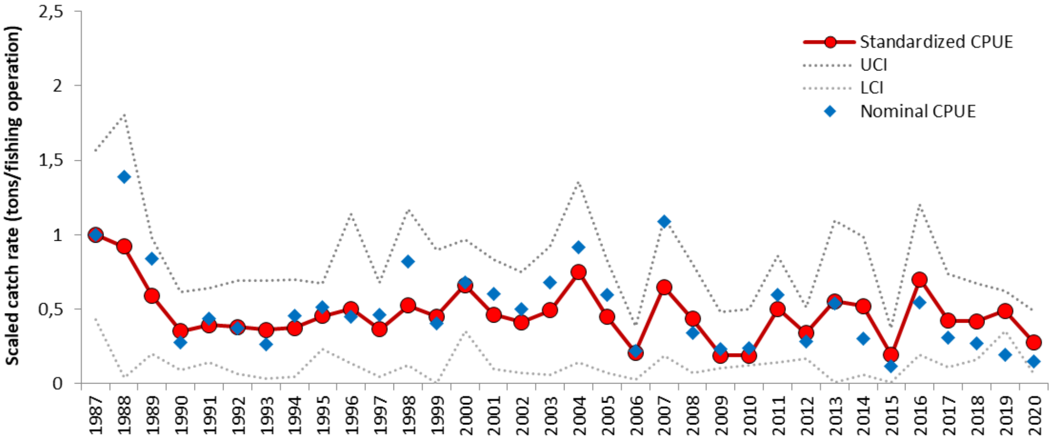


Figure 10. Scaled nominal (blue squares) and standardized (red line and circles) CPUE (t/fishing operation) of skipjack tuna caught by the Venezuelan baitboat fishery. Dotted lines represent 95% confidence intervals for the standardized CPUE.

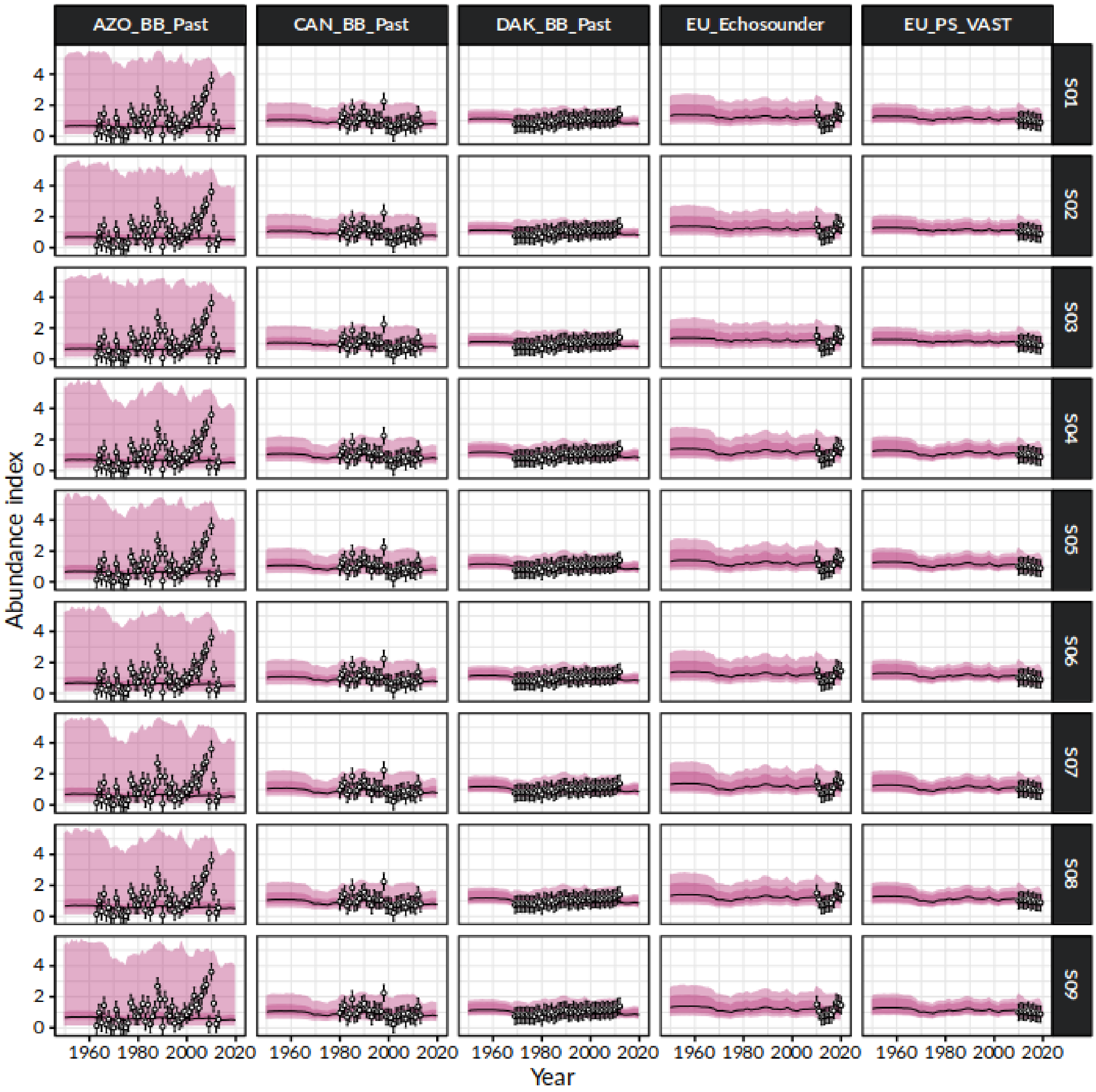


Figure 11. Time series of observed (circle) with error 95% CIs (error bars) and predicted (solid line) CPUE of East Atlantic skipjack tuna for the Bayesian state-space surplus production model JABBA for each scenario fitted. Dark shaded pink areas show 95% credibility intervals of the expected mean CPUE and light shaded blue areas denote the 95% posterior predictive distribution intervals.

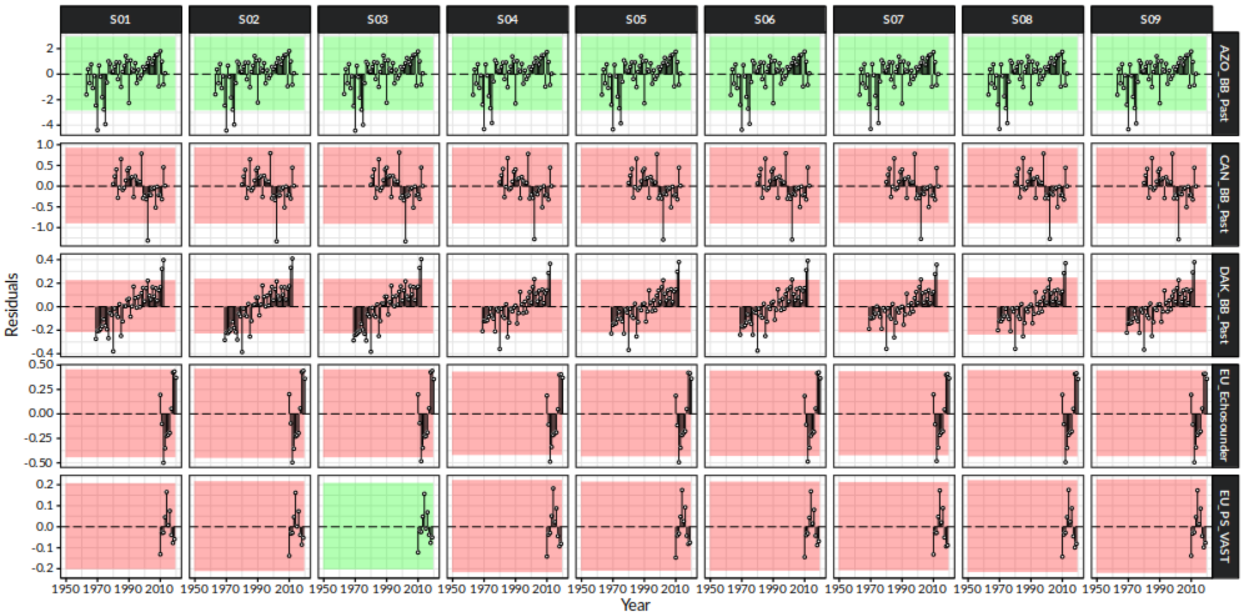


Figure 12. Runs tests to quantitatively evaluate the randomness of the time series of CPUE residuals for each scenario fitted for West Atlantic skipjack tuna. Green panels indicate no evidence of lack of randomness of time-series residuals (p>0.05), while red panels indicate the opposite. The inner shaded 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).

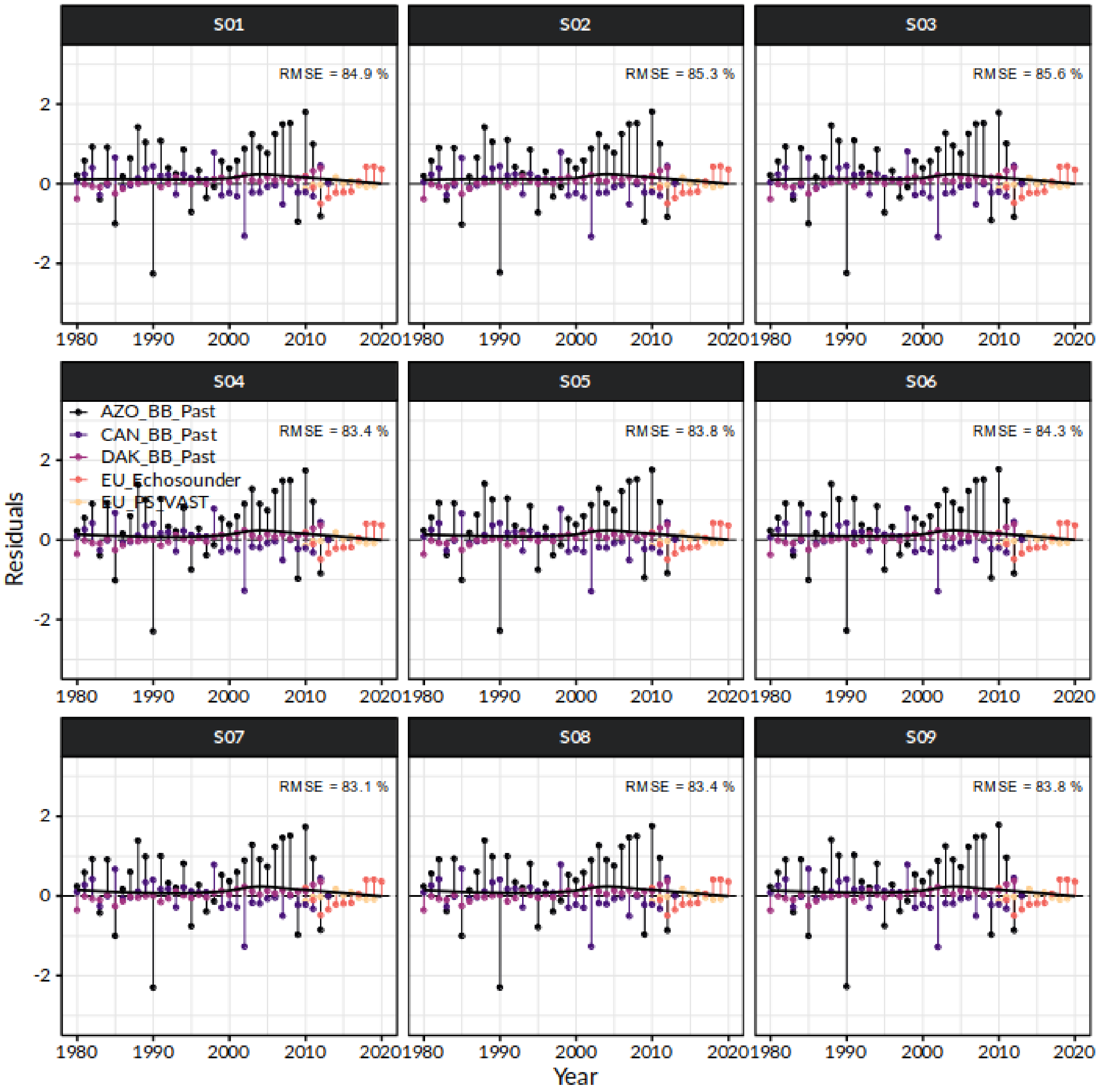
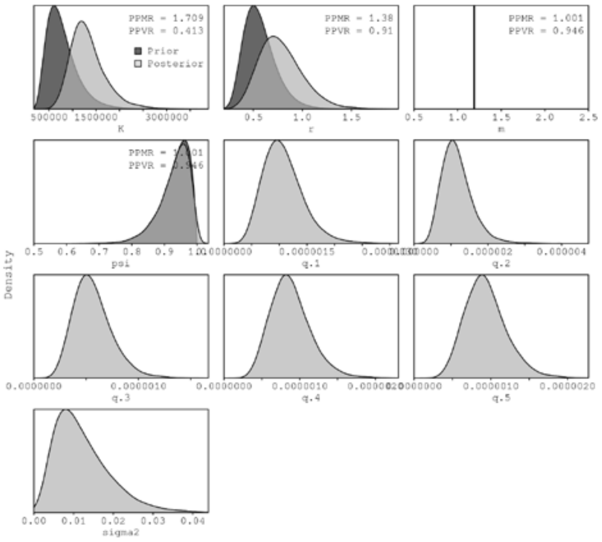
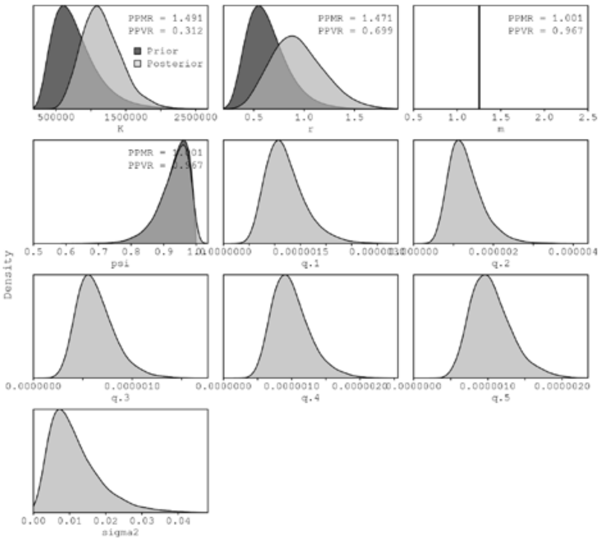


Figure 13. JABBA residual diagnostic plots for alternative sets of CPUE indices examined for each scenario fitted for the East Atlantic skipjack tuna. Solid black lines indicate a loess smoother through all residuals.

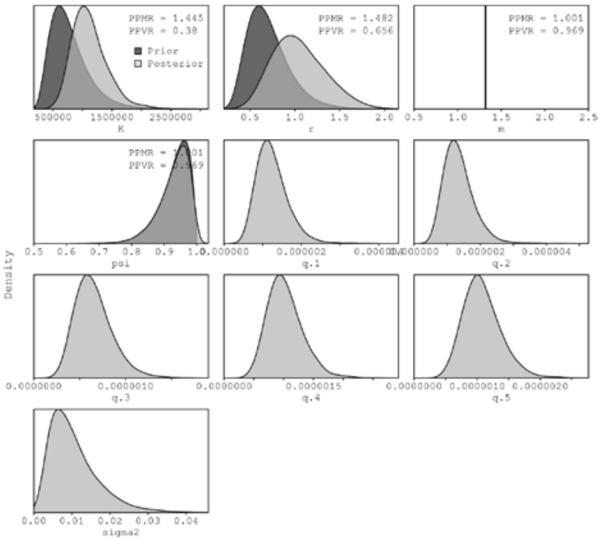
S01



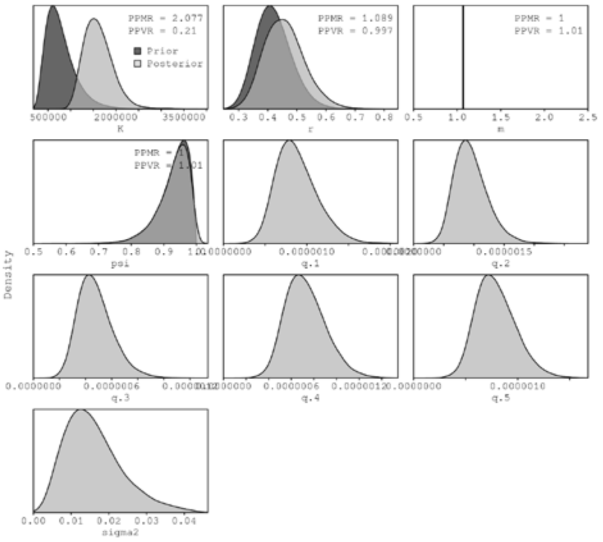
S02



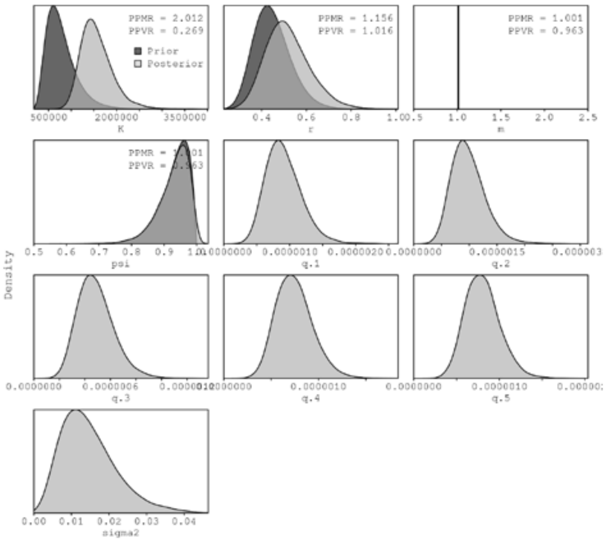
S03



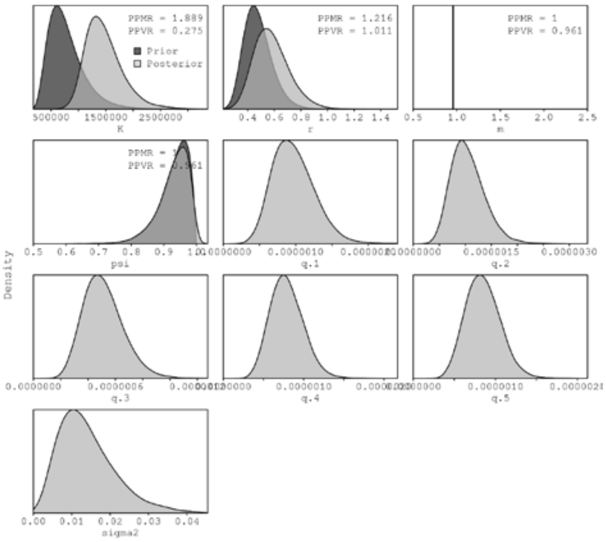
S04



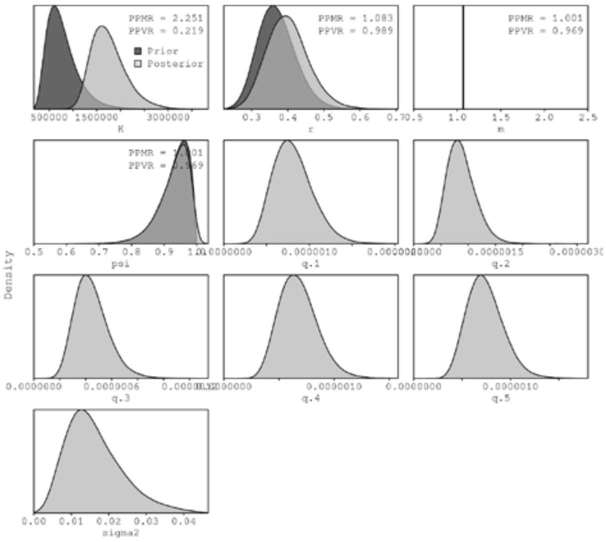
S05



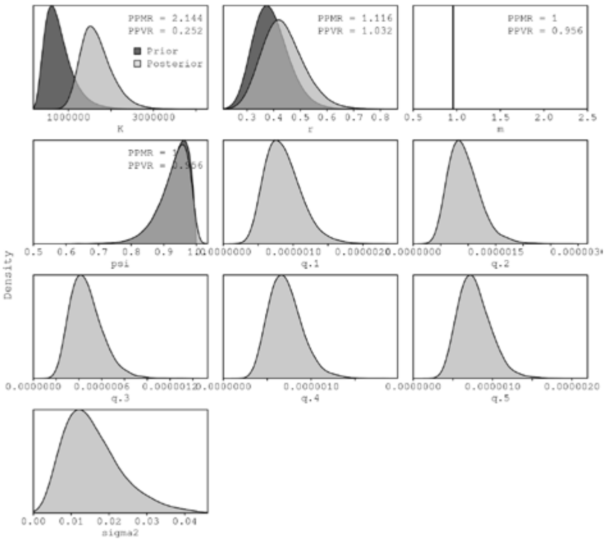
S06



S07



S08



S09

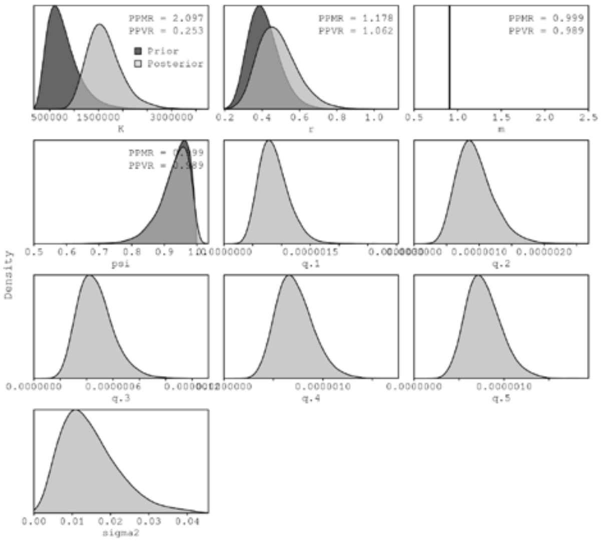


Figure 14. Prior and posterior distributions of various model and management parameters for the Bayesian state-space surplus production fitted for the East Atlantic skipjack tuna. PPRM: Posterior to Prior Ratio of Medians; PPRV: Posterior to Prior Ratio of Variances.

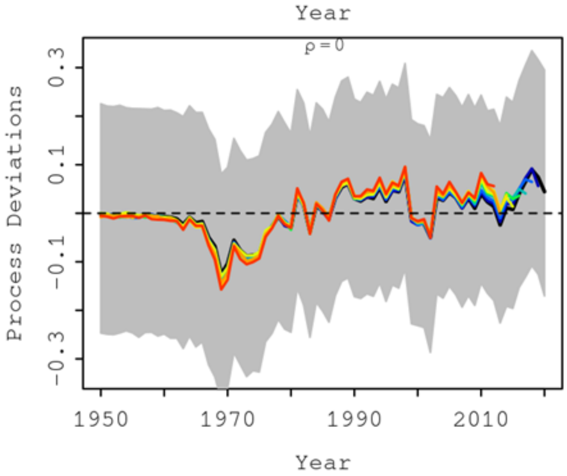


Figure 15. E-SKJ JABBA model run. Trends of process error deviations from the retrospective analyses when removing up to 5 years of the terminal input data.

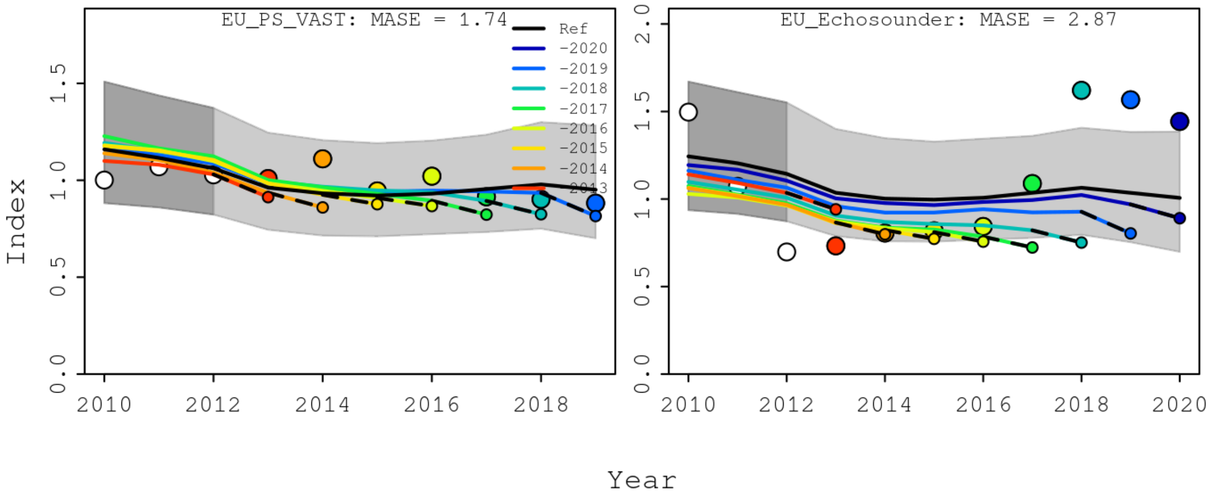


Figure 16. Hindcasting cross-validation results (HCxval) for the two scenarios S05 for East Atlantic skipjack tuna, showing one-year-ahead forecasts of CPUE values (2011-2019), performed with eight hindcast model runs relative to the expected CPUE. The CPUE observations, used for cross-validation, are highlighted as colour-coded solid circles with associated light-grey shaded 95% confidence interval. The model reference year refers to the end points of each one-year-ahead forecast and the corresponding observation (i.e., year of peel + 1).

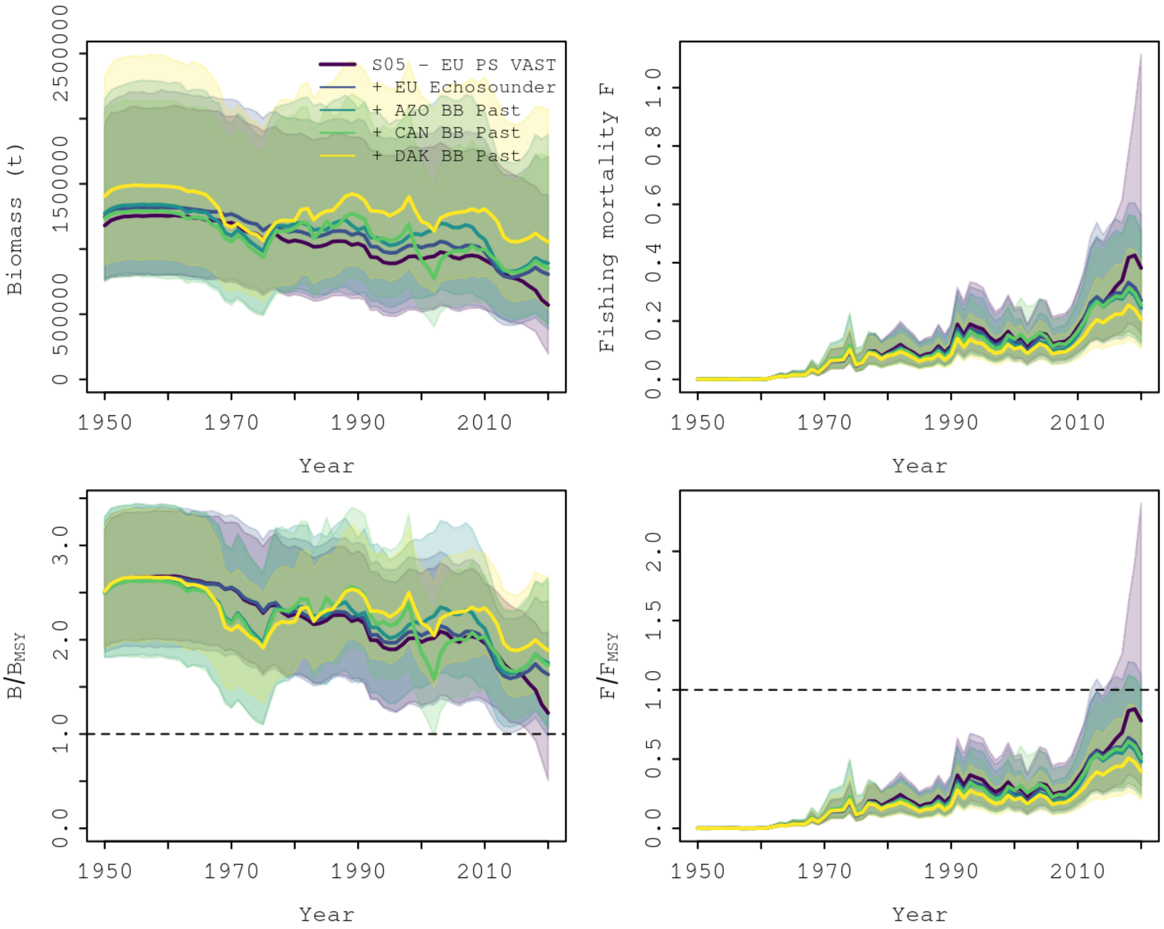


Figure 17. Sensitivity analysis performed for scenarios S05 showing the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and biomass relative to K (B/K) and surplus production curve (bottom panels) for the East Atlantic skipjack tuna.

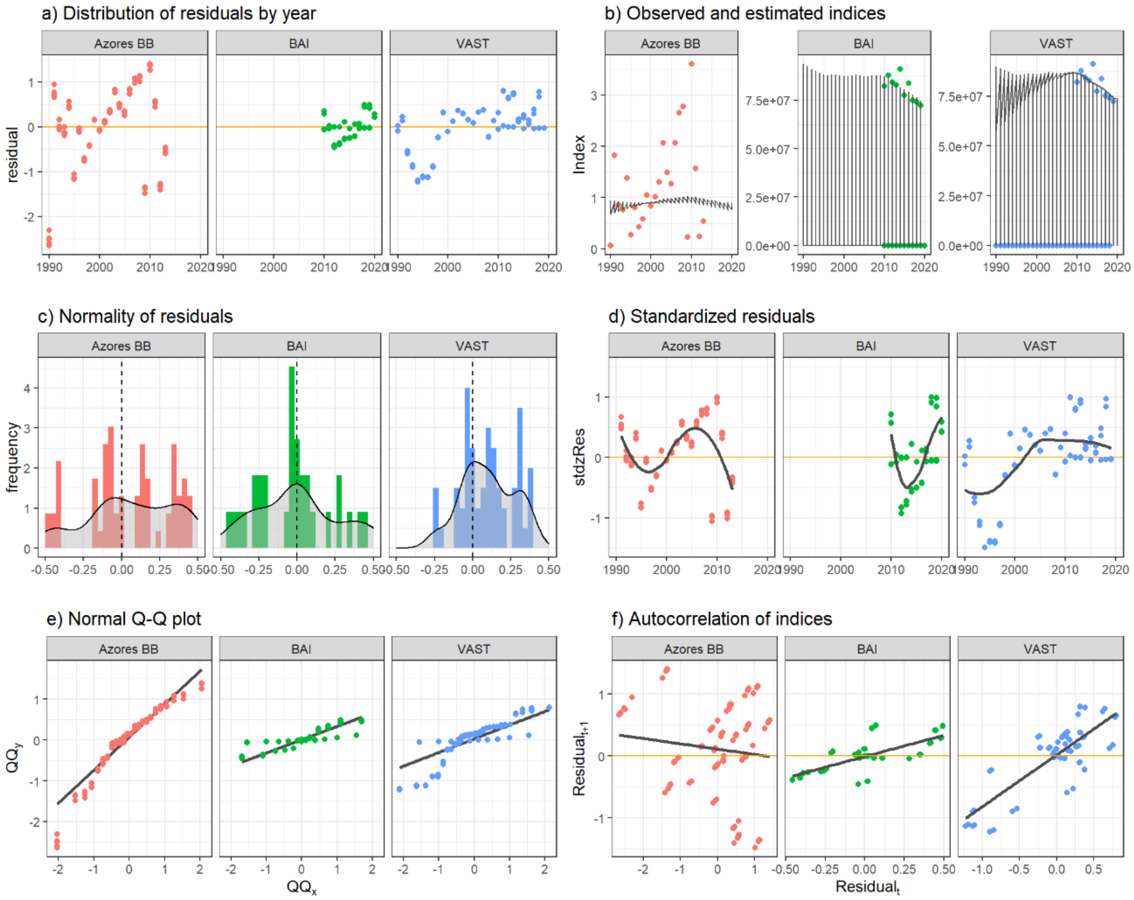


Figure 18. Diagnostics of fit for the proposed preliminary reference case MPB model.

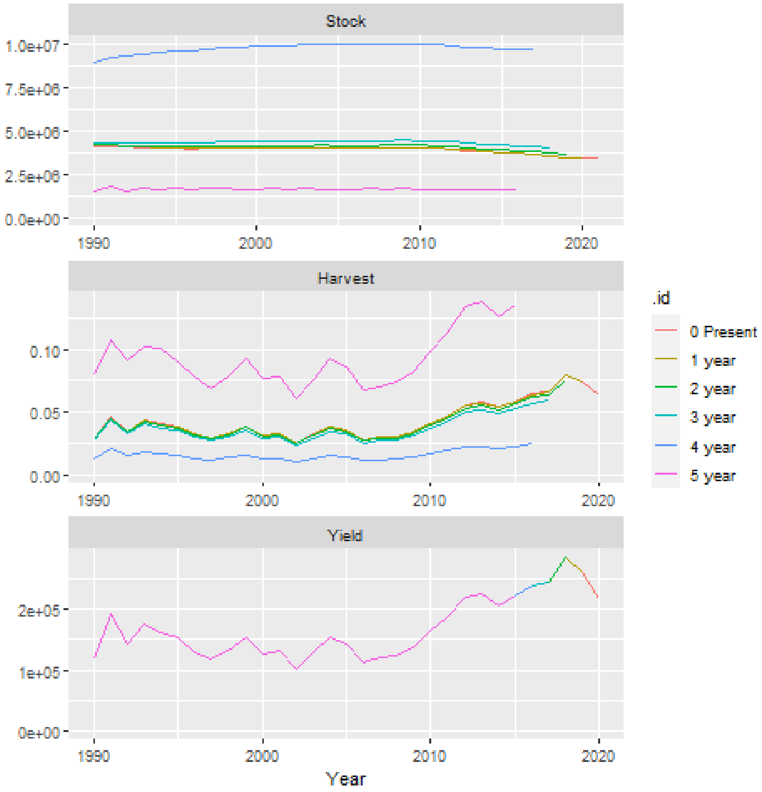


Figure 19. Retrospective analysis for the MPB preliminary reference run SKJ-E.

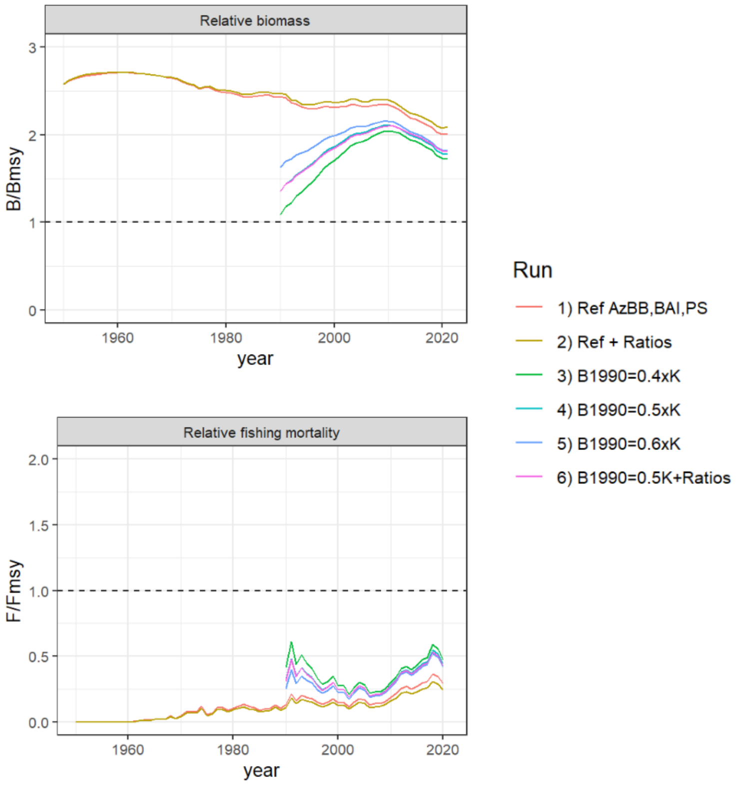


Figure 20. Diagnostics were presented to the Group including the production function

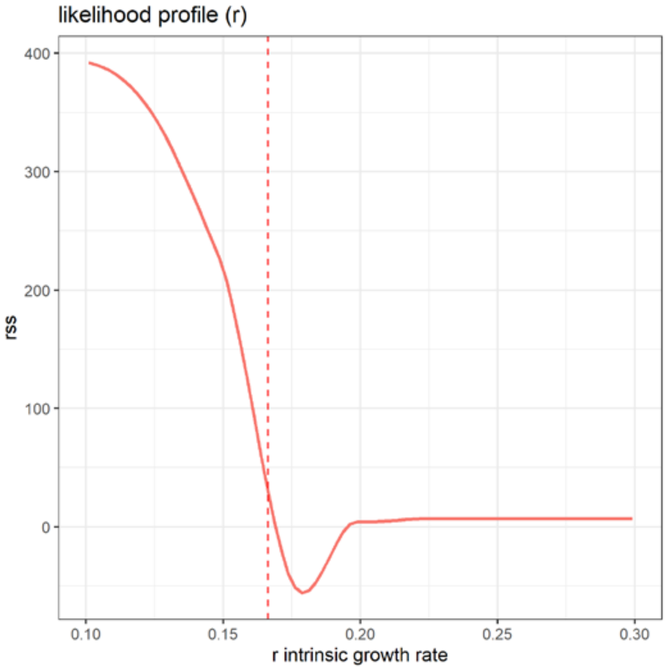


Figure 21. Likelihood profile for the intrinsic growth rate for the proposed preliminary reference case of the MPB SKJ-E.

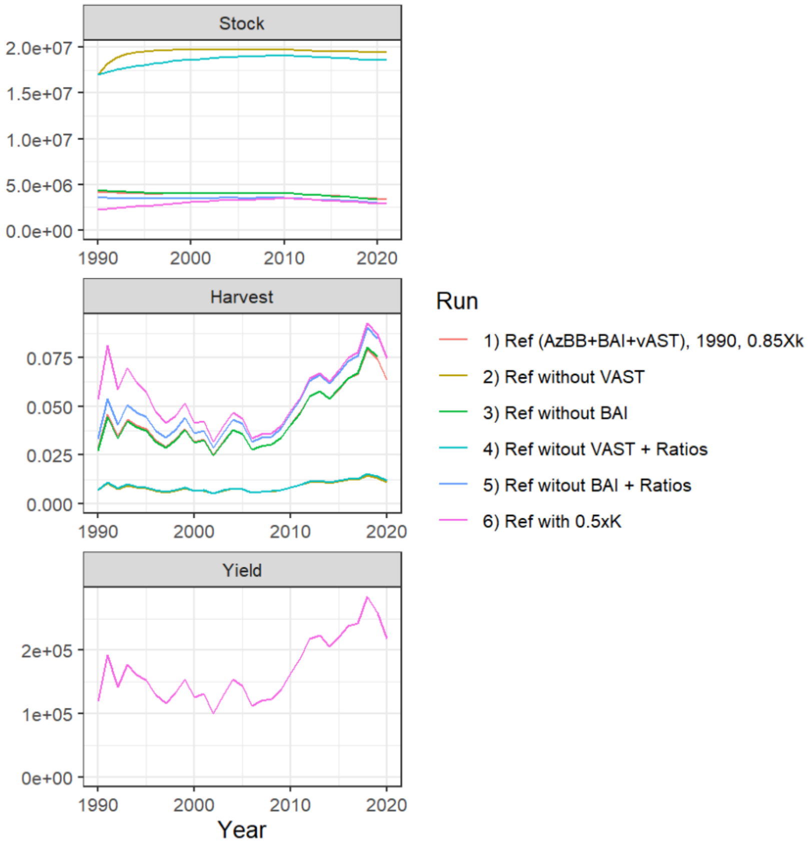


Figure 22. Estimated biomass and fishing mortality for the proposed preliminary reference case and alternatives from the MPB E-SKJ run.

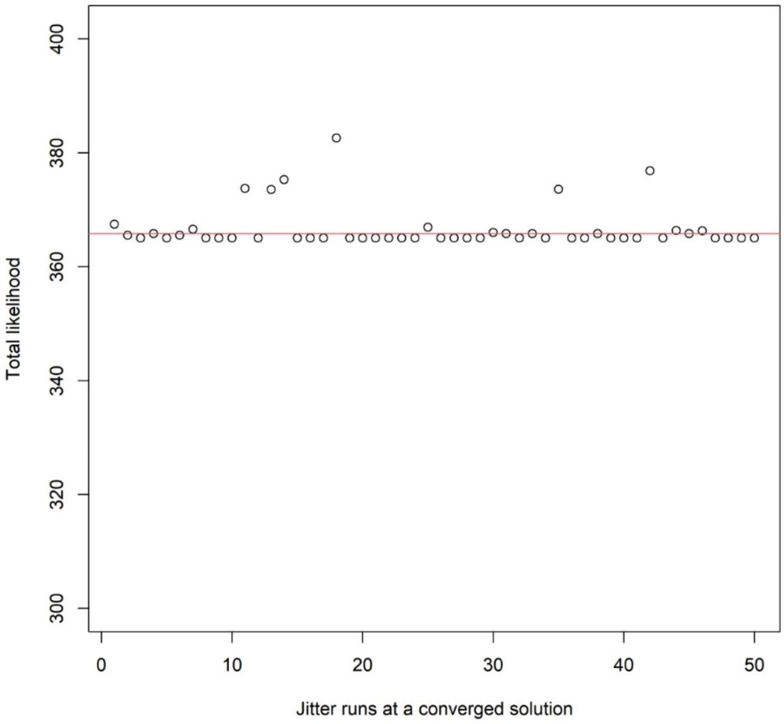


Figure 23. Jitter results for the reference case.

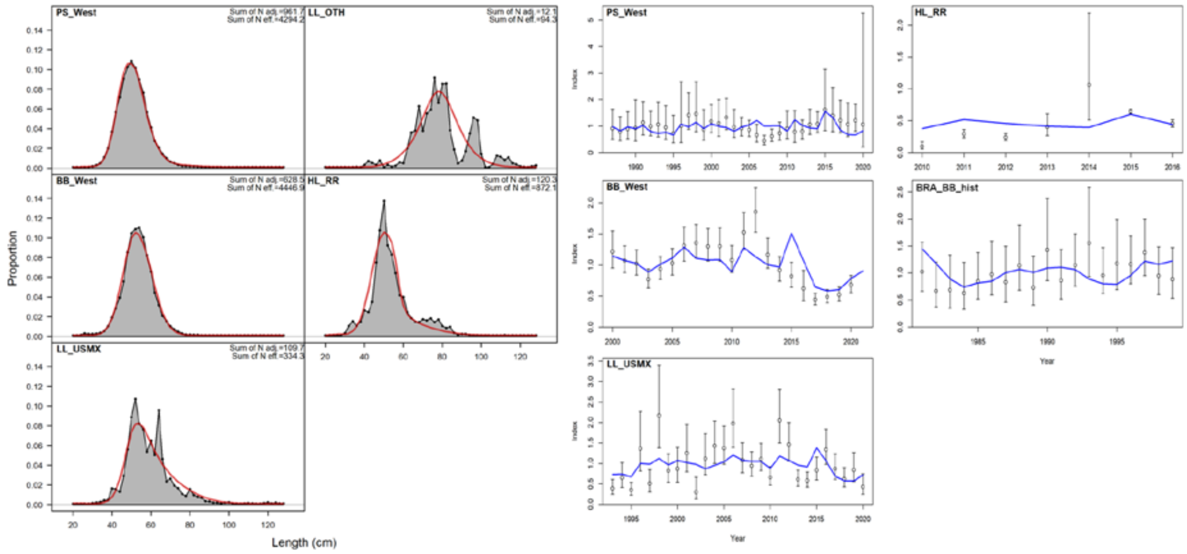


Figure 24. Model fits to the aggregated length compositions for each fleet (left panels) and for the index (right panels) for the reference case.

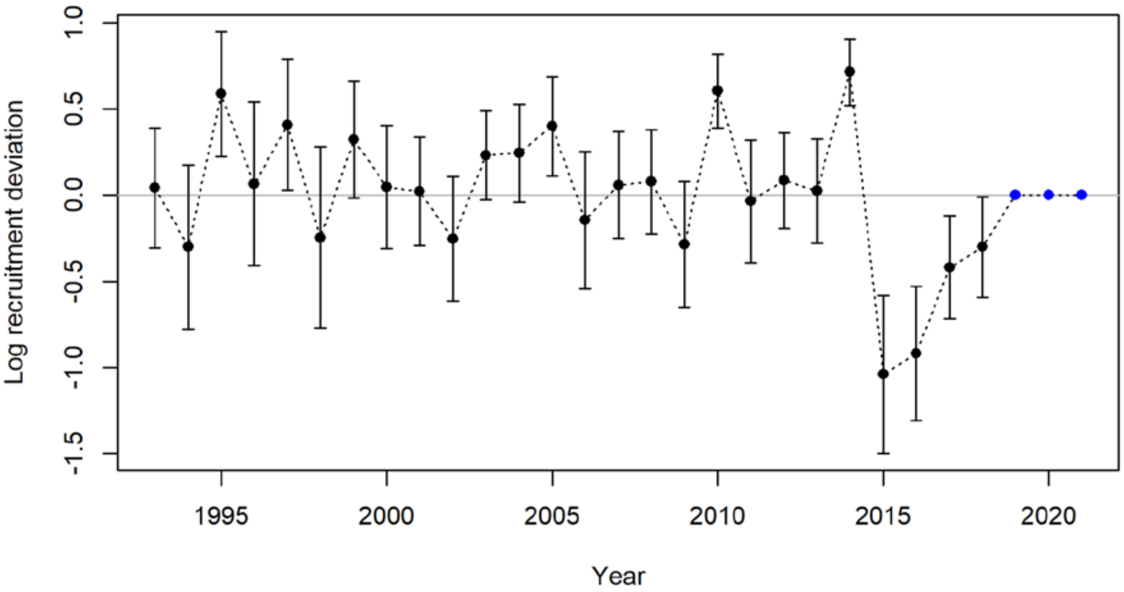


Figure 25. Recruitment deviations for the W-SKJ Stock synthesis model reference case.

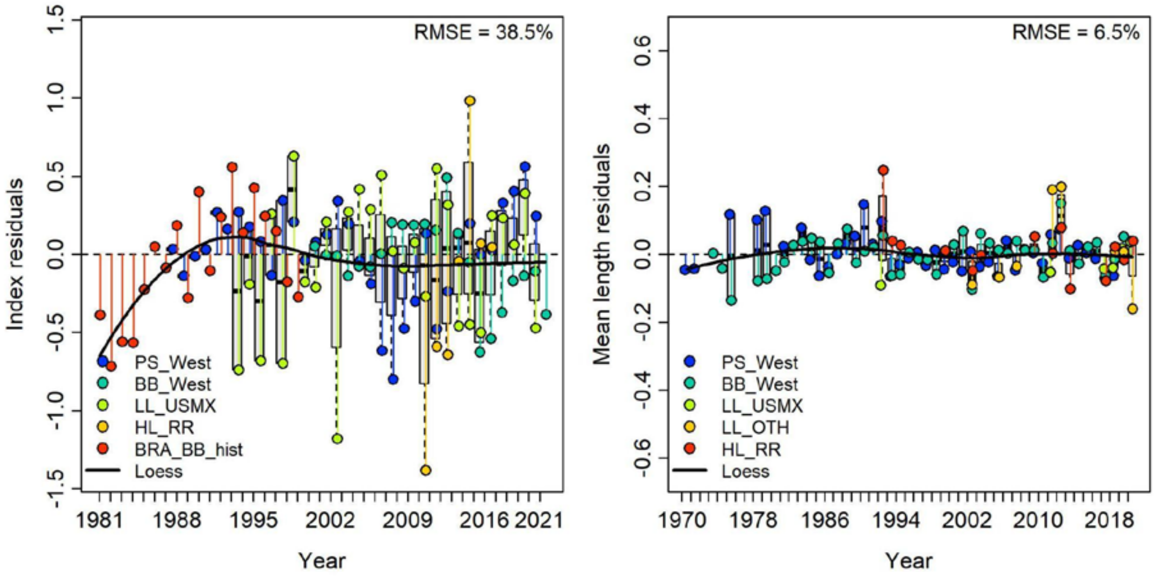


Figure 26. Joint residuals plot for the index (left panel) and length composition (right panel) fits for the W-SKJ Stock synthesis model reference case.

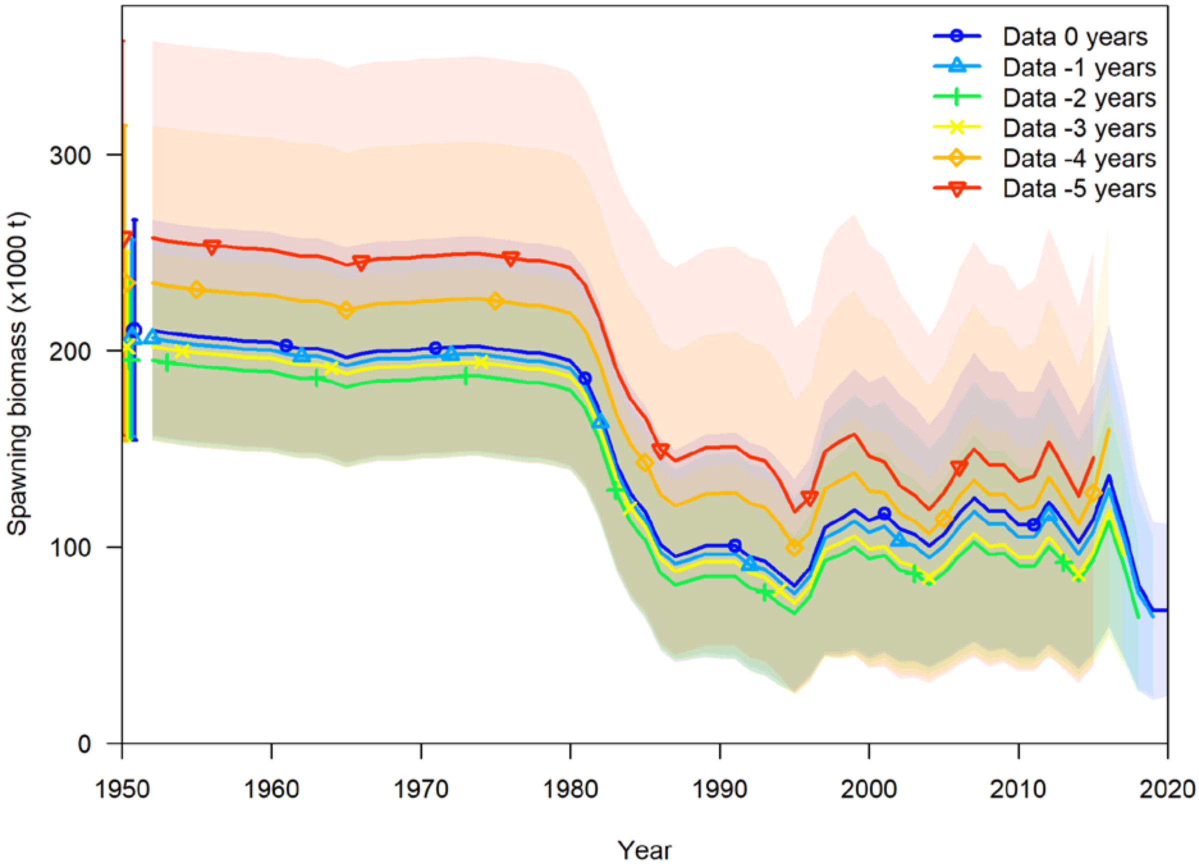


Figure 27. Retrospective plots of spawning stock biomass, for the W-SKJ Stock synthesis model reference case.

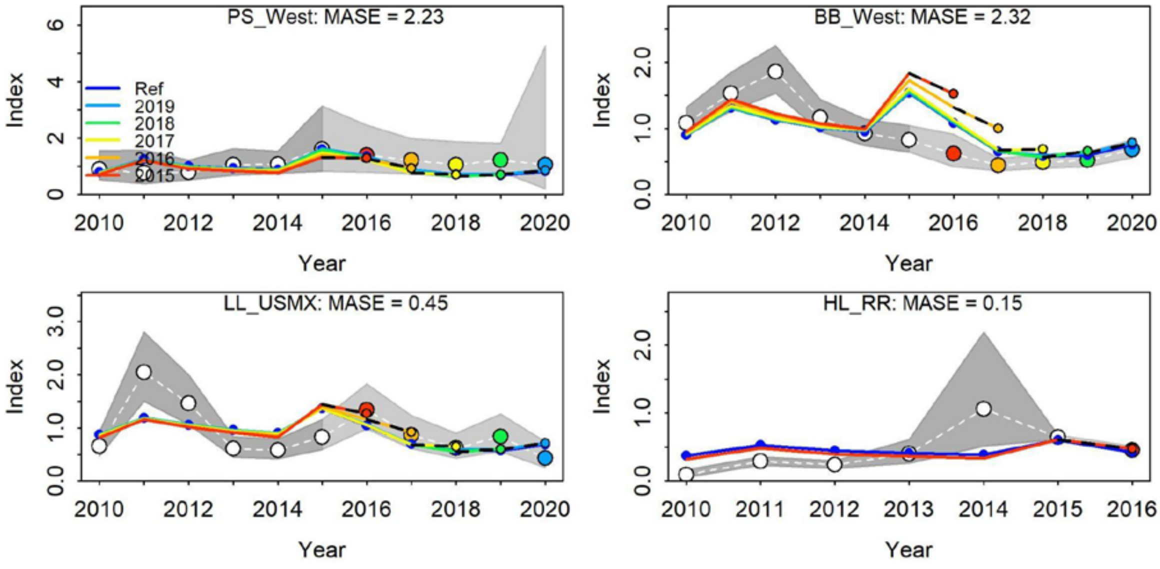


Figure 28. Hindcasting plots for the index fit for the W-SKJ Stock synthesis model reference case.

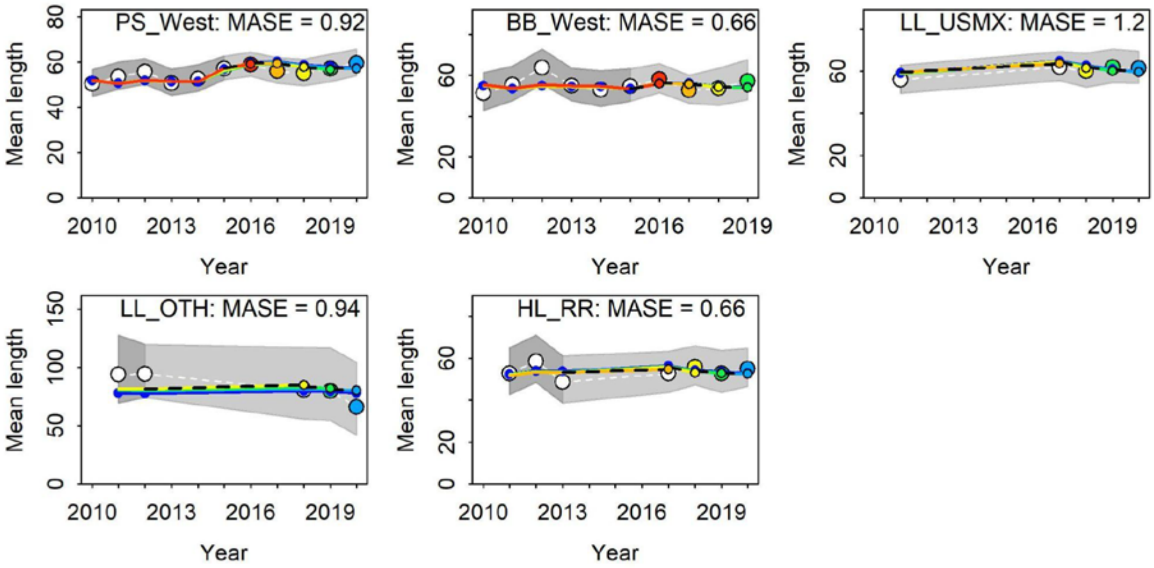


Figure 29. Hindcasting plots for the length composition fit in the W-SKJ Stock synthesis model reference case.

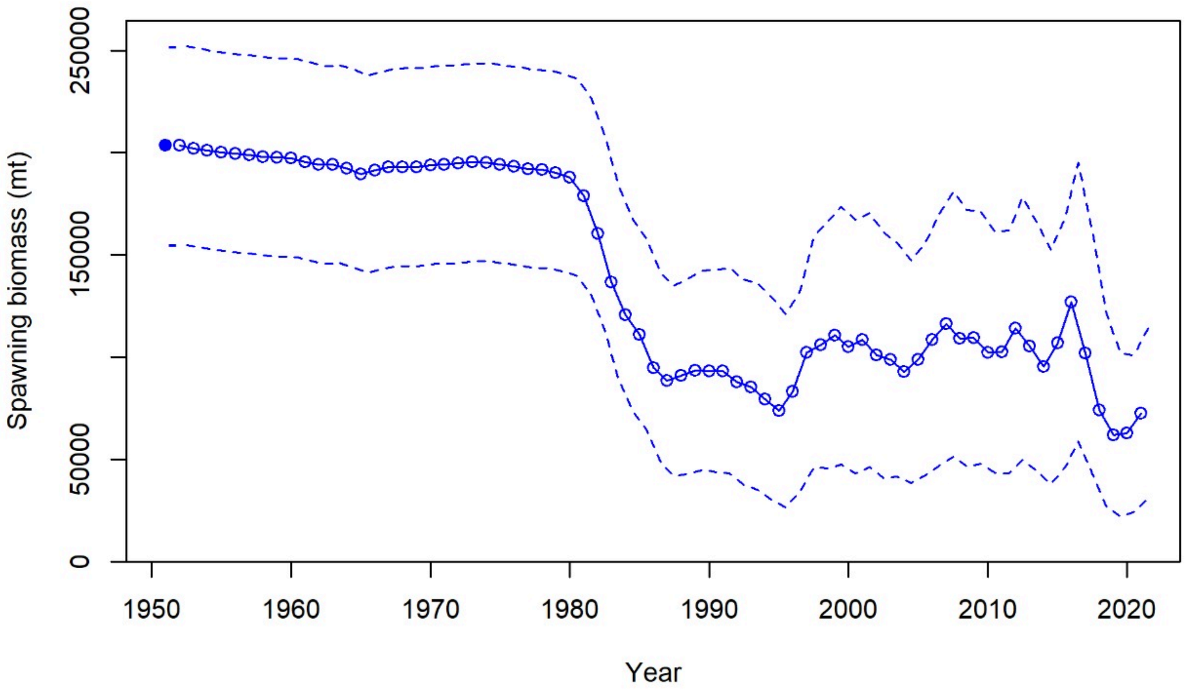


Figure 30. Spawning stock biomass estimates for the Stock Synthesis reference case of the western skipjack stock.

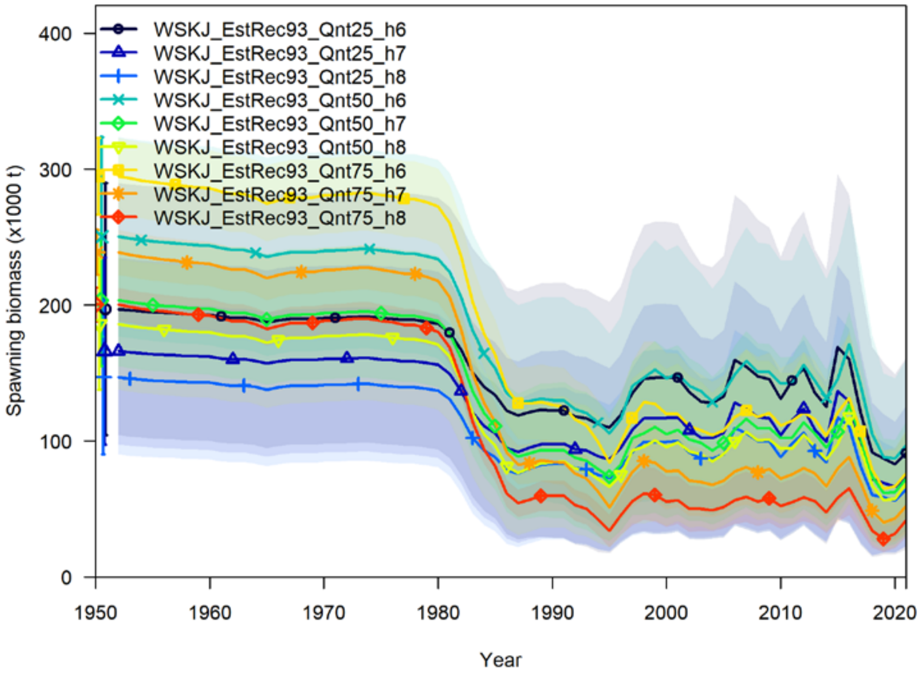


Figure 31. Spawning stock biomass trajectories across the Stock Synthesis uncertainty grid of the western skipjack stock.

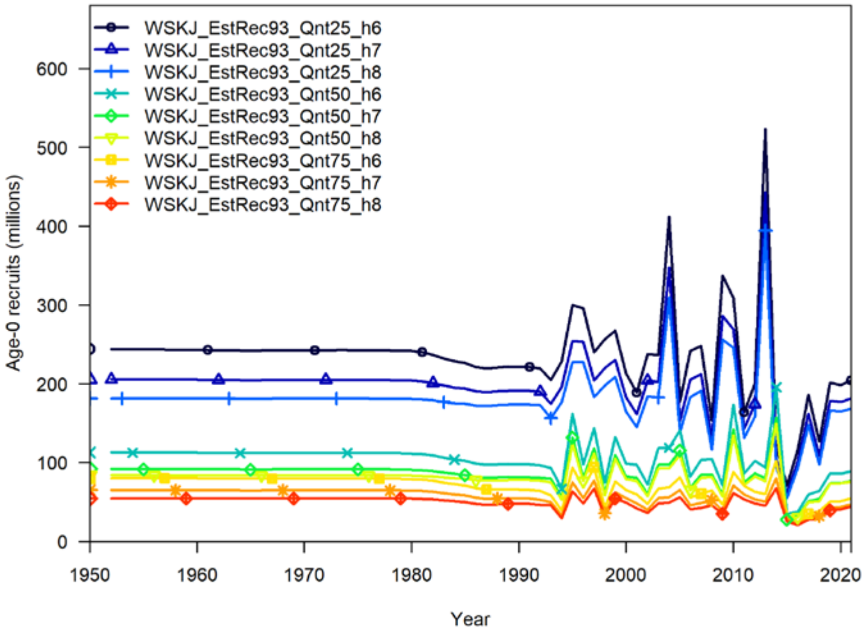


Figure 32. Age-0 recruits' trajectories across the Stock Synthesis uncertainty grid of the western skipjack stock.

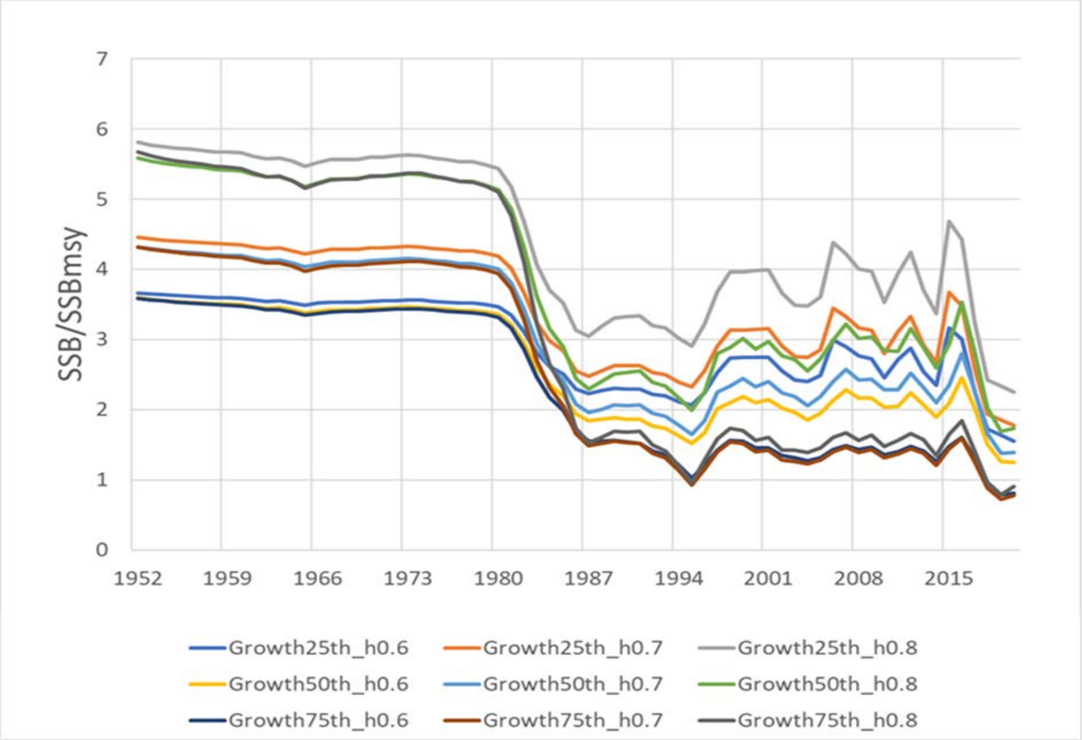


Figure 33. SSB/SSBM$_{SY}$ trajectories across the Stock Synthesis uncertainty grid of the western skipjack stock.

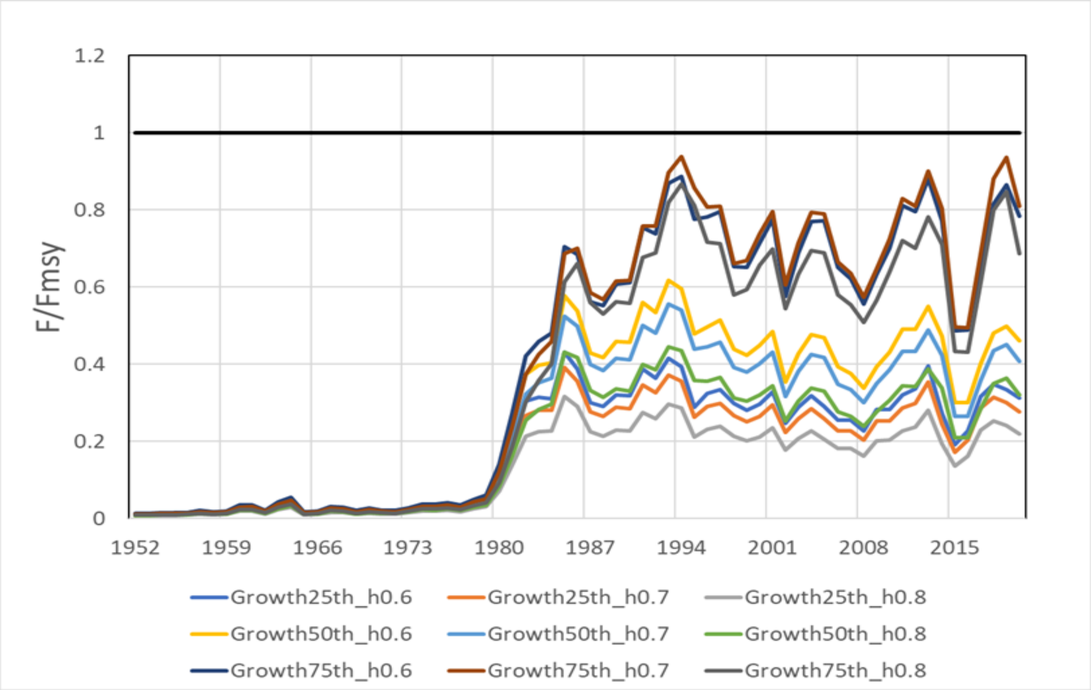


Figure 34. F/F$_{MSY}$ trajectories across the Stock Synthesis uncertainty grid of the western skipjack stock.

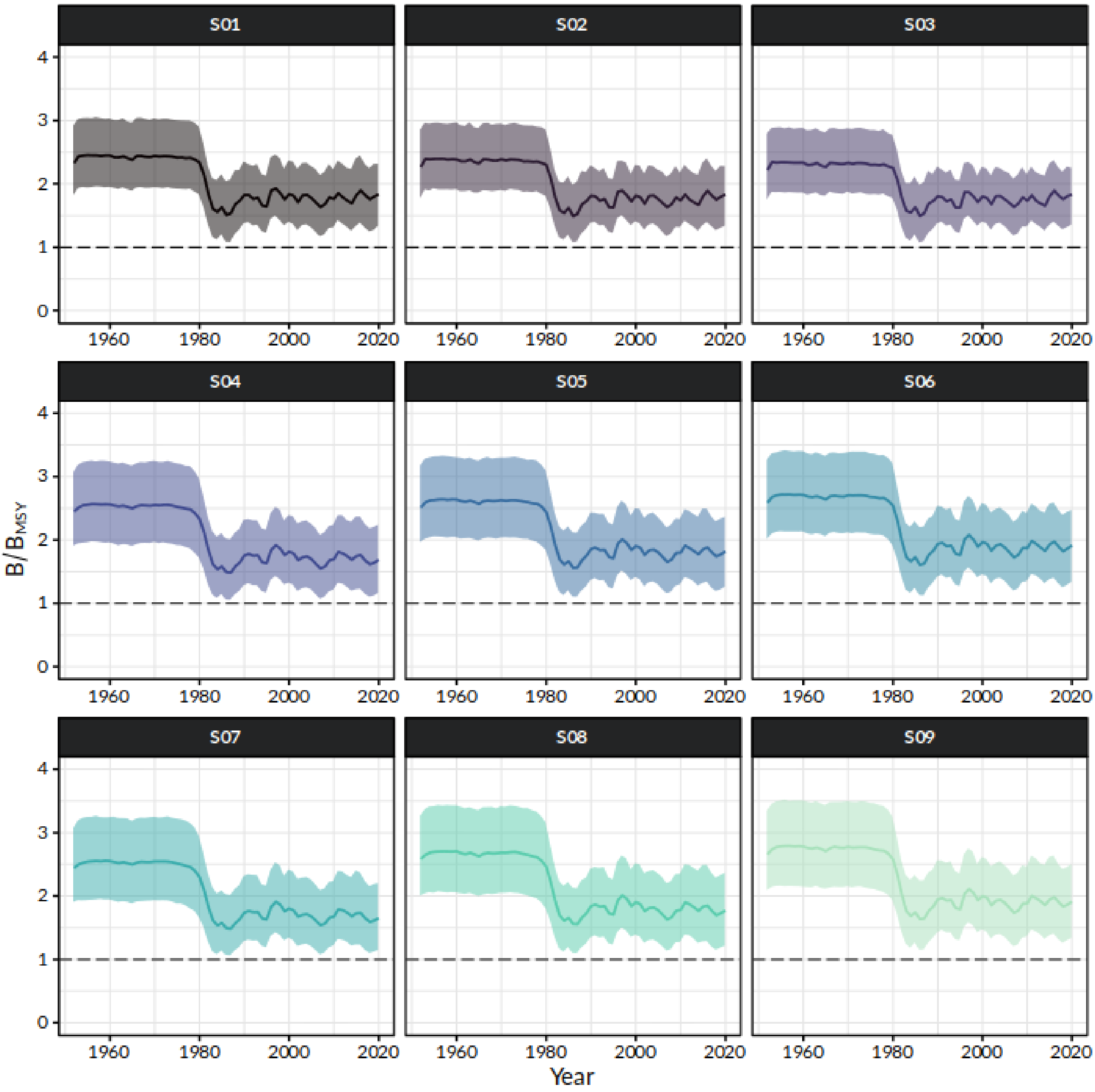


Figure 35. Trends in biomass relative to B_{MSY} (B/B_{MSY}) for each uncertainty grid scenario from the Bayesian state-space surplus production JABBA model fits to West Atlantic skipjack tuna.

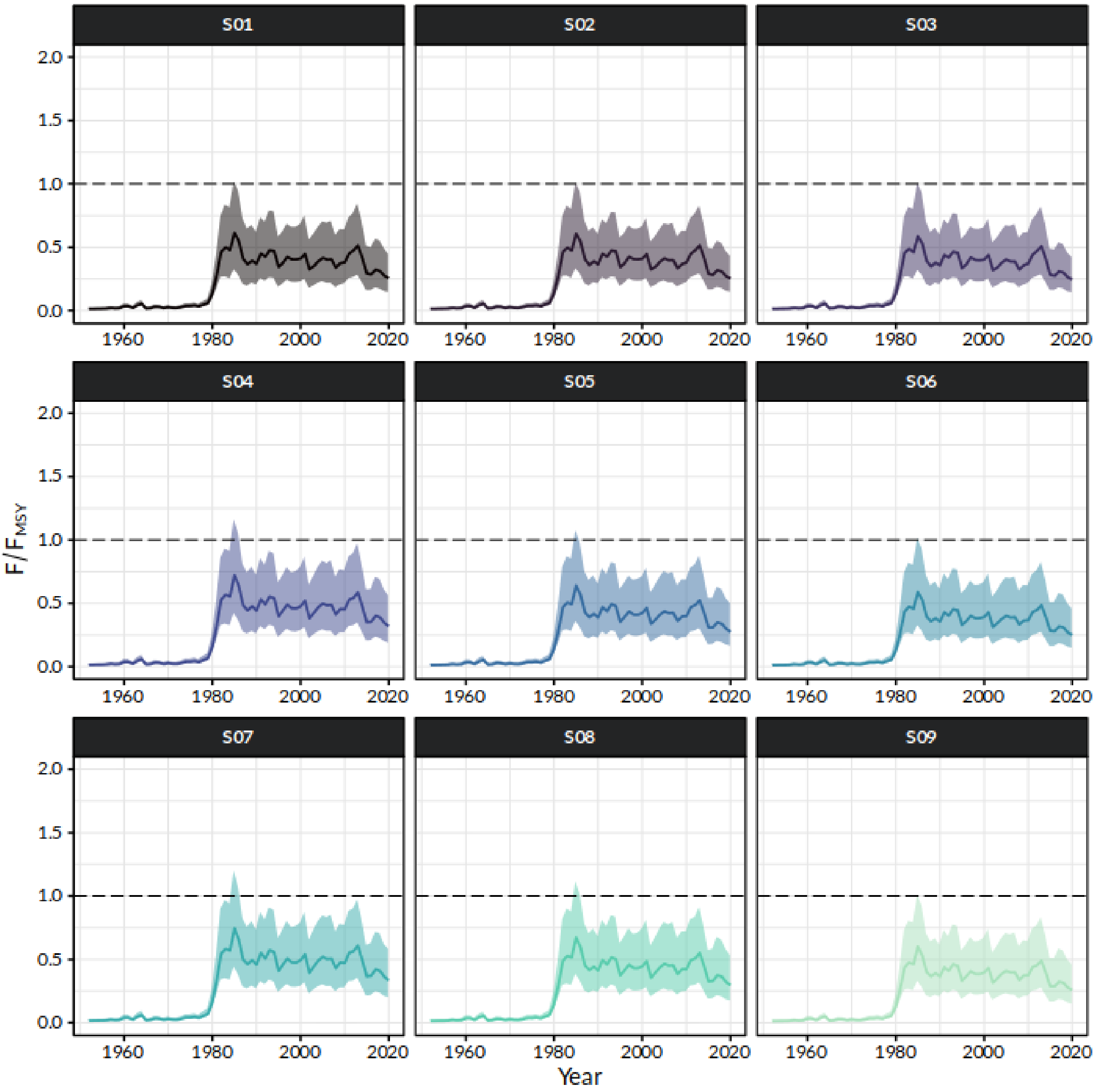


Figure 36. Trends in fishing mortality relative to F_{MSY} (F/F_{MSY}) for each uncertainty grid scenario from the Bayesian state-space surplus production JABBA model fits to West Atlantic skipjack tuna.

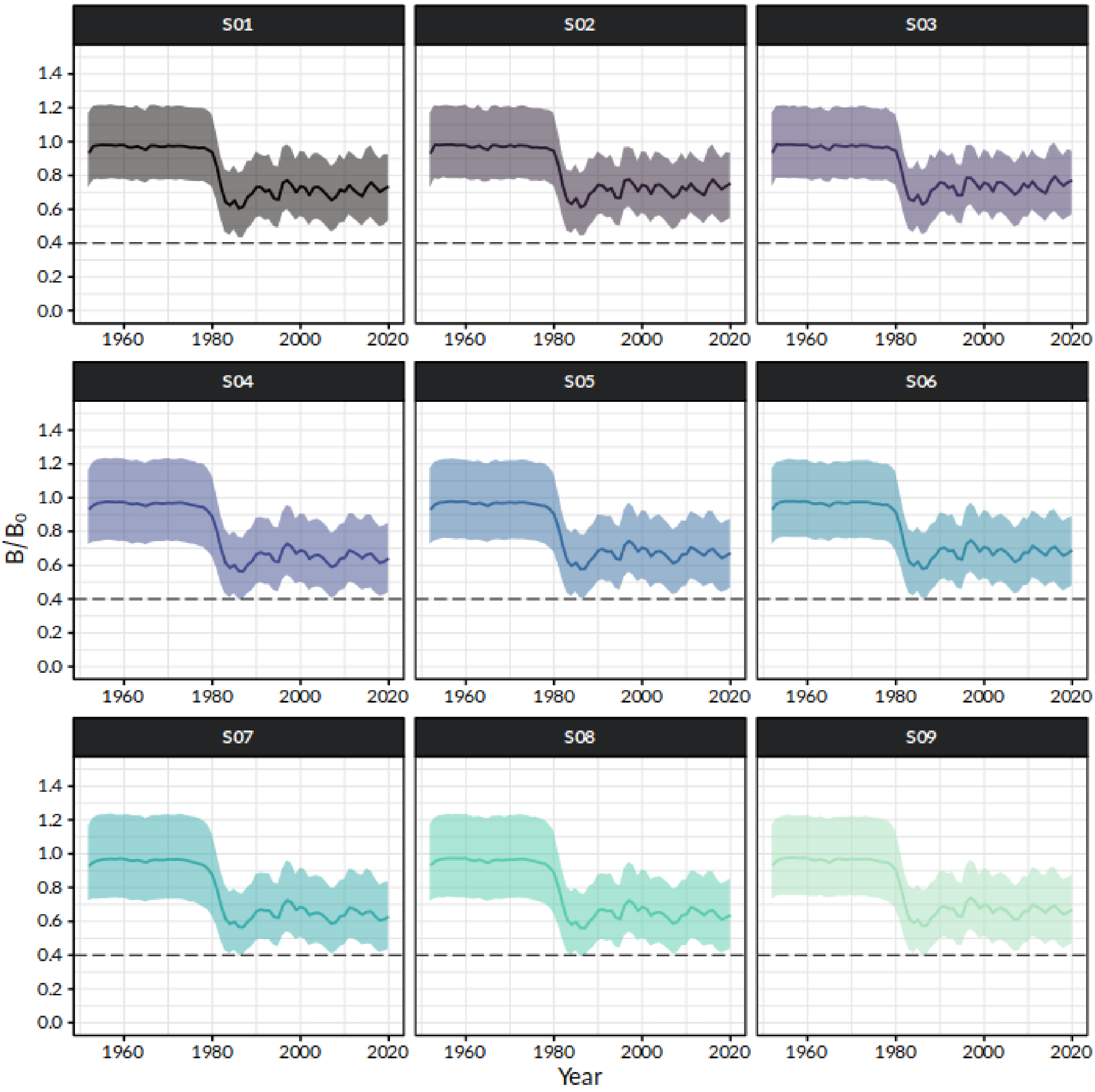


Figure 37. Trends in biomass relative to B₀ (B/B₀) for each uncertainty grid scenario from the Bayesian state-space surplus production JABBA model fits to West Atlantic skipjack tuna.

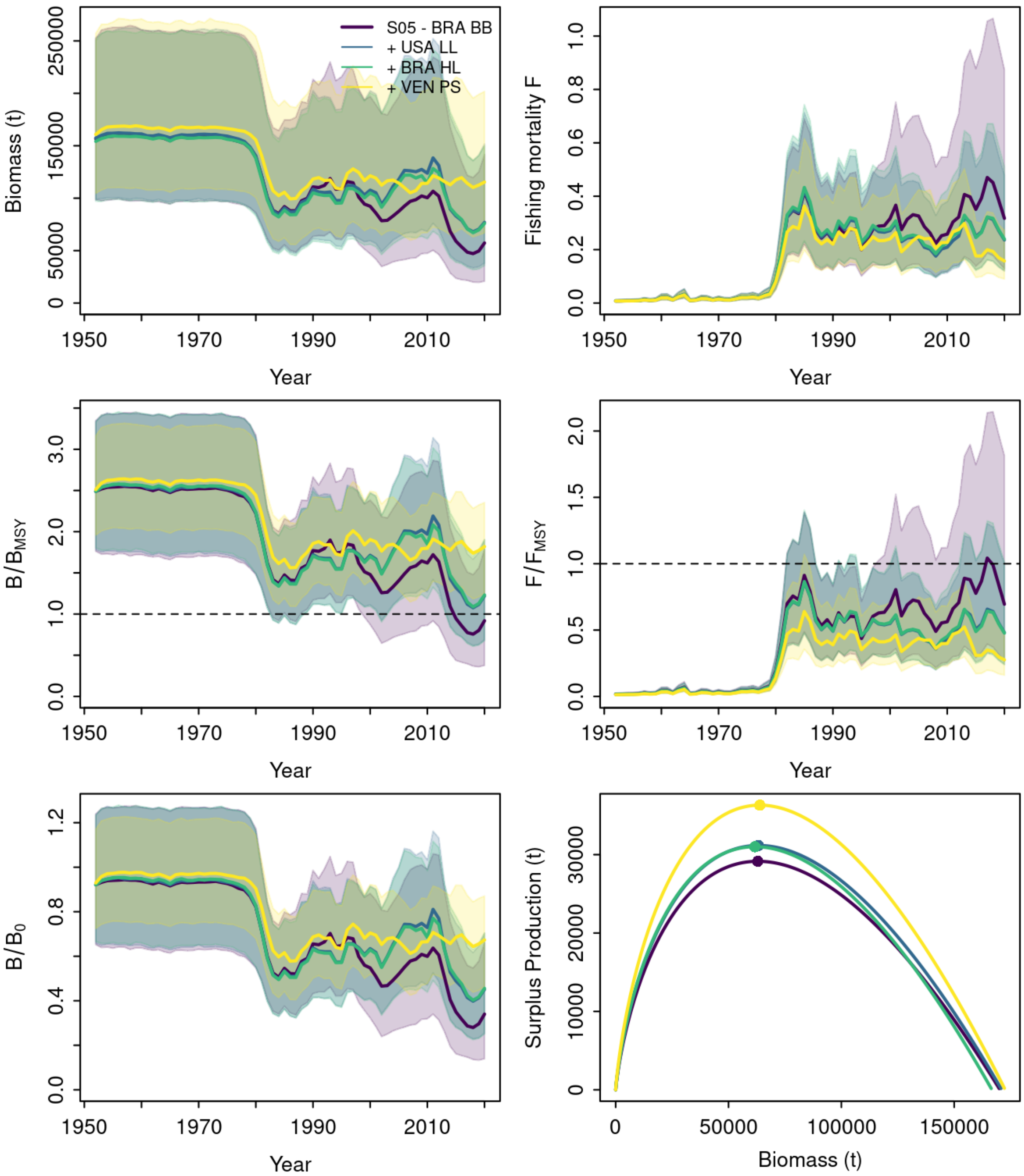


Figure 38. Sensitivity analysis performed for scenario S05 involving the stepwise addition of each CPUE series within the model, depicting the trends in biomass and fishing mortality (upper panels), biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (middle panels) and biomass relative to *K* (B/K) and surplus production curve (bottom panels) for the West Atlantic skipjack tuna.

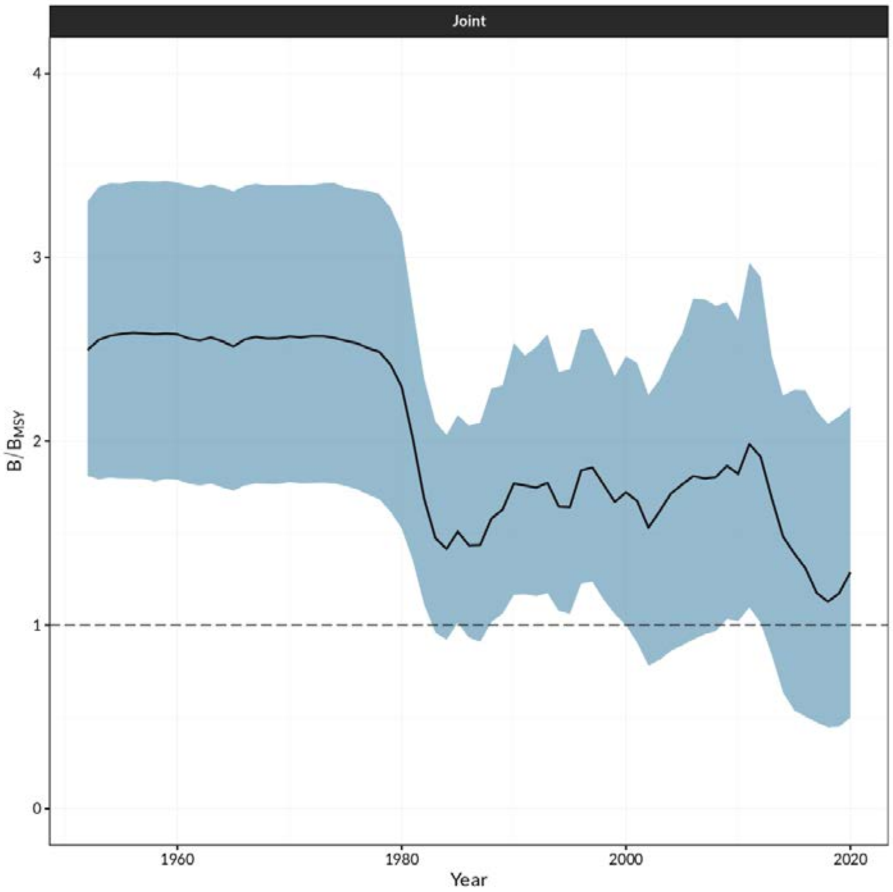


Figure 39. Trends in biomass relative to B$_{MSY}$ (B/ B$_{MSY}$) for the reference case scenario model (S05) where the indices were weighted proportional to the total catch by fleet.

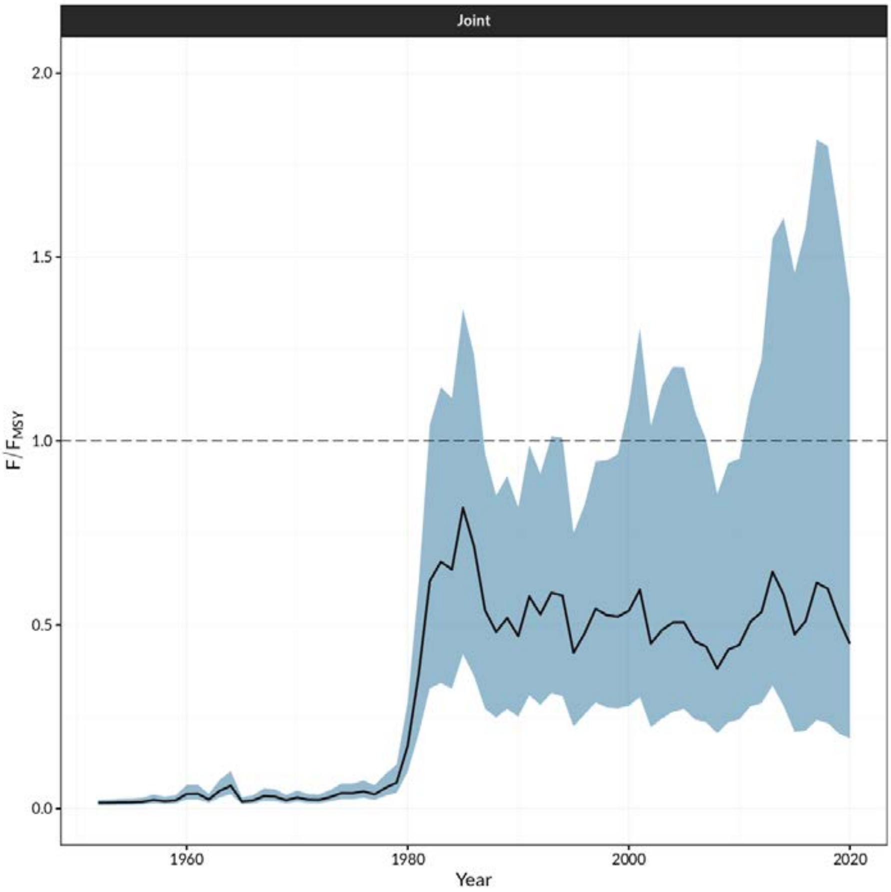


Figure 40. Trends in fishing mortality relative to F_{MSY} (F/F_{MSY}) for the reference case scenario model (S05) where the indices were weighted proportional to the total catch by fleet.

Figure 41. Annual estimates of SSB, Recruitment, SSB/SSBMSY and F/FMSY for the two stock assessment models considered for the western Atlantic stock (Stock Synthesis, JABBA).

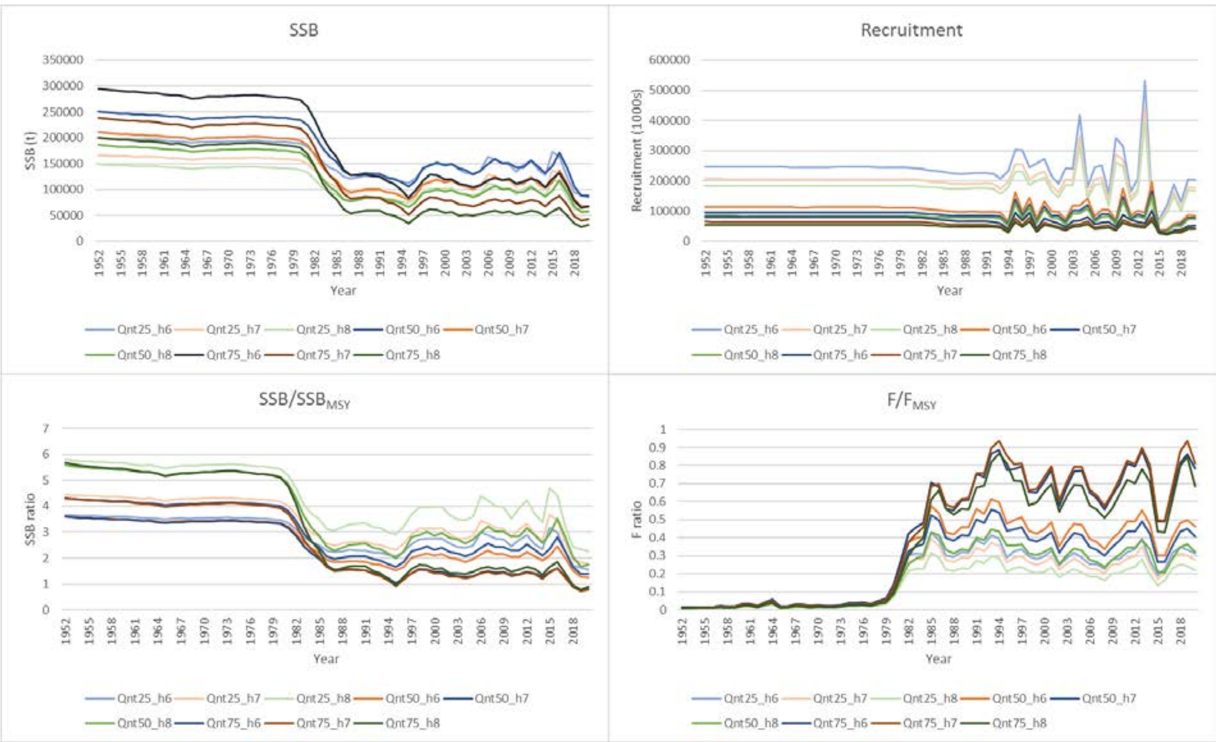


Figure 42. Annual estimates of the median SSB, Recruitment, SSB/SSBMSY and F/MSY from nine Stock Synthesis uncertainty grid runs, exploring uncertainty in natural mortality (M) and stock productivity (steepness, h).

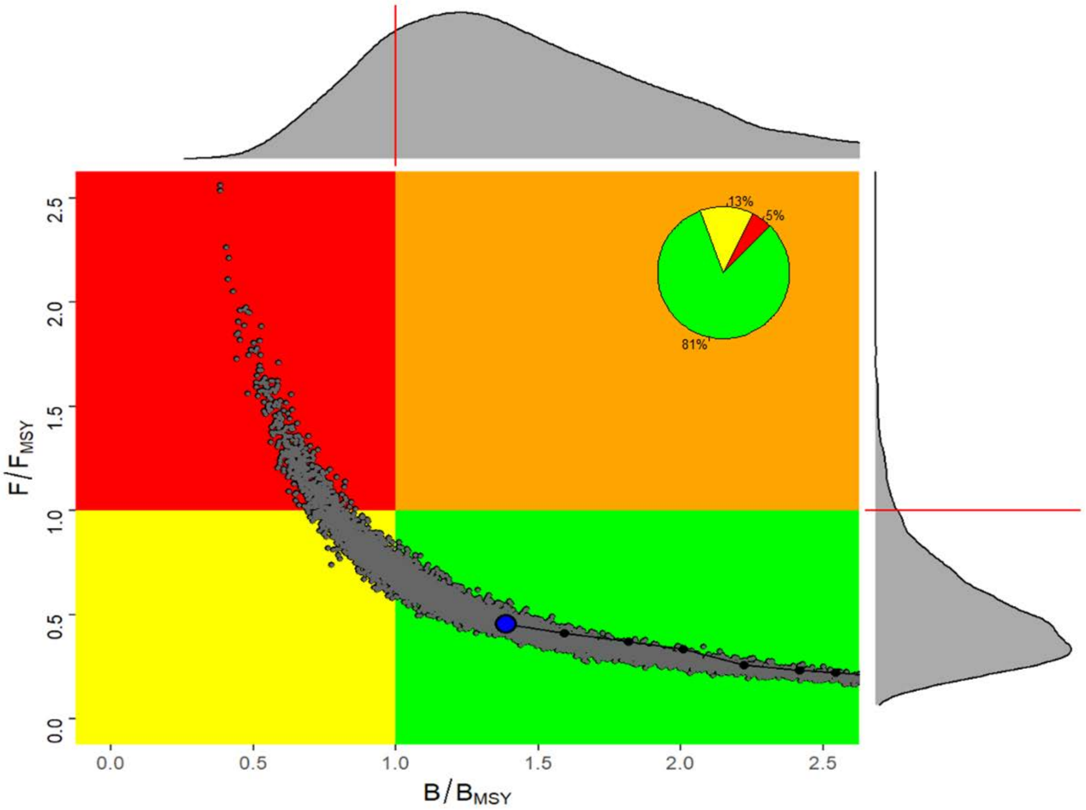


Figure 43. Kobe plot illustrating the current stock status and associated uncertainty quantified using (10000) MVLN iterations across nine uncertainty grid scenarios. All grid runs used Stock Synthesis and explored uncertainty in growth/natural mortality (M) and steepness (*h*).

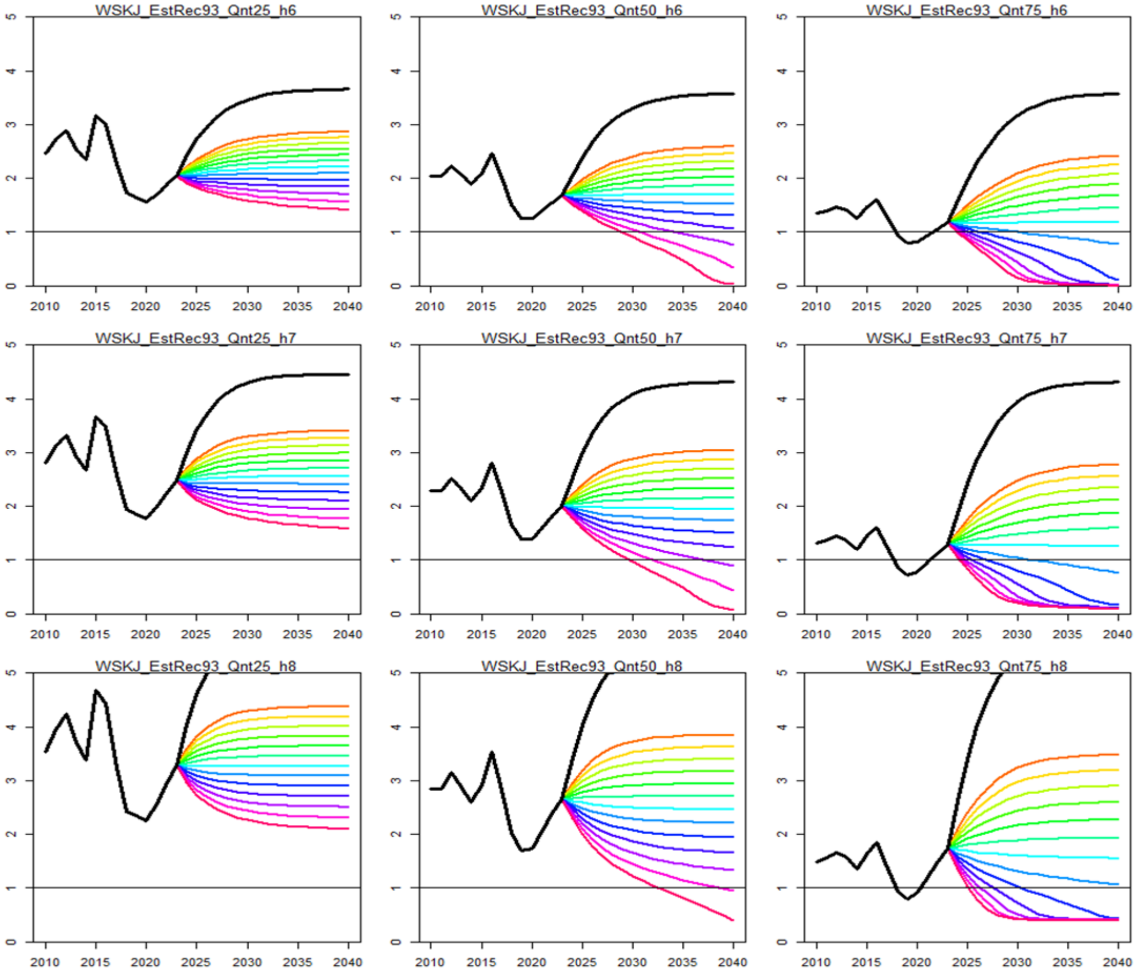


Figure 44. SSB/SSB$_{MSY}$ trajectories across 9 Stock Synthesis uncertainty grid runs under different constant catch scenarios for the western skipjack stock.

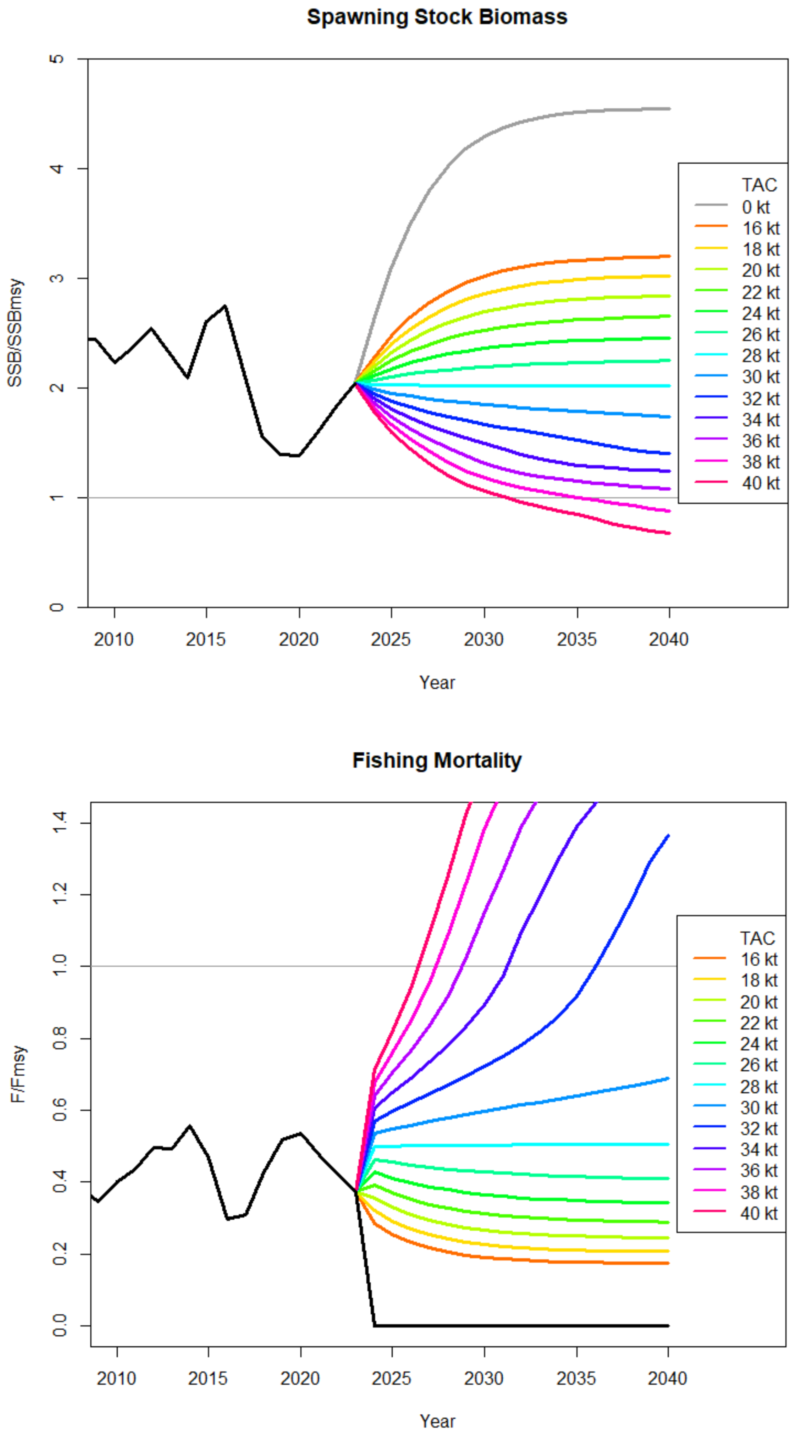


Figure 45. SSB/SSB$_{MSY}$ (upper panel) and F/F$_{MSY}$ (lower panel) trajectories combining 9 Stock Synthesis uncertainty grid runs under different constant catch scenarios for the western skipjack stock.

Appendix 1

Agenda

Objectives

The SCRS will conduct the 2022 assessment of Skipjack tuna stock with data up to 2020. An intersessional workplan agreed upon during the Data Preparatory meeting will define the parameters and models for the assessment analyses.

Tentative Agenda*

1. Opening, adoption of Agenda, and meeting arrangements [Secretariat]
2. Summary of available data for assessment and updates since Data Preparatory meeting []
    2.1. Fisheries statistics, size, and CAS estimates [C. Palma]
    2.2. Biological parameters and fleet structure [Serena W.]
    2.3. Relative indices of abundance [Mariela Narvaez]
3. Stock Assessment Models and other data relevant to the assessment [Teams SA models]
    3.1. Eastern stock
        3.1.1. Statistically integrated model, (Stocks Synthesis 3) [M. Lauretta]
        3.1.2. Surplus Production models (JABBA and MPB) [Daniel G.]
    3.2. Western stock
        3.2.1. Statistically integrated model, (Stocks Synthesis 3) [Eidi K.]
        3.2.2. Surplus Production models (JABBA) [Rodrigo S.]
4. Stock status results
    4.1 Eastern stock
        4.1.1 Statistically integrated model, Stocks Synthesis [Gustavo, Agurtzane]
        4.1.2 Surplus Production models, JABBA and MPB [Hilario M.]
        4.1.3 Synthesis of assessment results [J. Santiago]
    4.2 Western stock
        4.2.1 Statistically integrated model, Stocks Synthesis [Gustavo, Rodrigo, Shannon]
        4.2.2 Surplus Production models, JABBA [Fisch, .]
        4.2.3 Synthesis of assessment results [Shannon C.]
5. Projections Kobe Matrix for Skipjack tuna stocks [Thursday] [A. Kimoto]
    5.1 Eastern Stock
    5.2 Western stock
6. Recommendations
    6.1 Management
        6.1.1 Eastern Stock [A. Maufroy]
        6.1.2 Western stock [P. Travassos? To be confirmed]
    6.2 Research and statistics – including those with financial implications [K, Bradley]
7. Responses to the Commission [G. Diaz]
8. Other matters [D. Die]
9. Adoption of the report and closure

Appendix 2

List of participants

CONTRACTING PARTIES

BRAZIL
Cardoso, Luis Gustavo
Federal University of Rio Grande - FURG, Italy Av, sn, Campus Carreiros, 96203-900 Rio Grande - RS
Tel: +55 53 999010168, E-Mail: cardosolg15@gmail.com

Crespo, Osman
Marine Biologist, Universidade Federal Rural de Pernembuco, Departamento de Oceanografia e Pescas, Rua Prf. Doutor Frederico Machado, 4, 9901-862, Portugal
Tel: +351 913 112 367, E-Mail: osman.crespo@gmail.com

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

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

Sant'Ana, Rodrigo
Researcher, Laboratório de Estudos Marinhos Aplicados - LEMA Ecola do Mar, Ciência e Tecnologia - EMCT, Universidade do Vale do Itajaí - UNIVALI, Rua Uruquai, 458 - Bloco E2, Sala 108 - Centro, Itajaí, CEP 88302-901 Santa Catarina Itajaí
Tel: +55 (47) 99627 1868, E-Mail: rsantana@univali.br

CHINA, (P. R.)
Feng, Ji
Shanghai Ocean University, 999 Hucheng Huan Rd, 201306 Shanghai
Tel: +86 159 215 36810, E-Mail: fengji_shou@163.com; 276828719@qq.com; f52e@qq.com

Huang, Yucheng
Shanghai Ocean University, 999 Hucheng Huan Road, Shanghai, 201306
Tel: +86 177 989 21637, E-Mail: yuchenhuang0111@163.com

Wang, Yang
Research Assistant, Shangai Ocean University, 999 Hucheng Huan Road, Shanghai, 201306
E-Mail: shouwyh@163.com

Yang, Shiyu
Shanghai Ocean University, 999 Hucheng Huan Road, Shanghai, 201306
Tel: +86 185 021 91519, E-Mail: yangshiyu_shou@163.com

Zhang, Fan
Shanghai Ocean University, 999 Hucheng Huan Rd, 201306 Shanghai
Tel: +86 131 220 70231, E-Mail: f-zhang@shou.edu.cn

Zhu, Jiangfeng
Professor, Shanghai Ocean University, College of Marine Sciences, 999 Hucheng Huan Rd., 201306 Shanghai, China (P.R.)
Tel: +86 21 619 00554; +86 156 921 65061, Fax: +86 21 61900000, E-Mail: jfzhu@shou.edu.cn

EL SALVADOR
Chavarría Valverde, Bernal Alberto
Asesor en Gestión y Política pesquera Internacional, Centro para el Desarrollo de la Pesca y Acuicultura (CENDEPESCA), Final 1ª Avenida Norte, 13 Calle Oriente y Av. Manuel Gallardo, 1000 Santa Tecla, La Libertad
Tel: +506 882 24709, Fax: +506 2232 4651, E-Mail: bchavarria@lsg-cr.com

Galdámez de Arévalo, Ana Marlene
Jefa de División de Investigación Pesquera y Acuícola, Ministerio de Agricultura y Ganadería, Final 1a. Avenida Norte, 13 Calle Oriente y Av. Manuel Gallardo. Santa Tecla, La Libertad
Tel: +503 2210 1913; +503 619 84257, E-Mail: ana.galdamez@mag.gob.sv; ana.galdamez@yahoo.com

EUROPEAN UNION
Biagi, Franco
Senior Expert Marine & Fishery Sciences, Directorate General for Maritime Affairs and Fisheries (DG-Mare) - European Commission, Unit C3: Scientific Advice and data collection, Rue Joseph II, 99, 1049 Brussels, Belgium
Tel: +322 299 4104, E-Mail: franco.biagi@ec.europa.eu

Abascal Crespo, Francisco Javier
Fisheries Scientist, Ministerio de Economía y Competitividad, Instituto Español de Oceanografía, C.O. de Canarias, C/ Farola del Mar, 22, 38180 Santa Cruz de Tenerife, Spain
Tel: +34 922 549 400, Fax: +34 922 549 554, E-Mail: francisco.abascal@ieo.es

Akia, Sosthène Alban Valeryn
Doctorant, IRD, UMR MARBEC, Station Ifremer, Avenue Jean Monnet CS 30171, 34203 Séte, France
Tel: +33 758 312 795, E-Mail: sosthene.akia@ird.fr

Alzorriz, Nekane
ANABAC, Txibitxiaga 24 entreplanta, 48370 Bermeo, Bizkaia, Spain
Tel: +34 94 688 2806; +34 650 567 541, E-Mail: nekane@anabac.org

Déniz González, Santiago Félix
Instituto Español de Oceanografía, C/ La Farola del Mar n º 22 - Dársena Pesquera, 38180 Santa Cruz de Tenerife, Spain
Tel: +34 646 152 724, E-Mail: santiago.deniz@ieo.es

Gaertner, Daniel
Institut de Recherche pour le Developpement (IRD) UMR MARBEC (IRD/Ifremer/CNRS/UMII), CRH, CS 30171, Av. Jean Monnet, 34203 Sète Cedex, France
Tel: +33 4 99 57 32 31, Fax: +33 4 99 57 32 95, E-Mail: daniel.gaertner@ird.fr

Grande Mendizabal, Maitane
AZTI - Investigación Marina. Marine Research. Itsas Ikerketa Gestión Pesquera Sostenible. Sustainable Fisheries Management. Arrantza-kudeaketa Jasangarria, Herrera Kaia - Portualdea z/g., 20110 Pasaia, Spain
Tel: +34 667 100 124; +34 667 100 124, E-Mail: mgrande@azti.es

Herrera Armas, Miguel Angel
Deputy Manager (Science), OPAGAC, C/ Ayala 54, 2º A, 28001 Madrid, Spain
Tel: +34 91 431 48 57; +34 664 234 886, Fax: +34 91 576 12 22, E-Mail: miguel.herrera@opagac.org

Kaplan, David
Director Research, Institut de Recherche pour le Développement (IRD), UMR MARBEC (Univ. Montpellier, CNRS, Ifremer, IRD), Av Jean Monnet CS 30171, 34070 Sète Cedex, France
Tel: +33 499 573 225, E-Mail: david.kaplan@ird.fr

Maufroy, Alexandra
ORTHONGEL, 5 rue des sardiniers, 29900 Concarneau, France
Tel: +33 649 711 587, Fax: +33 2 98 50 80 32, E-Mail: amaufroy@orthongel.fr

Merino, Gorka
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualdea z/g, 20100 Pasaia - Gipuzkoa, Spain
Tel: +34 94 657 4000; +34 664 793 401, Fax: +34 94 300 4801, E-Mail: gmerino@azti.es

Pascual Alayón, Pedro José
Investigador, Ministerio de Ciencia, Innovación y Universidades, Instituto Español de Oceanografía, C.O. de Canarias, Vía Espaldón, Dársena Pesquera, Parcela 8, 38180 Santa Cruz de Tenerife, Islas Canarias, Spain
Tel: +34 922 549 400; +34 686 219 114, Fax: +34 922 549 500, E-Mail: pedro.pascual@ieo.es

Rojo Méndez, Vanessa
IEO Centro Oceanográfico de Canarias, C/ Farola del Mar nº 22, Dársena Pesquera, 38180 Santa Cruz de Tenerife, Spain
Tel: +34 922 549 400, Fax: +34 922 549 554, E-Mail: vanessa.rojo@ieo.es

Santiago Burrutxaga, Josu
Head of Tuna Research Area, AZTI-Tecnalia, Txatxarramendi z/g, 48395 Sukarrieta (Bizkaia) Basque Country, Spain
Tel: +34 94 6574000 (Ext. 497); +34 664 303 631, Fax: +34 94 6572555, E-Mail: jsantiago@azti.es; flarrauri@azti.es

Urtizberea Ijurco, Agurtzane
AZTI-Tecnalia / Itsas Ikerketa Saila, Herrera kaia. Portualdea z/g, 20110 Pasaia, Gipuzkoa, Spain
Tel: +34 667 174 519, Fax: +34 94 657 25 55, E-Mail: aurtizberea@azti.es

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

GUATEMALA
Alvarado Albarado, Stefanny Rebeca
Técnico, km 22 Ruta al Pacífico, Edificio La Ceiba 3er Nivel, 01064 Bárcena, Villa Nueva
Tel: +502 330 30005, E-Mail: stefannyalbarado@gmail.com

JAPAN
Matsubara, Naoto
Highly Migratory Resource Division, Fisheries Stock Assessment Center Fisheries Resources Institute, Fisheries Research and Education Agency, 2-12-4 fukuura, kanazawa-ku, Kanagawa Yokohama 236-8648
Tel: +81 45 788 7922; +81 45 788 5004, E-Mail: matsubaranaoto@affrc.go.jp; naotomatsubaraf91@gmail.com

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

MAURITANIA
Habibe, Beyahe Meissa
Chef du Laboratoire Évaluation des Ressources Vivantes Aquatiques (LERVA), Institut Mauritanien de Recherches Océanographiques et des Pêches - IMROP, B.P. 22, Cite IMROP Villa Nº 8, Nouadhibou
Tel: +222 2242 1047, Fax: +222 574 5081, E-Mail: bmouldhabib@gmail.com; beyahem@yahoo.fr

MOROCCO
Baibbat, Sid Ahmed
Chef de Laboratoire des Pêches, Centre régional de l'INRH à Dakhla, Institut National de Recherches Halieutiques (INRH), 2, BD Sidi Abderrahmane, ain diab., 20100 Dakhla
Tel: +212 661 642 573, E-Mail: baibbat@inrh.ma; baibat@hotmail.com

El Joumani, El Mahdi
Ingénieur Halieute, Institut National de Recherche Halieutique "INRH", Laboratoire de pêche au Centre Régional de l'INRH-Laayoune, Avenue Charif Erradi N 168 Hay el Ouahda 01, Laayoune
Tel: +212 661 114 418, E-Mail: Eljoumani.mehdi@gmail.com

NAMIBIA
Hanghome, Gustaf
Senior Fisheries Research Technician, Ministry of Fisheries and Marine Resources, National Marine Information and Research Centre, 1st Strand Street
Tel: +264 410 1000, Fax: +264 64 404385, E-Mail: Gustaf.Hanghome@mfmr.gov.na

Jagger, Charmaine
Fisheries Biologist, Ministry of Fisheries and Marine Resources, National Marine Information and Research Centre (NatMIRC), P.O. Box 912 Swakopmund, 1 Strand Street
Tel: +264 64 410 1000, Fax: +264 64 404385, E-Mail: Charmaine.Jagger@mfmr.gov.na

Shikongo, Taimi
Senior Fisheries Biologist, Ministry of Fisheries and Marine Resources, Large Pelagic Species, 1 Strand Street P.O. BOX 912, 9000 Swakopmund Erongo
Tel: +264 644 101 000, Fax: +264 644 04385, E-Mail: Taimi.Shikongo@mfmr.gov.na; tiemeshix@gmail.com

NICARAGUA
Barnuty Navarro, Renaldy Antonio
Hidrobiólogo, Director - Dirección de Investigaciones Pesqueras - Instituto Nicaragüense de la Pesca y Acuicultura (INPESCA), Km 3.5 carretera Norte, Contiguo al edificio de la Big Cola, Managua
Tel: +505 22 4424 01 Ext. 140; +505 842 04110, E-Mail: rbarnutti@inpesca.gob.ni

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

Kebe, Papa
Consultant, Villa numéro 288 Sipres-II Dakar, B.P. 45.828, Dakar Fann
Tel: +221 33 867 92 82; Tel. Cellular: +221 77 565 02 87, E-Mail: papa.amary@gmail.com

Ndiaye, El Hadji
Direction des Pêches maritimes, 20000 Dakar
Tel: +221 77 543 6301, E-Mail: elhandiaye@yahoo.fr

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

ST. VINCENT AND GRENADINES
Connell, Shamal
Fisheries Officer, Fisheries Division Ministry of Agriculture, Forestry, Fisheries, Industry and Labour, Richmond Hill, VC0120 Kingstown
Tel: +784 456 2738, E-Mail: volcanicsoils@hotmail.com; fishdiv@gov.vc

Jardine-Jackson, Cheryl
Fisheries Officer / Data Unit, Fisheries Division, Ministry of Agriculture, Forestry, Fisheries, Rural Transformation, Industry and Labour
Tel: +1 784 456 2738, E-Mail: cejmespo@yahoo.com; cejackson@outlook.com

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
Bradley, Kirsty
Fisheries Scientist, CEFAS, Pakefield Road, Lowestoft Suffolk NR33 0HT
Tel: +44 1502 524 404, E-Mail: kirsty.bradley@cefas.co.uk

Wright, Serena
Fisheries Scientist, Centre for Environment, Fisheries and Aquaculture Science (Cefas), ICCAT Tagging programme St. Helena, Pakefield Road, Lowestoft NR33 0NG
Tel: +44 1502 52 1338; +44 797 593 0487, E-Mail: serena.wright@cefas.co.uk

UNITED STATES
Brown, Craig A.
Chief, Highly Migratory Species Branch, Sustainable Fisheries Division, Southeast Fisheries Science Center, NOAA, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 305 586 6589, E-Mail: craig.brown@noaa.gov
Cass-Calay, Shannon
Director, NOAA Fisheries, Southeast Fisheries Science Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 305 361 4231, Fax: +1 305 361 4562, E-Mail: shannon.calay@noaa.gov

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

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

Fisch, Nicholas
Southeast Fisheries Science Center, 101 Pivers Island Road, Beaufort, North Carolina 28516
Tel: +1 727 798 8424, E-Mail: nickcfisch@gmail.com; nicholas.fisch@noaa.gov

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

Norelli, Alexandra
PhD Student, University of Miami, Cooperative Institute for Marine & Atmospheric Studies, CIMAS Office 303, RSMAS, 4600 Rickenbacker Causeway, Miami FL 33149
Tel: +1 203 918 0949, E-Mail: apn26@miami.edu; alexandra.norelli@rsmas.miami.edu

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

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

URUGUAY
Forselledo, Rodrigo
Investigador, Dirección Nacional de Recursos Acuáticos - DINARA, Laboratorio de Recursos Pelágicos, Constituyente 1497, CP 11200 Montevideo
Tel: +598 2400 46 89, Fax: +598 2401 3216, E-Mail: rforselledo@gmail.com

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

Leiva, Rony
Analista de la Gerencia de Ordenación Pesquera
E-Mail: ronyleivamartinez@gmail.com

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

OBSERVERS FROM INTERGOVERNMENTAL ORGANIZATIONS

INDIAN OCEAN TUNA COMMISSION - IOTC
Fu, Dan
Stock Assessment Expert, IOTC, Victoria, Mahe, Seychelles
Tel: +248 252 5471, E-Mail: dan.fu@fao.org

OBSERVERS FROM NON-GOVERNMENTAL ORGANIZATIONS

BRAZILIAN ASSOCIATION OF FISH INDUSTRIES - ABIPESCA
Mello, Carlos
Technical Director, Associaçao Brasileira das indústrias de pescados - ABIPESCA, Áreas Norte, Quadra 601 Boco H, Edificio ION, Sala 1920, 70830-018 Brasília, DF, Brazil
Tel: +55 619 950 85491, E-Mail: carlos@abipesca.com.br; iccat@abipesca.com.br

INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION – ISSF
Justel, Ana
ISSF-Spain, Plaza Santa María Soledad Torres Acosta 1, 5ª Planta, 28004 Madrid, Spain
Tel: +34 91 745 3075; +34 696 557 530, E-Mail: ajustel@iss-foundation.org

Murua, Hilario
Senior Scientist, International Seafood Sustainability Foundation (ISSF), 655 15th Street NW, Suite 800, Washington, DC 20005, United States
Tel: +34 667 174 433; +1 703 226 8101, E-Mail: hmurua@iss-foundation.org

WORLDWIDE FUND FOR NATURE – WWF
Buzzi, Alessandro
WWF Mediterranean, Via Po, 25/c, 00198 Rome, Italy
Tel: +39 346 235 7481, Fax: +39 068 413 866, E-Mail: abuzzi@wwfmedpo.org

SCRS CHAIRMAN
Melvin, Gary
SCRS Chairman, St. Andrews Biological Station - Fisheries and Oceans Canada, Department of Fisheries and Oceans, 285 Water Street, St. Andrews, New Brunswick E5B 1B8, Canada
Tel: +1 506 652 95783; +1 506 651 6020, E-Mail: gary.d.melvin@gmail.com; gary.melvin@dfo-mpo.gc.ca

SCRS VICE-CHAIRMAN
Arrizabalaga, Haritz
Principal Investigator, SCRS Vice-Chairman, AZTI Marine Research Basque Research and Technology Alliance (BRTA), Herrera Kaia Portualde z/g, 20110 Pasaia, Gipuzkoa, Spain
Tel: +34 94 657 40 00; +34 667 174 477, Fax: +34 94 300 48 01, E-Mail: harri@azti.es

*****

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

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

Appendix 3

List of Papers and Presentations

DocRef	Title	Authors
SCRS/2022/044	Datos estadísticos de la pesquería de túnidos de las islas Canarias durante el periodo 2000 a 2021	Delgado R.
SCRS/2022/045	Actualización de algunos parámetros biológicos del listado de la pesquería de las islas Canarias	Delgado R.
SCRS/2022/089	Standardized catch rates for skipjack tuna (*Katsuwonus pelamis*) from the Venezuelan baitboat fishery in the Caribbean Sea and adjacent waters of the western central Atlantic for the period of 1987-2020	Narvaez M., Evaristo E., Marcano J.H., Gutiérrez X., Arocha F.
SCRS/2022/093	Data input and assessment models settings for the evaluation of east and west Atlantic skipjack tuna stocks.	Anon
SCRS/2022/095	East Atlantic skipjack tuna Stock Synthesis analyses	Urtizberea A., Merino G., Ortiz M., Kimoto A., Lauretta M., Ailloud L., Mourato B., SantAna R., Akia S., Santiago J., Gaertner D., Palma C., Mayor C.,Taylor N., Díaz G., Calay S., and Die D.
SCRS/2022/098	Preliminary western Atlantic skipjack tuna stock assessment 1952-2020 using Stock Synthesis	Cardoso L.G., Kikuchi E., Sant'Ana R., Lauretta M., Kimoto A., and Mourato B.L.
SCRS/2022/099	Bayesian Surplus Production Models (JABBA) applied to the Western Atlantic Skipjack tuna stock assessment	Sant'Ana R., Kikuchi E., Mourato B.L., Kimoto A., Ortiz M., and Cardoso L.G.
SCRS/2022/100	Bayesian Surplus Production Models (JABBA) applied to the Eastern Atlantic Skipjack tuna stock assessment	Sant'Ana R., Kikuchi E., Mourato B.L., Kimoto A., Ortiz M., and Cardoso L.G.
SCRS/2022/102	Stock assessment for east Atlantic skipjack using a biomass production model	Merino G., Urtizberea A., Santiago J., Laborda A., and Sant'Ana R.
SCRS/P/2022/031	Preliminary stock status and projection results of the western skipjack stock using Stock Synthesis	Cardoso L.G., Kikuchi E., Lauretta M., Kimoto A., Sant’Ana R., and Mourato B. L.

Appendix 4

SCRS Documents and Presentation Abstracts as provided by the authors

SCRS/2022/044 – This document presents a summary of the development and current composition of the Canary Islands baitboat fleet and the catches made between 2000 and 2021. This paper also presents size histograms of the different species caught in 2021 and the average between 2015 and 2019. Until 2019, an estimate of the nominal fishing effort was made, distinguishing between vessels smaller and larger than 50 GRT, considering the former (vessels less than 50 GRT) carry out daily trips, whereas the latter carry out trips lasting more than a day, with an average of 9 days at sea. Since 2020, the effort of part of the fleet has been obtained directly from the logbooks, while the unloadings without logbook have continued to be calculated as before, that is, vessels less than 50 tons with 1-day at sea and larger with 9-days at sea.

SCRS/2022/045 – This document updates some biological parameters of skipjack caught by the baitboat fleet based in the Canary Islands. The equations of length-live weight, length-gutted weight, length-weight by sex and sex ratio by length are obtained, with sizes ranging from 38 cm to 82 cm.

SCRS/2022/089 - 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 (1987-2020), considering as categorical variables year, season/quarter, area, association with whales, association with the whale shark and baitboat capacity. As indicators of overall model fitting, diagnostic plots were evaluated. Standardized catch rates started declining since 1988, until 1990. From that point on, the trend shows a relatively stable trend which increased their variability since 2005, decreasing for the most recent year of the time series (2020).

SCRS/2022/093 - Following the decision of the Tropical Tunas Working Group during the 2022 Skipjack Data Preparatory meeting an intersessional online meeting was convened to review final data inputs and recommendations for the assessment models settings in preparation for the evaluation of the East and West SKJ stocks. This document summarizes the biological and fisheries inputs for the assessment models for both stocks, including the initial settings for the uncertainty grid and sensitivity analyses to be included in the assessment evaluation.

SCRS/2022/095 - This paper presents the preliminary results of the Stock Synthesis analysis for the East Atlantic skipjack tuna. The application of stock assessment models is difficult to apply to skipjack due to the biological characteristics of the species and the changes in the fisheries' characteristics with time. An assessment model has been developed considering two indices; the standardized CPUE fishing under non-owned dFADs using the VAST methodology and a relative abundance index based on acoustic biomass observations from FAD buoys. The biological parameters were agreed upon during an intersessional meeting as well as the model structural uncertainty. So the grid is composed of 9 alternative parameterizations of steepness, and growth (the derived natural mortality from growth). Sensitivity analyses were done in the exclusion of different indices of abundance, different re-weighting methods and assumptions in f-ballpark. Standard model diagnostics were conducted using SS3 and the SSdiags R package and included fits to index and length compositions, jitter of starting parameters, randomness tests of model residuals, retrospective analyses, profiles of key estimated parameters, and hindcasting.

SCRS/2022/098 - This document describes the provisional version of the stock assessment model using Stock Synthesis (SS) for the western Atlantic stock of skipjack, including the initial model setup, fleet definitions, selectivity and parameterizations. The model runs from 1952 to 2020 and was fit to length composition data, 5 indices and 5 fishing fleets. Growth was fixed in the model, with three alternative growth scenarios considered based on a comprehensive meta-analysis of skipjack growth studies and recommendations from the stock assessment team. The associated natural mortality-at-age vectors were tested, along with three alternative values of growth quantiles to construct the model uncertainty grid. However, initial runs showed poor performance, an alternative parameterization within SS was applied using a Lorenzen function with the same assumed asymptotic natural mortality-at-age recommended by the stock assessment team for each growth curve scenario. Model diagnostics demonstrated fast and stable convergence, acceptable retrospectives, informed estimation of population absolute scale (R0), and a robust solution across different starting values. A comprehensive set of model diagnostics are presented for this provisional reference case, as well as the model estimates of SSB and recruitment across the entire uncertainty grid.

SCRS/2022/099 - Bayesian State-Space Surplus Production Models were fitted to Western Atlantic skipjack tuna catch and CPUE data using the 'JABBA' R package. The ten scenarios were based on the previous assessment and on the uncertainty grid proposed during the 2022 SKJ Data Preparatory Meeting, which in summary corresponded to nine runs based on variations in growth parameters and steepness. To implement these scenarios in a Bayesian surplus production model, a Pella-Tomlinson production function was used and priors for r and B_{MSY}/B0 were derived using the concept called Age-Structured Equilibrium Model (ASEM). All scenarios showed a similar trend for the trajectories of B/B_{MSY} and F/F_{MSY} over time.

SCRS/2022/100 - Bayesian State-Space Surplus Production Models were fitted to Eastern Atlantic skipjack tuna catch and CPUE data using the 'JABBA' R package. The ten scenarios were based on the previous assessment and on the uncertainty grid proposed during the 2022 SKJ Data Preparatory Meeting, which in summary corresponded to nine runs based on variations in growth parameters and steepness. To implement these scenarios in a Bayesian surplus production model, a Pella-Tomlinson production function was used and priors for rand BMSY/B0 were derived using the concept called Age-Structured Equilibrium Model (ASEM). All scenarios showed a similar trend for the trajectories of B/B_{MSY} and F/F_{MSY} over time.

SCRS/2022/102 - In this paper, we present a preliminary run for the assessment of East Atlantic Ocean skipjack using a biomass dynamic model. The preliminary diagnostics suggest there are problems of convergence when using the five indices available for the assessment. Therefore, we propose a run with total catch and CPUE from Azores baitboat (1963-2014), purse seine using FADs (2010-2019) and data from echosounder buoys (2010-2020) as a starting point. In this document, we show the estimated trends, reference points and a set of diagnostics of fit for further discussion and possible refinement during the stock assessment session.

SCRS/P/2022/031 - Not provided by the author(s)