REPORT OF THE 2018 ICCAT BIGEYE TUNA STOCK ASSESSMENT MEETING

(Pasaia, Spain 16-20 July 2018)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the AZTI-Tecnalia Laboratory in San Sebastian, Pasaia (Spain) from July 16 to 20, 2018. Dr Hilario Murua (BET Species Group Rapporteur) opened the meeting and welcomed meeting participants ("The Group"). Dr Murua highlighted the importance of the work to be done by the Group during the meeting, indicating that at the upcoming Commission Panel 1 meeting in Bilbao, the preliminary results of this evaluation will be considered. Dr Mauricio Ortiz, on behalf of the Executive Secretary, thanked AZTI-Tecnalia for hosting the meeting and the EU for providing funds. Dr Murua proceeded to review the Agenda, which was adopted with some minor changes (**Appendix 1**).

The List of Participants is included in **Appendix 2**. The List of Documents and Presentations provided to the meeting and related summaries are attached as **Appendices 3** and **4**, respectively. The following participants served as Rapporteurs:

Item 1: M. Ortiz
Item 2: A. Kimoto, M. Ortiz
Item 3: J. Walter, G. Merino, H. Winker, M. Lauretta, K. Satoh
Item 4: J. Walter, G. Merino, H. Winker, M. Lauretta, K. Satoh, H. Murua, Y. Cheng, A. Kimoto
Item 5: S. Cass-Calay, T. Kitakado
Item 6: H. Murua, D. Die
Item 7: C. Brown, D. Die, G. Merino
Item 8: D. Die, M. Neves Santos, M. Ortiz

2. Summary of available data for the stock assessment

2.1 Biology

No new information on bigeye biology was presented at this meeting. Biological input parameters used with the assessments models were agreed during the 2018 data preparatory meeting (Anon, 2018) and are summarized in **Tables 1 and 2.** Age-size information derived from hard parts biological samples (otoliths and spines) was kindly provided by several scientists to be investigated as input in the Stock Synthesis model (Hallier et al., 2005, Draganick and Pelczarski, 1984, Robb Allman, NOAA, pers.comm.).

2.2 Catch, effort, size and CAS/CAA estimates

The Secretariat presented to the Group the updated statistical information available (T1NC: Task I nominal catches; T2CE: Task II catch and effort; T2SZ Task II size frequencies; T2CS: Task II catch-at-size) on Atlantic bigeye tuna in the ICCAT database system (ICCAT-DB). It covers the period 1950 to 2017, and contains all the recoveries, revisions and corrections adopted during the 2018 data preparatory meeting (Anon, 2018), including all the official data received until June 16, 2018. All the Secretariat estimations (CATDIS: estimations of T1NC stratified by trimester and a 5x5 geographical grid; CAS/CAA: catch-at-size and catch-at-age estimations) were made using the updated information.

Catches (T1NC)

The Atlantic bigeye tuna nominal catches (T1NC, 1950 to 2017) are presented in **Table 3** (cumulative catches by gear and year in **Figure 1**). The largest fraction of the 2017 catches, were reported officially by CPCs (including overall "faux poisons" estimates for 2015, 2016 and 2017) and replaced all prior carry overs made by this Group. The Atlantic bigeye tuna catches were also updated (as well as yellowfin and skipjack) with the new Ghanaian estimations (BB+PS) between 2006 and 2017 (SCRS/2018/109). The new Ghanaian estimations changed the proportions of tropical tunas catches, reducing considerably the Atlantic bigeye tuna catches and increasing the yellowfin catches without a clear pattern for skipjack.

Reported catches show that catches for the period 2010-2015, when the TAC was 85,000 t [Rec. 09-01], ranged from 67,849 to 80,172 t (**Figure 2**). In 2016-2017 catches were 79,909 t and 76,982 t, respectively, greater than the TAC of 65,000 t [Rec. 16-01]. These TAC recommendations were implemented through annual catch limits for two different group of CPCs (**Table 4**): group A includes CPCs in Rec. 16-01 paragraph 3 and group B includes CPCs in Rec. 16-01 paragraph 4. Aggregated reported catches for group A CPCs have always been below the aggregated limits (**Figure 3a and 3b**). On the other hand, aggregated catches of group B CPCs have grown, especially since 2013 (**Figure 3b**). Reported catches from group B CPCs represented 17% of the total catch in 2010 and 33% in 2017. It is worth noting that catches from group B CPCs have grown for all gear types, including handlines, a gear type that prior to 2010 did not significantly contribute to the landings. Some of the increases seen in the catch from group B CPCs may be due to improvements in reporting.

The intention of Rec. 16-01 was to reduce catches of Atlantic bigeye tuna. Comparison of the average annual catches for the period 2010-2015 with those for the period 2016-2017 show (**Table 3**) that many fleets have increased average landings and only a few fleets (baitboats and longline for group A CPCs and other fleets for group B) have reduced such landings, most fleets having increased landings.

Overall, improvements were made to the Atlantic bigeye tuna T1NC statistics over the last three years. For example, unclassified gear catches have been identified and reclassified, flag based catches series have better discrimination (residual NET ETRO combined catches) and are now more complete, and the geographical distribution of catches has improved reasonably. However, the Group considers that, some historic longline catch series are still incomplete or poorly known for some CPCs as presented in the bigeye tuna catalogue (**Table 5**). Concerns were also raised with regard to the estimation of the catch series of "faux poissons" (PS catches going to local markets), especially those catches landed in fishing ports not regularly sampled. Also, concerns were raised on the spatial strata used in the species composition correction of the T3/T3+ software as it has been shown that there is significant variation of species composition within the larger geographical areas assumed by the model (Fonteneau and Pascual-Alayon 2018 in press ab, Deledda et al. in press). The Group was informed that there is currently a study to revisit the procedure of T3/T3+ software to estimate the species composition.

Catch and effort (T2CE)

Several improvements were made to T2CE over the last three years, including: revisions of T2CE series in BB/PS/LL, recoveries of monthly based T2CE datasets, discrimination of MIX-FIS catches by flag from 1980 onward (pending MIX-FIS series before 1980), and NEI ETRO discrimination by flag before 2007. The Atlantic bigeye tuna catalogue (1988 to 2017) in **Table 5** summarises the availability of T2CE with Atlantic bigeye tuna for the most important catch (T1NC) series. Today, over 90% of all the T2CE datasets are monthly based with a 5x5 or higher geographical resolution. Nevertheless, T2CE still has some grouped datasets (MIX-KR+PA, MIX-FIS, NEI-ETRO), not all the important series are complete, and, many datasets are marked for future revisions (geographical inconsistencies, no effort, etc.). The Secretariat is constantly working with CPCs and scientists on the recovery of these datasets. The T2CE information is crucial to obtain catches by quarter and a 5x5 standard geographical grid (CATDIS), an important information to provide spatial distribution of catch and effort for assessment models that want to consider spatio-temporal structure.

CATDIS

The Atlantic bigeye tuna CATDIS estimations (T1NC catches by trimester and 5x5 geographical grid) were completely revised; 1950 to 1979 with minor adjustments and, fully rebuilt from 1980 to 2017 in order to match the changes in T1NC, and the improvements made in T2CE. As shown in **Figure 4**, the current Atlantic bigeye tuna CATDIS estimations between 1980 and 2016 (2017 is preliminary) is mainly based on T2CE data (~90%). The CATDIS was also classified into the 15 Atlantic bigeye tuna fisheries for input to stock synthesis assessment as agreed during the data preparatory meeting (Anon. in press). The total catches by those 15 fisheries and year are presented in **Table 6** and **Figure 5**.

Size frequencies (T2SZ)

The T2SZ information on Atlantic bigeye tuna has also improved over the last couple of years. The European related BB/PS series (1980 onwards) were partially or totally revised. The Ghana BB/PS series were also updated from 2006 onwards (except 2007). MIX-FIS BB combined fleet series (EU-France, Côte d'Ivoire and Senegal) for BB from 1980 onwards was split by flag. And many other corrections were made to several Flags (Korea, EU-Portugal, EU-Spain, South Africa, etc.). These improvements resulted in a larger number of fish sampled to be used in SS3 (see SCRS/P/2018/046) and more size information available to estimate the Atlantic bigeye tuna size composition of the catches (catch-at-size, CAS).

CAS/CAA

By default, CAS estimations made by the Secretariat use a combination of, a) T2SZ datasets extrapolated (weight based) to total catches (T1NC), b) CPC based CAS estimations (T2CS) reported to ICCAT, and, c) a set of standard substitution rules (based on fisheries similarities: fleet/gear/region). This approach was used for Atlantic bigeye tuna without any changes to the methodology used in the past.

Due to the large amount of changes made to T1NC and the revisions in T2SZ (including the CPCs T2CS updates) the CAS between 1980 and 2017 was entirely rebuilt (minor adjustments between 1975 and 1979). The resulting CAS matrix (in 5 cm class bins) is shown in **Table 7**. On average (1980-2017), the level of substitutions represents about 15% (**Figure 6**) of the total catches in weight with high oscillations (3% to 37%) across the entire time series. The problematic years identified are the 90s (~22% of substitutions, due to the lack of size data for the "NEI (Fleets related)" data). Good size coverage was observed in the late 2000s (less than 10% of substitutions); however, in recent years the substitution ratio has increased again to levels around 15%, mostly due to the lack of size data in the "new" Brazilian handline fishery. Mean weights, overall and by gear group, obtained from the CAS estimations (**Figure 7**) have slightly changed.

The CAS was converted to CAA with the same algorithms used in the 2015 assessment (Anon. 2016). Briefly, the CAA was estimated from size data using the von Bertalanffy growth model for Atlantic bigeye tuna from Hallier et al. 2005 and natural mortality cohort-age-decrease in numbers, by year–quarter strata. At the meeting the CAA was updated assuming the Richard's growth model of Hallier et al. 2005 and age slicing as agreed in the 2018 data preparatory meeting because this is the growth curve used in the stock assessment.

2.3 Relative abundance indices

Indices of abundances were reviewed, evaluated and recommendations for its use in assessment models, at the 2018 data preparatory meeting (Anon, 2018). No new indices or updates were presented at this meeting, final indices used in the different models are show in **Table 8**.

In discussion of these specification of SS3 assessment models, a concern was raised regarding the joint longline CPUE across Japan, Korea and US, for which the Japanese longline selectivity was assumed as a proxy of this joint CPUE series. In general, when producing standardised CPUE by combining data across multiple fisheries, investigation needs to be undertaken to ensure selectivity patterns are similar among the fleets. Otherwise the resulting joint standardised index is likely to be biased over time, especially if catch composition among fisheries has been changing. To address this issue, the Group agreed to continue the discussion for next stock assessment along the following lines:

1) More careful examination will be pursued to evaluate if the selectivities are reasonably similar
2) The inclusion of time-varying selectivity in the SS3 for a particular fleet should be examined (see proposed guidelines below)
3) Use of age/size information for the CPUE standardisation (size or age-based standardized CPUE indices or using the mean size as a covariate) may help reduce or eliminate such a bias.

3. Stocks Assessment Methods and other data relevant to the assessment

3.1 Production models

In accordance with the recommendations by the 2018 ICCAT bigeye tuna data preparatory meeting (Anon, 2018), two alternative estimation frameworks for fitting surplus production models were applied during this assessment. These were the maximum likelihood tool mpb (Kell, 2016; https://github.com/laurieKell/mpb) and the Bayesian state-space model JABBA (Winker et al. 2018;

http://github.com/JABBAmodel). In contrast to mpb, the Bayesian state-space formulation for JABBA can account for both process and observation error.

3.1.1 mpb

Documents SCRS/2018/099 and SCRS/2018/100 presented a proposal for conducting a stock assessment for the Atlantic bigeye tuna using the biomass dynamic model mpb (Kell, 2016). Document SCRS/2018/099 contains a 'continuity' stock assessment using the same data and model specifications of the 2015 stock assessment scenarios. Document SCRS/2018/100 contains runs using the CPUE indices made available in the 2018 data preparatory meeting. For all models, a suite of diagnostics of fits was presented.

The Group discussed the results and requested some further analysis of retrospective patterns. These results were presented to the Group and it was decided to choose one Reference Case for mpb using the split Joint R2 index (**Figure 8**) fitted with the Fox production function. It was decided to add the diagnostic of fits including residuals (**Figure 9**), likelihood profiles (**Figure 10**), retrospective analysis (**Figure 11**) and hindcasting (**Figure 12**), to the report of the stock assessment meeting. The Group also noted the model specifications (starting values and fixed values) used to run the mpb-Reference Case (**Table 9**).

3.1.2 JABBA

A detailed description of the JABBA model implementation, model diagnostics and initial stock status results were presented in document SCRS/2018/110. Consistent with mpb, the Group decided to choose the split Joint R2 CPUE (**Figure 13**) for the JABBA-Reference Case based on the goodness-of-fit, parameter precision and favorable residual and process error patterns compared to the alternative CPUE scenarios. The Group noted that that the initially assumed Fox model with an inflection point at B_{MSY}/K~0.37 may not necessarily be comparable with the agreed SS3 input steepness values of h = 0.7, 0.8 and 0.9. The linear relationship between h and SB_{MSY}/SB_0 is shown in relation to the Fox model in **Figure 14.** To facilitate comparability between JABBA and SS3 results, the Group therefore decided to use input of B_{MSY}/K = 0.332 (h = 0.7), 0.306 (h = 0.8) and 0.278 (h = 0.9) to calculate the shape parameter of the surplus production function. As a result, the final set of models comprised three runs (JABBA-uncertainty grid runs), where the run with 0.306 (h = 0.8) was used to investigate several diagnostic and sensitivity tests. The Group noted that a similar approach was not possible with mpb, which is constrained to a minimum B_{MSY}/K = 0.37 (Fox). In accordance with the SS3 observation variance estimation, the observation error was assumed to be represented by CPUE index CVs, which were scaled so that they averaged 0.2, but preserving the inter-annual variability. Priors on the r and K production function parameters were implemented with vague lognormal priors to convey minimal prior information on the parameter estimates. Additional, sensitivity tests requested by the Group confirmed that the priors did not have any notable influence on the parameter estimates, suggesting that data were informative (SCRS/P/2018/047). Similarly, it was possible to 'freely' estimate the process variance, using an uninformative inverse-gamma prior (SCRS/P/2018/048). A summary of JABBA-uncertainty grid model specifications is provided in **Table 10**.

The Group requested a number of additional JABBA model diagnostics. Routine diagnostics for each of the three JABBA-uncertainty grid runs, for the selected case (e.g. h= 0.8) from the uncertainty grid and/or for the initial Fox model run were provided. For example, 'JABBA' residual plot with depicted Root-Mean-Squared-Errors (RMSEs) as a goodness-of-fit measure were provided for the three scenarios of the JABBA-uncertainty grid (**Figure 15**). Model fit plots show the observed and predicted CPUE values in log scale (**Figure 16**). Due to the Bayesian estimation framework, log-likelihood profile plots were substituted by prior and posterior plots (**Figure 17**). Consistent with mpb and SS3, retrospective analysis (**Figure 18**) and hindcasting cross-validation (**Figure 19; Table 11**) were considered as important model diagnostics. In general, the Group agreed that model diagnostics were robust.

3.2 Stock Synthesis 3

3.2.1 Model setup and data inputs

An initial assessment of the Atlantic bigeye tuna stock using Stock Synthesis (Methot and Wetzel, 2013) was conducted in advance of the 2018 Bigeye Tuna Stock Assessment Session as agreed in 2018 bigeye data preparatory meeting. The full assumptions and data inputs to this model are described in SCRS/2018/111. Model inputs were discussed in detail at the 2018 data preparatory meeting (Anon, 2018).

The key assumptions and configurations of the initial "preliminary reference model" were as follows: the preliminary reference model is constructed as a seasonal model with 4 seasons and a timeframe from 1950 – 2017. The model has three areas for partitioning fleets-as-areas, similar to the 2015 model but does not have explicit movement between the areas and hence functions as a non-spatial, one-area model. The model starts in 1950 and assumes that the stock starts at virgin conditions.

The Group discussed the initial models (SCRS/2018/111, runs 1-15) presented by the author and a number of additional model runs were discussed, proposed, and conducted. A set of diagnostics were run for evaluating model performance that included fits to the joint LL index, length composition residuals, retrospective analysis, hindcasting, likelihood profiling, fixed parameter influence diagnostics and sensitivity analysis on influential parameters. The details of these runs are provided in **Table 12** and the presentations (SCRS/P/2018/051 - 054).

3.2.2 Natural mortality

Natural mortality (M) was parameterized in a manner similar to 2015 assessment with a Lorenzen 2005 function where M was scaled according the growth curve externally to stock synthesis. A fixed natural mortality vector was used in the SS3 as a single parameter for each age input.

One important model diagnostic was to profile natural mortality. This was achieved by replacing the fixed vector of M at age parameters with the Lorenzen scaling option in Stock Synthesis 3 (SS3) and profiling the preliminary reference model. The results indicated that the length composition favored a higher natural mortality but this was negatively correlated with the estimated steepness. Hence rather than using a value of M, estimated internally by SS3, that had the lowest log-likelihood of the evaluated range; 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, it was chosen to use a value of 0.35 for age 4 mortality which correspond to a steepness estimate of 0.7 as alternative M. This was similar to the 'high' vector used in 2015 assessment and represented a 25% increase in M over the baseline. To maintain consistency with the model structure the Group considered two fixed vectors of M in the SS3-uncertainty grid (**Table 2**)

3.2.3 Growth, morphometric relationships and reproduction

As outlined in Section 2.1, the Group decided to use a Richards formulation of the growth model according to Hallier et al. 2005 (L_{inf}=179.9, K=0.281, $t_{0=}$-.32, b=-7.185 and m=2280.4). Weight of Atlantic bigeye tuna in kilograms was estimated from straight fork length in centimeters as:

$$W_a = (2.396E\text{-}05)*SFL\text{^}2.9774 \qquad \text{(Parks et al. 1982)}$$

Fecundity was modeled as a direct function of female body weight. The maturity schedule used was adopted from previous assessments: 0% for ages 0-2, 50% for age 3, and 100% for ages 4-10.

Sensitivity analysis on growth was done with SS3 comparing the preliminary reference model with the estimated parameters by the SS3 model when including the Hallier et al. 2005 data in the model and letting the model estimate growth. The results suggest that the model estimates lower growth than the preliminary reference model. However, the plots of the residuals show that the model underestimates growth. This could be because the catch date from Hallier et al. 2005 data was not available and therefore, the model could not know the season where the fish was born. Therefore, the model did not have enough information to estimate growth correctly. This indicates that more studies on growth are necessary to improve the growth model which would improve the assessment.

3.2.4 Fleet structure

Similar to the 2015 assessment the model used 15 different fleets (**Table 13, Figure 20**). Fleet structure was largely the same as in 2015 with a few exceptions. First the handline fishery off northern Brazil was combined with fleet 8 TRO-North BB late as it had similar size composition. Next most of the 'Other" LL and Other fleets (13-15) is now identified to gear type, permitting the correct placement of PS-FAD and BB catches into their respective fleets. The fleets retain their respective area representation but the model no longer has three separate areas to account for fish movement between them. Differential selectivity for each fleet was modeled to account for availability in different areas.

3.2.5 Abundance Index inputs

Three different abundance indices variations were used initially (Section 2.3). The first was the Joint LL index split 1979 when the vessel ID (SCRS/2018/58) was included. The second was the continuous version of the joint LL index without vessel ID and the third used the split index plus the Dakar EU Baitboat index (SCRS/2018/60). To effectively split the index a separate catchability parameter was estimated for each time period. Indices were input as annual indices with a mean CV=0.2 but allowed to vary with the interannual variability in the estimated standard error of the index. The index variance was modeled as lognormal and the index CV was converted to log-scale standard errors for input logscale.

$$\mathrm{SE}= \sqrt{\ln{(1+CV^2)}}$$

To obtain the interannual variance for the joint index the geometric mean of each seasonal CV was obtained and used as input for the annual index. Indices were input as annual values. Evaluation of the 2015 model comparing index input as seasonal or annual indicated very little difference between either type of input.

3.2.6 Length composition

Length composition data were initially processed by the Secretariat (SCRS/P/2018/46) to remove outlier and to achieve generally homogenous fleet structure. After removal of outlier, no fish above 220 cm remained in the dataset. Fleet structure remained the same as in 2015 with some exceptions for fleets 13-15 which contained mostly Chinese Taipei longline + other fleets in areas 1, 2 and 3, respectively. Since 2013 there has been increasing catches of PS-FAD fish in area 3, which were originally assigned to fleet 15 making its size samples skewed towards smaller fish in recent years. These PS-FAD fish were placed in the fleet 4 ESFR_FADS2_PS_9117. Additionally, the Brazilian handline fishery was assigned to fleet 8_BB_FisTropN2_8014 as its size composition was similar based on limited size sampling from this fishery.

Length composition was input with an initial sample size equal to the ln(N) to decrease the weight of multiple samples within a fleet, season, and year combination.

3.2.7 Stock recruitment

A Beverton-Holt stock recruitment relation was assumed to model the number of recruits as a function of spawning stock biomass. Virgin recruitment (R0) was freely estimated and steepness (h) was fixed at a value of 0.8 for the preliminary reference model and at 0.7 or 0.9 for the uncertainty grid. Profiling on steepness indicated that there was insufficient information in the data to freely estimate it. Annual variation in recruitment (sigmaR) was fixed at 0.4 and with 0.2 and 0.6 used for sensitivity runs and the uncertainty grid. The estimated total annual recruitment was distributed across the four seasons according to seasonal allocations estimated in the model. Deviations in annual recruitment were estimated from 1974 to 2016. The lognormal bias correction ($-0.5\sigma^2$) for the mean of the stock recruit relationship was applied during the period 1974 to 2016 with a bias correction ramp applied according to Methot and Taylor, 2011 recommendations and with a maximum bias correction subsequently reduced to 0.2 given the limited information content in the model to estimate recruitment deviations.

3.2.8 Selectivity

Length-based selectivity was estimated for each of the fifteen fleets (**Table 13**). Fleets 1-4 (purse seine) were modeled with 5-knot cubic splines, fleet 5 (5_BB+PS_Ghana2_6517) was modeled with a cubic spline and fleets 6-9 (baitboat) were modeled with double normal distribution. Fleets 10, 12, 13 and 15 (areas 1 and 3 longlines) were modelled with a five-knot spline function and fleet 11 (Japan longline in area 2) was modeled with a double normal distribution. Fleet 14 (mostly Chinese Taipei) was modeled with a double normal selectivity in the first time period and asymptotic selectivity in the last time block period from 2005 onwards.

3.2.9 Data weighting

Input sample sizes for the length composition were initially input as the natural log of the sample size. This greatly diminished the input sample sizes, which often were in the 1000s. Length composition weight was further reduced by using a weighting factor of 0.5 which was eventually reduced to 0.1 for the final SS3-

Reference Case (run 19). This allows the model to better fit the CPUE index and improve the retrospective pattern of the models. Input variance adjustments were altered according to recommendations in Francis and Hilborn, 2011.

3.2.10 Consideration of a possible change in selectivity

Upon examination of diagnostics of fits to the length composition, it was noted that there were large positive Pearson residuals after 1992 with lack of fit to large fish and small fish for fleet 11 (Japanese LL in region 2). It was suggested that such lack of fit could be associated with a possible change in selectivity. A discussion was held on whether such change in selectivity could be justified on the basis of changes in the longline operations of this fleet. A number of possible factors were examined:

- the number of hooks between floats
- the influence plots from the CPUE standardization
- the geographical distribution of Atlantic bigeye tuna catches

The trend in the number of hooks between floats (NHF) in the Japanese longline fishery was reviewed, which revealed an increasing trend from mid-1970s to early 1990s, after which deep longline sets become dominant (**Figure 21**). This was considered to be part of the justification for the change in selectivity during this period.

Catches for the Japanese LL fleet 11 in the equatorial area (25 N to 20 S) from CATDIS (cdisBET5017_v1_forSS3_v2.xls) were plotted by year and latitudinal band. It was observed that in the latitudes between the equator and 10 degrees south and north (**Figures 22a** and **22c**), there was an initial peak of catches around 1965 and a decline afterwards so that catches were low during the 1970s. Catches started increasing again in the beginning of the 1980s and were large until the middle of the 1990s, when they started to decline. The increase and decline of the catch were much larger in the south of the equator (**Figure 22a**). Catches south of the equator were three times larger than those north of the equator in the 1980s and 1990s. In the 2000s and 2010s the catches between 10 N and 10 S had been low at levels similar to those in the 1960s. Catches from other latitudinal bands north and south respectively of 10 degrees N and 10 degrees south have fluctuated without much of a trend for the entire history. This suggests that during the 1980s and 1990s the Japanese longline fleet caught very large catches in the equatorial area, but these catches have largely disappeared in the 2000s.

There was enough evidence for changes in operations that the Group decided to add an additional time block to SS3 in the fit for fleet 11 in 1992. An additional set of selectivity parameters were fitted to fleet 11 for the period 1992-onwards.

The new fit somewhat improved the likelihood, predicted better the mean lengths and reduced the Pearson residuals from the fit to the length composition.
The Group agreed to include the changes of selectivity from 1992 onwards for the Japanese LL fleet (fleet 11).

However, the Group agreed that general guidelines to define and select time block for fishery selectivity changes could be developed. For example, the following could be investigated before a time block for fishery selectivity s applied:

- Analyze empirical evidence of changes in factors that might have influenced fishery selectivity such as fishing fleet dynamics, fish distributions, fishing gear and/or regulations;
- Make preliminary time blocks and fit the model to data;
- Evaluate residual distributions for potential temporal patterns for possible adjustment of time blocks defined at the very beginning; and
- Repeat the above procedure until temporal patterns of residuals are resolved within each time block.

3.2.11 Model Diagnostics

The SS3-Reference Case (run 19) and all sensitivity runs have positive definite hessians and maximum gradient components less than 0.0001. Most parameters were estimated with relatively high precision and little correlation. Only the 3 area model has some bounded parameters and due to poor diagnostics performance the model was excluded from consideration for the structural uncertainty grid.

Diagnostic evaluation of fits to the index (**Figure 23**) and length composition data (**Figure 24**) did not indicate a lack of fit to the data. The full suite of diagnostics (Pearson residual plots, fits for each season, year and fleet) for length composition fits were evaluated but are not shown in this report. Estimated selectivities from SS3 model are shown in **Figure 25.** The likelihood profile across the range of hypothesized R0, sigmaR and steepness values are shown in **Figures 26** and **28**.

Model retrospective analyses were conducted across candidate SS3 runs, and this diagnostic tool was used as a primary model selection criterion to select the reference case. Overall, run 19 performed best in retrospective diagnostics (**Figure 29**), and this run was selected as the SS3-Reference Case for building the reference grid.

3.2.12 Model Hindcasting

SCRS/P/2018/50 evaluated the future predictability of the SS3 assessment models using a hindcasting approach (Kell et al., 2016), where the models are retrospectively re-run by removing recent years' data (both of abundance indices and length composition) and the biomass trajectories are forecasted up to the most recent year. For this purpose, the following four different SS3 runs were evaluated across three different hindcasting periods (3, 5 and 10 years removed from the time series) and compared to the models that utilized the complete time series.

1) Preliminary reference model (run 1)
2) Run 17 (lambda = 0.1)
3) Run 18 (lambda = 0.1 and additional time-block)
4) Run 19 (lambda = 0.1, additional time-block, and with a maximum bias correction of 0.2) – final Reference Case

During the hindcast sensitivity analysis, the predicted abundance indices in the recent years were removed and calculated by multiplication of catchability and vulnerable biomass. These predicted CPUEs for the recent period were visually compared with the observed index values (**Figure 30**) as well as quantitatively via the root mean squared error (RMSE) shown in **Table 14**. The results showed that the performance of prediction is dependent on the hindcasting years because the recent behavior of the (joint) abundance indices in last 10 years has a decreasing period (2008-2012) and an increasing trend (2013-2017); which greatly influenced model predictions. For this reason, the prediction of 5 hindcasting years was quite difficult for any SS3 runs.

3.2.13 Sensitivity runs

A suite of sensitivity runs was conducted by the Group with the purpose of diagnosing models to include in the uncertainty grid. The sensitivity runs (**Table 12**) were outlined at the data workshop. An additional three sensitivity runs were added that evaluated increases (+25%, run 14) and decreases (-10%, run 15) in the total catch for fleet 4_ESFR_FADS2_PS_9117 in response to uncertainties in total removals of small fish and asymptotic selectivity for Fleet 11_Japan_LL2_6117 (run 13). At the assessment meeting, a number of additional concerns such as a time-block on selectivity for Fleet 11 in 1992, decreasing weight on the length composition data to a lambda of 0.1 and reducing the magnitude of bias correction for estimation of recruitment deviations were explored, giving a total of 19 model runs (**Table 12**).

3.3 VPA-2box

The catch-at-age matrix for the VPA was estimated using the Richards model of bigeye growth (Hallier et al., 2005). The CAA was developed and made available to the Group late in the week and, therefore, due to time constrains the Group decided not to run the VPA this time.

4. Stock status results

4.1 Production models

4.1.1 mpb

The procedure for rejecting scenarios was based on the diagnostics recommended by the data preparatory group. One scenario was chosen as mpb-Reference Case to represent stock status and historical trends, i.e. using the split Joint R2 indices as the abundance indicator. 500 bootstraps were run to produce the results of this Reference Case. **Tables 15** and **16** show the estimated parameters and MSY based benchmarks summarized by means, medians and 90% confidence intervals. **Figures 31** and **32** show the estimated trajectory of the stock on a Kobe diagram and the densities of the relative stock status estimates in 2017. **Figure 32** also shows the probabilities of the stock being in the different quadrants of the Kobe plot. According to the estimates of the mpb-Reference Case, Atlantic bigeye stock is currently overexploited and undergoing overexploitation (red area of the Kobe plot) with very high probability (90.8%).

4.1.2 JABBA

The JABBA runs over the fixed B_{MSY}/K input values (0.278, 0.306 and 0.332) produced similar trajectories for fishing mortality (F) and biomass relative to unfished biomass (B/K) for the three JABBA-uncertainty grid runs (**Figure 33**). Over the initial period 1950-1990, total biomass estimates were the highest for B_{MSY}/K = 0.278 and the lowest for B_{MSY}/K = 0.332, but similar thereafter. Both MSY (76,768 – 78,606 t) and B_{MSY} estimates were similar for each uncertainty grid runs (**Table 17**). Point estimates of B_{2017}/K for the year 2017 ranged from 0.244-0.252 for the JABBA-uncertainty grid (**Tables 17 and 18**), where B_{MSY}/K = 0.278 (high h = 0.9) resulted in the most pessimistic B_{2017}/K. The opposite is the case for the B/B_{MSY} and F/F_{MSY}, where B_{MSY}/K = 0.278 (h = 0.9) produced the most optimistic stock status trajectories for B/B_{MSY} and F/F_{MSY}. This can attribute to predetermining the maximum of the surplus production curve (MSY) along the B_{MSY}/K axis by the choice of the shape parameter m (and steepness h in SS3), which appears to be compensated by increased estimates of K as the reference point B_{MSY}/K is decreased (**Table 17**). The Fox model results were included to facilitate comparison with the mpb-Reference Case (**Table 17**). The combined uncertainty about the stock status reference trajectories of exploitable biomass B, biomass depletion B/K, B/B_{MSY} and F/F_{MSY} for the three uncertainty grid runs and the initial Fox model run are presented in **Figures 33** and **34**. The combined posteriors B_{2017}/B_{MSY} and F_{2017}/F_{MSY} from JABBA uncertainty grid runs (**Figure 35**) predicted with 85.5% probability that the stock remains overfished and that overfishing is still occurring (red quadrant).

4.2 Stock Synthesis (SS3)

The final SS3-Reference Case (run 19) showed substantially improved fits to the indices, improved retrospective performance over the suite of sensitivity runs. Several key parameters such as steepness and sigmaR could not be estimated and therefore were fixed in all model runs. The primary purpose of constructing the Reference Case was to be used as a basis from which to build the uncertainty grid.
Recruitment deviations show some trend in residuals with higher recruitment between 1990-2000 (**Figure 36**). The estimated stock recruitment relationship shows some evidence of a relationship between SSB and recruits (**Figure 37**) but nonetheless there was insufficient contrast in the data to estimate steepness from the profiles (see figures in section 3). Recruitment by season indicates that the highest fraction of recruits is estimated to be born in season 2 (Apr-June) and the lowest in season 4 (Oct-Dec). Time series of the numbers at age shows little evidence of strong cohort structure and a decline in the mean age in the population over time (**Figure 38**).

Evaluation of the sensitivity runs and subsequent model scoping runs conducted at the meeting indicates that they showed very similar recruitment and stock biomass trajectories. Additionally, all sensitivity runs were in quite similar agreement on stock status with respect to SSB/SSB_{MSY} and F/F_{MSY}, with recent increases in F and decreases in SSB since the 2015 assessment.

Uncertainty grid evaluation

After the evaluation of diagnostics for the SS3-Reference Case (run 19) and most of the sensitivity runs, the final uncertainty grid was developed from the two natural mortality vectors, three sigmaR values

(0.2,0.4,0.6) and three steepness values (0.7,0.8,0.9). This resulted in 18 total model runs for the structural uncertainty grid (**Table 19**). A generalized linear model was used to evaluate the effect of the grid factors on the key model outputs and indicated that most model factors were significant and had influential impacts on the outputs; which supported the model configurations selected for the reference uncertainty grid**.** All 18 model runs converged and had maximum gradient component values <0.001.

Deterministic results of the 18 SS3-uncertainty grid runs show a long-term decline in SSB with the current estimate being at the lowest level in the time series (**Figure 39**). Fishing mortality (average F on ages 1-7) spiked starting in the early 1990s and then has remained high since then, peaking in recent years (**Figure 39**). Recruitment estimates show two 'clusters' depending upon the assumed natural mortality rate, but overall very similar estimated cohorts (**Figure 39**).

All the deterministic runs point estimates of SSB/SSB_{MSY} and F/F_{MSY} (**Figure 40**) indicated that $F>F_{MSY}$ and $SSB<SSB_{MSY}$ in the last year. The uncertainty grid shows that, despite a broad range of assumptions regarding stock productivity (steepness) and model parameterization, the results are all in agreement regarding recent stock status and trends.

Deterministic stock status for the SS3-uncertainty grid results indicate that current fishing mortality rates (**Tables 20 and 21**) is above F_{MSY} and spawning stock is below SSB_{MSY}. **Figure 41** show the estimated trajectory for all SS3-uncertainty grid runs of the stock on a Kobe diagram. Calculations of the time-varying benchmarks show a long-term increase in SSB_{MSY} and a general long term decrease in MSY (**Figure 42**).

4.3 VPA-2box

The VPA analysis was not conducted.

4.4 Synthesis of assessment results

The Group carefully evaluated model diagnostics for each modeling platform and evaluated a series of sensitivity analyses. Each of the modeling platforms showed strong performance which is likely a reflection of the clear signals in the joint longline index.

The models show consistent results both in absolute magnitude of the stock and in stock status (**Figures 43** and **44**). The three platforms indicate that the Atlantic bigeye tuna stock is overfished and undergoing overfishing. The models estimate similar MSY at between 76,232 and 80,359 t. The stock status results are also similar between 1.21 and 1.63 for F_{2017}/F_{MSY} and between 0.59 and 0.82 for B_{2017}/B_{MSY} or SSB_{2017}/SSB_{MSY} (**Table 22**).

The production models diverged from Stock Synthesis in the recent trends of estimated fishing mortality rates. SS3 indicated an increase in F in recent years whereas the production models indicated relatively flat trajectories. This may be due to the increasing catch of small fish which is accommodated in the age-structured models.

The Group agreed that the uncertainty grid developed from the SS3-Reference Case (run 19) be used for management advice. The SS3 uncertainty grid includes 18 model configurations that were investigated to ensure that major sources of structural uncertainty were incorporated and represented in the ultimate assessment results. The results of two production models, mpb and JABBA, will be also used to support the advice.

The SS3 integrated statistical assessment model allows the incorporation of more detailed information, both for the biology of the species as well as fishery data, including the size data and selectivity by different fleet and gear components. As SS3 allows modelling of the changes in selectivity of different fleets as well as to investigate the effect of the length/age structure of the catches of different fisheries in the population dynamic, productivity and fishing mortality; this was the preferred model to be used for the management advice.

5. Projections

The Group agreed to project each of the models (i.e. JABBA, mpb, SS3) using the following general specifications.

- Projection interval: the Group agreed to make projections over a 15 year interval, 2018-2032.
- 2018 Catch: Fixed at 78,445 t, the average catch during 2016-2017, which corresponds to the years when Recommendation 15-01 was fully implemented.
- Constant catch projections were made at 0 t, and 40,000 – 90,000 t, in 5,000 t intervals.
- Recruitment:
  - SS3: based on the estimated stock recruitment relationship with 0 recruitment deviations
- Selectivity and fleet allocations: It is necessary to specify the selectivity pattern for projections. The appropriate pattern is model specific.
  - JABBA and mpb: see section below
  - SS3: average of the last two years of the model (2016-2017)

5.1 Production models

5.1.1 mpb

Catch projections from the 500 iterations developed from the mpb-Reference Case were carried out using catch limits from 40,000 to 90,0000 t projected forward for 15 years. The deterministic trajectories for relative biomass and fishing mortality are shown in **Figure 45** and probabilistic results from the boostrap projections in **Table 23**.

5.1.2 JABBA

Catch projections from JABBA uncertainty grid runs were constructed by combining the posteriors from each run. The combined posterior comprised a total of 30,000 MCMC iterations for each projection year. Projections were made until 2032 with 2019 being assumed the implementation year. The projections are shown in **Figure 46** for a stepwise increase between 40,000 and 90,000 t at an interval of 5,000 t. Kobe projection matrices summarizing the probabilities of attaining harvest rates below F_{MSY}, biomass above and achieving the stock to be within in the green quadrant of the Kobe phase plot are summarized in **Table 24.**

5.1.3 SS3

Catch projections from 18 SS3 uncertainty grid runs were carried out at constant catches ranging from 40,000 to 85,000 t. The results are shown using deterministic trajectories for relative spawning stock biomass (**Figures 47 and 48**) and fishing mortality (**Figures 49 and 50**).

The Group recommended that final management advice be developed from the 18 SS3-uncertainty grid as described in section 4.4. A full characterization of SS3 projections will be conducted intersessionally, and the results to be presented in a separate SCRS document during the September Species Group meeting, including Kobe strategy matrices with bootstrap estimates of uncertainty across the 18 SS3-uncertainty grid.

6. Recommendations

6.1 Research and statistics

- Noting that the joint LL standardized CPUE index was an improvement over fleet-specific indices because of the integrated temporal and spatial coverage it afforded to index stock biomass, and because it minimizes data conflicts in the stock assessment models, the Group recommends that the joint longline CPUE standardization for bigeye should continue in the future, and this effort should also be expanded to other species. The Group also agreed that further development work should be assigned a high priority (Section 2.3) and for this will need to:

  - request CPCs to commit to develop a joined longline index for tropical tunas based on combining set by set data
  - find a mechanism for sharing the data prior to the data preparatory meetings so as to produce an SCRS paper with the combined index
  - agree on a procedure to protect the confidentiality of the national data
  - agree on a methodology to combine the data
  - ensure that the tropical group scientists have the ability to conduct the analysis (during the bigeye data preparatory meeting an external scientist led the analysis)
- Considering the importance of having a recruitment index, the Group recommends that further attempts be done to produce standardized CPUE for the FAD purse seine fishery and baitboat fisheries. Noting the work done on biomass estimates from acoustic buoys information, the Group recommends further exploration on these data for the development of fishery independent index.
- Considering the work of the AOTTP on Oxytetracycline tagging and the development of otolith reference set for bigeye and yellowfin, the Group recommends that the growth of bigeye and yellowfin, including hard parts and tagging data, is considered a priority research investigation as this will allow to improve the stock assessment reducing the uncertainty of the models in relation to this important biological parameter.
- Considering the difficulty of the selection of stock assessment models, base case or reference grid models within a particular stock assessment model, and the process of weighing across scenarios/models for the provision of the management advice, the Group recommends that the Working Group on Stock Assessment Methods (WGSAM) develop formal criteria and protocols for inter- and intra- stock assessment model selection as well as weighting across models and/or scenarios within a particular model for the management advice.
- Recommend that the tropical tunas MSE project team does the utmost possible to consult and communicate periodically with the Tropical Tunas Species Group and SCRS so as to improve the development of the MSE and increase the likelihood that project products will be accepted by the SCRS.
- To enable the SCRS to evaluate the impact of potential changes of the capacity management plan of Ghana, the Group recommends that the ICCAT Secretariat requests Ghana to grant Ghanaian/SCRS scientists permission to access and analyze the AVDTH and VMS data from their purse seine and baitboat fleets to estimate fishing capacity by vessel type.
- The Group requests that CPCs that use FADs to capture tropical tunas prepare analyses reporting any changes in the distribution of effort and catch during and around the current moratoria and to compare such distributions to those prior to the implementation of the current moratoria.
- The Group recommends that alternative methods (slicing, inverse length key etc.) used to develop catch at age for tropical tunas should be tested prior to the next assessment.
- Noting that the AOTTP has received a request for support activities which will analyse the data already collected by the programme, the Group recommends that those scientists interested in such activities provide proposals to the AOTTP Coordinator for consideration prior to the 2018 Species Group meeting.

7. Other matter

7.1 Responses to Commission requests

The Group discussed the Commission requests relevant to tropical tunas (**Table 25**) and developed a workplan to be able to provide responses. These responses will be finalized at the species group meeting in September.

7.1.1 Strategies and data requirements for review of impacts on the level of catches of potential Ghanaian comprehensive and detailed capacity management plan

ICCAT Rec. 16-01, paragraph 12c, states that "Ghana shall be allowed to change the number of its vessels by gear type within its capacity limits communicated to ICCAT in 2005, on the basis of two baitboats for one purse seine vessel. Such change must be approved by the Commission. To that end, Ghana shall notify a comprehensive and detailed capacity management plan to the Commission at least 90 days before the Annual Meeting. The approval is notably subject to the assessment by the SCRS of the potential impact of such a plan on the level of catches."

Although there is no pending request from Ghana to change its capacity management plan at this time, the Group discussed the nature of such an assessment of catch impacts, and what would be needed for carrying it out. Such an assessment is complicated by the fact that catches have typically been shared between vessel types (PS and BB), and the SCRS has generally concluded that Ghanaian data from both gears should be treated as a combined gear. Ultimately, it would be necessary to calculate the relative catch capacities of one PS vessel compared to two BB vessels. The Group determined that it would be best to request information from Ghanaian statistical correspondents/scientists that would enable the calculation of the relative fishing power of PS and BB vessels. This would require looking at the detailed logbook and VMS data at the vessel level, providing information on catch and fishing mode with enough temporal and spatial resolution for the analysis.

An approach comparing annual changes in numbers of PS and BB vessels along with effort levels to annual catch levels was proposed. However, the Group considered that it may be difficult to separate the changes due to shifting proportions of vessel type from changes due to population size and availability.

7.1.2 Defining the procedure to update the analysis of the effects of the current moratoria on FADs

ICCAT Rec. 16-01, paragraph 15 requests the SCRS to "evaluate the efficacy of the area/time closure referred to in paragraph 13 for the reduction of catches of juvenile bigeye and yellowfin tunas. In addition, the SCRS shall advise the Commission on a possible alternative area/time-closure of fishing activities on FADs to reduce the catch of small bigeye and yellowfin tuna at various levels."

The Group noted that there is only one year of data available covering the period after implementation of the current time-area closure on FAD fishing. This limits the strength and options for analyses. Changes in stock status during the last year can only be evaluated for Atlantic bigeye tuna, for the other stocks there has not been evaluation since this moratorium was imposed. Given the uncertainty in fishing mortality estimates by age in 2017 (see section 4), it is challenging to determine whether Atlantic bigeye tuna mortality of younger ages has changed significantly in the last year and whether any change is related to the time/area moratorium.

As was done for previous moratoria, it will be necessary to investigate changes in the distribution and level of fishing activity and catches in the area and time of the moratoria in comparison to other time/areas.

Additionally, it was suggested that tagging information from the AOTTP programme, for fish tagged within and outside the closure, could be used to evaluate impact on the survival of fish in the closed area vs outside. However, it was pointed out that during 2017 there were few tagged fish released from within the moratoria area.

The Group agreed to update previous evaluation of FAD time-area closure, including longer time periods or larger areas needed to achieve various levels of catch reduction of small fish.

7.1.3 Develop a table that quantifies the expected impact on MSY, B_{MSY}, and relative stock status for both bigeye and yellowfin resulting from reductions of the individual proportional contributions of major fisheries to the total catch

ICCAT Rec. 16-01, paragraph 49c requests the SCRS to "develop a table for consideration by the Commission that quantifies the expected impact on MSY, B_{MSY}, and relative stock status for both bigeye and yellowfin resulting from reductions of the individual proportional contributions of longline, FAD purse seine, free school purse seine, and baitboat fisheries to the total catch."
The Group agreed that this response would be finalized at the species group meeting in September 2018. Such response would be developed with two sets of information. First, by looking at the historical analysis of fishing impacts that was conducted during this meeting. Second by considering the results of projections under different hypotheses about future relative contribution of main gear groups, which will be conducted intersessionally.

Fishery impact analysis

A presentation was made to the Group on the results of a historical fishery impact analysis (SCRS/P/2018/050). The method is based on the idea that given an estimated historical evolution of the stock biomass, one can determine the impact of an individual fleet by removing the historical mortality generated by that fleet. As such mortality is removed, the stock responds by growing in size. This growth is a measure of the foregone growth potential resulting from the harvests of each fleet, thus it is an indicator of the impact of each fleet on the overall stock spawning biomass.

The fishery impact analysis was conducted based on the results of 18 SS3-uncertainty grid (**Table 26**). The fishery defined in the SS3 (F1 - F15) were assigned as FSC (F1-3; purse seine free school fishery), FAD (F4 and 5; purse seine FAD fishery), BB (F6-9; baitboat fishery) and LL (F10-15; longline fishery). The Group requested and agreed to include the mixed fishery of BB and PS of Ghana (F5) in the FAD fishery category for the fishery impact analysis. The Group requested that the fishery impact results be presented as proportional reduction from unfished levels. The results of this updated analysis are shown in **Table 27** and **Figure 51**.

Trajectories of portions of the impact attributed to each fishery category on spawning biomass indicated substantial historical changes along with the fishery development (**Figure 51**). In early part of the analytical period BB and LL fishery had large impact, then FSC fishery developed after 1970s, and finally the FAD fishery emerged in the late 80s. The LL fishery, which mainly caught larger fish, historically had the largest impact, but it showed a declining trend after around 2000 to its present average value of 0.28 (relative to unfished biomass level) in average for recent three years (2015-2017) throughout 18 SS3-uncertainty grid runs (**Table 27**). The magnitude of the impact on FAD fishery, which mainly harvest the smaller immature juvenile fish, had the largest impact after 2010, and it reached 0.32 in recent years. The impact of BB fishery in the recent three years was the third largest one (0.16) and the FSC fishery showed smallest impact on the spawning biomass (0.10). The differences in the fishery impact among 18 SS3-uncertainty grid runs were small although the differences increased in recent years particularly for BB and FSC fisheries (**Figure 51**). The impact for each fishery category for the entire period and all SS3-uncertainty grid runs are presented in **Appendix 5**.

Projections for different relative contribution of gear groups

A presentation was made on a method, still under development, that uses a Shiny app to enable evaluation of the impact of changing the relative contribution of various gear groups. The application is designed to work with the results of the SS3 model. When finalized, this application should allow the SCRS to address the request of the Commission. The Group agreed to form an ad hoc group of scientists to work inter-sessionally to design, implement, and report on these analyses conducted with the Shiny app.

One initial suggestion made to this ad hoc group was that Ghana catches were most appropriately included within the PS FAD grouping. The Group also requested that efforts be made to enable these analyses to include all 18 SS3-uncertainty grid configurations that will be used to develop the management advice. As a first step, the Group agreed to conduct this analysis with three model configurations; in order of priority: a scenario closest to the median of the 18 SS3-uncertainty grid runs and then adding the upper and lower extremes scenarios.

Two types of methods were proposed to develop hypotheses about the future mixture of gears to be used in the simulations. First, the historical proportions of the catch generated by different gear groups would be examined and periods of time where the mixture was more or less constant would be used to develop hypotheses for the future. Second, the future proportion of a given gear would be increased/decreased by a fixed percentage (e.g. 10%, 20%) and the proportion of the catch from the other gears would be adjusted proportionally to their current distribution.

7.1.4 Workplan to develop responses to the FAD working group recommendations

The Chair of the SCRS reported on his intention to develop the workplan prior to the species group meeting in September. The Group recommended that the workplan should include an action aiming to provide detailed suggestions on how to change the form required to report on FAD related fishing activities. It was also noted that the IOTC and WCPFC have had recent meetings were progress has been made in the technical definitions of FAD related terms. Reports of such meeting and those from the CECOFAD project should inform the development of the workplan.

7.2 Progress on MSE

The project team that was recently awarded the ICCAT contract to start the development of the MSE for tropical tunas made a short presentation of the terms of reference for the contract, the project partners and the initial schedule of activities for 2018. The team emphasized the fact that the project only started in June 2018. The main outcome of this initial phase is the development of a workplan to develop the MSE simulations and the initial work to develop candidate operating models. The team presented the chosen platform (FLBEIA: http://flbeia.azti.es/) to be used in such development. The team is proposing to use the results of the most recent SS3-based assessments of yellowfin and bigeye tuna to condition the Operating Models (OMs). As a first test to demonstrate the flexibility of FLBEIA the team has developed preliminary OMs for Atlantic bigeye tuna and yellowfin tuna. The team also explained the emphasis of their project on effective communication with the SCRS and stakeholders. To facilitate this the team plans to attend and report to the SCRS Tropical Tunas Species Group meeting in September and to have a project meeting in December. Additionally, the team is developing a Shiny app that will allow displaying the results of the MSE simulations in a more effective manner.

The Group emphasized the need of doing the utmost to ensure effective communication between the project team developing the MSE simulations and the Tropical Tunas Species Group and SCRS. Suggestions included the use of short webinars at different times of the day to give the opportunity to as large a group of SCRS scientists as possible. It was also suggested that regular meetings of the Group could be expanded an extra day so as to dedicate a full day to the communication of MSE progress and improve the consultation process. The request was made to allow for voluntary participation of SCRS scientists to the planned project meeting that is to take place at the end of 2018 in AZTI, however, the team clarified that they only have funding to support the travel of tropical tunas rapporteurs and team members. The project team accepted the suggestions of using webinars and agreed to open the later meeting to all those interested.

It was also recommended that the process of independent review of the tropical tunas MSE models being developed should start early in the ICCAT MSE process. This is consistent with the recommendations made by the SCRS Working Group on Stock Assessment Methods (WGSAM) and the tRFMO MSE Technical Group. The SCRS workplan for tropical tunas MSE recognizes this need and intends the review process to start in 2019, six months after the start of the MSE tropical tunas project.

The initial demonstration of the operating models provided by the project team are not spatially explicit. The Group suggested that the possibility of developing a simple spatial model (e.g. one with three areas) should be considered in the development of the OM. The Group recommended that the project team uses the uncertainty grid of SS3 models developed for the assessment of the Atlantic bigeye tuna stock as the basis for the initial set of OMs for Atlantic bigeye tuna MSE.

8. Adoption of the report and closure

The Report of the 2018 ICCAT Bigeye Tuna Stock Assessment Meeting was adopted. Dr Murua thanked the participants and the Secretariat for their hard work and collaboration to finalise the assessment and the report on time. The meeting was adjourned.

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Table 1. Summary of the current assumptions concerning life history attributes for Atlantic bigeye tuna.

Life history attribute	**Assumption used by the SCRS**	**Source (see also ICCAT Manual)**	**Notes**
Growth model of size at age	Richards growth model* L_{inf}=179.9, K=0.281, $t_{0=}$-.32, b=-7.185 and m=2280.4 See values in Table 2.1.2	Hallier et al. (2005)	Recommended at 2018 data preparatory meeting
Length-weight relationship	RW = $(2.396\ 10^{-05}) * SFL^{2.9774}$ Kg and cm See values in Table 2.1.2	Parks et al. (1982)	
Natural mortality	Starting at age 1: 0.73, 0.46, 0.36, 0.31, 0.28, 0.26, 0.25, 0.24, 0.23, 0.23, 0.22 See Table 2.1.2, the Group also considered alternative Ma assumption for SS3	Lorenzen (2005) developed using the Hallier et al. (2005) Richards growth curve	Reference M = 0.2794 over the "fully selected" age classes (1-15)
Longevity	Close to 15 years	ICCAT manual	
Spawning-at-age	50% spawning at age 3 Starting at age 1: 0, 0, 0.5, 1 (ages older 4)	2015 Atlantic bigeye tuna assessment report	
Spawning area	Spawning takes place in a vast zone in the vicinity of the equator	ICCAT manual	
Spawning season	from January to June to the south of Brazil, from December to April in the Gulf of Guinea and during the third quarter	ICCAT manual	

*Richard's parameters for the growth formulation in the SS3 model.

Table 2. Life history table summarizing Length-at-age (*La*), Weight-at-age (*Wa*), Maturity-at-age (*Mat*) and two alternative assumptions about the natural mortality-at-age (*Ma*) used as fixed input in the SS3 uncertainty grid runs.

Age	0	1	2	3	4	5	6	7	8	9	10+
L_a (cm)	10.0	57.6	85.2	110.0	130.1	145.1	155.9	163.4	168.5	172.0	175.6
W_a (kg)	0.076	4.3	13.8	29.3	48.2	66.6	82.4	94.6	103.7	110.0	117.0
Mat	0	0	0	0.5	1	1	1	1	1	1	1
M_a (ref)	0.727	0.456	0.358	0.308	0.279	0.26	0.248	0.239	0.233	0.228	0.221
M_a (alt)	0.909	0.570	0.447	0.385	0.348	0.325	0.31	0.299	0.291	0.286	0.276

Table 3. Estimated catches (t) of Atlantic bigeye tuna (*Thunnus obesus*) by area, gear and flag adopted by the WG as best estimates of total removals (July 18, 2018).

				1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
TOTAL (A+M)				808	1651	2018	2951	2932	4808	2779	8720	4290	7732	9113	17060	23132	26039	23631	39394	25386	25252	23911	36889	42433	55866	47287	56991	64093	61301	45302	54880	52693	45975	63597	67869	73682	59586	71171	78262
Landings	A+M		Bait boat	808	1651	2018	2951	2932	4808	2769	8266	3837	6254	6127	5805	7112	10927	5698	9822	5320	11434	3792	9770	10518	11846	9304	13620	17922	14636	9939	12758	14629	9591	12350	10124	6950	9853	11480	17651
			Longline	0	0	0	0	0	0	10	454	453	1478	2986	11255	16020	15112	17928	29572	20046	13726	19683	24149	28526	39904	33293	38453	39535	41347	27847	29531	28796	27560	41677	41608	51803	33757	43303	52595
			Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	449	716	174	481	366	365	292	163	247	415
	A+M		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	20	92	436	2970	3389	4116	4690	4918	6636	5318	7067	11875	9094	8343	9204	15656	14476	15654	16063	7554
Landings(FP)	A+M		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	116	161	158	77	46
Discards	A+M		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landings	A+M	CP	Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	28	70	197	181	678	1183	812	782	698	505	776	521	698	419
			Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0
			Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111	95	146	142	131	115	50	47	464	45	27	72	200	293	167	112
			China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	130	0	339	721	0	6	1640	1129	1295	628	1425	1308	1041	450	76
			EU.España	0	0	0	0	0	0	0	0	0	0	0	0	98	491	144	1017	1145	1272	1399	1810	4072	7418	4015	5681	4515	8882	7436	9736	6849	5419	8430	10010	9332	8794	13617	10340
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	400	2400	840	10	60	1740	155	3346	3088	2828	3624	3224	4007	4079	5821	7076	7407	5775	5612	6456	5601	6923	3585	4226
			EU.Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU.Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
			EU.Portugal	808	1651	2018	2951	2932	4808	2769	8266	3837	6254	6127	5805	6588	8021	4684	8670	4133	8051	1597	5620	5133	2892	3962	5855	10945	6813	2929	4522	5350	3483	3706	3086	1861	4075	4354	6457
			EU.United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Gabon	0	0	0	0	0	0	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	0	0
			Ghana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	73	84	170	237	124	238	332	780	791	491	2162	1887
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Guinea Ecuatorial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Guinée Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Honduras	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Japan	0	0	0	0	0	0	10	454	453	1478	2904	11044	15746	14505	17366	28663	17578	9012	11345	11783	9504	21299	19665	22014	22946	17548	8170	10144	9863	12150	20922	22091	33513	15212	24870	32103
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	289	320	263	1857	4079	7353	5730	6018	7831	10493	6923	8090	9716	8022	10235	12274	10809	9383	8989	10704
			Liberia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	170	324	394	414	387	622	625	552	120	30
			Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Namibia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	182	2710	2081	2091	2135	1493	2127	513	4518	2500	3182	3930	3322	4461
			Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			S. Tomé e Príncipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	299	794	1014	330	879	473	822	658	254	449	238	43	139	165	160	219	313
			Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	286	214	0	0	0	0	0	0	0	0	1	0	0	0	0	0	19	422	381	137	187	60	102
			St. Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	191	41	22
			U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	18	148	195	544	212	113	865	67	28	331	248	212	202	158	422	315	539	639
			U.S.S.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	385	680	1820	1677	2200	2580	2729	1637	2961	3367	3652	4907	4086	2202	2229	2813	2832	635	352	1233	870
			UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			UK.Sta Helena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	22	8	9	14	23	14	19	0
			UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Uruguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	397	605	714	597
			Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Venezuela	0	0	0	0	0	0	0	0	0	0	26	48	67	54	137	160	329	224	185	143	136	92	117	15	24	0	21	464	244	347	661	1684	1027	4284	4142	2918
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	20	47	54	0	672	2521	6039	8456	8538	6191	5639	4314	3499	4464	3701	3364	2970	2486	2561	1887	2147	1623	925	1220
			Guyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NCO	Argentina	0	0	0	0	0	0	0	0	0	0	56	163	213	235	187	400	200	75	347	200	100	44	0	25	18	95	176	84	23	0	0	0	0	0	0	100
			Benin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	45	0	0	0
			Cambodia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Congo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	8
			Cuba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89	300	217	886	1027	4100	3200	2000	2600	2400	1900	1300	1800	2300	2300	1385	711	521	421	447	239
			Dominica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Faroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Grenada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			NEI (Flag related)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	369	354
			Saint Kitts and Nevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Sta. Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Togo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	52	18
Landings(FP)	A+M	CP	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	41	24
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	93	14	3
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Guinée Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NCO	Mixed flags (EU tropical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	116	65	58	23	20
Discards	A+M	CP	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued). Estimated catches (t) of Atlantic bigeye tuna (*Thunnus obesus*) by area, gear and flag adopted by the WG as best estimates of total removals (July 18, 2018).

				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
TOTAL (A+M)				65445	57416	66410	78720	85264	97197	100117	113862	134936	128028	120751	110266	107935	121643	103727	91201	75726	87702	90058	67889	59141	69510	63364	76324	75930	76366	71059	67849	75029	80172	79909	76982
Landings	A+M		Bait boat	15618	13458	9710	12672	18280	17740	16248	16467	20361	25576	18300	21276	19131	22301	12365	14540	8523	11450	20336	13058	10554	9827	6499	11446	7731	12420	10257	9236	8732	8003	6788	8222
			Longline	39942	35570	47766	58420	56537	61590	62459	62871	78898	74862	74930	68311	71856	77227	72010	56122	47351	55356	49325	37960	34182	46231	41063	43533	42520	37899	34930	32245	36769	40364	36272	34063
			Other surf.	550	626	469	605	287	400	548	648	977	561	353	535	428	673	451	766	221	447	361	716	552	449	220	258	477	1003	1152	2761	4917	5706	6342	7286
	A+M		Purse seine	9286	7148	7864	6379	9413	15527	19227	31586	32668	25361	26628	19152	15531	20258	17537	19516	19418	19582	19016	15129	13310	12311	14810	20007	24209	23767	23883	22975	24002	25073	29319	26439
Landings(FP)	A+M		Purse seine	48	613	600	644	747	1941	1636	2290	2032	1667	540	993	989	1184	1363	257	214	867	1019	1026	542	692	772	1081	994	1277	823	632	609	989	1187	972
Discards	A+M		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	2	0	0
			Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	
Landings	A+M	CP	Barbados	0	0	0	0	0	0	0	0	0	0	0	24	17	18	18	6	11	16	19	27	18	14	14	7	12	7	15	11	26	30	19	24
			Belize	0	0	0	0	0	0	0	0	0	10	0	5	195	0	134	96	0	0	0	0	4	60	70	234	249	1218	1242	1336	1502	1877	1764	1262
			Brazil	873	756	946	512	591	350	790	1256	601	1935	1707	1237	776	2024	2768	2659	2582	2455	1496	1081	1479	1593	958	1189	1173	1841	2120	3623	6456	7750	7660	7694
			Canada	11	144	95	31	10	26	67	124	111	148	144	166	120	263	327	241	279	182	143	187	196	144	130	111	103	137	166	197	218	257	171	214
			Cape Verde	86	60	117	100	52	151	305	319	385	271	299	228	140	9	2	0	1	1	1	1077	1406	1247	444	545	554	1037	713	1333	2271	2764	1680	1053
			China PR	0	0	0	0	0	0	0	70	428	476	520	427	1503	7347	6564	7210	5840	7890	6555	6200	7200	7399	5686	4973	5489	3720	3231	2371	2232	4942	5852	5514
			Curaçao	0	0	0	0	0	0	0	0	0	0	1893	2890	2919	4016	3098	3757	2221	3203	3526	27	416	252	1721	2348	2688	3441	2890	1964	2315	2573	3598	2844
			Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	790	576	47	507	635	441	12	544	342
			EU.España	10884	9702	8475	8263	10355	14705	14656	16782	22096	17849	15393	12513	7110	13739	11250	10133	10572	11120	8365	7618	7454	6675	7494	11966	11272	13100	10914	10082	10736	10058	11469	11595
			EU.France	4122	3435	4024	3261	5023	5576	6888	12719	12263	8363	9171	5980	5624	5529	5949	4948	4293	3940	2926	2816	2984	1629	1130	2313	3329	3507	3756	3222	3549	2548	4566	3792
			EU.Ireland	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	10	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	
			EU.Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			EU.Portugal	7428	5036	2818	5295	6233	5718	5796	5616	3099	9662	5810	5437	6334	3314	1498	1605	2590	1655	3204	4146	5071	5505	3422	5605	3682	6920	6128	5345	3869	3135	2187	2789
			EU.United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	32	0	0	0	0	0	0	0	0
			El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	992	1450	1726
			FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	21	0	28	6	0	2	3	0	2	0	0	0	0	0	0	
			Gabon	0	0	0	0	0	0	0	1	87	10	0	0	0	184	150	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Ghana	1720	1178	1214	2158	5031	4090	2866	3577	4738	5517	4751	10174	10647	11704	5632	9864	6480	9061	17888	8860	2307	2559	3372	4515	6253	3541	4276	3818	4216	6815	6096	4299
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	736	831	998	949	836	998	913	1011	282	262	163	993	340	1103	1528
			Guinea Ecuatorial	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	50	0	58	0	3	10	17	4	11
			Guinée Rep.	0	0	0	0	0	0	0	0	0	334	2394	885	0	0	0	0	0	0	0	0	0	0	0	0	328	322	1516	1429	902	0	0	
			Honduras	0	0	0	0	0	0	44	0	0	61	28	59	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Japan	23081	18961	32064	39540	35231	30356	34722	35053	38503	35477	33171	26490	24330	21833	24605	18087	15306	19572	18509	14026	15735	17993	16684	16395	15205	12306	15390	13397	13603	12391	10316	10977
			Korea Rep.	6084	4438	4919	7896	2690	802	866	377	386	423	1250	796	163	124	43	1	87	143	629	770	2067	2136	2599	2134	2646	2762	1908	1151	1039	675	562	432
			Liberia	0	0	0	206	16	13	42	65	53	57	57	57	57	57	57	57	57	57	0	0	0	0	0	0	0	0	0	0	0	0	27	
			Libya	0	0	0	0	0	0	508	1085	500	400	400	400	400	400	400	31	593	593	0	0	4	0	0	0	0	0	0	0	0	0	0	
			Maroc	0	8	2	8	68	206	81	774	977	553	654	255	336	1444	1160	1181	1154	1399	1145	786	929	700	802	795	276	300	300	308	300	309	350	411
			Mauritania	0	0	0	0	0	0	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	
			Mexico	0	0	0	0	0	0	0	1	4	0	2	6	8	6	2	2	7	4	5	4	3	3	1	1	3	1	1	2	1	2	2	2
			Namibia	0	0	0	0	0	0	0	0	715	29	7	46	16	423	589	640	274	215	177	307	283	41	146	108	181	289	376	135	240	465	359	355
			Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	
			Norway	0	0	60	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Panama	5173	5701	3865	3242	6150	7446	9991	10138	13234	9927	4777	2098	1252	580	952	562	211	0	1521	2310	2415	2922	2263	2405	3047	3462	1694	2774	2315	1289	2337	1590
			Philippines	0	0	0	0	0	0	0	0	0	0	0	0	1154	2113	975	377	837	855	1854	1743	1816	2368	1874	1880	1399	1267	532	1323	1964	0	0	
			Russian Federation	0	0	0	0	0	0	5	0	0	0	13	38	4	8	91	0	0	0	0	1	1	26	73	43	0	0	0	0	0	0	0	
			S. Tomé e Príncipe	0	0	5	8	6	3	4	4	3	6	4	5	6	5	4	4	4	4	11	6	4	0	92	94	97	100	103	107	110	633	421	393
			Senegal	144	470	137	0	0	10	5	9	126	237	138	258	730	1473	1131	1308	565	541	574	721	1267	805	926	1042	858	239	230	646	371	1031	1500	3020
			Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			South Africa	168	200	561	367	296	72	43	88	79	27	7	10	53	55	249	239	341	113	270	221	84	171	226	159	145	153	47	435	332	193	121	218
			St. Vincent and Grenadines	0	0	0	0	0	154	818	1740	812	519	596	545	1937	2940	1921	1143	130	103	18	0	114	567	171	293	396	38	25	16	30	496	622	889
			Trinidad and Tobago	0	0	1	19	57	263	0	3	29	27	37	36	24	19	5	11	30	6	5	9	12	27	69	56	40	33	33	37	59	77	37	28
			U.S.A.	1085	1074	1127	847	623	975	813	1090	1402	1209	882	1138	929	1263	574	1085	601	482	416	484	991	527	508	515	571	722	867	881	859	831	525	773
			U.S.S.R.	1071	1887	1077	424	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
			UK.Sta Helena	0	5	1	1	3	3	10	6	6	10	10	12	17	6	8	5	5	0	0	0	25	18	28	17	11	190	51	19	17	44	77	44
			UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	0	
			Uruguay	177	204	120	55	38	20	56	48	37	80	124	69	59	28	25	51	67	59	40	62	83	22	27	201	23	15	2	30	0	0	0	
			Vanuatu	0	0	0	0	0	470	676	1807	2713	2610	2016	828	0	314	0	0	0	0	104	109	52	132	91	34	42	39	23	9	4	0	0	
			Venezuela	1136	349	332	115	161	476	270	809	457	457	189	274	222	140	221	708	1241	847	1060	243	261	318	122	229	85	264	98	94	169	132	156	152
		NCC	Chinese Taipei	1125	1488	1469	940	5755	13850	11546	13426	19680	18023	21850	19242	16314	16837	16795	16429	18483	21563	17717	11984	2965	12116	10418	13252	13189	13732	10805	10316	13272	16453	13115	12028
			Guyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	25	10
		NCO	Argentina	41	72	50	17	78	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Benin	15	6	7	8	10	10	7	8	9	9	9	30	13	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Cambodia	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Congo	19	10	10	14	15	12	12	14	9	9	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Cuba	171	190	151	87	62	34	56	36	7	7	5	0	0	0	0	0	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Dominica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Faroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	11	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Grenada	0	0	0	0	0	65	25	20	10	10	0	1	0	0	0	0	0	0	0	0	0	10	31	0	0	0	0	0	0	0	0	
			NEI (ETRO)	0	0	0	0	0	357	364	42	356	915	0	7	0	0	0	362	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			NEI (Flag related)	758	1406	2155	4650	5856	8982	6146	4378	8964	10697	11862	16565	23484	22190	15092	7907	383	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Saint Kitts and Nevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
			Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	0	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Sta. Lucia	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	2	0	2	0	0	0	0	0	0	0	0	0	6	0	
			Togo	24	22	7	12	12	6	2	86	23	6	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landings(FP)	A+M	CP	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	46	42	16	41	23	0	0	
			Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	28	37	38	61	102	40	22	45	97	0	0	
			Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	25	20	13	117	59	46	60	34	42	0	0	
			Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	95	45	0	0	0	
			EU.España	34	355	204	192	242	625	571	764	605	371	58	255	328	487	474	0	0	223	244	143	88	49	190	250	211	216	98	80	143	0	0	
			EU.France	8	154	233	281	352	653	686	1032	970	713	314	437	467	553	607	229	205	446	397	222	79	26	51	150	122	394	192	56	54	0	0	
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	28	15	26	9	18	6	11	5	15	0	0	
			Guinée Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	0	60	20	22	74	203	288	245	209	0	0	
			Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	106	135	97	85	38	70	41	80	27	0	0	
		NCO	Mixed flags (EU tropical)	7	103	164	172	153	663	379	494	457	582	169	301	193	143	281	28	8	198	378	294	189	348	337	375	324	257	0	0	0	989	1187	972
Discards	A+M	CP	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
			South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	

Table 4. Changes in the average annual catches (t) for each gear group during the periods 2010-2015 and 2016-2017. Also shown the percentage change for each gear group.

	CPCs group A			CPCs group B		
	2010-2015	2016-2017	% change	2010-2015	2016-2017	% change
LL	34,118	30,463	-11%	3,339	4,705	41%
PS	14,617	15,198	4%	10,261	13,760	34%
BB	8,537	6,820	-20%	859	685	-20%
HL				2,232	6,236	179%
others	127	314	148%	311	265	-15%

Table 5. Atlantic bigeye tuna ICCAT SCRS catalogue on statistics (Task-I and Task-II) of the major 50 flags (July 18, 2018).

Species	Stock	Status	FlagName	GearGrp	DSet	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
BET	A+M	CP	Japan	LL	t1	31664	39419	35024	29488	34128	35053	38503	35477	33171	26490	24330	21833	24605	18087	15306	19572	18509	14026	15735	17993	16684	16395	15205	12306	15390	13397	13603	12391	10316	10977
BET	A+M	CP	Japan	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	NCC	Chinese Taipei	LL	t1	1469	940	5744	13850	11546	13426	19680	18023	21850	19242	16314	16837	16795	16429	18483	21563	17717	11984	2965	12116	10418	13252	13189	13732	10819	10316	13272	16453	13115	12028
BET	A+M	NCC	Chinese Taipei	LL	t2	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab
BET	A+M	CP	EU.España	PS	t1	5600	5091	6302	9395	9362	12495	12700	9971	8970	6240	4863	5508	6901	5923	7038	6595	4187	3155	3416	3359	5456	8019	7910	8050	7485	6849	6464	5574	6808	6064
BET	A+M	CP	EU.España	PS	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	NCO	NEI (Flag related)	LL	t1	2155	4650	5856	8982	6146	4378	8964	10697	11862	16565	23484	22190	15092	7907	383															
BET	A+M	NCO	NEI (Flag related)	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1															
BET	A+M	CP	EU.España	BB	t1	2588	2761	3814	5484	5518	4901	9848	8073	6248	6260	2165	8563	4084	3897	3164	4158	3838	4417	3783	3007	1959	3868	2819	4506	2913	2389	3463	3508	3835	4811
BET	A+M	CP	EU.España	BB	t2	abc	abc	abc	ac	ac	ac	ac	ac	ac	abc	ac	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	EU.Portugal	BB	t1	2724	5279	6159	5598	5639	5493	3036	9629	5810	5437	6334	3314	1498	1605	2420	1572	3161	3721	4626	4872	2738	5121	2872	6470	5986	5240	3737	3012	1677	2408
BET	A+M	CP	EU.Portugal	BB	t2	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab
BET	A+M	CP	EU.France	PS	t1	1754	1502	2636	3971	5682	11733	11046	7076	7128	4671	4149	4056	4620	3584	3668	3628	2736	2135	2481	1157	1039	2193	3294	3663	3766	3253	3528	2531	4184	3582
BET	A+M	CP	EU.France	PS	t2	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	China PR	LL	t1						70	428	476	520	427	1503	7347	6564	7210	5840	7890	6555	6200	7200	7399	5686	4973	5489	3720	3231	2371	2232	4942	5852	5514
BET	A+M	CP	China PR	LL	t2						-1	b	b	b	-1	a	a	a	ab	ab	a	ab	ab	ab	a	ab	ab	ab	ab	ab	ab	abc	ab	abc	-1
BET	A+M	CP	Ghana	PS	t1									1328	2970	3138	6648	3468	5621	5606	5330	6201	5444	2136	2369	2868	3558	5370	3030	3914	3356	3410	6249	5757	3990
BET	A+M	CP	Ghana	PS	t2									abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Ghana	BB	t1	1214	2158	5031	4090	2866	3577	4738	5517	3423	7204	7509	5056	2164	4242	873	3731	11687	3416	171	190	504	957	883	511	362	461	806	564	339	309
BET	A+M	CP	Ghana	BB	t2	abc	abc	ac	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Panama	PS	t1	18	85	717	1013	2517	4113	5378	4304	1934	431	175	319	378	89	63		1521	2461	2521	3057	2360	2490	3085	3531	1736	2853	2341	1289	2022	1485
BET	A+M	CP	Panama	PS	t2	b	b	b	ab	a	ab	ab	ab	ab	ab	ab	a	ab	ab	ab		ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Panama	LL	t1	3847	3157	5258	6320	7474	5998	7709	5623	2843	1667	1077		484	473	148														315	105
BET	A+M	CP	Panama	LL	t2	-1	-1	-1	-1	a	-1	-1	-1	-1	-1	-1		a	-1	-1														-1	-1
BET	A+M	CP	Curaçao	PS	t1									1893	2890	2919	3428	2359	2803	1879	2758	3343	13	441	272	1734	2465	2747	3488	2950	1998	2357	2573	3598	2844
BET	A+M	CP	Curaçao	PS	t2									ab	ab	ab	a	ab	ab	ab	ab	ab	b	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Korea Rep.	LL	t1	4919	7896	2690	802	866	377	386	423	1250	796	163	124	43	1	87	143	629	770	2067	2136	2599	2134	2646	2762	1908	1151	1039	677	562	432
BET	A+M	CP	Korea Rep.	LL	t2	ab	ab	ab	ab	ab	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	ab	ab	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Brazil	LL	t1	946	512	591	350	790	1256	596	1935	1707	1237	644	2024	2762	2534	2582	2374	1379	1014	1423	927	785	1009	1055	1452	1165	1377	1966	2606	2322	1044
BET	A+M	CP	Brazil	LL	t2	ab	ab	ab	ab	ab	ab	ab	ab	a	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	a	a	a	-1
BET	A+M	CP	EU.France	BB	t1	2503	2040	2739	2258	1892	2018	2187	2000	2357	1746	1942	1998	1921	1593	786	758	587	597	571	261	141	269	156	238	175	25	74	51	135	127
BET	A+M	CP	EU.France	BB	t2	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Philippines	LL	t1											1154	2113	975	377	837	855	1854	1743	1816	2368	1874	1880	1399	1267	532	1323	1964			
BET	A+M	CP	Philippines	LL	t2											a	a	a	-1	-1	a	a	a	a	a	a	ab	ab	abc	abc	abc	abc			
BET	A+M	CP	Brazil	HL	t1																			3	7	0	69	22	210	555	2012	4332	4967	5336	6538
BET	A+M	CP	Brazil	HL	t2																			-1	-1	-1	-1	a	-1	-1	-1	a	-1	-1	b
BET	A+M	CP	U.S.A.	LL	t1	710	600	559	855	564	836	943	982	713	795	696	930	532	682	536	284	310	312	521	381	428	430	443	603	582	509	584	574	386	572
BET	A+M	CP	U.S.A.	LL	t2	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Cape Verde	PS	t1																		1151	1433	1283	482	605	655	1076	734	1377	2361	2757	1679	1048
BET	A+M	CP	Cape Verde	PS	t2																	b	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab
BET	A+M	CP	Senegal	BB	t1	4			5		5	11	60	84	204	676	1473	1131	1308	565	541	574	721	1267	804	926	1041	843	215	226	639	361	501	577	287
BET	A+M	CP	Senegal	BB	t2	ab	ab	b	a		a	a	a	ac	a	a	ab	a	ab	ab	ab	ab	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac
BET	A+M	CP	EU.España	LL	t1	491	603	481	451	347	150	153	176	233	268	385	116	598	211	333	427	417	104	337	346	268	327	751	700	585	865	928	868	604	646
BET	A+M	CP	EU.España	LL	t2	ab	ab	ab	ab	ab	ab	ab	ab	ab	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	b	b	b	b
BET	A+M	CP	Guatemala	PS	t1																736	831	1054	977	851	1024	922	1029	288	273	168	1007	340	1103	1528
BET	A+M	CP	Guatemala	PS	t2																ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc
BET	A+M	CP	Vanuatu	PS	t1				470	676	1807	2713	2610	2016	828		314																		
BET	A+M	CP	Vanuatu	PS	t2		b		a	a	a	a	a	a	a		a																		
BET	A+M	NCO	Mixed flags (EU tropical)	PS	t1	164	172	153	663	379	494	457	582	169	301	193	143	281	28	8	198	378	294	189	348	337	375	324	257				989	1187	972
BET	A+M	NCO	Mixed flags (EU tropical)	PS	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	b	b	-1	-1	-1	-1	-1	-1	-1	b	b	b	b	b	b	b	b	-1	-1	-1
BET	A+M	CP	Maroc	LL	t1												700	770	857	913	889	929	519	887	700	802	795	276	99	90	88	80	100	100	123
BET	A+M	CP	Maroc	LL	t2												-1	-1	-1	-1	b	abc	abc	abc	abc	ab	ab	-1	-1	-1	-1	b	ab	a	ab
BET	A+M	CP	Belize	PS	t1											195		87	96								186	246	704	1246	1274	1362	1654	1290	975
BET	A+M	CP	Belize	PS	t2											a		ab	ab		b						abc	ab	ab	ab	ab	ab	ab	ab	abc
BET	A+M	CP	Guinée Rep.	PS	t1								334	2394	885								72		60	20	22	402	525	1804	1674	1111			
BET	A+M	CP	Guinée Rep.	PS	t2								a	a	a								-1		-1	-1	-1	-1	-1	ac	ac	ac			
BET	A+M	CP	St. Vincent and Grenadines	LL	t1											1412	1870	1215	506	15	103	18		114	567	171	292	396	37	25	15	30	496	622	889
BET	A+M	CP	St. Vincent and Grenadines	LL	t2											-1	-1	-1	-1	a	a	a		a	a	a	a	a	a	ab	a	ab	a	ab	ab
BET	A+M	CP	Maroc	PS	t1	2	8	68	206	81	774	977	553	654	255	336	744	390	324	241	510	216	267	42											
BET	A+M	CP	Maroc	PS	t2	b	b	b	ab	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab											
BET	A+M	CP	Venezuela	PS	t1	101	22	53	321	169	326	140	140	131	205	214	75	181	513	1055	690	611	92	211	220	102	122	49	223	87	70	121	88	112	107
BET	A+M	CP	Venezuela	PS	t2	ab	a	a	-1	-1	b	ab	ab	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	-1
BET	A+M	CP	St. Vincent and Grenadines	PS	t1				154	817	1737	812	519	521	418	327	193	139	422																
BET	A+M	CP	St. Vincent and Grenadines	PS	t2				ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab																
BET	A+M	CP	U.S.A.	RR	t1	134	180	47	74	104	149	263	20	147	334	228	318	34	366	50	192	101	165	447	127	71	78	118	110	270	345	252	198	127	193
BET	A+M	CP	U.S.A.	RR	t2	ab	ab	ab	ab	ab	ab	ab	ab	b	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	-1
BET	A+M	CP	EU.Portugal	LL	t1			23	50	53	11		33					1		170	83	42	332	443	633	619	484	527	273	133	100	131	112	500	364
BET	A+M	CP	EU.Portugal	LL	t2			a	a	a	-1		a					-1		a	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab
BET	A+M	CP	Libya	LL	t1					308	785	400	400	400	400	400	400	400	31	593	593			4											
BET	A+M	CP	Libya	LL	t2					-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			-1											
BET	A+M	CP	Canada	LL	t1	95	31	10	26	67	124	111	147	133	161	109	244	285	220	265	161	135	169	172	137	107	107	97	121	155	190	186	249	166	208
BET	A+M	CP	Canada	LL	t2	b	b	b	-1	a	a	a	a	a	a	a	ab	ab	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	ab
BET	A+M	CP	Namibia	LL	t1							708			3		286	482	280	196	150	133	276	228	26	112	48	133	26	196	35	186	371	236	264
BET	A+M	CP	Namibia	LL	t2							a			-1		a	-1	ab	a	-1	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	a	-1
BET	A+M	CP	El Salvador	PS	t1														3														992	1450	1726
BET	A+M	CP	El Salvador	PS	t2														a														abc	abc	abc
BET	A+M	CP	Senegal	PS	t1	133																											429	895	2686
BET	A+M	CP	Senegal	PS	t2	ab	a	a																									abc	abc	ac
BET	A+M	CP	Curaçao	BB	t1												588	740	955	342	445	183	27												
BET	A+M	CP	Curaçao	BB	t2												a	ab	ab	ab	ab	ab	ab												
BET	A+M	CP	South Africa	LL	t1	8										53	37	201	135	319	105	222	220	78	148	200	127	137	124	35	294	282	143	111	196
BET	A+M	CP	South Africa	LL	t2	a										a	ab	ab	ab	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab
BET	A+M	CP	Brazil	BB	t1							5				132		6	126	0	81	42	56	48	650	159	93	97	174	401	235	159	178	2	113
BET	A+M	CP	Brazil	BB	t2							a				a		-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	-1
BET	A+M	NCO	NEI (ETRO)	PS	t1				357	364	42	356	915		7				362	68															
BET	A+M	NCO	NEI (ETRO)	PS	t2	b	b	a	abc	ac	abc	abc	abc	c	ac	c	c	c	abc	abc	c	c	c	c	c			a							
BET	A+M	CP	Venezuela	LL	t1	113	27	49	99	14	355	246	292	57	57	4	61	38	17	33	66	278	80	23	84	6	102	31	27	9	18	30	44	31	35
BET	A+M	CP	Venezuela	LL	t2	b	b	b	-1	-1	-1	-1	-1	-1	b	b	ab	a	-1	-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	-1
BET	A+M	CP	S. Tomé e Príncipe	PS	t1	5	8	6	3	4	4	3	6	4	5	6	5	4	4	4	4	11	6	4		86	88	91	100	103	107	110	633	421	393
BET	A+M	CP	S. Tomé e Príncipe	PS	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
BET	A+M	CP	Japan	PS	t1	400	121	207	868	594																									
BET	A+M	CP	Japan	PS	t2	ab	ab	a	a	-1																									
BET	A+M	CP	South Africa	BB	t1	553	367	296	72	43	88	76	27	7	10		18	48	104	22	8	49	1	6	15	23	32	8	28	12	142	50	50	10	22
BET	A+M	CP	South Africa	BB	t2	a	a	a	a	a	a	a	a	a	a		a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
BET	A+M	CP	St. Vincent and Grenadines	BB	t1									71	125	196	876	566	215	116															
BET	A+M	CP	St. Vincent and Grenadines	BB	t2									a	a	a	ab	ab	ab	ab	b														
BET	A+M	CP	Côte d'Ivoire	LL	t1																						790	576						465	311
BET	A+M	CP	Côte d'Ivoire	LL	t2																						a	a						a	-1
BET	A+M	CP	Belize	LL	t1								10		5			47						4	60	70	60	48	556	12	103	163	224	474	287
BET	A+M	CP	Belize	LL	t2								a		a			a						a	a	a	ab	ab	ab	ab	a	a	ab	a	-1

Table 6. Atlantic bigeye tuna total catch distribution by fishery fleet ID (1-15) for stock synthesis assessment model input.

	Fleet														
YearC	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1950	0	0	0	0	0	0	0	0	808	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	1651	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	2018	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	2951	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	2932	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	4808	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	2769	0	10	0	0	0	0
1957	0	0	0	0	0	0	0	0	8266	0	454	0	0	0	0
1958	0	0	0	0	0	0	0	0	3837	0	453	0	0	0	0
1959	0	0	0	0	0	0	0	0	6254	0	1478	0	0	0	0
1960	0	0	0	0	0	0	0	0	6127	0	2904	0	0	26	56
1961	0	0	0	0	0	0	0	0	5805	0	10932	112	0	211	0
1962	0	0	0	0	0	92	334	0	6686	6	15487	228	0	100	199
1963	0	0	0	0	0	410	2005	0	8512	52	14391	47	0	77	545
1964	5	0	0	0	0	168	702	0	4828	529	15665	1142	0	163	428
1965	0	0	0	0	0	127	8	0	9687	3052	23128	2358	0	589	445
1966	20	0	0	0	0	9	33	0	5278	2153	12119	3303	0	1765	705
1967	92	0	0	0	0	665	1446	0	9323	701	6729	1119	0	3679	1498
1968	436	0	0	0	0	671	125	0	2996	1326	7618	1342	5	7905	1488
1969	2970	0	0	0	0	652	1972	0	7146	253	7436	2577	263	10871	2749
1970	3389	0	0	0	0	663	1122	0	8733	2531	4987	1476	234	17415	1885
1971	4116	0	0	0	0	1222	741	0	9883	7550	11895	813	164	16846	2637
1972	4690	0	0	0	0	1874	388	0	7042	4251	13168	659	286	12530	2399
1973	4918	0	0	0	30	2521	792	0	10277	7357	11847	751	319	15822	2358
1974	6636	0	0	0	73	2826	908	0	14115	15955	4452	455	316	16242	2115
1975	5318	0	0	0	84	576	1444	0	12532	6860	9881	650	313	21252	2391
1976	7037	0	0	0	170	1325	1320	0	7154	4733	2423	142	1360	16105	3533
1977	11875	0	0	0	237	1822	2616	0	8083	2801	6218	118	1396	16774	2940
1978	9094	0	0	0	121	1233	4075	0	9200	3490	5718	93	550	15958	3161
1979	8343	0	0	0	183	1032	1997	0	6379	4107	7472	378	465	12394	3225
1980	9183	0	0	0	281	2165	0	2153	7881	6720	13229	527	313	18557	2586
1981	15465	0	0	0	779	2436	0	1604	5662	6554	13603	887	130	19256	1493
1982	14274	0	0	0	791	1440	0	1672	3454	3212	28964	690	358	16393	2433
1983	15618	0	0	0	487	175	0	3110	6267	2479	12367	296	750	15838	2198
1984	15323	0	0	0	2147	117	0	3213	6820	3277	20341	692	776	17053	1410
1985	7120	0	0	0	1887	13	0	4816	11415	3478	27480	643	864	18709	1836
1986	0	9058	0	0	1708	0	0	4031	10155	3635	18344	820	1597	14414	1681
1987	0	7758	0	0	1116	0	0	2783	9562	3345	14443	787	1386	13203	3032
1988	0	8464	0	0	1214	442	0	2631	5423	2745	28164	755	1045	11637	3890
1989	0	7023	0	0	2158	166	0	2466	7882	3065	35717	637	823	14236	4546
1990	0	10160	0	0	5031	329	0	3244	9676	4141	30088	795	661	18623	2515
1991	0	0	3425	14042	4090	108	0	2700	10842	3940	24548	1000	1105	29122	2274
1992	0	0	4616	16247	2866	77	0	2356	10949	4099	28922	1108	1049	26395	1434
1993	0	0	9558	24318	3577	7	0	2927	9957	2134	31938	982	1393	23944	3128
1994	0	0	6310	28391	4738	243	0	2930	12449	1944	33665	2894	1691	34713	4968
1995	0	0	3829	23199	5517	234	0	2869	16956	1338	31318	2821	1421	35609	2916
1996	0	0	3413	22427	4751	481	0	3319	11077	2520	28985	1665	1177	37984	2951
1997	0	0	3045	14131	10174	280	0	2743	11049	2979	22757	754	1489	39847	1020
1998	0	0	2620	10762	10647	90	0	3785	7747	3290	19992	1048	1704	45253	997
1999	0	0	2684	12110	11704	147	0	7116	9982	3159	17522	1151	3273	50608	2185
2000	0	0	2987	12444	5632	218	0	5739	4245	3206	20937	463	2254	42372	3230
2001	0	0	3002	11149	9864	703	0	4968	4626	4279	13281	527	2954	34528	1319
2002	0	0	3419	10606	6480	1183	0	2680	3787	2551	12281	474	2049	27258	2958
2003	0	0	3517	11603	9061	808	0	2150	4762	2778	15741	1053	1774	32933	1523
2004	0	0	2504	11331	17888	176	0	2728	5819	3338	14529	642	1774	27732	1596
2005	0	0	2095	8605	8860	200	0	2150	7293	2971	10791	264	1794	21773	1093
2006	0	0	4663	7053	2307	139	0	2768	7484	1750	13864	121	2406	15620	965
2007	0	0	2813	7821	2559	27	0	2037	7590	190	17650	154	1808	25875	987
2008	0	0	2665	10049	3372	37	0	1246	4726	170	15731	783	1687	21723	1174
2009	0	0	4361	13169	4515	71	0	2156	8350	248	15908	239	1530	24828	949
2010	0	0	4251	15582	6253	36	0	2050	4784	239	14818	148	2109	25147	515
2011	0	0	4050	17960	3541	18	0	1681	10419	195	11984	127	1547	23899	945
2012	0	0	4125	16667	4276	63	0	1583	8803	90	13100	2200	1746	17610	794
2013	0	0	3912	16338	3818	158	0	2931	7697	51	11868	1478	1861	16000	1735
2014	0	0	4449	16751	4216	10	0	5221	7026	181	12977	446	2159	20590	1003
2015	0	0	3380	16468	6814	116	0	5795	6494	33	11425	933	2106	25830	777
2016	0	0	4898	19851	6096	169	0	6843	4774	4	9793	519	2237	23973	752
2017	0	0	3552	19863	4299	180	0	7809	6462	12	10298	667	2374	20734	731

Table 7. CAS matrix in 5 cm class bins for Atlantic bigeye tuna used in the stock assessment.

Li5cm	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
20	0	0	0	0	4	2	0	0	0	0	0	0	0	1	0	0	0	0	0	33	13	4	4	29	92	126	175	197	292	21	78	0	75	90	360	249	115	41	11605	95	1	1402	1334
25	0	0	0	321	0	3663	246	340	335	164	98	102	1298	1271	1363	1581	5770	4717	4857	4751	3877	1144	2275	2505	1687	2143	1191	1211	3490	7116	6540	3470	4126	12076	7418	3452	11507	2954	5539	9088	12463	16602	31983
30	643	1042	1021	9397	235	3551	44493	27569	28753	24127	27270	24544	85814	113242	101772	107114	312890	281522	289207	254645	216114	73663	186262	167035	78796	81022	64552	30973	120325	194925	111546	87406	107261	251325	139191	137151	117765	135923	151820	382945	2616948	394801	515006
35	17792	126058	82086	32926	38500	112910	325318	250400	223570	231469	203332	214180	434230	456070	471259	487586	1141675	1101713	1107843	1186130	860438	440110	932504	760689	851723	863366	652184	325583	940887	1191667	727035	469812	582844	950186	831028	1290059	929412	719814	914984	1278823	3445268	1386028	1320081
40	111321	418562	264101	243835	141051	238032	676539	559360	315494	529781	417170	433913	473276	455052	671376	905201	1696208	1441767	2094417	1973339	1669716	1595392	1461679	1562559	1683666	1450218	1679296	1393871	1864813	2524649	1331998	667609	904966	1226739	1338682	1903963	2041982	1210230	1362374	1692056	1447684	2146670	1781104
45	222496	509560	525401	325045	372976	460262	670324	693280	558093	811535	628391	845682	532113	552071	959943	1500534	1689470	1601427	2258587	3139661	2755159	2853330	2742007	2407116	2570182	1704655	1683791	1709965	1867413	3569883	2071944	869927	942709	1105554	1037235	1635834	1537444	1131103	1090509	1210226	1149596	1557500	1697621
50	140346	320623	385553	212038	202274	352030	444109	539630	425426	504074	316378	397926	251647	276833	405408	791808	839514	1050931	1534626	1791324	1519847	1428387	2307435	2013993	1888800	1417988	1128171	1171489	1338792	2027833	1364519	599586	636190	679398	731756	967549	835485	910162	909992	872739	958752	1189814	1385025
55	93511	294971	347241	272279	179671	285764	401838	417039	341122	424951	288833	364279	191338	214208	282605	442617	421479	571205	756554	685502	529061	596534	685696	811181	809786	824068	543204	601885	609246	756827	496334	339398	232677	352726	449372	488356	521550	568632	660938	574634	637995	809509	939002
60	90701	224963	167894	224247	132143	142071	226248	161830	172719	286226	207624	266344	157042	126064	167128	248251	297681	324159	496748	482030	340045	326208	247681	344737	426227	431279	342805	365747	297231	420508	274222	196037	142054	186465	273953	290488	340379	366263	364071	360194	398549	563875	623026
65	73892	131421	102126	159072	84467	92339	124341	97068	129019	263324	182976	201105	126063	89370	98339	162609	227491	228309	304138	373148	304761	173476	149984	168823	270813	235404	226277	216973	216042	236134	172172	124436	97223	123822	199336	168709	225437	213180	177247	172371	287601	347068	342776
70	32221	52483	62695	115145	62058	72741	84330	74269	72164	172684	126841	186897	85571	65525	96889	108810	206542	170016	170784	267203	278766	135601	172772	105382	208982	126628	127237	94129	129473	137159	74851	72289	58136	82519	127671	89925	141922	98126	105613	91778	147118	191476	192751
75	30380	40767	55231	107138	59675	74971	84121	78986	117588	176209	179140	287875	97574	70141	115741	92317	188485	135433	203829	257560	320322	151221	171617	86489	194739	125254	141551	84704	126890	147024	86417	70087	65864	50428	115766	93292	125052	77810	100967	91162	127334	160159	160062
80	56241	47585	63998	101444	69274	69548	92241	75367	134780	150573	163378	189122	86517	65714	96958	84083	154321	122682	221297	238922	255084	141981	167232	110328	222308	152455	118169	74648	103870	108009	67569	55469	58023	49931	108692	94859	104714	96705	129742	94071	116700	137866	113643
85	78300	48544	69396	82337	71087	43489	89682	75758	91591	86500	113870	119072	61462	78813	73408	105170	142217	108369	230394	224214	196823	139631	140709	105023	193830	163748	113141	69627	90812	95263	67491	48914	54393	46475	101860	91497	96148	105706	144321	67480	110527	138336	123475
90	116292	43922	65912	76209	90050	53323	78814	63212	79224	94274	100513	75618	57428	90256	55593	120298	127432	121567	164539	226959	166240	147171	131696	186293	234548	189962	118632	71125	75768	98725	75176	72247	66637	57302	106414	80321	84144	126680	108356	58414	75302	128832	100690
95	114007	49552	82368	86816	105863	55269	68935	60119	70349	92564	93159	69105	71209	95472	51794	122544	121711	133439	150901	209372	150928	166422	150400	180462	233005	201971	119212	76417	72405	83998	80575	112939	63103	61143	88033	84207	105564	120744	107990	76375	74000	125734	98341
100	92838	46103	86565	73176	88293	68435	83373	90423	80097	115466	111589	75672	86847	106418	75768	126697	127472	163975	161879	166213	160478	157171	136826	150574	204265	205371	137912	90524	74061	86715	92016	127179	77432	78687	90715	84257	96601	115044	79941	105319	73931	100372	85156
105	57214	44770	66446	57376	48642	89826	75918	100240	66853	88903	87723	77013	79991	105509	81672	131126	137176	158415	162415	189423	158040	136291	122375	160009	233319	220627	141911	83823	72371	70494	69823	94821	54510	59317	75524	76519	104043	92737	87819	128199	76253	82706	70776
110	55393	45063	59736	62847	49201	128279	89993	102936	69523	99134	91891	78510	74317	103520	101693	123268	110965	160327	128571	167698	158881	145922	131357	144211	189016	165962	139228	82888	67454	76387	70127	93782	75067	52947	63841	54282	90934	80142	77543	59356	89830	79950	76082
115	66632	43415	66351	63943	51112	134448	96480	105888	77856	108197	110447	99617	81218	119967	139263	140400	131344	165377	148884	219839	224644	158494	157808	141565	203391	198115	140140	98651	85822	85572	66397	82386	67382	53583	74413	70719	102979	86108	82924	83208	85064	77367	67778
120	80721	48029	64295	64525	64191	132159	100379	111396	78173	105044	114919	100208	79567	118531	134440	130882	128333	170609	144388	161924	210728	165903	164094	155072	170769	173932	154690	113768	92192	89563	78320	76983	81914	63533	88800	72150	85061	73776	58853	63338	72825	66065	60988
125	77130	51651	74733	64377	55938	95993	95769	115860	87270	95092	111636	95325	85110	127430	148411	152039	218289	162764	167641	142929	142016	143638	192672	186273	157604	152856	148856	99986	107811	106951	75558	57969	65487	60144	81097	71751	79141	79691	56665	76701	68713	64487	57540
130	84077	50429	63970	54799	56601	90411	106907	118806	86425	91345	119758	85658	80019	108362	123966	126825	174679	118205	127198	109140	108097	109236	146913	135822	125559	113288	126037	91346	100120	96217	74756	56454	70126	70037	82236	66765	65865	67501	54132	71093	67438	61553	60233
135	78668	57520	68575	52849	44313	59487	91685	108418	77265	88474	113137	76785	78924	105135	115068	124422	150479	111372	119363	126443	110969	115501	119917	101401	112113	75237	103361	93695	141594	102134	72213	48743	66449	65548	81529	74096	65167	71460	58283	76900	66933	59238	49746
140	69144	50315	64722	50976	38901	72764	78105	88117	59333	71424	96526	68857	90492	71804	97641	92178	85258	86364	101849	116059	108143	116094	94672	98398	96837	66196	85091	85289	118278	79137	61658	51129	65090	64269	69738	58238	55239	50818	45929	57699	65322	53006	51800
145	58159	44759	55583	39303	34131	46754	53676	62559	46652	56347	78013	53088	63363	53271	83793	77026	68992	65526	91646	121253	91340	94593	63062	67508	72977	52648	62641	60060	91011	63824	54382	46971	55514	51534	64497	60550	52323	56208	46748	62079	58479	47720	50131
150	47406	34903	38965	32899	30864	56882	47858	51097	36552	44606	63445	39839	46503	39399	59059	52616	45339	58672	63999	75713	79059	78276	56185	60538	57980	39901	44064	43179	55840	49611	42071	44765	57715	46957	57025	59877	44775	39754	39345	44444	49216	45125	49070
155	39176	33177	30001	28924	26881	29853	34055	47195	31300	31992	43633	28690	27143	30457	43381	37959	35514	46646	50982	71939	53991	63048	42597	42133	43328	29017	27501	32798	37922	38690	33287	35431	46271	38059	52267	51846	40977	36688	35976	39991	38266	38459	50658
160	36339	26512	29739	28026	25602	34441	33596	35297	26635	24626	35530	27246	21937	22623	30475	22198	26915	37810	36098	47530	52408	61666	37969	33187	35288	33642	21449	26882	31192	37708	26796	32210	48966	36399	37811	35620	35484	27107	29364	30722	34604	35017	29958
165	26851	19060	22275	21672	18716	16718	21136	25285	23460	22028	22428	16731	14536	16239	24217	14623	16105	25169	29383	40953	38925	52019	23590	24368	21807	24691	16351	19131	23435	23679	19741	22893	37833	27321	31480	33879	29548	23032	28530	29137	26455	26036	23131
170	24479	15666	13277	19500	15006	17492	14532	14948	14139	12376	12217	8709	7940	10583	12803	8058	8205	17228	16756	25712	33290	36677	19203	19254	19039	23263	12428	13092	16553	13489	14089	14868	33210	23382	22170	24091	20680	14929	18963	24081	19469	19319	15845
175	17718	7220	8172	10760	10530	6253	6874	8958	9604	6760	5259	3896	4786	5863	6861	3005	3992	9644	10977	18640	22574	20294	10744	11298	10621	10917	9295	11228	11324	7503	8218	7855	20923	15344	14794	17216	13993	13800	13711	19752	15251	13803	11119
180	13062	6187	6089	8643	7588	5664	6426	3450	5701	3131	2177	1872	1106	2053	2597	1939	3014	3019	3933	8995	16986	15779	9712	8501	7456	6208	5366	4842	5676	4253	5916	4124	14436	11937	9081	10458	8025	6684	6713	12725	10401	6779	8272
185	5134	3021	3750	3790	2725	2162	2567	1550	3398	1447	989	587	371	783	1238	1429	365	765	1141	3983	5217	8152	5243	3224	3340	1985	3929	2543	3303	2386	2651	1879	6800	5726	4578	5280	4496	4274	4201	6457	5454	3990	3688
190	3281	1054	1295	2447	2176	1132	1772	725	1063	630	410	16	288	259	539	296	738	508	422	1312	3903	3643	2297	2500	2653	1236	2622	1210	1654	1100	1075	867	3689	3131	1967	2337	1959	2620	1635	2510	2825	1822	1468
195	1268	215	859	1234	868	2201	555	107	599	94	179	1	10	262	82	22	53	204	54	183	863	1519	954	1886	1409	596	2694	875	2177	567	456	480	1525	1745	1017	724	827	1304	779	1298	1622	719	793
200	505	127	425	721	533	191	274	23	117	31	48	3	8	23	0	15	0	51	0	37	318	356	131	631	362	185	30	48	215	90	69	26	108	623	108	422	135	657	61	334	148	134	324
205	95	10	2	459	196	196	8	35	79	8	46	7	7	73	0	13	0	0	0	0	25	50	7	21	0	36	49	2	85	63	6	0	0	278	12	24	18	183	2	33	582	1241	72
210	61	0	0	220	294	31	21	52	18	814	0	0	2	31	0	0	0	0	0	0	0	2	10	170	12	7	0	4	139	5	2	34	4	249	0	0	1	107	0	3	7	0	1
215	0	0	0	60	196	0	0	40	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0	1	0	0	20	0	0	0	3	104	0	2	0	67	0	72	381	1215	72
220	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	20	1	0	0	165	0	28	0	0	0	0	2	0	0	30	0	0	0	59	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	8	0	45	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
235+	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	1	0	15	0	0	0	2	0	0	1	0	0	0	0	0	2	0	0	0	0	7	78	0	0	7	0	0	0

Table 8. Indices of abundance used for the stock assessment models in 2018 for Atlantic bigeye tuna.

#Year	Season	FLEET	Split index LL	se	#Year	Season	FLEET	Join Index LL	se	#Year	Season	FLEET	Dakar BB (	se
1959	3	11	0.84239028	0.230736	1959	3	11	0.9337	0.282739	2005	2	8	57.5	0.15303
1960	3	11	0.924894646	0.175929	1960	3	11	1.0315	0.219615	2006	2	8	121.5	0.204016
1961	3	11	1.171200439	0.159676	1961	3	11	1.3931	0.201225	2007	2	8	178.5	0.203102
1962	3	11	1.003365656	0.154303	1962	3	11	1.1995	0.196459	2008	2	8	8.2	0.209276
1963	3	11	1.151746271	0.133985	1963	3	11	1.3352	0.173845	2009	2	8	23.1	0.203536
1964	3	11	1.16873039	0.123982	1964	3	11	1.3612	0.161205	2010	2	8	93.2	0.201021
1965	3	11	1.229211723	0.113359	1965	3	11	1.4588	0.147425	2011	2	8	53.6	0.201576
1966	3	11	1.077172656	0.151021	1966	3	11	1.2133	0.188373	2012	2	8	22.7	0.204071
1967	3	11	1.042464111	0.152763	1967	3	11	1.2204	0.194758	2013	2	8	17	0.206634
1968	3	11	1.192956678	0.166541	1968	3	11	1.4055	0.209489	2014	2	8	8.9	0.206037
1969	3	11	1.073523011	0.170496	1969	3	11	1.26	0.213898	2015	2	8	18.2	0.203563
1970	3	11	0.938194298	0.171144	1970	3	11	1.1213	0.214343	2016	2	8	52.5	0.201637
1971	3	11	0.841309221	0.166222	1971	3	11	1.0888	0.206064	2017	2	8	53.7	0.202501
1972	3	11	0.851690909	0.230265	1972	3	11	1.2998	0.279603					
1973	3	11	0.877861102	0.256158	1973	3	11	1.3807	0.307703					
1974	3	11	0.817914717	0.318274	1974	3	11	1.2503	0.38416					
1975	3	11	0.658735616	0.232476	1975	3	11	1.0036	0.279024					
1976	3	11	0.714293672	0.252858	1976	3	11	1.0731	0.304098					
1977	3	11	1.041727717	0.305217	1977	3	11	1.6427	0.362498					
1978	3	11	0.866912163	0.334596	1978	3	11	1.3489	0.389556					
1979	3	11	1.811155629	0.342619	1979	3	11	1.5938	0.259526					
1980	3	11	1.718294913	0.264445	1980	3	11	1.392	0.213535					
1981	3	11	1.736565244	0.213992	1981	3	11	1.3496	0.170701					
1982	3	11	1.399386032	0.208054	1982	3	11	1.1106	0.165236					
1983	3	11	1.474841532	0.275414	1983	3	11	1.2015	0.229679					
1984	3	11	1.549553288	0.228724	1984	3	11	1.299	0.193381					
1985	3	11	1.547070456	0.190641	1985	3	11	1.3018	0.159764					
1986	3	11	1.662470259	0.237214	1986	3	11	1.4073	0.202137					
1987	3	11	1.869170724	0.228945	1987	3	11	1.4813	0.192019					
1988	3	11	1.835219979	0.20779	1988	3	11	1.5567	0.182822					
1989	3	11	1.42212793	0.186029	1989	3	11	1.2058	0.165552					
1990	3	11	1.143517347	0.18766	1990	3	11	1.0107	0.168975					
1991	3	11	1.139375771	0.188566	1991	3	11	0.9685	0.169527					
1992	3	11	1.074277213	0.207792	1992	3	11	0.8654	0.185911					
1993	3	11	1.06101979	0.195005	1993	3	11	0.8861	0.178386					
1994	3	11	0.903109584	0.188819	1994	3	11	0.7512	0.17413					
1995	3	11	0.949885098	0.187278	1995	3	11	0.7879	0.172525					
1996	3	11	0.752068502	0.18135	1996	3	11	0.6336	0.16403					
1997	3	11	0.665301579	0.177175	1997	3	11	0.5438	0.160799					
1998	3	11	0.71791811	0.186378	1998	3	11	0.5922	0.169057					
1999	3	11	0.681286916	0.190533	1999	3	11	0.5534	0.173315					
2000	3	11	0.743619742	0.177737	2000	3	11	0.6377	0.162256					
2001	3	11	0.599078252	0.183433	2001	3	11	0.5405	0.166327					
2002	3	11	0.568458395	0.195768	2002	3	11	0.5252	0.176483					
2003	3	11	0.554234824	0.185035	2003	3	11	0.4967	0.1679					
2004	3	11	0.479006421	0.182176	2004	3	11	0.4524	0.165177					
2005	3	11	0.494989525	0.162811	2005	3	11	0.4822	0.147537					
2006	3	11	0.583636884	0.184937	2006	3	11	0.5286	0.16941					
2007	3	11	0.611168105	0.185242	2007	3	11	0.5139	0.169634					
2008	3	11	0.48687444	0.174336	2008	3	11	0.4128	0.159562					
2009	3	11	0.457270771	0.171663	2009	3	11	0.3819	0.157838					
2010	3	11	0.444521544	0.172692	2010	3	11	0.3788	0.159022					
2011	3	11	0.416777112	0.165687	2011	3	11	0.3772	0.151					
2012	3	11	0.439456869	0.172574	2012	3	11	0.3976	0.158085					
2013	3	11	0.625637996	0.192691	2013	3	11	0.5872	0.176002					
2014	3	11	0.608172878	0.201151	2014	3	11	0.5225	0.18442					
2015	3	11	0.682793846	0.209838	2015	3	11	0.569	0.191227					
2016	3	11	0.579743472	0.205179	2016	3	11	0.4857	0.186747					
2017	3	11	0.564820733	0.202627	2017	3	11	0.4688	0.184284					

Table 9. Model specifications for the mpb-Reference Case for Atlantic bigeye tuna.

Parameter	Starting value and range
r (intrinsic growth rate, yr^{-1})	0.2 [0.02, 2]
K (carrying capacity, tons)	$1.191x10^6$ [$1. 191x10^5$, $1. 191x10^7$]
B0/K	0.95 [fixed]
Shape parameter (p)	0.001 [fixed]

Table 10. Summary JABBA uncertainty grid model specifications for Atlantic bigeye tuna.

Quantity	Specification	Abbreviation
CPUE	Joint R2 Early no vessel id (1959-1978) Joint R2 Late vessel id (1979-2017)	JR2_early JR2_late
Unfished biomass	$K \sim$ lnorm(log(1,581139),1.726) with 0.025th = 500,000 and 0.975th = 5,000,000	K
Intrinsic rate of population increase	$r \sim$ lnorm(log(0.5),1.66) with 0.025th = 0.05 and 0.975th = 5	r
Initial biomass depletion	$psi \sim$ lnorm(1,0.05)	psi
Biomass at MSY relative to the unfished biomass	$B_{MSY}/K = 0.278$ $B_{MSY}/K = 0.306$ $B_{MSY}/K = 0.332$	B_{MSY}/K
Process variance	$\sigma^2_{proc} \sim$ inverse-gamma (0.001,0.001)	σ^2_{proc}
catchability coefficient	$q \sim$ uniform (10^{-30},1000)	q

Table 11. Residual mean squared error (RMSE) from log-CPUE residuals for hindcasting periods of 3, 5 and 10 years fitted with an initial Fox model and the JABBA uncertainty grid runs based on alternative input values of B_{MSY}/K. Red text indicates the models with better predictive performance.

Scenario	Number of hindcast years		
	HCY = 3	HCY = 5	HCY = 10
Fox	0.191	0.452	0.417
h=0.7	0.173	**0.365**	**0.317**
h=0.8	0.178	0.389	0.384
h=0.9	**0.168**	0.372	0.391

Table 12. SS3 run specifications considered in the Atlantic bigeye tuna stock assessment. Runs 1-15 were conducted in SCRS/2018/111 and runs 16-19 were further considered in the meeting. Run 19 was selected as SS3-Reference Case to build the uncertainty grid.

Run	Description
1	Preliminary reference model (SCRS/2018/111): split_index, h =0.8, sigmaR=0.4
2	Based on run 1. change split_index to continuous_index
3	Based on run 1. 3-area model
4	Based on run 1. use best fit M based on profile
5	Based on run 1. change steepness to 0.7
6	Based on run 1. change steepness to 0.9
7	Based on run 1. add Dakar BB CPUE
8	Based on run 1. down weight length comps (lambda=0.25)
9	Based on run 1. estimate growth
10	Based on run 1. change sigmaR =0.2
11	Based on run 1. change sigmaR =0.6
12	Based on run 1. change M to the alternative M jointComb
13	Based on run 1. change selectivity to asymptotic
14	Based on run 1. add 25% on PSFAD catch
15	Based on run 1. minus 10% on PSFAD catch
16	Based on run 1. add time-block in 1992 on fleet11
17	Based on run 1. change the tail of length comps 0.001
18	Based on run 1. down weight length comps (lambda=0.1)
19	Based on run 18. add time-block in 1992 on fleet11

Table 13. Description of fleets used in the formulation of the SS3 model for Atlantic bigeye tuna.

Fishery	Region	Name	Fleets	Gear	Years
1	2	Early PS	21, 8, 73, 29, other	PS	1965-1985
2	2	Transition PS	21, 8, 73, 29, other	PS	1986-1990
3	2	Late PS Free School	21, 8, 73, 29, other	PS	1991-2017
4	2	Late PS FAD	21, 8, 73	PS	1991-2017
5	2	Ghana BB+PS	27	BB+PS	1965-2017
6	2 (S of 10N)	TRO-South BB	21, 8, 73, other	BB	1962-2017
7	2 (N of 10N)	TRO-North BB early	21, 8, 73, 50, 53, 65, other	BB	1965-1979
8	2 (N of 10N)	TRO-North BB late	21, 8, 73, 50, 53, 65, other	BB	1980-2017
9	1	Northern BB	45,153, 154, other	BB	1965-2017
10	1	Japan LL North	12	LL	1961-2017
11	2	Japan LL TRO	12	LL	1961-2017
12	3	Japan LL South	12	LL	1961-2017
13	1	Other LL North	5, others	LL + others	1965-2017
14	2	Other LL TRO	3, 5, others	LL + others	1965-2017
15	3	Other LL South	3, 5, 20, others	LL + others	1961-2017

Table 14. Residual mean squared error (RMSE) of hindcast SS3 models, demonstrating the ability of the alternative runs to predict the observed CPUE in the recent period. Red text indicates the models with better predictive performance, and blue text indicates poor model prediction performance.

RMSE for log CPUE		HCY=3	HCY=5	HCY=10
1	Ref	0.834	0.695	0.204
2	Sensitivity 17	0.356	0.688	0.331
3	Sensitivity 18	0.351	0.704	0.167
4	Sensitivity 19	0.350	0.666	0.182

RMSE for CPUE		HCY=3	HCY=5	HCY=10
1	Ref	0.342	0.303	0.205
2	Sensitivity 17	0.186	0.302	0.176
3	Sensitivity 18	0.183	0.306	0.136
4	Sensitivity 19	0.180	0.289	0.140

Table 15. MSY based benchmarks, stock status and estimated model parameters for the mpb-Reference Case for Atlantic bigeye tuna.

Variable	Mean	Median	90%LCI	90%UCI
MSY (x 1,000 t)	80.051	80.359	69.340	88.348
B_{MSY} (x 1,000 t)	413.506	411.499	278.845	628.778
F_{MSY}	0.207	0.194	0.110	0.317
F_{2017}/F_{MSY}	1.429	1.373	0.926	2.121
B_{2017}/B_{MSY}	0.712	0.707	0.468	0.989
B_{2017}/K	0.262	0.260	0.172	0.364
r (yr-1)	0.207	0.195	0.110	0.317
K (x 1,000 t)	1123.463	1118.011	757.601	1708.341

Table 16. The mpb-Reference Case estimates of biomass, fishing mortality, biomass relative to B_{MSY}, and fishing mortality relative to F_{MSY} between 1950 and 2017 for Atlantic bigeye tuna with 90% confidence intervals.

mpb	Biomass			Fishing mortality			B/B_{MSY}			F/F_{MSY}		
Year	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI
1950	1055142	706943	1589816	0.001	0.001	0.001	2.581	1.774	3.990	0.004	0.003	0.006
1951	1064765	717870	1598357	0.002	0.001	0.002	2.605	1.802	4.012	0.008	0.005	0.011
1952	1071776	724572	1605123	0.002	0.001	0.003	2.623	1.819	4.029	0.010	0.006	0.014
1953	1077122	728806	1610780	0.003	0.002	0.004	2.636	1.829	4.043	0.014	0.009	0.020
1954	1080539	730769	1614882	0.003	0.002	0.004	2.645	1.834	4.053	0.014	0.009	0.020
1955	1083336	732128	1618550	0.004	0.003	0.007	2.652	1.838	4.062	0.022	0.015	0.033
1956	1083731	731179	1619936	0.003	0.002	0.004	2.653	1.835	4.066	0.013	0.009	0.019
1957	1086082	732561	1623197	0.008	0.005	0.012	2.659	1.839	4.074	0.041	0.027	0.059
1958	1082049	727562	1620155	0.004	0.003	0.006	2.649	1.826	4.066	0.020	0.013	0.029
1959	1083204	728580	1621881	0.007	0.005	0.011	2.652	1.829	4.071	0.036	0.024	0.053
1960	1080700	725834	1619974	0.008	0.006	0.013	2.645	1.822	4.066	0.043	0.028	0.062
1961	1077286	722575	1616897	0.016	0.011	0.024	2.637	1.814	4.058	0.080	0.052	0.117
1962	1066563	712395	1606214	0.022	0.014	0.032	2.609	1.788	4.031	0.110	0.072	0.161
1963	1051762	699317	1590637	0.025	0.016	0.037	2.573	1.755	3.992	0.125	0.081	0.185
1964	1036770	687341	1573858	0.023	0.015	0.034	2.536	1.725	3.950	0.116	0.075	0.171
1965	1026898	681374	1561302	0.038	0.025	0.058	2.512	1.710	3.919	0.194	0.125	0.287
1966	1003025	661414	1534328	0.025	0.017	0.038	2.454	1.660	3.851	0.128	0.082	0.191
1967	997345	661255	1524213	0.025	0.017	0.038	2.440	1.660	3.826	0.128	0.082	0.190
1968	992780	661276	1515287	0.024	0.016	0.036	2.430	1.660	3.803	0.122	0.078	0.180
1969	990338	662631	1508627	0.037	0.024	0.056	2.424	1.663	3.786	0.189	0.122	0.277
1970	975335	650622	1489674	0.044	0.028	0.065	2.388	1.633	3.739	0.220	0.142	0.324
1971	957326	636468	1467111	0.058	0.038	0.088	2.344	1.597	3.682	0.295	0.189	0.436
1972	928871	612796	1433380	0.051	0.033	0.077	2.274	1.538	3.598	0.258	0.164	0.384
1973	913582	604021	1411542	0.062	0.040	0.094	2.237	1.516	3.543	0.316	0.201	0.469
1974	890958	587809	1382146	0.072	0.046	0.109	2.182	1.475	3.469	0.364	0.230	0.542
1975	864611	568576	1348444	0.071	0.045	0.108	2.118	1.427	3.384	0.358	0.226	0.536
1976	844912	556786	1320628	0.054	0.034	0.081	2.070	1.397	3.315	0.271	0.170	0.404
1977	844003	563743	1311290	0.065	0.042	0.097	2.070	1.415	3.291	0.328	0.208	0.484
1978	833859	559510	1293192	0.063	0.041	0.094	2.047	1.404	3.246	0.319	0.203	0.468
1979	827118	558449	1278842	0.056	0.036	0.082	2.034	1.402	3.210	0.280	0.179	0.409
1980	828010	564350	1272429	0.077	0.050	0.113	2.041	1.416	3.194	0.387	0.248	0.560
1981	811159	551259	1248932	0.084	0.054	0.123	2.000	1.384	3.135	0.421	0.270	0.612
1982	792282	536909	1223103	0.093	0.060	0.137	1.953	1.348	3.070	0.468	0.299	0.682
1983	770029	519936	1193536	0.077	0.050	0.115	1.897	1.305	2.996	0.389	0.248	0.570
1984	764810	520669	1181698	0.093	0.060	0.137	1.888	1.307	2.966	0.467	0.299	0.679
1985	748558	509665	1159748	0.105	0.067	0.154	1.849	1.279	2.911	0.525	0.335	0.763
1986	727149	493820	1132484	0.090	0.058	0.133	1.796	1.239	2.842	0.451	0.287	0.659
1987	721548	493898	1120226	0.080	0.051	0.116	1.785	1.240	2.812	0.399	0.255	0.578
1988	724479	501989	1116954	0.092	0.059	0.132	1.793	1.260	2.803	0.460	0.296	0.658
1989	717892	499521	1104889	0.110	0.071	0.158	1.778	1.254	2.773	0.550	0.354	0.783
1990	699582	485225	1081308	0.122	0.079	0.176	1.733	1.218	2.714	0.610	0.392	0.873
1991	676601	467098	1048983	0.144	0.093	0.208	1.677	1.172	2.633	0.719	0.461	1.034
1992	644097	440283	1006359	0.155	0.099	0.227	1.596	1.105	2.526	0.777	0.494	1.130
1993	611757	415003	962898	0.186	0.118	0.274	1.514	1.042	2.417	0.929	0.588	1.364
1994	568369	379677	907962	0.237	0.149	0.355	1.402	0.953	2.279	1.186	0.739	1.766
1995	506997	327576	840829	0.253	0.152	0.391	1.252	0.822	2.110	1.262	0.757	1.942
1996	455485	286736	784037	0.265	0.154	0.421	1.127	0.720	1.968	1.326	0.765	2.093
1997	413972	254745	734738	0.266	0.150	0.433	1.024	0.639	1.844	1.340	0.746	2.151
1998	382951	233669	694034	0.282	0.156	0.462	0.949	0.586	1.742	1.425	0.773	2.296
1999	354718	214248	653935	0.343	0.186	0.568	0.880	0.538	1.641	1.740	0.925	2.822
2000	312143	178908	598943	0.332	0.173	0.580	0.775	0.449	1.503	1.691	0.861	2.882
2001	285577	157667	558305	0.319	0.163	0.578	0.711	0.396	1.401	1.625	0.812	2.875
2002	270685	145444	536719	0.280	0.141	0.521	0.673	0.365	1.347	1.425	0.701	2.588
2003	269800	146559	535357	0.325	0.164	0.598	0.671	0.368	1.344	1.650	0.814	2.974
2004	257501	135825	519206	0.350	0.173	0.663	0.640	0.341	1.303	1.779	0.862	3.295
2005	241337	120714	495705	0.281	0.137	0.562	0.600	0.303	1.244	1.433	0.681	2.795
2006	244664	123806	493890	0.242	0.120	0.478	0.610	0.311	1.240	1.226	0.595	2.374
2007	259978	136356	503032	0.267	0.138	0.510	0.643	0.342	1.263	1.370	0.687	2.534
2008	266235	139798	502802	0.238	0.126	0.453	0.656	0.351	1.262	1.226	0.626	2.253
2009	277026	151967	510925	0.276	0.149	0.502	0.686	0.381	1.282	1.419	0.742	2.496
2010	275114	154271	502101	0.276	0.151	0.492	0.686	0.387	1.260	1.405	0.752	2.446
2011	275203	157282	495355	0.277	0.154	0.486	0.682	0.395	1.243	1.408	0.766	2.413
2012	274286	159126	490392	0.259	0.145	0.447	0.679	0.399	1.231	1.309	0.720	2.219
2013	278120	162638	488988	0.244	0.139	0.417	0.690	0.408	1.227	1.222	0.690	2.073
2014	284551	171488	496073	0.264	0.151	0.438	0.711	0.430	1.245	1.305	0.752	2.174
2015	288944	178429	490883	0.277	0.163	0.449	0.716	0.448	1.232	1.378	0.812	2.233
2016	286161	175237	481228	0.279	0.166	0.456	0.713	0.440	1.208	1.390	0.825	2.266
2017	283296	170241	473703	0.272	0.163	0.452	0.707	0.468	0.989	1.373	0.926	2.121

Table 17. Summary, including MSY based benchmarks, of posterior quantiles denoting the median and the 95% confidence intervals of parameter estimates for the JABBA uncertainty grid runs and the Fox model run.

	B_{MSY}/K = 0.306 (Ref: h = 0.8 Ref)			**B_{MSY}/K = 0.332 (low: h = 0.7 Ref)**		
Estimates	Median	2.50%	97.50%	Median	2.50%	97.50%
K	1349994	958351	2270464	1262803	899757	2018226
r	0.132	0.07	0.199	0.154	0.088	0.229
ψ (psi)	0.934	0.853	1.019	0.937	0.853	1.021
σ_{proc}	0.032	0	0.089	0.045	0	0.084
m	0.706	0.706	0.706	0.82	0.82	0.82
F_{MSY}	0.188	0.099	0.281	0.188	0.107	0.279
B_{MSY} (t)	413106	293261	694776	419299	298754	670128
MSY (t)	77493	65695	86427	78608	68454	87446
B_{1959}/K	0.926	0.814	1.015	0.927	0.813	1.021
B_{2017}/K	0.252	0.185	0.338	0.257	0.191	0.339
B_{2017}/B_{MSY}	0.822	0.606	1.106	0.775	0.575	1.02
F_{2017}/F_{MSY}	1.214	0.848	1.738	1.272	0.923	1.792

	B_{MSY}/K = 0.278 (high: h = 0.9 Ref)			**Fox (B_{MSY}/K = 0.37)**		
Estimates	Median	2.50%	97.50%	Median	2.50%	97.50%
K	1408989	1017500	2224121	1210227	831436	1812324
r	0.117	0.067	0.171	0.182	0.111	0.276
ψ(psi)	0.936	0.852	1.019	0.977	0.896	1.064
σ_{proc}	0.045	0	0.084	0.055	0.045	0.071
m	0.597	0.597	0.597	1.012	1.012	1.012
F_{MSY}	0.196	0.112	0.287	0.18	0.11	0.273
B_{MSY} (t)	391753	282904	618391	447876	307694	670697
MSY (t)	76768	66141	85521	80760	69153	89300
B_{1959}/K	0.927	0.811	1.017	0.953	0.841	1.037
B_{2017}/K	0.244	0.183	0.323	0.274	0.199	0.36
B_{2017}/B_{MSY}	0.879	0.659	1.163	0.741	0.537	0.972
F_{2017}/F_{MSY}	1.148	0.816	1.615	1.297	0.95	1.836

Table 18. The JABBA-uncertainty grid (across all 3 runs) estimates of biomass, fishing mortality, biomass relative to B_{MSY}, and fishing mortality relative to F_{MSY} between 1950 and 2017 for Atlantic bigeye tuna with 90% confidence intervals.

JABBA	Biomass			Fishing mortality			B/B_{MSY}			F/F_{MSY}		
Year	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI
1950	1240751	847788	2023536	0.001	0.000	0.001	3.024	2.536	3.582	0.003	0.003	0.004
1951	1239957	844771	1998779	0.001	0.001	0.002	3.015	2.508	3.582	0.007	0.006	0.009
1952	1237758	839951	1993526	0.002	0.001	0.002	3.010	2.476	3.586	0.009	0.007	0.011
1953	1237151	832727	1984821	0.002	0.001	0.004	3.007	2.459	3.581	0.013	0.010	0.016
1954	1235847	832269	1978343	0.002	0.001	0.004	3.003	2.437	3.579	0.013	0.010	0.016
1955	1235677	830123	1977098	0.004	0.002	0.006	3.001	2.422	3.576	0.021	0.017	0.027
1956	1231687	828311	1964746	0.002	0.001	0.003	2.996	2.401	3.571	0.012	0.010	0.016
1957	1231055	826229	1965863	0.007	0.004	0.011	2.998	2.400	3.573	0.038	0.031	0.049
1958	1225457	819302	1954436	0.004	0.002	0.005	2.980	2.376	3.559	0.019	0.015	0.024
1959	1225083	813544	1954060	0.006	0.004	0.010	2.977	2.369	3.551	0.033	0.028	0.044
1960	1230931	822951	1963898	0.007	0.005	0.011	2.987	2.398	3.557	0.039	0.032	0.051
1961	1245414	842988	1990260	0.014	0.009	0.020	3.024	2.476	3.586	0.073	0.060	0.093
1962	1246502	844271	2004018	0.019	0.012	0.027	3.028	2.488	3.584	0.098	0.082	0.125
1963	1250455	853689	2017360	0.021	0.013	0.031	3.043	2.534	3.598	0.110	0.091	0.139
1964	1251421	858112	2027687	0.019	0.012	0.028	3.043	2.553	3.598	0.100	0.083	0.125
1965	1249374	859949	2029984	0.032	0.019	0.046	3.041	2.550	3.600	0.167	0.138	0.208
1966	1215500	830304	1982558	0.021	0.013	0.031	2.960	2.449	3.531	0.111	0.091	0.139
1967	1200507	817218	1956289	0.021	0.013	0.031	2.929	2.416	3.494	0.111	0.091	0.140
1968	1190258	811271	1942050	0.020	0.012	0.029	2.903	2.382	3.474	0.106	0.087	0.134
1969	1169052	793248	1899152	0.032	0.019	0.047	2.854	2.327	3.423	0.167	0.137	0.212
1970	1135835	762561	1844957	0.037	0.023	0.056	2.770	2.225	3.333	0.198	0.162	0.254
1971	1102514	729900	1793975	0.051	0.031	0.077	2.685	2.128	3.245	0.269	0.220	0.349
1972	1067524	700751	1745026	0.044	0.027	0.067	2.601	2.052	3.161	0.235	0.192	0.306
1973	1047592	689619	1720578	0.054	0.033	0.083	2.555	2.009	3.105	0.288	0.235	0.375
1974	1020511	665926	1678685	0.063	0.038	0.096	2.485	1.946	3.029	0.333	0.271	0.435
1975	988906	640193	1643382	0.062	0.037	0.096	2.412	1.880	2.944	0.329	0.267	0.428
1976	973366	633250	1622892	0.047	0.028	0.072	2.376	1.863	2.904	0.247	0.200	0.320
1977	981889	649973	1645178	0.056	0.033	0.084	2.397	1.908	2.929	0.296	0.239	0.379
1978	976685	651649	1640185	0.054	0.032	0.081	2.383	1.908	2.914	0.286	0.230	0.365
1979	972957	654515	1637477	0.047	0.028	0.070	2.378	1.908	2.912	0.250	0.200	0.318
1980	976237	662724	1637022	0.065	0.039	0.096	2.385	1.918	2.939	0.345	0.273	0.437
1981	958757	651399	1625618	0.071	0.042	0.104	2.346	1.887	2.908	0.375	0.295	0.473
1982	936805	631029	1595976	0.079	0.046	0.117	2.291	1.829	2.854	0.417	0.327	0.529
1983	914530	616998	1568525	0.065	0.038	0.097	2.237	1.787	2.811	0.345	0.269	0.438
1984	910818	616963	1557803	0.078	0.046	0.115	2.228	1.792	2.812	0.414	0.320	0.524
1985	896430	610346	1542005	0.087	0.051	0.128	2.191	1.769	2.779	0.463	0.356	0.585
1986	874238	596004	1510021	0.075	0.043	0.110	2.138	1.733	2.742	0.397	0.302	0.499
1987	864785	593329	1490592	0.066	0.039	0.097	2.113	1.713	2.714	0.352	0.267	0.445
1988	855860	592426	1456106	0.078	0.046	0.112	2.092	1.692	2.667	0.411	0.313	0.521
1989	828265	572575	1388804	0.095	0.057	0.137	2.029	1.620	2.545	0.502	0.390	0.642
1990	790930	544827	1310164	0.108	0.065	0.156	1.939	1.528	2.405	0.569	0.449	0.738
1991	755396	518424	1245519	0.129	0.078	0.187	1.852	1.447	2.288	0.680	0.539	0.886
1992	713335	488296	1170891	0.140	0.086	0.205	1.751	1.363	2.151	0.740	0.591	0.969
1993	674331	462171	1105858	0.169	0.103	0.246	1.656	1.293	2.037	0.891	0.713	1.160
1994	624922	427528	1032947	0.216	0.131	0.316	1.534	1.195	1.889	1.139	0.914	1.482
1995	561638	380374	940666	0.228	0.136	0.337	1.378	1.078	1.713	1.203	0.959	1.558
1996	507122	338934	861475	0.238	0.140	0.356	1.243	0.969	1.559	1.257	1.001	1.621
1997	464324	307815	798591	0.237	0.138	0.358	1.137	0.888	1.437	1.256	0.997	1.608
1998	435773	290616	756006	0.248	0.143	0.371	1.066	0.841	1.356	1.313	1.028	1.661
1999	409233	273118	717655	0.297	0.170	0.445	1.001	0.796	1.283	1.576	1.224	1.976
2000	368731	239590	664046	0.281	0.156	0.433	0.899	0.714	1.178	1.498	1.138	1.861
2001	341465	216985	622302	0.267	0.147	0.420	0.832	0.654	1.101	1.424	1.071	1.779
2002	325255	204983	595271	0.233	0.127	0.369	0.793	0.618	1.055	1.240	0.928	1.555
2003	323444	206202	584649	0.271	0.150	0.425	0.790	0.618	1.040	1.444	1.087	1.812
2004	309443	196145	560938	0.291	0.161	0.459	0.755	0.586	1.001	1.550	1.165	1.955
2005	294103	182433	540474	0.231	0.126	0.372	0.717	0.549	0.962	1.232	0.913	1.571
2006	299961	188194	544602	0.197	0.109	0.314	0.731	0.561	0.973	1.053	0.780	1.344
2007	312352	200834	552487	0.223	0.126	0.346	0.762	0.588	0.998	1.187	0.892	1.519
2008	311496	200627	541608	0.203	0.117	0.316	0.760	0.584	0.986	1.084	0.820	1.403
2009	317169	206451	543501	0.241	0.140	0.370	0.776	0.594	0.994	1.278	0.979	1.676
2010	313660	202529	536910	0.242	0.141	0.375	0.766	0.579	0.981	1.287	0.987	1.706
2011	312582	201912	536337	0.244	0.142	0.378	0.765	0.576	0.980	1.297	0.993	1.723
2012	315215	204044	540506	0.225	0.131	0.348	0.770	0.584	0.991	1.198	0.908	1.589
2013	326627	215386	557513	0.208	0.122	0.315	0.798	0.610	1.033	1.105	0.826	1.463
2014	338927	227314	572374	0.221	0.131	0.330	0.828	0.633	1.080	1.176	0.868	1.572
2015	343760	231142	579560	0.233	0.138	0.347	0.840	0.640	1.104	1.239	0.901	1.676
2016	340644	227928	572626	0.235	0.140	0.351	0.831	0.622	1.109	1.246	0.894	1.724
2017	337138	224084	568562	0.228	0.135	0.344	0.824	0.601	1.115	1.210	0.851	1.723

Table 19. Uncertainty grid specifications from the SS3-Reference Case for Atlantic bigeye tuna. Total number of grid runs is 18.

Grid specifications				N
Index		split (ves ID>79)		1
M	Mref(0.28)	Malt(0.35)		2
steepness	0.7	0.8	0.9	3
lambda		0.1		1
sigmaR	0.2	0.4	0.6	3
number of runs				18

Table 20. Reference Points, stock status and approximate 90% confidence intervals across all 18 SS3-uncertainty grid runs for Atlantic bigeye tuna.

Quantity	Mean*	Median*	90% LCI**	90% UCI**
F_{2017}/F_{MSY}	1.633	1.629	1.143	2.123
SSB_{2017}/SSB_{MSY}	0.611	0.590	0.426	0.797
Virgin SSB (t)	1421250	1404845	1010578.04	1831921.96
Virgin total biomass (t)	1607423.889	1593220	1196506.124	2018341.654
Virgin recruitment (1000 age 0)	24913	24808	16576	33250
SSB_{MSY}	436256	425601	427919	444593
F_{MSY} (avg F, ages 1-7)	0.194	0.193	0.150	0.238
MSY (t)	76182	76232	72664	79700

*mean and median were calculated across all 18 uncertainty grid runs

**90% confidence interval calculated as mean +/- 1.68*SE

Table 21. The SS3-uncertainty grid estimates (across all 18 runs) of biomass, fishing mortality, biomass relative to B_{MSY}, and fishing mortality relative to F_{MSY} between 1950 and 2017 for Atlantic bigeye tuna with 90% confidence intervals.

SS3	SSB			Fishing mortality			SSB/SSB_{MSY}			F/F_{MSY}		
Year	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI	Median	90% LCI	90% UCI
1950	1404845	1010578	1831922	0.001	0.001	0.001	4.076	3.155	5.258	0.003	0.003	0.004
1951	1404085	1009851	1831129	0.001	0.001	0.002	4.073	3.154	5.255	0.007	0.006	0.008
1952	1402460	1008329	1829394	0.002	0.001	0.002	4.069	3.151	5.248	0.009	0.007	0.010
1953	1400445	1006518	1827167	0.002	0.002	0.003	4.063	3.147	5.239	0.013	0.011	0.015
1954	1397645	1004033	1824045	0.002	0.002	0.003	4.054	3.142	5.227	0.013	0.011	0.014
1955	1394975	1001781	1820957	0.004	0.004	0.004	4.046	3.137	5.216	0.021	0.018	0.024
1956	1390840	998177	1816269	0.002	0.002	0.003	4.034	3.129	5.199	0.012	0.010	0.014
1957	1388745	996678	1813568	0.007	0.006	0.008	4.031	3.127	5.195	0.038	0.032	0.043
1958	1381665	990366	1805710	0.003	0.003	0.004	4.008	3.114	5.158	0.018	0.016	0.021
1959	1378620	988191	1801776	0.006	0.005	0.007	4.008	3.112	5.161	0.033	0.028	0.038
1960	1373275	983770	1795481	0.007	0.006	0.008	3.998	3.107	5.142	0.038	0.033	0.044
1961	1366995	978533	1788144	0.012	0.010	0.013	4.044	3.121	5.231	0.070	0.060	0.078
1962	1353470	966375	1773234	0.017	0.015	0.020	3.849	3.072	4.817	0.097	0.084	0.109
1963	1335415	950255	1753216	0.029	0.025	0.034	3.526	2.940	4.228	0.128	0.109	0.145
1964	1317270	934640	1732526	0.020	0.017	0.023	3.661	2.981	4.495	0.104	0.090	0.117
1965	1298930	919538	1710892	0.027	0.023	0.031	3.816	2.992	4.874	0.168	0.145	0.186
1966	1266015	891158	1673365	0.017	0.015	0.019	3.719	2.930	4.729	0.108	0.094	0.120
1967	1251915	881531	1654738	0.028	0.024	0.032	3.337	2.800	3.985	0.127	0.110	0.145
1968	1245110	878369	1644263	0.019	0.017	0.022	3.499	2.865	4.280	0.106	0.093	0.120
1969	1238055	874588	1633904	0.041	0.035	0.047	3.278	2.766	3.890	0.184	0.159	0.209
1970	1221080	861176	1613343	0.041	0.036	0.047	3.320	2.771	3.986	0.203	0.176	0.230
1971	1197440	841653	1585514	0.053	0.045	0.060	3.292	2.737	3.972	0.271	0.235	0.304
1972	1160195	809922	1542579	0.048	0.041	0.055	3.142	2.648	3.743	0.241	0.210	0.270
1973	1134645	790199	1510990	0.063	0.054	0.072	3.071	2.593	3.653	0.302	0.262	0.339
1974	1104120	765844	1474112	0.077	0.066	0.088	2.981	2.530	3.532	0.362	0.316	0.407
1975	1067690	736370	1430554	0.067	0.058	0.077	2.912	2.471	3.463	0.337	0.295	0.376
1976	1031640	708364	1386210	0.061	0.052	0.070	2.744	2.370	3.203	0.280	0.241	0.314
1977	1002605	692009	1348405	0.088	0.075	0.101	2.635	2.290	3.066	0.363	0.310	0.418
1978	957339	666304	1292914	0.087	0.075	0.100	2.526	2.193	2.945	0.365	0.305	0.430
1979	929617	648341	1245099	0.069	0.060	0.080	2.458	2.122	2.905	0.301	0.253	0.354
1980	913653	644775	1210181	0.083	0.072	0.095	2.479	2.092	2.973	0.405	0.341	0.475
1981	882594	631576	1167154	0.099	0.085	0.114	2.369	1.999	2.812	0.460	0.382	0.543
1982	844589	610657	1119850	0.096	0.083	0.111	2.290	1.924	2.740	0.485	0.405	0.570
1983	807666	588846	1073779	0.085	0.073	0.098	2.203	1.835	2.645	0.410	0.340	0.486
1984	786831	580937	1045232	0.097	0.084	0.111	2.166	1.787	2.615	0.485	0.402	0.574
1985	762695	566016	1013307	0.093	0.080	0.106	2.152	1.751	2.645	0.501	0.420	0.593
1986	746447	557019	986804	0.083	0.072	0.095	2.044	1.678	2.455	0.444	0.369	0.522
1987	753189	568897	984835	0.071	0.061	0.081	2.079	1.685	2.488	0.381	0.316	0.449
1988	763113	582763	989165	0.082	0.072	0.094	2.115	1.696	2.549	0.438	0.364	0.520
1989	763876	587290	985089	0.095	0.082	0.109	2.133	1.700	2.581	0.527	0.437	0.630
1990	732925	561454	950861	0.117	0.101	0.135	1.990	1.603	2.382	0.631	0.519	0.764
1991	687231	523120	901067	0.164	0.141	0.185	1.821	1.482	2.176	0.821	0.675	0.998
1992	645223	491629	849972	0.177	0.154	0.202	1.677	1.373	1.993	0.899	0.728	1.098
1993	606998	465153	799816	0.244	0.216	0.278	1.558	1.261	1.852	1.165	0.928	1.413
1994	565754	437245	742718	0.296	0.262	0.337	1.465	1.175	1.754	1.480	1.172	1.798
1995	510307	395162	669051	0.293	0.261	0.335	1.338	1.071	1.605	1.503	1.197	1.820
1996	451684	348590	593652	0.298	0.263	0.339	1.187	0.955	1.416	1.555	1.234	1.892
1997	399102	306649	524478	0.294	0.259	0.332	1.052	0.849	1.252	1.513	1.197	1.842
1998	361598	278271	470619	0.269	0.239	0.304	0.966	0.772	1.156	1.452	1.147	1.765
1999	340288	264347	432147	0.320	0.288	0.367	0.897	0.713	1.084	1.704	1.333	2.081
2000	316827	252159	397450	0.268	0.241	0.310	0.819	0.658	1.005	1.481	1.161	1.798
2001	309582	253555	381857	0.291	0.261	0.331	0.783	0.620	0.976	1.452	1.127	1.770
2002	312908	260899	377579	0.263	0.235	0.299	0.783	0.609	0.988	1.280	0.991	1.565
2003	311282	262337	371787	0.321	0.285	0.363	0.780	0.603	0.995	1.543	1.193	1.894
2004	284430	240195	342720	0.374	0.332	0.425	0.711	0.548	0.900	1.872	1.427	2.320
2005	257593	217675	312692	0.250	0.223	0.285	0.613	0.483	0.776	1.407	1.081	1.712
2006	255627	218032	307253	0.209	0.186	0.243	0.628	0.484	0.799	1.117	0.861	1.368
2007	265324	226974	312959	0.213	0.187	0.244	0.631	0.490	0.809	1.259	0.977	1.522
2008	255316	218709	302167	0.180	0.156	0.209	0.601	0.470	0.773	1.193	0.905	1.447
2009	244383	210672	293548	0.244	0.211	0.283	0.582	0.450	0.749	1.497	1.127	1.816
2010	231195	195137	280215	0.257	0.223	0.301	0.540	0.416	0.701	1.602	1.191	1.953
2011	226832	187699	274166	0.257	0.226	0.306	0.527	0.400	0.694	1.615	1.190	1.990
2012	223599	184403	270716	0.235	0.208	0.281	0.523	0.390	0.692	1.459	1.079	1.807
2013	236864	199436	281038	0.222	0.197	0.262	0.547	0.406	0.733	1.340	0.996	1.660
2014	255831	225027	300724	0.239	0.212	0.281	0.606	0.443	0.804	1.443	1.069	1.786
2015	263452	233812	307212	0.264	0.232	0.313	0.627	0.457	0.832	1.577	1.143	1.981
2016	255294	223795	297174	0.276	0.241	0.325	0.595	0.435	0.794	1.618	1.172	2.063
2017	254233	222443	291399	0.303	0.257	0.364	0.590	0.426	0.797	1.629	1.143	2.123

Table 22. Statistics summary of stock status, benchmarks, and key parameters from the three stock assessment models for Atlantic bigeye tuna.

Assessment Method	SS3			JABBA			mpb		
Estimates	Median	90%LCI	90%UCI	Median	90%LCI	90%UCI	Median	90%LCI	90%UCI
F_{2017}/F_{MSY}	1.629	1.143	2.123	1.210	0.851	1.723	1.373	0.926	2.121
B_{2017}/B_{MSY}*	0.590	0.426	0.797	0.824	0.601	1.115	0.707	0.468	0.989
B_{MSY}*	425601	427919	444593	408041	290355	665500	411499	278845	628778
F_{MSY}	0.193	0.150	0.238	0.191	0.105	0.283	0.194	0.110	0.317
MSY	76232	72664	79700	77636	66601	86575	80359	69340	88348
K**	1404845	1010578	1831922	1342195	941998	2183037	1123463	1118011	757601
r	-	-	-	0.133	0.072	0.212	0.195	0.110	0.317

*SBB (SS3) or exploitable biomass (production models)

**Virgin SSB (SS3) or carrying capacity (production models)

Table 23. Estimated probabilities for catch projections from the mpb-Reference Case for Atlantic bigeye tuna summarizing a) probability of biomass being above B_{MSY} (not overfished); b) probability of F being below F_{MSY} (overfishing not occurring), and c) probability of being in the green quadrant of the Kobe plot (not overfished and overfishing not occurring).

a) p(B>Bmsy)															
TAC (x1,000 t)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	6	7	31	61	84	94	97	99	100	100	100	100	100	100	100
40	6	7	16	32	49	60	72	80	85	90	92	94	95	97	97
45	6	7	15	28	43	54	63	72	80	84	88	90	92	94	94
50	6	7	14	25	36	48	57	64	71	76	82	84	87	88	91
55	6	7	13	21	31	40	48	56	62	68	72	75	81	82	84
60	6	7	12	17	25	34	40	47	52	57	62	66	69	71	74
65	6	7	11	15	20	27	32	37	42	47	50	53	56	58	61
70	6	7	9	13	16	20	24	28	32	35	37	40	44	46	48
75	6	7	8	11	13	14	17	19	22	24	26	28	28	31	32
80	6	7	8	8	9	11	12	12	13	14	14	16	16	18	18
85	6	7	7	7	6	6	6	7	6	6	6	6	6	7	7
90	6	7	6	5	5	5	4	3	2	2	2	2	2	2	1

b) p(F<Fmsy)															
TAC (x1,000 t)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100
40	10	84	90	93	95	96	98	99	99	99	99	100	100	100	100
45	10	73	83	88	91	93	95	95	96	97	98	99	99	99	99
50	10	62	71	78	84	88	90	92	92	94	94	95	95	96	96
55	10	51	59	66	71	76	81	84	86	87	89	90	91	92	93
60	10	42	48	54	60	63	68	71	74	76	80	81	83	84	84
65	10	29	36	42	47	51	55	58	60	62	65	67	69	70	72
70	10	21	26	30	34	37	39	44	46	47	50	51	53	54	55
75	10	14	17	19	22	24	26	28	30	31	33	34	35	36	37
80	10	10	12	12	13	13	14	15	16	17	18	18	19	19	20
85	10	6	6	6	6	6	6	6	6	7	6	6	6	6	6
90	10	4	3	3	3	2	2	2	2	2	2	1	1	1	1

c) p(Green)															
TAC (x1,000 t)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	6	7	31	61	84	94	97	99	100	100	100	100	100	100	100
40	6	7	16	32	49	60	72	80	85	90	92	94	95	97	97
45	6	7	15	28	43	54	63	72	80	84	88	90	92	94	94
50	6	7	14	25	36	48	57	64	71	76	82	84	87	88	91
55	6	7	13	21	31	40	48	56	62	68	72	75	81	82	84
60	6	7	12	17	25	34	40	47	52	57	62	66	69	71	74
65	6	7	11	15	20	27	32	37	42	47	50	53	56	58	61
70	6	7	9	13	16	20	24	28	32	35	37	40	44	46	48
75	6	7	8	11	13	14	17	19	22	24	26	28	28	31	32
80	6	7	8	8	9	11	11	12	13	14	14	16	16	18	18
85	6	6	6	6	5	5	5	6	6	6	6	6	6	6	6
90	6	4	3	3	3	2	2	2	2	2	2	1	1	1	1

Table 24 Estimated probabilities for catch projections from the JABBA uncertainty grid for Atlantic bigeye tuna summarizing a) probability (%) of biomass being above B_{MSY} (not overfished); b) probability of F being below F_{MSY} (overfishing not occurring) and c) probability of being in the green quadrant of the Kobe plot (not overfished and overfishing not occurring) under different global catch quotas over a projection period of 15 years until 2032. The Kobe projection matrix was constructed by combining projected posteriors of B/B_{MSY} and F/F_{MSY} from the JABBA uncertainty grid runs.

a) Probability (%) of ($F/F_{MSY} < 1$)

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
40000	98	99	99	100	100	100	100	100	100	100	100	100	100	100
45000	94	97	98	99	99	99	99	99	100	100	100	100	100	100
50000	86	91	94	96	97	98	98	98	99	99	99	99	99	99
55000	74	82	86	90	92	94	95	96	96	97	97	97	98	98
60000	59	67	73	78	82	85	87	89	90	91	92	93	93	94
65000	43	50	56	61	65	69	72	75	77	79	81	82	83	84
70000	29	34	38	41	45	48	51	54	56	58	60	62	63	64
75000	19	21	23	25	27	28	30	31	33	34	35	36	37	38
80000	11	12	12	13	13	14	14	15	15	16	16	16	16	16
85000	7	7	7	7	7	6	6	6	6	6	6	6	6	6
90000	4	4	3	3	3	3	3	2	2	2	2	2	2	2

b) Probability (%) of ($B/B_{MSY} > 1$)

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	12	51	84	95	98	99	100	100	100	100	100	100	100	100
40000	12	28	49	67	80	88	92	95	97	98	98	99	99	99
45000	12	26	43	60	73	82	88	92	94	96	97	97	98	98
50000	12	23	38	53	65	75	82	87	90	92	94	95	96	97
55000	12	21	33	45	56	65	73	79	83	86	89	91	92	93
60000	12	19	28	37	46	54	61	67	72	76	80	82	84	86
65000	12	17	23	30	36	42	48	53	58	62	65	69	71	74
70000	12	15	19	23	27	31	35	38	41	45	47	50	52	55
75000	12	14	16	18	20	21	23	25	26	28	29	30	32	33
80000	12	12	13	13	14	14	14	15	15	15	15	16	16	16
85000	12	11	10	10	9	9	8	8	8	7	7	7	7	7
90000	12	10	8	7	6	5	5	4	4	4	3	3	3	3

c) Probability (%) of green (($F/F_{MSY} < 1$ & $B/B_{MSY} > 1$)

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	12	51	84	95	98	99	100	100	100	100	100	100	100	100
40000	12	28	49	67	80	88	92	95	97	98	98	99	99	99
45000	12	26	43	60	73	82	88	92	94	96	97	97	98	98
50000	12	23	38	53	65	75	82	87	90	92	94	95	96	97
55000	12	21	33	45	56	65	73	79	83	86	89	91	92	93
60000	12	19	28	37	46	54	61	67	72	76	80	82	84	86
65000	12	17	23	29	36	42	48	53	58	62	65	69	71	74
70000	12	15	19	23	27	31	35	38	41	44	47	50	52	55
75000	11	13	15	17	19	21	23	24	26	27	29	30	31	32
80000	9	10	11	11	12	12	13	13	14	14	14	15	15	15
85000	7	7	7	6	6	6	6	6	6	6	6	6	5	5
90000	4	4	3	3	3	3	3	2	2	2	2	2	2	2

Table 25. Active Commission requests relevant to tropical tunas requiring responses from the SCRS.

Recommendation	Subject	Summary of response provided by the SCRS in 2017
Rec. 16- 01, paragraph 12c	Assess the potential impact of Ghana's comprehensive and detailed capacity management plan on the level of tropical tuna catches.	This work could not be conducted in time to respond to the Commission in 2017. The Group recommended that the Secretariat compile the data needed to support the analysis of Ghanaian fishing capacity in time to conduct these analyses in 2018.
Rec. 16-01, paragraph 15	Evaluate the efficacy of the area/time closure referred to in paragraph 13 in relation with the protection of juveniles of tropical tunas.	The SCRS plans to conduct an evaluation of the effect of the moratorium on the mortality of juvenile tropical tunas in 2018. The work plan is on page 281 of the *Report for Biennial Period 2016-2017, Part II (2017), Vol. 2.*
Rec. 16- 01, paragraph 49 (a)	Recommendations made by the FAD Working Group (Annex 8) and develop a work plan.	The SCRS Chair, with the help of the rapporteurs of tropical tunas, billfish, sharks, Sub-Committees on Statistics and Ecosystems will prepare, before the end of 2017, a FAD research work plan to coordinate the SCRS response to the recommendations made by the ICCAT Ad Hoc Working Group on FADs. This work plan will be reviewed by the appropriate working groups and subcommittees during the intersessional meetings in 2018 and reviewed by the SCRS in plenary in 2018.
Rec. 16-01, paragraph 49 (c)	Develop a table that quantifies the expected impact on MSY, B_{MSY}, and relative stock status for both bigeye and yellowfin resulting from reductions of the individual proportional contributions of major fisheries to the total catch.	The Group plans to conduct an analysis that will directly respond to this request in 2018 (see section 7.1.3).

Table 26. Example of SS3 starter file modifications for evaluating the effect of each major fishery on the spawning biomass of Atlantic bigeye tuna.

```
starter file
### Stock Synthesis Version 3.0.11
_BET_2018_refV2.dat
_BET_2018_split.ctl
#control.ss_new
1 # 1 # 0=use init values in control file; 1=use ss3.par (set to 1)
1 # run display detail (0,1,2)
0 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed checkup.sso file (0,1)
1 # write parm values to ParmTrace.sso
2 # 2 # report level in CUMREPORT.SSO (0,1,2)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence
1 # Number of bootstrap datafiles to produce
0 # 6 # Turn off estimation for parameters entering after this phase (set to 0)
…..
```

data file (for the baitboat case, F5 – F9)	
…..	…..
259 # Number of Catch Observations	259 # Number of Catch Observations
0 0 0 0 0 0 0 0 510.68 0 0 0 0 0 0 1950 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1950 2
0 0 0 0 0 0 0 0 297.32 0 0 0 0 0 0 1950 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1950 3
0 0 0 0 0 0 0 0 1043.48 0 0 0 0 0 0 1951 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1951 2
0 0 0 0 0 0 0 0 607.52 0 0 0 0 0 0 1951 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1951 3
0 0 0 0 0 0 0 0 1275.43 0 0 0 0 0 0 1952 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1952 2
0 0 0 0 0 0 0 0 742.57 0 0 0 0 0 0 1952 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1952 3
0 0 0 0 0 0 0 0 1865.12 0 0 0 0 0 0 1953 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1953 2
0 0 0 0 0 0 0 0 1085.88 0 0 0 0 0 0 1953 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1953 3
0 0 0 0 0 0 0 0 1853.11 0 0 0 0 0 0 1954 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1954 2
0 0 0 0 0 0 0 0 1078.89 0 0 0 0 0 0 1954 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1954 3
0 0 0 0 0 0 0 0 3038.79 0 0 0 0 0 0 1955 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1955 2
0 0 0 0 0 0 0 0 1769.21 0 0 0 0 0 0 1955 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1955 3
0 0 0 0 0 0 0 0 1750.09 0 2.05 0 0 0 0 1956 2	0 0 0 0 0 0 0 0 0 0 2.05 0 0 0 0 1956 2
0 0 0 0 0 0 0 0 1018.91 0 2.78 0 0 0 0 1956 3	0 0 0 0 0 0 0 0 0 0 2.78 0 0 0 0 1956 3
0 0 0 0 0 0 0 0 0.00 0 5.20 0 0 0 0 1956 4	0 0 0 0 0 0 0 0 0 0 5.20 0 0 0 0 1956 4
…..	…..

Table 27. Average proportions of the impact attributed to each fishery category on spawning biomass in the last three years (2015-2017) for 18SS3-uncertainty grid. Unexploited spawning stock biomass of a simulated population of Atlantic bigeye was 1.0. The predicted biomass of each model is 1 - sum of portions of the impact attributed to each fishery category. The fishery defined in the stock synthesis model (F1 - F15) are assigned as FSC (F1-3), FAD (F4 and 5), BB (F6-9), LL (F10-15). The FAD fishery category contained mixed fishery of BB and PS of Ghana.

model	FSC	FAD	BB	LL
1	0.11	0.32	0.17	0.29
2	0.11	0.32	0.17	0.29
3	0.10	0.33	0.16	0.29
4	0.10	0.31	0.16	0.29
5	0.09	0.32	0.15	0.28
6	0.07	0.32	0.14	0.27
7	0.13	0.32	0.18	0.29
8	0.12	0.32	0.18	0.29
9	0.10	0.33	0.17	0.29
10	0.11	0.32	0.17	0.28
11	0.09	0.32	0.16	0.28
12	0.08	0.33	0.14	0.28
13	0.13	0.31	0.19	0.29
14	0.12	0.32	0.18	0.29
15	0.10	0.33	0.17	0.29
16	0.11	0.32	0.17	0.28
17	0.09	0.32	0.16	0.28
18	0.08	0.33	0.14	0.28
average	0.10	0.32	0.16	0.28

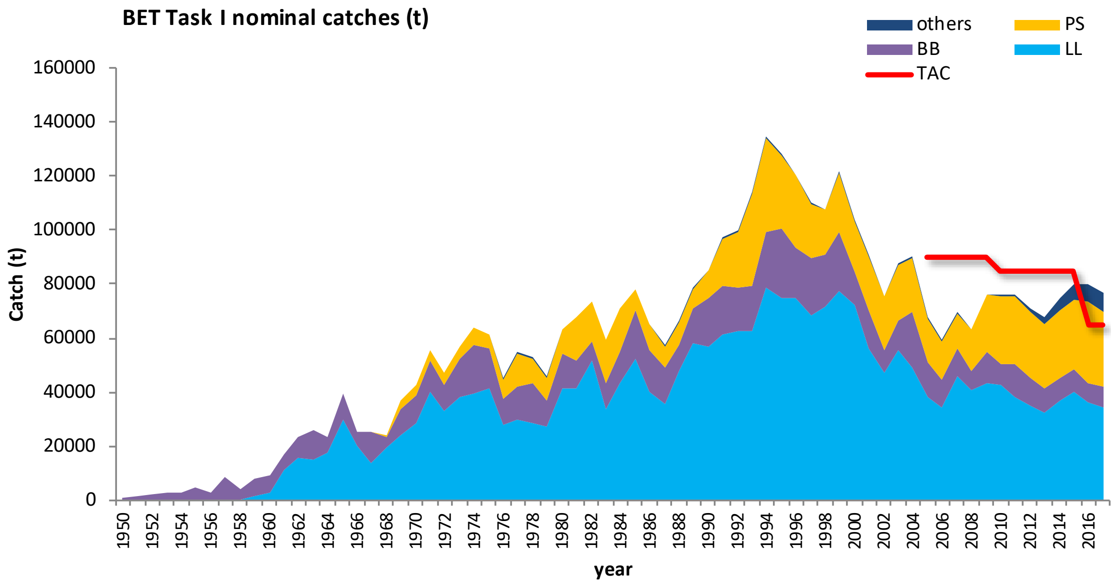


Figure 1. Atlantic bigeye tuna (*Thunnus obesus*) Task I cumulative catches (t) by gear type between 1950 and 2017.

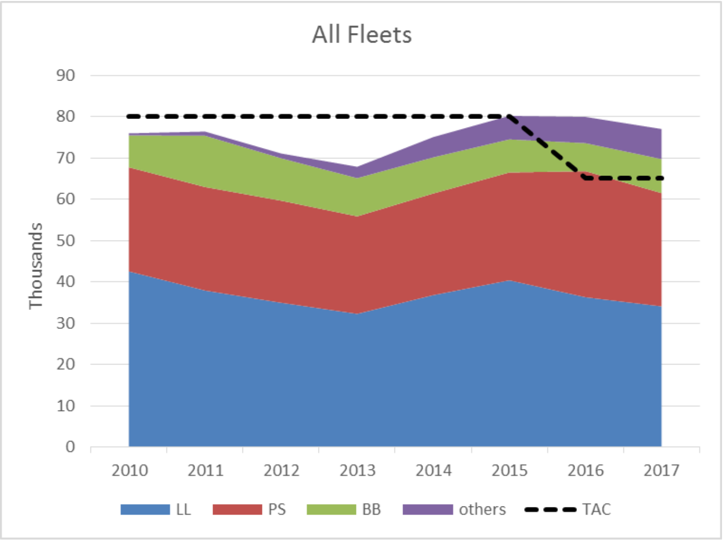


Figure 2. Catches of Atlantic bigeye tuna by gear type for the period 2010-2017.

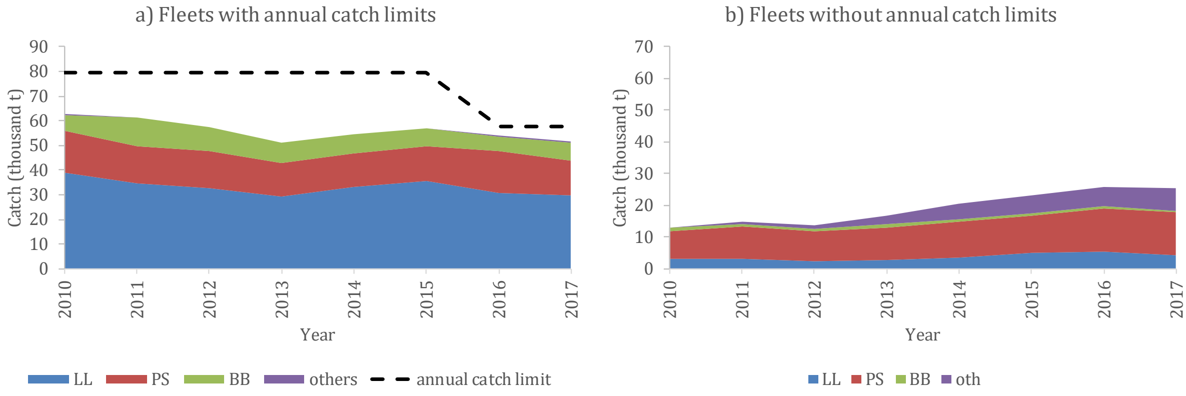


Figure 3. Catches of Atlantic bigeye tuna by gear type for the period 2010-2017 for CPCs with annual catch limits in paragraph 3 of Rec. 16-01 (a) and for CPCs with annual catch limits in paragraph 4 of Rec. 16-01.

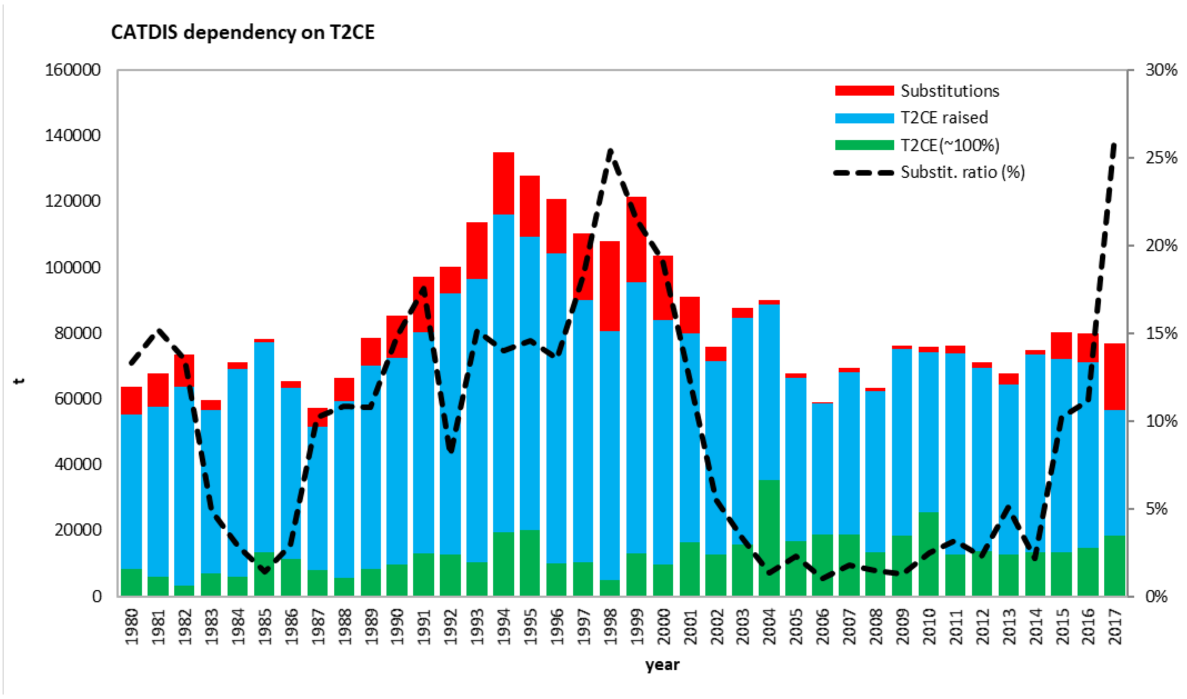


Figure 4. Distribution of total Atlantic bigeye tuna catch and effort (T2CE) 1980 – 2017 by source of information. T2CE submitted by CPCs (green bars), T2CE raised (blue bars) and estimated based on substitutions (red bars) information. The broken line represents the trend of percent of catch requiring substitutions to fulfill information.

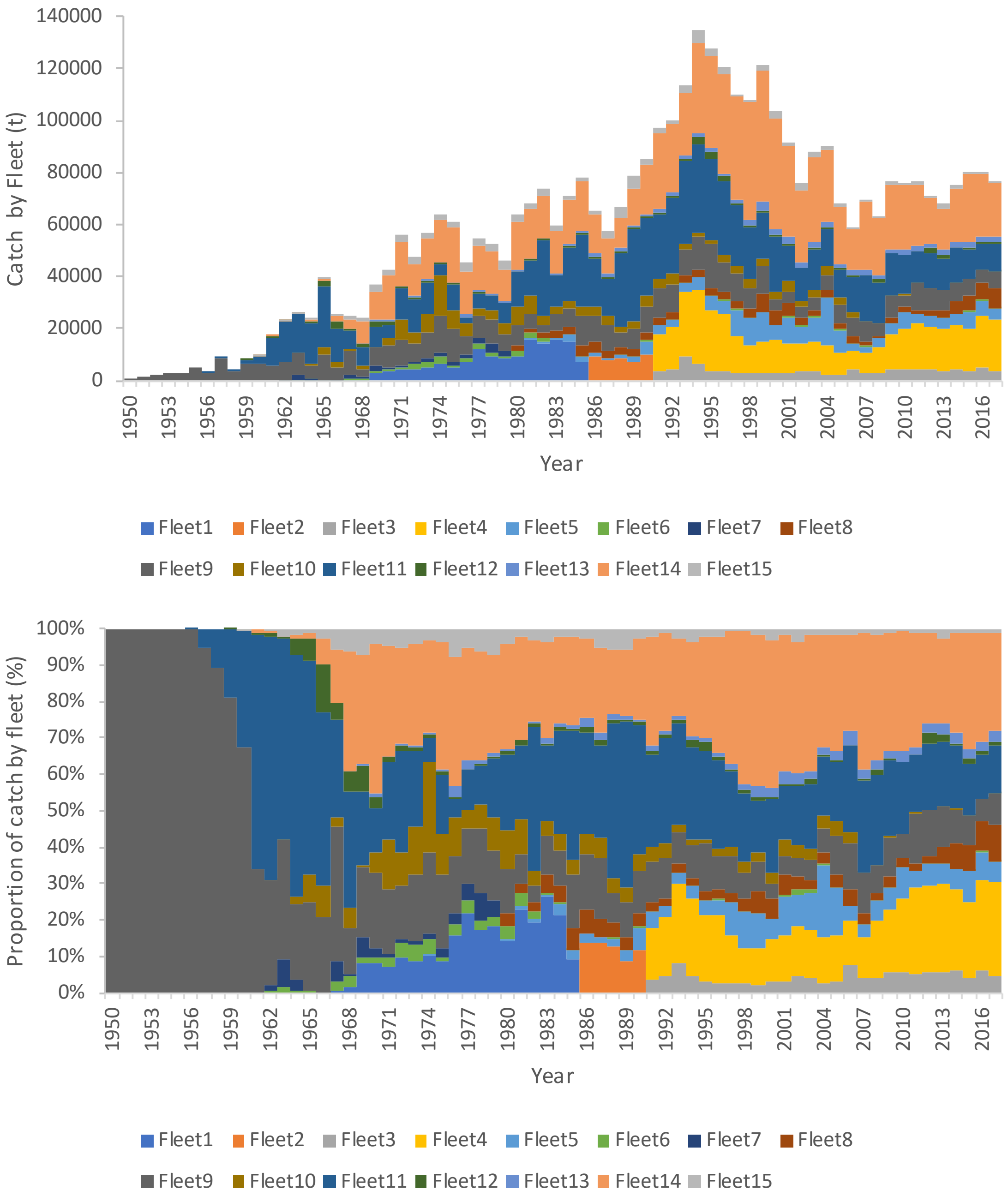


Figure 5. Total Atlantic bigeye tuna catch by fishery fleet ID used as input for the stock synthesis model. Bottom plot shows the proportion by fleet for each year.

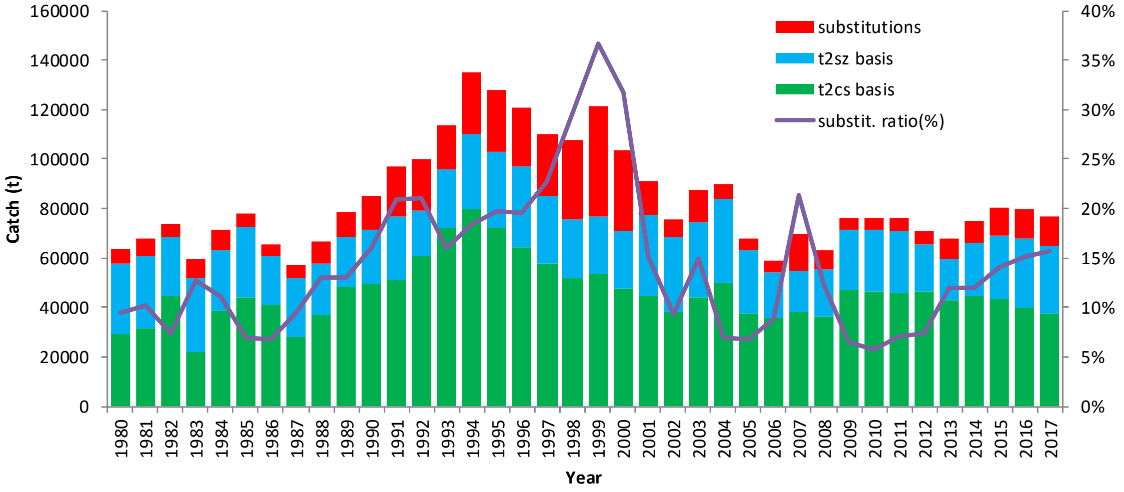


Figure 6. Distribution of total Atlantic bigeye tuna CAS (T2SZ) 1980 – 2017 by source of information. T2CS submitted by CPCs (green bars), T2SZ size samples data (blue bars) and size distribution estimated based on substitutions (red bars) information. The line represents the trend of percent of size distribution requiring substitutions to fulfill information.

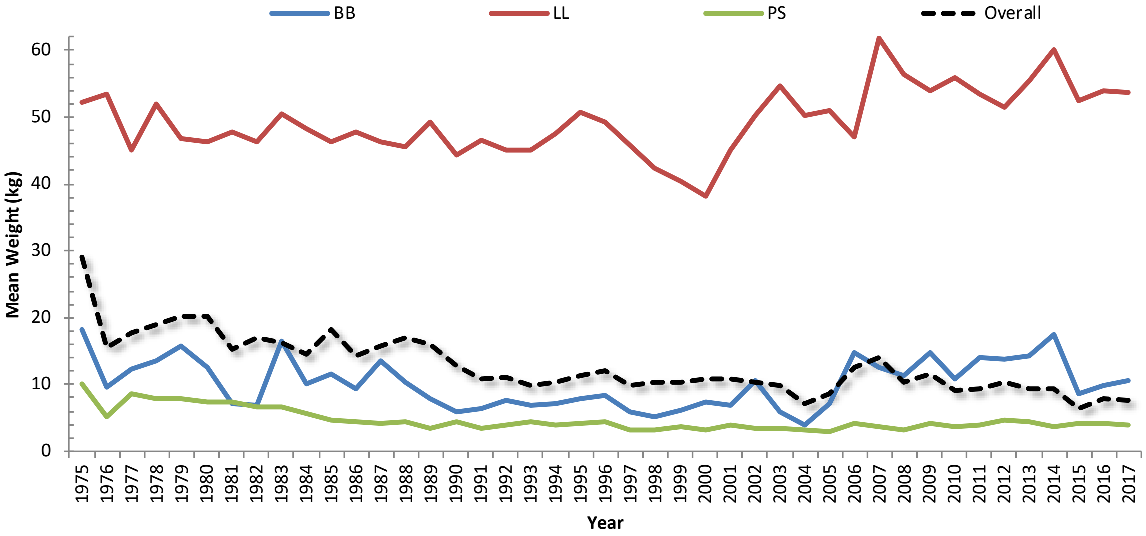


Figure 7. Atlantic bigeye tuna mean weight (kg) estimates from the CAS matrix by main gear type (BB baitboat, LL longline, PS purse seine) and overall.

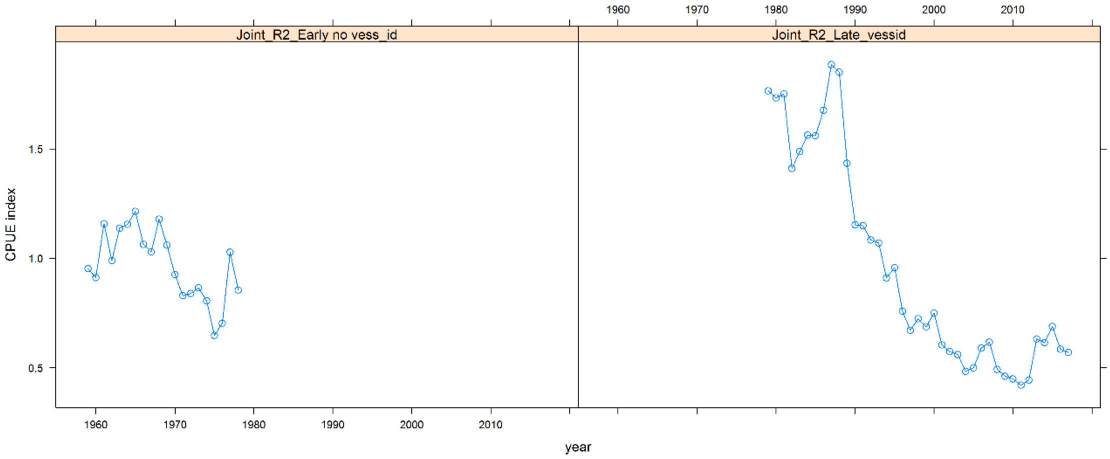


Figure 8. CPUE index used in the mpb-Reference Case for Atlantic bigeye tuna.

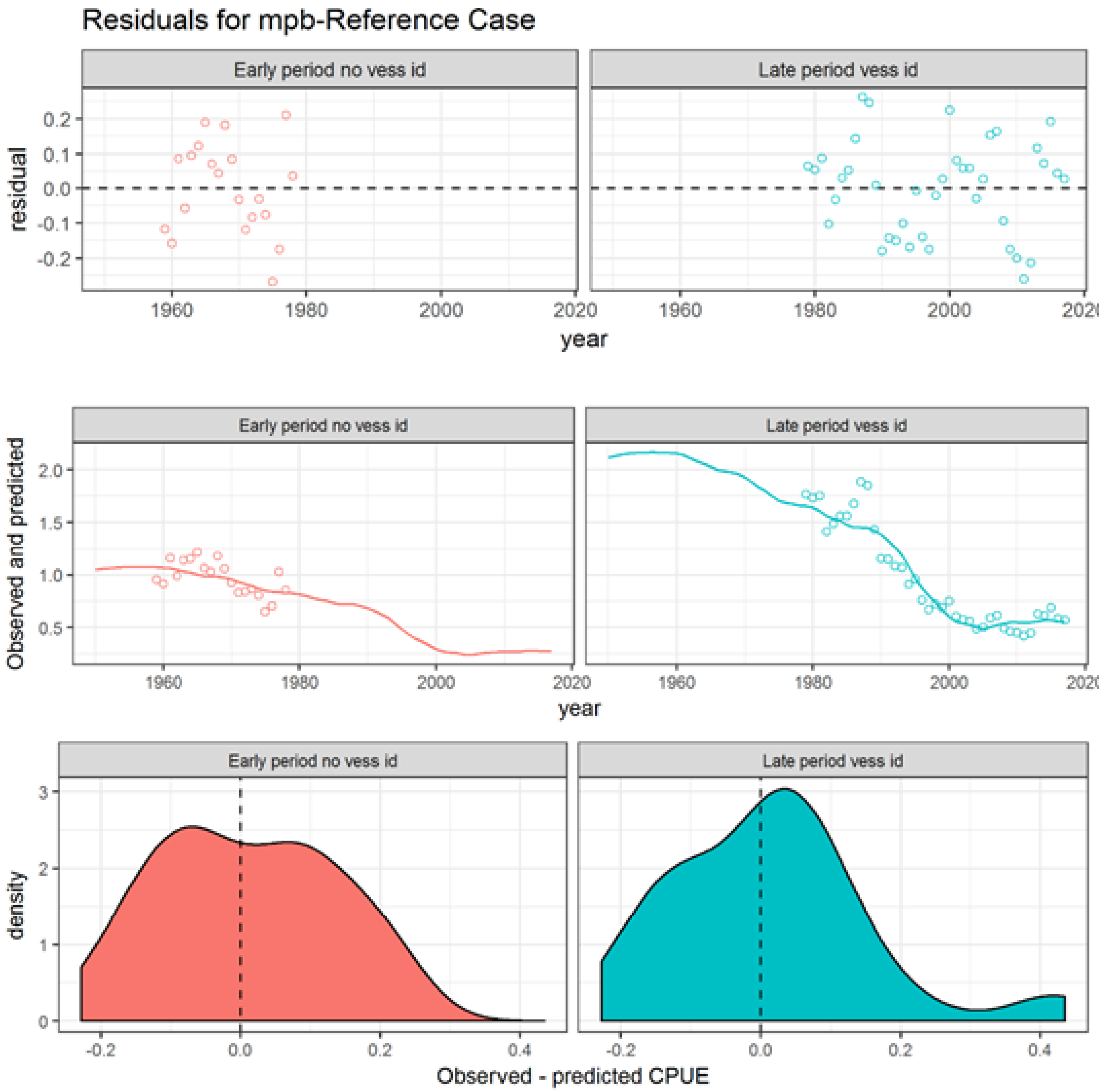


Figure 9. Residuals of fit from the mpb-Reference Case for Atlantic bigeye tuna.

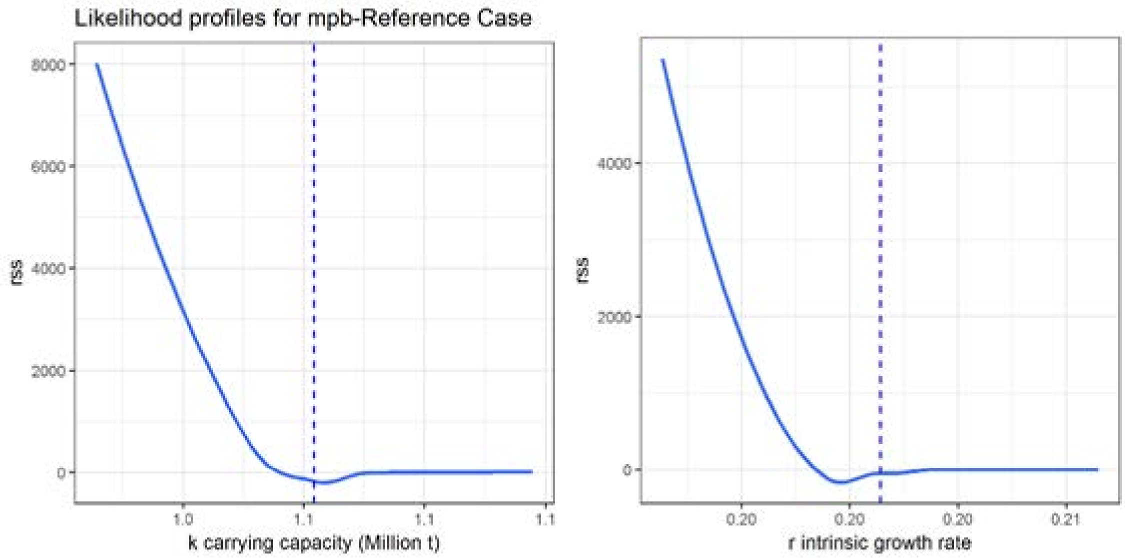


Figure 10. Likelihood profiles for the intrinsic growth parameter (r) and carrying capacity (K) in millions tons from the mpb-Reference Case for Atlantic bigeye tuna.

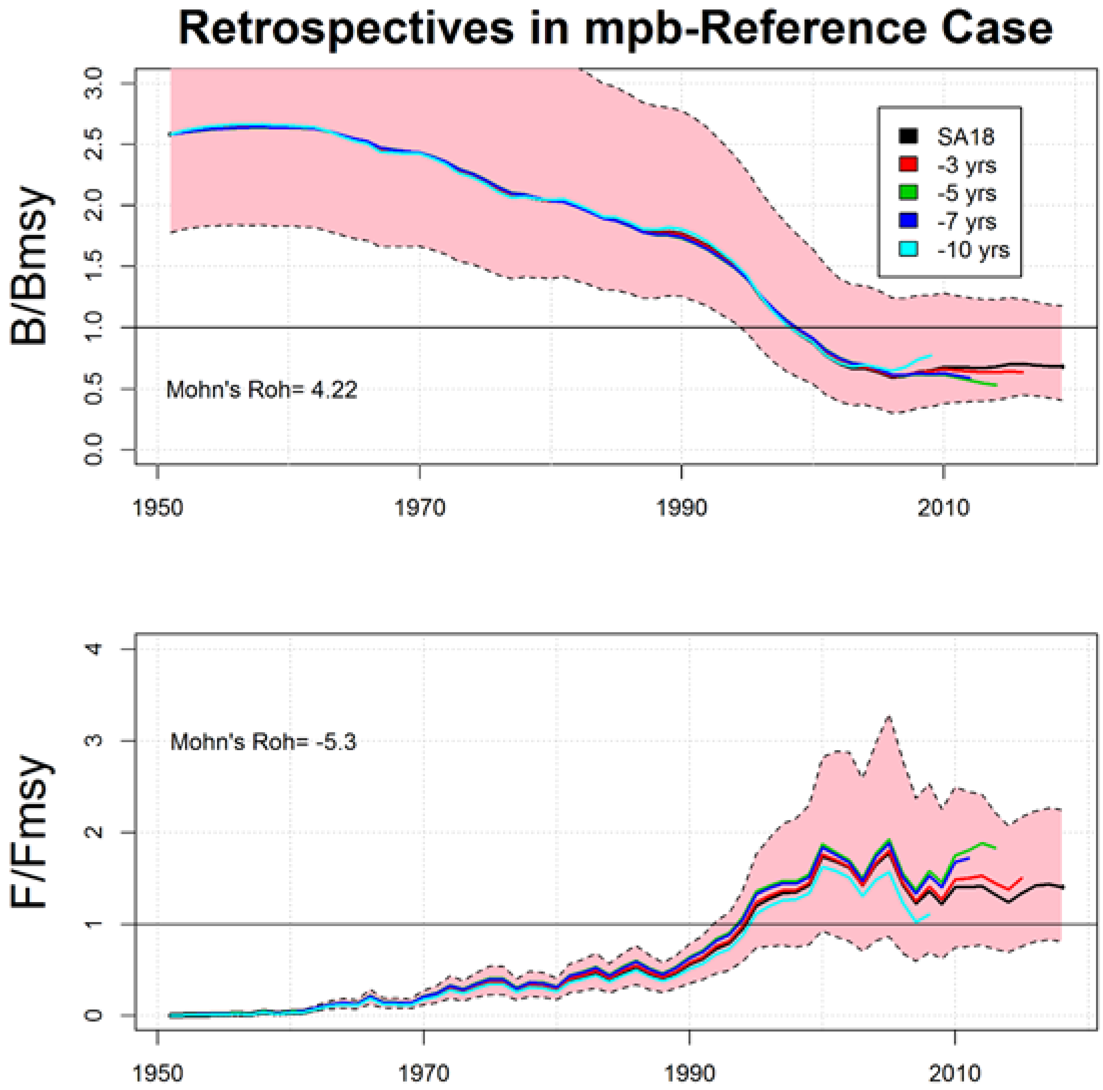


Figure 11. Retrospective analysis of the mpb-Reference Case for Atlantic bigeye tuna.

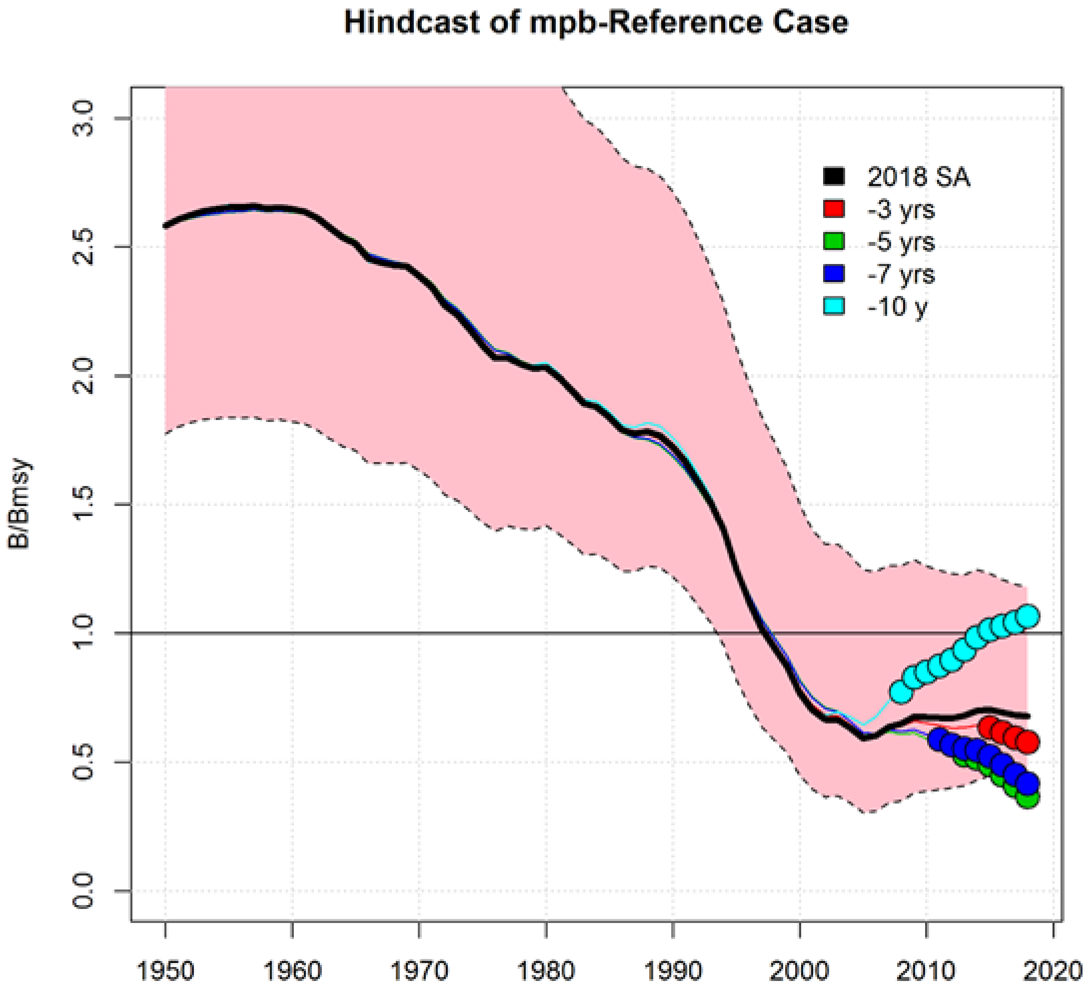


Figure 12. Hindcast analysis of the mpb-Reference Case for Atlantic bigeye tuna. The predicted abundance indices for (none fitted) hindcasting periods of 0, 3, 5, 7 and 10 years fitted with the mpb-Reference Case.

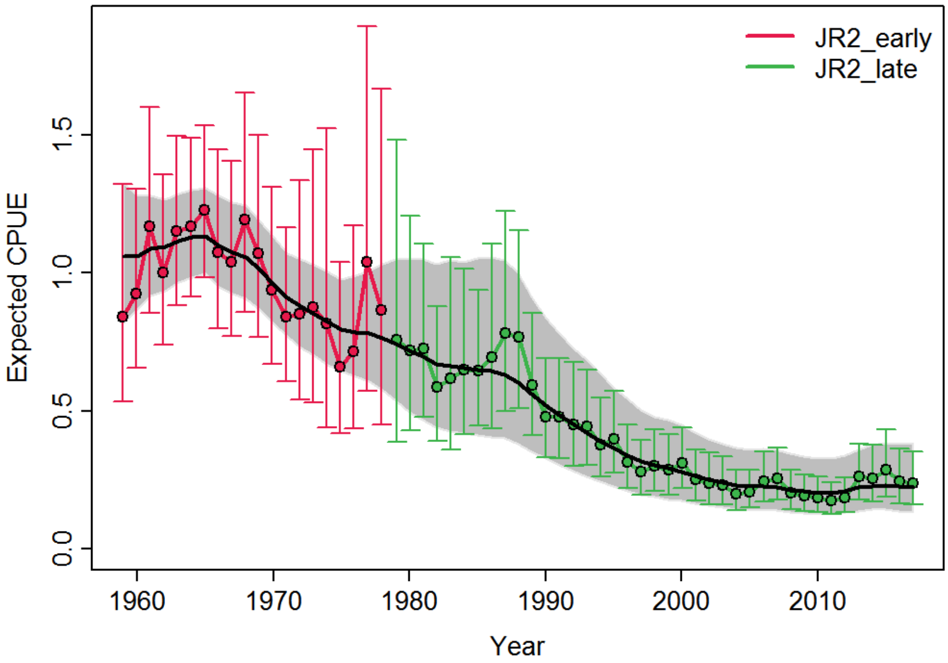


Figure 13. Trends in the split Joint R2 CPUE indices used as JABBA-uncertainty grid for Atlantic bigeye tuna, which is produced using the state-space CPUE averaging tool implemented in JABBA.

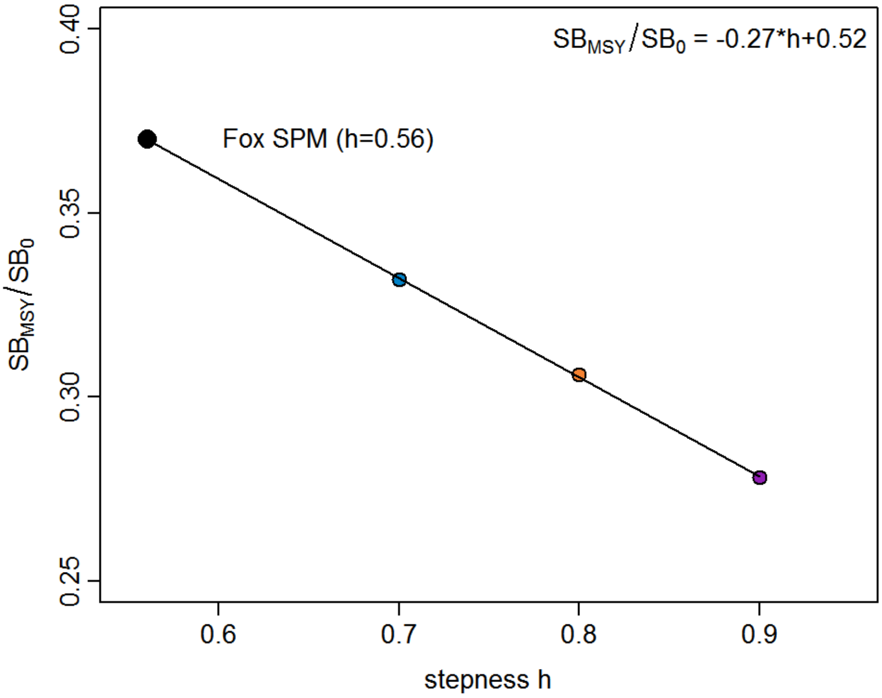


Figure 14. Showing the linear relationship between steepness *h* in values and predicted SB_{MSY}/SB_0 ratio for the Stock Synthesis (SS3) runs used for 2018 ICCAT bigeye tuna stock assessment. The solid black circle denotes the approximate position of *h* = 0.56 that would correspond to B/B_{MSY} ~ 0.37 for the Fox surplus production model.

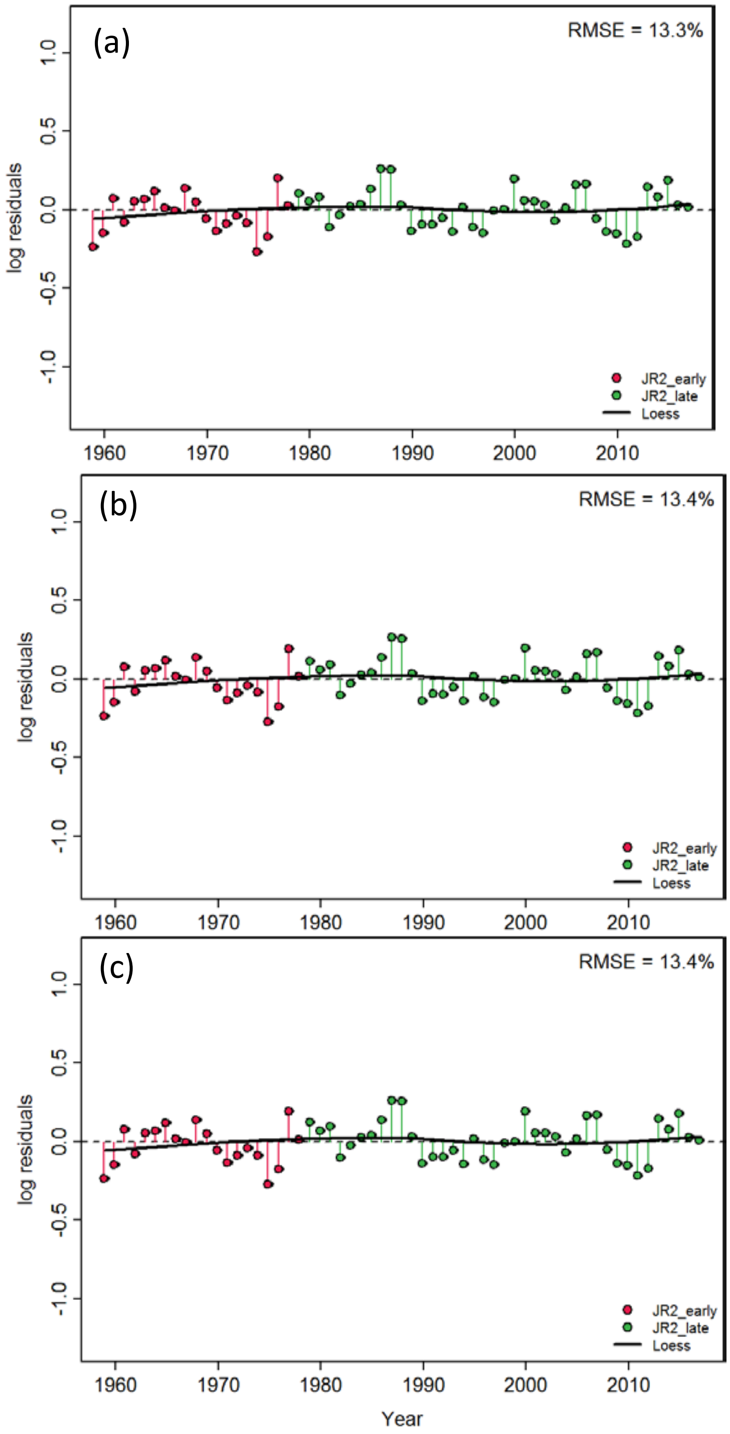


Figure 15. JABBA residual diagnostic plots were examined for the three uncertainty grid runs using *B*/*B*$_{MSY}$ input values of (a) 0.278 (*h* = 0.9), (b) 0.332 (*h* = 0.8) and (c) 0.332 (*h* = 0.7). Solid black lines indicate a loess smoother through all residuals.

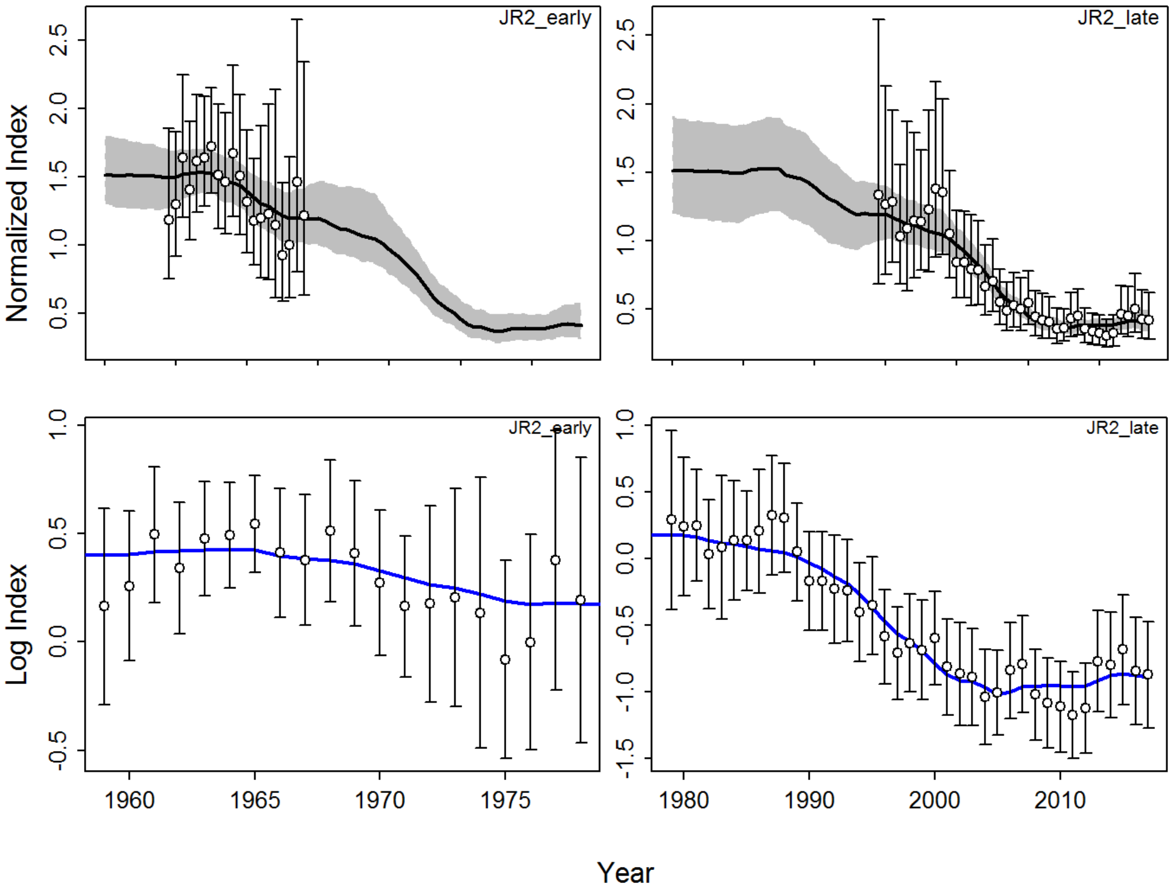


Figure 16. JABBA fits to the standardized split Joint JR2 CPUE indices shown for the selected run of the JABBA-uncertainty grid with $B/B_{MSY} = 0.306$ ($h = 0.8$). The plots show relative to the predicted (upper panel) and on log scale (lower panel) for the observed period. The solid lines denote the model predicted value and the circles are observed data values. Grey shaded areas and vertical black lines represent the estimated 95% confidence intervals around the CPUE values.

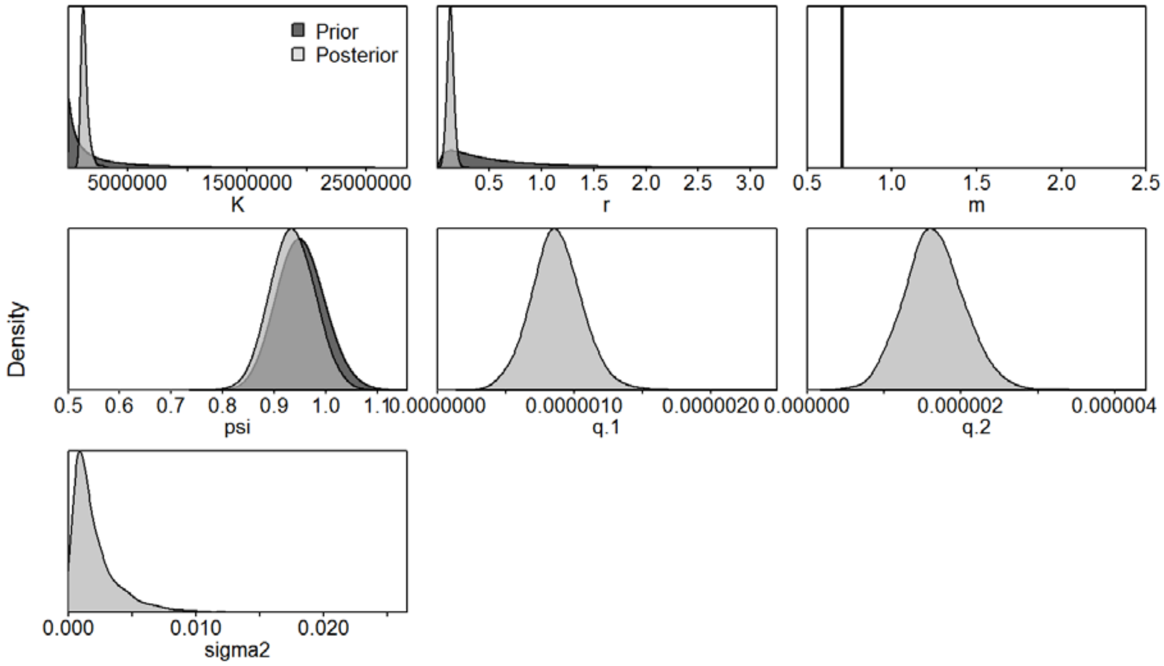


Figure 17. Prior and posterior distributions for estimable JABBA model parameters shown for a selected run of the JABBA-uncertainty grid with B/B_{MSY} = 0.306 (h = 0.8). Posteriors distributions are plotted using generic kernel densities.

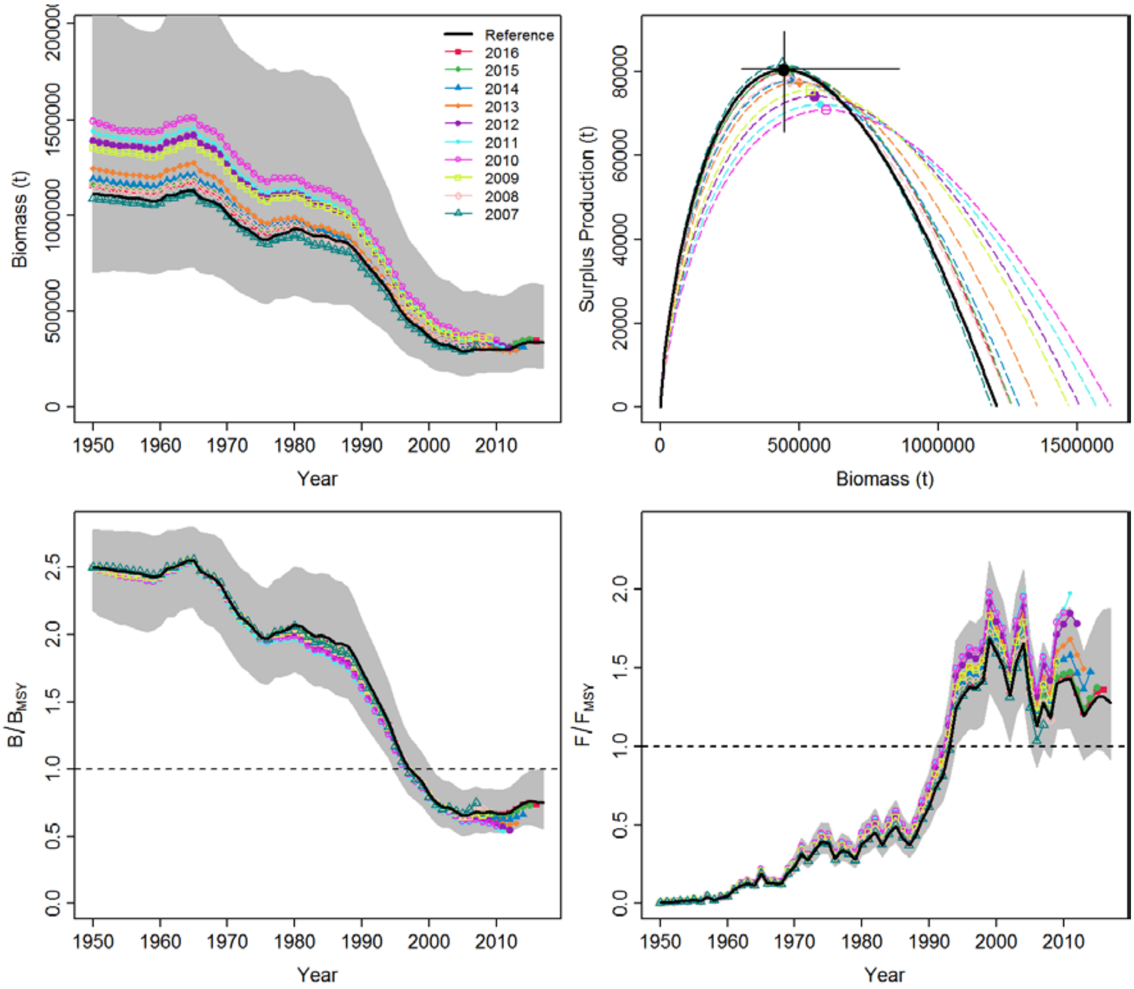


Figure 18. Retrospective analysis for stock biomass (t), surplus production function (maximum = MSY), B/B_{MSY} and F/F_{MSY} shown for the initial JABBA Fox model run. The label "Reference" indicates the model fits and associated 95% CIs for complete CPUE time series 1959-2017. The numeric year label indicates the retrospective results, sequentially excluding CPUE data back to 2007. Grey shaded areas denote the 95% CIs, which in the case of the production curve (panel top-right) are indicated by crosshair defining the maximum of the surplus production curve.

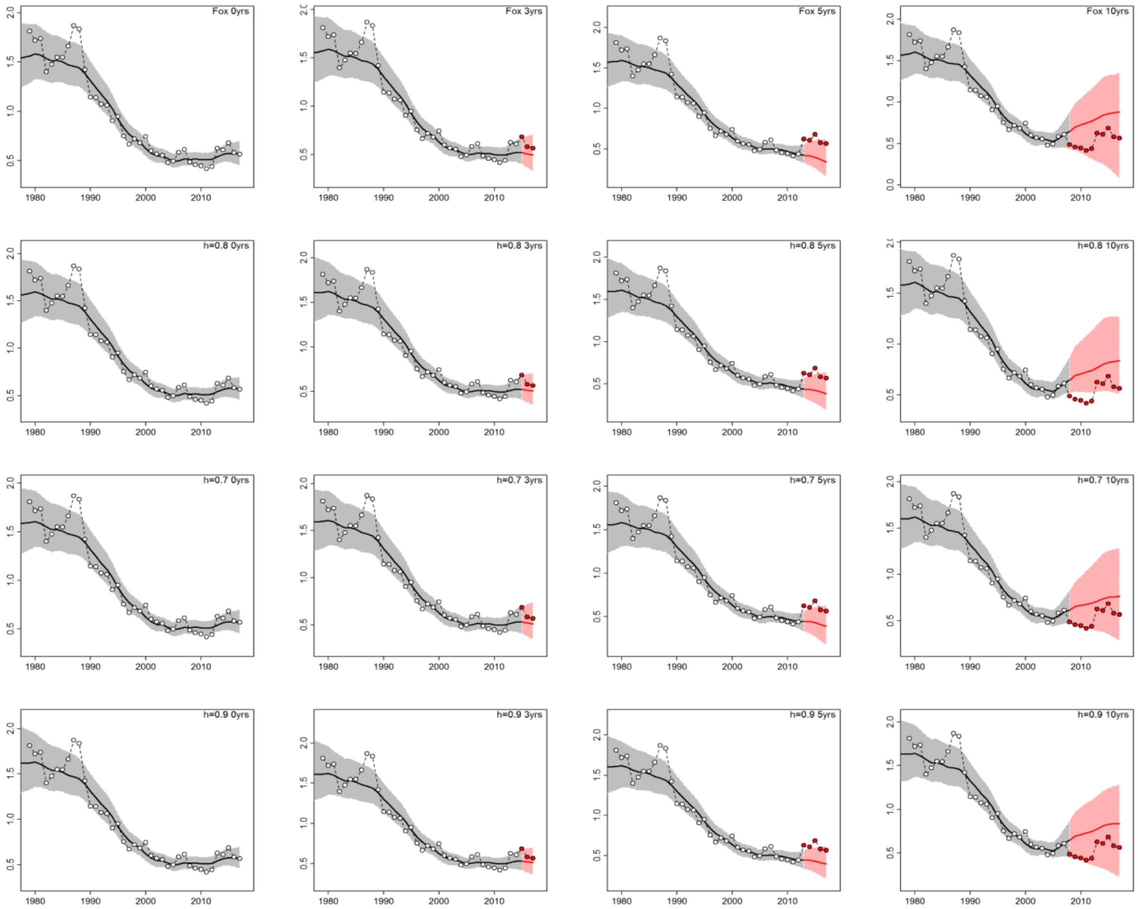


Figure 19. The predicted abundance indices for (none fitted) hindcasting periods of 0, 3, 5 and 10 years fitted with JABBA Fox model and JABBA-uncertainty grid using alternative input values of BMSY/K. Predicted mean CPUE and 95%CIs are denoted by black lines with grey shaded area and red lines with red shaded areas for the fitted and hindcasting years, respectively.

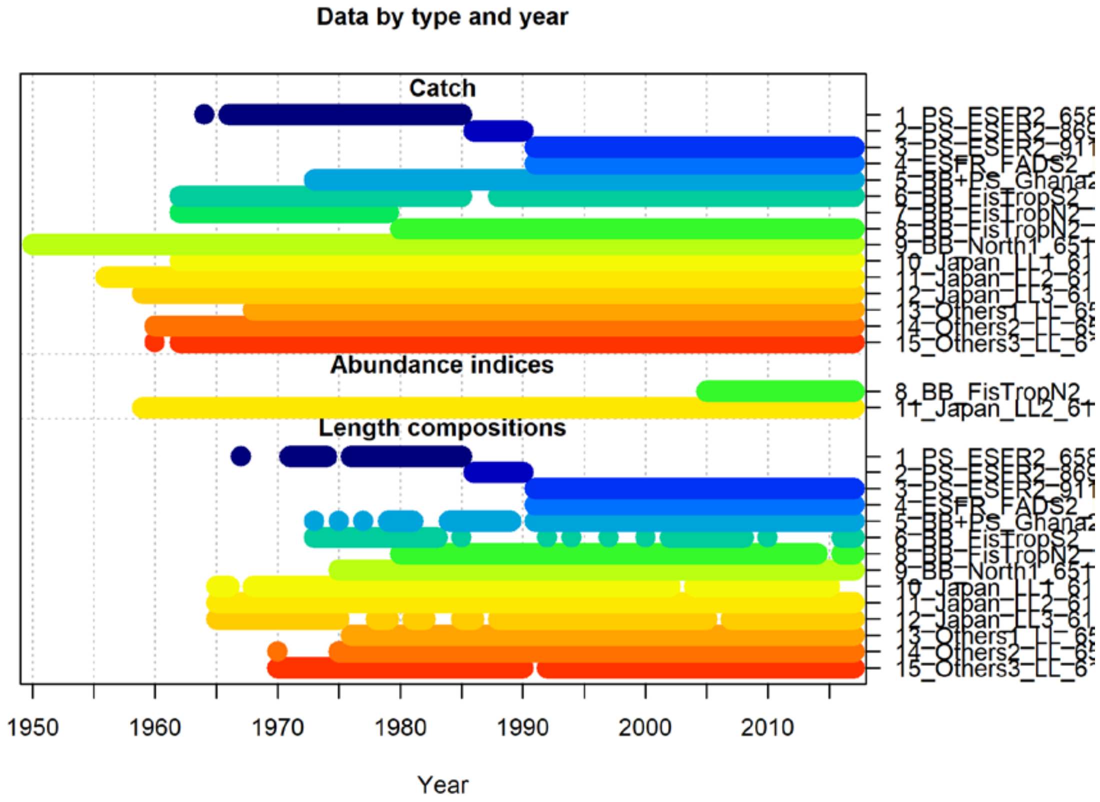


Figure 20. Data sources for the SS3 assessment of Atlantic bigeye tuna.

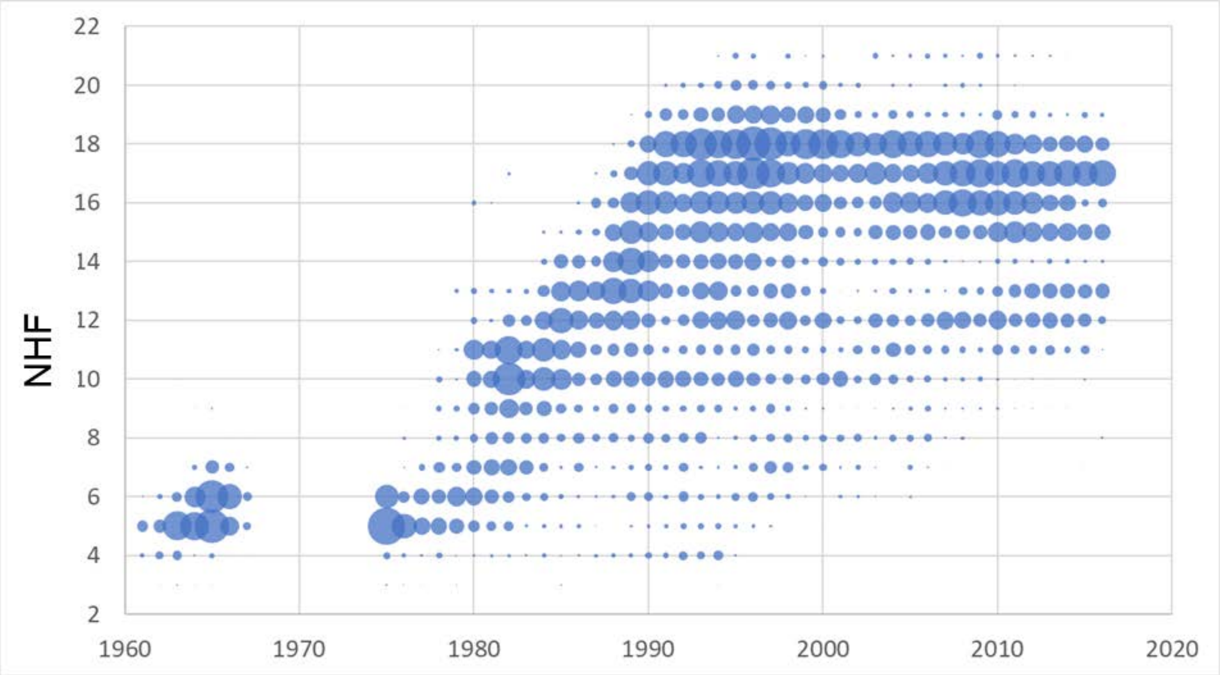


Figure 21. Historical change of the proportion of fishing effort by the number of hooks between floats (NHF) by Japanese longline fishery in the Atlantic. Note: the information is incomplete before 1975.

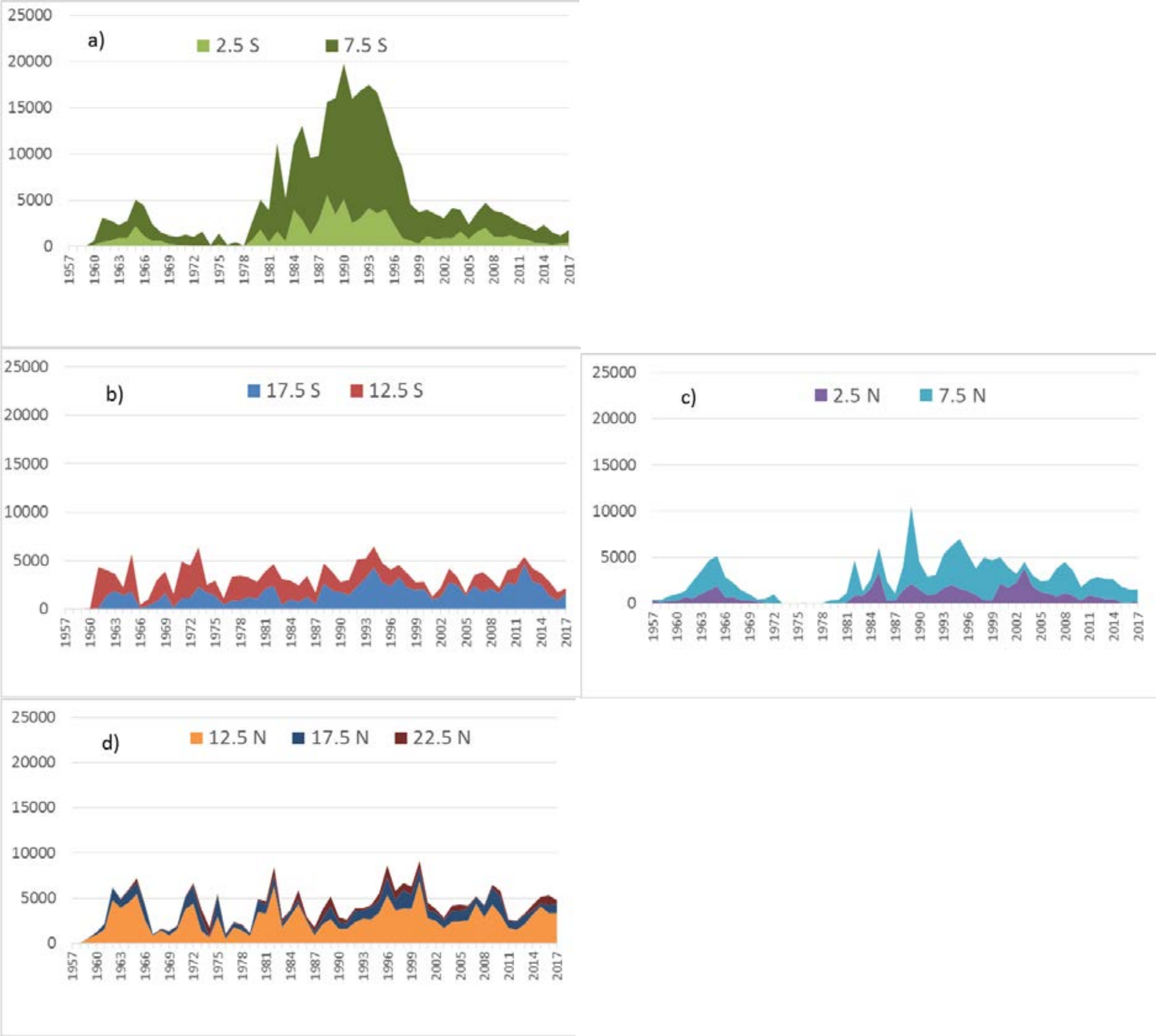


Figure 22. History of catches of Japanese longline from CATDIS by latitudinal bands of 5 degrees. Each panel correspond to different areas a) southern equatorial, b) far southern equatorial, c) northern equatorial, d) far northern equatorial. Note the large increase in catches in the southern equatorial in the 1980s and 1990s.

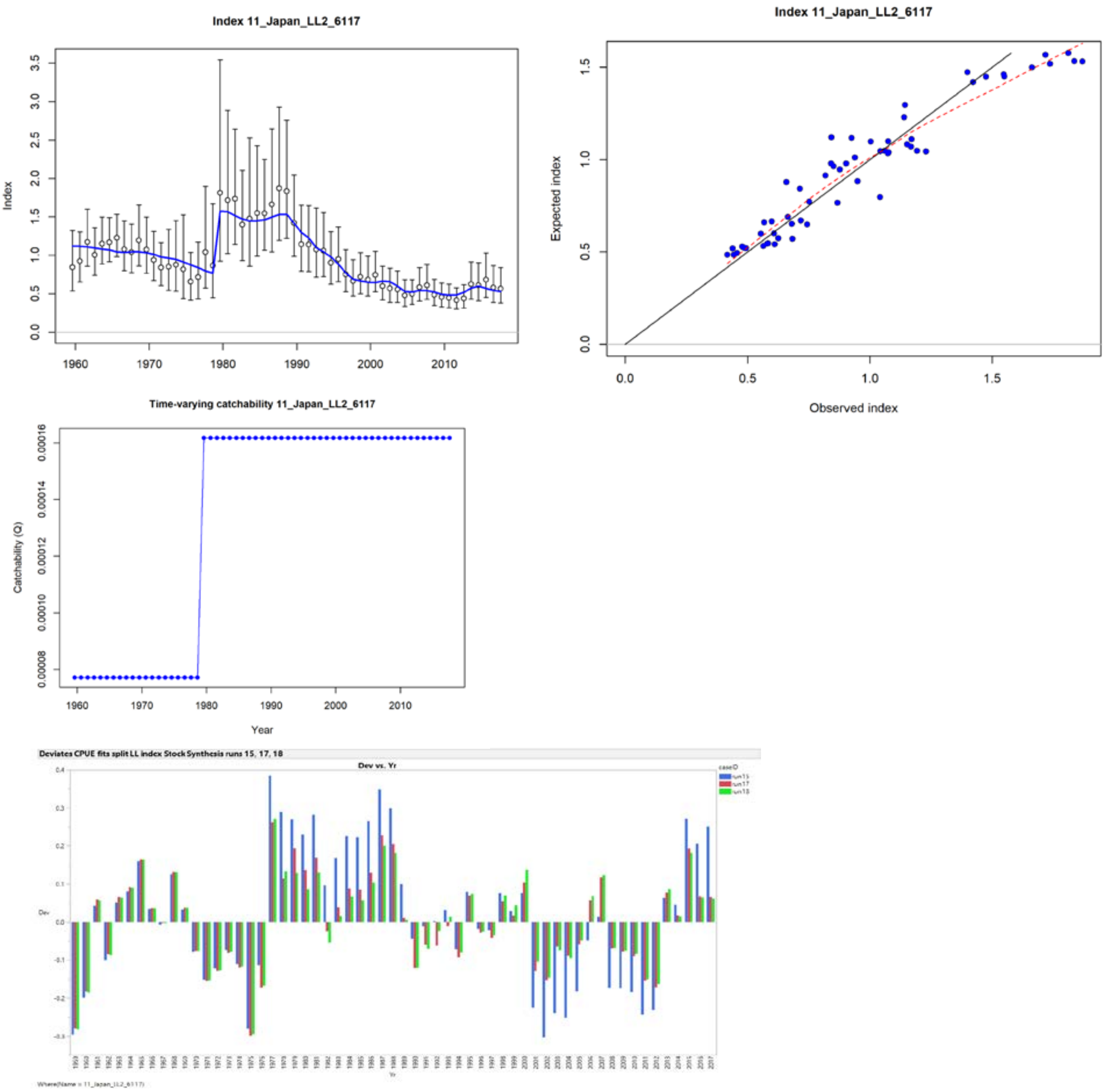


Figure 23. SS3 model fits and estimated catchability to the joint longline CPUE index of Atlantic bigeye tuna (run 19 – above and runs 15, 17, and 18 shown).

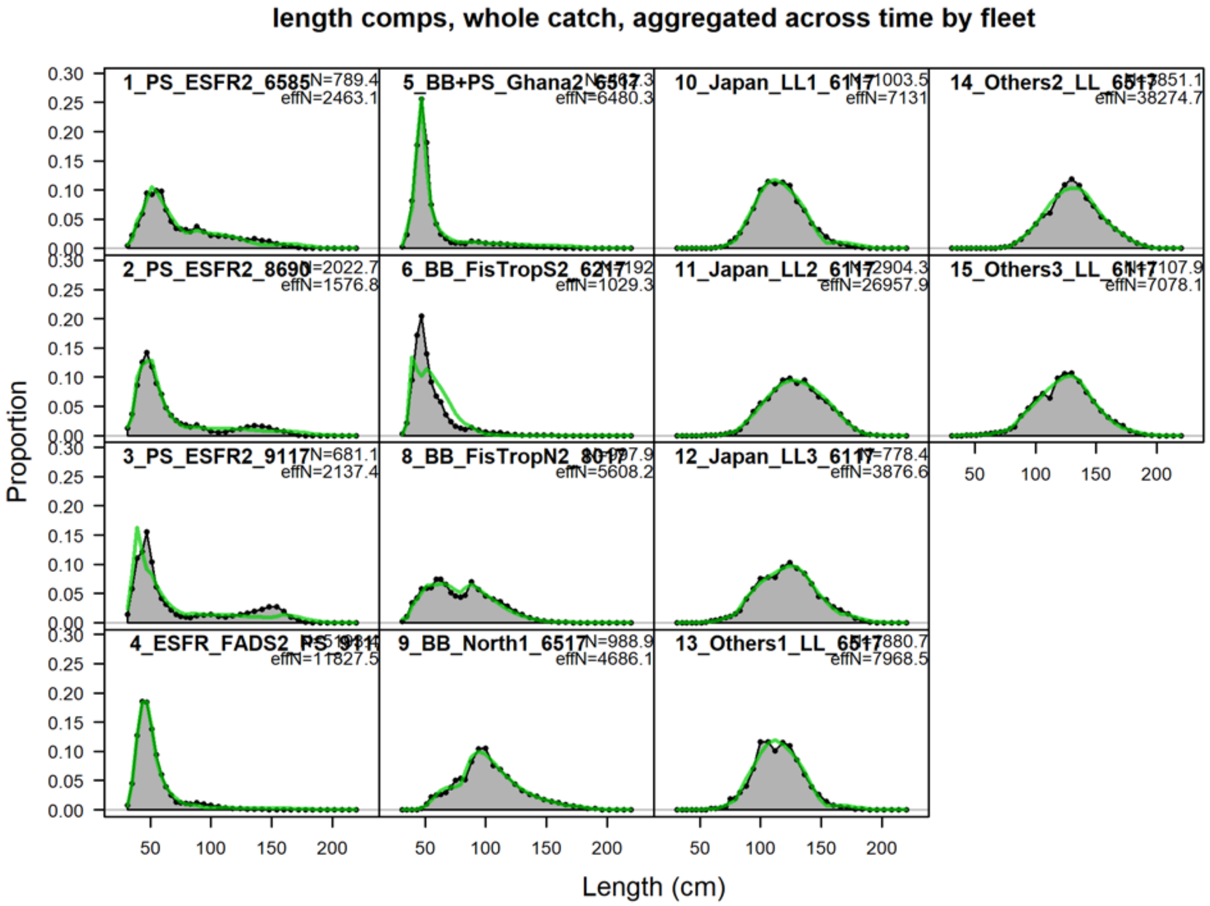


Figure 24. SS3 model fits to the length composition data of Atlantic bigeye tuna for the SS3-Reference Case (run 19).

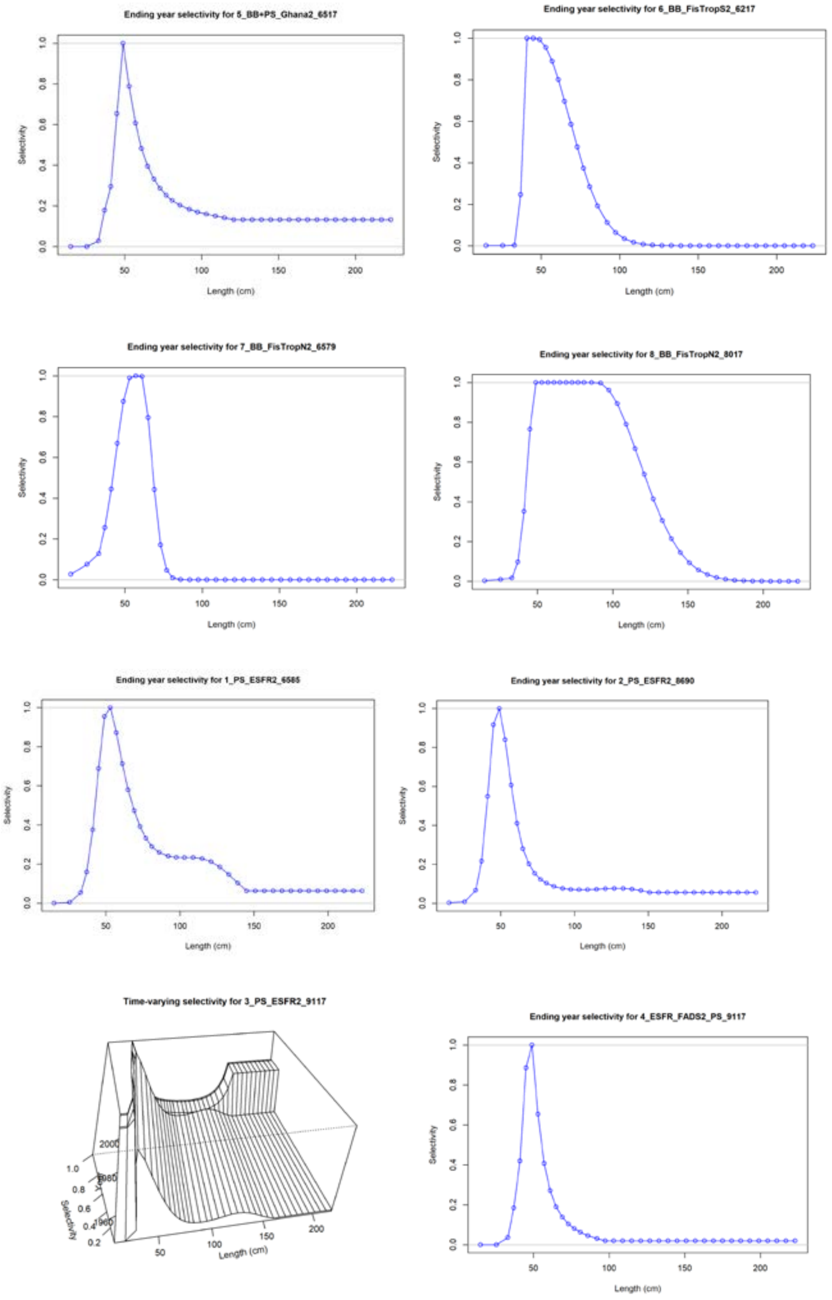


Figure 25. Estimated selectivities of purse seine and baitboat fleets catching Atlantic bigeye tuna for the SS3-Reference Case (run 19).

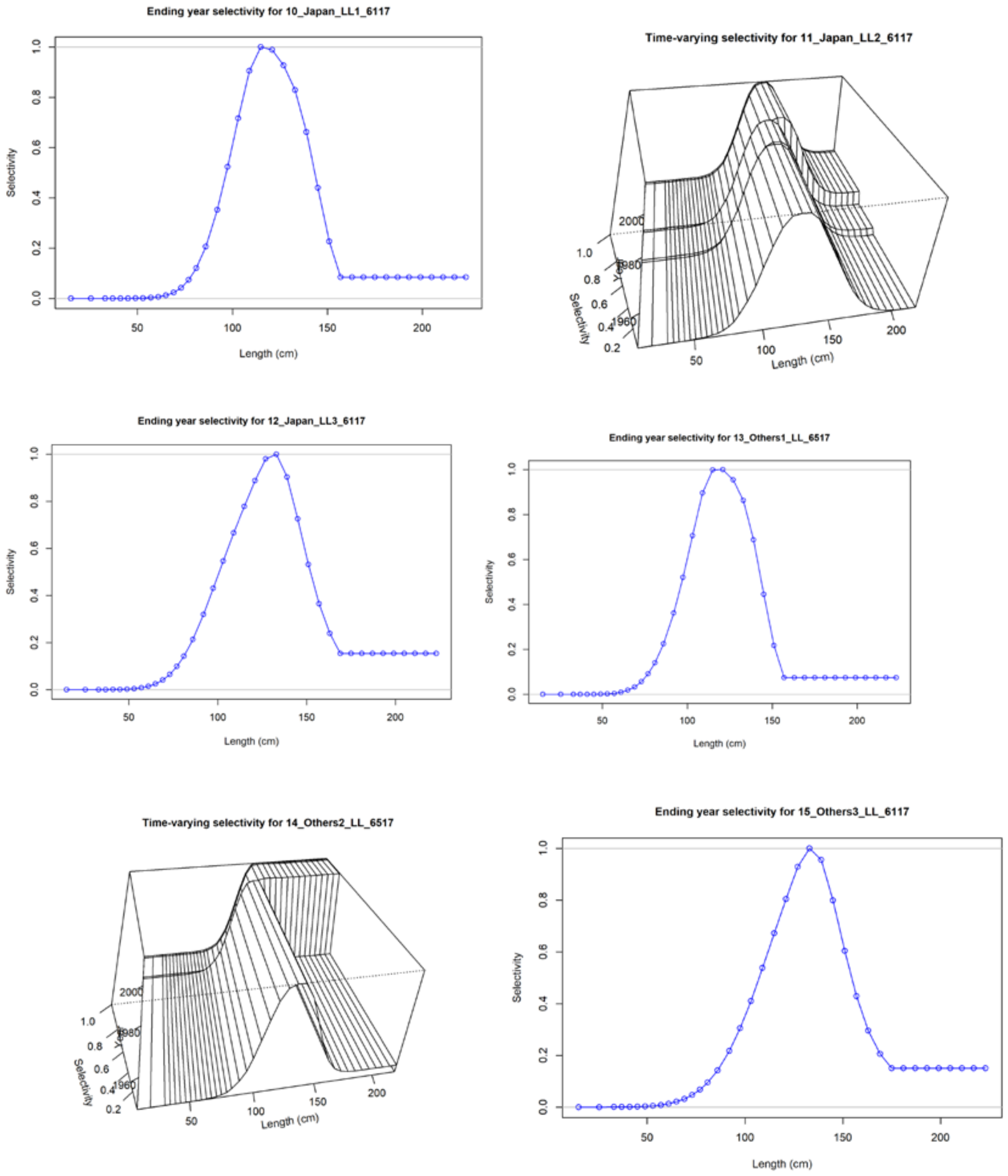


Figure 25 (continued). Estimated selectivities of longline fleets catching Atlantic bigeye tuna for the SS3-Reference Case (run 19).

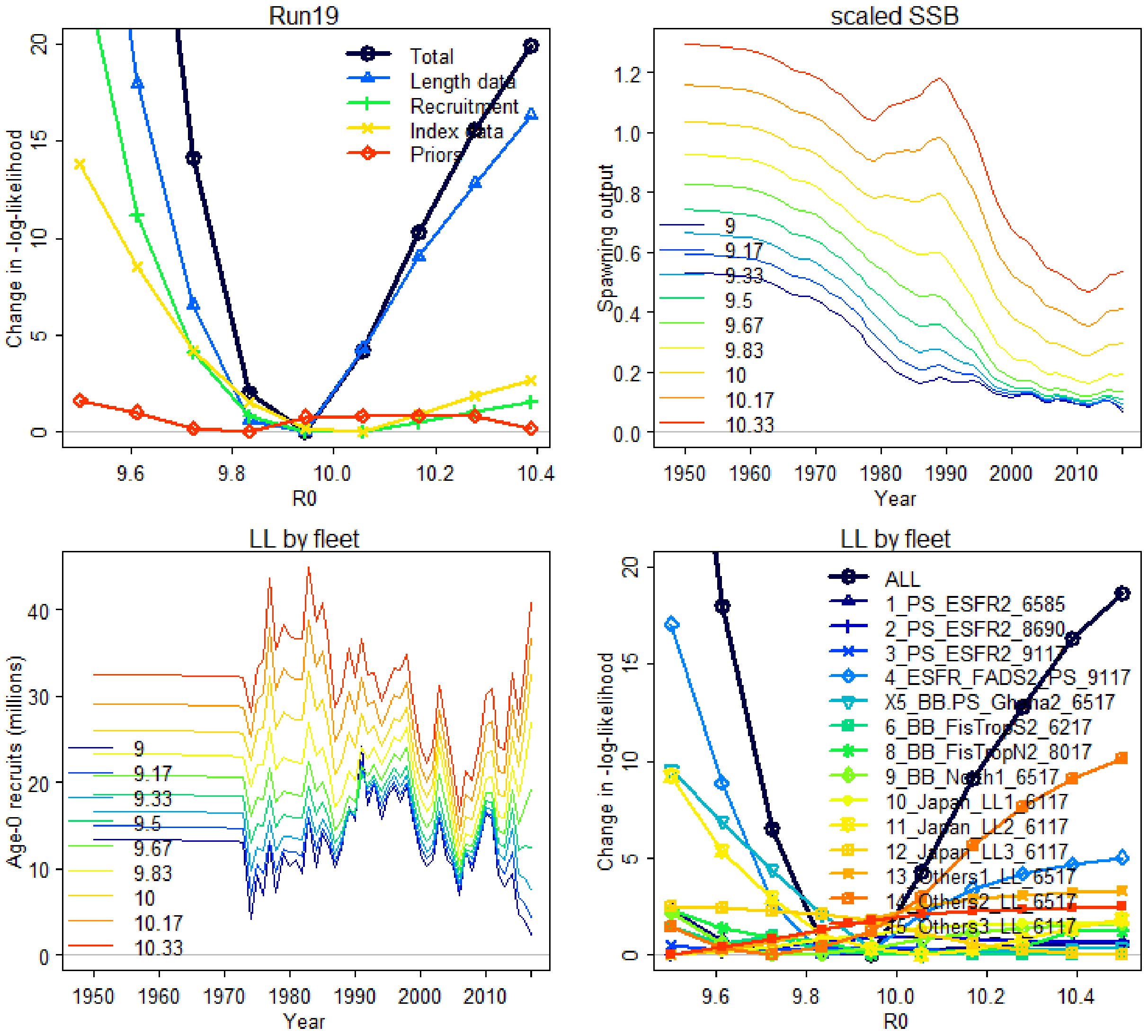


Figure 26. Likelihood profiles of R0 and resulting SSB and recruitment across each fleet by data source used in the SS3 reference case model (run 19) of Atlantic bigeye tuna.

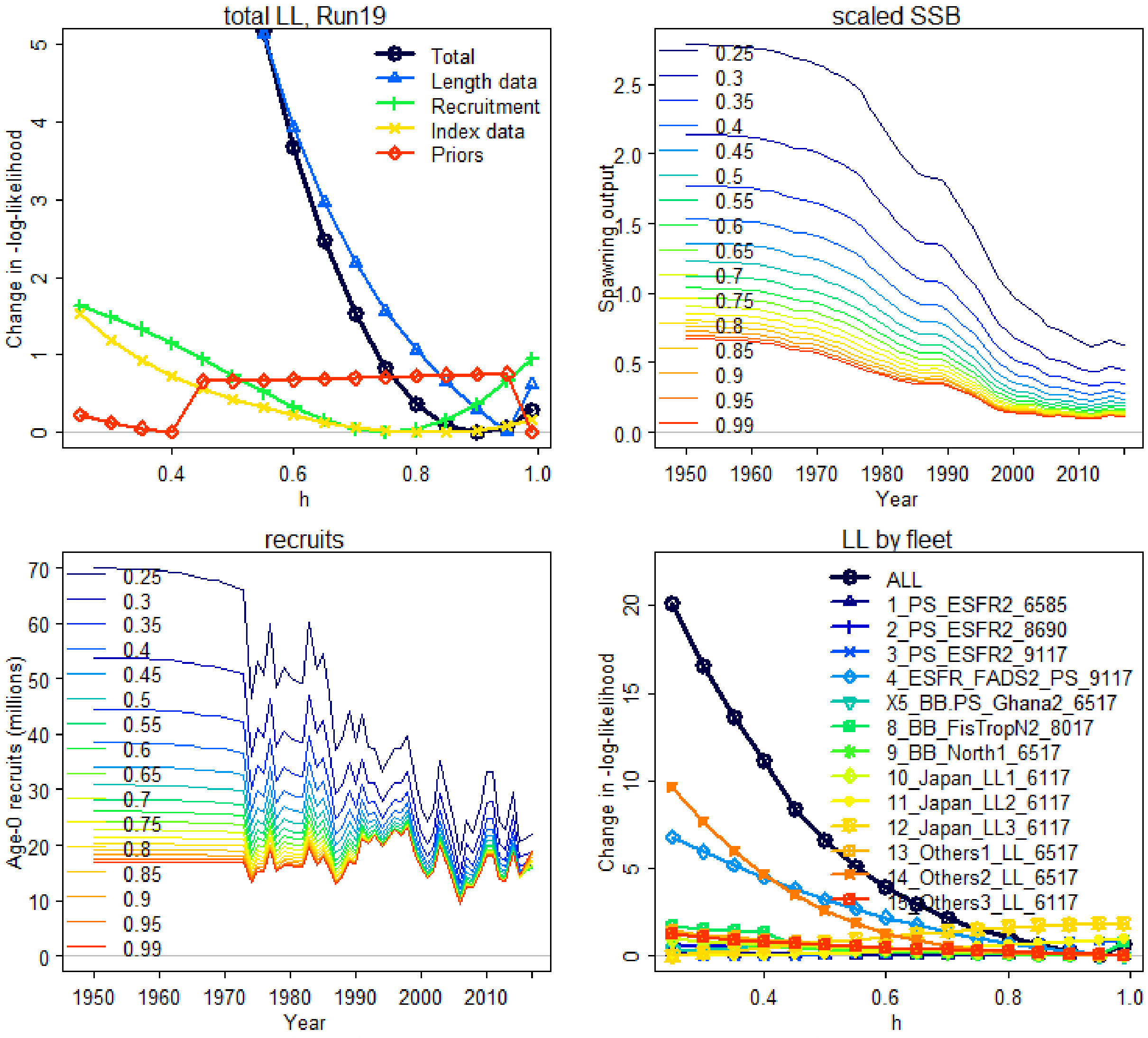


Figure 27. Likelihood profiles of steepness and resulting SSB across each fleet by data source used in the SS3 reference case model (run 19) of Atlantic bigeye tuna.

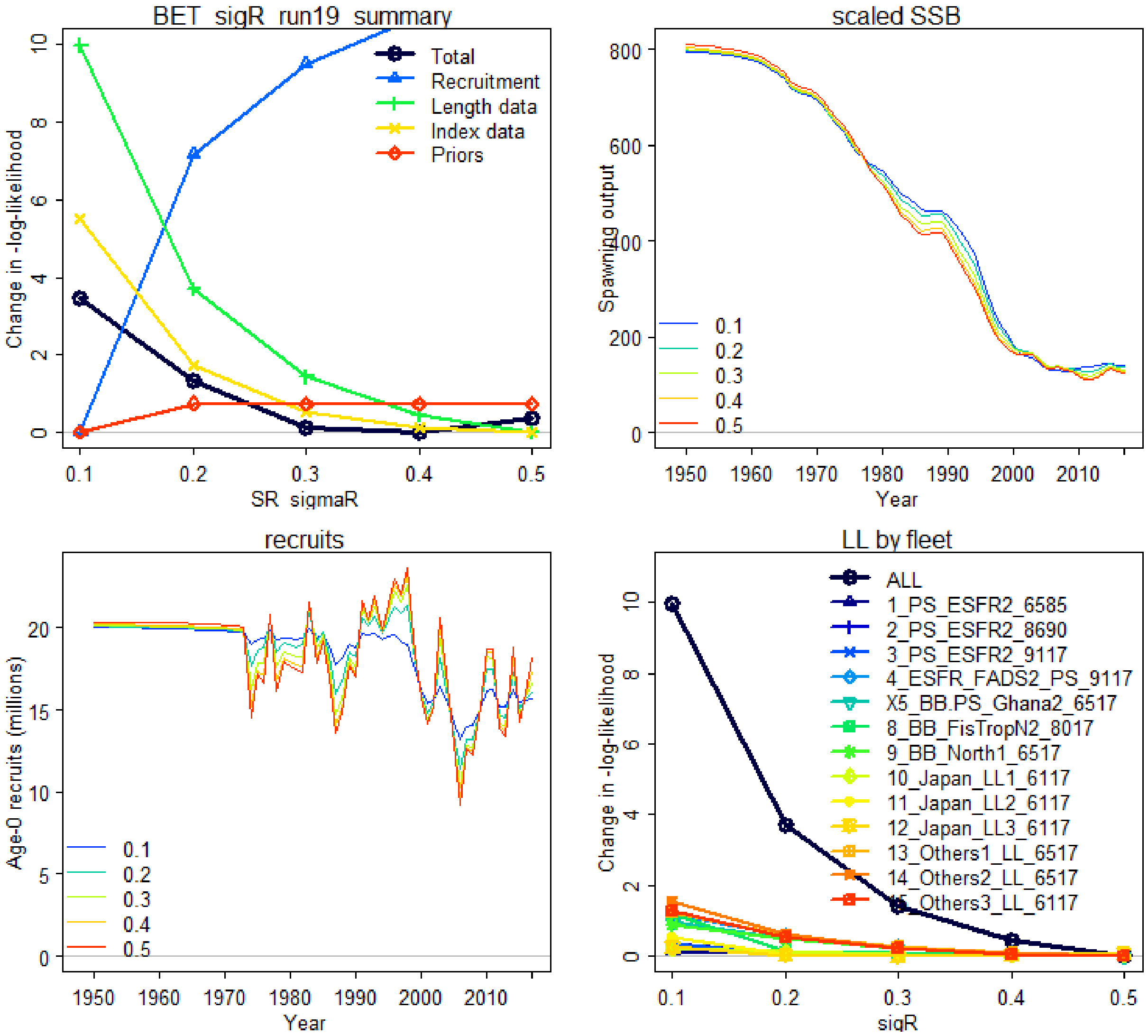


Figure 28. Likelihood profiles of sigmaR and resulting SSB and recruitment across each fleet by data source used in the SS3 reference case model (run 19) of Atlantic bigeye tuna.

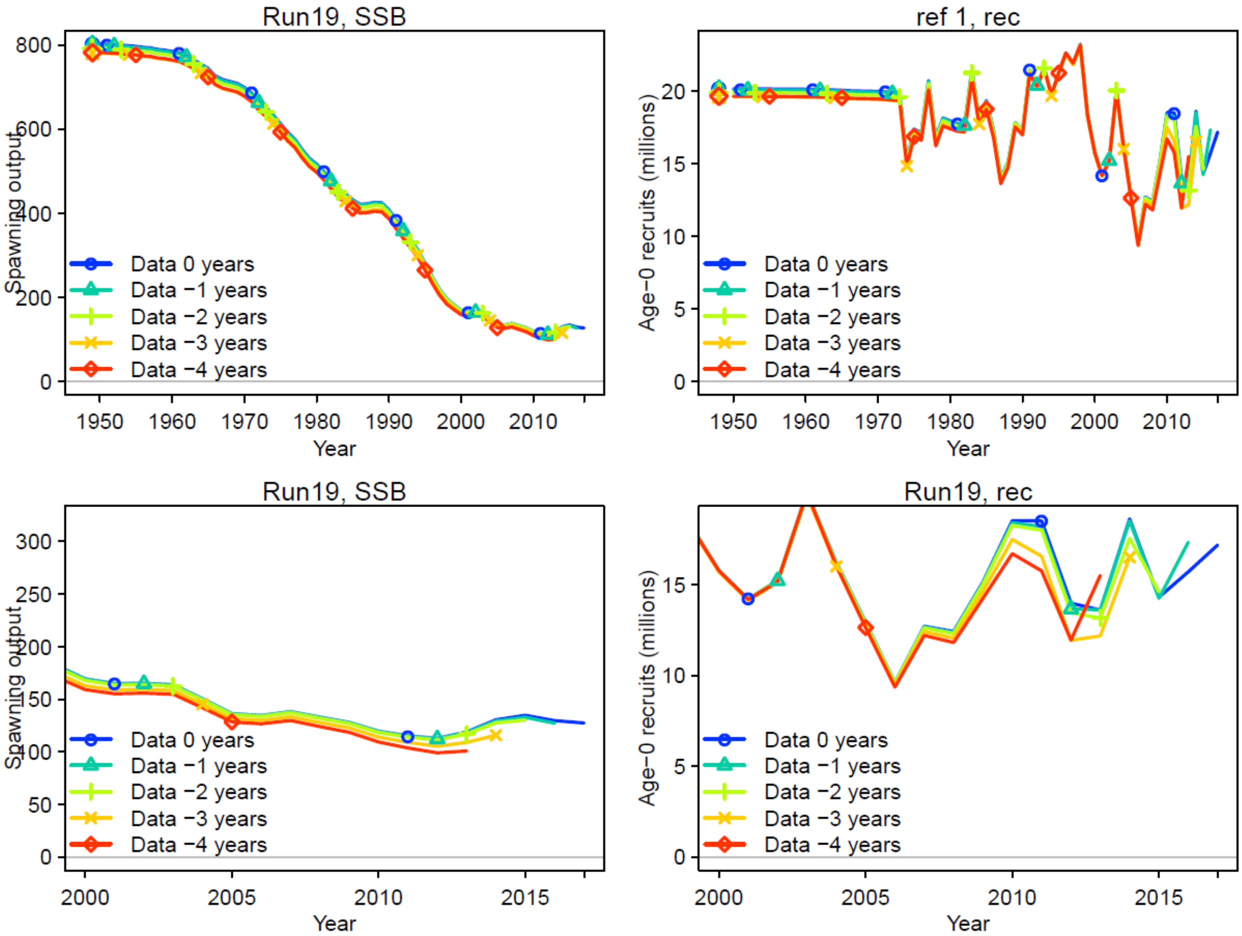


Figure 29. Retrospective diagnostics for the SS3-Reference Case (run 19) for Atlantic bigeye tuna.

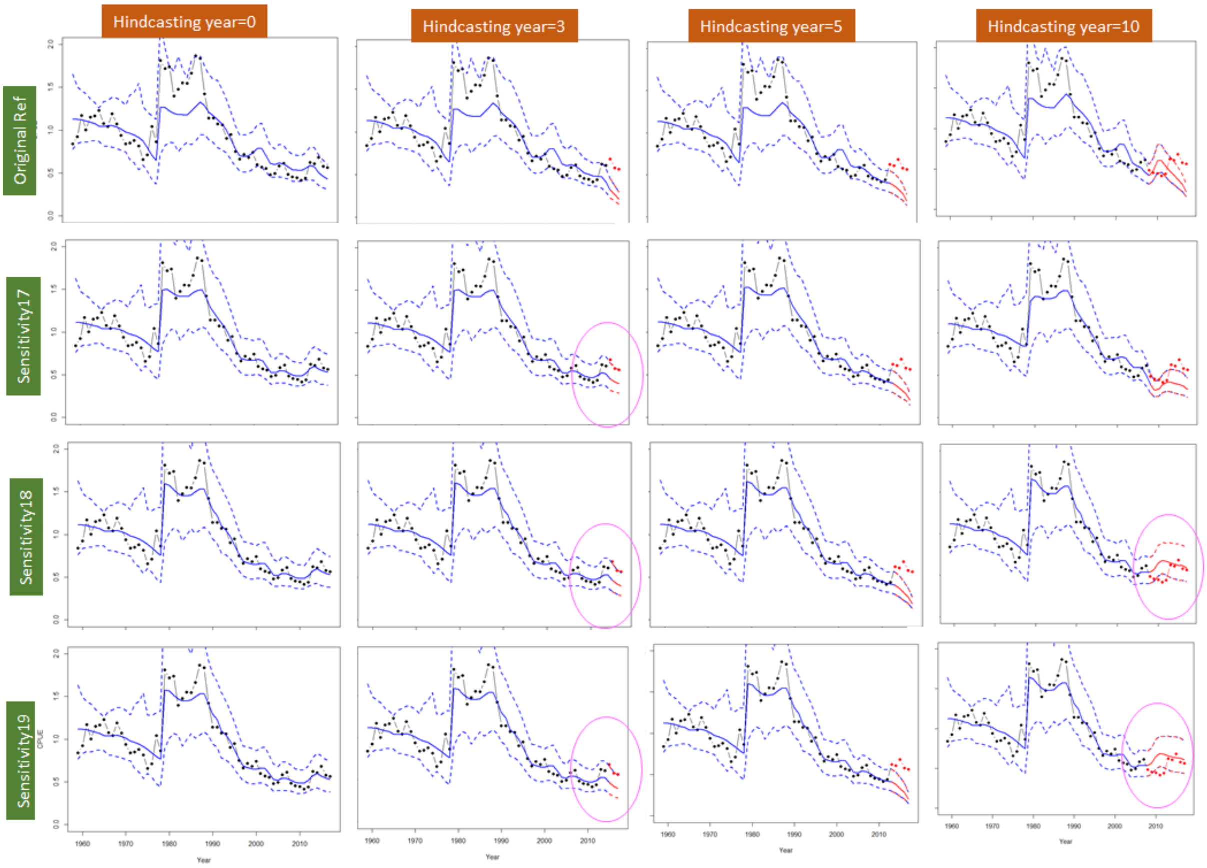


Figure 30. The predicted abundance indices in the hindcasting years for SS3 based 4 different sensitivity scenarios under 3 different hindcasting years (3, 5, and 10 years). Pink circles showed acceptable fitting.

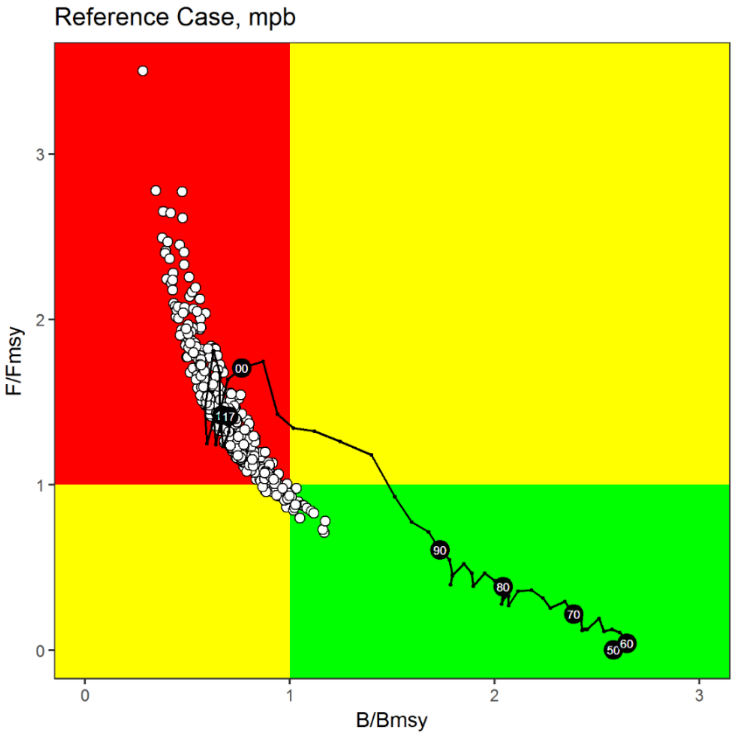


Figure 31. Estimated median historical trend of Atlantic bigeye using the mpb-Reference Case (black line). 500 bootstraps for 2017 of biomass and fishing mortality relative to BMSY and FMSY.

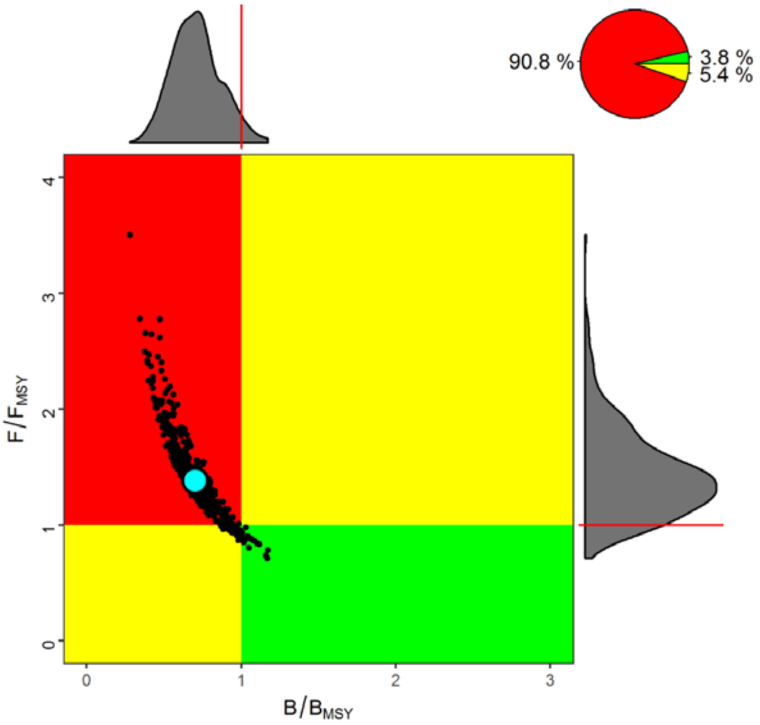


Figure 32. Left-panel: estimated for 2017 biomass and fishing mortality relative to BMSY and FMSY showing the marginal density of the estimates for the mpb-Reference Case for Atlantic bigeye tuna. Top-right panel: Estimated probabilities of the stock being in each of the Kobe plot quadrants estimated from the 500 bootstrapped iterations.

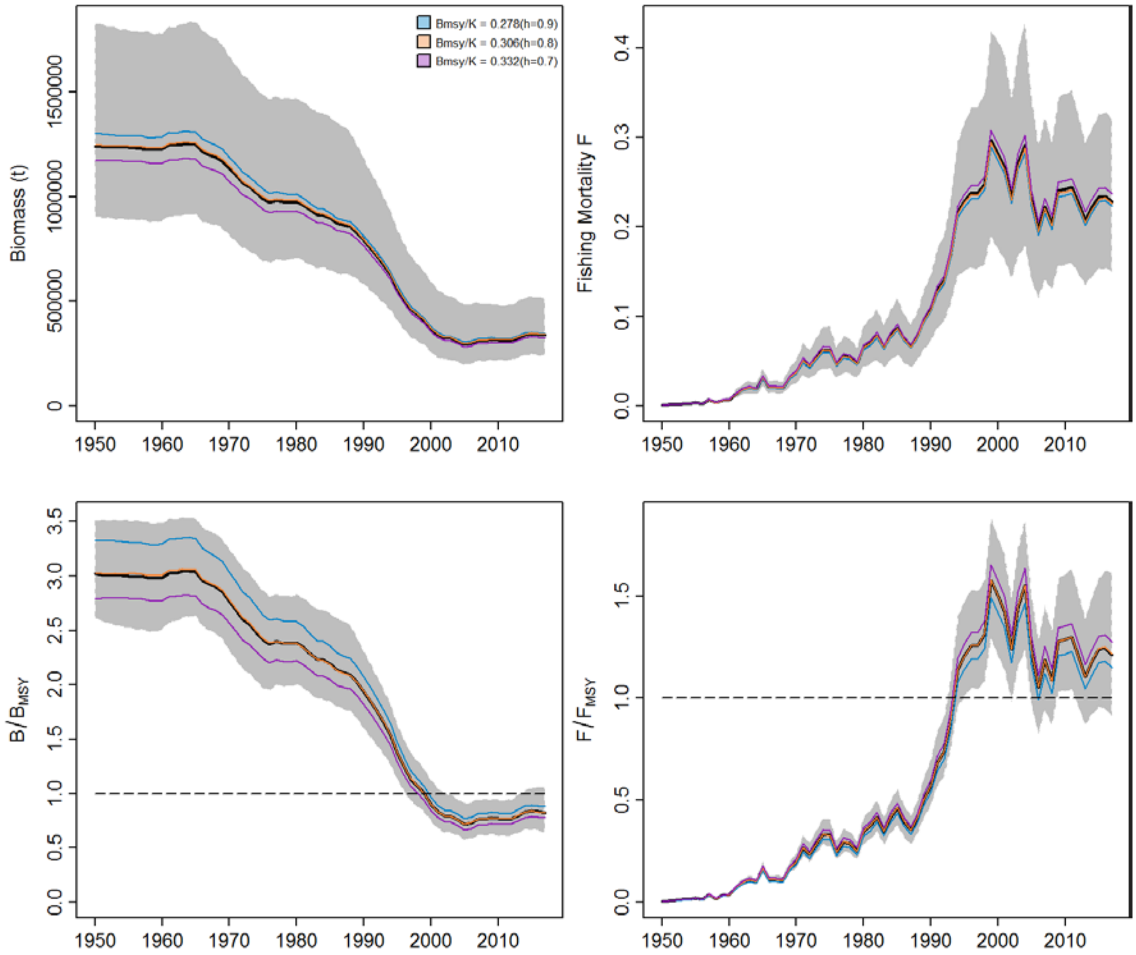


Figure 33. Trajectories of biomass (t), fishing mortality *F*, B/B_{MSY} and F/F_{MSY} predicted from combined posteriors from the Atlantic bigeye tuna JABBA uncertainty grid runs. Grey shade areas represent the 95% confidence interval.

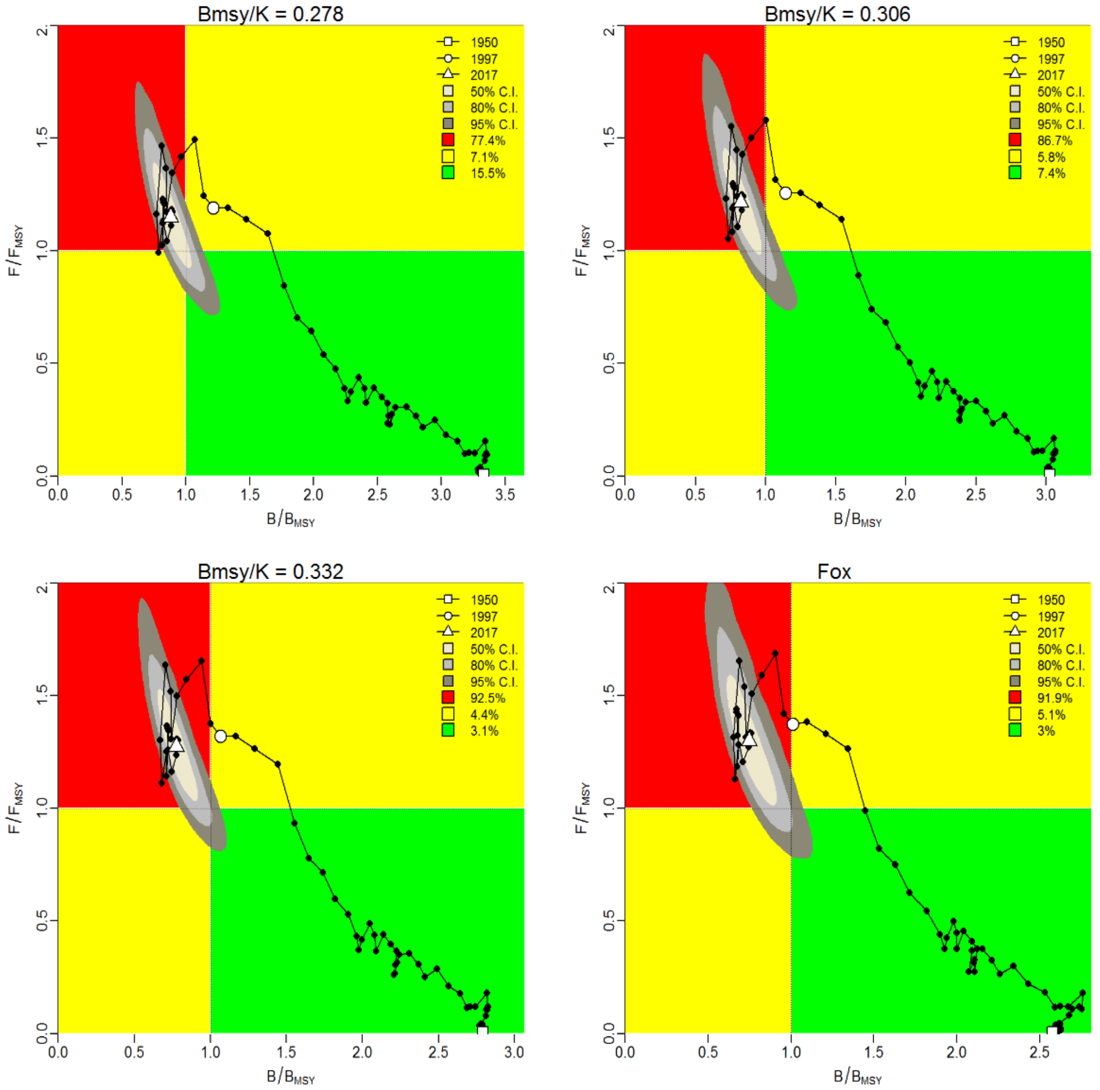


Figure 34. Kobe phase plot showing estimated trajectories (1950-2017) of B/B_{MSY} and F/F_{MSY} for the Atlantic bigeye tuna JABBA three uncertainty grid runs and the initial Fox production model run. The value different grey shaded areas denote the 50%, 80%, and 95% confidence interval for the terminal assessment year 2017. The probability of the terminal year points falling within each quadrant is indicated in the figure legend.

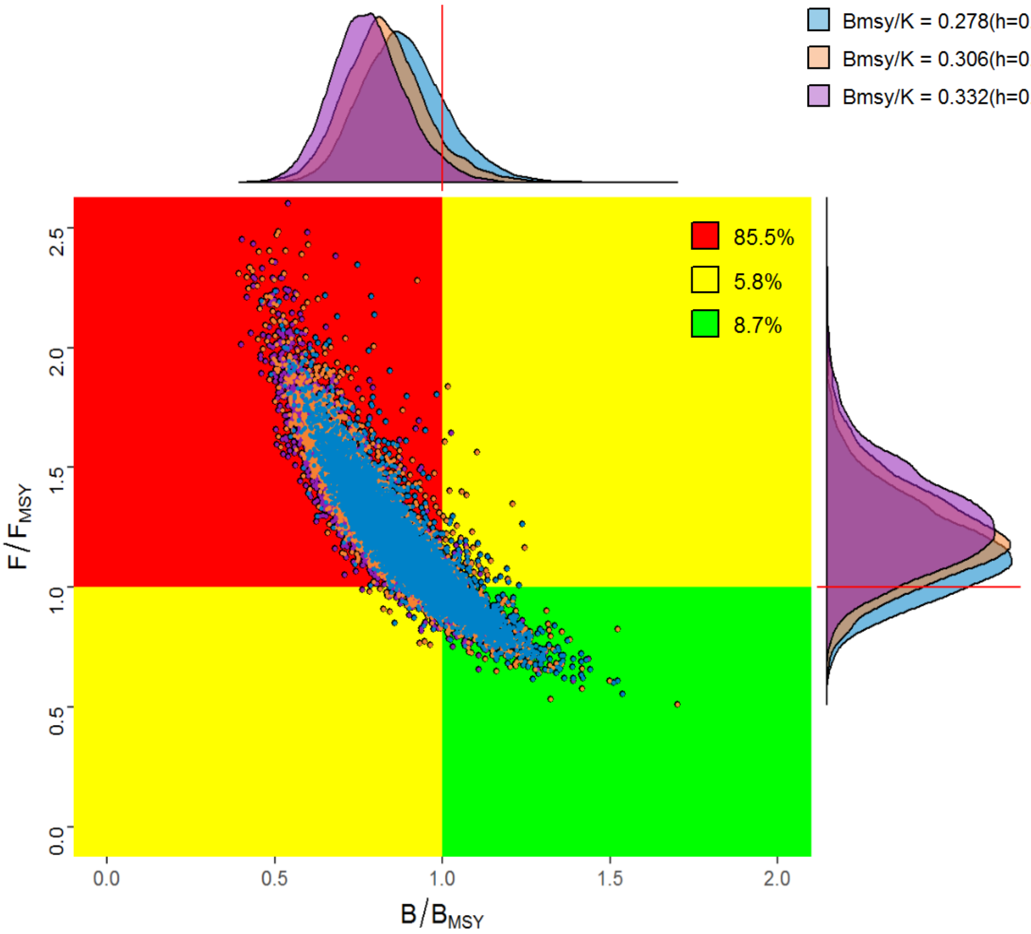


Figure 35. Kobe phase plot showing the combined posteriors of B/B_{MSY} and F/F_{MSY} for the terminal assessment year 2017 from the Atlantic bigeye tuna JABBA uncertainty grid runs for the three alternative B_{MSY}/K input values. The probability of the terminal year points falling within each quadrant is indicated in the figure legend.

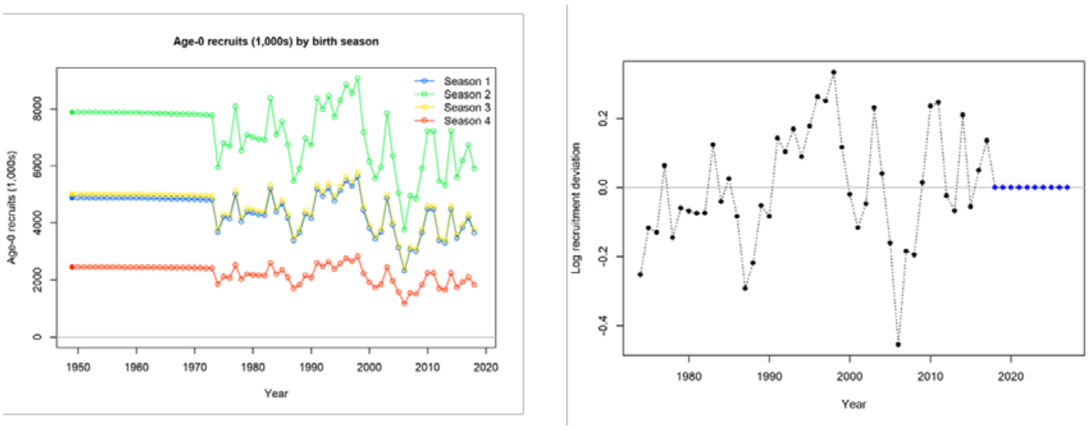


Figure 36. Time series of recruits by season and recruitment deviations (blue dots are forecast deviations) for the SS3-Reference Case (run 19) for Atlantic bigeye tuna.

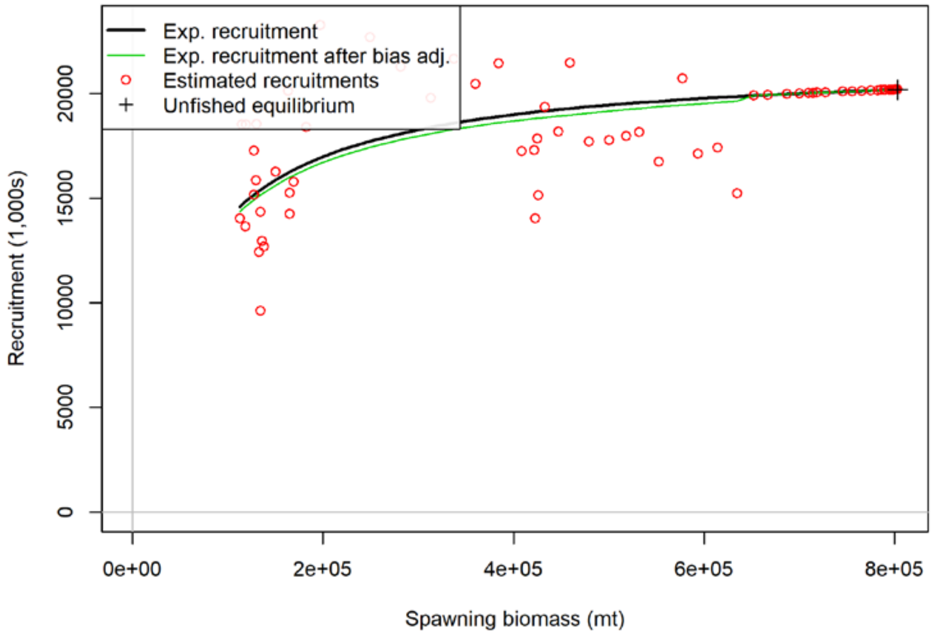


Figure 37. Estimated Beverton-Holt Spawner-recruit relationship and recruitment (age 0) deviations for the SS3-Reference Case (run 19) for Atlantic bigeye tuna. Green line is the bias-adjusted recruitment level during the period where recruitment deviations are estimated. The level of the adjustment, or reduction in recruitment level is determined by a bias correction factor that makes the mean recruitment level during the period where recruitment deviation estimation period equal to R0.

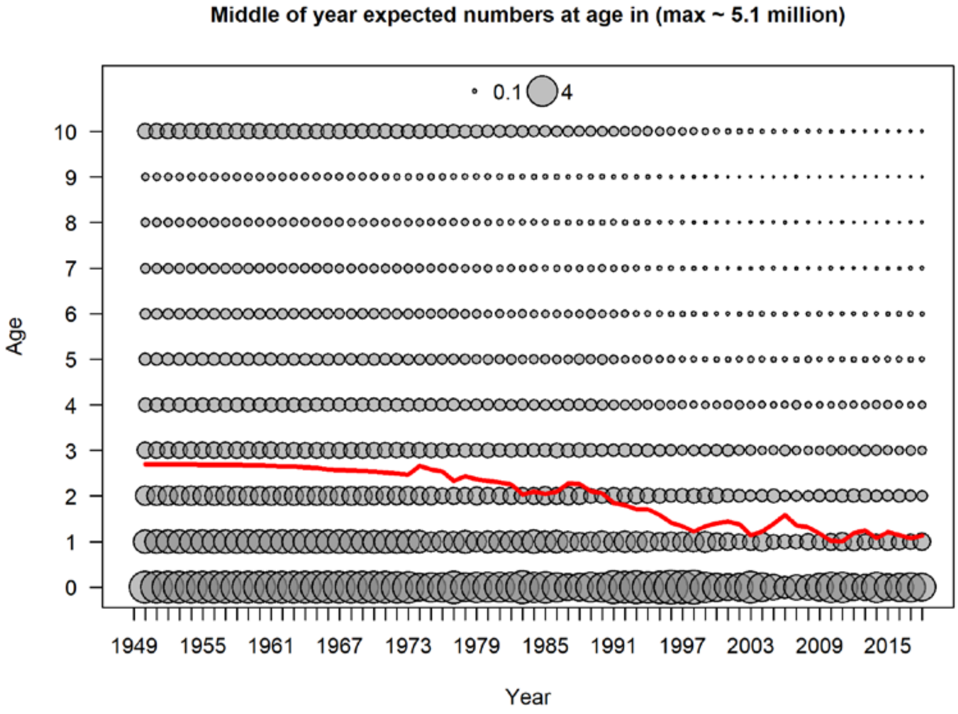


Figure 38. Numbers at age (0 to 10+) and mean age in the population (red line) over time for the SS3-Reference Case for Atlantic bigeye tuna.

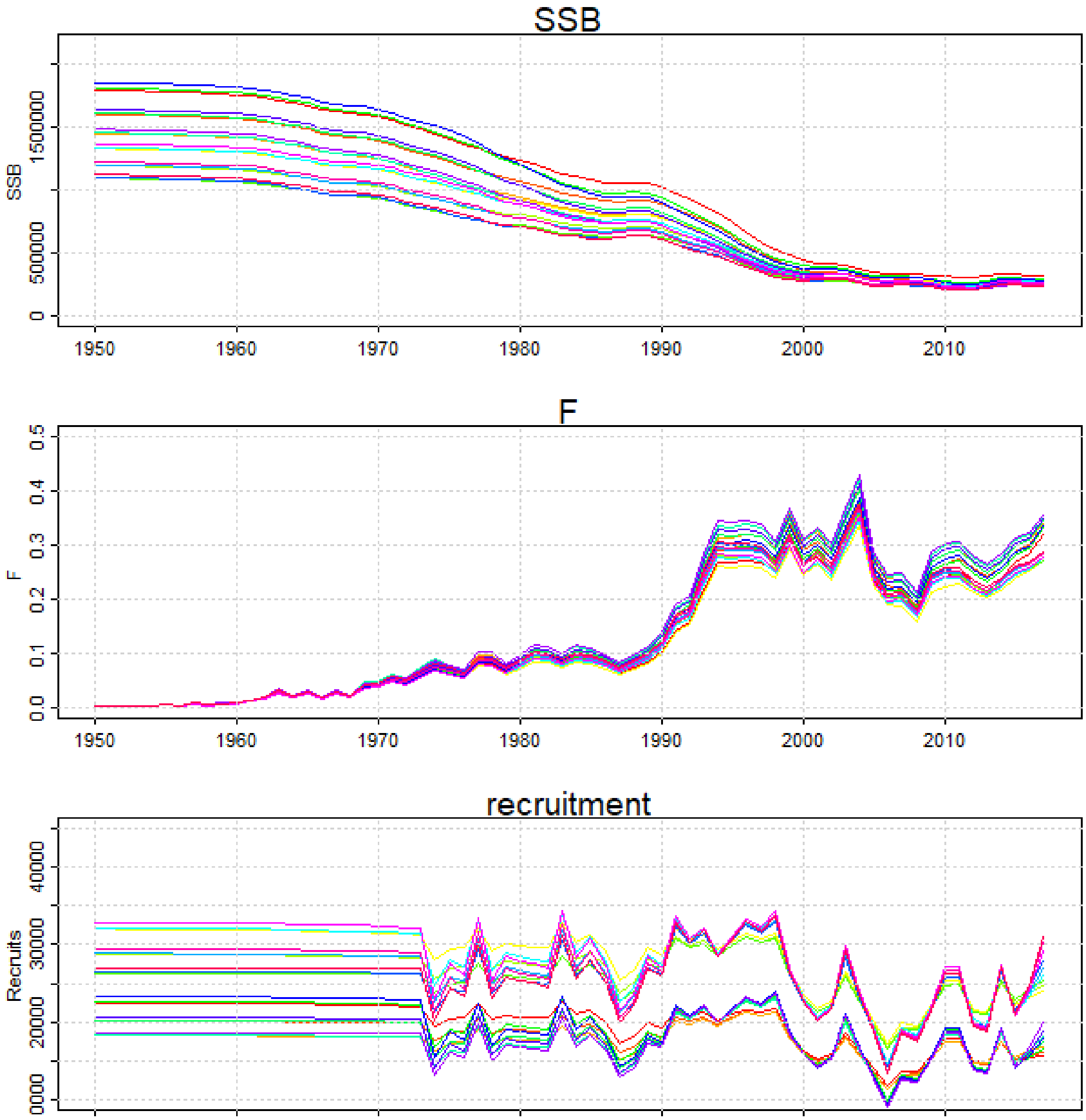


Figure 39. Spawning stock biomass (t), fishing mortality (average F on ages 1-7) and recruitment (age 0) for the 18 SS3-uncertainty grid runs for Atlantic bigeye tuna.

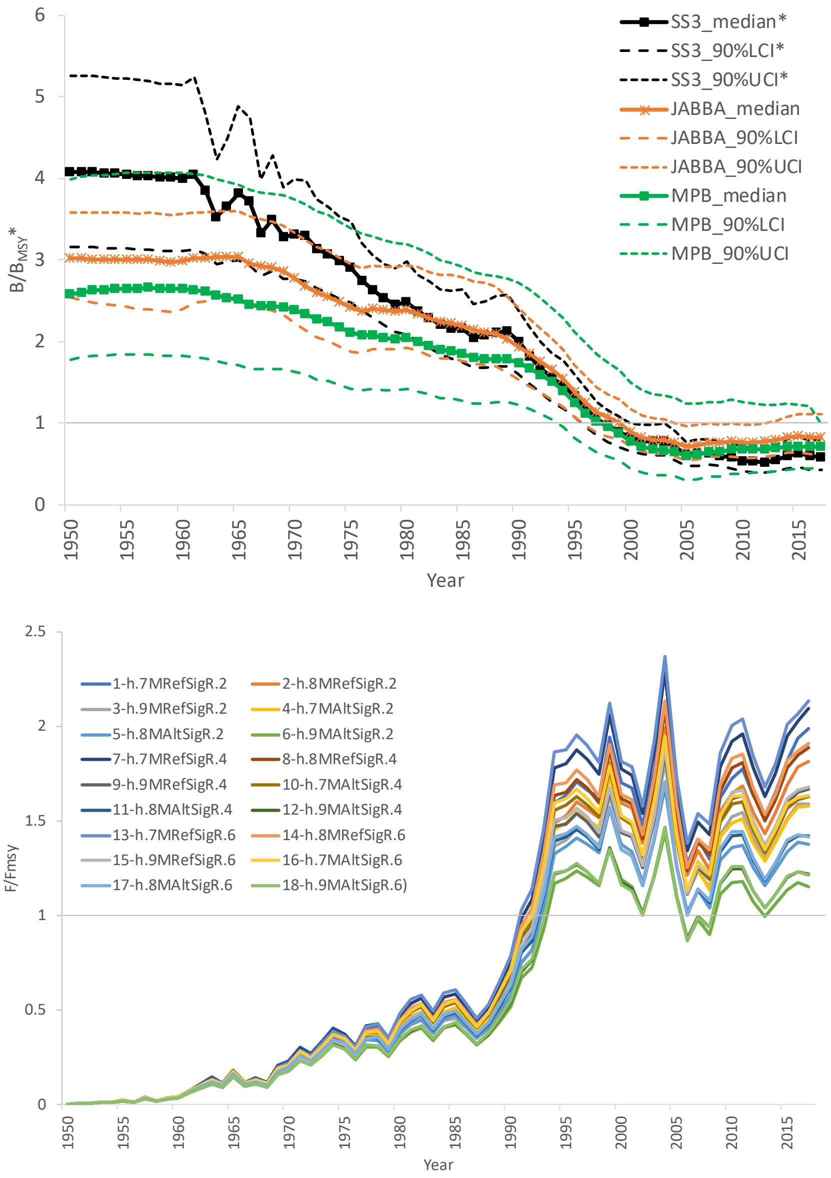


Figure 40. Estimated SSB/SSB$_{MSY}$, F/F$_{MSY}$ for the 18 SS3-uncertainty grid runs for Atlantic bigeye tuna. For each run the benchmarks are calculated from the year-specific selectivity and fleet allocations.

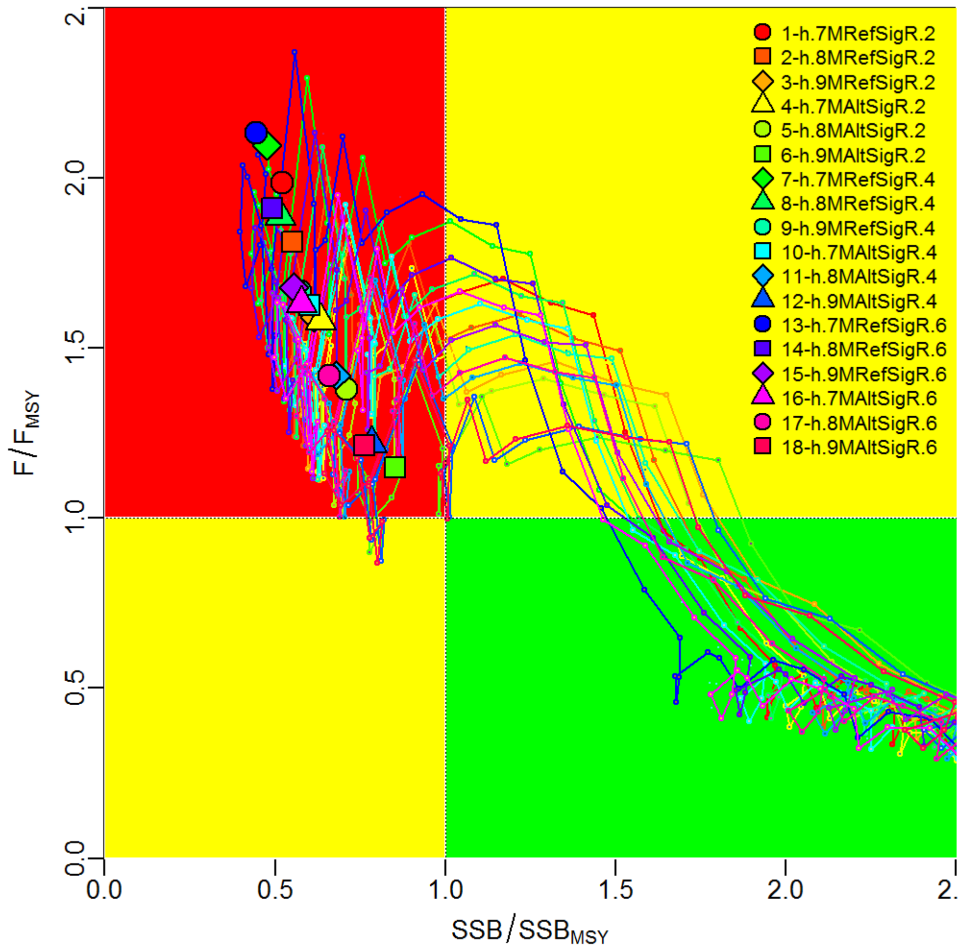


Figure 41. Kobe phase plot for the deterministic runs of the 18 SS3-uncertainty grid runs for Atlantic bigeye tuna. For each run the benchmarks are calculated from the year-specific selectivity and fleet allocations.

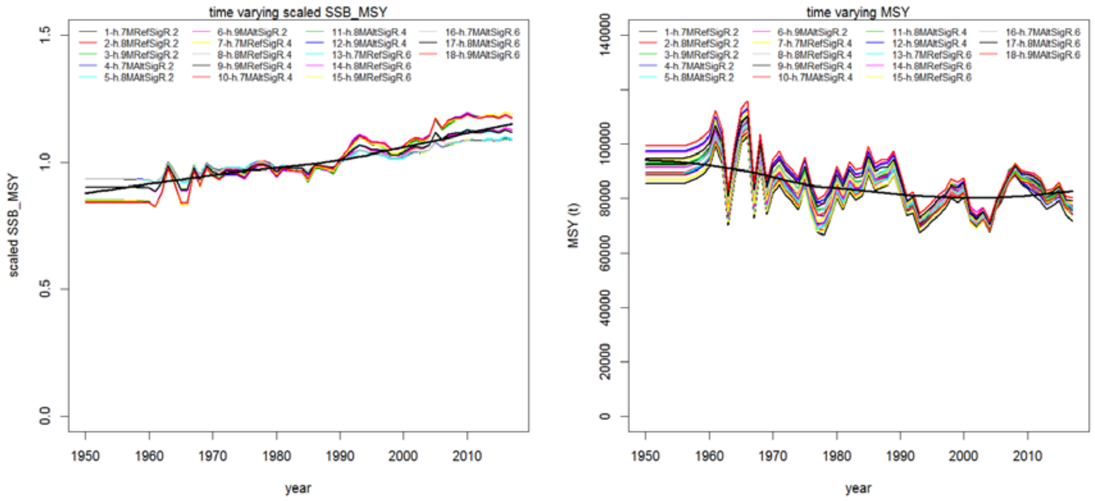
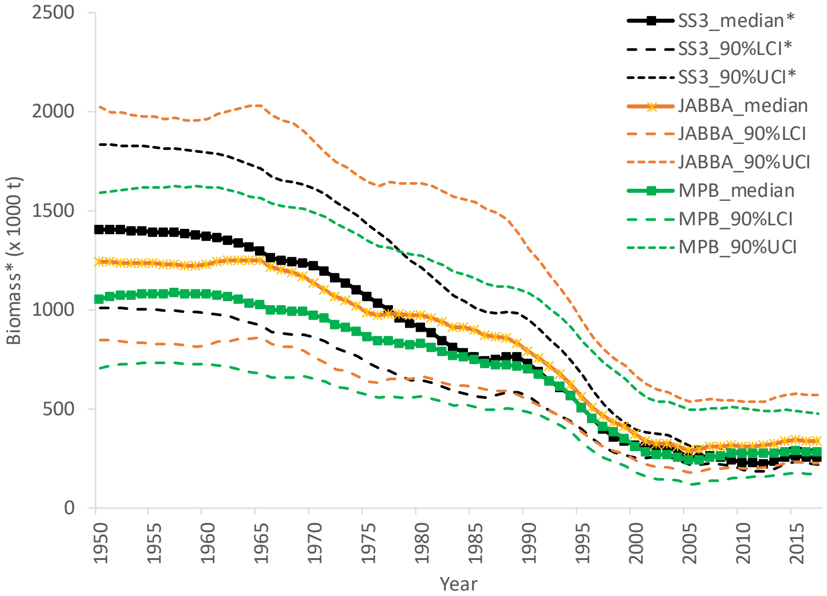


Figure 42. Year-specific SSB at MSY and MSY for 18 SS3-uncertainty grid model runs for Atlantic bigeye tuna. Black solid line is a Loess smooth fitted across all runs.



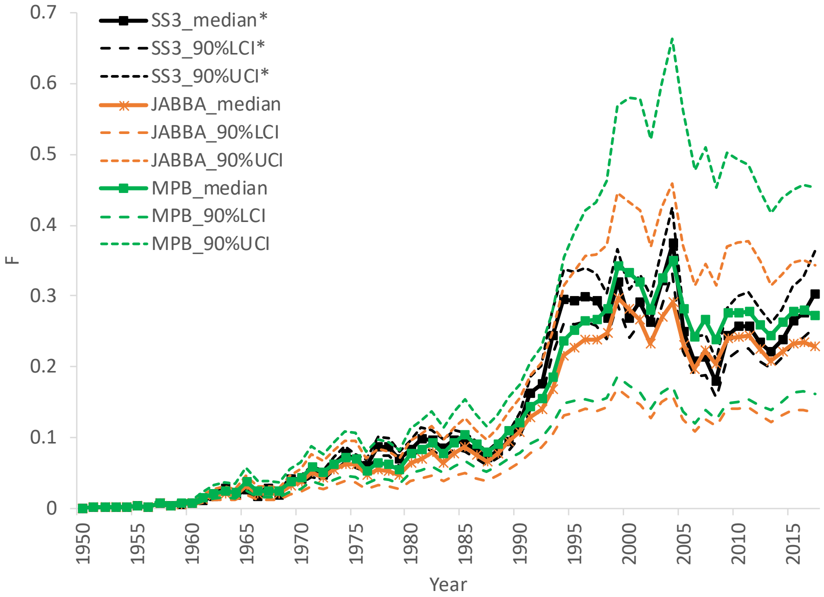
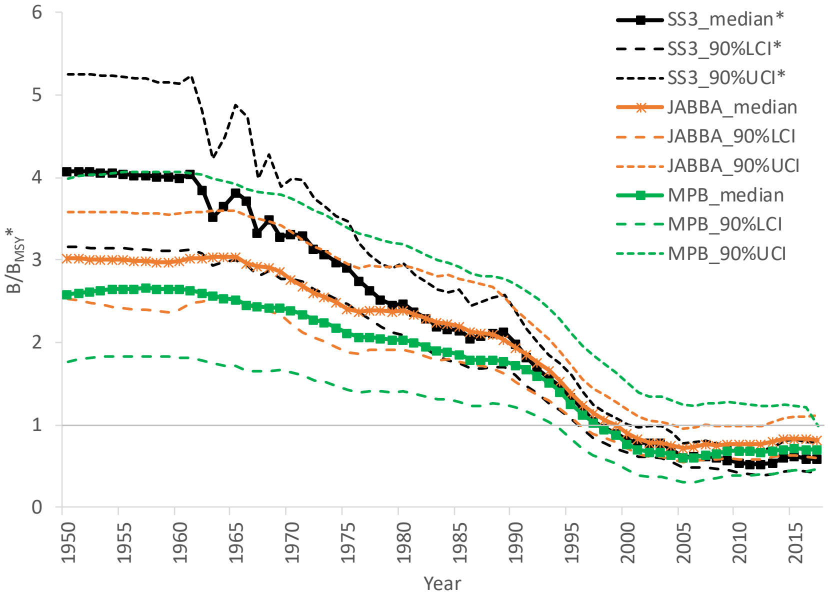


Figure 43. Comparison of SS3, JABBA, and mpb estimates of SSB (SS3) or exploitable biomass (production models), and fishing mortality (SS3, average F for ages 1-7) or exploitation rate (production models) between 1950 and 2017 for Atlantic bigeye tuna with 90% confidence intervals.



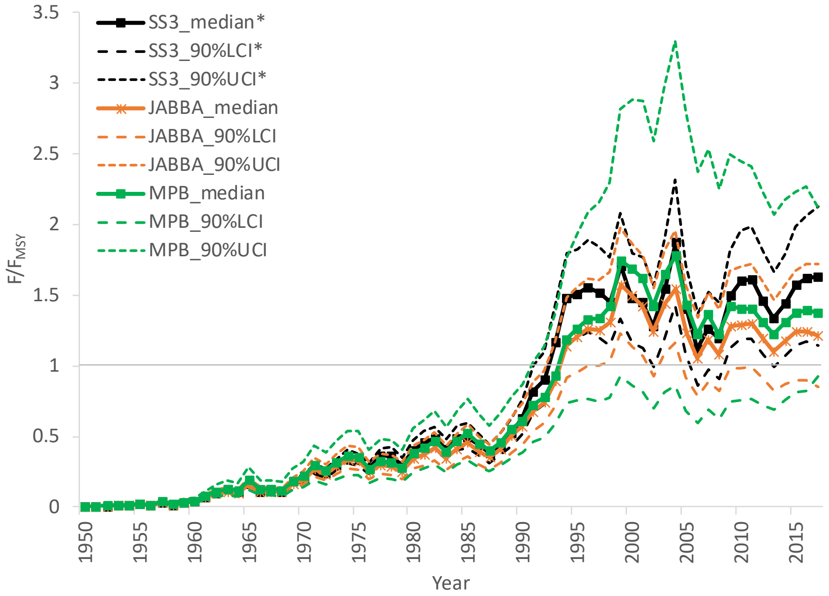


Figure 44. Comparison of SS3, JABBA, and mpb estimates of SSB/SSB$_{MSY}$ (SS3) or B/B$_{MSY}$ (exploitable biomass for production models) and F/F$_{MSY}$ (average F for ages 1-7 for SS3, and exploitation rate for production models) between 1950 and 2017 for Atlantic bigeye tuna with 90% confidence intervals.

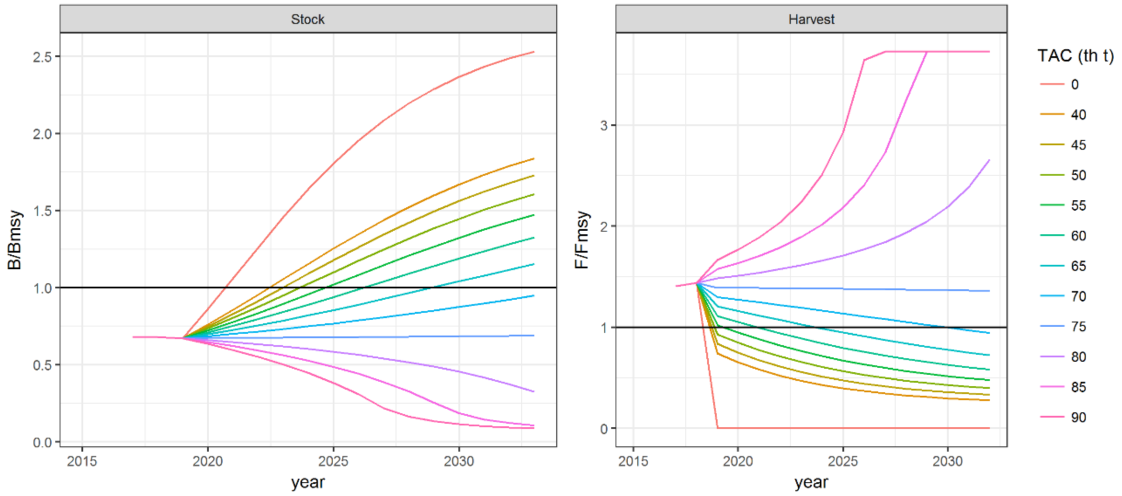


Figure 45. Projections of B/B_{MSY} and F/F_{MSY} from the mpb-Reference Case for Atlantic bigeye tuna under different TACs implemented from 2019 onwards.

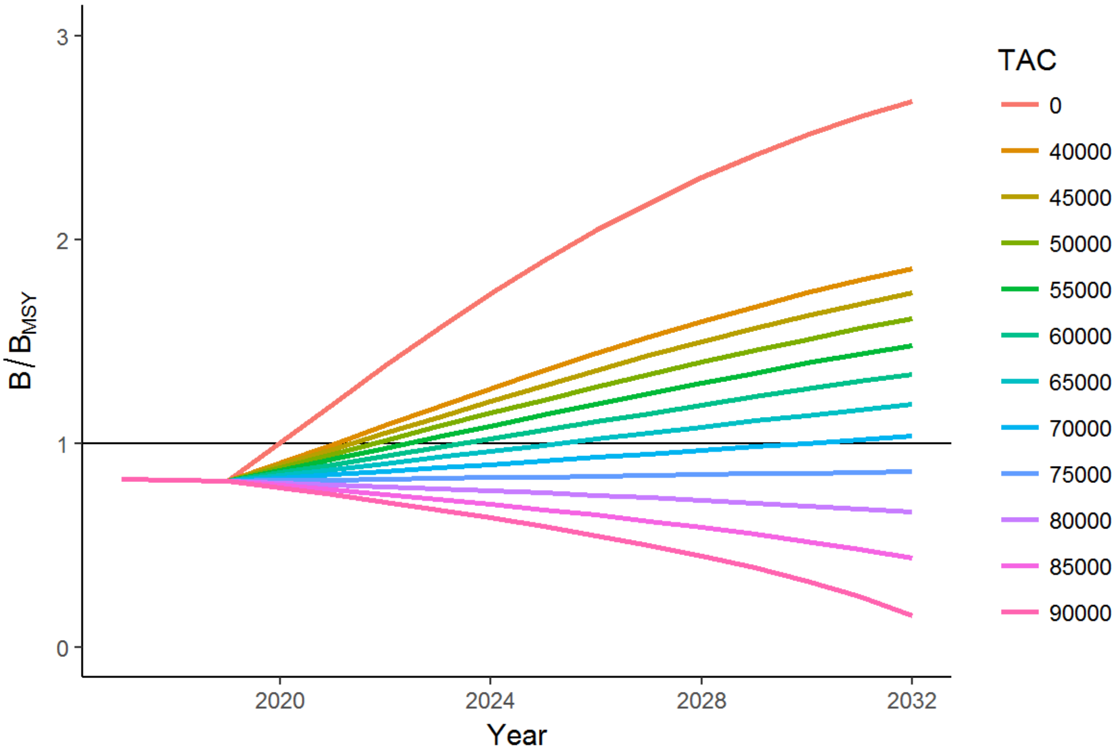


Figure 46. Projections medians of B/B_{MSY} posteriors from the JABBA uncertainty grid runs for Atlantic bigeye tuna under different TACs implemented from 2019 onwards.

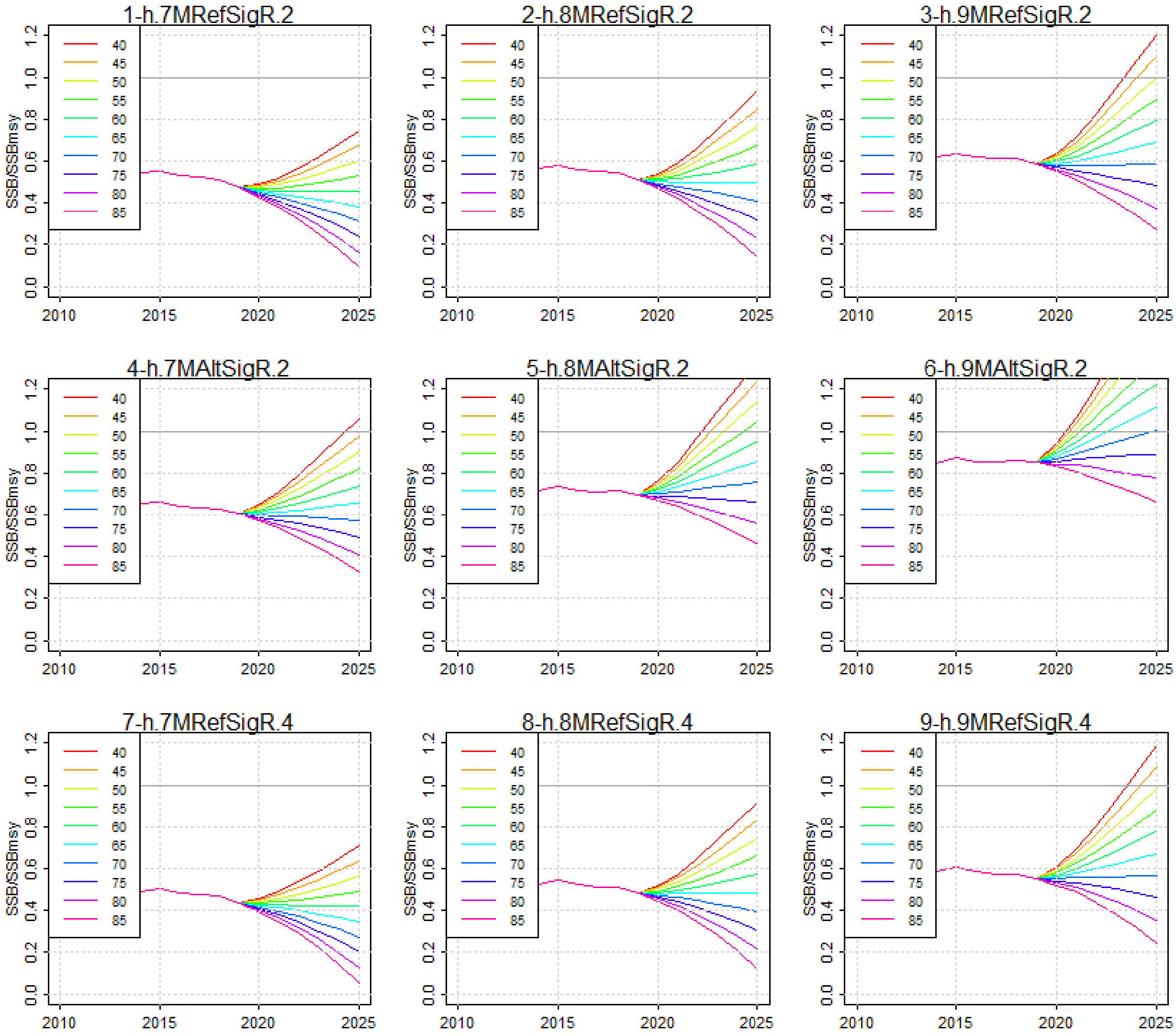


Figure 47. Projections of SSB/SSB$_{MSY}$ for SS3-uncertainty grid runs 1-9 at 40,000-85,000 t constant TACs for Atlantic bigeye tuna.

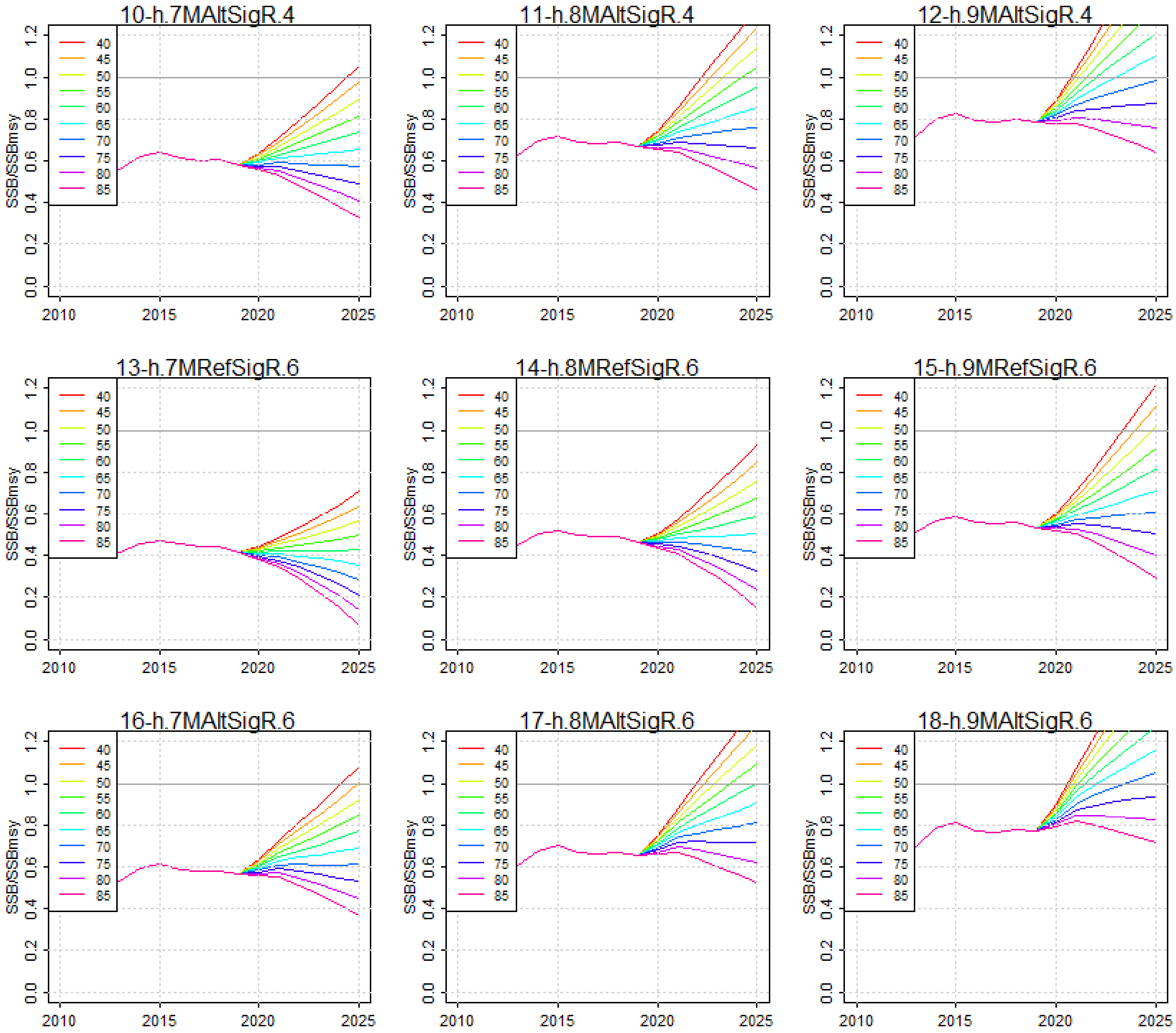


Figure 48. Projections of SSB/SSB$_{MSY}$ for SS3-uncertainty grid runs 10-18 at 40,000-85,000 t constant TACs for Atlantic bigeye tuna.

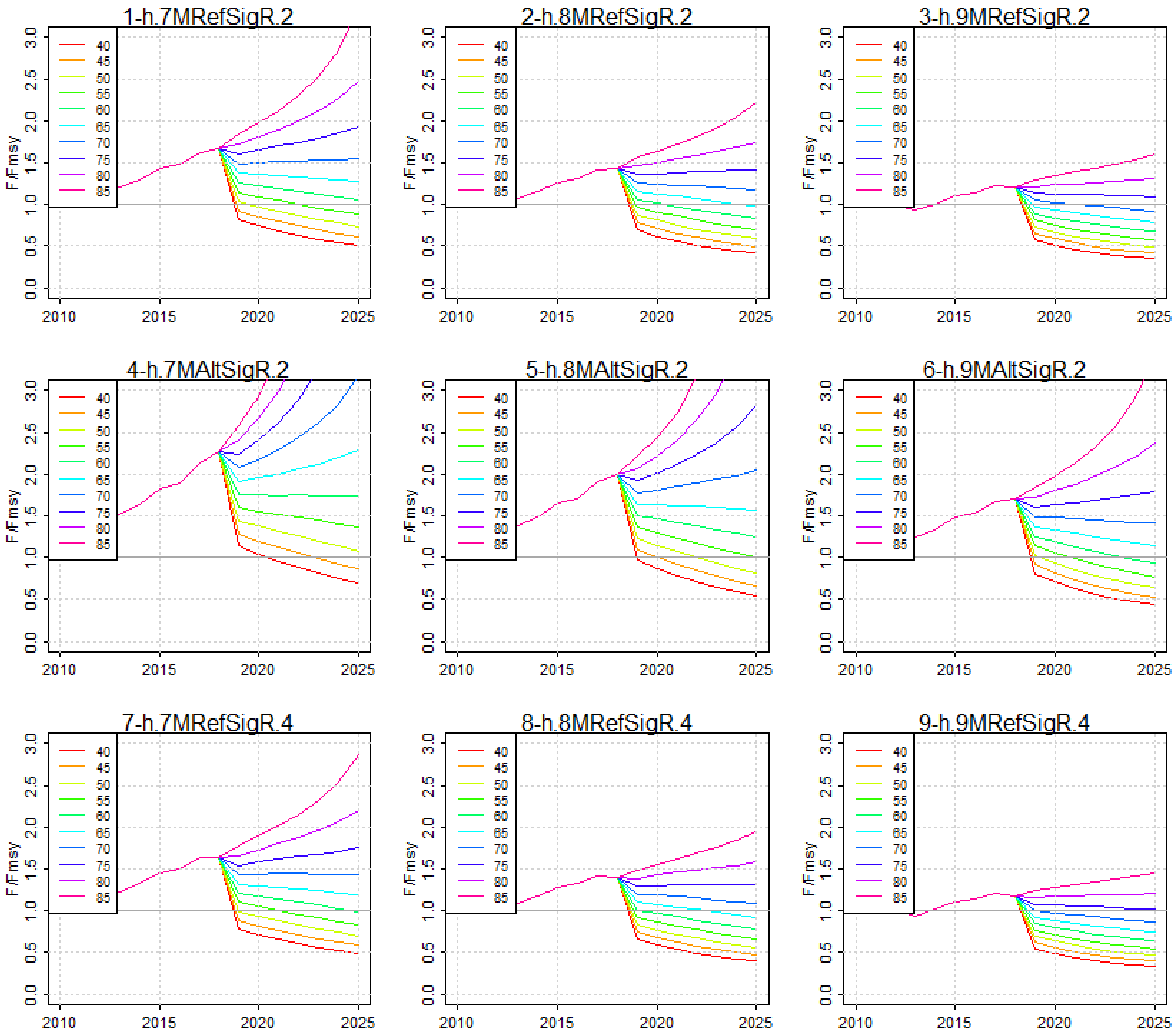


Figure 49. Projections of F/FMSY for SS3-uncertainty grid runs 1-9 at 40,000-85,000 t constant TACs.

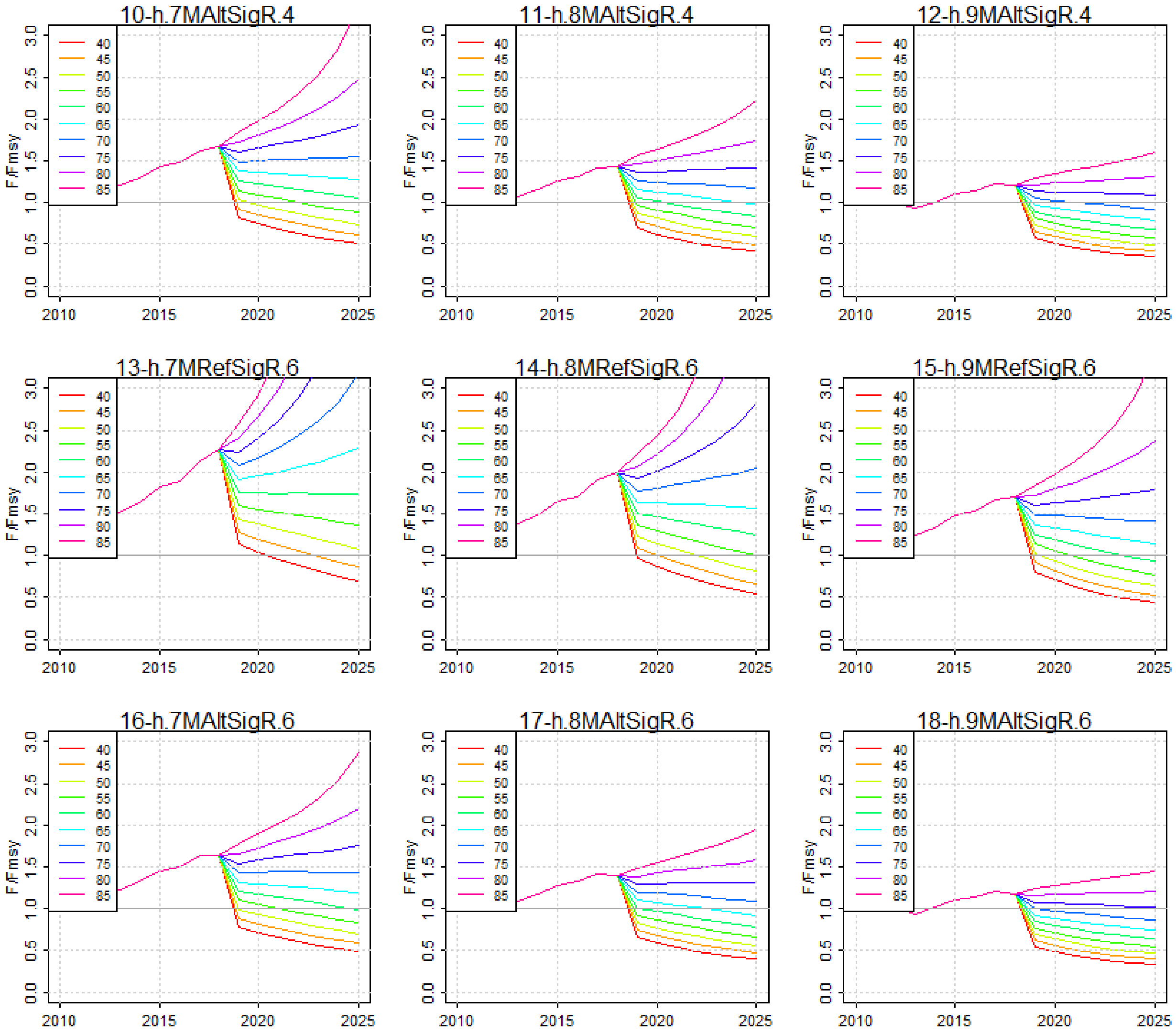


Figure 50. Projections of F/FMSY for SS3-uncertainty grid runs 10-18 at 40,000-85,000 t constant TACs.

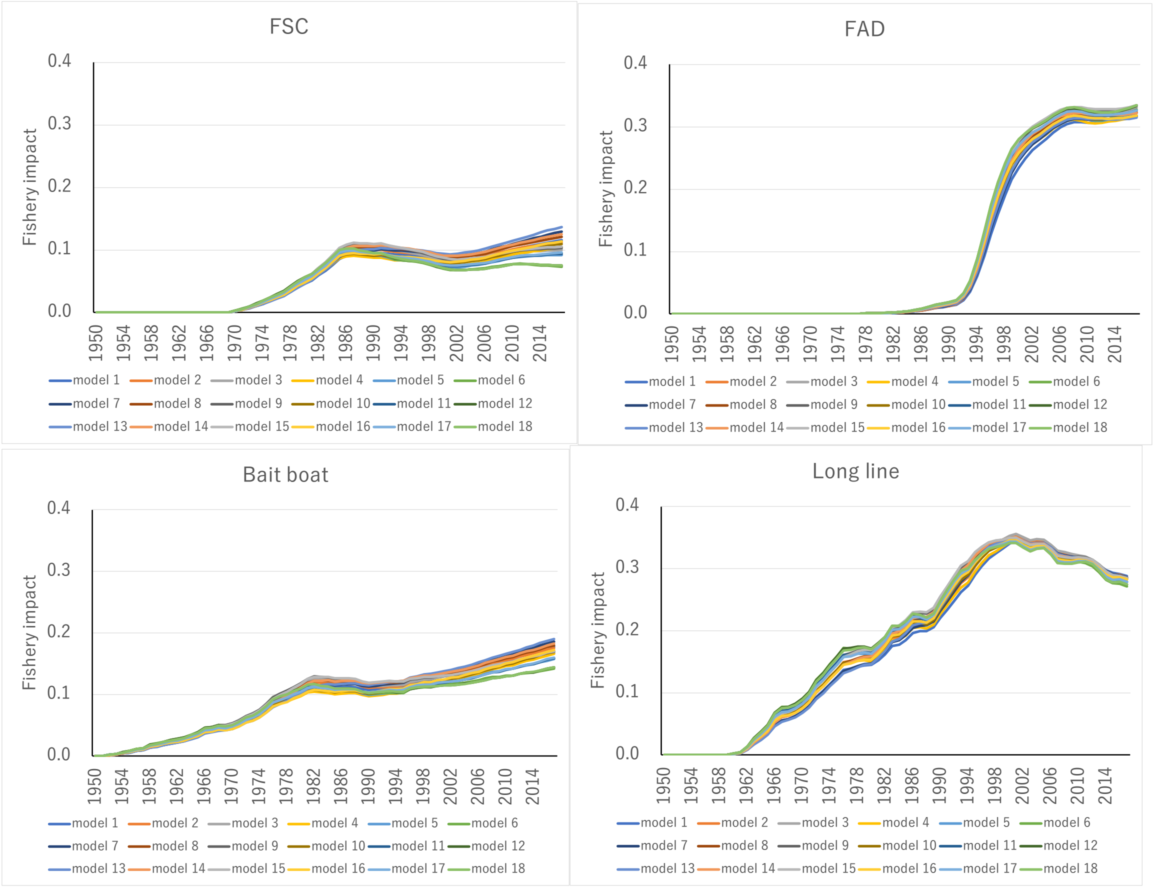


Figure 51. Trajectories of proportions of the impact attributed to each fishery category on spawning biomass among 18 SS3-uncertainty grid runs. The fishery defined in the stock synthesis model (F1 - F15) are assigned as FSC (F1-3), FAD (F4 and 5), BB (F6-9), LL (F10-15). The FAD fishery category contained mixed fishery of BB and PS of Ghana.

Appendix 1

Agenda

1. Opening, adoption of Agenda and meeting arrangements
2. Summary of available data for the stock assessment
    2.1. Biology
    2.2. Catch, effort, size and CAS/CAA estimates
    2.3. Relative abundance indices
3. Stocks Assessment Methods and other data relevant to the assessment
    3.1. Stock Synthesis
    3.2. BioDyn
    3.3. VPA–2 Box
    3.4. JABBA
4. Stock status results
    4.1. Stock Synthesis
    4.2. BioDyn
    4.3. VPA 2 Box
    4.4. JABBA
    4.5. Synthesis of assessment results
5. Projections
    5.1. Production models
    5.2. SS3
6. Recommendations
    6.1. Research and statistics
7. Other matters
    7.1. Responses to Commission requests
        7.1.1. Changes on Ghanaian capacity plans
        7.1.2. Analysis of time/area moratorium
        7.1.3. Impact on MSY due to different relative contribution by major gears
        7.1.4. FAD WG recommendations
    7.2. ICCAT - MSE Project for tropical tunas
8. Adoption of the report and closure

Appendix 2

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Appendix 3

List of documents and presentations

Reference	**Title**	**Authors**
SCRS/2018/058	Collaborative study of bigeye tuna CPUE from multiple Atlantic Ocean longline fleets in 2018	Hoyle S.D., Hsiang-wen J.H., Kim D.N., Lee M.K., Matsumoto T., and Walter J.
SCRS/2018/060	Standardized bigeye tuna CPUE index of the baitboat fishery based in Dakar (2005-2017)	Santiago J., Merino G., Murua H., and Pascual-Alayón P.
SCRS/2018/081	Standardization of bigeye tuna CPUE in the Atlantic Ocean by the Japanese longline fishery which includes cluster analysis	Matsumoto T. et al.
SCRS/2018/099	Continuity stock assessment for Atlantic bigeye using a biomass production model	Merino G., Murua H., Urtizberea A., Santiago J., Winker H., and Walter J.
SCRS/2018/100	Alternatives for the stock assessment for Atlantic bigeye using a biomass production model	Merino G., Murua H., Urtizberea A., Santiago J., Winker H., and Walter J.
SCRS/2018/106	Datos estadísticos de la pesquería de túnidos de las Islas Canarias durante el periodo 1975 a 2017	Delgado de Molina R.A.
SCRS/2018/108	Updated standardized bigeye tuna CPUE of Taiwanese longline fishery in the Atlantic Ocean	Hoyle S.D., and Huang J.H.
SCRS/2018/109	Estimation of Ghana Tasks I and II purse seine and baitboat catch 2006 – 2017: data input for the 2018 bigeye stock assessment	Ortiz M., and Palma C.
SCRS/2018/110	Bayesian State-Space Surplus production model JABBA assessment of Atlantic bigeye tuna (*Thunnus obesus*) stock	Winker H., Kerwath S., Merino G., and Ortiz M.
SCRS/2018/111	Atlantic bigeye tuna stock assessment in Stock Synthesis	Walter J., Hiroki Y., Satoh K., Matsumoto T., Urtizberea-Ijurco A., Ortiz M., and Schirripa M.
SCRS/2018/112	A simple operating model for a basis of a discussion about the development of a management strategy evaluation for tropical tuna fisheries	Urtizberea A., Merino G., García D., Korta M., Santiago J., Murua H., Walter J., Die D., and Gaertner D.
SCRS/P/2018/046	Bigeye tuna size frequency samples input stock synthesis	Ortiz M., and Palma C.
SCRS/P/2018/047	JABBA goes bigeye: Sensitivity tests to prior assumptions, revised BMSY/K values	Winker H., Merino G., and Walter J.
SCRS/P/2018/048	JABBA goes bigeye: Additional sensitivity runs	Winker H., and Kitakado T.
SCRS/P/2018/049	JABBA goes bigeye: Hind Casting and Cross-Validation	Winker H., and Kitakado T.
SCRS/P/2018/050	Hindcasting for SS3 assessment for ICCAT BET	Kitakado T., Walter J., Yokoi D., Matsumoto T., and Satoh K.

SCRS/P/2018/051	Diagnostic methodology for the integrated stock assessment model	Satoh K., Yokoi, D., Walter J., Matsumoto T., and Kitakado T.
SCRS/P/2018/052	BET SS.2018_Part1.inputs and diagnostics	Walter J., Hiroki Y., Satoh K., Matsumoto T., Urtizberea-Ijurco A., Ortiz M., and Schirripa M.
SCRS/P/2018/053	BET SS.2018_Part2.results	Walter J., Hiroki Y., Satoh K., Matsumoto T., Urtizberea-Ijurco A., Ortiz M., and Schirripa M.
SCRS/P/2018/054	BET SS.2018_Part3.diagnostics for runs17,18, and 19	Walter J., Hiroki Y., Satoh K., Matsumoto T., Urtizberea-Ijurco A., Ortiz M., and Schirripa M.

Appendix 4

SCRS Documents and Presentations Abstracts as provided by the authors

SCRS/2018/058 - In April 2018 a collaborative study was conducted between national scientists with expertise in Chinese, Japanese, Korean, Taiwanese, and USA longline fleets, and an independent scientist. The meetings addressed Terms of Reference covering several important issues related to bigeye tuna CPUE indices in the Atlantic Ocean. The study was funded by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the International Seafood Sustainability Foundation (ISSF). The meeting developed joint CPUE indices based on analysis of combined data from the Japanese, Korean, Taiwanese, and US fleets. The meeting also welcomed the availability of data from the Chinese longline fleet, and began the process of preparing and exploring this new dataset for future analysis.

SCRS/2018/060 - not provided by the authors.

SCRS/2018/081 - Standardization of bigeye tuna CPUE by Japanese longline in the Atlantic Ocean was conducted using generalized linear models (GLM) with log normal errors. The models incorporated fishing power based on vessel ID where available, and used cluster analysis to account for targeting. The variables year-quarter, vessel ID, latlong5 (five-degree latitude-longitude block), cluster, number of hooks per basket and number of hooks per set were used in the standardization. The numbers of clusters selected were 4 for all the regions. Dominant species differed among clusters. The effects of each covariate varied by region. The CPUE trends were similar to those estimated using the 'traditional method' (without vessel ID and cluster analysis), though with some differences due to the inclusion of vessel effects and cluster variables.

SCRS/2018/099 - In this document we develop a continuity stock assessment for the 2018 evaluation of Atlantic bigeye (*Thunnus obesus*) using a biomass production model. With the models and indices used in the 2015 stock assessment we explore the impact of the new information from recent catch and CPUE standardization. For this we first replicate the 2015 stock assessment, re-run the 2015 scenarios using reviewed catch until 2015 and finally run the assessment using the catch and CPUE series available for the 2018 session. We present a series of diagnostics for the three scenarios that may be considered as the 2018 continuity stock assessment. These diagnostics suggest that this year's biomass dynamic models are run using alternative model-sets. The preliminary results indicate that this stock is overexploited (B<BMSY) and subject to overexploitation (F>FMSY).

SCRS/2018/100 - In this document we explore alternative scenarios for the 2018 stock assessment of Atlantic bigeye (*Thunnus obesus*). In brief, we show the diagnostics of four alternative fits to four CPUE indices. The results shown in this document are aimed for discussion during the stock assessment meeting.

SCRS/2018/106 – Este documento presenta un resumen de la evolución y composición actual de la flota de cebo vivo de las Islas Canarias y de las capturas realizadas entre 1975 y 2017. Igualmente se presentan los histogramas de tallas de las distintas especies capturadas en 2017, así como la media de las tallas del periodo reciente (2012 - 2016). Se ha realizado una estimación del esfuerzo de pesca nominal, distinguiendo entre barcos menores y mayores de 50 toneladas de registro bruto, considerando que los primeros realizan mareas diarias, con una media de nueve horas de mar, mientras que los segundos realizan mareas superiores a un día.

SCRS/2018/108 – Data for the Taiwanese fleets for three regions (north, tropical, and south separated by 25N and 15S) were analysed to understand it's characteristics and further used to estimate indices of bigeye tuna between 2005 to 2017. Indices were estimated using two approaches, delta lognormal and lognormal + constant. All models included the explanatory variables year-quarter and 5° cell as categorical variables, and a cubic spline on hooks as a covariate. Models for tropical regions included a cubic spline fitted to hooks between floats, while models for temperate areas included a categorical variable for cluster. Some models included vessel identity as a categorical variable. The results showed the standardized bigeye tuna cpue were stable and slightly increased after 2013.

SCRS/2018/109 - Information from the AVDTH Ghana fisheries and other sources was used to estimate the task I and II for the Ghanaian tuna baitboat and purse seine fisheries during 2006 – 2017. Catch and landing data collected and managed by the Marine Fisheries Research Division (MRFD) of Ghana included both landings and logbook information from 2005 up to 2017. The estimation of total Ghana catches, catch composition and quarterly-spatial (5°x5°) distribution followed the recommendations from the SCRS Tropicals working group agreed during the bigeye data preparatory meeting. Sampling for species composition and size distribution were review and compared to equivalent European sampling to determine appropriate sampling for the different components of the Ghana fleets by major gear type. In summary, estimates of total bigeye catch from the AVDTH database were lower compared to prior reports.

SCRS/2018/110 - As for several other assessments conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT), the 2015 scientific stock assessment advice for Atlantic bigeye tuna (*Thunnus obesus*) originated from a combination of surplus production model and age-structured model runs based on 'A Stock Production Model Incorporating Covariates' (ASPIC) and Stock Synthesis (ss3), respectively. The aim of this contribution is to extend the assessment toolbox for Atlantic bigeye tuna by the Bayesian State-Space Surplus Production Model software 'JABBA' to provide a parsimonious 'control' model for the more parameter demanding ss3 model. We apply JABBA to four initial scenarios based on alterative sets of CPUE indices, which we evaluate with a variety of model diagnostics. While priors for the key parameters r and K are purposefully kept uninformative, we specifically focus on developing an informative prior for approximating the expected range of process error for year-to-year biomass variation from a stochastic age-structured simulation model. The model diagnostics provided ample support for use of the split, Joint-Research CPUE index used in the reference case. To facilitate comparability between JABBA and ss3 results, we further explored the structural uncertainty of the model for the reference case model by implementing a small, one-dimensional grid of BMSY/K values corresponding to ss3 output ratios of SBMSY to unfished spawning biomass (SB0), which could be directly related to the range of steepness values (h=0.7-0.9) considered for the spawner-recruitment relationship in ss3. Based on multi-model inference from the JABBA runs over the range of BMSY/K input values, we predict with 86.9% probability that the stock remains overfished and 80% probability that overfishing is still occurring. Corresponding future projections predict that stock rebuilding would be achieved with a 56% probability by 2026 under the current global quota of 65,000 t, whereas the actual reported catch of around 75,000 t is unlikely to allow rebuilding of the stock within the next 10 years. The results are discussed in the context of model robustness and multi-model inference for potential integration into the ICCAT 2018 bigeye stock assessment advice. While this initial JABBA assessment appears sufficiently robust for inference about the stock status, we caution against the use JABBA projections for specific quota recommendations in the case of bigeye tuna, because the relative impact of the different fleets can currently not be explicitly accounted for with (aggregated-) biomass dynamic models.

SCRS/2018/111 - This paper represents a stock assessment of Atlantic Bigeye tuna using the age and length structured integrated assessment model Stock Synthesis (SS). SS 3.24 version was used and the model configuration is largely similar to that of the 2015 assessment though it is condensed to a single area and benefits from a joint longline index rather than many separate longline indices with conflicting trends. Additionally, the model benefits from substantially revised length composition input which has reduced conflicting length data and homogenized the fleet structure. Initially we constructed a reference model and tested its performance across a suite of standard model diagnostic tests which indicated decent model performance. Then we produced a series of fourteen sensitivity models that evaluated different model formulations (3-area, alternative natural mortality, different steepness, sigma-R, selectivity and +25% and -10% sensitivity to Purse seine FAD catches. After evaluation of the sensitivity runs, a structured uncertainty grid across steepness (0.7, 0.8, 0.9), sigma-R (0.2, 0.4, 0.6), longline selectivity (domed vs asymptotic in area 2), and three index treatments (joint split index, joint full index and joint split with Dakar BB index) resulting in 216 model runs was constructed. This uncertainty grid captures much of the key uncertainties in model inputs and parameter assumptions and may be considered for quantification of Kobe advice.

SCRS/2018/112 – The objective of the project is the development of a multispecific model based on Management Strategy Evaluation (MSE) for tropical tuna fisheries on the Atlantic Ocean in order to evaluate the economical and biological impact of different management plans on a multispecific fisheries context. The MSE model will be built with FLBEIA, a bio-economic impact assessment model based on MSE approach. FLBEIA has been applied in many case studies and thus many of the utilities of the model has been validated. Here we are going to show the simplest conditioning option of an MSE with two stocks, bigeye and yellowfin tuna fisheries on the Atlantic Ocean based on their latest assessment and the web application that we are developing in order to share the results.

SCRS/P/2018/046 – not provided by the authors.

SCRS/P/2018/047 – Presented updated JABBA stock status results based on revised input values of BMSY/K, together with a sensitivity analysis that explored alternative precision levels associated with the prior assumptions for the unfished biomass (K) and intrinsic rate (r). The revised BMSY/K ratios of 0.332, 0.306 and 0.278 corresponded to the stock synthesis derived SSBMSY/SBB0 ratios for the steepness values of h = 0.7, 0.8 and 0.9, respectively, where BMSY/K = 0.306 (h = 0.8) was considered as the reference case. The sensitivity analysis results demonstrated that increasing the CVs for r and K simultaneously from 200% (reference case) to 500% had no discernible effect on the stock status estimates, suggesting that the data were highly informative with regards to these two key parameters.

SCRS/P/2018/048 – Presented additional JABBA runs to explore the sensitivity of the prior assumptions for the process error and the biomass depletion (B1950/K) in 1950. The results illustrated that inflating the precision of the two priors did not influence the final stock status estimates. Based on these results, it was concluded that was it was feasible to estimate process error using an uninformative inverse-gamma prior with a scale and shape parameter of 0.001.

SCRS/P/2018/049 – Presented a hint-casting cross-validation for three alternative JABBA scenarios. The results showed that all three scenarios performed adequately over three year period, whereas hind-casting over five and ten years showed notable discrepancies between the observed and the predicted CPUE. This suggests that JABBA projections over more than three years should be interpreted with caution.

SCRS/P/2018/050 – The abstract is available in Section 3.2.12 Model Hindcasting.

SCRS/P/2018/051 – According to the discussion on the data preparatory meeting, diagnostic methodology for the integrated stock assessment model has been applied including ASPM diagnosis (Maunder et al. 2015, Minte-Vera et al. 2017), likelihood profiling of R0, Steepness, Linf and M (Wang et al. 2014), retrospective analysis and residual plots for size data. The standard deviation of the normalized residual (Francis, 2011) and RMSE (Root mean square error) between observed and predicted cpues were also calculated. Using these tools, the initial reference case and main one-off-sensitivity models were screened for potential model mis-specification during the meeting to develop the 18 grid models.

SCRS/P/2018/052 – not provided by the authors.

SCRS/P/2018/053 – not provided by the authors.

SCRS/P/2018/054 – not provided by the authors.

Appendix 5

Fishery impact analysis

Table of the proportions of the impact attributed to each fishery category on spawning biomass from 1950 to 2017 for each SS3-uncertainty grid run. Unexploited spawning stock biomass of a simulated population of Atlantic bigeye tuna was 1.0. The predicted biomass of each model is 1 - sum of portions of the impact attributed to each fishery category. The fishery defined in the stock synthesis model (F1 - F15) are assigned as FSC (F1-3), FAD (F4 and 5), BB (F6-9), LL (F10-15).

FSC	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13	model 14	model 15	model 16	model 17	model 18
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0.01	0.01	0	0	0	0	0.01	0.01	0	0	0	0	0.01	0.01
1972	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1973	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1974	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1975	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1976	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.03
1977	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1978	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04
1979	0.04	0.04	0.05	0.04	0.05	0.05	0.04	0.04	0.05	0.04	0.05	0.05	0.04	0.04	0.05	0.04	0.05	0.05
1980	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06
1981	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06
1982	0.06	0.06	0.07	0.06	0.07	0.07	0.06	0.07	0.07	0.06	0.07	0.07	0.06	0.07	0.07	0.06	0.07	0.07
1983	0.07	0.07	0.08	0.07	0.07	0.08	0.07	0.07	0.08	0.07	0.08	0.08	0.07	0.08	0.08	0.07	0.08	0.08
1984	0.08	0.08	0.09	0.08	0.08	0.09	0.08	0.09	0.09	0.08	0.09	0.09	0.08	0.09	0.09	0.08	0.09	0.09
1985	0.09	0.09	0.1	0.09	0.09	0.1	0.09	0.1	0.1	0.09	0.1	0.1	0.09	0.1	0.1	0.09	0.1	0.1
1986	0.09	0.1	0.1	0.09	0.1	0.1	0.09	0.1	0.11	0.09	0.1	0.1	0.1	0.1	0.11	0.09	0.1	0.1
1987	0.09	0.1	0.11	0.09	0.1	0.1	0.1	0.1	0.11	0.09	0.1	0.1	0.1	0.11	0.11	0.1	0.1	0.1
1988	0.09	0.1	0.11	0.09	0.09	0.1	0.1	0.1	0.11	0.09	0.1	0.1	0.1	0.11	0.11	0.09	0.1	0.1
1989	0.09	0.1	0.11	0.09	0.09	0.1	0.1	0.1	0.11	0.09	0.1	0.1	0.1	0.11	0.11	0.09	0.1	0.1
1990	0.09	0.1	0.1	0.09	0.09	0.09	0.1	0.1	0.11	0.09	0.09	0.09	0.1	0.11	0.11	0.09	0.09	0.09
1991	0.1	0.1	0.1	0.09	0.09	0.09	0.1	0.11	0.11	0.09	0.09	0.09	0.1	0.11	0.11	0.09	0.1	0.1
1992	0.09	0.1	0.1	0.09	0.09	0.09	0.1	0.1	0.11	0.09	0.09	0.09	0.1	0.11	0.11	0.09	0.09	0.09
1993	0.09	0.1	0.1	0.08	0.08	0.08	0.1	0.1	0.1	0.09	0.09	0.09	0.1	0.1	0.11	0.09	0.09	0.09
1994	0.09	0.1	0.1	0.08	0.08	0.08	0.1	0.1	0.1	0.09	0.09	0.09	0.1	0.1	0.1	0.09	0.09	0.09
1995	0.09	0.09	0.1	0.08	0.08	0.08	0.1	0.1	0.1	0.09	0.09	0.08	0.1	0.1	0.1	0.09	0.09	0.08
1996	0.09	0.09	0.09	0.08	0.08	0.08	0.1	0.1	0.1	0.09	0.08	0.08	0.1	0.1	0.1	0.09	0.09	0.08
1997	0.09	0.09	0.09	0.08	0.08	0.08	0.1	0.1	0.1	0.08	0.08	0.08	0.1	0.1	0.1	0.09	0.08	0.08
1998	0.09	0.09	0.09	0.08	0.08	0.08	0.09	0.09	0.09	0.08	0.08	0.08	0.1	0.1	0.09	0.08	0.08	0.08
1999	0.09	0.09	0.09	0.08	0.08	0.07	0.09	0.09	0.09	0.08	0.08	0.07	0.09	0.09	0.09	0.08	0.08	0.07
2000	0.08	0.08	0.08	0.07	0.07	0.07	0.09	0.09	0.09	0.08	0.07	0.07	0.09	0.09	0.09	0.08	0.08	0.07
2001	0.08	0.08	0.08	0.07	0.07	0.07	0.09	0.09	0.08	0.08	0.07	0.07	0.09	0.09	0.09	0.08	0.07	0.07
2002	0.08	0.08	0.08	0.07	0.07	0.07	0.09	0.09	0.08	0.08	0.07	0.07	0.09	0.09	0.08	0.08	0.07	0.07
2003	0.08	0.08	0.08	0.08	0.07	0.07	0.09	0.09	0.08	0.08	0.07	0.07	0.1	0.09	0.09	0.08	0.08	0.07
2004	0.09	0.09	0.08	0.08	0.07	0.07	0.09	0.09	0.09	0.08	0.08	0.07	0.1	0.09	0.09	0.08	0.08	0.07
2005	0.09	0.09	0.08	0.08	0.08	0.07	0.1	0.09	0.09	0.08	0.08	0.07	0.1	0.09	0.09	0.09	0.08	0.07
2006	0.09	0.09	0.09	0.08	0.08	0.07	0.1	0.09	0.09	0.09	0.08	0.07	0.1	0.1	0.09	0.09	0.08	0.07
2007	0.09	0.09	0.09	0.08	0.08	0.07	0.1	0.1	0.09	0.09	0.08	0.07	0.11	0.1	0.09	0.09	0.08	0.07
2008	0.1	0.1	0.09	0.09	0.08	0.07	0.1	0.1	0.09	0.09	0.08	0.07	0.11	0.1	0.09	0.09	0.08	0.07
2009	0.1	0.1	0.09	0.09	0.09	0.08	0.11	0.1	0.1	0.09	0.09	0.08	0.11	0.11	0.1	0.1	0.09	0.08
2010	0.1	0.1	0.1	0.09	0.09	0.08	0.11	0.11	0.1	0.1	0.09	0.08	0.11	0.11	0.1	0.1	0.09	0.08
2011	0.1	0.1	0.1	0.09	0.09	0.08	0.11	0.11	0.1	0.1	0.09	0.08	0.12	0.11	0.1	0.1	0.09	0.08
2012	0.11	0.1	0.1	0.1	0.09	0.08	0.12	0.11	0.1	0.1	0.09	0.08	0.12	0.11	0.1	0.1	0.09	0.08
2013	0.11	0.11	0.1	0.1	0.09	0.08	0.12	0.11	0.1	0.1	0.09	0.08	0.12	0.12	0.1	0.11	0.09	0.08
2014	0.11	0.11	0.1	0.1	0.09	0.08	0.12	0.11	0.1	0.1	0.09	0.08	0.13	0.12	0.1	0.11	0.09	0.08
2015	0.11	0.11	0.1	0.1	0.09	0.07	0.12	0.12	0.1	0.11	0.09	0.08	0.13	0.12	0.1	0.11	0.09	0.08
2016	0.11	0.11	0.1	0.1	0.09	0.07	0.13	0.12	0.1	0.11	0.09	0.07	0.13	0.12	0.1	0.11	0.09	0.08
2017	0.12	0.11	0.1	0.1	0.09	0.07	0.13	0.12	0.1	0.11	0.09	0.07	0.14	0.12	0.11	0.11	0.1	0.07

FAD	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13	model 14	model 15	model 16	model 17	model 18
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0.01	0.01	0	0	0.01	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01
1986	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1987	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1988	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1989	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02
1990	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1991	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1992	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1993	0.04	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05
1994	0.06	0.07	0.07	0.07	0.08	0.08	0.07	0.07	0.08	0.08	0.08	0.09	0.07	0.07	0.08	0.08	0.08	0.09
1995	0.09	0.1	0.11	0.11	0.12	0.12	0.1	0.11	0.12	0.11	0.12	0.13	0.1	0.11	0.12	0.12	0.13	0.13
1996	0.13	0.14	0.15	0.14	0.16	0.17	0.14	0.15	0.16	0.15	0.16	0.17	0.14	0.15	0.16	0.16	0.17	0.17
1997	0.16	0.17	0.19	0.18	0.19	0.2	0.17	0.19	0.2	0.19	0.2	0.21	0.18	0.19	0.2	0.19	0.2	0.21
1998	0.19	0.2	0.22	0.21	0.22	0.23	0.2	0.22	0.23	0.22	0.23	0.24	0.21	0.22	0.23	0.22	0.23	0.24
1999	0.22	0.23	0.24	0.23	0.25	0.26	0.23	0.24	0.26	0.24	0.25	0.26	0.23	0.25	0.26	0.24	0.26	0.27
2000	0.24	0.25	0.26	0.25	0.26	0.27	0.25	0.26	0.27	0.26	0.27	0.28	0.25	0.26	0.28	0.26	0.27	0.28
2001	0.25	0.26	0.28	0.26	0.27	0.28	0.26	0.27	0.29	0.27	0.28	0.29	0.26	0.28	0.29	0.27	0.28	0.29
2002	0.26	0.28	0.29	0.27	0.28	0.29	0.27	0.29	0.3	0.28	0.29	0.3	0.28	0.29	0.3	0.28	0.29	0.3
2003	0.27	0.28	0.29	0.28	0.29	0.3	0.28	0.29	0.3	0.29	0.3	0.3	0.28	0.3	0.31	0.29	0.3	0.3
2004	0.28	0.29	0.3	0.29	0.3	0.3	0.29	0.3	0.31	0.29	0.3	0.31	0.29	0.3	0.31	0.3	0.3	0.31
2005	0.29	0.3	0.31	0.3	0.31	0.31	0.3	0.31	0.32	0.3	0.31	0.32	0.3	0.31	0.32	0.3	0.31	0.32
2006	0.3	0.31	0.32	0.3	0.31	0.32	0.3	0.32	0.32	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.33
2007	0.3	0.31	0.32	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.33	0.31	0.32	0.33	0.32	0.32	0.33
2008	0.31	0.31	0.32	0.31	0.32	0.32	0.31	0.32	0.33	0.32	0.32	0.33	0.31	0.32	0.33	0.32	0.33	0.33
2009	0.31	0.31	0.32	0.31	0.32	0.32	0.31	0.32	0.33	0.32	0.32	0.33	0.31	0.32	0.33	0.32	0.32	0.33
2010	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.32	0.33	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.33
2011	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.32	0.33	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.32
2012	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.32	0.33	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.32
2013	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.32	0.33	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.32
2014	0.31	0.32	0.32	0.31	0.31	0.32	0.31	0.32	0.33	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.32
2015	0.31	0.32	0.32	0.31	0.32	0.32	0.31	0.32	0.33	0.31	0.32	0.33	0.31	0.32	0.33	0.31	0.32	0.33
2016	0.32	0.32	0.33	0.31	0.32	0.32	0.32	0.32	0.33	0.32	0.32	0.33	0.31	0.32	0.33	0.32	0.32	0.33
2017	0.32	0.32	0.33	0.32	0.32	0.33	0.32	0.32	0.33	0.32	0.33	0.33	0.31	0.32	0.34	0.32	0.33	0.33

BB	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13	model 14	model 15	model 16	model 17	model 18
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0.01	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01
1955	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1956	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1957	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1958	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1959	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1960	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1961	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03
1962	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.03
1963	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
1964	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1965	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.03	0.04	0.03	0.04	0.04
1966	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04
1967	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05
1968	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05
1969	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05
1970	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05
1971	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06
1972	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.06
1973	0.06	0.07	0.07	0.06	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.07
1974	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.07	0.07	0.06	0.07	0.07	0.06	0.07	0.07
1975	0.07	0.08	0.09	0.07	0.08	0.08	0.07	0.08	0.09	0.07	0.08	0.08	0.07	0.08	0.08	0.07	0.08	0.08
1976	0.08	0.09	0.1	0.08	0.09	0.09	0.08	0.09	0.1	0.08	0.09	0.09	0.08	0.09	0.09	0.08	0.09	0.09
1977	0.09	0.1	0.1	0.09	0.09	0.1	0.09	0.09	0.1	0.09	0.09	0.1	0.08	0.09	0.1	0.08	0.09	0.1
1978	0.09	0.1	0.11	0.09	0.1	0.1	0.09	0.1	0.11	0.09	0.1	0.1	0.09	0.1	0.1	0.09	0.09	0.1
1979	0.1	0.1	0.11	0.09	0.1	0.1	0.1	0.11	0.11	0.09	0.1	0.11	0.1	0.1	0.11	0.09	0.1	0.11
1980	0.1	0.11	0.12	0.1	0.1	0.11	0.1	0.11	0.12	0.1	0.11	0.11	0.1	0.11	0.12	0.1	0.1	0.11
1981	0.11	0.12	0.12	0.1	0.11	0.11	0.11	0.12	0.13	0.11	0.11	0.12	0.11	0.12	0.13	0.11	0.11	0.12
1982	0.11	0.12	0.13	0.1	0.11	0.12	0.11	0.12	0.13	0.11	0.11	0.12	0.11	0.12	0.13	0.11	0.11	0.12
1983	0.11	0.12	0.12	0.1	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11
1984	0.11	0.12	0.12	0.1	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11
1985	0.11	0.12	0.12	0.1	0.1	0.11	0.12	0.12	0.13	0.1	0.11	0.11	0.12	0.12	0.13	0.1	0.11	0.11
1986	0.11	0.12	0.12	0.1	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11
1987	0.11	0.12	0.12	0.1	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11
1988	0.11	0.12	0.12	0.1	0.11	0.11	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.11	0.11	0.11
1989	0.11	0.11	0.12	0.1	0.1	0.1	0.11	0.12	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.1	0.1	0.1
1990	0.11	0.11	0.11	0.1	0.1	0.1	0.11	0.12	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.1	0.1	0.1
1991	0.11	0.11	0.11	0.1	0.1	0.1	0.11	0.12	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.1	0.1	0.1
1992	0.11	0.11	0.11	0.1	0.1	0.1	0.12	0.12	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.11	0.11	0.1
1993	0.11	0.11	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.12	0.12	0.11	0.11	0.11
1994	0.11	0.11	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.11	0.11	0.1	0.12	0.12	0.12	0.11	0.11	0.1
1995	0.11	0.11	0.12	0.1	0.1	0.1	0.12	0.12	0.12	0.11	0.11	0.1	0.12	0.12	0.12	0.11	0.11	0.1
1996	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.12	0.12	0.11	0.11	0.11	0.13	0.13	0.13	0.11	0.11	0.11
1997	0.12	0.12	0.12	0.11	0.11	0.11	0.13	0.13	0.13	0.12	0.11	0.11	0.13	0.13	0.13	0.12	0.11	0.11
1998	0.12	0.12	0.12	0.11	0.11	0.11	0.13	0.13	0.13	0.12	0.12	0.11	0.13	0.13	0.13	0.12	0.12	0.11
1999	0.12	0.13	0.13	0.12	0.11	0.11	0.13	0.13	0.13	0.12	0.12	0.11	0.13	0.13	0.13	0.12	0.12	0.11
2000	0.13	0.13	0.13	0.12	0.12	0.11	0.13	0.13	0.13	0.12	0.12	0.11	0.14	0.13	0.13	0.12	0.12	0.11
2001	0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.11	0.14	0.13	0.13	0.12	0.12	0.11
2002	0.13	0.13	0.13	0.12	0.12	0.12	0.14	0.14	0.13	0.13	0.12	0.12	0.14	0.14	0.13	0.13	0.12	0.12
2003	0.13	0.13	0.13	0.12	0.12	0.12	0.14	0.14	0.13	0.13	0.12	0.12	0.14	0.14	0.13	0.13	0.12	0.12
2004	0.14	0.14	0.13	0.13	0.12	0.12	0.14	0.14	0.14	0.13	0.12	0.12	0.15	0.14	0.14	0.13	0.12	0.12
2005	0.14	0.14	0.14	0.13	0.13	0.12	0.15	0.14	0.14	0.13	0.13	0.12	0.15	0.14	0.14	0.13	0.13	0.12
2006	0.14	0.14	0.14	0.13	0.13	0.12	0.15	0.15	0.14	0.14	0.13	0.12	0.15	0.15	0.14	0.14	0.13	0.12
2007	0.15	0.15	0.14	0.14	0.13	0.13	0.15	0.15	0.14	0.14	0.13	0.12	0.16	0.15	0.14	0.14	0.13	0.12
2008	0.15	0.15	0.15	0.14	0.14	0.13	0.16	0.15	0.15	0.14	0.14	0.13	0.16	0.15	0.15	0.14	0.14	0.13
2009	0.15	0.15	0.15	0.14	0.14	0.13	0.16	0.16	0.15	0.14	0.14	0.13	0.16	0.16	0.15	0.15	0.14	0.13
2010	0.16	0.16	0.15	0.15	0.14	0.13	0.16	0.16	0.15	0.15	0.14	0.13	0.17	0.16	0.15	0.15	0.14	0.13
2011	0.16	0.16	0.15	0.15	0.14	0.13	0.16	0.16	0.15	0.15	0.14	0.13	0.17	0.16	0.15	0.15	0.14	0.13
2012	0.16	0.16	0.16	0.15	0.15	0.13	0.17	0.16	0.16	0.15	0.15	0.13	0.17	0.17	0.16	0.16	0.15	0.13
2013	0.17	0.16	0.16	0.15	0.15	0.14	0.17	0.17	0.16	0.16	0.15	0.14	0.18	0.17	0.16	0.16	0.15	0.14
2014	0.17	0.17	0.16	0.16	0.15	0.14	0.18	0.17	0.16	0.16	0.15	0.14	0.18	0.17	0.16	0.16	0.15	0.14
2015	0.17	0.17	0.16	0.16	0.15	0.14	0.18	0.17	0.16	0.16	0.15	0.14	0.18	0.18	0.16	0.17	0.15	0.14
2016	0.17	0.17	0.16	0.16	0.16	0.14	0.18	0.18	0.17	0.17	0.16	0.14	0.19	0.18	0.17	0.17	0.16	0.14
2017	0.18	0.18	0.17	0.17	0.16	0.14	0.19	0.18	0.17	0.17	0.16	0.14	0.19	0.18	0.17	0.17	0.16	0.14

LL	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10	model 11	model 12	model 13	model 14	model 15	model 16	model 17	model 18
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1963	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03
1964	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.03	0.03	0.03	0.03	0.04
1965	0.03	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.04	0.04	0.04	0.05
1966	0.05	0.05	0.06	0.06	0.06	0.07	0.05	0.05	0.06	0.06	0.06	0.07	0.05	0.05	0.06	0.06	0.06	0.07
1967	0.06	0.06	0.07	0.06	0.07	0.08	0.06	0.06	0.07	0.06	0.07	0.08	0.05	0.06	0.07	0.06	0.07	0.08
1968	0.06	0.06	0.07	0.07	0.07	0.08	0.06	0.06	0.07	0.07	0.07	0.08	0.06	0.06	0.07	0.06	0.07	0.08
1969	0.06	0.07	0.08	0.07	0.08	0.08	0.06	0.07	0.08	0.07	0.08	0.08	0.06	0.07	0.07	0.07	0.08	0.08
1970	0.07	0.08	0.08	0.08	0.08	0.09	0.07	0.08	0.08	0.08	0.08	0.09	0.07	0.08	0.08	0.08	0.08	0.09
1971	0.08	0.09	0.09	0.09	0.09	0.1	0.08	0.09	0.09	0.09	0.09	0.1	0.08	0.08	0.09	0.08	0.09	0.1
1972	0.09	0.1	0.11	0.1	0.11	0.12	0.09	0.1	0.11	0.1	0.11	0.12	0.09	0.1	0.11	0.1	0.11	0.12
1973	0.1	0.11	0.12	0.11	0.12	0.13	0.1	0.11	0.12	0.11	0.12	0.13	0.1	0.11	0.12	0.11	0.12	0.13
1974	0.11	0.13	0.14	0.13	0.14	0.15	0.11	0.12	0.14	0.13	0.14	0.15	0.11	0.12	0.13	0.12	0.13	0.14
1975	0.13	0.14	0.15	0.14	0.15	0.16	0.12	0.14	0.15	0.14	0.15	0.16	0.12	0.13	0.15	0.13	0.15	0.16
1976	0.14	0.15	0.16	0.15	0.16	0.17	0.14	0.15	0.16	0.15	0.16	0.17	0.13	0.15	0.16	0.14	0.16	0.17
1977	0.14	0.15	0.16	0.15	0.16	0.17	0.14	0.15	0.16	0.15	0.16	0.17	0.14	0.15	0.16	0.15	0.16	0.17
1978	0.14	0.15	0.17	0.15	0.16	0.17	0.14	0.16	0.17	0.15	0.17	0.17	0.14	0.15	0.17	0.15	0.16	0.17
1979	0.14	0.16	0.17	0.15	0.16	0.17	0.15	0.16	0.17	0.16	0.17	0.17	0.14	0.16	0.17	0.15	0.16	0.17
1980	0.14	0.16	0.17	0.15	0.16	0.17	0.15	0.16	0.17	0.15	0.16	0.17	0.15	0.16	0.17	0.15	0.16	0.17
1981	0.15	0.16	0.17	0.16	0.17	0.18	0.16	0.17	0.18	0.16	0.17	0.18	0.16	0.17	0.18	0.16	0.17	0.18
1982	0.16	0.17	0.18	0.17	0.18	0.19	0.17	0.18	0.19	0.17	0.18	0.19	0.17	0.18	0.19	0.18	0.18	0.19
1983	0.18	0.19	0.2	0.19	0.2	0.21	0.18	0.19	0.2	0.19	0.2	0.21	0.18	0.2	0.21	0.19	0.2	0.21
1984	0.18	0.19	0.2	0.19	0.2	0.2	0.19	0.2	0.21	0.19	0.2	0.21	0.19	0.2	0.21	0.19	0.2	0.21
1985	0.18	0.2	0.21	0.19	0.2	0.21	0.19	0.2	0.21	0.2	0.21	0.21	0.2	0.21	0.22	0.2	0.21	0.22
1986	0.2	0.21	0.22	0.2	0.22	0.22	0.21	0.22	0.23	0.21	0.22	0.23	0.21	0.22	0.23	0.21	0.22	0.23
1987	0.2	0.21	0.22	0.21	0.22	0.22	0.21	0.22	0.23	0.21	0.22	0.23	0.21	0.22	0.23	0.22	0.22	0.23
1988	0.2	0.21	0.22	0.2	0.21	0.22	0.21	0.22	0.23	0.21	0.22	0.22	0.21	0.22	0.23	0.21	0.22	0.22
1989	0.21	0.22	0.23	0.21	0.22	0.23	0.22	0.23	0.23	0.22	0.22	0.23	0.22	0.23	0.24	0.22	0.23	0.23
1990	0.22	0.23	0.24	0.23	0.24	0.24	0.23	0.24	0.25	0.24	0.24	0.25	0.24	0.25	0.25	0.24	0.24	0.25
1991	0.23	0.25	0.26	0.24	0.25	0.26	0.25	0.26	0.27	0.25	0.26	0.26	0.25	0.26	0.27	0.26	0.26	0.27
1992	0.25	0.26	0.27	0.26	0.27	0.28	0.26	0.28	0.29	0.27	0.28	0.28	0.27	0.28	0.29	0.27	0.28	0.28
1993	0.26	0.28	0.29	0.27	0.28	0.29	0.28	0.29	0.3	0.28	0.29	0.29	0.29	0.3	0.3	0.29	0.29	0.3
1994	0.27	0.29	0.3	0.28	0.29	0.29	0.29	0.3	0.31	0.29	0.3	0.3	0.3	0.31	0.31	0.29	0.3	0.3
1995	0.29	0.3	0.31	0.3	0.31	0.31	0.31	0.32	0.32	0.31	0.31	0.31	0.31	0.32	0.33	0.31	0.31	0.31
1996	0.3	0.32	0.33	0.31	0.32	0.32	0.32	0.33	0.33	0.32	0.32	0.32	0.32	0.33	0.33	0.32	0.32	0.32
1997	0.32	0.33	0.34	0.32	0.33	0.33	0.33	0.34	0.34	0.33	0.33	0.33	0.34	0.34	0.34	0.33	0.33	0.33
1998	0.32	0.34	0.34	0.33	0.33	0.33	0.34	0.34	0.34	0.33	0.34	0.34	0.34	0.34	0.35	0.34	0.34	0.34
1999	0.33	0.34	0.35	0.33	0.34	0.34	0.34	0.34	0.35	0.34	0.34	0.34	0.34	0.35	0.35	0.34	0.34	0.34
2000	0.34	0.35	0.35	0.34	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34
2001	0.35	0.35	0.36	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34
2002	0.34	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.34	0.34	0.34	0.34	0.33
2003	0.34	0.34	0.35	0.34	0.34	0.33	0.34	0.34	0.34	0.33	0.33	0.33	0.34	0.34	0.34	0.33	0.33	0.33
2004	0.34	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.34	0.34	0.34	0.34	0.33	0.33
2005	0.34	0.34	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.34	0.34	0.34	0.34	0.33	0.33
2006	0.33	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.33	0.33	0.33	0.33	0.32	0.32
2007	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.32	0.32	0.32	0.32	0.31	0.31
2008	0.32	0.33	0.33	0.32	0.32	0.31	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31
2009	0.32	0.32	0.32	0.32	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31
2010	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31
2011	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31	0.31
2012	0.31	0.31	0.31	0.31	0.31	0.3	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
2013	0.31	0.31	0.31	0.3	0.3	0.29	0.31	0.3	0.31	0.3	0.3	0.3	0.3	0.3	0.31	0.3	0.3	0.3
2014	0.3	0.3	0.3	0.29	0.29	0.28	0.3	0.29	0.3	0.29	0.29	0.28	0.3	0.29	0.3	0.29	0.29	0.28
2015	0.29	0.29	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.28	0.28
2016	0.29	0.29	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.28	0.28
2017	0.29	0.29	0.28	0.28	0.28	0.27	0.29	0.28	0.28	0.28	0.28	0.27	0.29	0.28	0.28	0.28	0.28	0.28