REPORT OF THE 2017 ICCAT BLUEFIN STOCK ASSESSMENT MEETING

(Madrid, Spain 20-28 July, 2017)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat in Madrid 20 to 28 July 2017. Dr. Clay Porch (USA), the Species Group ("the Group") Coordinator and meeting Chairman, opened the meeting and welcomed participants. Drs. Gary Melvin (Canada) and Ana Gordoa (EU-Spain), the Rapporteurs for the western Atlantic and eastern Atlantic and Mediterranean stocks, respectively, served as co-Chairs. Mr. Driss Meski (ICCAT Executive Secretary) welcomed the participants and highlighted the importance of the meeting due to the high Commission expectations of the assessment as regards to the revisions to the old data, availability of new data, and the updating of the indices of abundance. The Chairs proceeded to review the Agenda which was adopted with minor changes (**Appendix 1**).

The List of Participants is included in **Appendix 2.** The List of Documents presented at the meeting is attached as **Appendix 3**. The following served as rapporteurs:

Sections	*Rapporteur*
Items 1 and 9	M. Neves dos Santos
Item 2	G. Melvin
Item 3	
Item 3.1 and 3.2	G. Diaz, M. Ortiz, A. Kimoto
Item 3.3 and 3.4	A. Hanke
Item 3.5	J. Hoenig, L. Ailloud
Item 3.6	H. Arrizabalaga, L. Kerr
Item 3.7	A. Gordoa, G. Melvin
Item 4	J.J. Maguire, S. Cadrin
Item 5	T. Itoh, C. Porch, S. Nakatsuka, A. Kimoto, J. Walter
Item 6	C. Brown, T Rouyer, J. Walter, S. Cadrin, M. Lauretta, R. Sharma
Item 7	A. Hanke, C. Porch, G. Melvin, A. Gordoa and D. Die
Item 8	G. Melvin and A. Gordoa

2. Review of the scientific papers presented at the Working Group

The Coordinator noted that 26 documents and 1 presentation had been submitted for review. The respective summaries are compiled in **Appendix 4**, as provided by the authors. Priority was given for those documents directly related with the 2017 bluefin tuna stock assessment. Due to the lack of time, the four papers were not presented nor reviewed by the Group. The first of these papers refer to Task II (SCRS/2017/171), of which a first draft was presented and accepted during the Data Preparatory meeting to update the French and Spanish purse seine catch-at-size for the Mediterranean bluefin tuna fisheries between 1970 and 2010. The second corresponding to Task I data (SCRS/2017/169) comprised the revision of Atlantic bluefin tuna nominal catches from EU-Spain. Document SCRS/2017/149 provided a preliminary report of the ICCAT GBYP aerial survey for bluefin tuna spawning aggregations conducted in 2017. Finally, document SCRS/2017/131 provides the distribution of both conventional and electronic tags that were deployed in the Atlantic Ocean and in the Strait of Gibraltar, and later recovered or popped-off in the Mediterranean Sea.

3. Review and update data for stock assessment

3.1 Biology

Document SCRS/2017/083 presented five different hypothesis of natural mortality (M) for western bluefin tuna. All five hypotheses were confronted with empirical survival estimates from a discrete Brownie tag return model applied to the conventional tagging data for the period 1965 to 2016. Although the conventional tagging data contained considerable information on survival over time, no one hypothesis of natural mortality could be selected from the set of candidates based on the analysis. However, if the survival estimates for the period 1995 to 1999 are an accurate measure of total survival and representative of larger fish compared to other periods, then a natural mortality rate greater than 0.12 per year for this group is inconsistent with the results.

The Group noted that the Brownie model provided estimates of total survival for tag cohorts, aggregated across ages, which were used to refute several hypotheses about the natural mortality rate of Atlantic bluefin. The Group asked how the estimates of M at age values were obtained. It was explained that the estimates were obtained using a Lorenzen function based on the mean weight-at-age estimated from the adopted growth curve and length-weight relationship, and scaled to an asymptotic rate of 0.1. It was noted that the estimated survival patterns from the tagging analysis were different from the apical fishing mortality (F) trends estimated by the VPA. However, the Group discussed that this result was not unexpected because both the age composition of the tagged fish and the overall selectivity of the fleets have changed over time. For example, in the 1970s most tag deployments and recaptures were of small bluefin tuna from the U.S. purse seine fishery. Survival estimates from the tagging analysis indicate lower survival during this time period, consistent with both tagging of younger fish and higher levels of F on younger fish as estimated in the VPA. Tag-based survival estimates have increased, largely due to a shift towards tagging larger fish rather than reflecting the overall pattern of apical F from the VPA. The Group also discussed whether M might have changed over time. While there was a general agreement that this could be the case, the Group felt that it had insufficient data to estimate this and thus agreed to assume a constant M-at-age vector for the assessment. Furthermore, the Group was informed of the results of a new study that estimated western bluefin tuna natural mortality using acoustic tags in Canada. This study estimated M ranging from 0.04 to 0.09 (pers. comm. A. Boustany 2017). It was also pointed out that the CCSBT considers in the operating model a range of values for M at age 10 whose median of about 0.07 is somewhat lower than 0.1 (pers. comm. R. Hillary 2017). The Group acknowledged this issue and proposed scaling the Lorenzen function to asymptote at a value of M=0.07 for the oldest fish as a sensitivity run.

Document SCRS/2017/164 presented estimates of the fraction of the western bluefin tuna that spawn by age based on a comparison of the age frequency of fish collected on the Gulf of Mexico spawning grounds with the age frequency estimated from the 2014 assessment (Anon. 2015). The results suggest that fish under the age of nine seldom spawn in the Gulf of Mexico and that peak spawning frequency is not achieved until about age 15. The authors recommended a procedure for estimating the fraction spawning at age based on the estimated selectivity of fish on the presumed spawning grounds (rather than relying on out of date assessments).

The age and length composition from the landings used in the study was assumed to be representative of the length composition of the bluefin tuna in the Gulf of Mexico. The Group also acknowledged that since the data were collected by scientific observer programmes, data quality was probably not an issue of concern. It was discussed if size selectivity could have affected the results of the analysis and if selectivity could be dome shaped. The Group noted that if that is the case, then the results would be even more skewed towards older ages. Finally, it was noted that the Mexican bluefin tuna fishery has shown a broader range of sizes in some years, including fish as small as 120 cm FL, and it was suggested that these data should be included in future analysis. However, the Group agreed that the fraction of those small fish in the total catch was negligible and using that data would not significantly change the results of the current analysis.

Document SCRS/2017/170 provided the results of using direct ageing to estimate a length-age key and a growth curve of eastern bluefin tuna. The study used otoliths and spines collected between 1984 and 2013.

The Group noted that the growth fitting results showed a relatively poor fit of ages eight and above. It was noted that it seems to be a selectivity bias in the fitting of smaller fish. It was mentioned that the Group might want to consider using different growth functions for different age ranges. It is well known that energy allocation shifts from growth in the earlier ages to reproduction output in the older ages. Therefore, it is not implausible that growth can be better described using more than just one growth function. For example, the Group could consider using the growth estimated by Cort (1991) and Cort *et al.* (2014) for the earlier ages and the Allioud *et al.* (2017) growth function for the older ages. The Group also discussed using observed mean length at age from the raw data instead of the growth curve for using cohort slicing. The Group decided to apply the Cort (1991) growth curve for cohort slicing despite apparent miss-fitting to older ages. However, the Group noted that a growth function is needed for stock status projections.

Apart from these new contributions, a summary of the current assumptions concerning life history attributes as used in the assessment is provided in the **Table 1** for the West Atlantic and East Atlantic and Mediterranean stocks.

3.2 Catch estimates

During the March data preparatory meeting (Anon., in press) the Group reviewed the basic Task I and Task II CAS and size data (refer to section 3.1 of that report for details). During the intersession, the Secretariat finalized the consultations with scientists and CPCs to classify the catches by gear from the unknown category. As agreed by the Working Group, the Task I was updated to include the so-called "inflated catches" as part of the best estimate of total removals for East bluefin tuna for the period 1998-2007. The inflated catches were all assigned to the purse seine gear. **Table 2** and **Figure 1** present the total catch used in the current assessment for each stock for the period 1950–2015. The Secretariat also provided a compilation of the historical catches of bluefin tuna since 1512, recovered primarily under the ICCAT GBYP initiatives (**Figure 2**).

For assessment models that require fleet-specific catch statistics (see section 4), the Secretariat, in collaboration with the lead analysts, prepared the distribution of the Task I into the fleet-structure. A total of 13 fleet-gear categories were created for the East bluefin tuna, and 11 fleet-gear categories for the West bluefin tuna. These fleet-gear categories were also directly associated with the corresponding size frequency samples as input for the catch statistical models. **Table 3** shows the fleet-gear structure and the corresponding allocation of catch by year (**Figure 3**).

3.2.1 Review Task I statistics to be used for projections

During the data preparatory meeting it was agreed to use 2015 as the terminal year for assessment purposes. The Secretariat informed the Group that prior to this meeting there were incomplete reports of bluefin catches for 2016. During the meeting scientists from the main fleets reported their preliminary estimates of 2016 catches for the western stock: Japan 345.4 t, Canada 480 t, and USA 1,025 t. For the other flags it was agreed to carry-over the catches of 2015. In total, the estimated catch for West bluefin tuna was 1,912.4 t in 2016. For the assessment model that required fleet-gear specific catches, the same fleet-gear proportions as in 2015 were assumed. **Table 4** summarizes the estimates for 2016 West bluefin tuna catches. For the East bluefin tuna, there were no preliminary reports available, therefore the Working Group agreed using the TAC allocation for 2016 (19,296 t) for projections.

3.2.2 Task II size

Document SCRS/2017/166 presents a detailed review and preliminary analyses of size frequency samples for bluefin tuna. In relation to the Task II size frequencies (T2SZ) harmonization task, progress was reported at the data preparatory meeting (Anon. in press). During the intersession, there were important updates to the size data:

West bluefin tuna:

i) Update of the size samples for the Canadian hand-line fishery for the period 1974-1985. These size samples were also used for the construction of the CAS and CAA for this particular gear-fleet.
ii) Review of the size samples from the USA Gulf of Mexico longline fleet where some fish had been miscoded in the ICCAT data base as fork length measurements when in fact they were pectoral fin to fork measures. Scientist will provide updated values and appropriate conversion factors for these size samples. In the meanwhile, these samples were converted to SFL for statistical catch-at-length analysis.

East bluefin tuna:

i) Update of the size samples for the EU-France and EU-Spain purse seine fleets (SCRS/2017/171) for the period 1970-2010, based on mean weight per set operation.
ii) Update of the stereo-camera size measures from the caged bluefin tuna 2014-2015.
iii) Update of the estimated size at capture from harvested farm bluefin tuna (SCRS/2017/024) for the period 2008-2015.

Most of the new size samples were also integrated into the estimation of the CAS and CAA. For the East bluefin tuna, some size samples were available from two or more sources (e.g. stereo-camera, back calculated size at catch from harvested farm fish, and Annual Reports), creating a potential duplication of information mainly from purse seine and trap fisheries. A priority scheme was applied when overlapping of size data was available. This scheme gave highest priority to samples from the stereo-camera reports, followed by back-calculation from harvested fish, and least importance to Annual Reports.

All size samples were revised and allocated into the fleet-gear structure for the catch-statistical models, creating annual size frequency samples (SCRS/2017/166). A minimum of 75 measured fish per year was imposed for each size-frequency samples, fleet-gear strata. Samples with extreme skewness or kurtosis were also carefully revised and checked before being included, and fish greater than 350 cm SFL were excluded. **Figure 4** shows the size distribution in each fleet-gear category for the West and East stocks.

3.2.3 Catch at size and Catch at Age

Most of the new size samples were also integrated into the estimation of the CAS and CAA. The CAS was constructed by the Secretariat following similar guidelines as in prior assessments for substitutions by fleet, gear, area and quarter when size samples, CAS or CAA were unavailable. **Table 5** presents the substitutions used in the current CAS. During the intersession the Secretariat created a CAA using the 'cohort slicing' method as done in prior assessments based on the monthly estimated size at age from the growth models; von Bertalanffy growth model for the East and Mediterranean bluefin tuna stock (Cort, 1991; Cort *et al.*, 2014) and Richards growth model for the West bluefin tuna stock (Ailloud *et al.*, 2017). An alternative ageing protocol was used to generate a CAA, using a parametric growth (same growth models) that uses variance of size at age to estimate a probability distribution of ages for a given size. Document SCRS/2017/181 compares both ageing protocols using a catch curve analyses on the estimated CAA. Overall both ageing protocols estimated comparable CAA and estimates of total mortality from the catch curve were similar for the west stock, some more variable for the east stock.

3.3 Relative abundance estimates and CPUE

The relative abundance indices recommended for use in the stock assessment were outlined in detail at the data preparatory meeting and are briefly listed under "Methods". The reader is referred to the data preparatory report for further details (Anon. in press).

Document SCRS/2017/082 provided three standardized relative indices of bluefin tuna abundance using fish caught by the Atlantic Moroccan and EU-Portugal traps in the area close to the Strait of Gibraltar. These were based on factors such as year, month and TrapID/location. A single index covered 1998 to 2016 and two separate indices were created for 1998 to 2011 and from 2012 to 2016 in response to possible changes in the fishing operation (e.g. the quotas was reached in short time).

The following paragraphs describe several index papers presented to the assessment but not used in the current assessment.

Document SCRS/2017/180 provided a standardized relative index of bluefin tuna abundance based on data from Tunisian purse seiners (2009 to 2016). The annual values of the CPUE have been high in the past three years and the overall trend was similar to the trend in the mean weight of the fish.

The Group noted that VMS data was available and could be used to improve future estimates of effort and it was indicated that this data was available for all the purse seine vessels.

Document SCRS/2017/172 provided an updated nominal index of relative bluefin tuna abundance using the Balfegó purse seiners and a second index based on the Balfegó joint purse seine fishing fleet. Both indices exhibited trends similar to the Japanese longline indices. The CPUE based on the joint fishing fleet was more stable than either the Japanese index or Balfegó vessels over the last three years. The average weight of fish in 2017, as estimated by skippers, did not differ from stereo-camera estimated weights of 2016.

The Group noted that joint fishing operations that caught fish for farms would affect the estimates of effort and consequently the CPUE trend and inquired about the availability of VMS data to correct or better define the effort. It was noted that this information should be available for the Balfegó vessels. The Group also inquired about the availability of echo sounder or sonar data to provide school density estimates. It was indicated that the area fished is small and did not correspond with the whole aerial survey area and that commercial echo sounders do not generally have the ability to record.

Document SCRS/2017/184 provided a nominal index of bluefin tuna abundance based on Japanese longline fishing operations on the Algerian territorial waters and under Algerian catch quota conducted between 2000 and 2006. The yield was shown to improve with increasing SST and temperatures of 20^{o} C were optimal. The prevalence of females also increased with increasing SST. Data for purse seine operations was also available (2010-2017) but did not produce an index of abundance due to the difficulty of defining a consistent unit of fishing effort.

The Group inquired about the measure of fishing effort used in the CPUE. It was indicated that the number of vessels was used for effort. The Group suggested that more appropriate measures of effort should be considered in the future.

3.4 Tagging

No new information was presented, although both electronic and conventional tagging data presented at the data preparatory meeting were summarized for input into mixing models. The Group noted that the data base for electronic tags did not include any information to indicate whether the tag had been recovered by the fishery or not. Several investigators provided this information during the course of the meeting, but the data set remained too incomplete for use in models during the meeting.

3.5 Age composition (age-length keys)

Document SCRS/2017/170 dealt with re-examination of historical spine readings and established that the historical method used for aging provides equivalent results to those obtained by using the currently adopted standardized methodology, and that these records can therefore be used for estimating growth and age composition. It also attempted to develop a new growth curve for the eastern Atlantic using the same methodology used for the west (e.g., the methodology of Ailloud *et al.*, 2017). Both the new von Bertalanffy and the Richards model gave rise to patterns in the residuals. The reason for the misfit was largely due to the lack of older individuals in the dataset as well as possible differences in selectivity pattern between young and old fish. Consequently, it was proposed to explore more flexible models. The Group proposed two possible alternatives when no acceptable parametric growth model is available: i) using mean lengths at age (from the raw data) to form an empirical growth curve and use this for cohort slicing the catch-at-size; or ii) use a "morphed curve" linking the Cort (1991) and Cort *et al.* (2014) model for younger ages and the Ailloud *et al.* (2017) model for older ages.

Document SCRS/2017/179, presented estimates of catch at age for both the eastern and western stocks based on the combined forward-inverse age-length key (Hoenig *et al.*, 2002). After initial problems in maximizing the likelihood, an ad hoc procedure was developed that bounded the estimates of probability-at-age away from zero and facilitated convergence. The Group noted that the catch at age matrix for the western Atlantic seemed to track strong and weak cohorts well. In general, the combined key gave results similar to cohort slicing with some differences in the magnitudes of the cohorts and the year class assigned to one strong cohort (**Figure 5**). However, three concerns about the combined key were raised by the Group: 1) Some cohorts seem to nearly disappear only to reappear a year later, causing instability in the VPA, 2) the calculated mean weight in the plus group was lower than that of the 15 year olds due to small sample sizes for age 15, and 3) a strong 2002 year class appears throughout the western catch at age matrix whereas there was concern that this might be the 2003 year class. For the eastern Atlantic, there were greater problems with convergence of the combined forward-inverse key due to small sample sizes of larger individuals; additionally, the estimates of age composition varied greatly from year to year for the most recent three years.

The catch at age estimates for the west from the combined forward-inverse key were run through the VPA and it was noted that it produced some odd patterns of extremely high F's followed by extremely low F's due to the apparent disappearance and reappearance of cohorts. It was therefore decided by the Group to conduct a run of the western VPA where the age composition for the most recent five years (2010-2015) was obtained from the combined forward-inverse age length key, and the age composition for years prior to 2010 obtained from cohort slicing. The plus group for the run was set at age 16+. The results were presented to the Group. Concern was expressed that there was an apparent shift in selectivity due to the change in method for estimating age composition. It was therefore decided to use cohort slicing to create the base VPAs and use the catch-at-age matrix from the combined forward-inverse key only as a sensitivity run. For the eastern VPA, it was decided to use the age composition obtained from cohort slicing based on the Cort (1991) and Cort *et al.* (2014) curve, despite being aware that there is a misfit to old specimens, since $L\infty$ is poorly estimated due to the lack of old fish in the fitting.

For the stock synthesis (SS3) models the age-length pairs were input as age frequency distributions by length bins (at 4 cm intervals for the East and 5 cm intervals for the West) for each year and fishery from which the data were collected. This effectively uses the data analogous to an age length key rather than as age composition. This input allowed the integrated models to use the information from sparse age-length data without assuming that the data was representative of ages across the full range of sizes. Aging data was input with both aging error and an aging bias, described below.

Upon further examination of the age data the Group noted that the mean size at age of spine samples appeared systematically larger than the mean size at age in the otolith samples (**Figures 6** and **7**). Ageing experts explained that spine readings for young fish (<7 years) are thought to be very reliable but expressed concern over the estimated ages of the otolith samples up to age 7 because young fish are known to deposit bands that can be misinterpreted as being annual in samples of young individuals, making otolith ages more likely to be overestimated. The data used to build the combined forward-inverse age-length key for the west stock consists mainly of otolith data (~10 spine samples), which could explain why the strong cohort apparent in the catch at age derived from the combined forward-inverse key was being assigned to the 2002 year class instead of the 2003. The Group recommended that an ageing bias vector be added to the Stock Synthesis model since it is able to account for that potential source of bias. Upon request, an ageing bias vector was produced using data from paired otolith-spine samples collected in the past (Rodriguez-Marin *et al.*, 2016) by assuming spine readings are correct for fish up to age 7 (**Table 6**). A vector of bias corrected aged otoliths was created by taking the weighted average of the age readings of otolith samples associated with each age group of the corresponding spine samples.

3.6 Stock composition (otolith microchemistry, genetics)

No new documents on stock composition were presented during the meeting. The Group agreed to rely on the stock composition data compiled during the 2016-2017 data preparatory meetings into an ICCAT Stock Composition Database. The database includes stock composition data from the ICCAT GBYP, Canada, USA and the EU. During the meeting, new stock composition data from the USA was added to the Database. This data is composed of assignments based on otolith chemistry of US-collected Atlantic bluefin tuna from the Gulf of Maine for the period 2010-2011. Individual assignment of this data was based on the random forest procedure (Hanke *et al.*, 2016). In addition, corrections to the database were made in the assignment of year and area to the individual assignments of origin. The final database was made available for the different models being used for stock assessment as well as the MSE approach.

The combined database includes 6,886 individuals with information on their probability of being eastern origin (**Figure 8**). Following the criteria adopted during the 2016 and 2017 data preparatory meetings, fish were assigned to origin only when the probability of eastern origin was lower than 0.3 (assigned to the west, n=2773) or higher than 0.7 (assigned to the east, n=2727).

Currently, the database allows for estimation of stock composition for all bluefin areas except the SC_ATL. **Figure 9** illustrates the proportion of eastern origin fish by area estimated from the ICCAT Stock Composition Database. Stock composition information by area suggests no mixed stock composition within the two main spawning areas (i.e. 100% western origin fish within the GOM and nearly 100% eastern origin fish within the MED), minimal mixed stock composition within SE_ATL, E_ATL, NE_ATL, and NC_ATL and greater mixed stock composition within the W_ATL, CAR, and GSL. Atlantic areas defined within the eastern stock boundary showed eastern origin proportions higher than 0.6, while western areas showed eastern proportions below 0.8.

Data to inform the estimates of stock proportions are most abundant since 2009, when most analyses have been conducted. However, data from the late 1970s and 1990s are available for certain areas (W_ATL and GOM). Results suggest that there is substantial inter-annual variation in the proportions estimated within a given area. Within single areas, proportions can also vary between fishing gears, especially in large areas (e.g. W_ATL) where different gears (e.g. longline and rod and reel) operate in different areas (**Figure 10**).

Information from the ICCAT Stock Composition Database was examined for the purpose of informing revision to population-of-origin VPAs (SCRS/2017/174). Temporal trends in proportion east were examined by fleet (defined by area and gear) to determine stock composition assumptions for population-of-origin VPAs. The following rules were used in determining stock composition to inform this model and resulting estimates are shown in **Figure 11**:

i) If data suggests annual differences in the proportion of eastern fish, time-varying estimates of stock composition are proposed by fleet.
ii) Multi-year estimates of proportion of eastern fish are proposed to be used for years with no data or sample sizes less than 14 (based on the minimum sample size needed to detect a difference between 0.7 and 0.3).
iii) Considering some apparent anomalies, median proportions among aggregated samples were used to determine stock composition by fleet.

3.7 Other data

No information was presented.

4. Methods relevant to the stock assessment

The 2017 stock assessment was conducted for both stocks of Atlantic bluefin tuna. In addition to substantial revisions to historical fishery data, new fishery-independent series of relative abundance, and new information on life history, a wide range of estimation models were applied to both stocks, including revised configurations of the virtual population analyses (VPAs), statistical catch-at-length, statistical catch-at-age and other integrated assessment models. Of these, the only models deemed to have progressed enough at the conclusion of the meeting to be considered as the basis of management advice were the VPA applications for the eastern stock (section 4.1) and the VPA and Stock Synthesis applications for the western stock (section 4.2). The specifications for the remaining models are given together in section 4.3.

4.1 Methods – East

4.1.1 VPA Specifications applied to the East Atlantic and Mediterranean stock

A revised configuration of the VPA-2Box software was used (Porch *et al.*, 2001, ICCAT Catalogue https://github.com/ICCAT/software/wiki/2.10-VPA2Box). In previous assessments, the approach was to start from the last assessment and progressively make modifications in a step by step process. Because of the large number of changes in the input data, the revision of Task I and Task II data, the revision of stock size indices, and the length of the time series, as a result of the various data preparatory meetings, such a progressive approach was impractical, and no continuity run was conducted. In this context, the ICCAT GBYP has been extremely useful in recovering and making available data, particularly on size composition (SCRS/2017/166).

An exploratory data analysis was conducted of the eastern Atlantic and Mediterranean bluefin dataset prepared for the Virtual Population Analysis in SCRS/2017/123. These data include the catch-at-age of the whole stock, catch per unit effort and their partial catches. The analysis explored correlations and conflicts between the CPUE series, the selection patterns of the main fleets and fishing mortality of the terminal ages the main parameter estimated by VPA. The analysis was used to help develop scenarios for use in the assessment.

Stock assessment models are vulnerable to abnormal observations (outliers), which may result in biased estimates of parameters, underestimation of uncertainty, and poor prediction skill. Therefore influential points should be identified and their impact explored. SCRS/2017/104 and SCRS/2017/124 therefore presented a cross-validation of the East Atlantic and Mediterranean Virtual Population Analysis assessment to show how to estimate bias and validate stock assessment scenarios.

Prior to the assessment meeting, a large range of options and parameters were explored such as testing different scenarios (SCRS/2017/168) for the ratio of the fishing mortality in the plus group to the last true age fishing mortality (F_{ratio}), the number of years and strength of the recruitment and vulnerability penalties, as well as consideration of the variance scaling of the indices of stock size. Two methods to calculate the average weights at age (WAA) were tested: i) based on the growth curve, ii) by dividing the total catch at age in weight by the total catch at age in numbers. Both approaches produced strongly decreasing WAA in the plus group (10+). This provided too many models to compare to one another. To reduce the number of runs, a first selection was made by excluding inappropriate ones. Models were considered inappropriate if they provided median SSB for the time series that were unrealistically high (>500,000 t), if the retrospective patterns of SSBs were too severe, and if model diagnostics were poor. The best of the remaining models were then ranked in terms of the Akaike information criterion (AIC). It was pointed out, however, that the model selection process cannot be based on AIC if constraints or data are changed among runs. Nevertheless, the results provided useful guidance for subsequent formulations developed during the meeting.

The model input parameters used in the analyses described below are summarized in **Table 1**.

The stock indices of abundance were as agreed at the March 2017 data preparatory meeting (**Table 7**):

1. 'MOR_SP_TP', Combined Morocco – EU-Spain trap for 1981 to 2011
2. 'MOR_POR_TP', Combined Morocco – EU-Portugal trap for 2012 to 2015
3. 'JPN_LL_EastMed', Japanese longline in the East and Mediterranean for 1975 to 2009
4. 'JPN_LL1_NEA', Japanese longline in the Northeast Atlantic for 1990 to 2009
5. 'JPN_LL2_NEA', Japanese longline in the Northeast Atlantic for 2010 to 2015
6. 'SP_BB1', EU-Spain baitboat for 1952 to 2006
7. 'SP_BB2', EU-Spain and EU-France baitboat for 2007 to 2014
8. 'FR_AER', French aerial survey for 2000 to 2003, 2009 to 2012 and 2014-2015
9. 'WMED_LARV', Larval index in the western Mediterranean for 2001 to 2005 and 2012 to 2015

The EU-France aerial survey index is based on the number of schools observed taking into account the detectability of various size of schools. While the number of small, medium and large schools has been recorded the actual size of what is a small, a medium or a large school in any given year is not known. Noting that the proportions of the various sizes of schools differed between the first and the two following periods, the Group decided to treat the first period (2000 to 2003) as a separate index (FR_AER1 and FR_AER2).

The Group noted that the depth sampled by oblique plankton tows for the larval survey had changed from about 69m in the first period (2001 to 2005) to 24 to 32m depending on the year in the second period (2012 to 2015). The authors explained to the Group by correspondence how the index had been standardized for account for the change in depth. Concerns remained that the series should be split; however, the Group decided to use it as a single series.

A three-year constraint on vulnerability (stdev=0.4, see document SCRS/2017/168 for details) and no constraints on recruitment or on the stock recruitment relationship were applied (for details on the VPA2-box a manual is available at https://github.com/ICCAT/software/wiki/2.10-VPA2Box). All CPUE indices belonging to the same gear class were equally weighted, whereas each fishery-independent survey series was weighted separately. Terminal year F's were estimated for ages 1 to 9. The F-ratios were estimated for 1968-1980, 1981-1995, 1996-2007, 2008-2015. The periods were decided based on the F-ratio trends estimated as a random walk (Runs 1-11 in **Table 8**), which appeared consistent with expectations based on major changes in regulations and other developments in the fishery.

The input and output files for the base VPA are included as **Appendix 5** (not included in the Report).

A brief description of the primary runs made during the meeting is provided in **Table 8.**

4.2 Methods – West

4.2.1 VPA Specifications applied to the West stock

A revised configuration of VPA-2Box, was used for the assessment (Porch *et al.*, 2001, available in the ICCAT software catalogue: https://github.com/ICCAT/software/wiki). A continuity configuration of VPA-2Box run from the 2014 assessment was updated with fishery and survey data through 2015 (SCRS/2017/173). The age range 1-16+ years was maintained for the base case configuration. Consistent with decisions made at the data preparatory meeting, the major changes for the 2017 assessment include:

- The natural mortality (M) assumption was revised from a constant instantaneous rate of M=0.14 to an age-varying rate derived from the Lorenzen method scaled to M=0.1 at the oldest ages. This decision was supported by an analysis of tag-recovery data (SCRS/2017/083);
- Two spawning-at-age scenarios were assumed to represent the fraction of each age class that spawns for the western stock; younger (25% spawning at age-3, 50% spawning at age-4, 100% spawning at ages-5+, as in the eastern bluefin tuna stock), and older (logistic function with 0% spawning at age-5, 50% spawning at age-10, and 100% spawning at age-15) based on age distribution in the Gulf of Mexico (SCRS/2017/164);
- Catch-at-age estimates were substantially revised with new growth curve (Ailloud *et al.*, 2017), new Task I (total catch) and Task II (age and size composition) data;
- The starting year of the assessment was revised from 1970 to 1974, because there were limited size composition samples before 1974;
- The Canadian rod and reel indices, 'CAN_GSL' and 'CAN_SWNS', were combined to form a single Canadian CPUE series ('CAN_Combined_RR') 1984-2015;
- The Japanese longline index in the western Atlantic West of 45^{o}W, was split to two series, 1976-2009 'JPN_LL' and 2010-2015 ''JPN_LL_RECENT', and the partial catch-at-age was revised to reflect recent changes in selectivity;
- Canadian Acoustic Survey was included as an index, 'CAN_GSL_Acoustic' 1994-2015; and
- Revised age ranges for tuning indices.

The following relative indices of abundance were used to calibrate the VPA as agreed at the 2017 data preparatory meeting (**Table 9**):

- 'Larval Survey', Gulf of Mexico larval survey 1977-2015
- 'CAN_GSL_Acoustic', Canadian Gulf of St. Lawrence acoustic survey, 1994-2015
- 'CAN_Combined_RR' (GSL and SWNS), Canadian combined large fish index for the Gulf of St. Lawrence and Southwestern Nova Scotia 1984-2015
- 'US_RR_66_114', US rod and reel of fish 66-114cm 1993-2015
- 'US_RR_115_144', US rod and reel of fish 115-144cm 1993-2015
- 'US_RR<145', US rod and reel of fish <145cm 1980-1992
- 'US_RR>195', US rod and reel of fish >195cm 1983-1992
- 'US_RR>177', US rod and reel of fish larger than 177cm
- 'JPN_LL', Japanese longline in the western Atlantic West of 45°W 1976-2009
- 'JPN_LL_RECENT', Japanese longline in the western Atlantic West of 45°W 2010-2015
- 'JPN_LL_GOM', Japanese longline in the Gulf of Mexico 1974-1981
- 'US_LL_GOM' US Gulf of Mexico pelagic longline 1992-2015

Many exploratory configurations were considered, including alternative catch-at-age derived from age-length keys, time-varying catchability of indices from the western Atlantic area, relative statistical weights of indices, fishing mortality rate of age-16+ relative to age-15 (F-ratios), time varying selectivity of the Japanese longline in the western Atlantic for 2010 to 2015, a penalty on vulnerability changes for the last three years, a younger oldest age group (age-10+), and alternative starting seeds for the iterative solution. The VPA Results were somewhat sensitive to the estimation of F-ratios, but the estimated ratios were not well determined. After considering and comparing the F-ratio estimates from SS3, the VPA F-ratios were fixed at 1 for the base case. Results were relatively insensitive to the age of the plus group (10Plus or 16Plus), except for estimates from 1970s. Results were relatively insensitive to the vulnerability penalty and alternative approaches to modelling selectivity of the JPN_LL_RECENT index. Absolute estimates of stock size varied among explorations, but general trends were consistent (**Figure 12**). Run 30 was selected as the base model based on the diagnostics from all exploratory analyses and other estimation models.

Revised estimates of catch-at-age based on a combined forward-inverse age-length key (SCRS/2017/179) did not adequately track cohorts to support the VPA assumption of no measurement error in the catch-at-age.

With some conflicting trends among indices, VPA results were sensitive to the statistical weighting of the indices. The conflicting recent trends in Canadian CPUE vs. US rod and reel CPUE of large fish (US_RR>177) were considered to reflect a shift in distribution from US to Canadian waters, and several model revisions were explored to resolve the conflict: i) Time-varying catchability was explored for western Atlantic indices, ii) Adjusted indices in the western Atlantic area were also explored to account for their relationship with the Atlantic Multidecadal Oscillation (AMO), and iii)several alternative approaches to index weighting.

The Group decided that, for the final west bluefin tuna VPA model: i) to exclude the Canadian CPUE (CAN_Combined_RR) and the US rod and reel index of large fish (US_RR>177); ii) to weight the two fishery independent indices according to their input CV (with a minimum CV of 0.3) and the fishery CPUE series by their input CV plus an additional variance term estimated within the VPA to account for additional process error. The CAN_Combined_RR' and the US_RR>177 indices were ultimately removed because they indicated opposing trends and were believed to be the indices most sensitive to the hypothesis of shifting spatial distribution of fish.

4.2.2 Stock Synthesis Specifications applied to the West stock

An application of Stock Synthesis (SS3) was developed for western Atlantic bluefin tuna with 1951-2015 catch (assumed to have no measurement error) from thirteen fleets (JAPAN_LL, USA_CAN_PSFS, USA_CAN_PSFB, USA_TRAP, USA_CAN_HARPOON, USA_RRFB, USA_RRFS, OTHER_ATL_LL, CAN_HOOKLINE, GOM_LL_US_MEX, JLL_GOM, CAN_TRAP, CAN_GSL1). Fleet structure and data inputs follow (SCRS/2017/166) with some modifications to achieve homogenous fleets and similar composition data: The US_CAN traps series was split, the US_CAN purse seine was split between PS-FS (<145 cm SFL) and PS_FB (>145 cm SFL), and the US_RR was split between RR-FS (<145 cm SFL) and RR_FB (>145 cm SFL).

The SS model was fit to eleven indices of stock size: IND1_JPN_LL, IDX2_US_RR_66_114, IDX3_US_RR_115_144, IDX4_US_RR<145, IDX5_US_RR>177, IDX6_US_RR>195, IDX7_US_LL_GOM, IDX8_JPN_LL_GOM, IDX9_CAN_Combined_RR, IDX10_Larval_Survey, IDX11_JPN_LL_Recent, and IDX12_CAN_GSL_ACOUSTIC (see **Table 9**) assuming lognormal error with CV of 0.2 for each index value in each year. Index selectivities were generally assumed to be identical to their respective fleet except for several size-specific indices for (e.g. US_RR_115_144), where the selectivity parameters were fixed to only select between these size ranges.

Size frequency data was input from 1955-2015 assuming multinomial distributions with iterative weighting of effective sample size, and age-length observations 1975-2015, assuming an aging error CV of 0.1 (Busawon D.S., *et al.* 2015). During the meeting a concern was raised that the otoliths may give an age estimate biased high due to a false band for young ages. A revised aging error and aging bias vector was obtained based upon paired otolith-spine readings and was used to account for aging bias:

Age	0.58	1.86	2.79	3.82	5.10	5.93	7.31	8.83	8.50	9.50	10.50
	11.50	12.50	13.50	14.50	15.50	16.50	17.50	18.50	19.50	20.50	21.50
	22.50	23.50	24.50	25.50	26.50	27.50	28.50	29.50	30.50	31.50	32.50
	33.50	34.50									
SE	0.14	0.41	0.54	0.62	0.73	0.75	0.89	1.07	1.09	1.14	1.22
	1.34	1.52	1.85	2.04	1.76	1.66	1.44	1.53	2.20	2.31	2.43
	2.54	2.65	2.77	2.88	2.99	3.10	3.22	3.33	3.44	3.56	3.67
	3.78	3.89									

Size at age was initially input with a CV as a function of age but was switched to be a function of length during the meeting to more closely match growth assumptions of Ailloud *et al*. (2017).

The initial SS model had 93 estimated parameters. Final model estimate parameters due to the inclusion of time blocks on selectivity and coefficients on the AMO relationship with catchability. Size-based selectivity was estimated as a logistic function for some fleets (CAN_HL, GOM_LL_US_MEX, JLL_GOM, CAN_TRAP, US_CAN_HARPOON, OTH_ATL_LL) and double-normal functions for the other fleets (JPN_LL, US_CAN_PSFS, US_CAN_PSFB, US_TRAP, US_RRFB, US_RRFS). Selectivity of CAN_GSL_Acoustic survey was assumed to be the same as the early CAN_GSL1 fisheries because of similar availability. In some cases severely confounded parameters were fixed to avoid high correlations between confounded parameters of the double normal selectivity.

A 'near virgin' stock was assumed for 1950, with an estimate of fishing mortality in the first year from two fleets (SA_CAN_HARPOON and USA_TRAP). A Beverton-Holt stock-recruitment function was assumed, and annual recruitment deviations were estimated from 1961 to 2015 with bias adjustment for back-transformation of recruitment deviations estimated on the log scale to recruitment on the arithmetic scale: The bias adjustment ramps up according to the amount of information in the data to estimate recruitment so years with good data have a large bias adjustment and years without have less (Methot and Taylor, 2011).

Growth was estimated internally with a Richards function and was estimated to be similar to Ailloud *et al.* (2017). The natural mortality rate M was assumed to be 0.1 for age-20, scaled with Lorenzen function of growth. Two spawning-at-age scenarios were assumed to represent the spawning scenario assumed for the eastern stock: younger (25% spawning at age-3, 50% spawning at age-4, 100% spawning at ages-5+) and older (logistic curve with 0% spawning at age-5, 50% spawning at age-10 , 100% spawning at age-15, based on age distribution in the Gulf of Mexico SCRS/2017/164). Steepness *h* was estimated to be 0.55 (older spawning) and 0.47 (younger spawning).

Similar to the VPA, there was poor fit to some CPUE indices (e.g., all positive residuals from IDX9_CAN_Combined_RR 2003-2015, and all negative residuals from IDX5_US_RR>177 2005-2015) and the recent time series of JPN_LL composition data (2010-2015). The poor composition data in early time period during peak catches resulted in high CVs on estimated recruitments.

Several alternative SS configurations were explored to investigate alternative M assumptions, alternative approaches to estimating selectivity of the JPN_LL, IDX2_US_RR_66_114, IDX3_US_RR_115_144, USRRFS and CAN_HOOKLINE, the addition of the JLL Brazil index, the inclusion of the AMO as a covariate to inform time-varying catchability (see Schirripa *et al.*, 2017), alternative approaches to estimating recruitment (including a test for regime shift, and unconstrained from a stock-recruit relationship).

Conditional likelihood profiles suggest that the data is consistent with a range of M=0.05 to M=0.1 and a relatively narrow range of steepness (h~0.55 to 0.6), but size composition data are more consistent with a lower value of *h* and age composition data are more consistent with a higher value of *h*.

Runs 8 (older spawning) and 9 (younger spawning) were selected as the base models based on diagnostics of all exploratory analyses and comparisons with results from other models.

4.3 Other methods

4.3.1 Alternative Assessments of the eastern and western Stocks (without mixing)

Stock Synthesis 3, ASAP 3, SAM and SCAL were also run using the same or very similar data.

Applications of SS3 were developed for both the West Atlantic (SCRS/2017/176) and eastern Atlantic and Mediterranean bluefin tuna stocks (SCRS/2017/175). Both sets of models were altered considerably during the meeting. The SS3 model for the western stock was considered sufficiently advanced by the close of the meeting to potentially be used along with the VPA as a primary basis for management advice and is described in detail in section 4.2.2 In contrast, some issues concerning the SS3 model for the eastern stock remained outstanding by the close of the meeting and the Group remained undecided as to whether to use the results as a primary basis for management advice. Accordingly, the description of the application to the eastern Atlantic and Mediterranean bluefin tuna stocks is included in the present section.

The SS3 application for the eastern Atlantic and Mediterranean bluefin tuna stock (SCRS/2017/175) grew from an earlier exploration detailed in Irie and Takeuchi (2015). It includes catch data for the years 1950-2015 (assumed to have no measurement error) from fifteen fleets (Baitboat 1 1952-2006, Baitboat 2 2007-2014, LL Japan EastMed 1960's-2009, LL Japan NEA1 1990-2009, LL Japan NEA2 2010-2015, Other LL 1950-2015, PS_Norway 1950-1981, PS_ EU (Croatia) 1990-2015, PS_EU (France and Spain) 1970-2015, PS Other 1951-2015, PS Inflated 1995-2006, Trap Morocco_EU (Spain) 1951-2011, Trap Morocco_EU (Portugal) 2012-2015, Trap Other 1951-2015, and Other 1951-2015). The SS3 model was fit to indices of abundance (SP_BB1 1952-2006, SP_BB2 2007-2014, JPN_LL_EastMed 1975-2009, JPN_LL1_NEA 1990-2009, JPN_LL2_NEA 2010-2015, MOR_SP_TP 1981-2011, MOR_POR_TP 2012-2015, WMED_LARV 2001-2015 with a gap in 2006-2011, FR_AER1 2001-2003, and FR_AER2 2009-2015 with a gap in 2013) assuming lognormal error with CV=0.4 for the larval and aerial surveys and CV=0.2 for all other indices. The SS3 model was fit to size frequency data 1951-2015 assuming multinomial distributions with a range of effective sample sizes, and age-length observations 1984-2015, fit to predicted length at age according to the growth parameters of Cort (1991) and assuming a CV of 0.1 at age-0, decreasing to CV=0.06 at age-25+.

Size-based selectivity was estimated as a spline for PS and BB, double-normal for LL, and logistic for Trap and Other. A Beverton-Holt stock-recruitment function was assumed, with fixed steepness (h=0.9), and annual recruitment deviations were estimated from 1951 to 2014. M was assumed to be 0.1 for age-20, scaled with Lorenzen function of growth. The spawning-at-age scenario for eastern stock was assumed (25% spawning at age-3, 50% spawning at age-4, 100% spawning at ages-5+). The base model (Run 60) included the conditional age at length data. An alternative configuration was tried with three selectivity periods for PS_ EU (France and Spain) (1950-1993, 1994-2006, 2007-2014), but it failed to converge unless conditional age at length data observations were removed from the likelihood.

Document SCRS/2017/182 applied the Statistical-Catch-at-Length (SCAL) methodology of Butterworth and Rademeyer (2017) to the catch, abundance index and proportions-at-length data available for the western and eastern North Atlantic bluefin tuna areas. Results were updated during the meeting in an attempt to be as comparable as possible to grouping of fisheries and selectivity blocking as specified (and re-specified) as the meeting progressed for the corresponding SS3 assessments. Specifying selectivity functions that provided satisfactory results which were reasonably compatible with the data proved challenging, particularly for the eastern area, as a result (in part) of the inconsistencies both within and between the abundances indices and catch-at-length information. For the western area, the SCAL results were broadly consistent with those for comparable runs of SS, particularly after about 1990, though they tended to show less variability in annual recruitment. This last result is unsurprising, as with only length information available, adjacent cohorts tend to be smeared together when their relative strengths are estimated. These SCAL analyses also indicated that the data were unlikely to be able to distinguish appreciably different assumptions concerning the spawner biomass-recruitment relationship. For the eastern area assessments, the agreement was not as close (and adequate convergence may not have been achieved in the time available), with the spawner biomass tending to be higher in absolute terms for SCAL compared to SS3, though the recruitment trends estimated by the two approaches were broadly similar.

These eastern analyses suggested to some that the data available may have insufficient information content to estimate biomass reliably in absolute terms.

Document SCRS/2017/153 presented ASAP runs for the West Atlantic, first run with the data from the 2014 stock assessment for ages 1 to 16plus from 1970 to 2013 (Run 4). Trends for SSB, recruitment and fishing mortality were similar to those estimated by the 2014 base VPA. Incorporating the new catch at age produced a different SSB trend when either the 2014 (Run 6) or the updated stock size indices (Run 7) were used (**Figure 13**). The new catch at age, weights at age and stock size indices were then used to extend the analyses to 1960 and 1950 (**Figure 14**, Runs 8 and 9). Extending to 1960 produced very high initial SSB with a declining trend overlapping the SSB estimates from the analysis starting in 1970. However, extending the analysis to 1950 (Run 9) produced substantially lower initial biomass that remained lower than in the other two analyses (Runs 7 and 8) until the late 1980s when SSB estimates were similar for those three analyses. While the runs starting in 1960 and in 1970 produced relatively high SSBs, the exploitable biomass (i.e. the total biomass times the selectivity) were very similar regardless of the starting year. The problem of high SSBs when starting in 1960 or 1970 was solved by setting Lambda =1 on initial numbers and using a low CV=0.1. This solution was first applied to East Atlantic and Mediterranean bluefin tuna and presented to the Group for comparison with the VPA results. The solution was later applied to western Atlantic bluefin tuna but there was insufficient time for the Group to consider the results.

The configuration for the East Atlantic and Mediterranean was similar to that for the West Atlantic: ages 1 to 16plus, catch at age for a single fleet 1950 to 2015, the same biological parameters as agreed at the 2017 bluefin tuna data preparatory meeting in 2017 for M and fraction spawning. Weights at age were from the ratio of total yield in mass to the total numbers caught. The same stock size indices as in the VPA were used. The fits to the stock indices were similar to those in the VPA, but those to the proportions at age could be improved with fine tuning of the selectivity blocks. The SSB trends with all the indices included were close to those of the VPA from the early 1980s onward and almost identical during 2007-2015. Following discussions of the influence of the larval index and the EU-France aerial survey on the overall results, a run was made without the larval index and one with both indices split in two periods. Both resulted in much lower SSBs with the lowest SSB estimates from the run where the two indices are split (**Figure 15**). Interestingly, while the larval index is an index of SSB, using it in the calibration produces, like in the VPA, a number of relatively strong year classes post 2003. Removing the larval index from the calibration considerably reduces the size of the year classes since 2003 (**Figure 16**).

A State Space assessment model (SAM) was used to better evaluate the impact of uncertainty on the stock assessment advice for the eastern Atlantic and Mediterranean Sea population (SCRS/2017/146). SAM uses the same datasets as the VPA, allows processes such as selectivity to evolve gradually over time, and has fewer parameters than full parametric statistical assessment models (such as SS, SCAL and ASAP). It separates process and measurement error, and quantities such as recruitment and fishing mortality are modelled as random effects, and the projection procedure is an integral part of the assessment rather than a separate procedure. SAM also allows a variety of validation procedures to be applied. The intention of using SAM was not to provide an alternative assessment to the VPA but to help identify the impact of uncertainty on the advice and to propose potential solutions that could be simulation tested using the MSE.

4.3.2 Mixing models: VPA-2Box overlap, population-of-origin VPAs

Input data from the most recent stock assessments of Atlantic bluefin tuna fisheries were revised to account for estimates of stock composition (SCRS/2017/174). Assessments of eastern and western fisheries were compared to assessments of eastern-origin and western-origin fish to evaluate the sensitivity of results to stock mixing, as well as to demonstrate a practical approach to operational assessments to account for stock mixing. Estimates of stock size and fishing mortality from the VPAs of both eastern- and western-origin Atlantic bluefin were generally similar to the 2014 ICCAT estimates based on eastern and western Atlantic mixed-stock fisheries, but the western VPA estimates were more sensitive to the assumption of no stock mixing than the eastern VPA. The analysis was revised to apply all available data on stock composition.

Document SCRS/2017/177 developed a simulation model to represent the spatial dynamics of Atlantic bluefin tuna and to test the performance of alternative stock assessment models. A simulation framework previously developed to explore how stock mixing affects the resource and fisheries was conditioned on the available information for Atlantic bluefin tuna and used to generate pseudo data with the same properties as the information available for stock assessment. The analytical framework was a stochastic, age-structured, stock-overlap model that was seasonally and spatially explicit with movement of eastern- and western-origin tuna informed by fishery-independent telemetry information. The operating model was conditioned with 1970 abundance at age, 1970-2013 age-1 abundance, and fishing mortality at age from the 2014 ICCAT stock assessments, which were modified to reflect decisions from the 2017 data preparatory meeting.

Document SCRS/2017/178 simulation tested the performance of VPAs for assessing mixed Atlantic bluefin tuna stocks. Pseudo-data with the typical patterns, quantity, and quality of data available for the most recent stock assessment of Atlantic bluefin tuna were generated using the operating model framework described in SCRS/2017/177. Separate eastern and western stocks were assessed using VPA-2BOX as the estimation model, and model performance was assessed by comparing results across simulations and to the stock and population views of the operating model. The estimation model was sensitive to process error (i.e., stock mixing) and measurement error, biasing estimates of spawning stock biomass, recruitment, and apical fishing mortality. The results suggest that separate virtual population analyses of eastern and western stocks accurately reflect general stock and population trends, but absolute estimates are considerably biased and may provide misleading management advice if the simulations are realistic. The operating model and estimation models will be revised to reflect decisions made at the 2017 ICCAT Atlantic bluefin tuna stock assessment session.

Analyses were also conducted during the meeting that examined the eastern and western populations simultaneously using the two-stock overlap model in VPA-2BOX following the methods described in Porch *et al.* 2001 and the 2008 ICCAT bluefin tuna stock assessment report (Anon. 2009). The approach assumes the two stocks overlap in time and space, but that the degree of overlap (proportion of the stock that moves from one area to the other) is constant in time and space. The boundary between the two areas was assumed to be 45°W. The overlap VPA was run using the eastern base case VPA (but removing the years 1968-1973) and a version of the western base case adapted to age 10+ (the overlap model requires the same years and age range). Preliminary runs used either the stock composition data (discussed above) or conventional tagging data to estimate the mixing rates. Future runs will also use the electronic tagging data, but this could not be done during the workshop because information indicating whether or not the tagged fish had been caught by the fishery had not yet been included in the database available at the workshop.

5. Stock status results

As discussed in section 4 (Methods), stock assessments were conducted for the eastern and western stocks separately (without mixing) using five different frameworks: VPA-2BOX, Stock Synthesis 3, ASAP 3, SAM and SCAL. In addition, two methods were used to examine the possible effects of stock mixing (based on applications of VPA-2BOX). Only the single-stock VPA and, in the case of the western stock, Stock Synthesis, were deemed sufficiently advanced at the conclusion of the meeting to be considered as the basis of management advice. Moreover, the Group requested several additional analyses to be presented during the forthcoming Species Group meeting in 27-29 September 2017. including an analysis explaining the reasons for differences between the VPA and SS3 results for the western stock (SCRS/2017/186), a detailed analysis of the catch at length and composition data from the different models to check for evidence of the recent high recruitments estimated for the eastern stock (SCRS/2017/187), updates on the analysis of bluefin tuna stock mixing (SCRS/2017/188, SCRS/2017/190) and a non-technical summary of major changes between the "synthesis" of the advice of the 2014 and 2017 stock assessment. Accordingly, the Group elected to defer the development of management recommendations to the Species Group meeting.

5.1 Stock status – East

The results from five stock assessment platforms were presented during the course of the meeting (VPA, Stock Synthesis, ASAP, SCAL and SAM). Of these, only the VPA was considered sufficiently advanced at the conclusion of the meeting to be considered as the primary basis for management advice for the eastern stock. Nevertheless, the Group expressed considerable concern over the reliability of the VPA given its assumption that catch-at-age is known exactly when in fact the size composition of many eastern Atlantic and Mediterranean fleets is poorly characterized for a number of years before the implementation of stereo video camera in 2014. Accordingly, the Group recommended considering the four other models (SS, ASAP, SCAL, and SAM) when developing the scientific advice at the September Species Group meeting.

5.1.1 VPA

VPA Diagnostics

The model diagnostics were examined. The fits to the available CPUE indices show some variance around the model predicted values; however strong temporal trends in the residuals were not observed (**Figure 17**). The retrospective analysis for the VPA was conducted back to 2010 (**Figure 18**). There is a high degree of retrospective inconsistency in recruitment estimates whereby the absolute levels of recruitment change substantially with the addition or removal of a single year of data. This inconsistency is most pronounced with the addition of the 2015 data where the 2004-2007 cohorts are now estimated to be equal to and often higher than the 2003 cohort.

The "jackknife" sensitivity analyses (removing one index of abundance at a time) showed generally similar trends, with some variations in recruitment, SSB and F of older fish (**Figure 19**). Estimates of SSB and F10+ for the years 1990-2009 were most sensitive to the removal of the Japanese longline CPUE for the East Atlantic and Mediterranean, Japanese longline CPUE in the northeast Atlantic, and the combined Morocco_EU (Spain) trap CPUE, because they are longer time series that target larger fish. The recent SSB trend became less optimistic without the larval survey index, and more optimistic without the Japanese longline CPUE in the East Atlantic and Mediterranean or the historical EU (Spain) baitboat CPUE.

VPA Results

The VPA base case results, which start in 1968, estimate that SSB peaked at about 350,000 t in the mid-1970s after increasing initially, followed by a decline to 170,000 t in 1991 and remained at around that value up to the mid-2000s. From the late 2000s, SSB exhibits a substantial increase up to 610,000 t in 2015 (**Figure 20**). A similarly strong increase was also estimated in the 2014 assessment; SSBs in 2013 were 650,000 t and 510,000 t in the 2014 and 2017 assessments, respectively. However, as in the 2014 assessment, there is uncertainty about the amplitude of the recent SSB increase estimated by the VPA as indicated by the results shown in **Figure 19**.

Recruitment (age 1) varied between 0.8 and 1.8 million fish until the 1980s, followed by a steady increase towards "high recruitment period" in the mid-1990s and mid-2000s when recruitment fluctuates at around 3 million to 4.5 million. It sharply decreased shortly from 2008 to 2010, but again increased sharply to over 4 million in 2012. Note that the last three year classes (2013-2015) were not shown because VPA generally does not provide reliable estimates of recent recruitment due to limited information about incoming year class strength and uncertainties in the indicators used to track recruitment. The 2014 assessment estimated extraordinarily large year classes in 2004-2007, the plausibility of which was questioned because they were much larger than the estimate for the 2003 year class. In the current assessment, the estimates for the 2004-2007 year-classes are still very large, but more comparable to the estimate for 2003. Nonetheless concern remains owing to the high degree of inconsistency observed in retrospective estimates of recruitment, suggesting that there are conflicting signals in the data as to the absolute magnitude of recent recruitment. In particular, the model estimates very high 2004-2007 year classes when the 2015 data are included that are not evident in earlier retrospectives. As these recruitments form much of the basis for the very high estimates of current SSB, the results from the VPA should continue to be interpreted with caution.

The estimated fishing mortality rates on the younger ages (i.e., average F for ages 2 to 5) displayed a continuous increase until the late 1990s and then showed a sharp decline to reach very low levels after the late 2000s (**Figure 20**). This result was not surprising because the reported catches at ages 2 to 3 have been reduced dramatically (i.e., being about 10% or less of what they were prior to 2007) in the recent years in response to the new minimum size regulations implemented in 2007. The trend of F in young ages was similar to that in the 2014 assessment. The fishing mortality for older fish (i.e. F at plus group for ages 10 and older) in the base case run showed an initial decline from 1968 to 1973, and slightly fluctuated around 0.06 afterwards. It sharply increased in 1994 and continued increasing up to 2007 (F10+=0.55). This period (from the mid-1990s to the mid-2000s) observed the highest level on fishing mortality of larger fish. Since 2008, there is a rapid decrease in F10+, as already noted in the previous assessments, which related to the regulation, i.e. the drastic reduction of TAC. The trend of F for large fish was similar to that in the 2014 assessment, though the value was generally higher in the 2017 assessment.

The Group also evaluated the results of a sensitivity analysis to the data and parameters used to examine some potential effects of structural uncertainties unaccounted in the base case (**Figure 21**). Changing the F-ratios led to a different perception of the stock status, a result which has been also reported in the previous assessments. In general, all the sensitivity runs resulted in a similar trend to the base case with increasing SSB in recent years, but the rate and amplitude of the increase in SSB remain sensitive to technical assumptions, such as the F-ratios and natural mortality for older ages. The estimated SSB for the last year ranged between 500,000 and 900,000 t. The case of M equal to 0.07 for the plus group showed more pessimistic results with high Fs, low recruitment and low SSB. The run that estimates F-ratio using a random walk without splitting the EU-France aerial survey series was most optimistic, leading to the highest final year SSB.

5.1.2 Other models

VPA results were compared to those from other assessment models, including Stock Synthesis 3 (SS3), ASAP, and SCAL (**Figure 22**). The SSB trend and its values since the mid-1980s were generally similar between ASAP and VPA, although ASAP did not show the peak in the mid-1970s estimated by VPA. SSB estimated by ASAP decreased from 450,000 t in 1950 to 210,000 t in 1970, then slightly increased to 250,000 t in the early 1980s followed by a slow decrease to 160,000 t in 2004. SSB showed a sharp increase since 2007 to 660,000 t in 2015. The values of SSB estimated by SS3 were lower than the others, and the trends were not similar except the recent increase since 2007. The SSB estimates from SS3 started at 470,000 t in 1950, decreased to 65,000 t in 1968, and remained at around 100,000 t until the mid-2000s with a slight increase to 150,000 t in the late 1990s. Similar to the other models, SS3 estimated SSB to increase from 110,000 t in 2005 to 240,000 t in 2015.

SSB estimated by an initial application of SCAL was the largest among the model results; SSB started at 170,000 t in 1950 and kept increasing with small fluctuation up to 2015 of 910,000 t. Across all the models, an increase of SSB since 2007 was commonly observed, however, the rate and amplitude were different among models.

In the comparison of estimated recruitment among models, it was a common feature that they were generally lower by the mid-1980s and higher afterwards (**Figure 23**). Recruitment estimates from SCAL were higher than other models before the mid-1980s, but similar to the other models thereafter. SS3 showed spikes in 1994 and 2004 for age 1, while SCAL showed spikes in 2003 and 2004. In the context that the 2003 year class has been considered to be a strong year class, SS3 and SCAL catch the feature well, whereas VPA and ASAP also catch the feature but are shown as moderate multiple peaks. These differences are considered mainly due to the differences on how to convert catch-at-size to catch-at-age. VPA and ASAP use the same catch-at-age data which relied on the cohort slicing with the substitution rules for missing data. SS3 and SCAL are more flexible than VPA in fitting to the actual size data and set fleet groups which do not require the complex substitution rules used for VPA. Recruitments after 2010 were variable, probably due to the low reliability of recruitment estimates in recent years mentioned above, especially since there was not enough information for younger ages as the catches were gradually shifted to larger fish due to the regulations and the nature of the fishery.

The Group discussed the appropriateness of using the results of the VPA base case to establish the status of the eastern bluefin tuna stock. Even with the incorporation of substantial revisions to historical fishery data, new fishery-independent series of relative abundance, and new information on life history, the VPA results still demonstrated substantial instability as indicated by retrospective and jackknife analyses. This was considered mainly due to continued poor quality of catch and size data, particularly in the past, and the general problem of aging using the cohort slicing method. Several cohorts may be included in one "slice" of cohorts in older ages. The Group sought to use an age-length key method instead, but the proposed approaches experienced difficulties due to the data sparsity. The statistical catch-at-length models, such as SS3 and SCAL, showed very different results particularly for the absolute value of biomass. However, the Group felt the settings for those models needed further work and therefore that the results from them were not more reliable than those of the VPA. Given the uncertainty in estimated biomass, the Group considered it was not advisable to use the biomass-related results to evaluate the current status of the stock and recommended not to include a Kobe plot in the Executive Summary. Moreover, the Group considered that catch advice based on $F_{0.1}$ would be more robust than if based on F_{MSY}, which is more dependent on assumptions regarding recruitment. It was noted that the current TAC corresponds to the long term yield under $F_{0.1}$ based on the low recruitment scenario (19,410 t).

5.1.3 Summary

This section summarizes the results from the analyses described in Sections 5.1.1 and 5.1.2. The input and output files for the base VPA (Run 24) are included as **Appendix 6b** (not included in this Report). The input and output files for the SS3 model were too voluminous to include in an appendix and can be obtained upon request from the ICCAT Secretariat. The output files contain a complete description of the results, including the matrices of estimated fishing mortality rates, abundance-at-age, stock biomass, recruitment, fits to indices, and estimated selectivities.

5.2 Stock status – West

Two stock assessment platforms (VPA and Stock Synthesis, detailed in section 4.2) were considered sufficiently advanced at the conclusion of the meeting to be considered as the basis of management advice for the western stock. In addition, two other models (ASAP and SCAL, detailed in section 4.3) were presented that provided useful insights.

5.2.1 VPA

VPA Diagnostics

The fits to the indices of abundance for the base VPA were generally improved in comparison to previous assessments (**Figure 24**). The improvement was mostly due to the exclusion of the CAN_Combined_RR and US_RR>177 CPUE indices, which showed conflicting trends for roughly the same age ranges that could not be reconciled by the VPA model. As discussed in section 4.2, the two indices were removed from the base model because the conflicting signals were deemed to be largely a reflection of a perceived northward shift in the abundance of large bluefin tuna (making them less available to the U.S. rod and reel fishery and more available to Canadian fisheries). Including the two indices also resulted in significant temporal trends in the residual patterns for these and other indices, which degraded model performance.

Bootstrapped estimates of 2015 spawning biomass and current apical fishing relative to $F_{0.1}$ suggested relatively little bias in the new base VPA (the median of the bootstraps was close to the point estimates, **Figure 25**). A retrospective analysis was also conducted for the base run by sequentially removing inputs of catch and abundance indices in annual increments back to 2010 (**Figure 26**). The long-term trend in estimated SSB was not highly sensitive to the retrospective removal of data owing to the fixed F-ratios. However, the SSB for the most recent years systematically increased as data were sequentially removed, suggesting the model may have a tendency to overestimate recent SSB. The estimated recruitment was less sensitive to the retrospective removal of data and showed little evidence of a consistent bias except that the addition of more years tended to mute the signal of the 2003 recruitment, probably as a result of the smearing of cohorts that tends to occur as a consequence of the slicing method for converting size to age. The estimates of fishing mortality rate similarly show little retrospective pattern except for the two oldest ages (**Figure 27**), which under the high spawning faction scenario contribute most to SSB.

The results of a 'jack-knife' sensitivity analyses, in which indices were removed from the base model one at a time, are summarized in **Figure 28.** In most cases the results were relatively insensitive to removing a single index. The exceptions were removal of the larval survey, which caused the model to estimate substantially higher SSB in recent years relative to the base, and removal of the US_RR>145 CPUE, which caused the model to estimate substantially lower SSB in recent years with little change since 1980. The estimates for the early years until 1980 were nearly identical among all runs because the F-ratio was fixed and the only flexibility the VPA has to respond to the changing information is in the terminal year fishing mortality rates for ages 1 to 15. Thus, only the most recent 15 cohorts are directly affected and earlier cohorts are indirectly affected to a decreasing extent with time.

VPA results

The 2017 base model results are consistent with previous analyses in that the SSB was estimated to decline sharply between 1974 and 1985, level off through the 1990s, and then begin increasing over the last decade (**Figure 29**). The estimates of recruitment (age 1) fall sharply after 1975 and then fluctuate around a lower level with little trend except for a relatively strong year-class in 2003 and exceptionally weak year classes in 2010 and 2011. The estimated apical fishing mortality rate was very high during the 1970s, but decreased substantially during the following decade when catch limits were imposed (**Figure 30**). Estimated fishing mortality rates fluctuated around 0.2 for the period from 1984 to 2005, with an observed decline since 2006. Until very recently (2012-2015), fishing mortality rates have exceeded $F_{0.1}$ substantially.

The recruitment estimates from the 2017 base VPA were generally higher than for the 2014 base and 2017 continuity run (set up as closely as possible to the 2014 base VPA). The trends in the estimated age 9+ biomass (the proxy for spawning biomass in previous assessments) were similar from 1974 to the mid-1990s, but diverged for more recent years (**Figure 31**). In general, the 2017 base model estimated a more rapid increase in SSB over the last decade compared to the previous assessment.

Sensitivity analyses were conducted to evaluate the robustness of the base case model to several key uncertainties: the use of the two large fish CPUE indices (CAN_Combined_RR and US_RR>177), a lower natural mortality rate (0.07 on the oldest age rather than 0.1), and equally weighting the indices (rather than the additional variance approach). Reducing the natural mortality rate resulted in lower estimates of recruitment and spawning biomass, but did not change the relative trends (**Figure 32).** Including the two large fish indices resulted in slightly larger recruitment estimates and a more rapid increase in estimated SSB since about 1985. Equally weighting all indices had relatively little effect, largely because the two conflicting indices (CAN_Combined_RR and US_RR>177) had been removed. Estimates of cohort strength and year class varied somewhat when an age-length key was applied to the recent years, but did not substantially alter the overall trend in SSB estimates. The Group was informed of an unquantified systematic error in the aging of younger fish, and therefore did not recommend using the age-length keys until the bias could be corrected. Use of the 'younger' spawning fraction ogive (i.e., assuming fish as young as age 3 contribute to SSB) increased the magnitude of SSB in comparison to the older spawning fraction ogive, but does not greatly change the rate of SSB increase in recent years (**Figure 33**). The sensitivity of the western assessment to stock mixing was also examined and is discussed in Section 5.3.

The Group noted that previous stock assessments determined stock status based on MSY-related benchmarks that were predicated on two alternative measures of long-term recruitment potential: a 'low recruitment' scenario based on recruitment levels estimated since 1975 and a 'high recruitment' scenario based on a Beverton and Holt spawner-recruit function fit to the SSB and recruitment estimates for all years (i.e., since 1970). Inasmuch as the size data prior to 1974 were deemed too unreliable to use in the 2017 VPA assessment, there are no longer enough data from the early period of the fishery to provide sufficient contrast for estimating the steepness of the Beverton-Holt curve. Accordingly, the Group could no longer bracket the range of possible MSY-based reference points from the VPA results and elected to focus on giving short-term advice based on $F_{0.1}$ (the fishing mortality rate corresponding to 10% of the slope of the yield per recruit curve at the origin) and a range of short-term assumptions about recruitment (see section 6.2 on projections).

5.2.2 Stock synthesis

Stock Synthesis Diagnostics

The fits to the indices of abundance for the base SS3 model were comparable to those of the VPA (**Figure 34**). In contrast to the VPA, CAN_Combined_RR and US_RR>177 CPUE indices were not excluded. Instead the respective scaling coefficients for the two CPUE indices and CAN_GSL_acoustic survey were linked to an index of the AMO (as discussed in section 4.2). This approach effectively reconciled the conflicting signals from the three indices consistent with the perception of a general northward shift in the abundance of large bluefin tuna (making them less available to the U.S. rod and reel fishery and more available to Canadian fisheries). Estimates of the coefficients for the effect of the AMO on CAN_Combined_RR, CAN_GSL_Acoustic and US_RR>177 indices were, respectively, 2.0, 0.88, and -0.83, indicating strong positive relationships for the Canadian indices and negative relationships for the US index. Estimated selectivities (**Figure 35**) were taken to be asymptotic for several major fleets and dome-shaped for the Japan longline. Fits to the length composition overall years (**Figure 36**) indicate relatively good fit to the composition data.

A retrospective analysis was conducted for the base run by sequentially removing inputs of catch, size/age composition and abundance indices in annual increments, back to 2010 (**Figure 37**). The long-term trend in estimated SSB was not highly sensitive to the retrospective removal of data. The estimated recruitment was also not sensitive to the retrospective removal of data and showed little pattern or evidence of a consistent bias. However, inclusion of the most recent ageing data increased the signal of the 2003 recruitment and decreased the signal of the 2002 recruitment compared to the retrospective model runs. This was likely a result of the additional years of age length data that informs upon the magnitude of the 2003 cohort.

The results of a 'jack-knife' sensitivity analyses, in which indices were removed from the base model one at a time, are summarized in **Figure 38.** Estimates for the early years prior to 1980 were nearly identical among all runs indicating little sensitivity of the model key scaling parameters to index inclusion. The results for more recent years were also relatively insensitive to removing a single index, with a few exceptions. Removal of the larval survey caused the model to estimate substantially higher SSB in recent years relative to the base. The model was also sensitive to the removal of either the CAN_Combined_RR index (lower biomass) or the US_RR>177 index (higher biomass) even with the environmental modulator (AMO index) on catchability (although not so sensitive as the VPA, which did not use the AMO index).

Stock Synthesis results

The base SS3 models with the older and younger ages of spawning are compared in **Figure 39**. The estimated total biomass and SSB showed a decline starting in 1965 that continues into the 1980s. Fishing mortality on older ages (10-20) was lower than $F_{0.1}$ but above F_{MSY} during this period of steep decline. However F on younger ages was quite high, resulting in the estimated declines. As for the VPA, the assumed age at spawning has little impact on the results except for the calculation of SSB itself, in which case assuming a lower age at spawning implies a higher total SSB (but with similar trends to the run with a higher age at spawning).

In contrast to the VPA, the SS3 model brings a longer term historical perspective to the assessment (back to 1950) and, when a Beverton-Holt spawner-recruit relationship is assumed (**Figure 40**), estimates steepness at 0.47 with the younger age of spawning and 0.55 with the older age of spawning. These estimates of steepness are similar to that estimated from the 2014 base VPA (0.58, Anon., 2015) and statistically preferred to 1.0

(based on AIC). Interestingly, the longer term historical view of the SS3 models is more consistent with the notion that recruitment declined after the 1970s due to a decline in SSB (**Figure 41**) than is the shorter term view afforded by the VPA, which appears to suggest that recruitment declined before the SSB. As in previous assessments, the perceived status of the stock differs dramatically when future recruitment is assumed to remain at recent (low) levels or assumed to follow the estimated Beverton-Holt relationship (see section 6.2).

A comparison of the various sensitivity runs to the base SS3 models is presented in **Figures 42** and **43**. A total of 11 sensitivity runs were conducted, many of which were simple additions to the models to improve fit or to account for necessary fleet structural changes or data inputs. The overall trends were similar for all runs, but some of them differ in scale. Use of the aging bias vector (run 7) sharpens the estimate of the 2003 cohort rather than blurring it between 2002 and 2003. Use of the AMO environmental index to scale potential changes in the availability of bluefin tuna to the CAN_Combined_RR fishery, CAN_GSL_ Acoustic survey and US_RR>177 fishery indices (run 8) has the effect of reducing the conflict in the three indices and slightly reduces recent SSB (**Figure 43**). Models with the greatest divergence were the low M=0.07 run and the model with no stock recruitment relationship imposed (**Figure 43**). Changing the weight-length relationship from previous assessments to the new relationship accepted by the SCRS (Rodriguez-Marin *et al.*, 2016) had a relatively minor effect (**Figure 43**).

5.2.3 Summary

The SS3 and VPA runs show relatively consistent patterns in that the SSB was estimated to decline between 1970 and 1985, level off through the 1990s, and then begin increasing over the last decade (**Figure 44**). However, the SS3 runs estimate higher SSB levels throughout most of the time series and especially for the period prior to the 1980s. Both models suggest the fishing mortality rate was very high during the 1970s, but decreased substantially during the following decade when catch limits were imposed (**Figure 45**). Both models estimate that the fishing mortality rates on age 10 and older fish have fluctuated around an average of 0.12-0.14 yr^{-1} since the 1980s with a marked decline after 2003, although the VPA estimates higher mortality rates during the late 1970s than does SS. The estimates of recruitment (age 1) fall sharply after 1975, and showed less annual fluctuation since that period. Relatively strong year-classes were estimated for 1988 and 2003, similar to results from previous assessments (e.g. 2012). SS3 diverges from the VPA in estimating a very strong 1994 cohort and a larger 2003 cohort (**Figure 44**). Previous VPA assessments have noted the appearance of 1994 as a strong cohort that eventually diminishes in subsequent VPAs. While SS3 and the VPA had similar absolute recruitment levels, the VPA has lower variability and then higher levels of F which result in lower levels of spawning biomass.

It was noted that, technically speaking, estimates of the steepness and the variance in recruitment about the predicted curve are not necessarily comparable in modeling frameworks such as VPA and SS3. However, the level of bias is unclear, and the Group postponed further discussion of how to use the results for management advice until the Species Group meeting in September 2017. It also became apparent during the meeting that the allotted time was insufficient to examine the SS results with the same level of scrutiny given to the VPA, or to determine the causes for the differences between the two frameworks. Nonetheless, the SS3 model provided an historical perspective that the VPA does not, and the Group considered it potentially of use to develop management advice. The Group recommended that the analytical team compare the WBFT SS3 and VPA results to determine the reason for differences and document them in an SCRS paper to be presented to the bluefin Species Group meeting in September (SCRS/2017/186).

5.2.4 Other models

The results of the base VPA and SS3 models are compared with the alternative stock assessment models presented at the assessment workshop (ASAP and SCAL) in **Figure 46** (older spawning) and **Figure 47** (younger spawning). The estimates of age 1 recruitment were similar across the 4 models with the exception of the years prior to 1960, for which the recruitments are not well-determined in any of the models. The ASAP model estimated somewhat higher recruitments after 1990 than were estimated by the other models, but otherwise the trends were similar. All models estimated generally higher recruitment levels in the 1960s and early 1970s than in subsequent years. They also consistently estimated relatively strong year classes in 1994 and 2003, followed by weaker year classes that are among the lowest in the time series. The estimates of SSB were similar in magnitude and trend for SCAL and SS3, showing a marked decline beginning in the 1960s that levels off around 1990 and increases again after about 2003. The trends estimated by the VPA suggest a less dramatic decline from 1974 to 1990 than is indicated by SCAL and SS3, but similar trends after 1990. The ASAP model, in contrast, estimates a much more moderate decline in SSB during the 1960s and 1970s than the other models do, and a more rapid increase in recent years to the highest levels in history.

5.3 Stock status –VPA with mixing between the eastern and western stocks

Two types of mixing analyses were presented to the Group. The first analysis (Cadrin *et al.*, 2017) deterministically assigned catch of eastern and western fisheries to population of origin using stock composition samples (see section 3.6). Estimates of stock size and fishing mortality from VPAs of eastern-origin and western-origin bluefin tuna were generally similar to the 2014 ICCAT estimates based on eastern and western Atlantic mixed-stock fisheries, but the western VPA estimates were more sensitive to the assumption of no stock mixing than the eastern VPA. Essentially, this approach assumes the ratio of eastern and western fish was constant during much of the historical period (implying that both the degree of overlap and relative abundance of the two stocks is constant, or else that the degree of overlap changes to exactly balance changes in relative stock abundance). The Group recommended that the population of origin VPAs to be updated through 2015, revised to apply 2017 base case VPA settings, and to apply time-varying estimates of stock composition for periods when adequate samples are available. This analysis will be included in a SCRS paper to be presented to the bluefin Species Group meeting in September (SCRS/2017/190).

The second analysis conducted during the meeting assumed the eastern and western populations overlap in time and space, but that the degree of overlap (proportion of the stock that moves from one area to the other) is constant in time and space. While in fact the degree of overlap may change through time, it is arguably a less restrictive assumption than the aforementioned approach. Preliminary analyses suggested that the estimates of the fraction of the eastern-origin population that sojourns in the west (eastern overlap) depended strongly on the type of data used (**Figure 48**). The tagging data suggested the overlap was very low for all age groups, whilst fitting to the proportion data suggested overlap rates of 0.5 percent for ages 1-3, over 1.5 percent for ages 4-9, and 0.01 percent for age 10+. The estimated overlap of western-origin fish into the eastern management zone was even more sensitive. Fitting to the tagging data produced estimates on the order of 15 percent for ages 1-3, but negligible for older ages. Fitting to the proportion data on the other hand produced estimates of very high overlap for ages 1-3 (over 50%) and 30% for ages 10+. The estimated trends in spawning biomass for both the east and the west were relatively insensitive to the use of the tagging data, except the rate of increase of the eastern stock was subdued somewhat compared to the runs without mixing or tagging data (**Figure 49**). On the other hand, the estimates of spawning biomass were very different when stock composition data were used. The trends for the western stock were similar to the runs without mixing, but the absolute abundance was lower and a slight downturn was estimated in the most recent years. The trends for the eastern stock suggest that, while the SSB has increased rapidly in recent years, it is not as dramatic as estimated by the runs with no mixing or using the tagging data, and is still below the levels estimated for the 1970s. Essentially, the model cannot reconcile the historic high eastern biomass levels estimated by the no mixing/tagging models with the relatively flatter indices in the western Atlantic and still fit the stock composition data.

In summary, the stock composition data were more informative than the conventional tagging data regarding stock status and perceptions of the degree of overlap of each population. However, it should be kept in mind that both data sets are incomplete in the sense that they do not represent random samples of the overall population. The Group noted that there was insufficient time to fully develop these mixing analyses during the course of the meeting and recommended that the authors refine their analyses and present them in the form of an SCRS document (SCRS/2017/188) to the Species Group meeting in September.

6. Projections

6.1 Review of the Rebuilding Plans for the Atlantic bluefin tuna and 2016 SCRS advice

The Group did not have the time to discuss this Agenda item.

6.2 Projections – East

6.2.1 Methods

VPA

Projections were carried out using the software PRO-2BOX (Porch, 2017) based on the VPA estimates for the base case. When projecting it is necessary to specify, biological parameters, selectivity patterns (including any modifications due to management measures that may be implemented), recruitment, and any modifications that may be made to circumvent the poorly estimated numbers-at-age for recent year classes from the VPA. The projections were investigated similarly as was done in 2014, i.e. three similar recruitment options (high recruitment being calculated over the 1990-2010 years, the medium one over the 1968-2010 years and the low one over the 1968-1980 years), but only one selectivity pattern was used over 2012-2014. Compared to the last assessment, the selectivity pattern was believed to be stabilized and therefore no further assumption was needed.

Biological parameters were identical to those used in the VPA. Natural mortality and proportion spawning varied by age, but were time invariant. Weights-at-age in the projections were derived from the average weights-at-age for ages 1 to 9 and the growth curve for the plus group (which allows changes in the mean weight of the plus group according to changes in the age composition due to the rebuilding/decline of the SSB). Since the most recent year-classes in VPA numbers-at-age tend to be poorly estimated, especially for the younger ages, the recruitment estimates for the 5 most recent year classes (2010, 2011, 2012, 2013, and 2015) were replaced with a random value from the stochastic recruitment specifications. These values were then projected forward in time accounting for the observed catches and the assumed natural mortality at age. This results in changes to both the number at age in 2016 (i.e. the first projection year) and the fishing mortality-at-age for the replaced 5 year-classes.

Kobe stock-status plots (quantifying the probability of the stock being in each of the four quadrants) were developed for the year 2016 from the bootstrapped VPA output under each of the three recruitment scenarios. Projections for future years assume the catch limits for 2016 (19,296t) and 2017 (23,655 t) were exactly met and then for subsequent years assume constant catch levels ranging from 0-50,000 t or one of two fishing mortality rates ($F_{current}$ and $F_{0.1}$). Current F ($F_{current}$) is computed as the apical geometric mean of fishing mortality at age over the last three years.

Stock Synthesis

For comparison, projections were also made using SS3 run 60 for the eastern stock, using the conditional catch at age and assuming future recruitment followed a Beverton-Holt stock-recruit function estimated within the model. For all scenarios, fixed catches were assumed for 2016 (19,296 t) and 2017 (23,655 t), based upon the catch limits for those years. Different fixed catch and F level scenarios were then projected for 2018 through 2026. The projected fixed catch levels ranged from 20,000 to 35,000 tons. The F based projections included the average F estimated by the model for 2012-2014, $F_{0.1}$ and 80% of F_{MSY}.

6.2.2 Results

VPA

The Kobe phase plots of 2016 stock status, based on $F_{0.1}$ and $SSB_{0.1}$, under the 3 different recruitment scenarios are shown in **Figure 50.** A Kobe pie chart was also constructed to show the proportion of bootstraps that lay in each coloured quadrant of the phase plot (**Figure 51**). The results suggest the stock is unlikely to be undergoing overfishing and, if the low or medium recruitment scenarios are correct, that the stock may have already recovered. If the high recruitment scenario is correct, the stock could still be overfished. If future catches are maintained near the 2017 TAC (23, 655 t), the stock is projected to have a greater than 60% chance of recovering by 2018 (and remaining so through 2025) under all three recruitment scenarios (**Table 10**). Current estimates also indicate that the rebuilding could be achieved by 2022 with catch limits up to 30,000 t with higher 60% probabilities for the 3 recruitment scenarios (**Figure 52**). The Group, however, reiterates that it has little confidence in the Kobe 2 matrices because of the poor fits of the VPA (see above) as well as unquantified uncertainties in the projections (especially future recruitment levels, current and future selectivity patterns).

Stock Synthesis

Results of the Stock Synthesis deterministic projections are shown in **Figure 53** and compared to reference levels of 40% B_0, and SSB_{MSY} as derived from the models. Model projections with catch levels are shown in **Table 11** and observed SSB levels are shown in **Table 12**. The results suggest the stock will not be rebuilt by 2022 unless the catch limit is less than 20,000 t.

6.3 Projections – West

6.3.1 Methods

VPA

The projections for the western stock were made using the software PRO-2BOX (Porch 2017) based on the bootstrap replicates of the fishing mortality-at-age and numbers-at-age matrices produced by the VPA-2BOX software. Short-term catch projections were computed based on 3 levels of future recruitment: the geometric mean of estimated recruitments for the periods 2010-2012, 2007-2012, and 2003-2012. Future recruitment was allowed to deviate stochastically from the geometric mean as a first-order multiplicative (lognormal) auto-correlated process. The standard deviation (sigmaR) and autocorrelation parameter (Rho) were estimated on a bootstrap by bootstrap basis. Recruitment estimates from the VPA for recent years, 2013 to 2015, were replaced with the geometric mean level of recruitment (calculated independently for each bootstrap).

Short-term catch projections were estimated based on two reference points: $F_{current}$ (apical geometric mean of fishing mortality at age over the last three years) and $F_{0.1}$. As for the eastern stock, the reference point $F_{0.1}$ was considered appropriate because the stock-recruitment relationship is unknown and estimates from the VPA were uninformative in terms of absolute biomass scaling owing to the removal of the early time series prior to 1974 when SSB and recruitment were expected to be higher. It should be noted that $F_{0.1}$ is calculated independent of any underlying stock recruitment relationship, and that in some cases $F_{0.1}$ can exceed F_{MSY} because of stock-recruitment relationship effects.

Stock Synthesis

Deterministic projections were conducted in SS3 during the course of the meeting (stochastic projections will be conducted intersessionally and presented to the Species Group in September). Recruitment projections were conducted for the years 2015-2021 as 2015 recruitment was not estimated in the model. Projections were conducted for four recruitment scenarios and two spawning scenarios. The first recruitment scenario assumed a Beverton-Holt stock-recruitment relationship with steepness = 0.55 (older spawning) or 0.47 (younger spawning) and sigmaR = 0.73 (older spawning) or 0.69 (younger spawning). The other three recruitment scenarios assume constant recruitment equal to the geometric mean recruitment (1000s age 0) over three periods:

3 years	2010-2012	117.3	118.9
6 years	2007-2012	127.9	129.5
10 years	2003-2012	165.9	167.1

To implement this in SS3, the recruitment deviations were adjusted to achieve recruitment approximately equal to the geometric mean for the three time periods using the SSB in 2015. These recruitment deviations were then input as forecast deviations. This input constant recruitment deviations, however the resulting recruitment was close to but not exactly the geometric mean recruitment.

Ten fixed catch limits (1000, 1250, 1500, 1750, 2000, 2250, 2500, 3000, 3250, and 3500 t) and two fishing mortality rates ($F_{0.1}$, F_{MSY}) were projected. The value of $F_{0.1}$ was obtained from the yield per recruit curve (**Figure 54**). The value of F_{MSY} was projected assuming deterministic recruitment provided by the stock-recruitment relationship. The resulting benchmark reference points are shown in **Table 13**.

Selection patterns and relative fishing mortality patterns are the average of 2006-2009 (pre-change in Japan longline selectivity). Preliminary reported catches were assumed for 2016 for each fleet in the model (total= 1,912 t) and the catch limit (2,000 t) was assumed to have been met in 2017 (allocated according to 2016 proportions across fleets). Yields from 2018-2021 were then calculated or fixed accordingly. Projections were then conducted for 2016-2021.

6.3.2 Results

VPA

The following results differ somewhat from those presented to the Group during the meeting, which were completed on the last day of the meeting and based on only a few bootstrap replicated. They should be considered preliminary until they are reviewed by the Group at the September Species Group meeting (as is noted earlier in the report under section 5).

Three alternative scenarios for future recruitment were projected to assess the effect on projected yield through the year 2022. The projected recruitments were the geometric mean recruitment over three recent periods prior to 2013, the prior three years (2010-2012), prior six years (2006-2012), and prior 10 years (2003-2012) (**Figure 55**). Since the most recent three years of recruitment (2013-2015) are not well estimated in the VPA, they were replaced by the geometric mean recruitment (calculated on a bootstrap by bootstrap basis). Projections were conducted on 500 non-parametric bootstraps of the base VPA.

The current status of the fishery estimated for 2015 was that overfishing was not occurring (**Table 14**). Current F (apical geometric mean of fishing mortality at age over the last three years) was estimated to be 0.078 (80% confidence interval of 0.065 to 0.096). Since estimates of stock-recruitment over the period of the VPA did not contain information to inform asymptotic recruitment levels, a benchmark fishing mortality proxy was used to estimate status, the fishing mortality rate of $F_{0.1}$ (see previous section on SS projections for detailed description), and biomass based benchmarks were not used. $F_{0.1}$ was estimated to be 0.11 (80% confidence interval of 0.10 to 0.12). The estimated ratio of current F to $F_{0.1}$ in 2015 was 0.72 (80% confidence interval of (0.59 to 0.85). The estimated probability of overfishing in 2015 was 0.004 based on nonparametric bootstrapping of the VPA.

The projected yield at $F_{0.1}$ (0.11) was estimated over the next three years (**Table 14**). Dependent on the projected recruitment level, the projected yield in 2018 is 2,403 mt , 2,444 mt (, and 2,498 mt for the three-year, six-year, and 10-ear recruitment scenarios, respectively. Yield is projected to decline over the next three years, with 2019 projected yields of 2,313 t (3yr), 2,338 t (6yr), and 2,422 t (10yr); 2020 projected yields are 2,208 t (3yr), 2,252 t (6yr), and 2,400 t (10yr). Eighty percent confidence intervals around the yield projections are shown in **Table 14**.

The probability of overfishing was estimated across a range of fixed catch limits and the three alternative recruitment scenarios (**Tables 15** to **17**). In general, a decrease in the probability of not overfishing was predicted across the scenarios at yields near the current. These results are consistent with the decline in yield predicted at a constant F of 0.10.

The predicted trends in stock total biomass and spawning biomass across the range of fixed catch limits are shown in **Figures 56** and **57**. The estimates of total biomass are independent of the age at spawning assumptions, however, the estimates of spawning biomass are dependent on the age at spawning, and therefore spawning biomass is shown for both the younger and older age-at-spawning assumptions (**Figure 57**). In general, total biomass was predicted to decline under the three-year and six-year recruitment scenarios and across most fixed catch limit levels. However, total biomass under the 10-year recruitment level showed a more optimistic trend across the range of projected yields. Projections of spawning biomass under the younger spawning assumption were similar to the total biomass predictions. Under the older spawning assumption, spawning biomass was predicted to decline across a large range of projected yields (**Figure 57**). The primary cause is the lower recruitment levels estimated after the 2003 year class. As the 2003 (and possibly adjacent) year class matured, an increase in spawning biomass occurred in the recent period, but later year classes were not estimated to be as strong, resulting in a predicted decline in spawner biomass into the future.

Stock Synthesis

Benchmarks for the western stock from SS runs 10 (older spawning) and 11 (younger spawning) are shown in **Table 13**. Fixed catch limit projections across all recruitment scenarios indicate that the level of assumed recruitment has little influence on 2018 catch limits (**Figure 58**) and that, across most recruitment and F scenarios the SSB will decline as the 2003 year class declines. Yields in the range of 1,500-2,000 t would be necessary to avoid the stock declines in these projections.

The projections suggest that, under all recruitment scenarios, fishing at the rate of $F_{0.1}$ could produce a catch of around 2,800 t in 2018, with a subsequent decrease to 2,400 t by 2021 (**Table 18, Figure 59**). A large component of these projected yields is made up of the 2003 year class, which becomes less important with time, causing the yields to decline after 2018. Projected yields at F_{MSY} are lower (~1,450 t), but also assume that recruitment will revert to the stock recruitment relationship which would assume higher recruitment than estimated for the three geometric mean time periods (**Figure 60**).

7. Recommendations

Recommendations statistics and research

- Noting the divergent trends in the handline (rod and reel) indices from the western Atlantic Ocean and the potential role of environmental factors, the Group recommends that effort be directed towards both identifying environmental factors that affect catchability at basin and local scales and incorporating these factors in the index standardization. The potential for combining the data and creating a joint handline index should also be explored.

- Recognizing the presence of gaps in the age-length data, the Group recommends that production aging of the backlog of eastern and Mediterranean otoliths focus primarily on the gaps in size and spatio-temporal fishery (ies) representativeness. Also, the effect of bin-size on age-length keys construction should be investigated. And, it also recommends that future sampling be structured to be representative of the temporal and spatial fishing patterns and provide sufficient calcified structures for annual age-length keys (~500 fish per year and stock, using length stratified sampling with fixed sample sizes per length bin to cover the range of sizes observed in the catch). The structure of the sampling can be guided by the effective sample sizes identified by the models.

- The Group recognizes the importance of collecting stock composition data and recommends that this effort include all the major fishing areas over the entire fishing season to be representative of the temporal and spatial fishing patterns.

- The Group requests that the historical and future time series of Mediterranean purse seine catches between small (<160 SFL) and large (>160 cm SFL) fish be better partitioned.

- The Group reiterates the importance of all CPCs to review and submit their Task II size frequency data by fleet. Furthermore an effort must be made to fill in the gaps in the size composition data (historical and future) to be representative of the temporal and spatial fishing patterns.

- The Group recommends that the comparability over time of the Mediterranean EU-France aerial survey and the larval survey be investigated further.

- The Group recommends that the data preparatory meeting agenda should prioritize evaluation of the key uncertainties in the assessment.

- The Group recommends that the bias issue detected in the direct ages from calcified structures be explored further with a view to correcting previously aged hard parts as well as providing a protocol that avoids the bias in future readings. Furthermore, the Group requests that paired hard parts be collected in both the East and West to help estimate the bias across all ages. Consideration should be given to conducting an ageing workshop.

- Upon resolution of the ageing discrepancies, an updated growth curve analysis for the East Atlantic should be attempted.

8. Other matters

No additional issues were discussed.

9. Adoption of the report and closure

Due to the limited time, some Agenda items were only partially reviewed prior to the close of the meeting: methods relevant to the stock assessment (4) and research recommendations (7). The review of the scientific papers presented at the Species Group (2), updating stock status (5) and other matters (8) were adopted by correspondence. No management recommendations were formally adopted as several key analyses were still pending. It is expected that management advice will be formulated as part of the Executive Summary at the September Species Group meeting. The remainder of the report was adopted during the meeting. The meeting was adjourned.

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Table 1. Summary of the current assumptions concerning life history attributes for the West Atlantic and East Atlantic and Mediterranean Bluefin tuna stocks (revised based on BFT 2012 stock assessment).

Life history attribute	***Assumption used by the SCRS***	***Source (see also ICCAT Manual)***	***Notes***
Growth (length at age)	West: Richards model A_1=0; A_2=34; L_1=33.0; L_2=270.6; K=0.22; p=-0.12 East & Med.: Von Bertalanffy model K= 0.093; L_∞=319 cm; t_0=-0.97	Ailloud *et al*. (2017) Cort (1991)	For the west, the SCRS adopted the growth curve of Ailloud *et al.* (2017) in 2017.
Growth (length-weight)	Area and season specific conversions are used, overall equations: West: $W=0.0000177054*L^{3.001251847}$ East & Med.: $W=0.0000350801*L^{2.878451}$	Rodriguez-Marin *et al*. (2015)	The seasonal specific conversions by area are in *ICCAT Manual* (BFT-Table2, conversion factor)
Natural mortality	West and East & Med.: Starting at age 1: 0.41, 0.32, 0.26, 0.22, 0.19, 0.17, 0.15, 0.14, 0.13, 0.12 (ages 10-11), 0.11 (ages 13-20), and 0.10 yr^{-1} (ages 20 plus)	Lorenzen (1996) mortality vector based on the growth model (Ailloud *et al*., 2017) and rescaled to have a value of 0.1 at age 20	SCRS/2017/083 Size-weight relationship (Rodriguez-Marin *et al*., 2015)
Longevity	West: 32 yr East & Med.: > 20 yr	Neilson and Campana (2008) Fromentin and Fonteneau (2001)	Based on radiocarbon traces. Based on tagging data.
Spawning-at-age	West older spawning: Starting at age 1: 0, 0, 0, 0, 0, 0.001, 0.007, 0.039, 0.186, 0.563, 0.879, 0.976, 0.996, 0.999, 1, 1 (age 20)	Porch and Hanke (2017)	Porch and Hanke (SCRS/2017/164) estimated spawning fraction oogive based on age composition data from the U.S. longline fishery in the Gulf of Mexico 2009-2014. Recent findings

	West younger spawning: Same as East Atlantic East & Med.: 50% spawning at age 4 (115 cm / 30 kg). Starting at age 1: 0, 0, 0.25, 0.5, 1 (ages older 5)	Anon. 1997	indicate fish were mature at age 5 (SCRS/2012/161). M_{50} at 105cm, (age 3.5) from Corriero *et al*. (2005)
Spawning area	West: Gulf of Mexico. East & Med.: Around Balearic Islands, Tyrrhenian Sea, central Mediterranean and Levantine Sea.	Multiple sources, see Rooker *et al.* (2007) and Fromentin and Powers (2005) or Mather *et al.* (1995) for reviews.	Other spawning areas have been identified, but not yet demonstrated to be important. See presentation 2012/149 for further information on spawning in the Mediterranean.
Spawning season	West: April to mid-June. East & Med.: eastern Med.: mid-May to mid-June western Med.: mid-June to mid-July	As above.	Timing of the spawning season can change from year to year due to environmental conditions.

Table 2. Task I NC best estimate BFT catch by stock.

			1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
TOTAL			27829	31334	39701	40359	37980	44636	30433	36419	34560	27983	27145	29703	35256	30195	35816	31262	23164	25674	16721
1-Landings	East BFT		26812	30211	39007	39275	37157	44092	30186	35873	33353	26334	26113	28083	29457	16357	17208	17095	15084	19734	13545
	ATE		20169	23021	32646	31275	29284	36783	24608	28470	26415	20338	19842	21657	24079	9314	10863	11046	9649	10819	5079
	MED		6643	7190	6361	8000	7873	7309	5578	7402	6938	5997	6272	6426	5378	7043	6345	6049	5435	8915	8466
	West BFT		1017	1123	694	1084	823	544	247	546	1207	1649	1032	1620	5799	13838	18608	14167	8080	5940	3176
1-Landings	ATE	Bait boat	2975	3872	4685	4135	5500	6559	3409	4017	4241	3800	1374	1597	1702	1554	1263	1984	3557	2018	1585
		Longline	0	0	0	0	0	0	0	33	2	56	481	223	2484	1618	645	438	91	141	208
		Other surf.	452	1790	1004	2202	312	1921	55	1004	0	0	0	0	0	0	0	0	0	0	0
		Purse seine	2200	6728	14752	10217	12145	13394	5313	6437	6399	6727	6501	11547	10358	1586	3520	3412	2778	4063	1206
		Sport (HL+RR)	1142	1724	2734	1167	1658	2316	1046	2030	623	1828	536	454	370	3	44	23	2	15	8
		Traps	13400	8906	9471	13553	9669	12593	14784	14949	15150	7927	10951	7835	9165	4553	5391	5189	3221	4582	2072
	ATW	Longline	0	0	7	1	0	5	0	46	72	283	340	373	1351	6558	12347	9465	3075	3126	1665
		Other surf.	468	270	334	198	130	135	47	58	61	125	119	78	44	22	24	58	47	58	63
		Purse seine	1	100	0	0	55	0	0	0	138	781	277	903	3768	5770	5150	3331	1006	2082	687
		Sport (HL+RR)	192	235	153	119	107	27	19	38	67	79	60	108	412	1185	608	1066	3731	361	635
		Traps	356	518	200	766	531	377	181	404	869	381	236	158	224	303	479	247	221	313	126
	MED	Bait boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	800	300	400	500	300	600
		Other surf.	607	916	1066	999	900	889	474	721	433	487	501	699	323	814	1058	507	100	100	100
		Purse seine	1390	1191	1667	1796	2283	1583	1215	1097	1032	755	674	816	595	1605	1306	470	1897	2937	3355
		Sport (HL+RR)	400	400	400	800	600	1200	900	500	700	700	900	1100	1000	1200	600	700	500	600	500
		Traps	4246	4684	3228	4405	4090	3637	2988	5084	4773	4054	4197	3811	3460	2624	3081	3972	2438	4978	3911
3-Discards	ATW	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Other surf.	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
		Sport (HL+RR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MED	Longline	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
1-Landings	ATE	Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	138
		EU.Denmark	818	1267	2113	800	898	1127	465	615	227	792	48	148	156	3	44	23	2	15	8
		EU.España	8416	5487	7181	9521	8446	11766	10854	11667	11860	6713	6521	5390	5437	2811	3360	4563	3333	4158	2564
		EU.France	1869	2893	2362	2364	3451	3031	1453	1550	1303	2031	553	907	965	543	400	621	1624	860	390
		EU.Germany	230	235	306	315	665	1096	569	1319	390	1002	445	293	199	0	0	0	0	0	0
		EU.Ireland	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
		EU.Portugal	1770	1571	2377	3130	1387	1485	2631	1052	806	1091	1537	1758	817	435	635	107	220	251	68
		EU.Sweden	94	222	316	52	95	94	12	96	6	34	42	13	15	0	0	0	0	0	0
		EU.United Kingdom	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
		Guinea Ecuatorial	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
		ICCAT (RMA)	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
		Japan	0	0	0	0	0	0	0	33	2	56	481	204	2484	1618	585	404	50	100	13
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Maroc	4773	4617	3240	4876	2198	4792	3311	5702	7961	5378	6000	4371	5276	3737	4315	2788	3379	3379	1088
		NEI (ETRO)	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
		Norway	2200	6728	14752	10217	12145	13394	5313	6437	3860	3241	4215	8572	8730	167	1524	2540	1041	2056	810
		Panama	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
		Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Algerie	100	100	100	98	62	98	56	52	78	0	0	0	0	0	0	0	150	150	150
		China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Bulgaria	733	660	666	732	1037	682	596	476	427	367	449	344	176	72	45	35	21	18	14
		EU.Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.España	168	273	553	54	597	60	136	345	282	374	561	620	377	1642	953	1635	651	481	611
		EU.France	507	816	966	899	798	783	329	615	294	384	400	599	214	668	953	390	1000	1500	2500
		EU.Greece	400	400	400	800	600	1200	900	500	700	700	900	1100	1000	1200	600	700	500	600	500
		EU.Italy	2229	2298	1766	2483	2344	2194	1926	2810	2953	1987	1740	1772	1956	2483	2642	1565	1591	3037	2888
		EU.Malta	100	100	100	100	102	106	145	106	139	103	101	100	109	146	105	117	100	100	100
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		ICCAT (RMA)	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
		Israel	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	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
		Libya	1000	1100	900	1700	1200	1200	1200	1200	1200	1100	1100	1000	800	100	400	600	700	800	1000
		Maroc	27.37	183.26	160.31	23.8	102.17	8.16	36.38	81.94	77.01	106.59	174.08	47.43	54.91	95.2	0	172	11	27	5
		NEI (Flag related)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NEI (combined)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NEI (inflated)	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
		Serbia & Montenegro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tunisie	721.65	729.47	470.39	521.9	377.2189	631.89	0	34	0	150.8876	438.09	420.07	404	260	376	601	364.5976	382.7751	237.26
		Turkey	0	0	0	0	0	0	0	800	400	500	300	300	200	100	0	100	100	1488	310
		Yugoslavia Fed.	657	531	279	588	654	346	253	382	388	224	109	123	87	277	271	134	246	331	150
	ATW	Argentina	0	0	0	0	0	0	0	0	0	0	0	0	106	271	204	100	100	60	21
		Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Canada	442	326	433	201	175	133	40	47	38	172	37	120	177	642	996	636	198	230	281
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
		Cuba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	139	465	2352	1351
		EU.United Kingdom	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
		ICCAT (RMA)	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	0	30	32	200	339	373	1219	6191	12044	9147	2471	694	272
		Korea Rep.	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
		NEI (ETRO)	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
		Panama	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
		Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		U.S.A.	575	797	261	883	648	411	207	469	1137	1277	656	1127	4297	6734	5364	4145	4846	2604	1239
		UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-Discards	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Croatia	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
		Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tunisie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATW	Canada	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	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
		U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
TOTAL			18036	16274	17776	14778	14883	24675	26537	28248	25675	20880	18690	19843	19875	24081	24253	26774	24743	21589	20775	27031	23926	26381	29318	34128	36642
1-Landings	East BFT		15024	10808	11185	10830	11012	19285	21465	22368	18980	15115	12435	14059	14105	22421	21699	24473	22063	19260	18271	24129	21161	23599	26389	31831	34258
	ATE		6253	6007	4811	4831	4862	6168	10180	5278	7153	6203	4855	4003	3580	6689	8059	7427	4806	4687	4453	6951	5448	6313	6543	7396	9317
	MED		8771	4802	6374	6000	6150	13117	11285	17090	11827	8912	7580	10056	10525	15732	13640	17046	17257	14572	13818	17178	15713	17286	19846	24435	24941
	West BFT		3012	5466	6591	3948	3871	5390	5072	5880	6695	5765	6255	5784	5770	1660	2554	2301	2680	2329	2504	2902	2766	2782	2929	2296	2384
1-Landings	ATE	Bait boat	2056	3017	3055	3032	3316	2385	3193	1868	3055	4126	2216	1707	1479	987	3128	2949	2364	2253	2129	2682	2685	1993	1653	1422	3884
		Longline	201	274	254	261	91	2243	2923	2048	1806	733	748	1002	575	2715	2626	1557	576	1008	1026	1187	962	1510	3196	3618	2802
		Other surf.	0	5	105	101	14	4	4	12	5	2	1	2	2	0	85	88	150	80	0	255	160	252	126	523	976
		Purse seine	1520	876	683	961	933	1459	3612	860	1426	257	266	437	266	650	262	373	86	276	255	202	147	54	46	462	24
		Sport (HL+RR)	1	14	1	6	2	0	0	0	300	451	1024	38	72	27	2	158	1	13	3	1	2	1	0	7	0
		Traps	2475	1820	713	469	506	78	448	490	561	633	600	817	1186	2309	1956	2302	1630	1057	1040	2624	1492	2504	1522	1365	1631
	ATW	Longline	593	268	1390	362	1156	985	1586	3185	3790	3252	3744	3983	3898	374	841	844	1240	771	1138	1377	705	741	903	689	712
		Other surf.	32	83	182	163	86	214	0	189	157	158	143	103	113	299	514	377	293	166	156	425	755	536	578	509	406
		Purse seine	1118	4288	3769	2011	1656	960	2320	1582	1502	1230	1381	758	910	237	384	401	377	360	367	383	385	384	237	300	295
		Sport (HL+RR)	1038	644	1144	1354	816	2955	1022	752	874	904	956	893	808	682	808	676	750	518	726	601	786	1004	1083	586	854
		Traps	231	183	106	58	157	276	144	172	372	221	31	47	41	68	7	3	20	0	17	14	1	2	0	1	29
	MED	Bait boat	0	0	0	0	0	0	0	0	0	0	0	0	100	53	391	1699	278	0	0	0	0	25	148	158	48
		Longline	400	69	129	236	520	2408	1400	1243	639	179	222	253	390	1587	980	1380	1396	966	974	1435	1364	1178	3057	3145	2470
		Other surf.	0	20	2	4	56	14	39	21	64	24	11	4	66	45	10	250	795	527	620	431	926	344	356	447	371
		Purse seine	3638	2396	3906	4084	4324	8119	8065	13970	9563	7299	6103	8541	8529	12131	10485	10624	12460	11116	10032	12566	10883	11797	13805	18580	20065
		Sport (HL+RR)	500	100	100	100	100	100	114	100	188	191	204	60	52	122	224	603	1007	811	810	1210	826	1559	769	952	1238
		Traps	4233	2216	2237	1575	1149	2476	1666	1756	1373	1219	1040	1198	1388	1794	1550	2490	1320	1153	1382	1537	1714	2382	1711	1152	749
3-Discards	ATW	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	514	99	102	119	115	128	211	88
		Other surf.	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
		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
		Sport (HL+RR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MED	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
		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
1-Landings	ATE	Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0	0	0	0	0	0	0	0
		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
		Chinese Taipei	114	46	12	2	1	12	5	3	2	0	3	5	6	16	2	3	16	197	20	0	109	0	0	0	6
		EU.Denmark	1	1	2	1	3	1	2	1	3	0	1	2	1	0	0	0	37	0	0	1	0	0	0	0	37
		EU.España	3422	3785	2975	2542	3280	1685	2649	2067	3088	4430	3629	2272	2499	2854	4540	4805	3627	2876	2477	4567	3567	3830	2273	2318	4962
		EU.France	534	732	680	740	551	522	692	267	592	723	275	260	153	150	400	602	490	348	533	724	460	510	565	894	1099
		EU.Germany	0	14	1	6	2	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
		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
		EU.Poland	0	0	100	100	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Portugal	419	34	0	97	0	191	303	24	14	56	35	24	17	41	128	34	29	193	163	48	3	27	103	128	91
		EU.Sweden	0	4	3	0	0	0	2	8	2	2	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0
		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
		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
		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
		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
		ICCAT (RMA)	0	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
		Japan	2	21	157	240	44	2195	2900	1973	1594	577	630	880	515	2573	2609	1514	420	739	900	1169	838	1464	2981	3350	2484
		Korea Rep.	0	0	0	19	43	36	15	3	2	0	1	0	0	0	3	0	77	0	0	0	0	0	0	0	0
		Maroc	835	692	143	653	514	655	2624	331	884	36	206	161	177	993	365	202	86	288	356	437	465	408	531	562	415
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	4	0	5	6	74	4	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	85	144	223
		Norway	927	677	738	430	421	869	988	529	764	221	60	282	161	50	1	243	0	31	0	0	0	0	0	0	0
		Panama	0	0	0	0	3	0	0	69	208	156	14	117	48	12	0	17	22	11	4	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	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
		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
	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Algerie	150	100	100	1	0	33	66	49	40	20	150	190	220	250	252	254	260	566	420	677	820	782	800	1104	1097
		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
		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	328
		EU.Bulgaria	9	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1418	1076	1058
		EU.Cyprus	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	14
		EU.España	617	349	182	212	420	203	120	253	158	165	139	133	354	989	812	2743	1460	701	1178	1428	1645	1822	1392	2165	2018
		EU.France	1500	1100	2200	1100	1400	1800	1600	3800	3182	1597	1578	1701	2350	4878	3660	3600	5430	3490	4330	5780	4434	4713	4620	7376	6995
		EU.Greece	500	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	11	131	156	159	182	201	175	447	439
		EU.Italy	3152	2264	2576	3718	3167	6868	7083	10369	6263	5047	4075	6285	6017	6658	5865	7140	7199	7576	4607	4207	4320	4122	3787	5006	5379
		EU.Malta	0	20	2	4	56	35	76	34	77	28	34	28	42	61	41	35	75	53	47	30	38	85	113	81	259
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	240	211	164
		Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		ICCAT (RMA)	0	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
		Israel	0	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	112	246	2195	1260	968	520	61	99	119	100	961	677	1036	1006	341	280	258	127	172	85	123	793
		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
		Libya	2000	500	600	449	475	1469	780	799	336	677	424	398	271	310	270	274	300	300	300	300	84	328	370	737	635
		Maroc	0	0	79	37	1	9	40	1	7	0	2	0	2	0	1	4	12	56	159	140	367.87	1149	925	205	79
		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
		NEI (combined)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	19	0	168	183	633	757	360	1799	1398	0
		NEI (inflated)	0	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	4	0	0	0	0	0	0	0	0	0	72	67	0	74	287	484	467
		Serbia & Montenegro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tunisie	148.7988	237.1538	285.0651	98.32	94.355	153.4438	87.2663	73.93	131	141	295.92	228	218	298	293	307	369	315	456	624	661	406	1366	1195	2132
		Turkey	393	138	22	68	66	34	17	181	177	127	27	391	565	825	537	869	41	69	972	1343	1707	2059	2459	2817	3084
		Yugoslavia Fed.	301	90	326	200	224	317	155	562	932	1049	756	573	376	486	1222	755	1084	796	648	1523	560	940	0	0	0
	ATW	Argentina	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	1	2	0	0	0
		Brazil	0	0	0	0	0	0	0	0	0	14	10	2	3	1	1	0	1	0	2	0	2	1	0	0	0
		Canada	363	1442	1082	477	1018	768	641	846	972	670	245	306	425	504	433	264	142	73	83	393	619	438	485	443	459
		Chinese Taipei	7	2	13	7	2	20	1	0	1	1	49	15	7	11	2	0	3	3	4	0	20	0	0	0	0
		Cuba	468	200	0	0	0	0	40	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		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
		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
		ICCAT (RMA)	0	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	116	66	1375	321	1097	905	1513	2902	3658	3144	3621	3936	3771	292	711	696	1092	584	960	1109	468	550	688	512	581
		Korea Rep.	0	0	0	11	23	20	8	7	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mexico	0	0	0	23	29	39	24	37	14	28	22	10	20	14	12	21	11	13	1	6	7	2	9	15	17
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	14	1	0	0	0	0	0	30	24	23	17	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
		Panama	0	0	0	0	2	0	0	157	92	58	10	9	14	12	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	1	3	2	14	14	14	2
		Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		U.S.A.	2058	3756	4119	3109	1698	3638	2845	1931	1956	1848	2297	1505	1530	812	1394	1320	1424	1142	1352	1289	1483	1636	1582	1085	1237
		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
		UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-Discards	MED	Albania	0	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.Croatia	0	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
		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
		Tunisie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATW	Canada	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
		Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		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
		U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	514	99.352	102.295	119.22	115.093	128.269	211	88

			1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL			48881	49545	54009	53545	52657	52772	52775	52784	53319	52305	52125	51756	51811	62638	26460	21798	13195	11781	12688	14726	14887	18042
1-Landings	East BFT		46769	47097	51497	51211	50000	50000	50000	50000	50000	50000	50000	50000	50000	61000	24460	19818	11338	9774	10934	13244	13261	16201
	ATE		7054	9780	12098	16379	11630	10247	10061	10086	10347	7396	7410	9039	7802	8441	8243	6684	4379	3984	3834	4163	3918	4841
	MED		39715	37317	39399	34831	38370	39753	39939	39914	39653	42604	42590	40961	42198	52559	16217	13133	6959	5790	7100	9081	9343	11360
	West BFT		2113	2448	2512	2334	2657	2772	2775	2784	3319	2305	2125	1756	1811	1638	2000	1980	1857	2007	1754	1482	1626	1842
1-Landings	ATE	Bait boat	2284	3093	5369	7215	3139	1554	2032	2426	2635	1409	1902	2282	1263	2436	2393	1260	725	636	283	243	95	172
		Longline	2311	4522	4212	4057	3789	3570	3736	3303	2896	2750	2072	2717	2306	1705	2491	1951	1194	1125	1139	1167	1194	1467
		Other surf.	590	555	273	60	387	404	509	558	631	521	290	424	831	502	181	297	124	35	49	141	210	193
		Purse seine	213	458	323	828	700	726	661	153	887	490	1078	1197	408	0	0	2	1	0	0	2	0	
		Sport (HL+RR)	25	0	0	237	28	33	126	61	63	109	89	11	99	11	12	11	44	51	53	46	43	104
		Traps	1630	1152	1921	3982	3586	3960	2996	3585	3235	2116	1978	2408	2895	3788	3166	3164	2292	2137	2311	2564	2376	2905
	ATW	Longline	539	491	545	382	764	915	858	610	729	186	644	425	565	420	606	366	529	743	478	470	497	553
		Other surf.	307	384	429	293	342	279	283	201	107	139	97	89	85	63	78	121	107	147	117	121	119	138
		Purse seine	301	249	245	250	249	248	275	196	208	265	32	178	4	28	0	11	0	0	2	29	38	34
		Sport (HL+RR)	804	1114	1032	1181	1108	1125	1121	1650	2036	1399	1139	924	1005	1023	1134	1251	1009	888	917	692	810	1085
		Traps	79	72	90	59	68	44	16	16	28	84	32	8	3	4	23	23	39	26	17	11	20	6
	MED	Bait boat	0	0	5	4	11	4	38	28	1	9	17	5	0	0	0	38	1	0	2	11	9	25
		Longline	6993	8469	9856	7313	4117	3338	3424	4144	3234	3482	3028	3411	3135	3269	2376	1344	1242	962	587	605	588	776
		Other surf.	776	545	417	282	284	228	728	354	340	198	197	175	81	85	0	0	1	1	1	21	29	3
		Purse seine	27948	23799	26021	24279	31792	33798	33237	33043	34044	37291	37869	36639	38363	48994	13540	11448	4986	4293	6172	7974	8184	9993
		Sport (HL+RR)	2307	3562	2149	2340	1092	1533	1773	1167	1520	1404	1325	619	494	117	149	160	448	356	202	240	289	361
		Traps	1691	942	951	613	1074	852	739	1177	515	221	154	112	125	93	152	144	281	165	125	222	232	192
3-Discards	ATW	Longline	83	138	167	155	123	160	222	105	211	232	181	131	149	100	159	207	174	202	224	145	139	19
		Other surf.	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	4	5
		Sport (HL+RR)	0	0	0	14	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	12	9	11	2
1-Landings	ATE	Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		China PR	0	0	0	0	85	103	80	68	39	19	41	24	42	72	119	42	38	36	36	38	37	45
		Chinese Taipei	20	4	61	226	350	222	144	304	158	0	0	10	4	0	0	0	0	0	0	0	0	
		EU.Denmark	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.España	3137	3819	6186	9519	4565	4429	3493	3633	4089	2172	2801	3102	2339	3680	3536	2409	1550	1483	1329	1553	1282	1655
		EU.France	336	725	563	269	613	588	542	629	755	648	561	818	1218	629	253	366	228	135	148	223	212	254
		EU.Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.Ireland	0	0	0	14	21	52	22	8	15	3	1	1	2	1	1	1	2	4	10	13	19	14
		EU.Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.Portugal	363	169	199	712	323	411	441	404	186	61	27	82	104	29	36	53	58	180	223	235	243	263
		EU.Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.United Kingdom	0	1	0	1	1	12	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
		Faroe Islands	0	0	0	0	67	104	118	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	1
		Guinée Rep.	330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		ICCAT (RMA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
		Iceland	0	0	0	0	2	27	0	0	1	0	0	0	0	0	0	0	0	2	5	4	30	37
		Japan	2075	3971	3341	2905	3195	2690	2895	2425	2536	2695	2015	2598	1896	1612	2351	1904	1155	1089	1093	1129	1134	1386
		Korea Rep.	4	205	92	203	0	0	6	1	0	0	3	0	1	0	0	0	0	0	0	0	0	
		Maroc	720	678	1035	2068	2341	1591	2228	2497	2565	1797	1961	2405	2196	2418	1947	1909	1348	1055	990	960	959	1176
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NEI (Flag related)	68	189	71	208	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Norway	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
		Panama	1	19	550	255	0	13	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	6	0	
		Seychelles	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	
		Sierra Leone	0	0	0	0	0	0	93	118	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	9	34	40
		Algerie	1560	156	638	829	1674	1760	2083	2098	2056	1504	1440	1500	1673	1489	1311	0	0	0	69	244	244	370
		China PR	97	137	93	49	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Chinese Taipei	709	494	411	278	106	27	169	329	508	445	51	267	5	0	0	0	0	0	0	0	0	
		EU.Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.Croatia	1410	1220	1360	1105	906	970	930	903	977	1139	828	1017	1022	825	834	619	389	371	369	384	385	456
		EU.Cyprus	10	10	10	10	21	31	61	85	91	79	105	149	110	1	132	2	3	10	18	17	18	22
		EU.España	2741	4401	2588	2209	2000	2003	2772	2234	2215	2512	2353	2758	2689	2414	2465	1769	1056	942	1064	948	1164	1238
		EU.France	11843	9604	9171	8235	7122	6156	6794	6167	5832	5859	6471	8638	7663	10200	2670	3087	1755	805	791	2191	2216	2565
		EU.Greece	886	1004	874	1217	286	248	622	361	438	422	389	318	255	285	350	373	224	172	176	178	161	195
		EU.Italy	6901	7076	10200	9619	4441	3283	3847	4383	4628	4981	4697	4853	4708	4638	2247	2749	1061	1783	1788	1938	1946	2273
		EU.Malta	580	590	402	396	409	449	378	224	244	258	264	350	270	334	296	316	136	142	137	155	160	182
		EU.Portugal	306	313	274	37	54	76	61	64	0	2	0	0	11	0	0	0	0	0	0	0	0	
		Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	77	77	155
		ICCAT (RMA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	1	0
		Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	
		Israel	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Japan	536	813	765	185	361	381	136	152	390	316	638	378	556	466	79.96	18.453	0	0	0	0	0	
		Korea Rep.	684	458	591	410	66	0	0	0	0	0	700	1145	26	276	335	102	0	0	77.039	80.496	80.525	
		Libya	1422	1540	1388	1029	1331	1195	1549.27	1941.152	637.607	752.223	1299.635	1090.69	1327	1358.23	1317.719	1081.639	644.583	0	756.186	928.858	932.63	1153.4491
		Maroc	1092	1035	586	535	687	636	695	511	421	760	819	92	190	640.588	531	369	205	182	223	309.41	310	322.1
		NEI (Flag related)	427	639	171	1058	761	78	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NEI (combined)	773	211	0	101	1030	1995	109	571	508	610	709	0	0	0	0	0	0	0	0	0	0	
		NEI (inflated)	0	0	0	0	9471.127	16893.496	16458.366	15297.74	15879.631	18873.392	18375.823	14164.033	18343.164	28233.779	0	0	0	0	0	0	0	
		Panama	1499	1498	2850	236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Serbia & Montenegro	0	2	4	0	0	0	4.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	49.62	40.5	0	33.83	0	0	0	0	39.627
		Tunisie	2773	1897	2393	2200	1745	2352	2184	2493	2528	791	2375.58	3249.3	2545	431	2679.247	1931.724	1042.18	851.527	1017.4	1056.6	1046.664	1247.83
		Turkey	3466	4219	4616	5093	5899	1200	1070	2100	2300	3300	1075	990	806	918	879.165	665.445	409.498	519.357	535.5506	551.19117	555.10382	1091.097
		Yugoslavia Fed.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATW	Argentina	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	13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
		Canada	392	576	597	503	595	576	549	524	604	557	537	600	733	491	575	530	505	474	477	480	463	531
		Chinese Taipei	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Cuba	0	0	0	0	0	0	0	0	74	11	19	27	19	0	0	0	0	0	0	0	0	
		EU.United Kingdom	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	1	0	0	3	1	10	5	0	4	3	2	8	0	0	0	0	9
		ICCAT (RMA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Japan	427	387	436	322	691	365	492	506	575	57	470	265	376	277	492	162	353	578	289	317	302	347
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	1	52	0	0	0	0	0	0	0	0	
		Mexico	4	23	19	2	8	14	29	10	12	22	9	10	14	7	7	10	14	14	51	23	51	53
		NEI (ETRO)	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	429	270	49	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	
		Sta. Lucia	43	9	3	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	
		U.S.A.	1163	1311	1285	1334	1235	1213	1212	1583	1840	1426	899	717	468	758	764	1068	803	738	713	502	667	877
		UK.Bermuda	0	0	1	2	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
		UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		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	
3-Discards	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.154	0	0	0	
		EU.Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.42	4.561	5.061	1.568	1.5122
		EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.561
		Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.76	4.242	0	
		Tunisie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.9	
		Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.175	0.242	0.171	0	
	ATW	Canada	0	0	0	6	16	11	46	13.2	36.9	14	14.6	0	2	0.4	1.2	2.9	24.5	36	16.6	0	0	2.74972
		Japan	0	0	0	8	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	0.2	1.1	0	0	0.09
		U.S.A.	83	138	171	155	110	149.1	176	98.4	174	218	166.657	130.846	147.188	99.639	157.674	204.396	149.617	166.2331	205.862	158.70694	142.9944	22.049

Table 3. Fleet definitions for the statistical catch at size/age models.

East & Med BFT				
Fleet_SS	**GearGrp**	**Flag**	**Min Year**	**Max Year(**
BB_SPA	BB	EU.España	1953	2006
BB_SPAFRA	BB	EU.España	2007	2015
		EU.France	2013	2015
LL_JPN_EM	LL	Japan	1956	2010
LL_JPN_NE	LL	Japan	1990	2015
LL_OTH	LL	Algerie	2000	2009
		Canada	1999	2014
		China PR	1995	2015
		Chinese Taipei	1983	2006
		EU.Croatia	2009	2013
		EU.Cyprus	2005	2015
		EU.España	1984	2015
		EU.France	2014	2015
		EU.Greece	1999	2013
		EU.Italy	1990	2015
		EU.Malta	2005	2015
		EU.Portugal	2005	2015
		Iceland	2012	2014
		Korea Rep.	1983	1983
		Libya	2002	2009
		Turkey	2014	2014
PS_FRA	PS	EU.France	1970	2015
PS_HRV	PS	EU.Croatia	2002	2015
PS_NOR	PS	Norway	1950	1984
PS_OTH			1975	2015
TRP_MARPOR	TP	EU.Portugal	2012	2015
		Maroc	2012	2015
TRP_MARSPA	TP	EU.España	1956	2011
		Maroc	2006	2011
TRP_OTH	TP	Algerie	1992	1992
		EU.España	2012	2015
		EU.Italy	1956	2011
		EU.Portugal	1958	2011
		Libya	1964	2005
		Tunisie	1990	1997
		Turkey	1976	1993
OTHER			1952	2015

West BFT			Values	
Fleet_SS	**GearGrp**	**Flag**	**Min YearC**	**Max YearC**
JAPAN_LL	LL	Japan	1957	2015
JPN_LL_GOM	LL	Japan	1973	1981
OTHER_LL	LL	Canada	1986	2015
		Chinese Taipei	1983	1997
		FR.St Pierre et Miquelon	2010	2013
		Japan (foreign obs.)	1981	1988
		U.S.A.	1983	2015
		UK.Bermuda	2009	2009
OTHER_LL_GOM	LL	Cuba	2002	2002
		Mexico	1994	2015
		U.S.A.	1984	2015
US_CAN_PSFB	PS	Canada	1977	1981
		U.S.A.	1979	2015
US_CAN_PSFS	PS	Canada	1977	1981
		U.S.A.	1979	1990
USA_CAN_HPN	HP	Canada	1993	2015
		U.S.A.	1983	2015
US_RR_FB	HL	U.S.A.	1983	2013
	RR	U.S.A.	1972	2015
CAN_HL	HL	Canada	2015	2015
	RR	Canada	1991	2015
	TL	Canada	1974	2015
US_RR_FS	HL	U.S.A.	1983	1991
	RR	U.S.A.	1976	2015
USA_TRP	TP	U.S.A.	1955	1961
CAN_TRP	TP	Canada	1975	2015
OTHER			1984	2013

Table 4. Preliminary estimates of total removals for the West BFT 2016 used for projections in the assessment models. Allocation by gear for 2016 used the same proportion as in 2015. No preliminary estimates of catch were available for East BFT 2016.

Decade	2010
Stock	BFT-W

Sum of Qty_t		YearC						
Flag	**GearCode**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	2016
Brazil	LLFB			1				
Brazil Total				**1**				
Canada	HAND						2	2
	HARPE	37	30	31	25	11	26	23
	LL-surf	89	112	65	67	61	74	67
	RR	324	295	347	325	331	389	350
	TL	40	30	34	52	40	35	32
	TRAP	39	26	17	11	20	6	6
	TRAW						1	1
	TROL		16					
Canada Total		**530**	**510**	**493**	**480**	**463**	**533**	480
FR.St Pierre et Miquelon	LL	8	0		0	0	9	
FR.St Pierre et Miquelon Total		**8**	**0**		**0**	**0**	**9**	9
ICCAT (RMA)	RR				0			
ICCAT (RMA) Total					**0**			
Japan	LL	353	578	289	317	302	347	
Japan Total		**353**	**578**	**289**	**317**	**302**	**347**	345
Mexico	LL	14	14	52	23	51	53	
Mexico Total		**14**	**14**	**52**	**23**	**51**	**53**	53
U.S.A.	HAND	3	1	1	0			
	HARP	29	70	52	45	68	77	88
	LL	239	241	295	208	222	89	101
	PS			2	43	42	39	44
	RR						694	792
	RRFB	571	419	420	250	378		
	RRFS	111	173	149	115	100		
	TRAW		0					
U.S.A. Total		**953**	**905**	**919**	**661**	**810**	**899**	1025
UK.Bermuda	LLSWO		0				0	
	RR			0	1			
UK.Bermuda Total			**0**	**0**	**1**		**0**	
UK.British Virgin Islands	RR					0	0	
UK.British Virgin Islands Total						**0**	**0**	
UK.Turks and Caicos	LLFB					0		
UK.Turks and Caicos Total						**0**		
Grand Total		**1857**	**2007**	**1754**	**1482**	**1626**	**1842**	1912

Table 5. Substitution table scheme for creating CAS/CAA for Atlantic bluefin tuna stocks.

			Used sz/cs series (P= previous year, D=discards)																
			BB	HL		LL								PS			SP	TP	TW
t1Stock	t1GearG	t1FlagN	EU.España	Croatia	EU.España	Canada	EU.Cyprus	EU.España	EU.Italy	EU.Malta	Japan	Mexico	U.S.A.	EU.France	EU.Italy	Turkey	EU.Italy	EU.Portugal	EU.France
ATE	BB	EU.France	X																
	HL	EU.France			X														
	LL	China P.R.									X								
		EU.France			X														
		EU.Portugal									X								
	PS	EU.Portugal																X	
	UN	EU.France																	X
MED	HL	Croatia		X															
		EU.France						X											
		EU.Greece		X															
	LL	EU.Cyprus					X												
		EU.France						X											
		EU.Greece					X												
		EU.Malta								X									
		Maroc						X											
	PS	Croatia												X					
		EU.España												X					
		EU.Greece												X					
		EU.Malta													X				
		Libya												X					
		Maroc												X					
		Syria Rep.												X					
		Tunisie												X					
		Turkey												X		X			
	SP	EU.España						X											
		EU.Italy						X									X		
	TP	EU.Italy							X										
	TW	EU.France												X					
	UN	EU.France												X					
		EU.Italy						x									X		
ATW	LL	Canada				X													
		Mexico										X							

Table 6. Age readings from paired otolith/spine samples obtained from 262 individuals (a) and resulting differences in otolith ages compared to reference spine ages (b).

a.

AGE READING FROM OTOLITH

AGE READING FROM SPINE	0	1	2	3	4	5	6	7	8	9	10	11	12
0	**22**	2											
1		**7**	4										
2		5	**11**	11	1								
3			2	**18**	10	1							
4			1	2	**14**	25	3						
5				1	7	**23**	11	7	2				
6					3	4	**11**	10	11	1	1	1	
7							1	**9**	7	9	1	2	1

b.

Spine reference age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
bias corrected otolith age reading	0.083	1.36	2.29	3.32	4.6	5.43	6.81	8.333

Table 7. Abundance indices used for East Atlantic in 2017 stock assessment.

series	SPN BB		SPN-FR BB		MOR-SPN TRAP		MOR-POR TRAP		JPN LL Eatl&Med		JPN LL NEAtl1		JPN LL NEAtl2		French Aerial survey 1		French Aerial survey 2		WMed Larval Survey	
age	2-3		3-6		6+		10+		6 - 10		4 - 10		4 - 10		2-4		2-4		Spawners	
indexing	Weight		Weight		Number		Number		Number		Number		Number		Number of schools		Number of schools			
area	East Atlantic		East Atlantic		East Atl and Med		East Atl and Med		East Atl and Med		NEast Atl		NEast Atl		West Med		West Med		West Med	
method	Delta lognormal		Delta lognormal		Neg. Binom.		Neg. Binom.		Delta Lognormal		Delta Lognormal		Delta Lognormal							
time of the year	Mid-year		Mid-year		Mid-year		Mid-year		Mid-year		Begin-year		Begin-year		Mid-year		Mid-year			
source	SCRS/2014/054		SCRS/2015/169		SCRS/2014/060		SCRS/2017/XXX		SCRS/2012/131		SCRS/2017/025		SCRS/2017/025		SCRS/2016/153		SCRS/2016/153		SCRS/P/2017/033	
Year	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Index**	**CV**	**Index**	**CV**	**Index**	**CV**
1952	179.22	0.43																		
1953	184.74	0.53																		
1954	226.46	0.41																		
1955	187.01	0.42																		
1956	470.53	0.43																		
1957	315.05	0.41																		
1958	252.25	0.41																		
1959	506.79	0.41																		
1960	485.16	0.43																		
1961	327.29	0.41																		
1962	180.12	0.46																		
1963	312.09	0.49																		
1964	457.40	0.42																		
1965	228.91	0.41																		
1966	349.10	0.42																		
1967	345.89	0.41																		
1968	447.00	0.42																		
1969	610.62	0.40																		
1970	594.66	0.43																		
1971	744.71	0.40																		
1972	525.63	0.41																		
1973	535.63	0.40																		
1974	245.39	0.44																		
1975	484.22	0.41							1.90	0.15										
1976	483.96	0.41							2.15	0.12										
1977	547.56	0.41							3.53	0.14										
1978	705.26	0.41							1.50	0.15										
1979	623.01	0.41							2.70	0.14										
1980	634.81	0.45							1.69	0.16										
1981	510.66	0.42			768.36	0.57			1.63	0.17										
1982	503.78	0.42			1038.12	0.35			3.32	0.13										
1983	625.14	0.43			1092.05	0.35			2.12	0.13										
1984	331.71	0.45			1200.27	0.35			1.62	0.12										
1985	1125.74	0.41			814.46	0.35			1.75	0.15										
1986	751.21	0.42			394.33	0.28			1.32	0.14										
1987	1008.43	0.42			433.53	0.28			2.16	0.13										
1988	1394.68	0.42			1014.56	0.28			1.35	0.14										
1989	1285.60	0.40			531.45	0.26			1.05	0.16										
1990	986.51	0.41			614.37	0.23			1.41	0.14	0.47	0.35								
1991	901.20	0.42			727.86	0.23			1.21	0.13	0.53	0.31								
1992	695.16	0.43			313.95	0.23			1.03	0.14	0.87	0.24								
1993	2093.55	0.40			325.36	0.23			1.04	0.14	0.74	0.22								
1994	1007.03	0.42			341.90	0.23			1.12	0.16	0.93	0.23								
1995	1235.91	0.41			223.43	0.23			1.42	0.15	0.97	0.22								
1996	1739.29	0.40			375.22	0.25			0.50	0.22	2.84	0.22								
1997	2246.41	0.40			992.41	0.25			0.53	0.21	1.51	0.24								
1998	879.51	0.41			925.14	0.25			0.71	0.17	0.87	0.25								
1999	339.77	0.44			1137.45	0.25			0.64	0.22	1.25	0.22								
2000	960.44	0.40			739.23	0.23			0.74	0.20	0.98	0.22			0.02	0.39				
2001	704.49	0.45			1284.62	0.23			0.96	0.17	1.83	0.21			0.01	0.37			5.50	0.18
2002	687.42	0.42			1130.42	0.23			2.05	0.15	0.82	0.22			0.01	0.50			2.76	0.26
2003	444.91	0.48			662.66	0.24			1.70	0.13	1.10	0.24			0.01	0.35			13.40	0.25
2004	1210.46	0.42			332.36	0.23			0.82	0.18	0.84	0.22							9.03	0.20
2005	2383.57	0.40			677.39	0.23			0.88	0.15	0.75	0.21							3.56	0.17
2006	850.09	0.48			633.94	0.23			1.91	0.15	0.83	0.22								
2007			2179.98	0.31	1000.60	0.23			0.94	0.19	0.84	0.22								
2008			2154.01	0.30	634.18	0.23			1.22	0.17	1.17	0.21								
2009			955.38	0.30	876.71	0.23			1.04	0.24	1.50	0.21					0.06	0.42		
2010			2126.20	0.31	1042.24	0.24							2.22	0.22			0.04	0.52		
2011			2785.47	0.30	674.97	0.23							4.45	0.26			0.09	0.34		
2012			2306.99	0.39			41.15	0.49					7.70	0.31			0.04	0.32	41.05	0.07
2013			1569.13	0.44			88.58	0.54					6.11	0.26					21.83	0.08
2014			678.29	0.41			48.54	0.50					9.70	0.30			0.17	0.38	25.41	0.10
2015							66.98	0.54					5.91	0.30			0.09	0.34	54.29	0.07
2016							64.03	0.53					5.47	0.28			0.41	0.28		
2017													7.19	0.30						

Table 8. Description of VPA runs made for the eastern Atlantic and Mediterranean stock during the 2017 bluefin tuna stock assessment meeting.

Run_1	Fratio estimated as random walk, starting value fixed at 0.5, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_2	Fratio estimated as random walk, starting value fixed at 0.75, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_3	Fratio estimated as random walk, starting value fixed at 1.25, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_4	Fratio estimated as random walk, starting value fixed at 1.5, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_5	Fratio estimated as random walk, starting value estimated, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_6	Fratio estimated as random walk, starting value fixed at 0.5, aerial survey not split, vulnerability of 1 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_7	Fratio estimated as random walk, starting value fixed at 0.75, aerial survey not split, vulnerability of 1 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_8	Fratio estimated as random walk, starting value fixed at 1.25, aerial survey not split, vulnerability of 1 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_9	Fratio estimated as random walk, starting value fixed at 1.5, aerial survey not split, vulnerability of 1 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_10	Fratio estimated as random walk, starting value estimated, aerial survey not split, vulnerability of 1 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_11	Fratio estimated as random walk, starting value fixed at 1, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_12	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 0.75, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_13	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 1, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately

Run_14	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 1.25, aerial survey not split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_15	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_16	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 0.75, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_17	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_18	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value fixed at 1.25, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_19	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices additive and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_20	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and all equal
Run_21	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices additive but one estimate for each index
Run_22	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices additive but one estimate for each survey and another for all CPUES
Run_23	Fratio estimated as random walk, starting value fixed at 1, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices additive and not disaggregated by groups of gears
Run_24	Base case, Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value estimated, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately
Run_25	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value estimated, aerial survey split, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately. Natural mortality using rescaled Lorenzen at 0.07.
Run_26	Fratio estimated as blocks (1968-1980, 1981-1995, 1996-2007, 2008-2015) starting value estimated, larval survey dropped, vulnerability of 0.4 over the three last years, weight of indices multiplicative and computed by group of gears, Longlines, Traps, Baitboats and each survey separately.

Table 9. Abundance indices used for West Atlantic in 2017 stock assessment.

series	US RR 66-114cm		US RR 115-144cm		US RR >177cm		US RR<145cm		US RR>195cm		US GOM PLL1		US GOM PLL2		Larval Survey		JPN LL1		JPN LL2		JPN LL GOM		CAN combined RR		Acoustic survey	
age	66-114cm		115-144cm		>177cm		<145cm		>195cm		8-16		8-16		8-16		4 - 10		5 - 16		9-16		7-16		8-16	
indexing	Number		Number		Number		Number		Number								Number		Number		Number					
area											GOM		GOM		GOM		West Atl		West Atl		GOM		GSL & SWNS		off PEI	
method	GLMM		GLMM		GLMM		GLMM		GLMM								Delta Lognormal RE		Delta Lognormal RE		Delta Lognormal RE					
time of the year																	Begin-year		Begin-year							
source	SCRS/2016/198		SCRS/2016/198		SCRS/2016/198		SCRS/1993/067		SCRS/1993/067		SCRS/2015/199		SCRS/2015/199		SCRS/2014/057		SCRS/2016/122		SCRS/2016/122		SCRS/1991/071		SCRS/2017/020		SCRS/2017/016	
Year	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**	**Std. CPUE**	**CV**
1970																										
1971																										
1972																										
1973																										
1974																					0.97	0.27				
1975																					0.53	0.21				
1976																	0.39	0.40			0.67	0.21				
1977															2.42	0.48	0.89	0.31			0.91	0.22				
1978															4.63	0.23	0.73	0.33			0.88	0.23				
1979																	0.82	0.28			1.29	0.28				
1980							0.80	0.43									1.40	0.28			1.16	0.27				
1981							0.40	0.52							1.15	0.81	1.11	0.26			0.55	0.24				
1982							2.10	0.33							1.36	1.20	0.78	0.27								
1983							1.11	0.26	2.81	0.10					0.90	1.02	0.46	0.34								
1984									1.25	0.19					0.31	0.32	0.67	0.29					0.57	0.14		
1985							0.63	0.64	0.86	0.30							0.83	0.27					0.31	0.16		
1986							0.78	0.43	0.50	1.10					0.34	0.42	0.01	1.55					0.18	0.21		
1987							1.22	0.40	0.53	0.48	1.31	0.29			0.31	0.46	0.37	0.33					0.22	0.37		
1988							0.99	0.38	0.94	0.36	0.64	0.32			1.13	0.32	0.35	0.37					0.60	0.14		
1989							0.99	0.43	0.76	0.36	0.99	0.31			0.70	0.36	0.69	0.30					0.64	0.13		
1990							0.90	0.34	0.63	0.34	0.77	0.32			0.34	0.35	0.48	0.32					0.23	0.11		
1991							1.26	0.35	0.82	0.28	1.29	0.30			0.31	0.57	0.60	0.30					0.22	0.11		
1992							0.82	0.42	0.91	0.28			1.14	0.35	0.43	0.34	1.09	0.26					0.24	0.11		
1993	1.16	0.36	1.10	0.21	0.66	0.30							0.64	0.36	0.47	0.66	0.98	0.27					0.24	0.12		
1994	0.27	0.44	0.28	0.38	0.89	0.28							0.47	0.39	0.53	0.34	0.90	0.27					0.21	0.12	0.03	0.28
1995	1.15	0.34	0.61	0.22	1.09	0.26							0.44	0.39	0.23	0.54	0.59	0.34					0.48	0.11	0.03	0.14
1996	1.71	0.37	0.73	0.22	3.57	0.25							0.26	0.40	0.78	0.49	2.24	0.27					0.27	0.11	0.07	0.10
1997	2.47	0.32	0.21	0.35	1.42	0.37							0.46	0.36	0.34	0.38	1.64	0.26					0.23	0.10	0.04	0.12
1998	1.44	0.36	0.77	0.17	1.56	0.25							0.50	0.37	0.11	0.54	0.76	0.29					0.35	0.10	0.04	0.21
1999	1.39	0.42	0.85	0.31	1.99	0.28							0.85	0.33	0.46	0.51	1.14	0.26					0.51	0.11	0.04	0.12
2000	0.99	0.50	1.33	0.39	0.60	0.27							1.24	0.33	0.24	0.51	1.13	0.27					0.32	0.11	0.02	0.14
2001	0.48	0.34	1.59	0.20	1.51	0.29							0.71	0.38	0.44	0.32	0.92	0.27					0.50	0.10	0.04	0.15
2002	1.54	0.39	2.55	0.26	1.85	0.23							0.66	0.39	0.24	0.62	0.78	0.28					0.75	0.11	0.02	0.19
2003	0.42	0.33	0.63	0.15	0.47	0.27							1.19	0.32	0.77	0.39	1.23	0.29					0.96	0.11	0.04	0.14
2004	2.31	0.31	0.61	0.19	0.74	0.27							1.08	0.32	0.50	0.67	1.11	0.30					1.09	0.11	0.04	0.07
2005	2.26	0.30	0.57	0.18	0.62	0.27							0.82	0.34	0.18	0.29	0.99	0.26					0.99	0.10	0.05	0.05
2006	0.61	0.33	1.45	0.19	0.49	0.35							0.58	0.39	0.50	0.35	1.53	0.29					1.27	0.10	0.06	0.07
2007	0.46	0.30	1.65	0.13	0.31	0.37							0.78	0.38	0.46	0.38	0.99	0.40					1.25	0.11	0.04	0.13
2008	0.36	0.32	1.14	0.16	0.38	0.35							1.78	0.33	0.32	0.38	1.36	0.45					1.11	0.11	0.03	0.08
2009	0.36	0.31	0.50	0.20	0.27	0.40							1.46	0.35	0.59	0.32	2.34	0.35					1.97	0.11	0.06	0.09
2010	0.63	0.32	1.20	0.17	1.03	0.26							1.22	0.34	0.34	0.51			0.60	0.37			2.31	0.12	0.07	0.04
2011	0.82	0.34	1.06	0.21	0.63	0.28							1.09	0.48	1.04	0.39			2.04	0.26			1.87	0.11	0.05	0.08
2012	0.41	0.40	1.12	0.23	0.72	0.25							3.39	0.37	0.28	0.47			2.54	0.27			2.08	0.11	0.10	0.07
2013	0.57	0.35	1.77	0.20	0.47	0.29							1.23	0.42	0.99	0.34			1.91	0.26			1.69	0.11	0.06	0.06
2014	0.70	0.37	0.94	0.26	0.64	0.27							1.02	0.44	0.26	0.37			2.38	0.28			1.71	0.11	0.08	0.06
2015	0.45	0.39	0.35	0.33	1.09	0.23							1.02	0.47	0.39	0.31			1.46	0.27			1.57	0.11	0.08	0.10
2016													1.14	0.47	2.47	0.26			3.67	0.29			2.35	0.12		
2017																			3.64	0.31						

Table 10. Projected probability that the fishing mortality rate on the eastern stock is less than $F_{0.1}$ based on projections of the VPA results under three recruitment levels (low, medium and high recruitment).

low

tac	2018	2019	2020	2021	2022	2023	2024	2025
50000	28	24	16	11	7	5	2	1
45000	53	44	31	22	15	11	8	5
40000	80	74	63	48	36	25	18	13
35000	93	92	88	80	71	62	48	38
30000	97	97	96	95	93	91	88	80
28000	98	98	97	97	96	95	94	91
26000	99	99	99	98	98	97	96	96
24000	100	99	99	99	99	99	99	98
23655	100	100	99	99	99	99	99	98
22000	100	100	100	100	100	100	100	100
20000	100	100	100	100	100	100	100	100
19296	100	100	100	100	100	100	100	100
18000	100	100	100	100	100	100	100	100
16000	100	100	100	100	100	100	100	100
14000	100	100	100	100	100	100	100	100
12000	100	100	100	100	100	100	100	100
10000	100	100	100	100	100	100	100	100
8000	100	100	100	100	100	100	100	100
6000	100	100	100	100	100	100	100	100
4000	100	100	100	100	100	100	100	100
2000	100	100	100	100	100	100	100	100
0	100	100	100	100	100	100	100	100

med

tac	2018	2019	2020	2021	2022	2023	2024	2025
50000	59	55	53	51	49	44	40	36
45000	81	78	76	76	73	70	67	64
40000	92	92	92	92	91	90	89	86
35000	98	98	98	98	97	98	97	97
30000	99	99	100	99	100	100	99	100
28000	100	100	100	100	100	100	100	100
26000	100	100	100	100	100	100	100	100
24000	100	100	100	100	100	100	100	100
23655	100	100	100	100	100	100	100	100
22000	100	100	100	100	100	100	100	100
20000	100	100	100	100	100	100	100	100
19296	100	100	100	100	100	100	100	100
18000	100	100	100	100	100	100	100	100
16000	100	100	100	100	100	100	100	100
14000	100	100	100	100	100	100	100	100
12000	100	100	100	100	100	100	100	100
10000	100	100	100	100	100	100	100	100
8000	100	100	100	100	100	100	100	100
6000	100	100	100	100	100	100	100	100
4000	100	100	100	100	100	100	100	100
2000	100	100	100	100	100	100	100	100
0	100	100	100	100	100	100	100	100

high

tac	2018	2019	2020	2021	2022	2023	2024	2025
50000	80	82	86	89	91	91	93	93
45000	92	93	95	97	97	97	98	98
40000	97	97	98	99	100	100	100	100
35000	99	99	100	100	100	100	100	100
30000	100	100	100	100	100	100	100	100
28000	100	100	100	100	100	100	100	100
26000	100	100	100	100	100	100	100	100
24000	100	100	100	100	100	100	100	100
23655	100	100	100	100	100	100	100	100
22000	100	100	100	100	100	100	100	100
20000	100	100	100	100	100	100	100	100
19296	100	100	100	100	100	100	100	100
18000	100	100	100	100	100	100	100	100
16000	100	100	100	100	100	100	100	100
14000	100	100	100	100	100	100	100	100
12000	100	100	100	100	100	100	100	100
10000	100	100	100	100	100	100	100	100
8000	100	100	100	100	100	100	100	100
6000	100	100	100	100	100	100	100	100
4000	100	100	100	100	100	100	100	100
2000	100	100	100	100	100	100	100	100
0	100	100	100	100	100	100	100	100

year

$P(F < F_{0.1})$ 25 50 75 100

Table 11. Short term projections, based on SS3 results, for eastern Atlantic and Mediterranean bluefin tuna stock based on different assumptions and catch limits.

Year	$0.8F_{MSY}$	$F_{0.1}$	10000	20000	25000	30000	35000
2016	19296	19296	19296	19296	19296	19296	19296
2017	23655	23655	23655	23655	23655	23655	23655
2018	20723	11802	10000	20000	25000	30000	35000
2019	20428	12093	10000	20000	25000	30000	35000
2020	20024	12288	10000	20000	25000	30000	35000
2021	19766	12527	10000	20000	25000	30000	35000
2022	19814	12916	10000	20000	25000	30000	35000
2023	20191	13486	10000	20000	25000	30000	35000
2024	20829	14212	10000	20000	25000	30000	35000
2025	21618	15033	10000	20000	25000	30000	35000
2026	22441	15878	10000	20000	25000	30000	35000

Table 12. SSB_t/SSB_{MSY} Ratios, based on SS3 results, for eastern Atlantic and Mediterranean stock for each of the projection scenarios.

Year	$0.8F_{MSY}$	$F_{0.1}$	10000	20000	25000	30000	35000
2016	0.89	0.89	0.89	0.89	0.89	0.89	0.89
2017	0.87	0.87	0.87	0.87	0.87	0.87	0.87
2018	0.85	0.85	0.85	0.85	0.85	0.85	0.85
2019	0.84	0.87	0.88	0.87	0.84	0.82	0.80
2020	0.84	0.91	0.92	0.91	0.85	0.81	0.77
2021	0.85	0.95	0.97	0.95	0.85	0.80	0.74
2022	0.87	0.99	1.02	0.99	0.86	0.79	0.71
2023	0.88	1.03	1.07	1.04	0.87	0.78	0.68
2024	0.90	1.07	1.12	1.08	0.89	0.77	0.66
2025	0.92	1.11	1.17	1.12	0.90	0.77	0.63
2026	0.93	1.15	1.23	1.17	0.92	0.77	0.61

Table 13. Benchmarks for the western stock from SS3 runs 10 (older spawning) and 11 (younger spawning).

	Run 10, older spawning	Run 11, younger spawning
SSB_Unfished	193516	243585
Total Biomass_Unfished	248007	250213
Recruits_Unfished	625.6	631.4
SSB_Btgt40%B0	77406.3	97434
SPR_Btgt40%B0	0.5241	0.5682
Fstd_Btgt40%B0	0.0440	0.0481
TotYield_Btgt40%B0	4543	4430
SSB_SPRtgtSPR40%	47133	40509
Fstd_SPRtgtSPR40%	0.0652	0.0866
TotYield_SPRtgtSPR40%	4357	3295
SSB_MSY	67006	94519
Spawning potential ratio at MSY	85.9167	0.5596
Recr_1997	248.8440	0.0496
Recr_1998	131.781	4432.2
F(avg 10-20) at MSY	0.0485	0.0496
F0.1(avg F 10-20)	0.0863	0.0863
SSB_F0.1	25910	39951
Yield_F0.1	3235	3144
$F_{current}$ (avg F 10-20) 2013-2015	0.0483	0.0483
$F_{current}/F_{0.1}$	0.56	0.56
$F_{current}/F_{MSY}$	0.996	0.974
current SSB	27612	38467
current $SSB/SSB_{F0.1}$	1.066	0.963
current SSB/SSB_{MSY}	0.412	0.407

Table 14. Projected yields, based on VPA results, of the western stock at a fishing mortality rate of 0.11 ($F_{0.1}$) under alternative recent recruitment scenarios.

F_current	0.078 (0.065-.096)		
F_0.1	0.11 (0.10-0.12)		
F_current/F_0.1	0.72 (0.59-0.85)		
Fishery Status	not overfishing		
Recruitment_Level	3-yr (2010-2012)	6-yr (2006-2012)	10-yr (2003-2012)
Projected_Recruits (2018)	81910 (54970-126100)	92455 (62390-138400)	134300 (71240-254100)
Projected_Recruits (2019)	82310 (55070-122500)	94505 (64170-148000)	130550 (70260-249500)
Projected_Recruits (2020)	82495 (56040-123100)	93885 (61110-150000)	129450 (73800-262700)
Projected_Catch_$F_{0.1}$_2018	2403 (1914-3084)	2444 (1943-3095)	2498 (2010-3212)
Projected_Catch_$F_{0.1}$_2019	2313 (1825-2963)	2338 (1871-2972)	2422 (1957-3121)
Projected_Catch_$F_{0.1}$_2020	2208 (1745-2852)	2252 (1798-2879)	2400 (1915-3050)

Table 15. Projected probability, based on VPA results, of not overfishing ($F<F_{0.1}$) the western stock under the 3-yr recruitment level.

Yield	2018	2019	2020	2021	2022
0	1.00	1.00	1.00	1.00	1.00
250	1.00	1.00	1.00	1.00	1.00
500	1.00	1.00	1.00	1.00	1.00
750	1.00	1.00	1.00	1.00	1.00
1000	1.00	1.00	1.00	1.00	1.00
1250	1.00	1.00	1.00	1.00	1.00
1500	1.00	0.99	0.99	0.99	0.97
1750	0.97	0.94	0.90	0.88	0.83
2000	0.86	0.79	0.70	0.65	0.59
2250	0.65	0.56	0.48	0.42	0.36
2500	0.43	0.34	0.29	0.25	0.20
2750	0.26	0.19	0.15	0.13	0.09
3000	0.12	0.09	0.06	0.05	0.03
3250	0.06	0.03	0.02	0.02	0.02
3500	0.02	0.02	0.02	0.01	0.01
3750	0.01	0.01	0.01	0.01	0.01
4000	0.00	0.00	0.00	0.00	0.00

Table 16. Projected probability, based on VPA results, of not overfishing ($F<F_{0.1}$) the western stock under the 6-yr recruitment level.

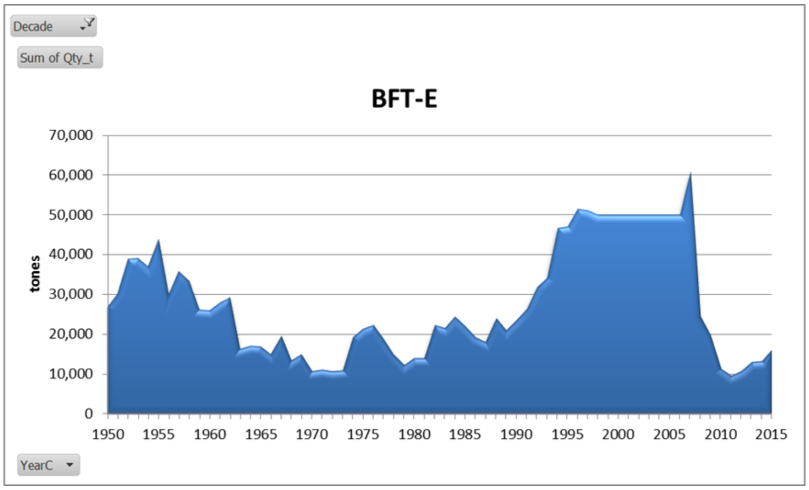
Yield	2018	2019	2020	2021	2022
0	1.00	1.00	1.00	1.00	1.00
250	1.00	1.00	1.00	1.00	1.00
500	1.00	1.00	1.00	1.00	1.00
750	1.00	1.00	1.00	1.00	1.00
1000	1.00	1.00	1.00	1.00	1.00
1250	1.00	1.00	1.00	1.00	1.00
1500	1.00	1.00	0.99	0.99	0.98
1750	0.97	0.95	0.93	0.91	0.89
2000	0.88	0.81	0.75	0.70	0.66
2250	0.67	0.59	0.52	0.48	0.43
2500	0.45	0.37	0.31	0.30	0.25
2750	0.27	0.21	0.16	0.14	0.12
3000	0.13	0.09	0.07	0.06	0.05
3250	0.06	0.04	0.02	0.02	0.02
3500	0.03	0.02	0.01	0.01	0.01
3750	0.01	0.01	0.01	0.01	0.01
4000	0.00	0.00	0.00	0.00	0.00

Table 17. Projected probability, based on VPA results, of not overfishing ($F<F_{0.1}$) western stock under the 10-yr recruitment level.

Yield	2018	2019	2020	2021	2022
0	1.00	1.00	1.00	1.00	1.00
250	1.00	1.00	1.00	1.00	1.00
500	1.00	1.00	1.00	1.00	1.00
750	1.00	1.00	1.00	1.00	1.00
1000	1.00	1.00	1.00	1.00	1.00
1250	1.00	1.00	1.00	1.00	1.00
1500	1.00	1.00	1.00	1.00	1.00
1750	0.98	0.98	0.98	0.97	0.97
2000	0.90	0.88	0.86	0.86	0.86
2250	0.75	0.69	0.65	0.67	0.69
2500	0.50	0.45	0.42	0.43	0.43
2750	0.33	0.27	0.25	0.27	0.27
3000	0.17	0.14	0.11	0.13	0.14
3250	0.09	0.06	0.04	0.05	0.06
3500	0.03	0.03	0.02	0.02	0.02
3750	0.02	0.01	0.01	0.01	0.01
4000	0.01	0.00	0.00	0.00	0.01

Table 18. Projected yields for the western stock from SS runs at various F levels and recruitment assumptions.

	Run 10: older spawning				
Assumed recruitment	SRR	3yr	6yr	10yr	SRR
F_{metric}	$F_{0.1}$	$F_{0.1}$	$F_{0.1}$	$F_{0.1}$	F_{MSY}
Prelim. Catch 2016 (t)	1912	1912	1912	1912	1912
TAC_2017 (t)	2000	2000	2000	2000	2000
ForeCatch 2018 (t)	2862	2815	2818	2830	1451
ForeCatch 2019 (t)	2768	2654	2662	2689	1457
ForeCatch 2020 (t)	2717	2507	2521	2572	1481
ForeCatch 2021 (t)	2680	2366	2387	2464	1509
rec 2015 (1000s)	279	120	131	170	279
rec 2016 (1000s)	281	121	132	171	281
rec 2017 (1000s)	282	121	132	172	282
rec 2018 (1000s)	281	121	132	171	281
rec 2019 (1000s)	274	118	129	167	281
rec 2020 (1000s)	264	113	124	160	278
	Run 11: younger spawning				
Assumed recruitment	SRR	3yr	6yr	10yr	SRR
F_{metric}	$F_{0.1}$	$F_{0.1}$	$F_{0.1}$	$F_{0.1}$	F_{MSY}
Prelim. Catch 2016 (t)	1912	1912	1912	1912	1912
TAC_2017 (t)	2000	2000	2000	2000	2000
ForeCatch_2018 (t)	2862	2822	2835	2846	1449
ForeCatch_2019 (t)	2754	2659	2675	2702	1449
ForeCatch_2020 (t)	2685	2510	2531	2580	1463
ForeCatch_2021 (t)	2627	2366	2393	2466	1480
rec 2015 (1000s)	253	119	130	167	253
rec 2016 (1000s)	252	118	129	166	252
rec 2017 (1000s)	249	117	128	165	249
rec 2018 (1000s)	245	115	125	162	245
rec 2019 (1000s)	238	111	121	156	245
rec 2020 (1000s)	233	106	116	151	247



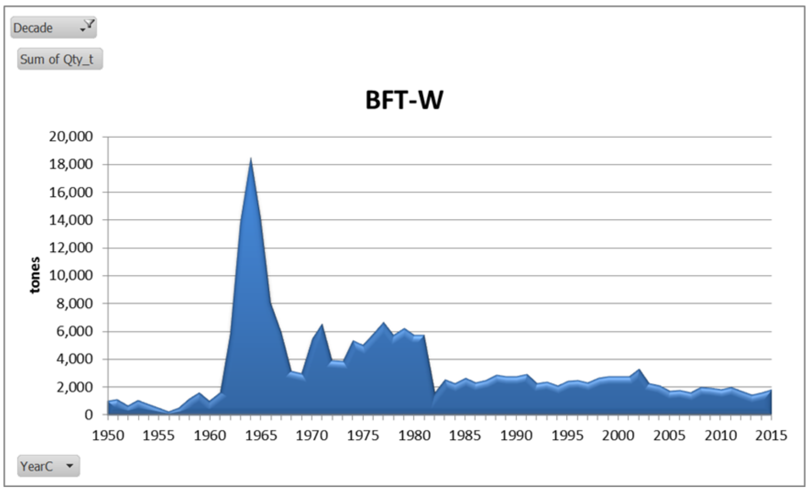


Figure 1. Bluefin tuna stocks best estimate of total catch removals 1950-2015.

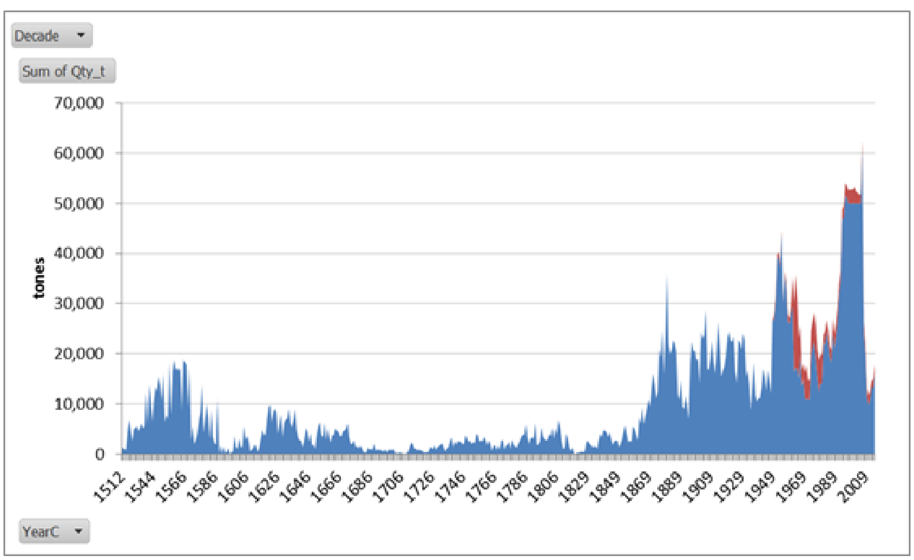


Figure 2. Atlantic bluefin tuna reconstructed catch 1512-2015. Blue area corresponds to the East stock, red to the West stock unit.

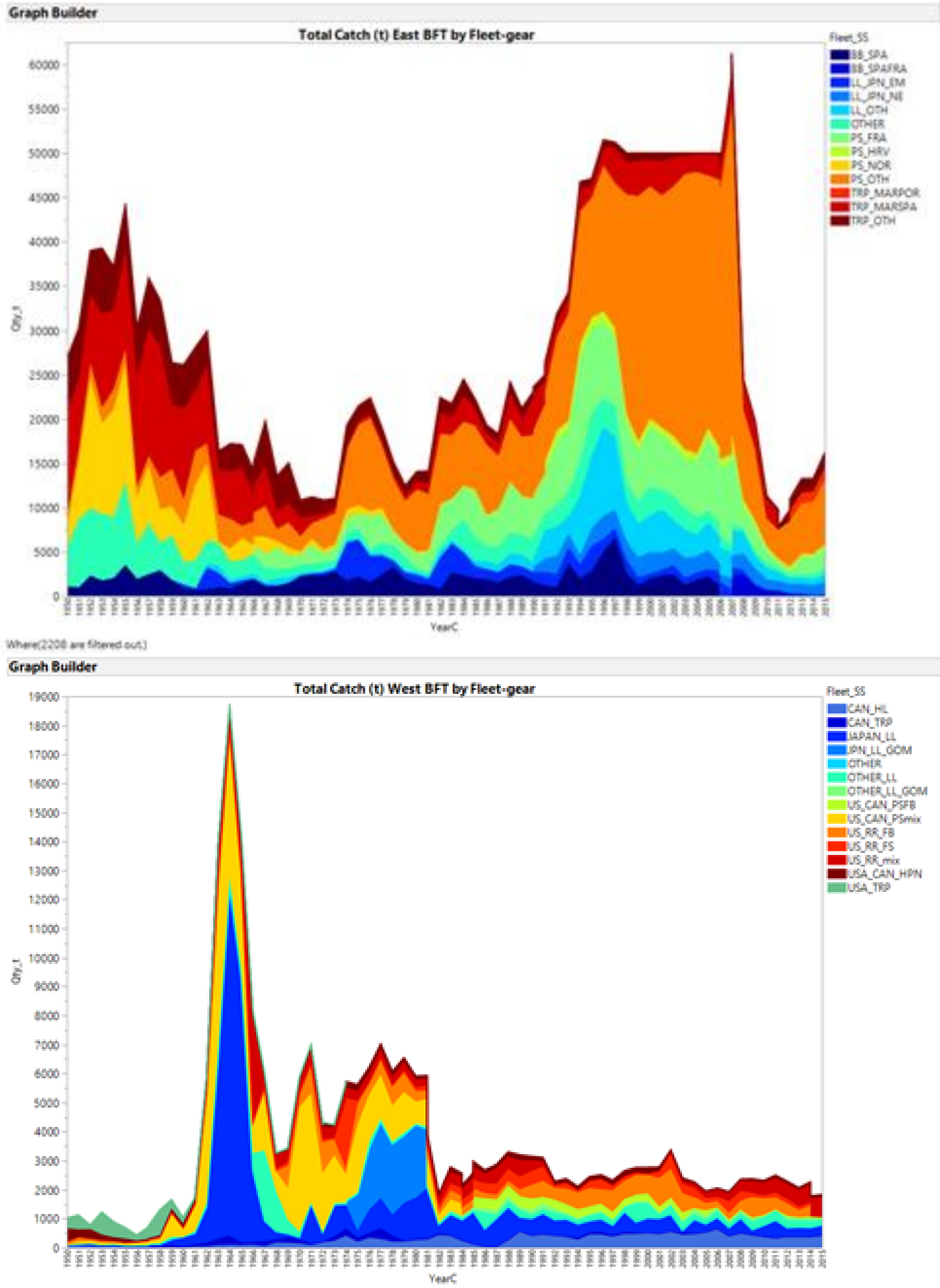


Figure 3. Total catch East (top) and West (bottom) BFT by fleet-gears categories used in catch statistical models.

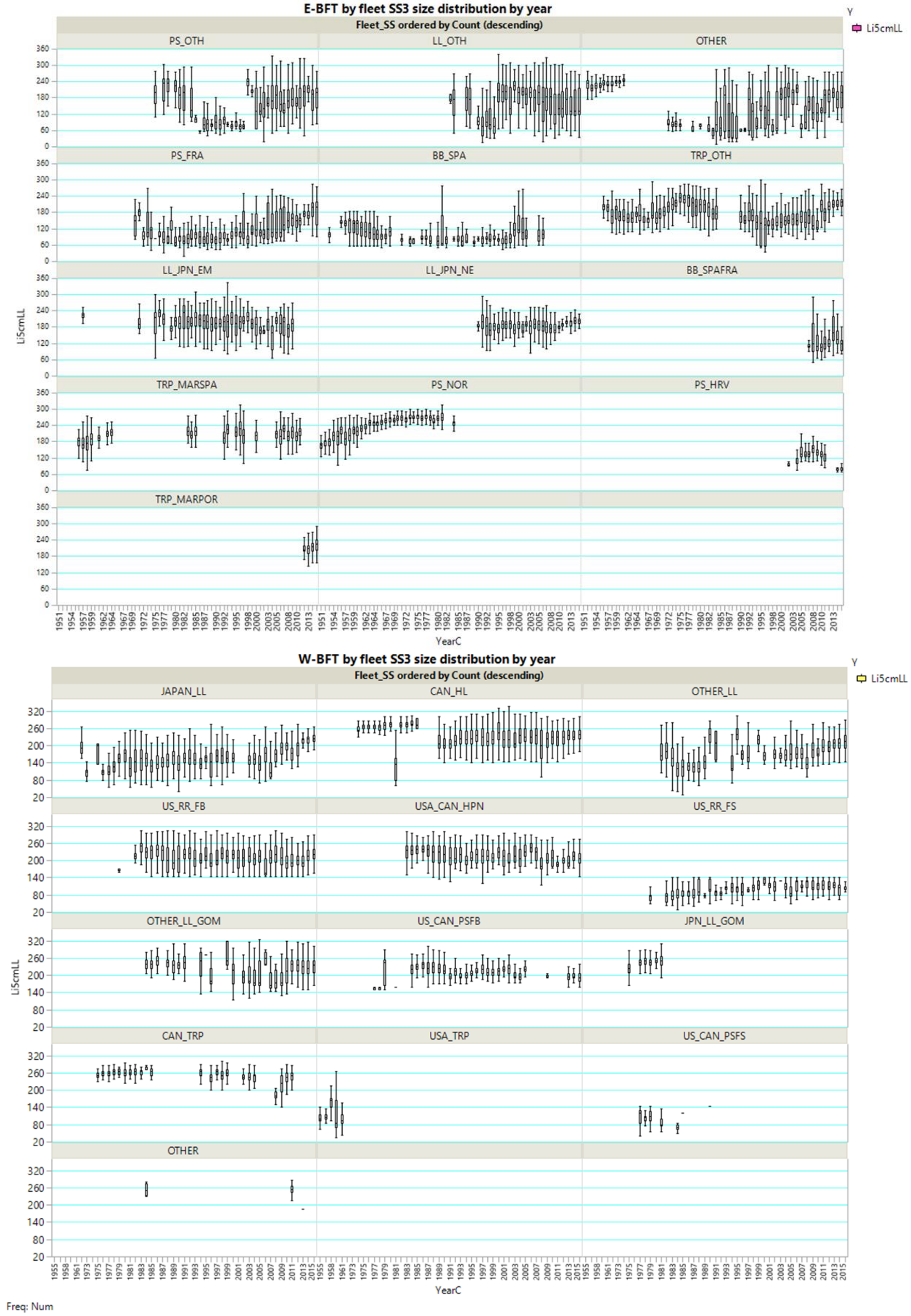


Figure 4. Bluefin tuna size frequency distribution by fleet-gear category used for stock synthesis models.

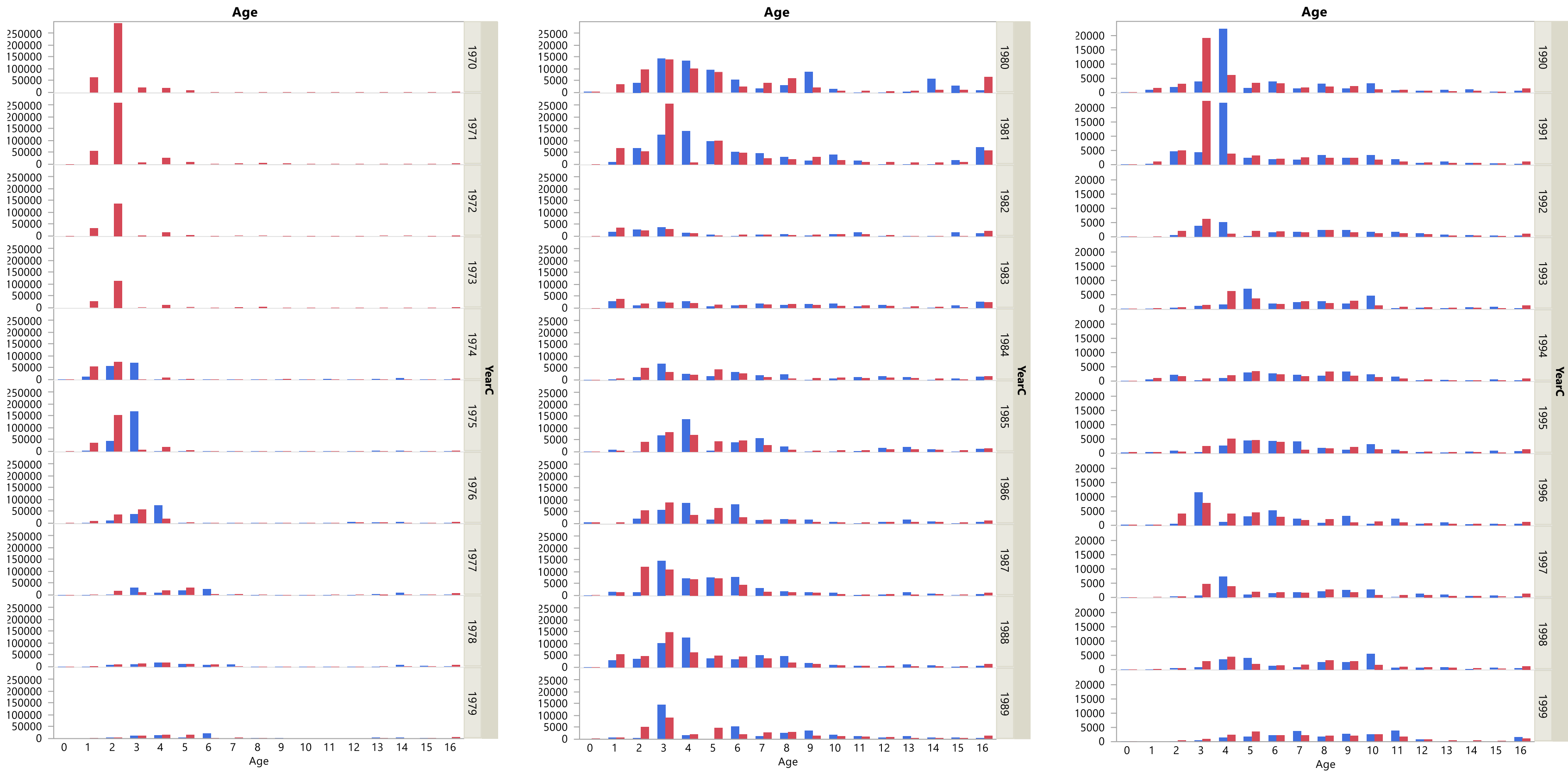


Figure 5. Histograms comparing the catch at age estimates from cohort slicing (red) and the combined forward inverse age-length key (blue).

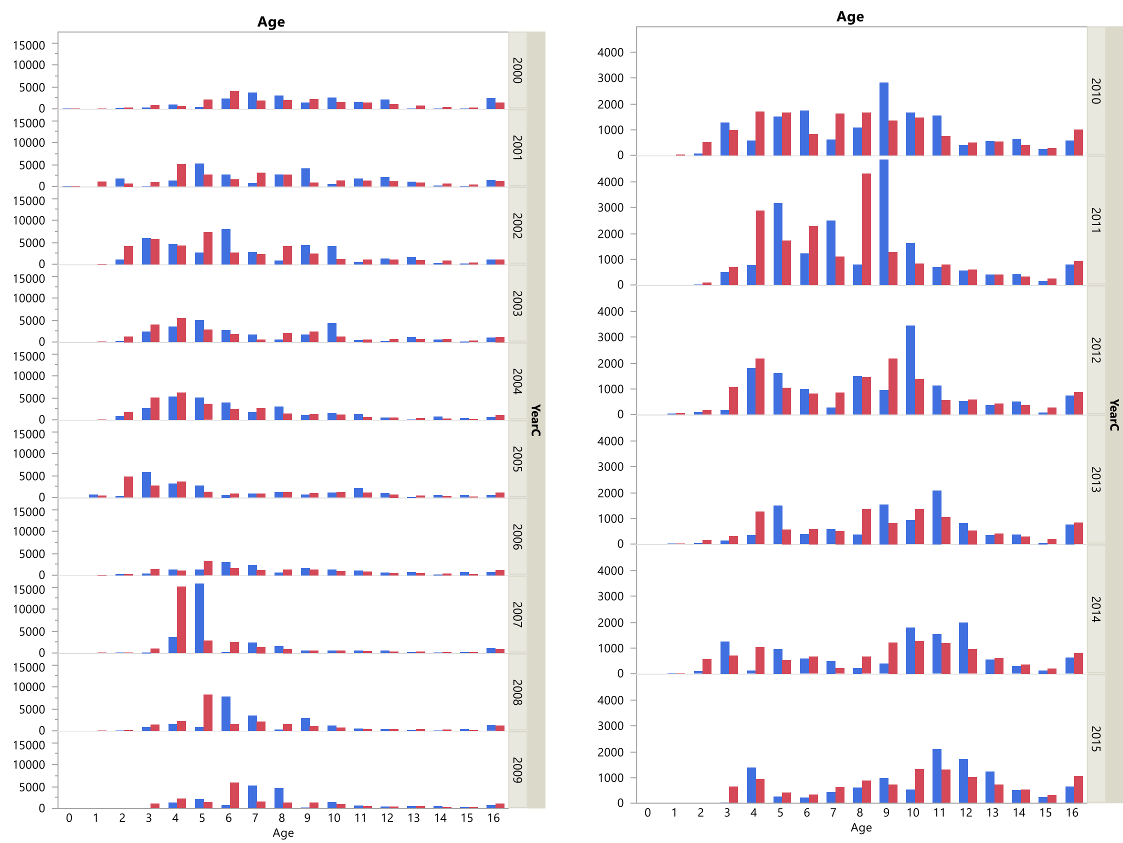


Figure 5. (continued) Histograms comparing the catch at age estimates from cohort slicing (red) and the combined forward inverse age-length key (blue).

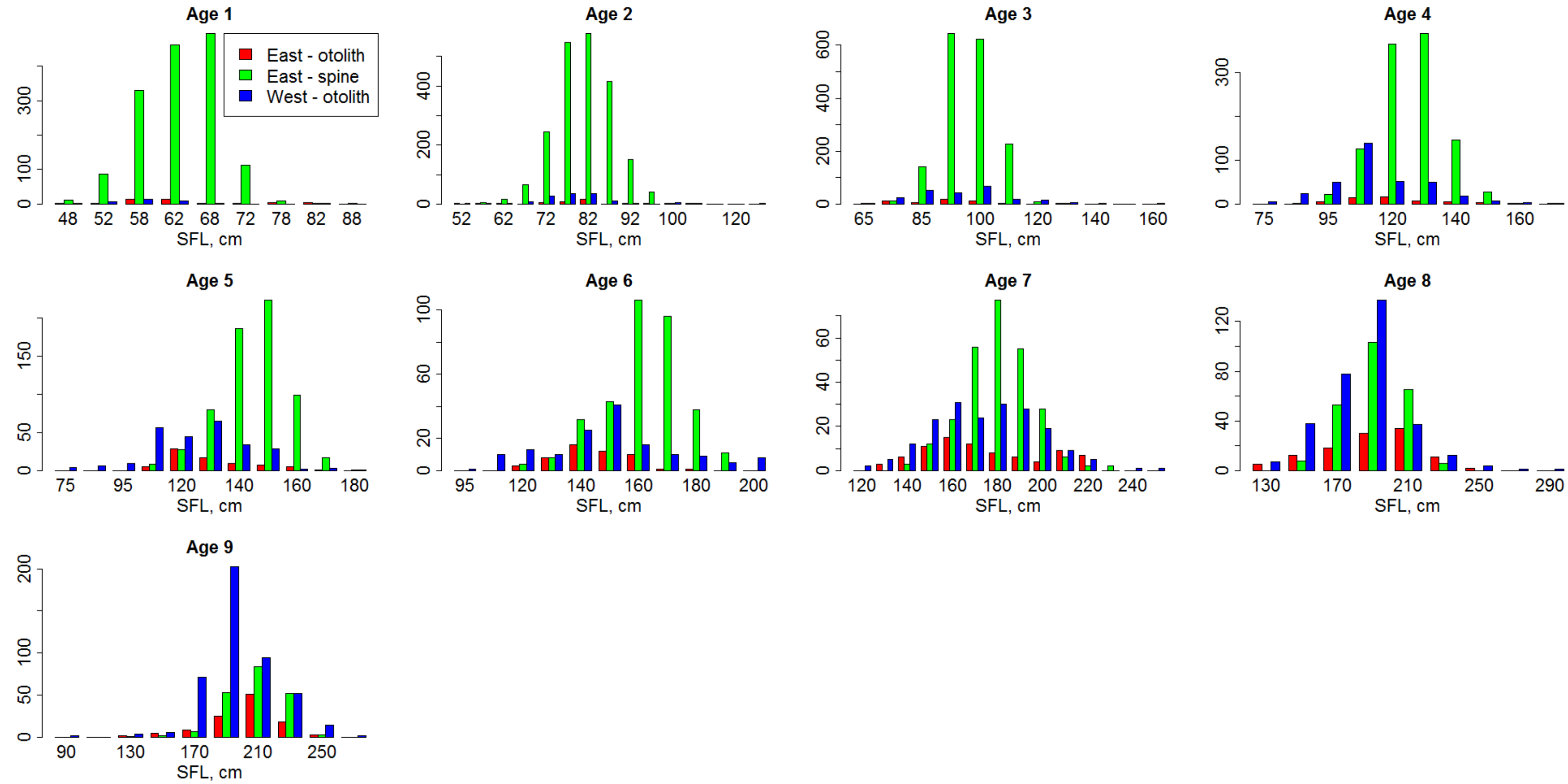


Figure 6. Histogram of eastern and western otolith and spine samples used in the combined forward inverse age-length key. Y-axis = number of samples.

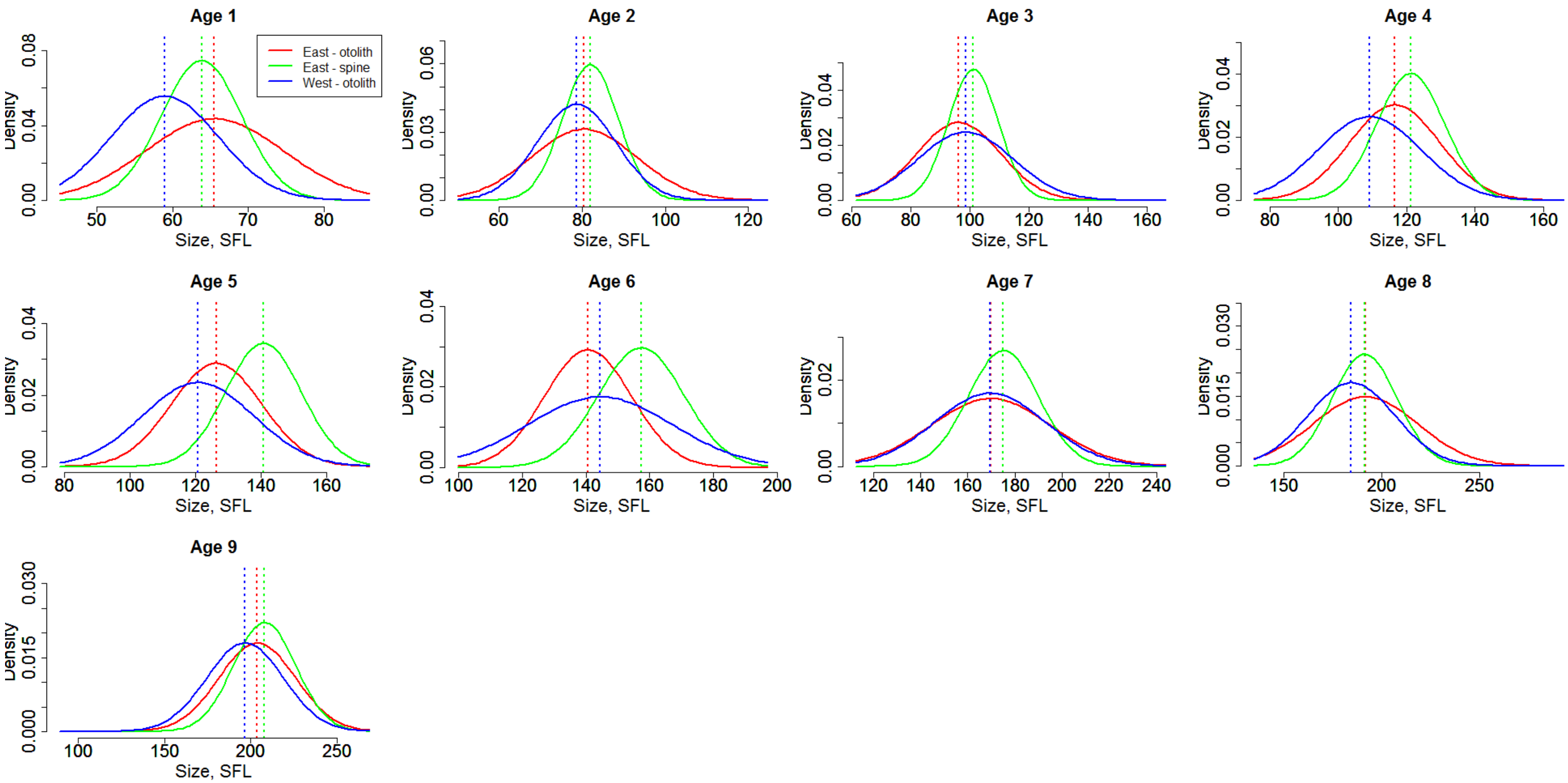


Figure 7. Normal distributions fitted to the eastern and western otolith and spine samples used in the combined forward inverse age-length key.

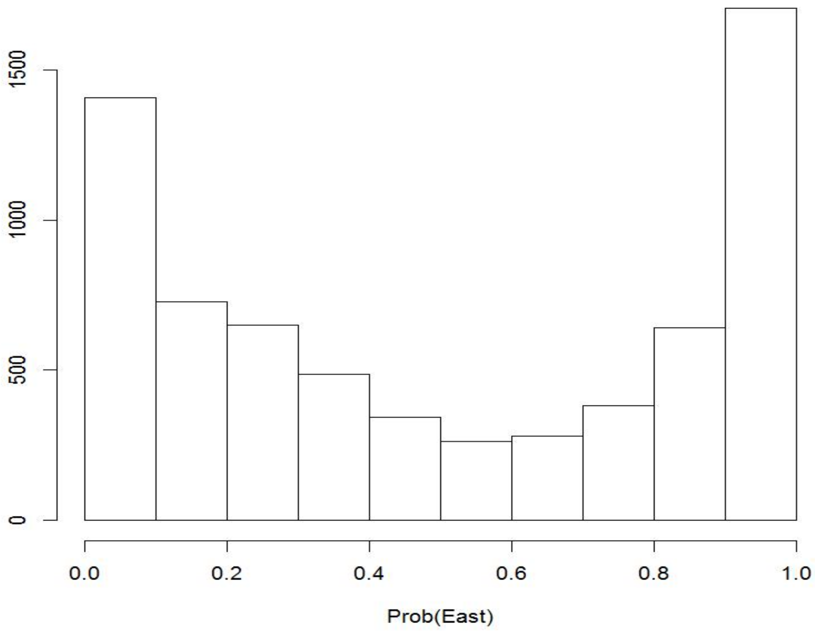


Figure 8. Histogram of stock composition data from the ICCAT Stock Composition Database indicating probability of being eastern origin.

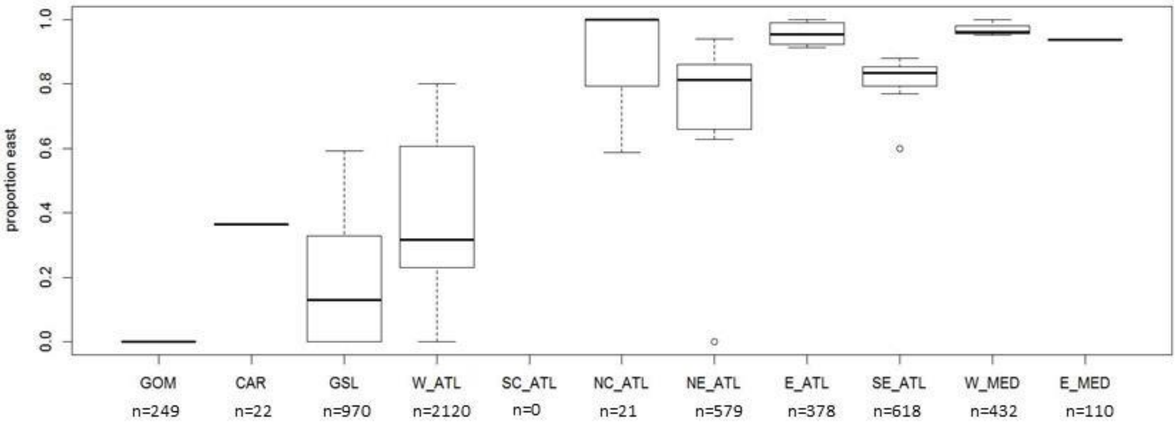


Figure 9. Boxplot of stock composition data from the ICCAT Stock Composition Database indicating proportion of eastern origin fish by area.

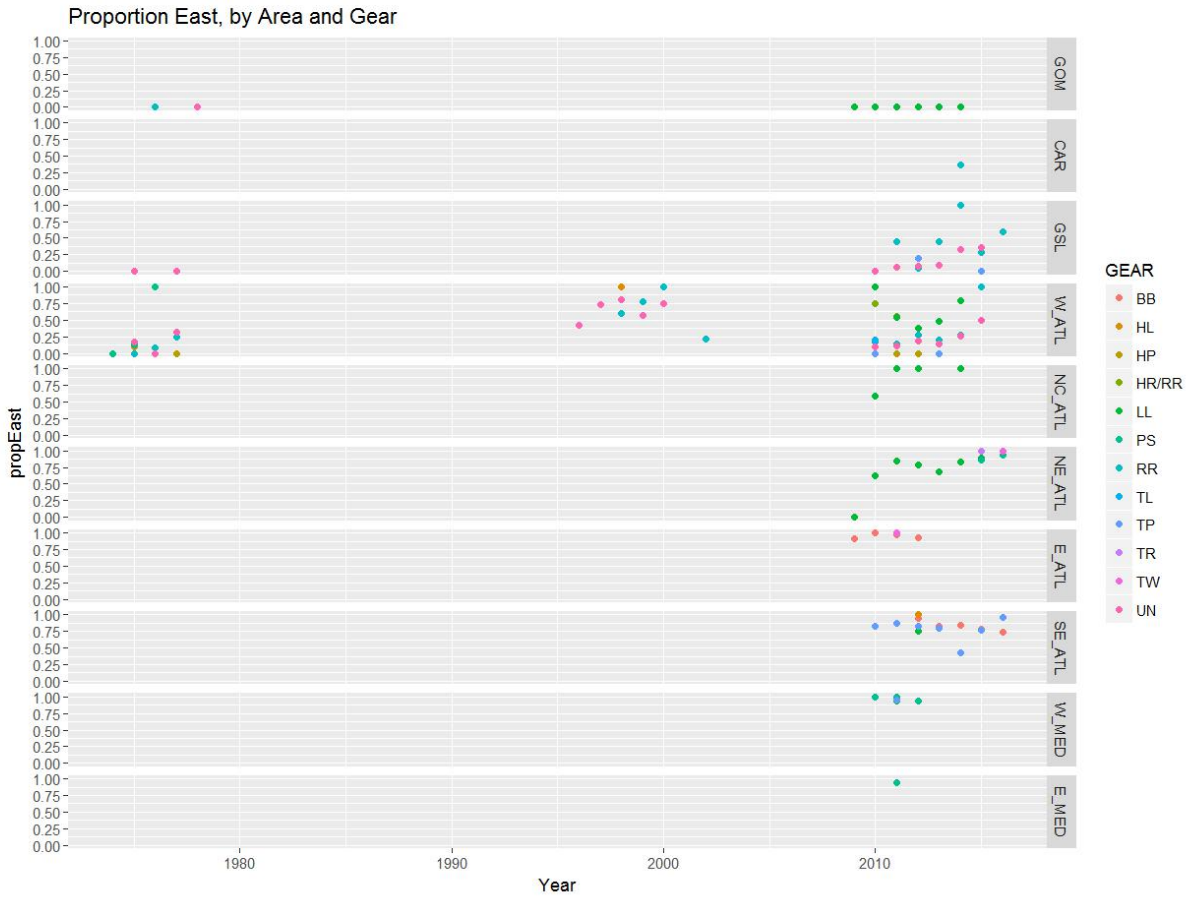


Figure 10. Estimated annual eastern proportions by area and gear from the ICCAT Stock Composition Database indicating proportion eastern origin.

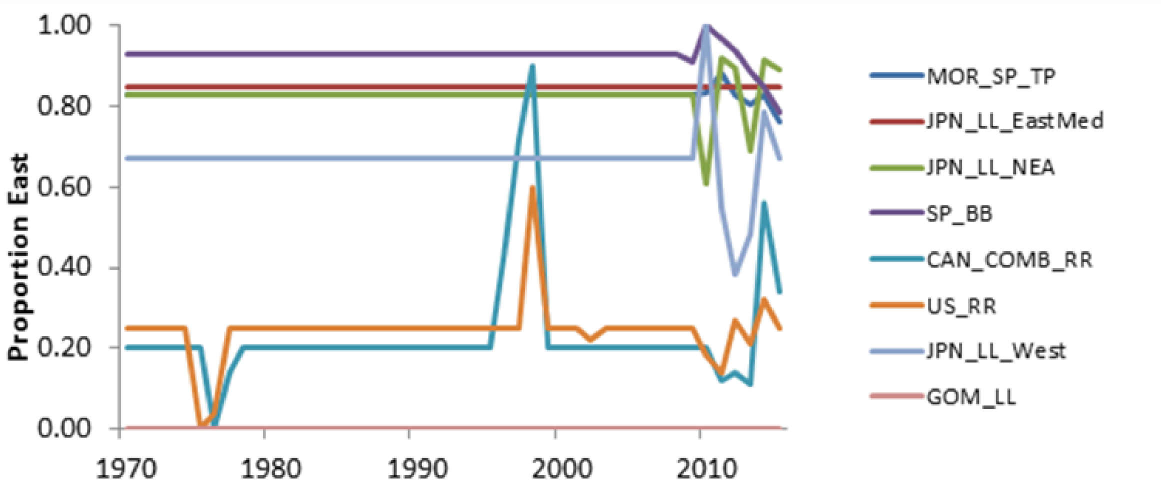


Figure 11. Estimated eastern proportions by year and fleet from the ICCAT Stock Composition Database.

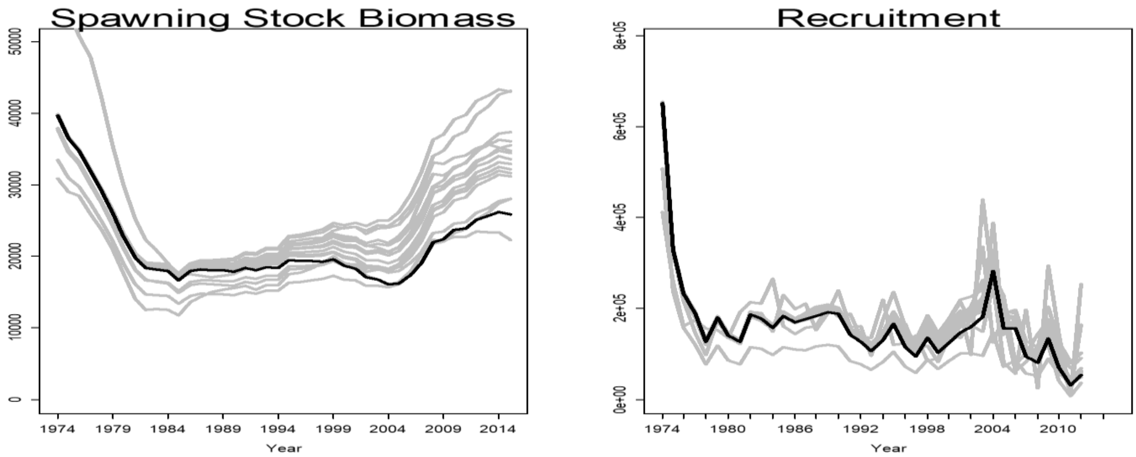


Figure 12. Estimates of SSB and recruitment for exploratory VPAs for the western stock (gray lines) compared to the eventual base case (black line).

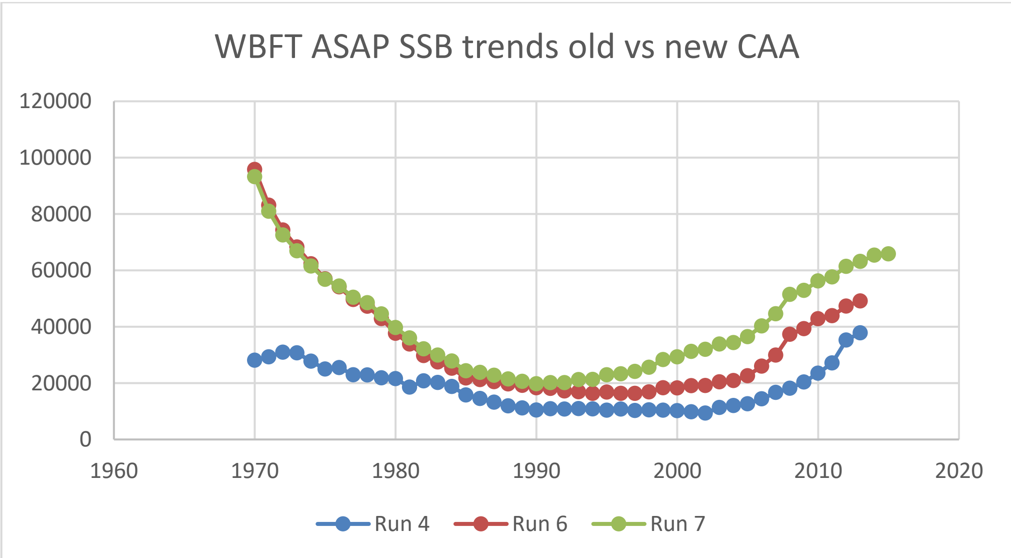


Figure 13. Effect of including the new CAA in ASAP runs for the western stock. Run 4 uses the 2014 CAA and stock size indices. Run 6 includes the new CAA and old stock size indices. Run 7 includes the new CAA and new stock size indices.

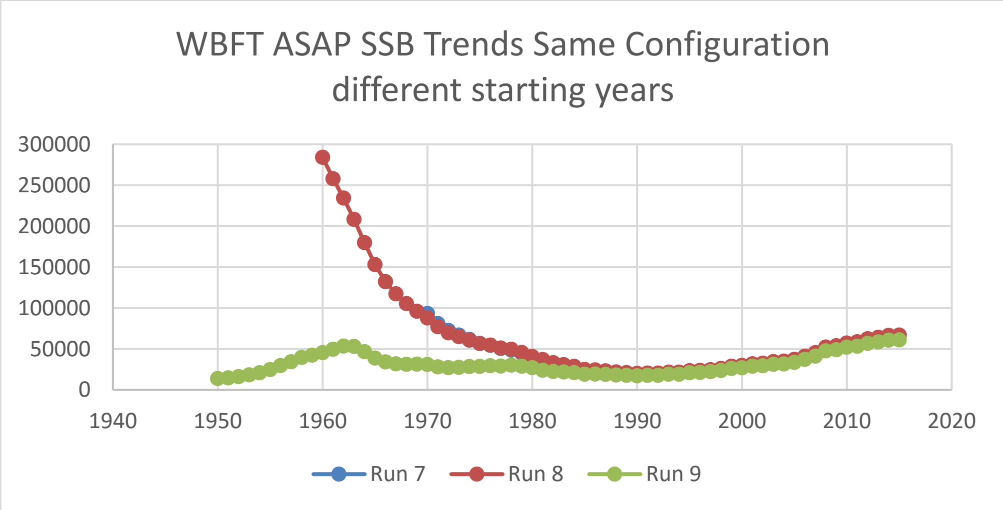


Figure 14. Effect of extending CAA to 1960 and 1950 in ASAP runs for the western stock. The discrepancy was later resolve in using lambda = 1 for initial numbers and CV=0.1.

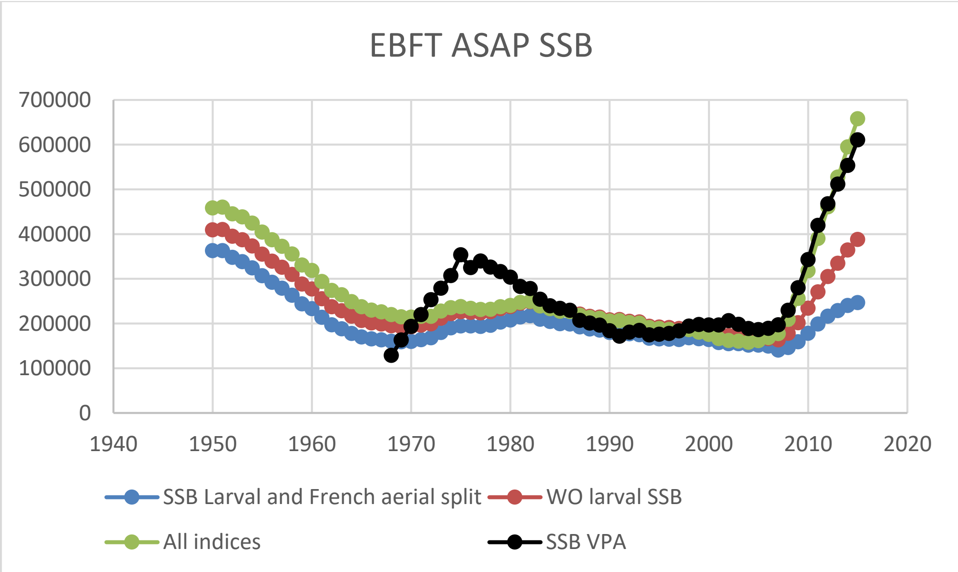


Figure 15. ASAP estimates of the SSB for the eastern stock with and without the larval index and when using split series for the larval index and the EU-France aerial survey

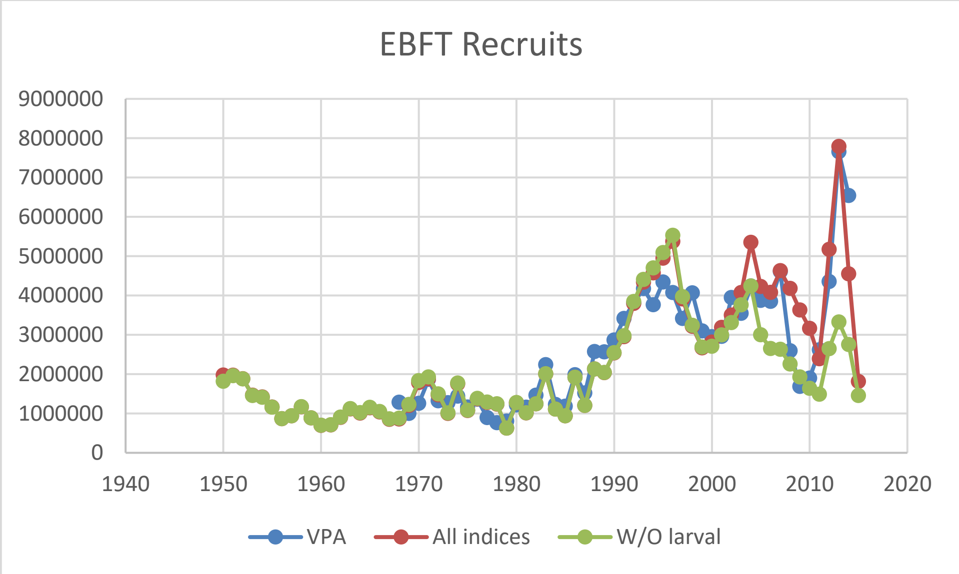


Figure 16.ASAP estimates of recruits (age 1) showing the influence of the Larval index. Removing the larval index reduces the size of the year classes after the 2003 year class.

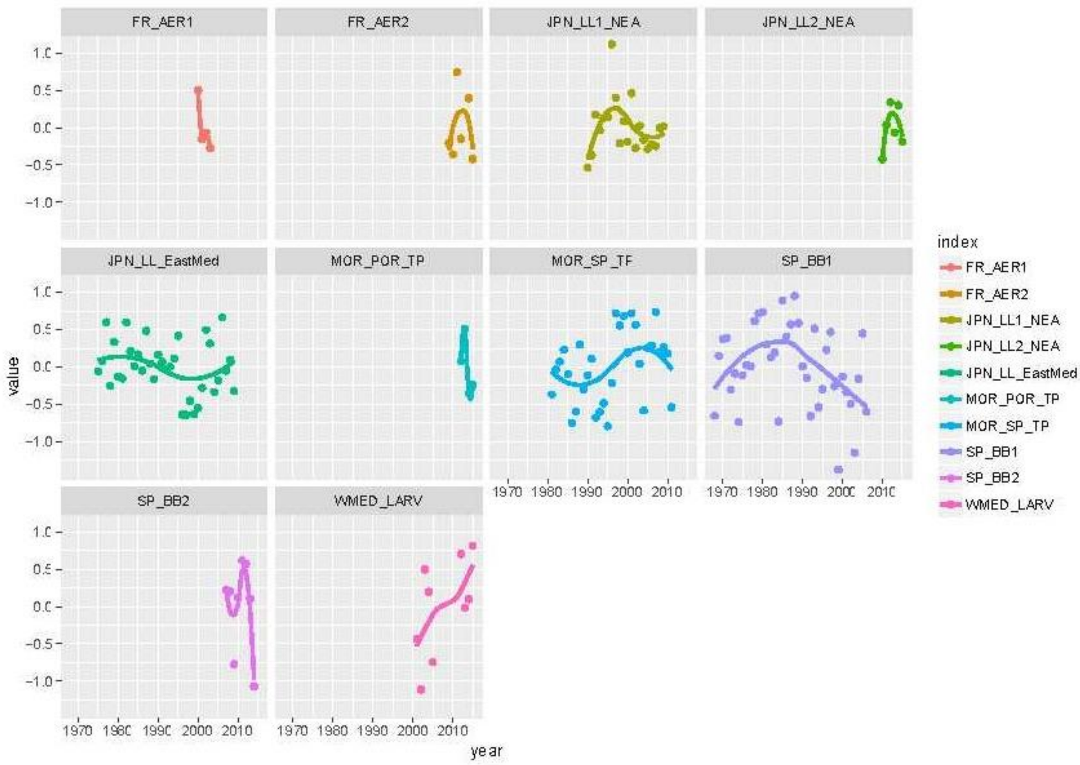


Figure 17. Fits to CPUE indices for the VPA base case for the eastern stock (observed shown as points, model predicted shown as lines).

Figure 18. Retrospective patterns in the VPA base case run for the eastern stock.

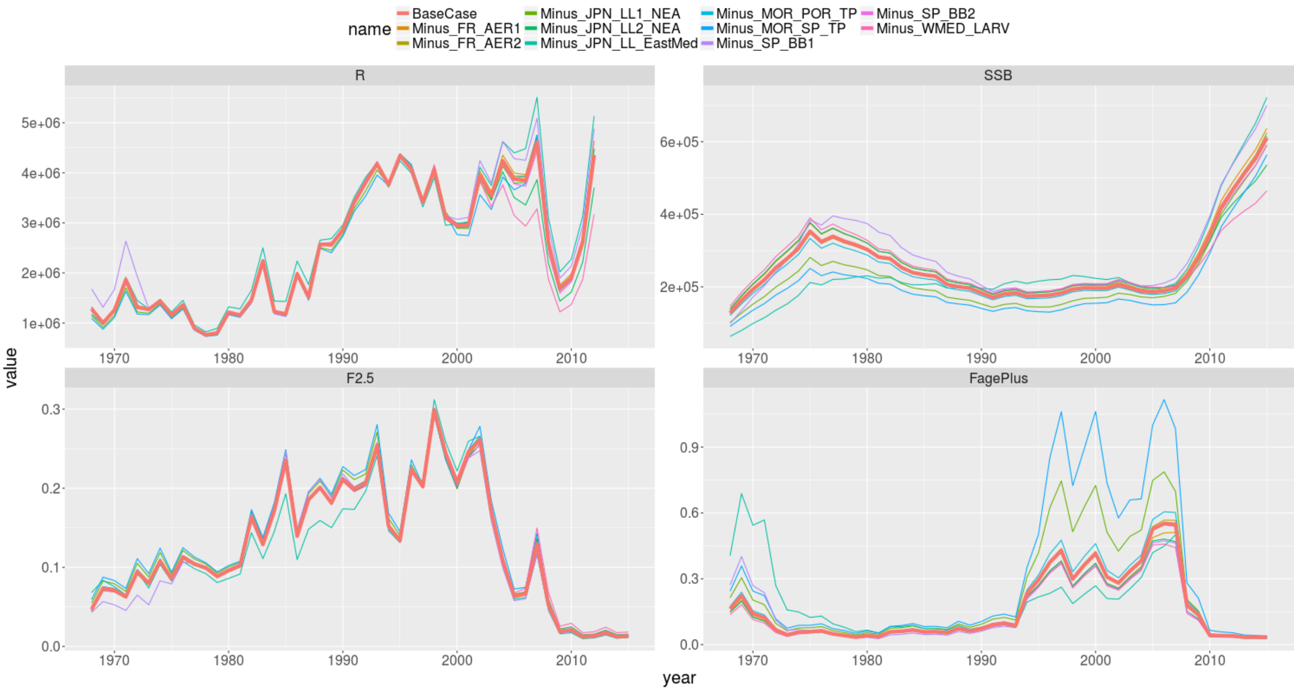


Figure 19. Jack-knife analysis demonstrating the effects of removing individual relative abundance indices from the VPA base case for the eastern stock.

Figure 20. Recruitment (in number of fish at age 1), spawning stock biomass (in metric tons), and fishing mortality (for ages 2 to 5 and 10+) estimates from VPA base case run for the eastern stock.

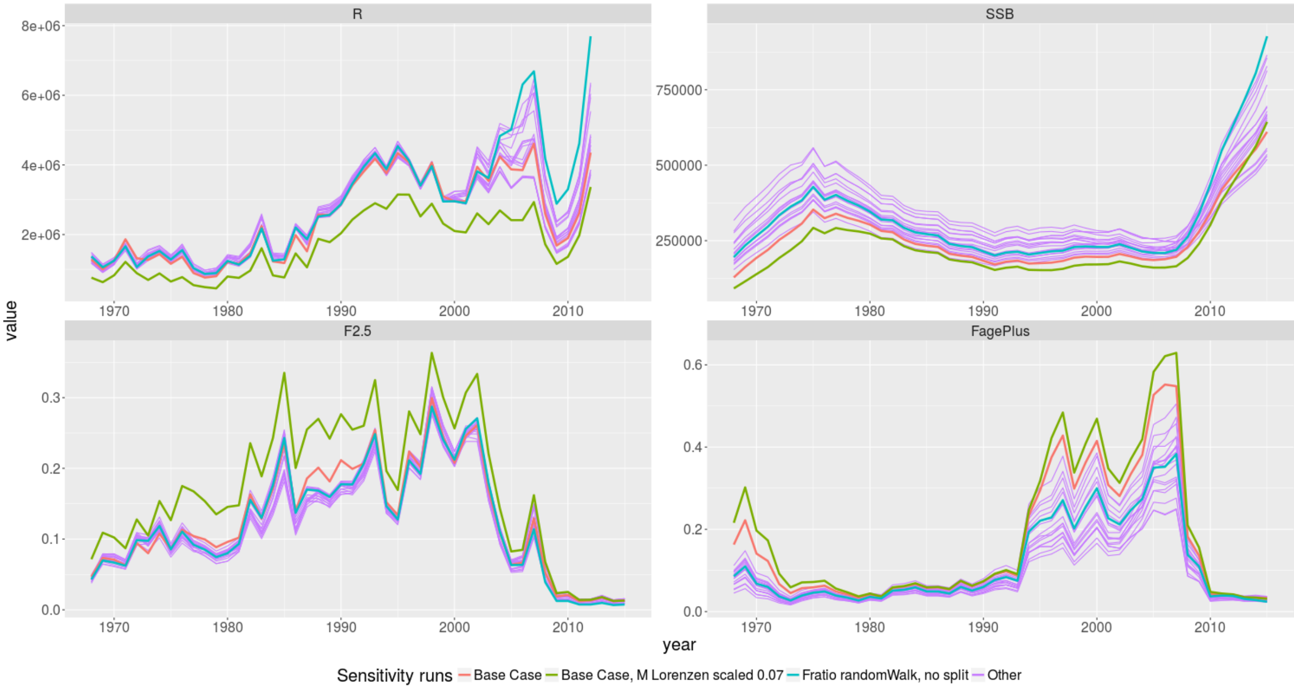


Figure 21. Sensitivity runs of the VPA against the base case for the eastern stock.

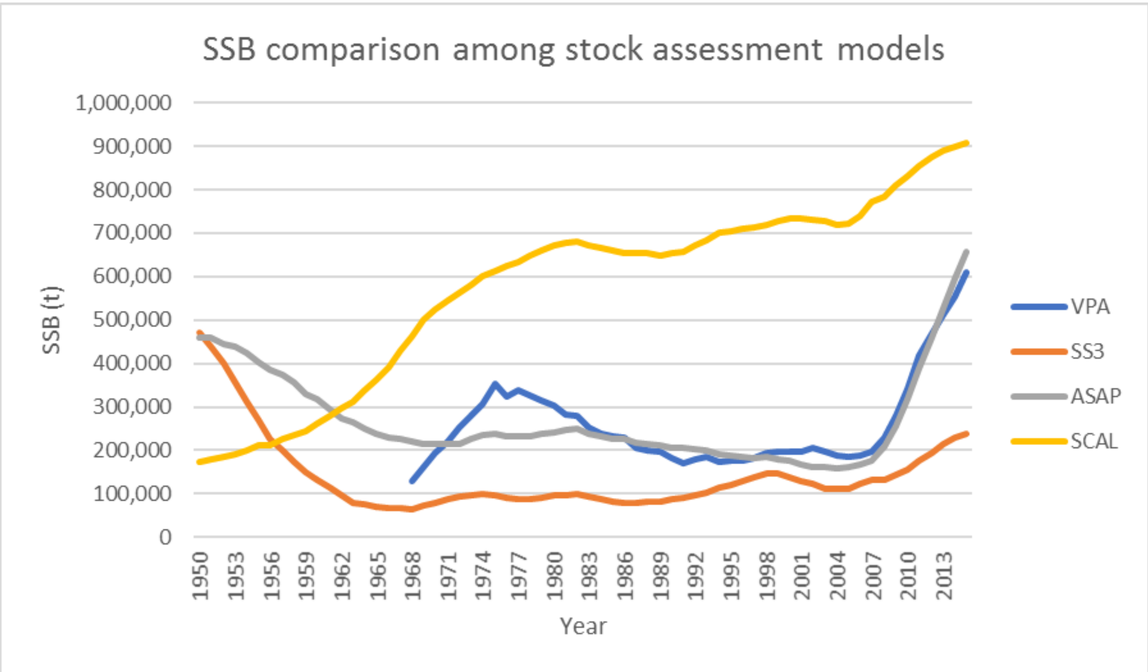


Figure 22. Spawning stock biomass (in metric ton) estimated by VPA and the other assessment models for the Eastern Atlantic and Mediterranean stock (assuming younger spawning). The base case or the most representative runs were used from each model.

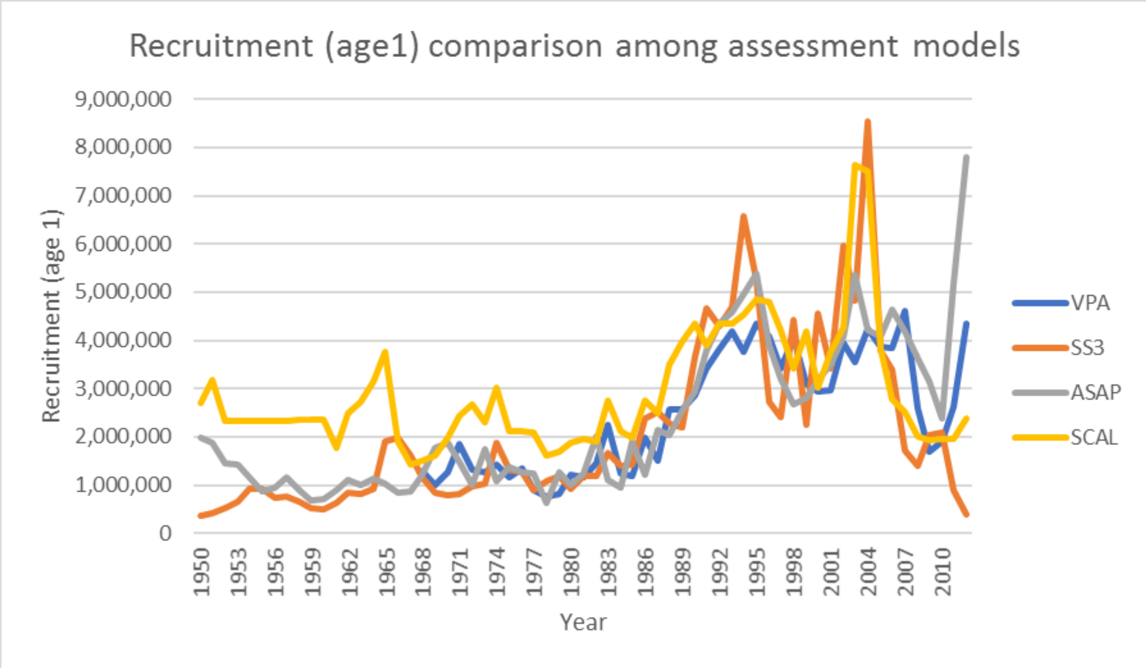


Figure 23. Recruitment (in number of fish at age 1) estimated by VPA and the other assessment models for the eastern stock. The base case or the most representative runs were used from each model.

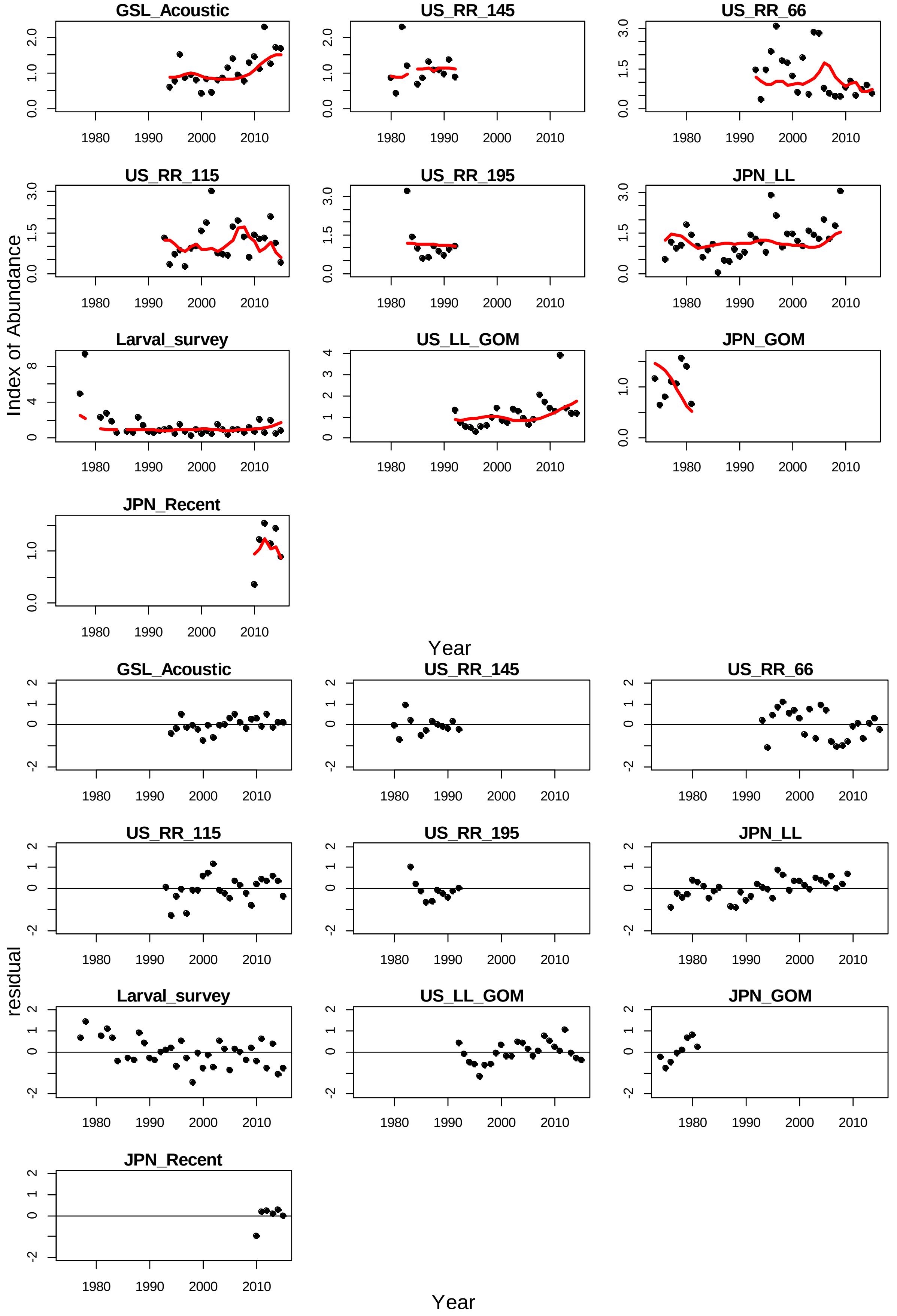


Figure 24. Fits to CPUE indices and model residuals for the VPA base case assessment of the western stock (observed shown as points, model predicted shown as lines).

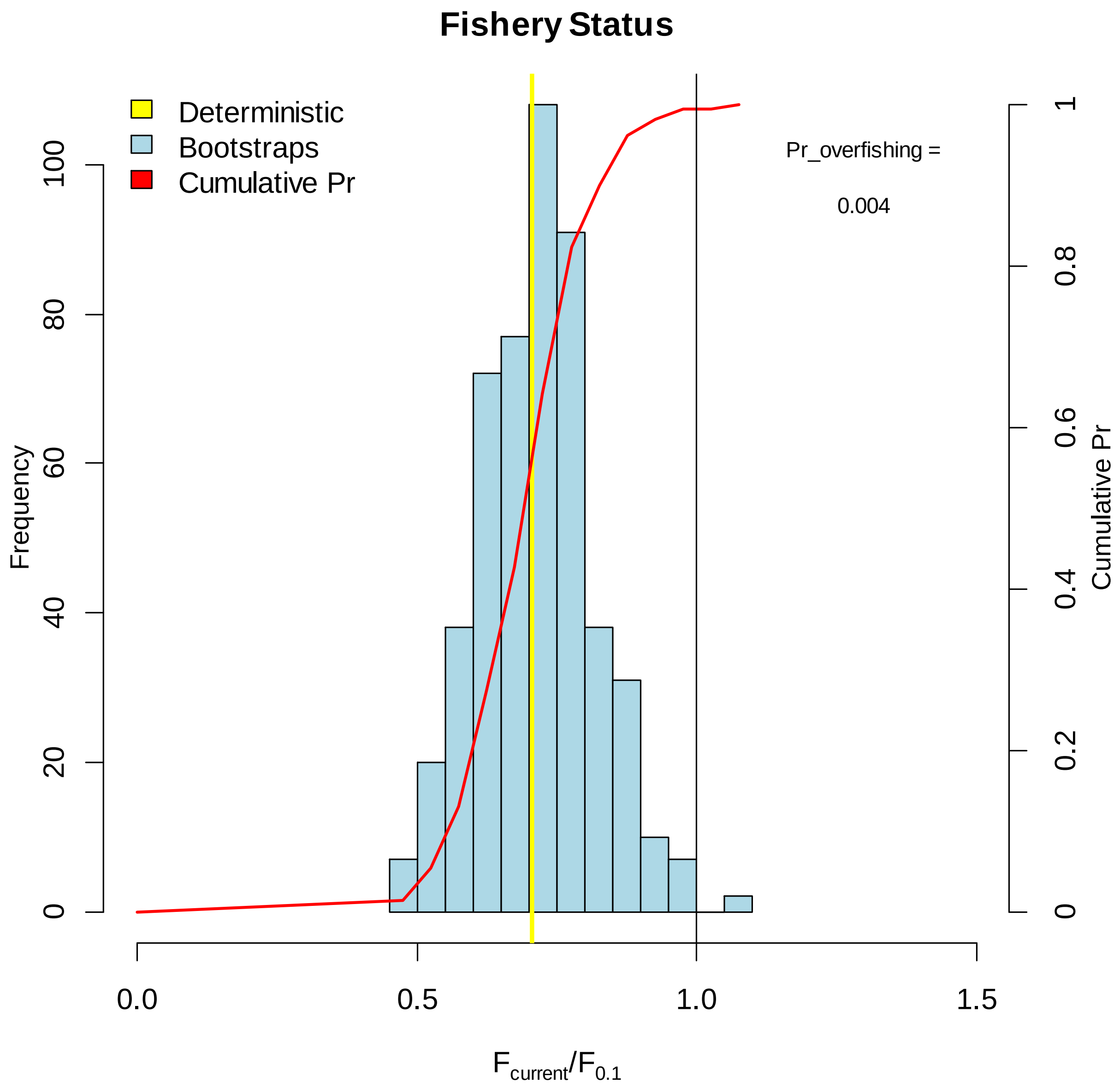


Figure 25. Distribution of bootstrapped estimates for the ratio of the geometric mean fishing mortality rate from 2012-2014 to $F_{0.1}$ (histogram and red cumulative frequency curve) compared to the maximum likelihood (deterministic) estimate (yellow) for the VPA base case assessment of the western stock.

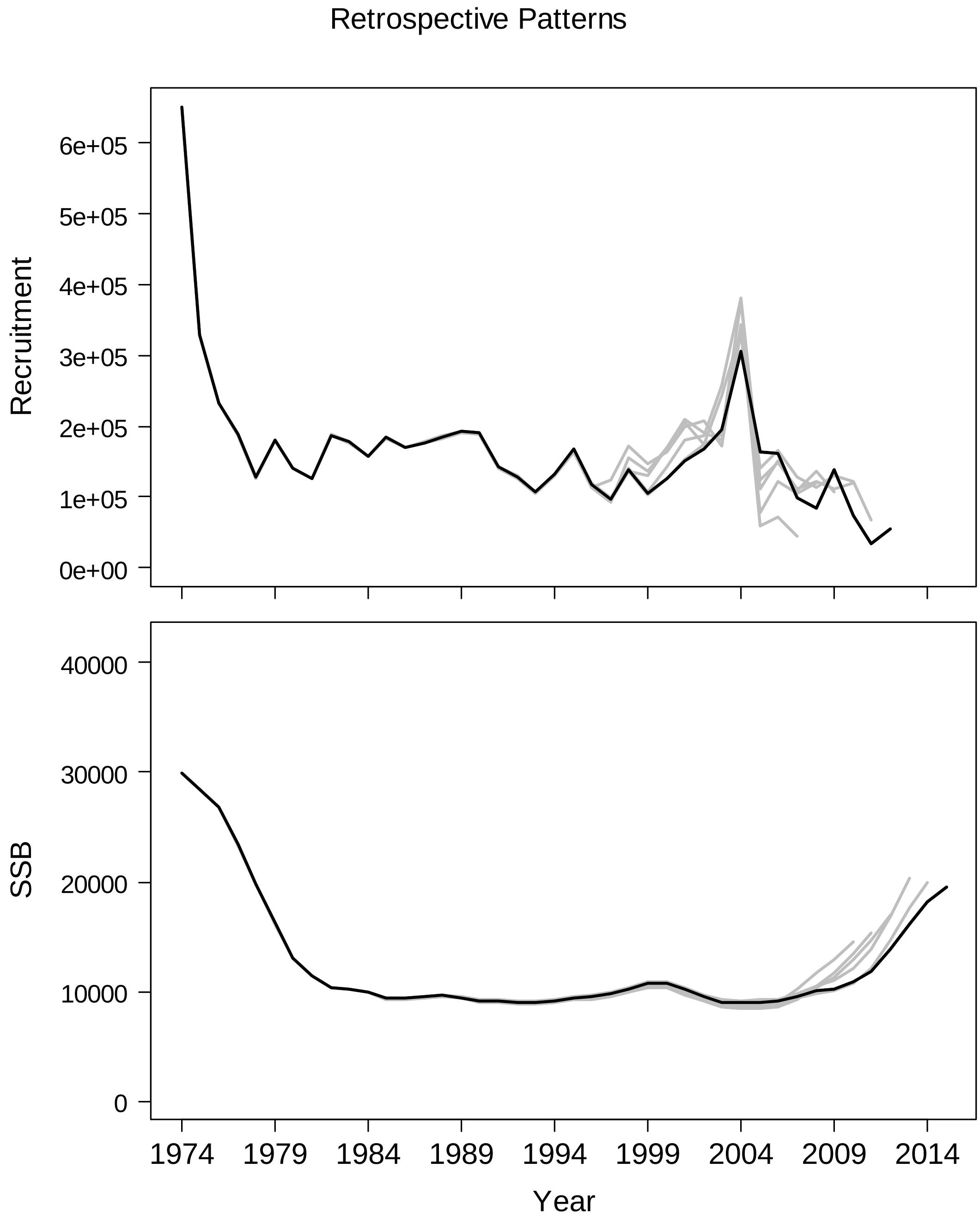


Figure 26. Retrospective patterns of recruitment and spawning biomass (calculated assuming older spawning) in the VPA base case assessment of the western stock.

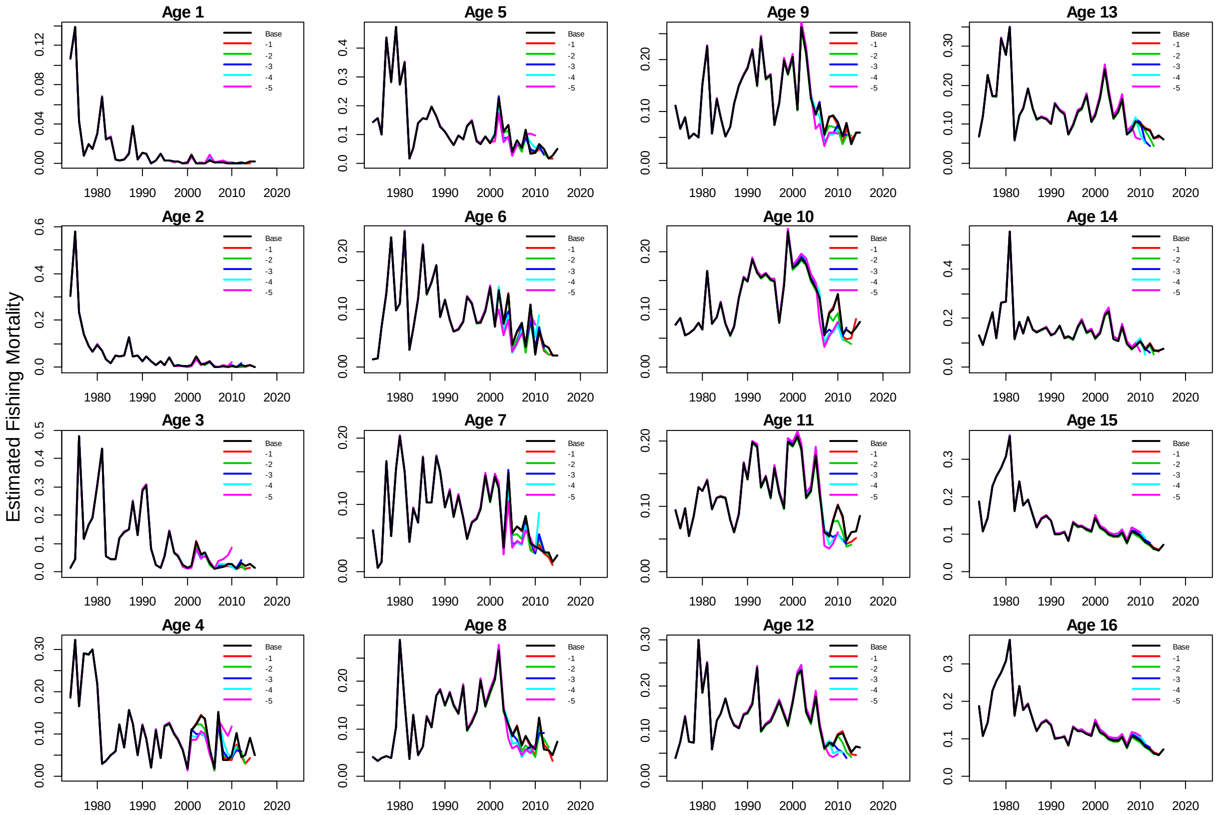


Figure 27. Retrospective patterns in the VPA base case estimates of the fishing mortality rate on the western stock.

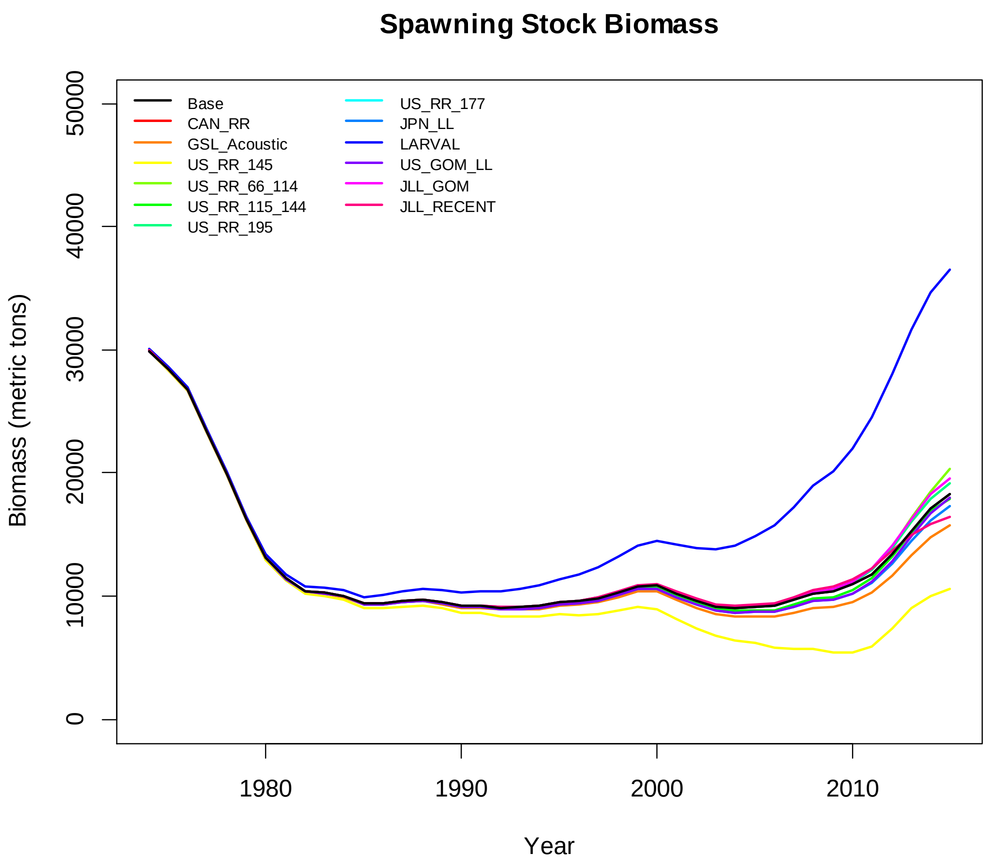
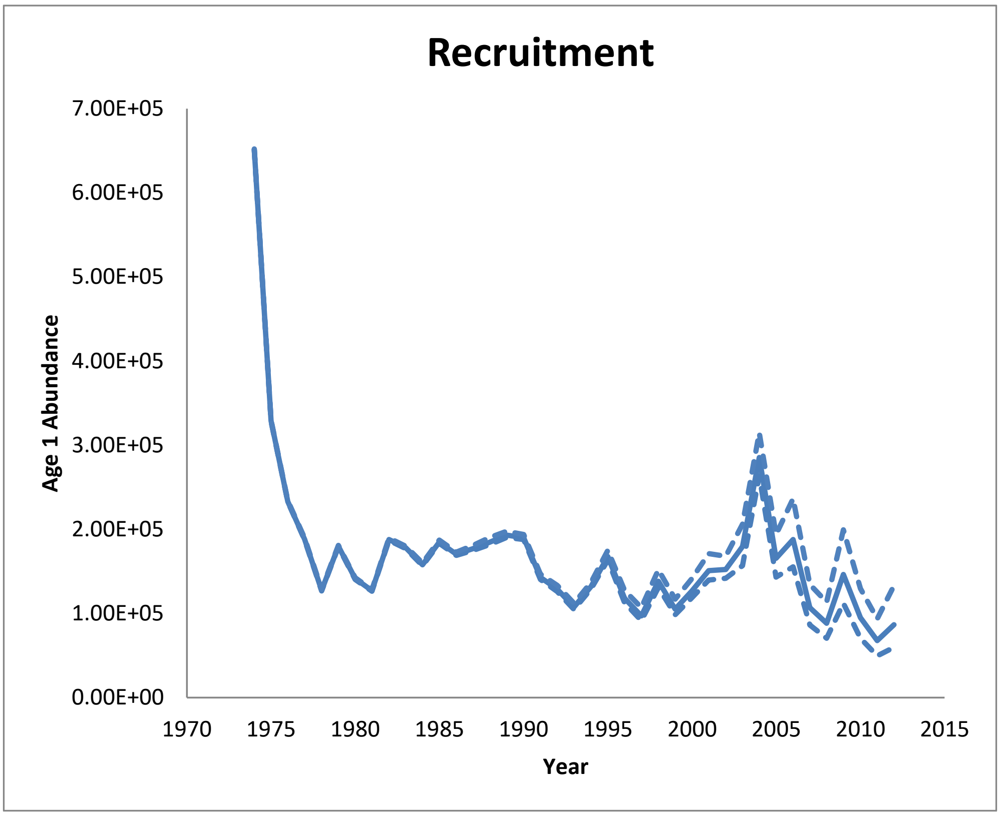


Figure 28. Jack-knife analysis demonstrating the effects of removing individual relative abundance indices from the VPA base case for the western stock. Spawning biomass is calculated here assuming older spawning.



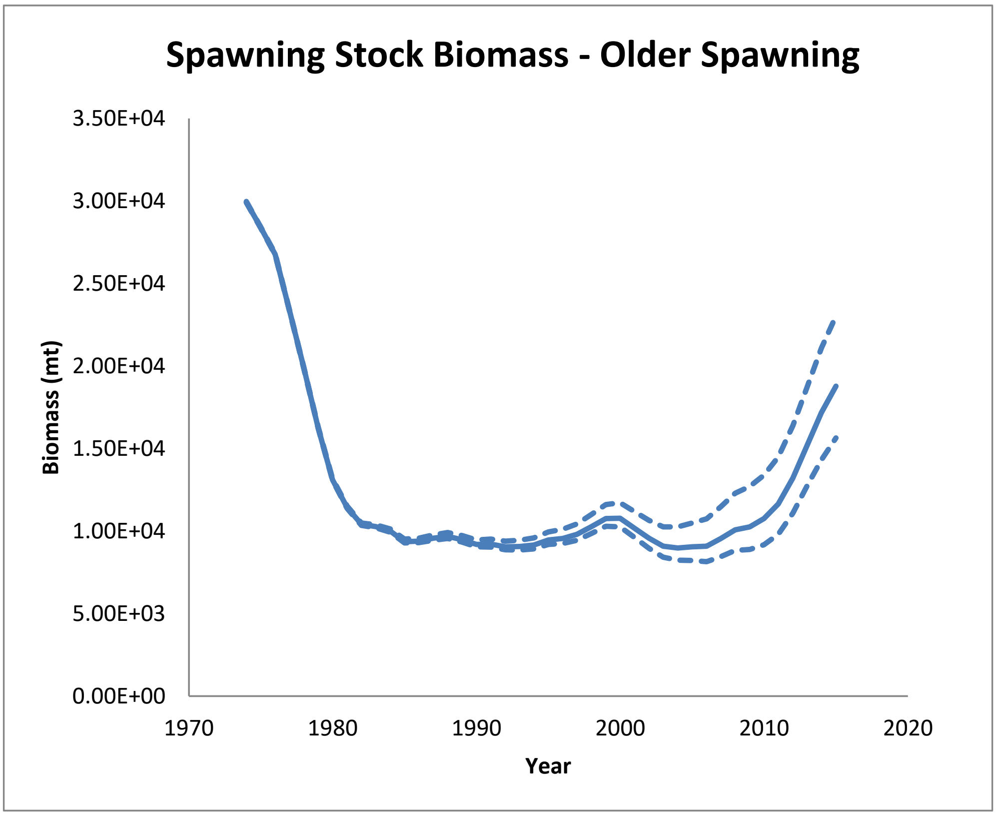
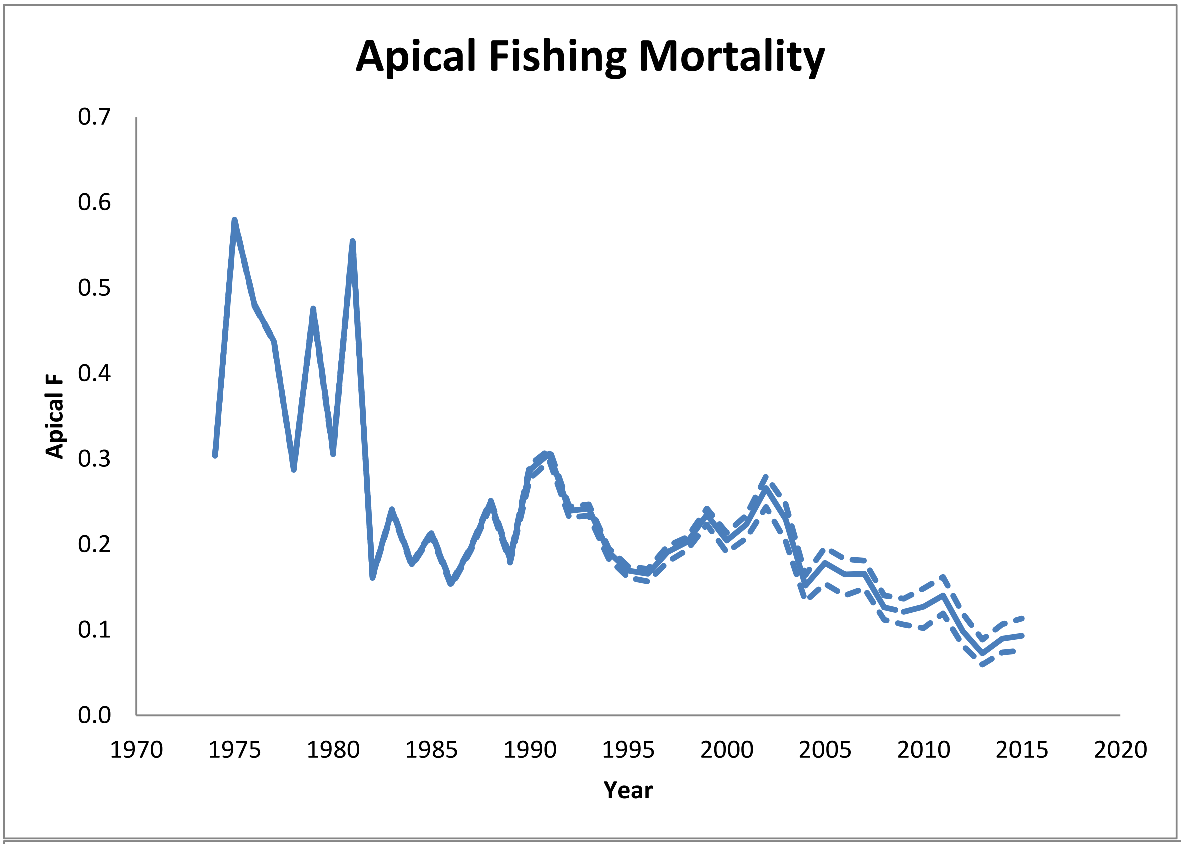


Figure 29. VPA base case estimates of the spawning biomass (assuming older spawning) and recruitment (age 1) for the western stock with 80% confidence intervals derived by bootstrapping.



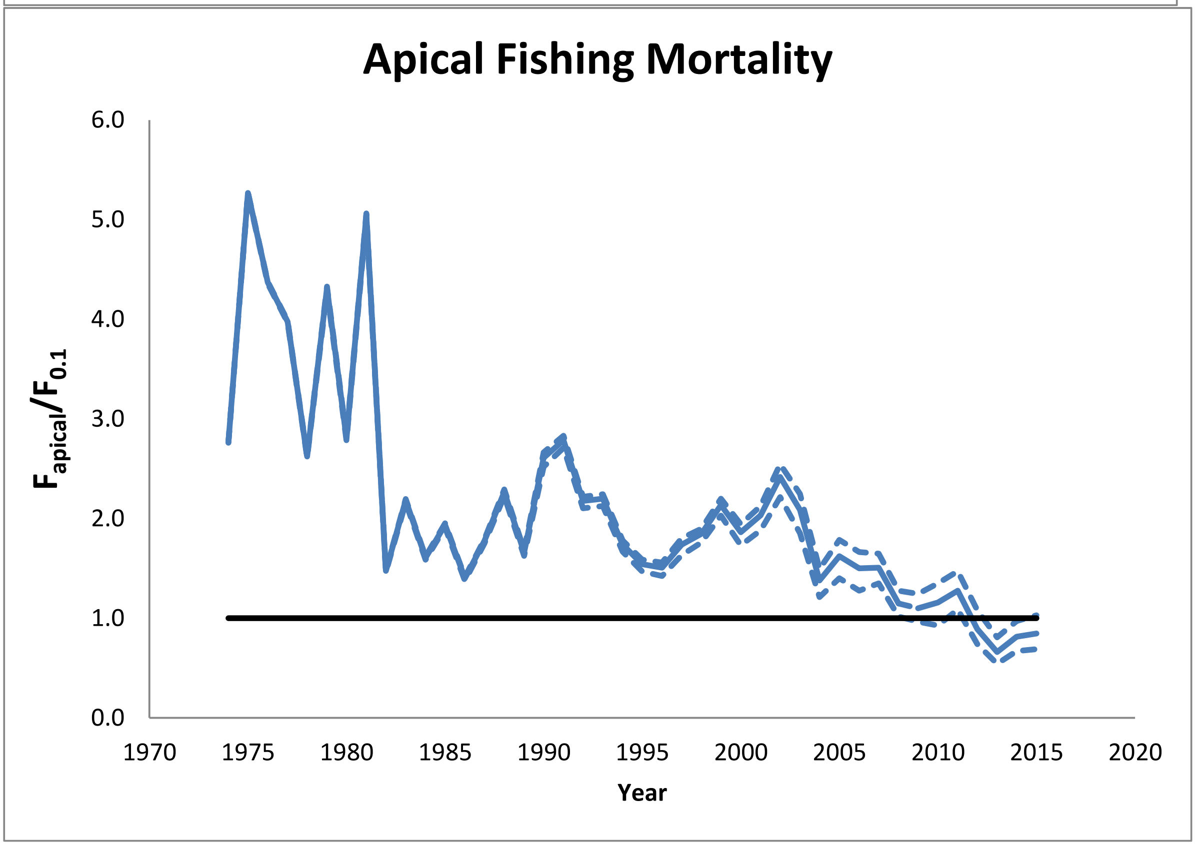
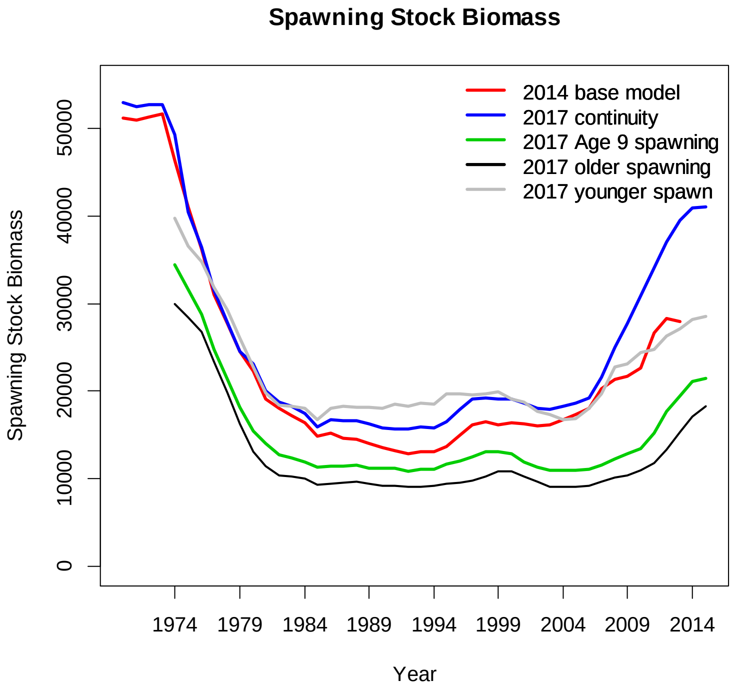


Figure 30. VPA base case estimates of the apical fishing mortality rate on the western stock with 80% confidence intervals derived by bootstrapping. Top graph gives the absolute scale and the bottom graph gives the values relative to $F_{0.1}$.



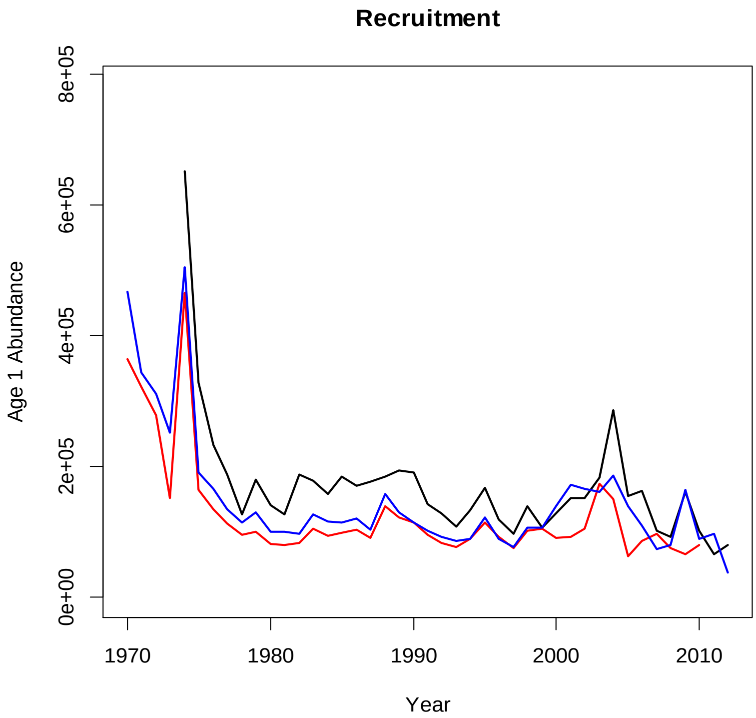


Figure 31. Comparison of 2017 base VPA (black: older spawning, and grey: younger spawning), 2017 continuity VPA (blue and green) and 2014 base VPA (red) for the western stock.

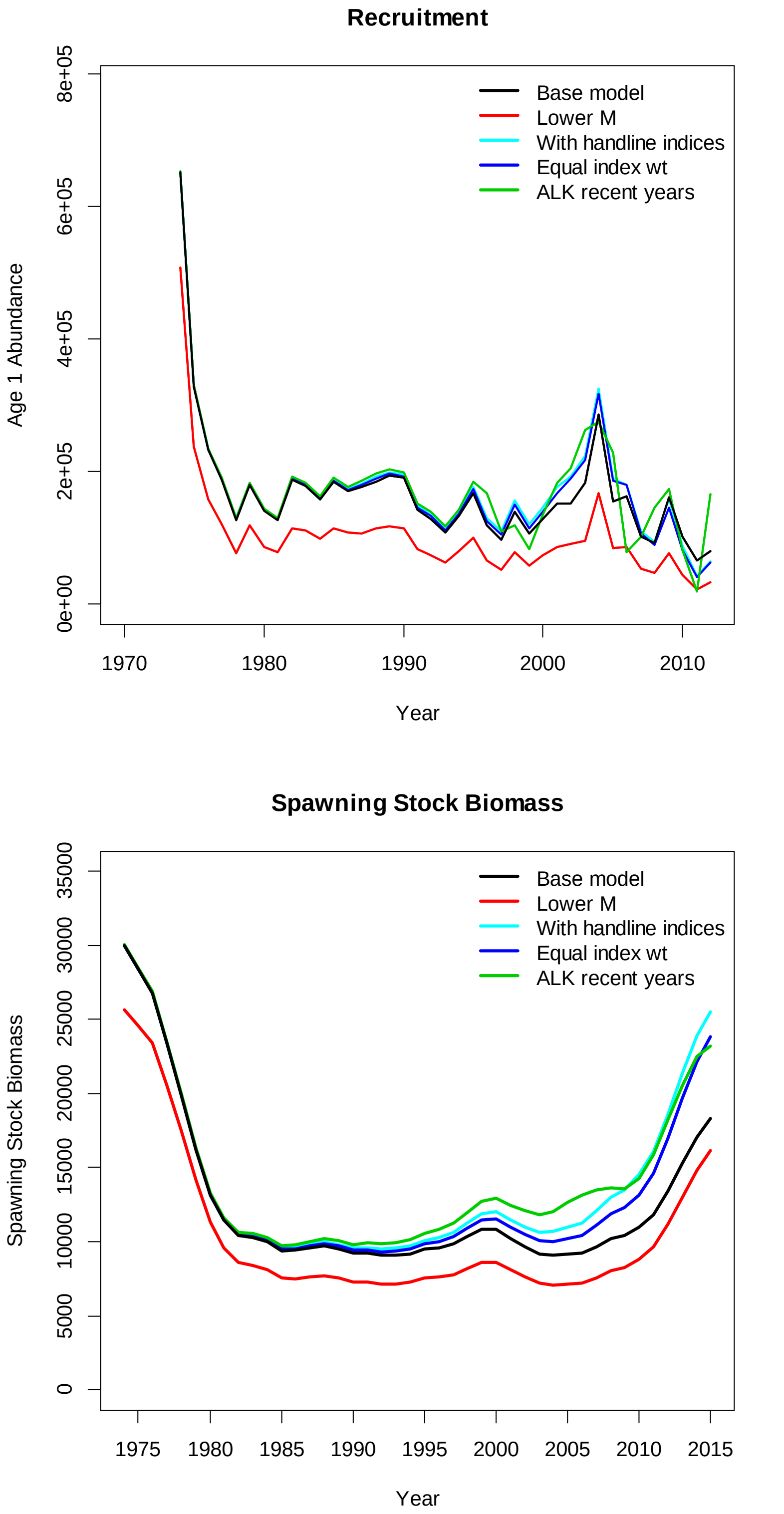


Figure 32 VPA results of **s**ensitivity runs for the western stock (coloured lines) compared to the base case (black) when the older spawning ogive is used to calculate SSB: lower natural mortality rate M (red), equal weighting of indices of abundance (dark blue), including the CAN_Combined_RR and US_RR>177 CPUE ('With_handlines_indices', light blue), and catch-at-age estimated with and age-length key (ALK) for 2010 to 2015 (green).

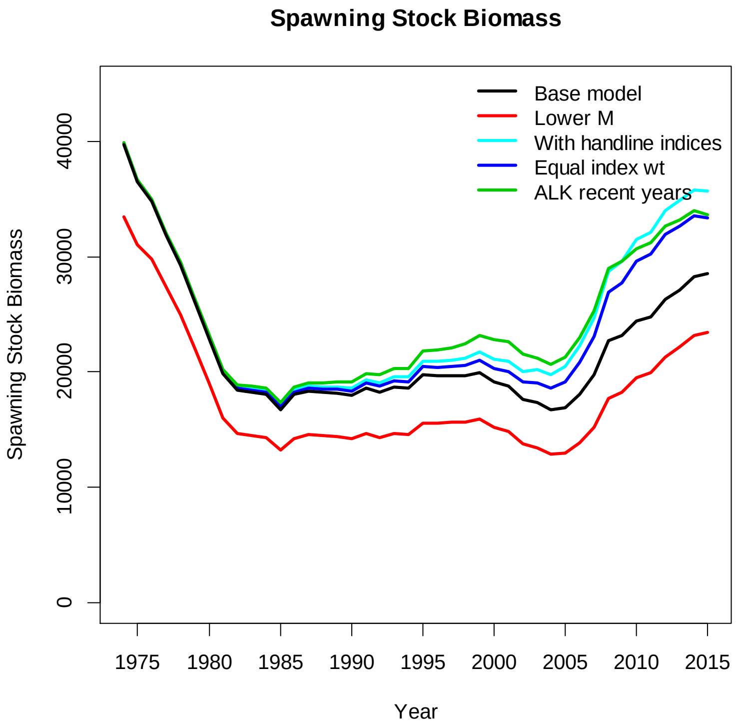


Figure 33. VPA results of **s**ensitivity runs for the western stock (coloured lines) compared to the base case (black) when the younger spawning ogive is used to calculate SSB: lower natural mortality rate M (red), equal weighting of indices of abundance (dark blue), including the CAN_Combined_RR and US_RR>177 CPUE ('With_handlines_indices', light blue), and catch-at-age estimated with and age-length key (ALK) for 2010 to 2015 (green).

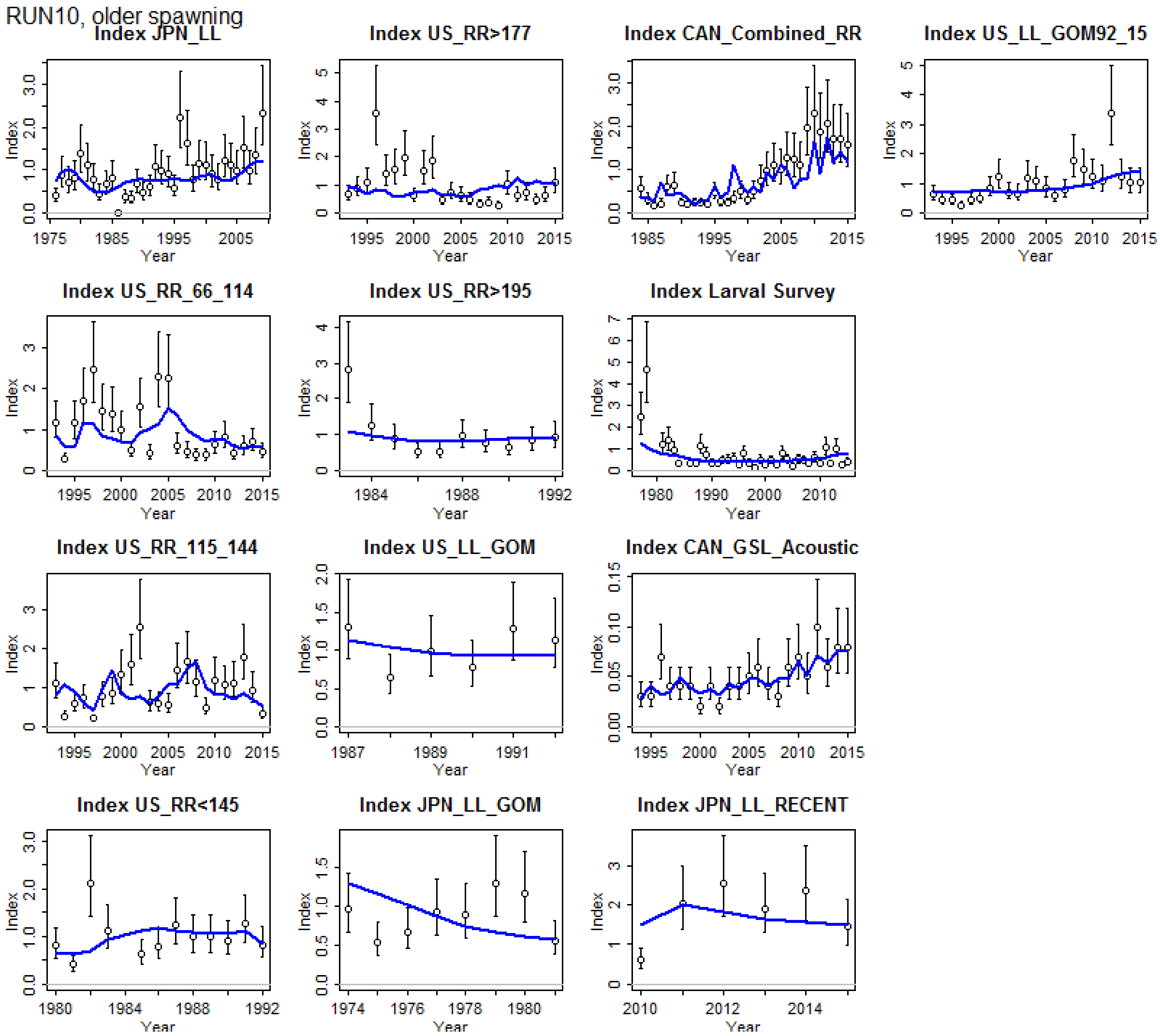


Figure 34. Fits to CPUE indices for SS run10 (assuming older spawning, and the results for SS run 11, younger spawning, are not shown as they are nearly identical) for the western stock.

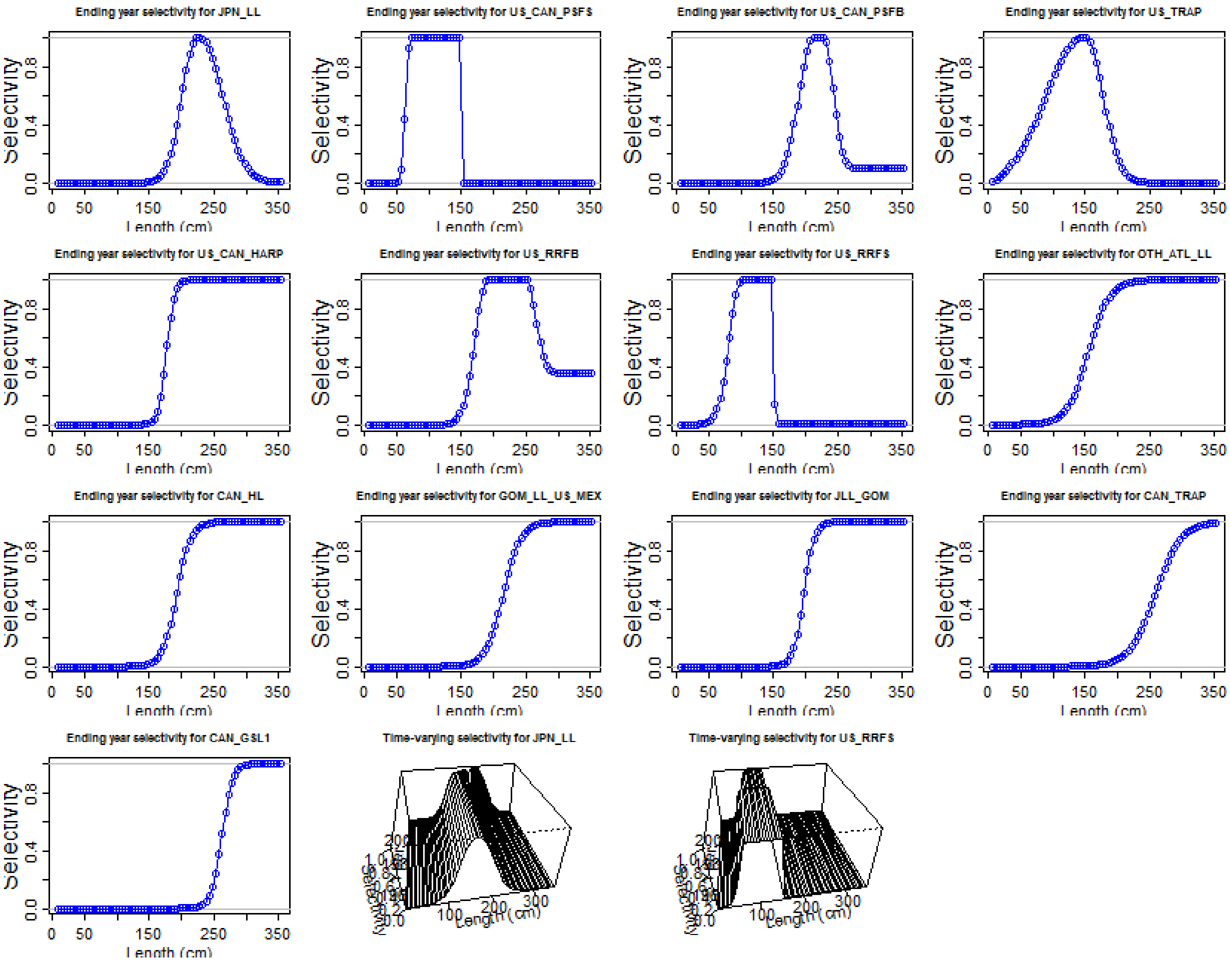


Figure 35. Estimated selectivity for SS run 10 (assuming older spawning, and the results for SS run 11, younger spawning, were essentially the same) for the western stock. For JPN_LL and US_RRFS time varying selectivity is shown on bottom.

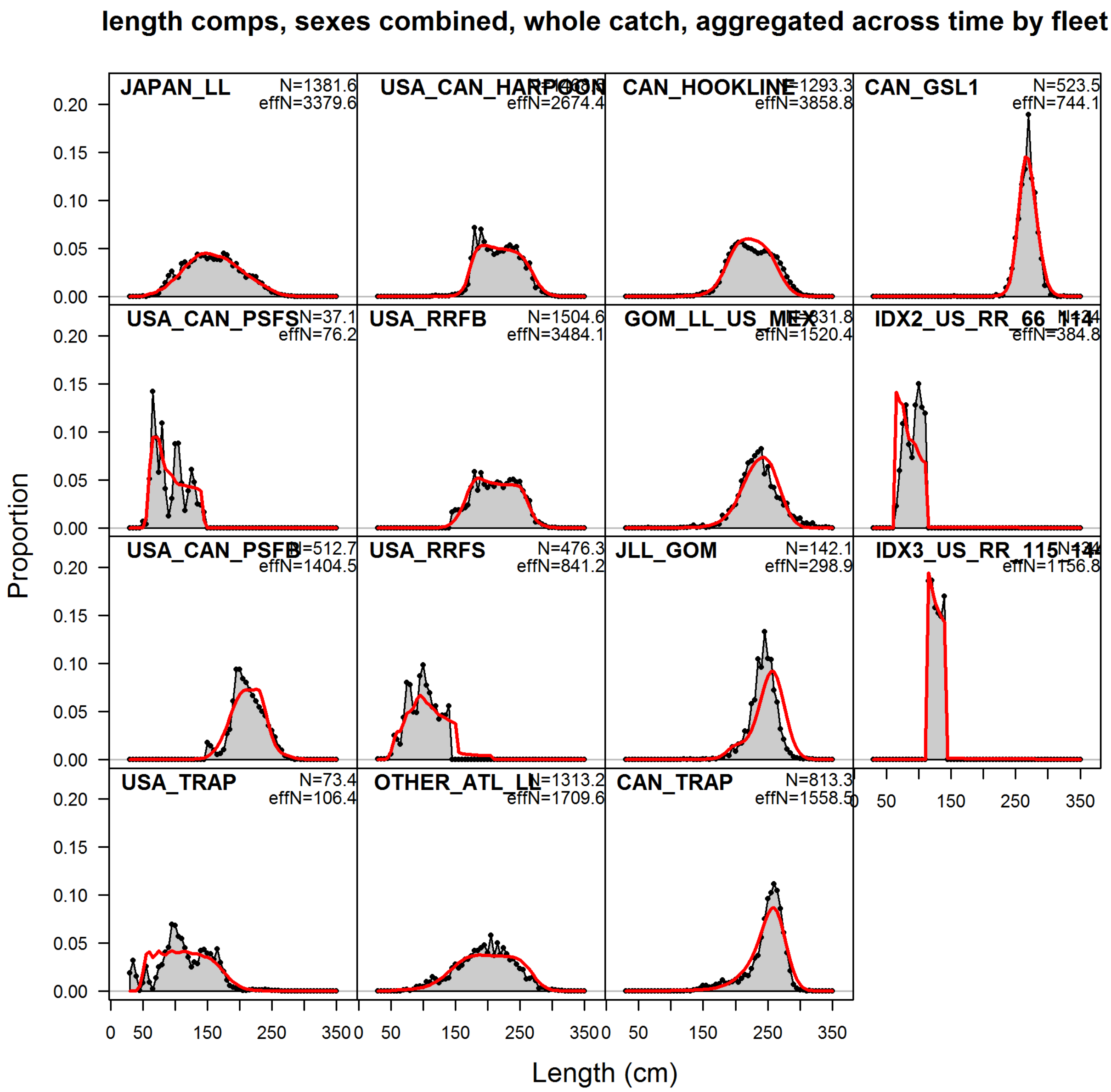


Figure 36. Fits to length composition data over all years for SS3 run 10 (assuming older spawning, and the results for SS3 run 11, younger spawning, are not shown for brevity as it is essentially the same) for the western stock.

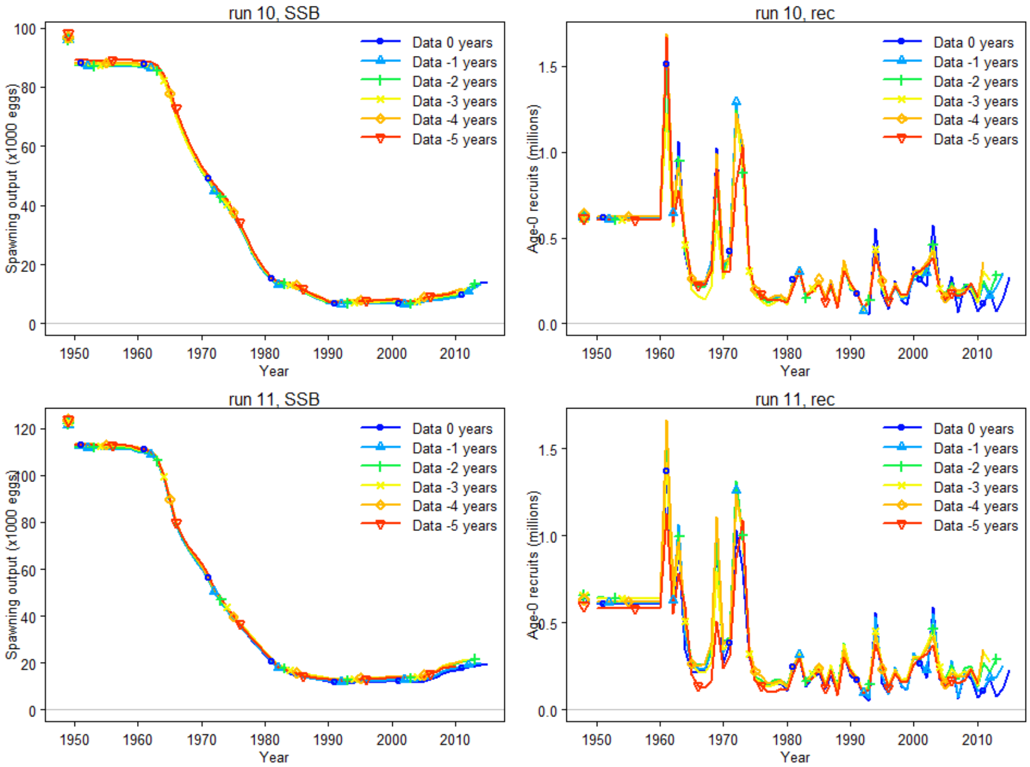


Figure 37. Retrospective plots of SSB and recruitment (age 0) for SS3 runs 10 (older spawning) and 11 (younger spawning) for the western stock.

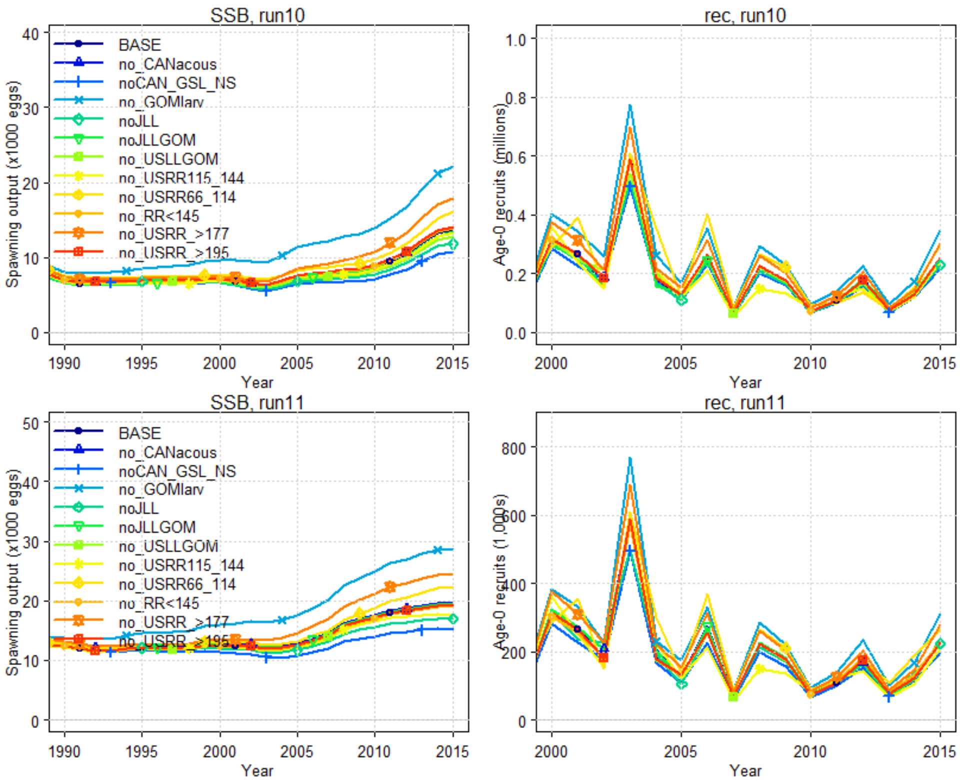


Figure 38. SSB and recruitment (age 0) estimates of 'jackknife' procedure of removing one index at a time for SS runs 10 (older spawning) and 11 (younger spawning) for the western stock.

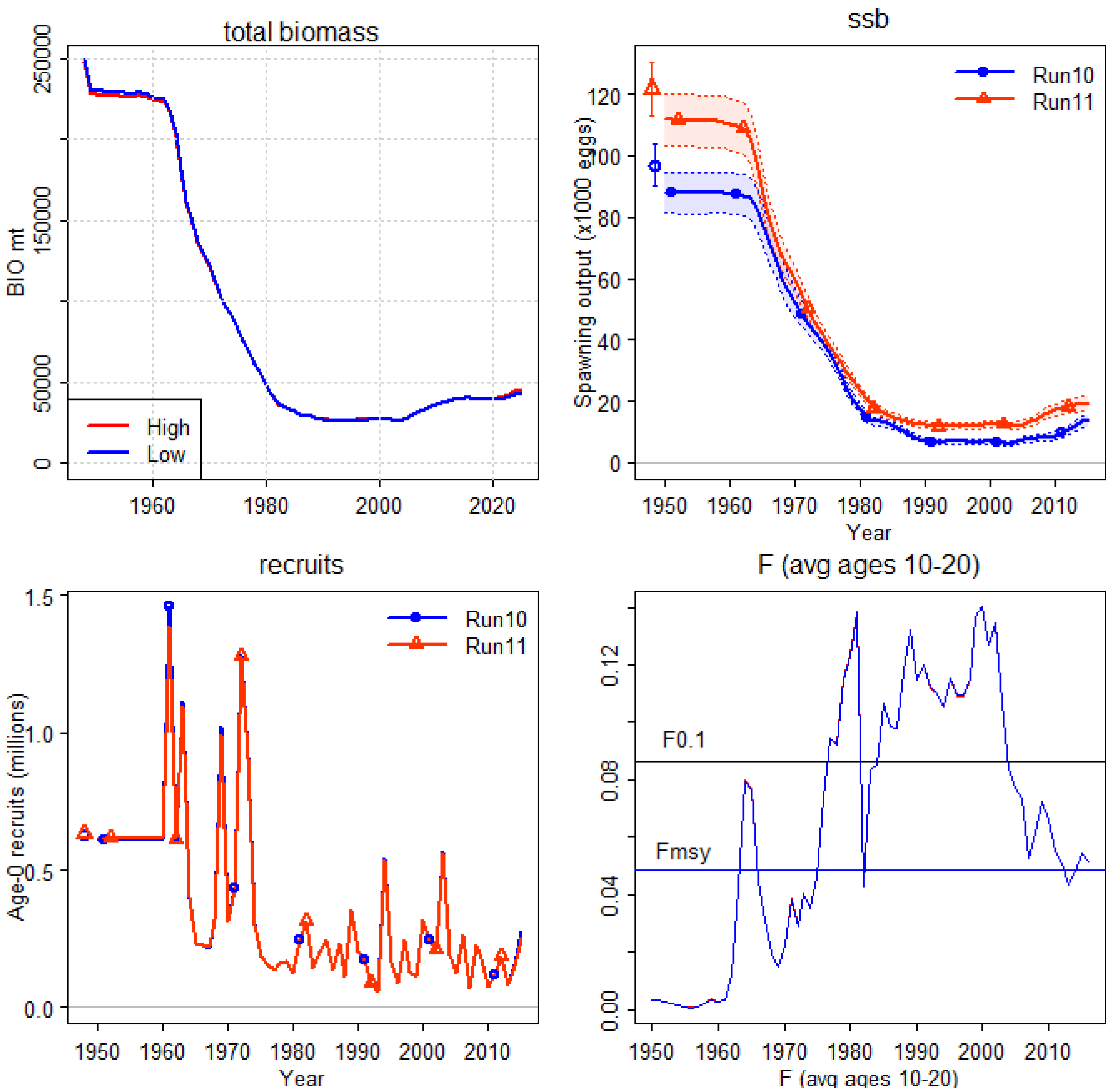


Figure 39. Time series of total biomass, SSB, recruits (age 0), and F (average F on ages 10-20) for SS3 runs 10 (older spawning) and 11 (younger spawning) for the western stock.

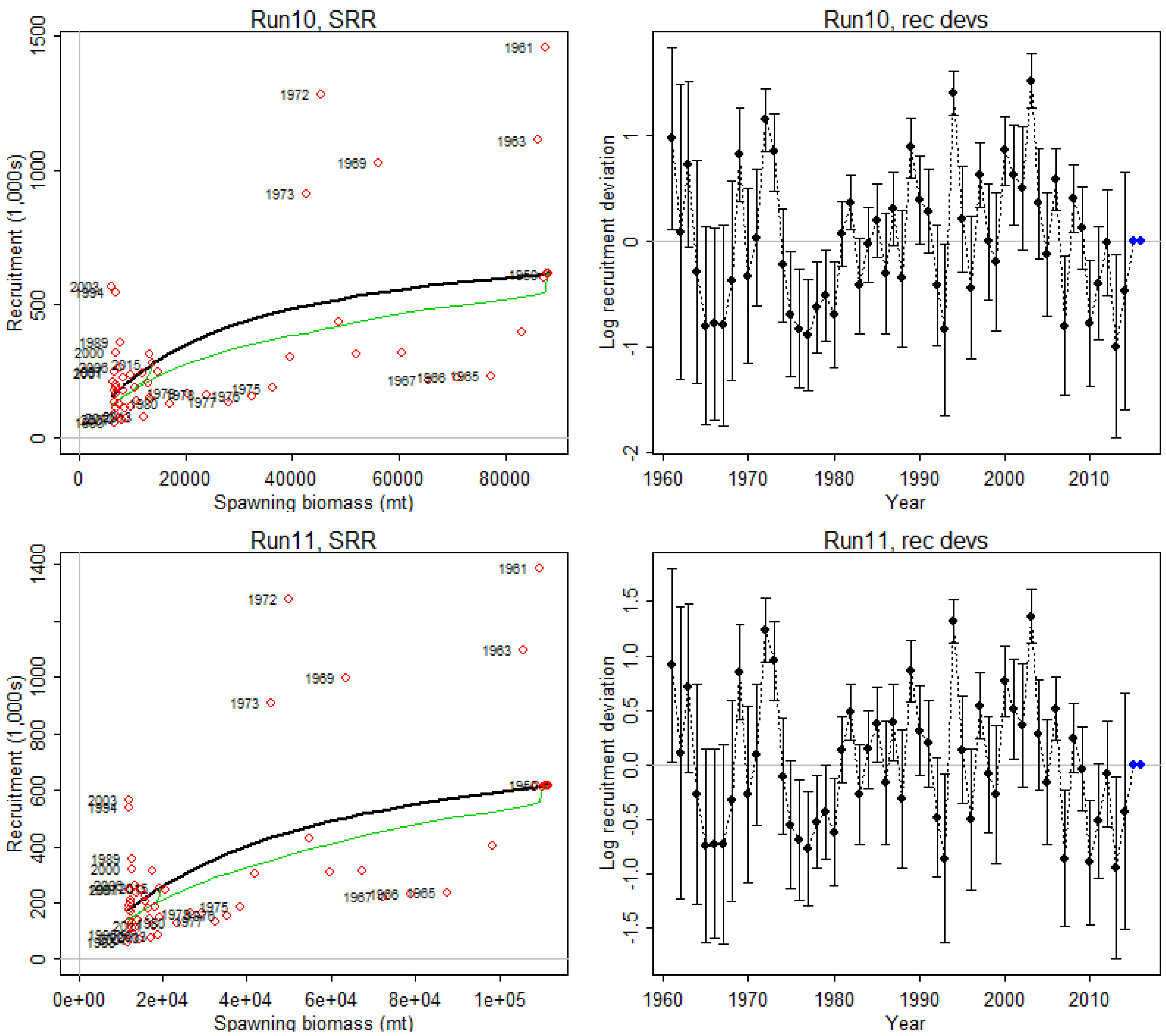


Figure 40. Estimated Beverton-Holt Spawner-recruit relationship and recruitment (age 0) deviations for SS runs 10 (older spawning - top) and 11 (younger spawning - bottom) for the western stock. Green line is the adjusted recruitment level during the period where recruitment deviations are estimated. 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 recruitment deviation estimation period equal to R0. Steepness was estimated to be 0.54 and 0.45, respectively, for SS3 runs 10 and 11. Blue points are 'future' recruitment deviations that are partially estimated for 2015 and not estimated for 2016.

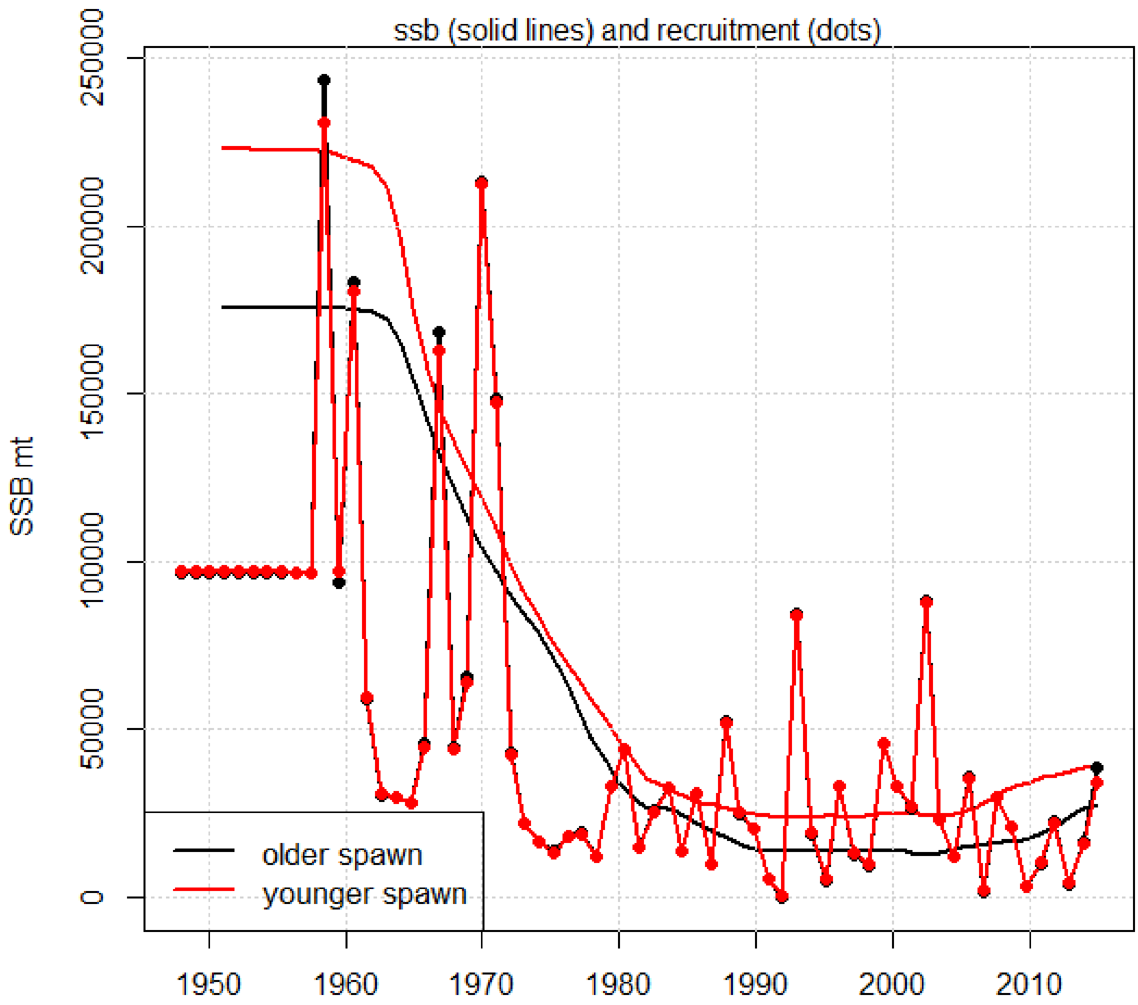


Figure 41. Time series of SSB, and recruits (age 0) from base SS3 model assuming older spawning (high in black) and younger spawning (low in red) for the western stock.

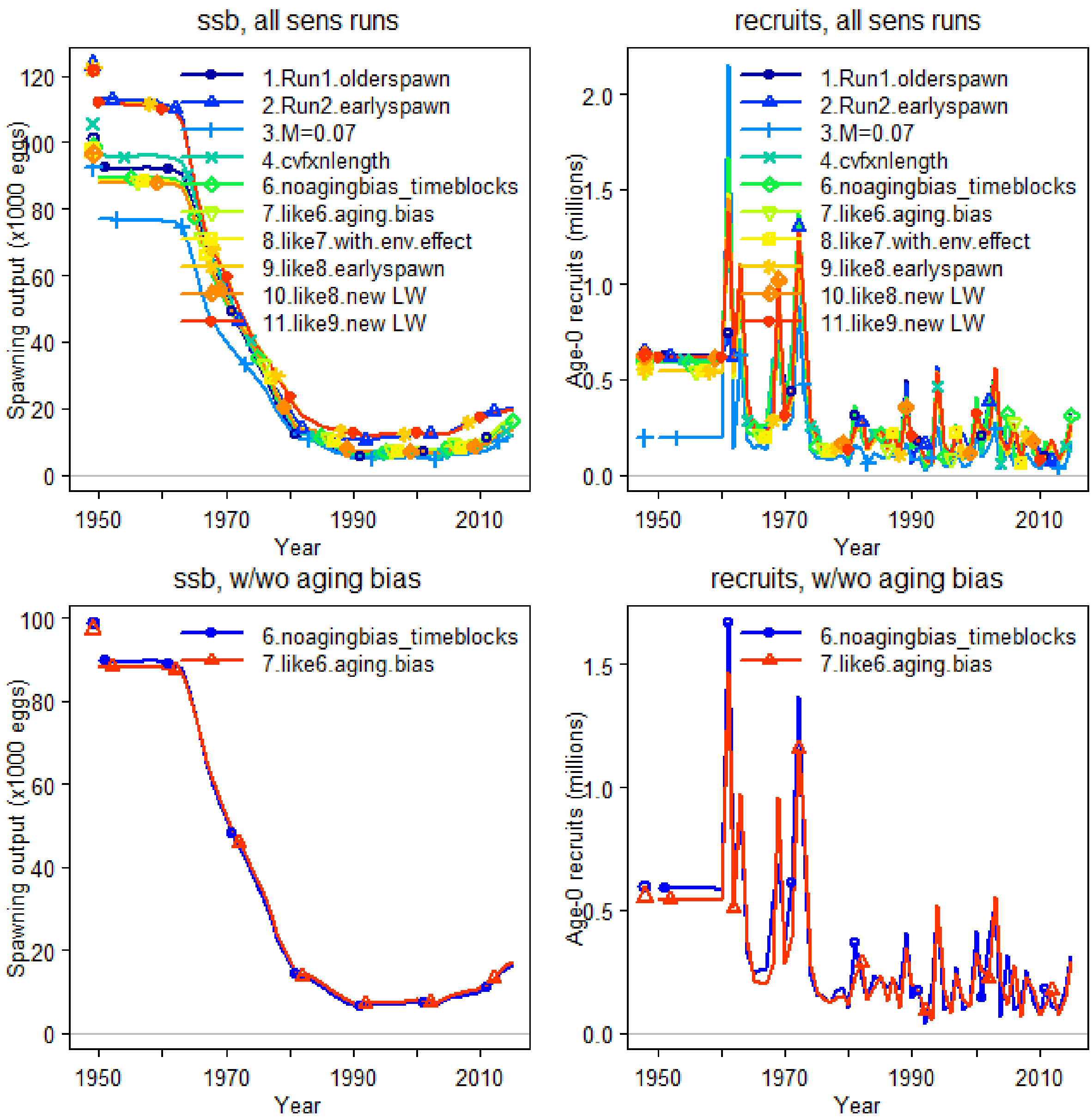


Figure 42. Time series of SSB and recruits (age 0) for all SS3 model sensitivity runs for the western stock except the unconstrained stock recruitment relationship which estimated recruits out of the scale of the runs for some years. Lower panel isolates the difference with or without the aging bias vector.

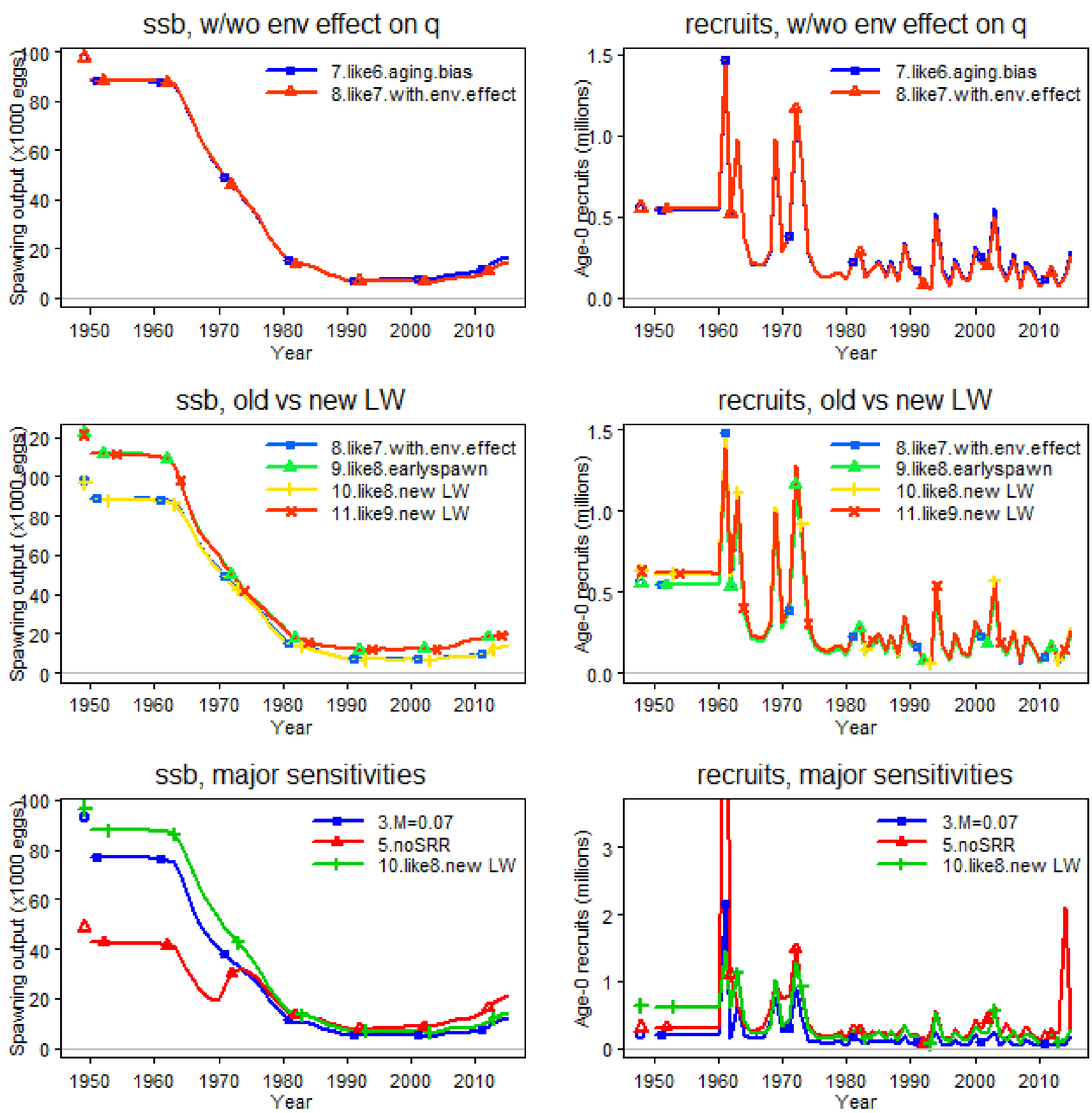


Figure 43. Time series of SSB and recruits (age 0) for SS3 sensitivity runs for the western stock. Upper panel isolates the difference with or without the environmental factor on catchability for three indices. Middle panels isolate the difference between the old and new length-weight relationship and lower panel shows runs with the greatest divergence compared to the base, older spawning run which was the lower M=0.07 and the run without a stock recruitment relationship imposed.

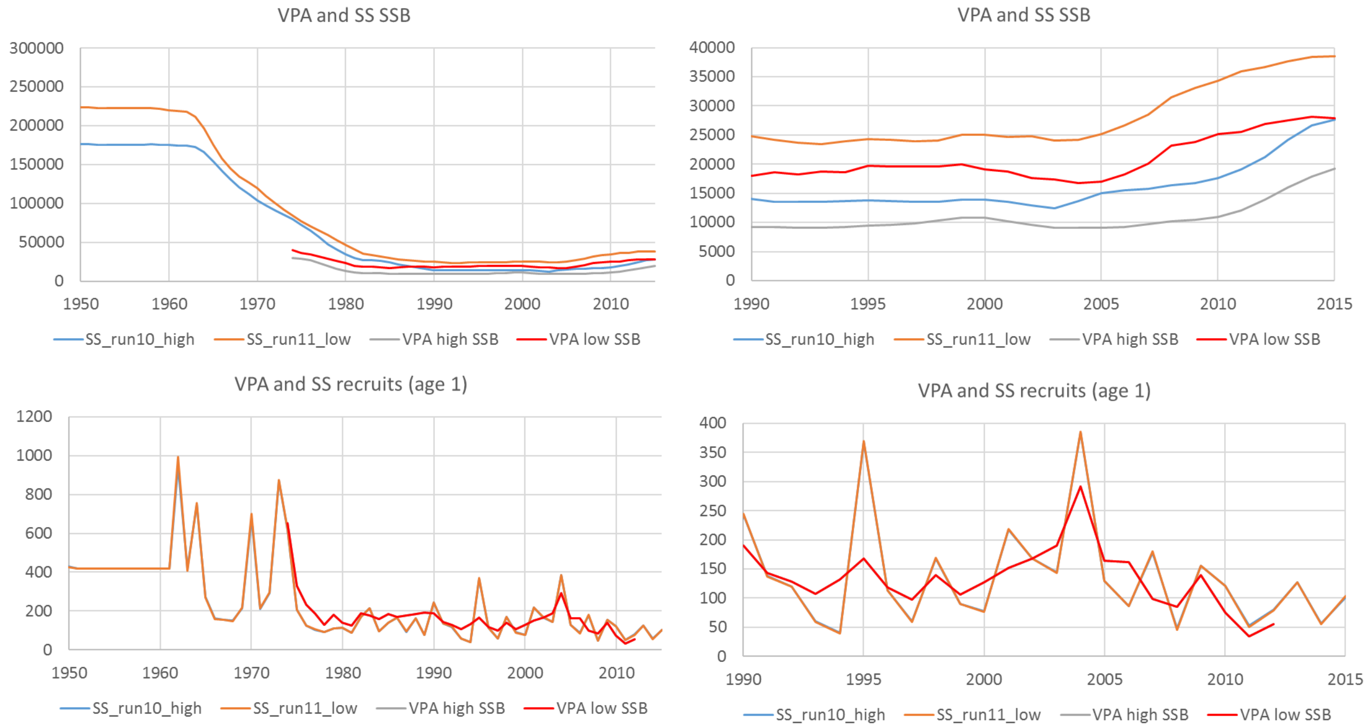


Figure 44. Comparison of VPA and SS3 estimates of SSB and recruits (age 1) for the western stock.

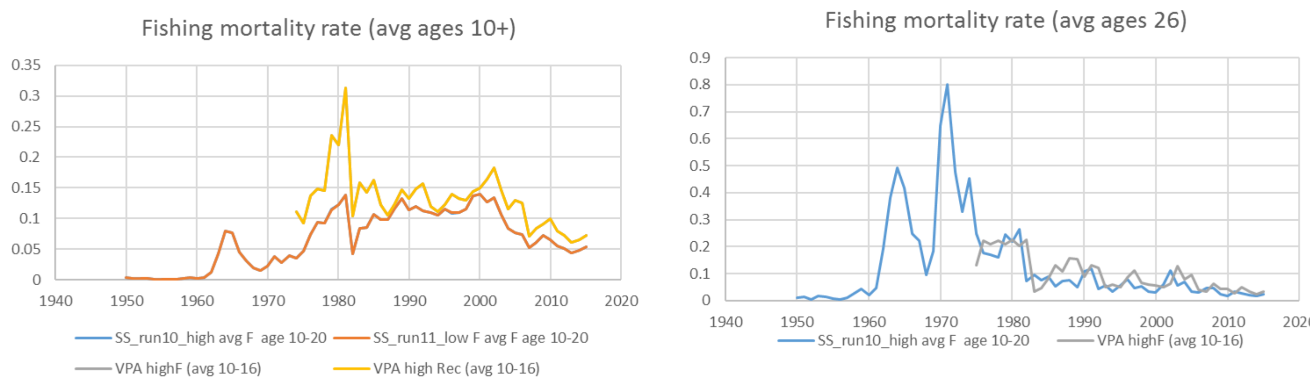


Figure 45. Comparison of VPA and SS3 estimates of F on ages 10+ and F for the western stock.

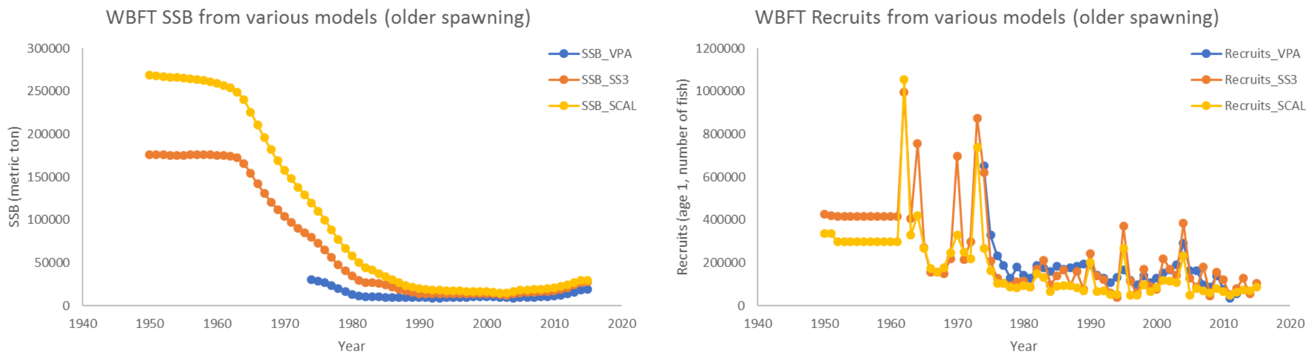


Figure 46. Comparison of several models (VPA, SS, and SCAL) SSB and recruits for the western stock assuming older spawning.

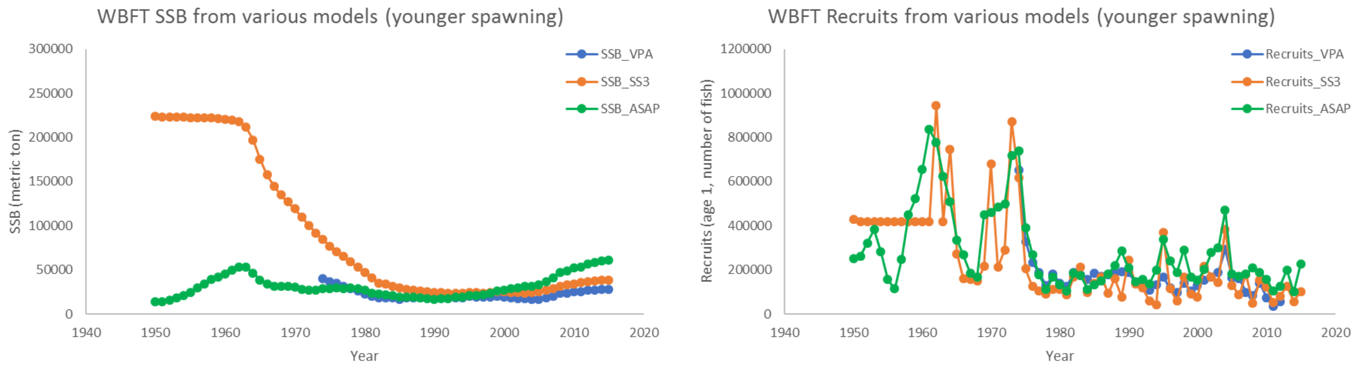


Figure 47. Comparison of several models (VPA, SS3, and ASAP) SSB and recruits for the western stock assuming younger spawning.

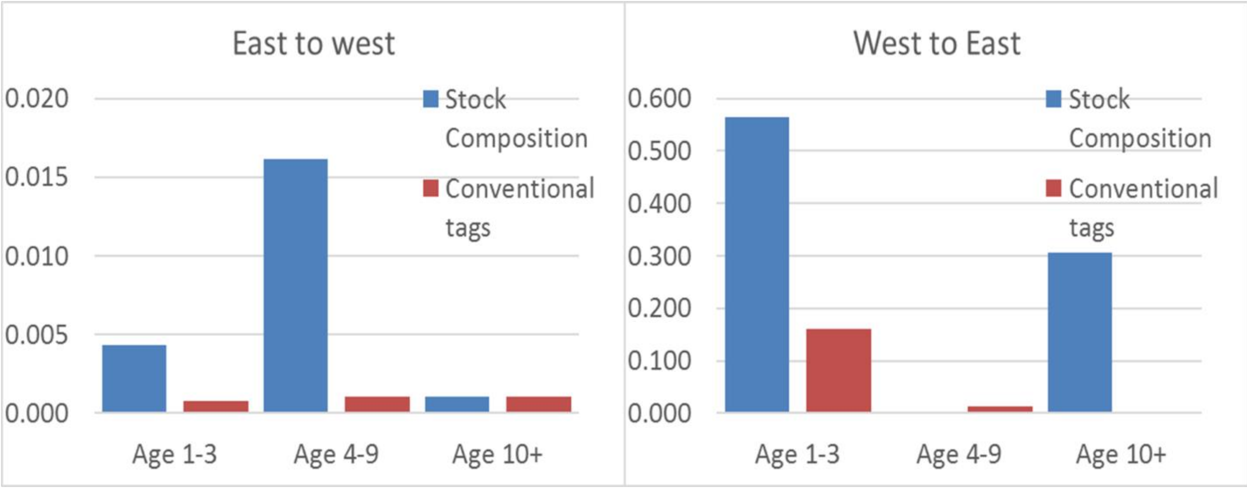


Figure 48. Estimated fraction of the eastern stock that moves to the west (left graph) and fraction of the western stock that moves east (right graph) by age groups using the overlap model in VPA-2box.

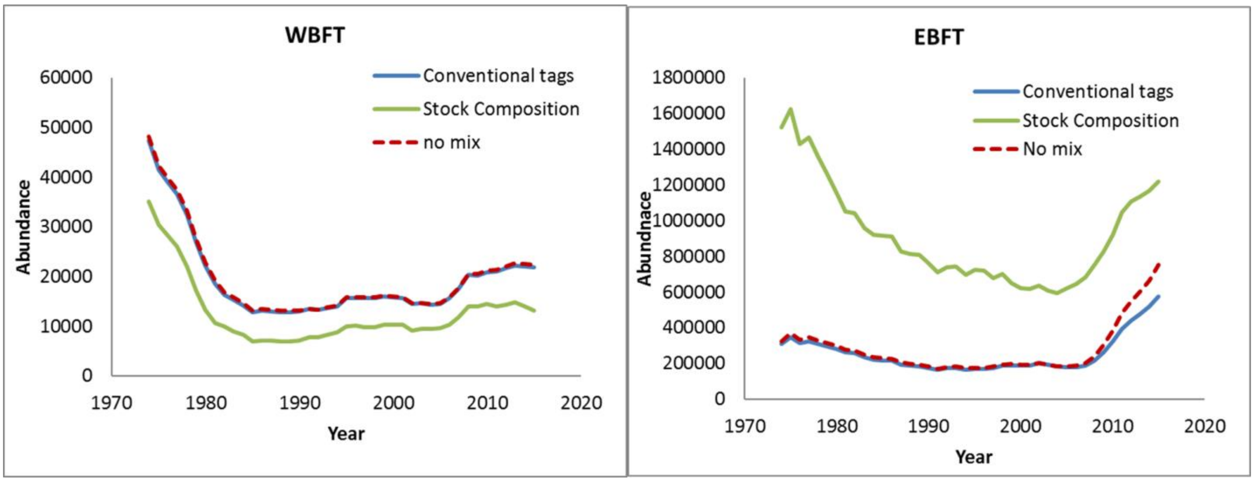


Figure 49. Estimated spawning biomass (computed with younger spawning oogive) of the western (WBFT) and eastern (EBFT) stocks using the overlap model with conventional tag data (blue) and stock composition data (green) compared to the results obtained with no mixing (and without tagging or stock composition data).

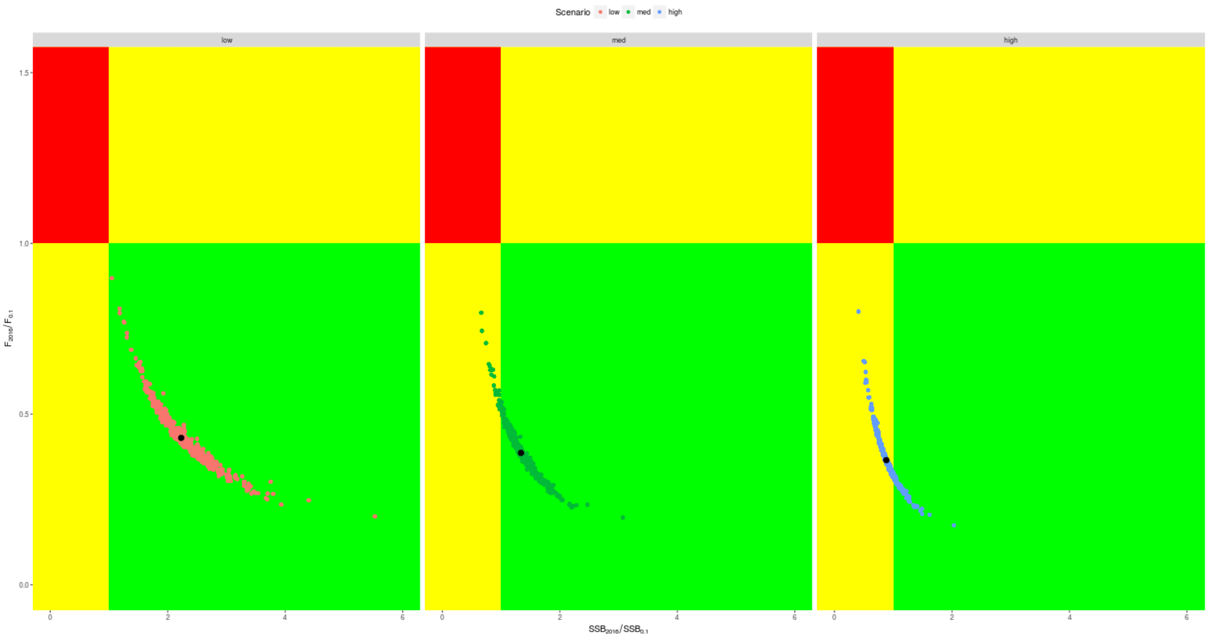


Figure 50. Kobe phase plot representing the Eastern Atlantic and Mediterranean stock status for VPA base case run and its uncertainty, under different recruitment scenarios.

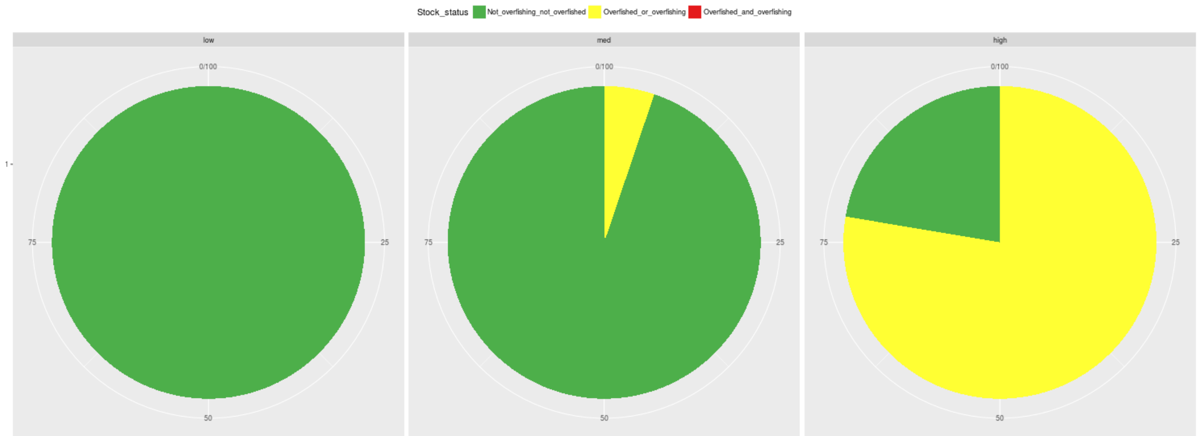


Figure 51. Kobe pie chart representing the percentage of bootstraps falling within the different status categories in 2016.

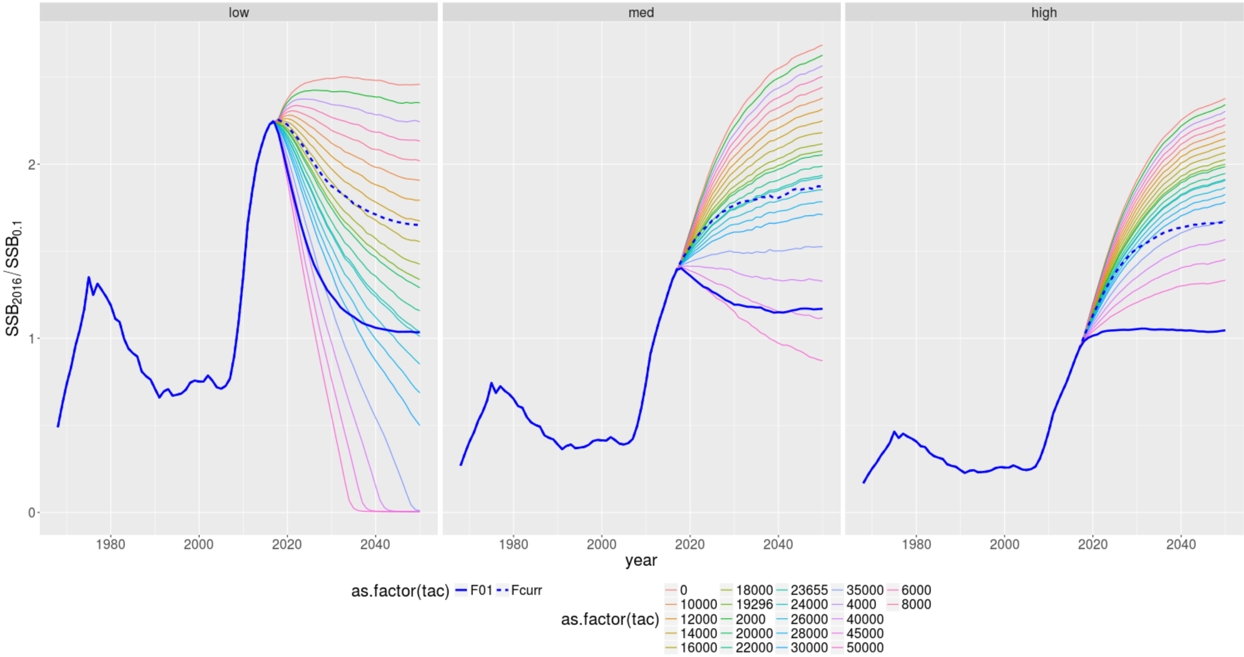


Figure 52. Projected spawning stock biomass, based on VPA results, of the eastern stock relative to the equilibrium value at $F_{0.1}$ under the three alternative recruitment scenarios with catch limits ranging from 0-50,000 t and with two fishing mortality rates ($F_{current}$ and $F_{0.1}$). Note that the calculation of $SSB_{0.1}$ assumes that recruitments will remain at the same levels into the future.

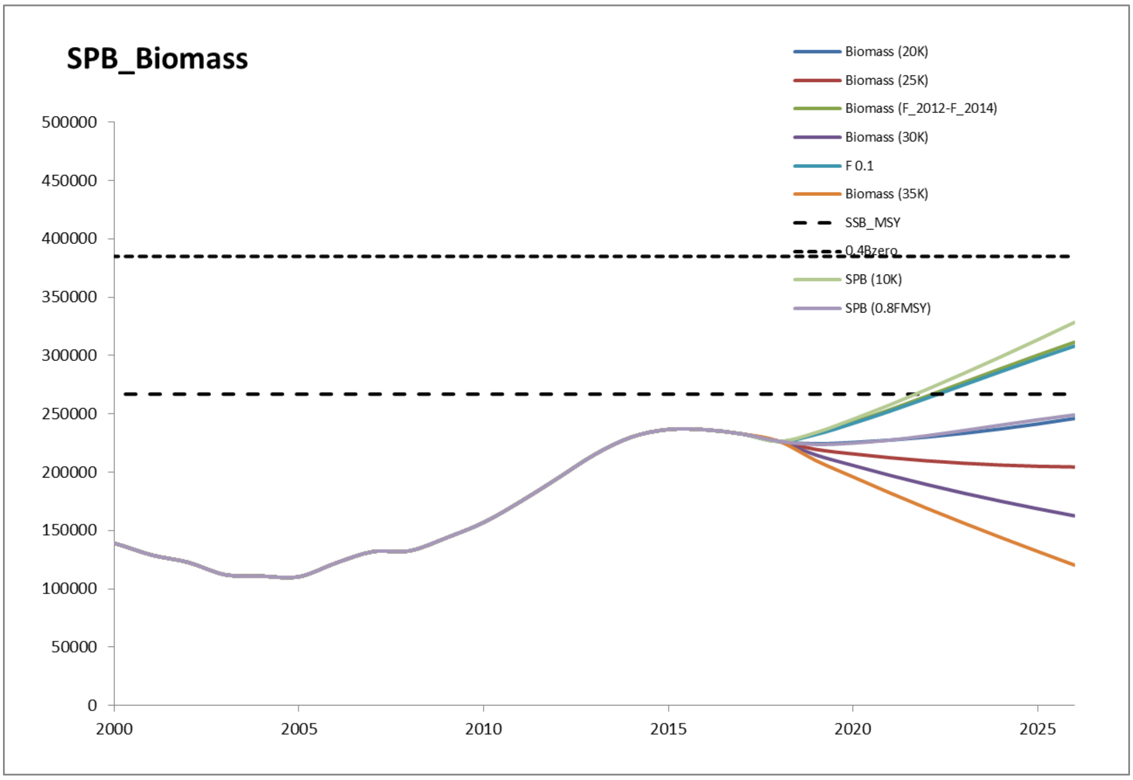


Figure 53. Projections based on different assumptions of F and catch limits from 2017 to 2026, from the SS3 model for the Eastern Atlantic and Mediterranean bluefin tuna.

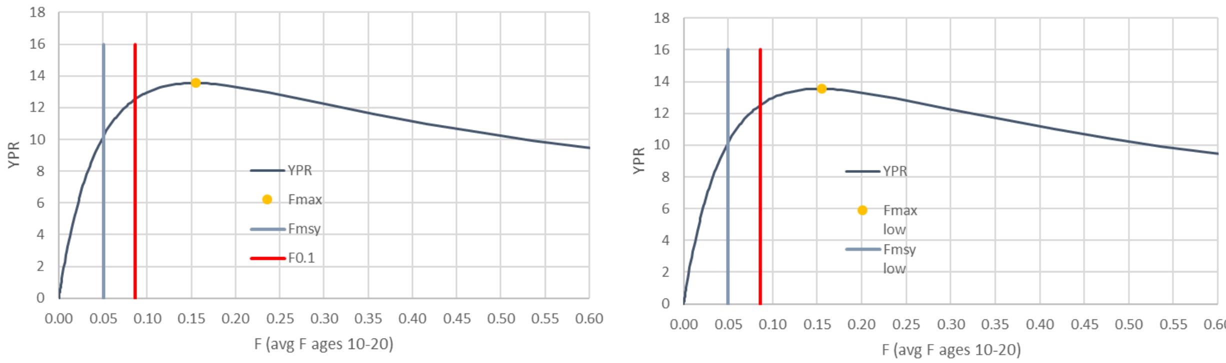


Figure 54. Western stock yield per recruit for SS3 runs 10 (older spawning - left) and 11 (younger spawning - right).

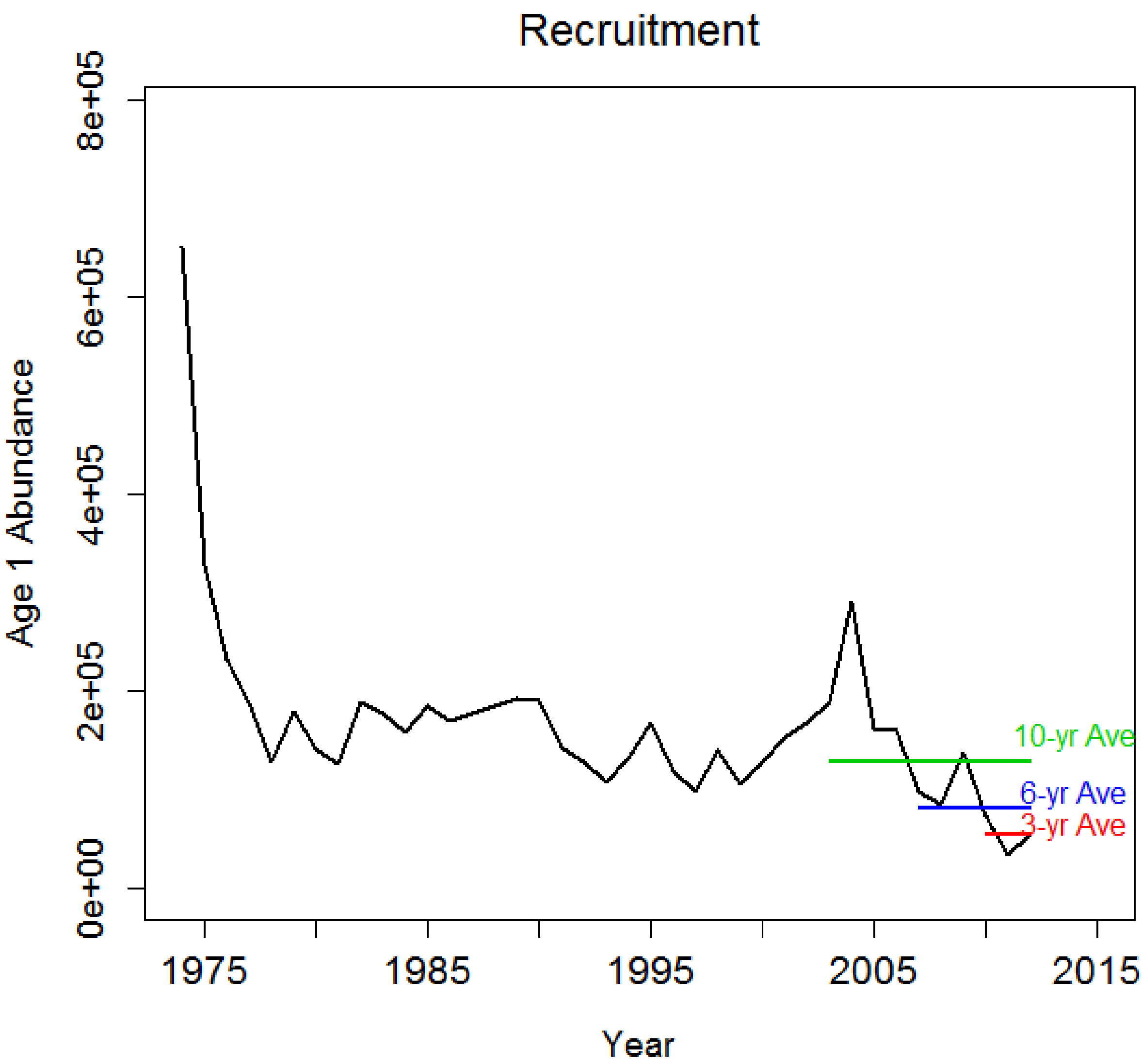
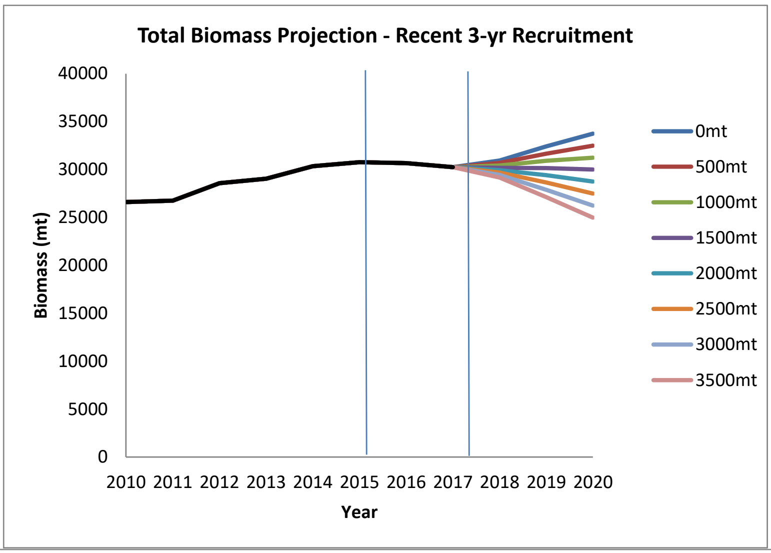
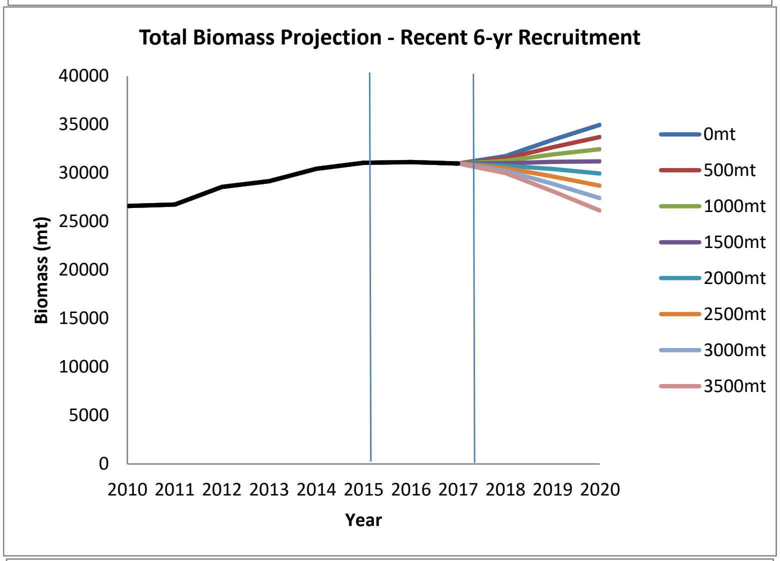


Figure 55. Projected recruitment levels (age 1) derived from the base-case VPA for the western stock under three alternative scenarios (geometric mean recruitment over 3 years, 6 years, and 10 years).





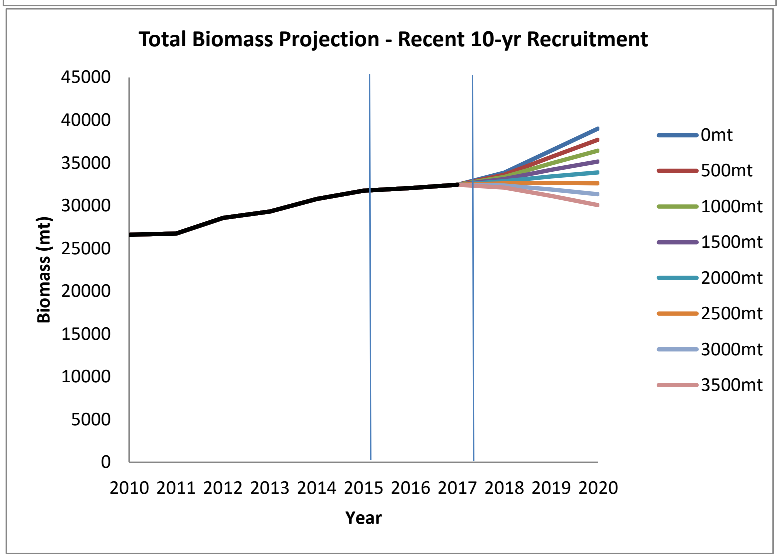


Figure 56. Projected total biomass, based on VPA results, for the western stock under the three recruitment scenarios and different constant yield levels.

Younger Spawning Assumption | **Older Spawning Assumption**

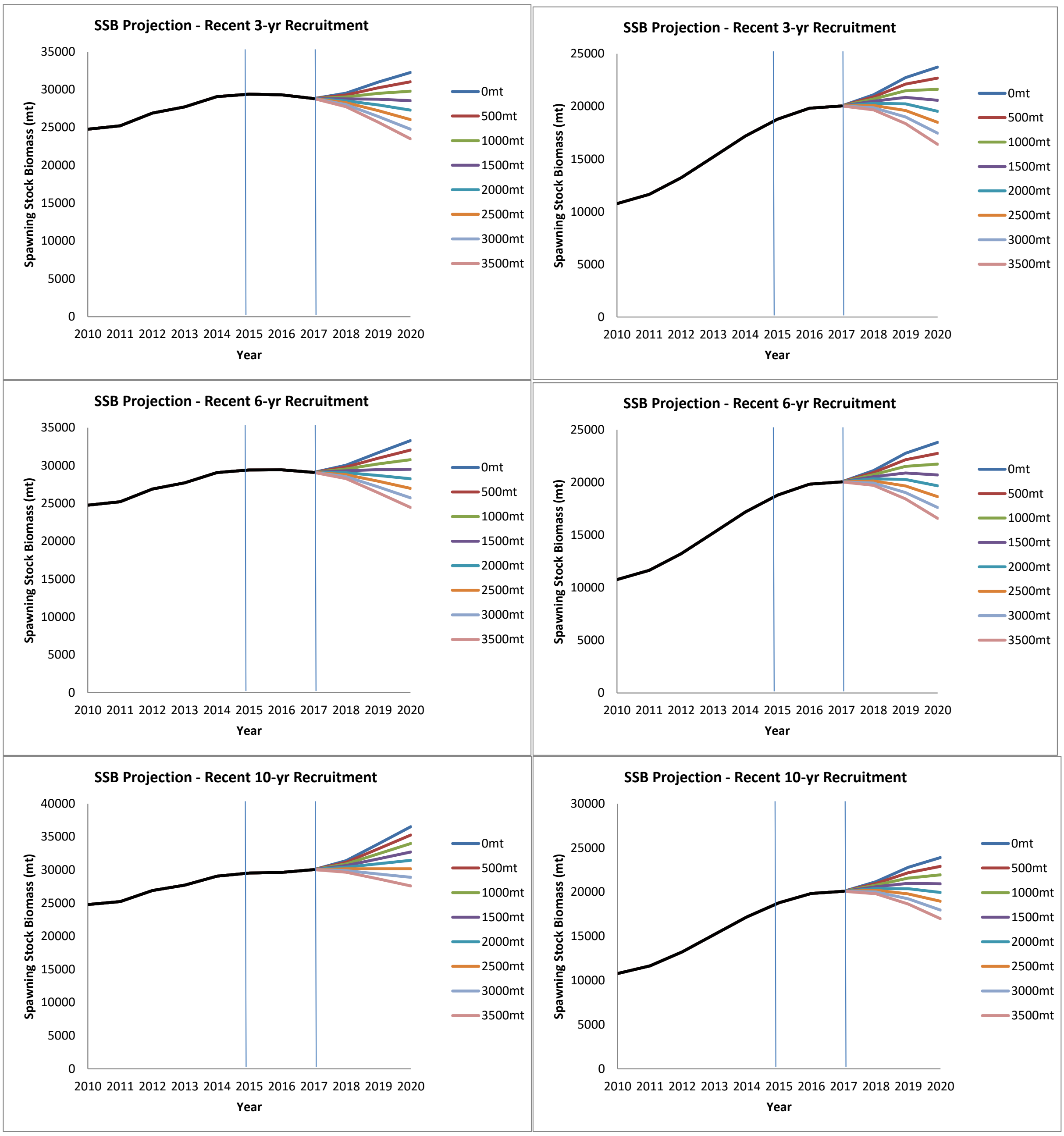


Figure 57. Projected spawning stock biomass, based on VPA results, for the western stock under alternative recruitment scenarios and spawning-at-age assumptions.

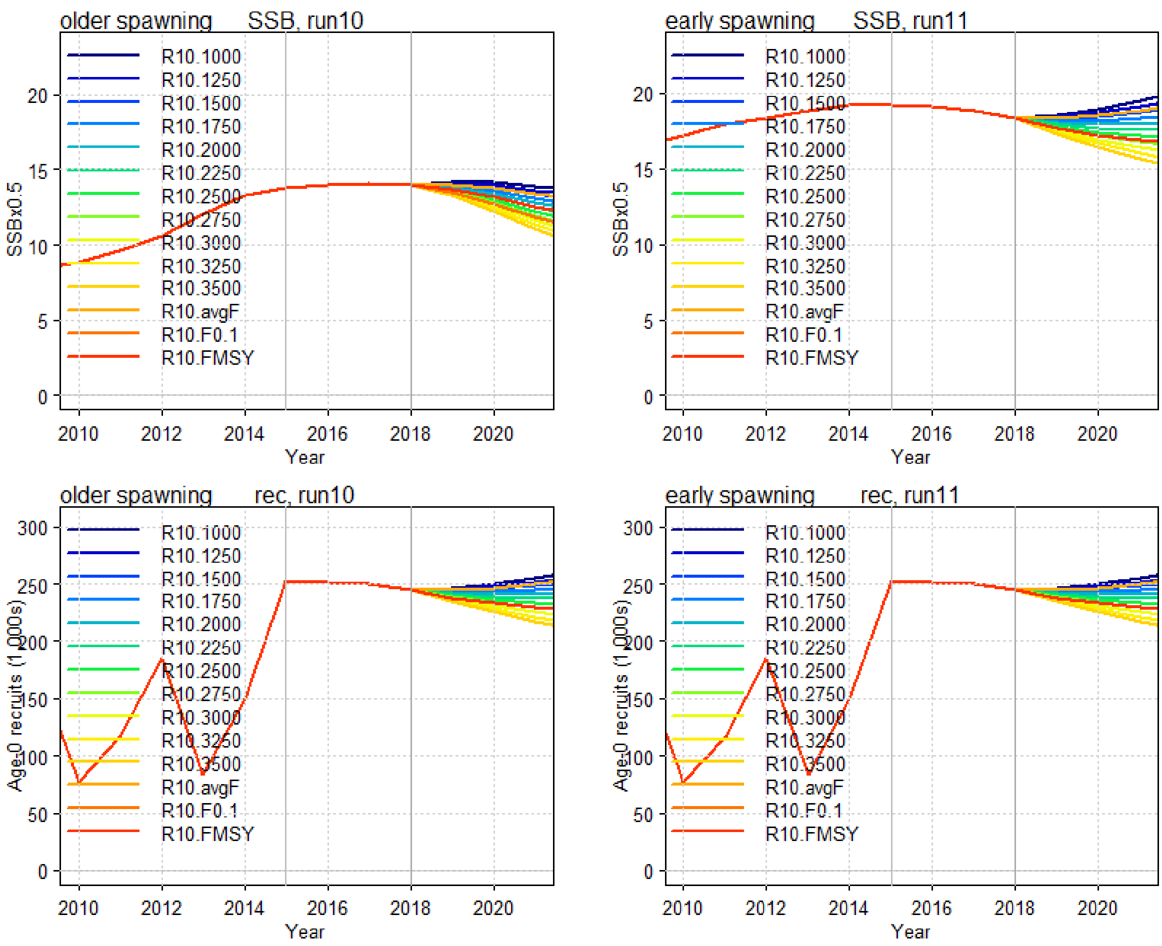


Figure 58. Projected SSB (top) and recruits (age 0, bottom) across the fixed catch limits and $F_{0.1}$, F_{MSY} and average of the current F scenarios from SS3 for the western stock, assuming older spawning (left) and younger spawning (right). Recruitment is drawn from the Beverton and Holt stock recruitment relationship assuming the long-term average recruitment for these runs.

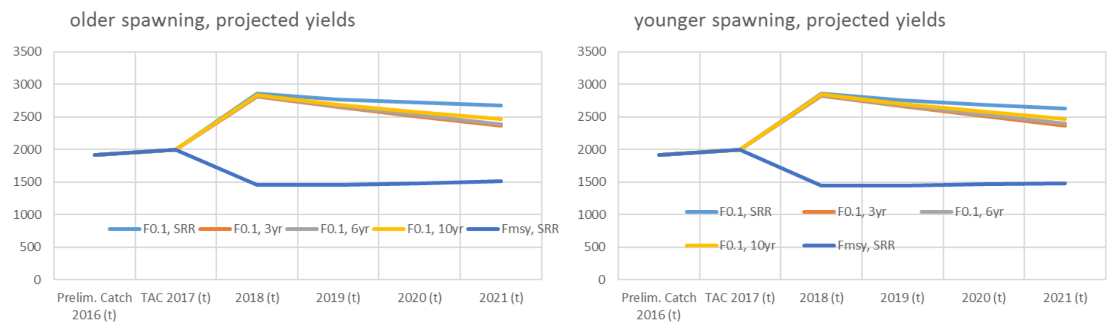


Figure 59. Projected yields from SS3 for the western stock assuming older (right) and younger spawning (left), at $F_{0.1}$ for the 3, 6 and 10 year recruitments and F_{MSY} assuming that recruitment deviations from the Beverton and Holt stock-recruitment relationship are drawn from the high (2003-2012), medium (2007-2012) or low (2009-2012) years or revert to the long-term average recruitment (SRR).

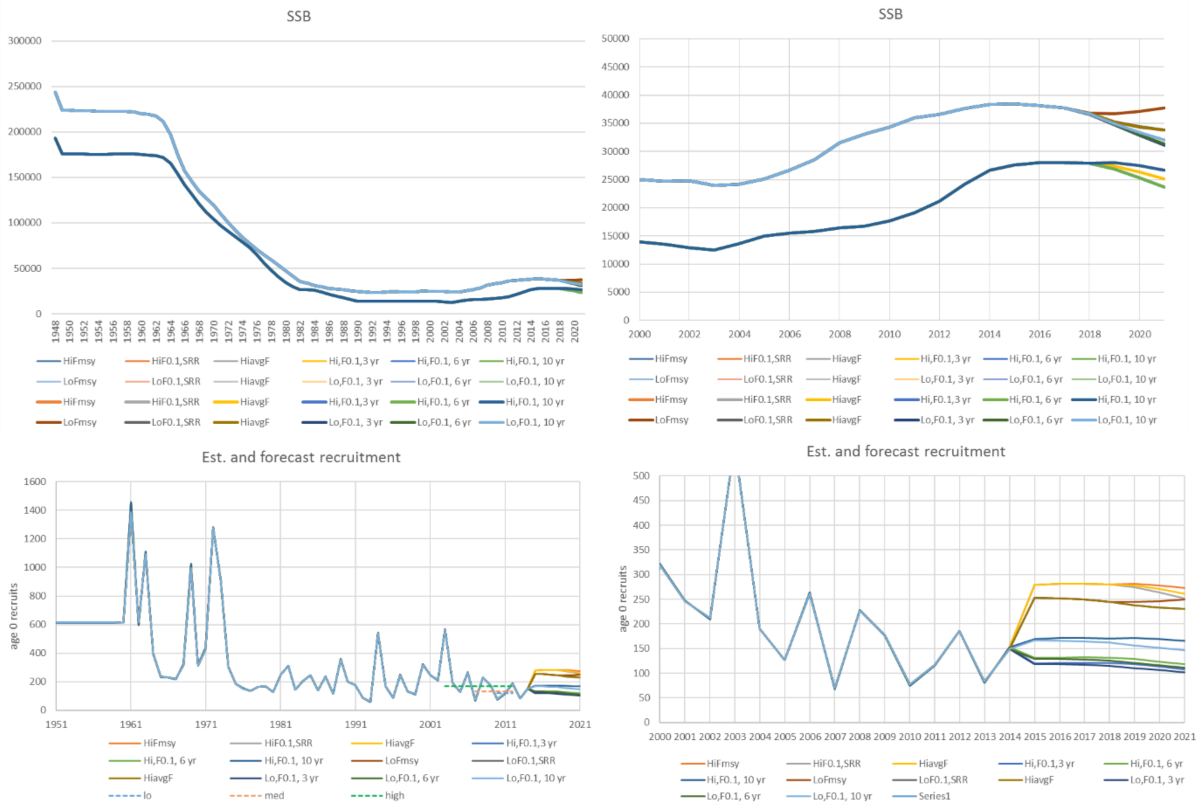


Figure 60. Historical estimated and future projected spawning biomass and recruitment (age 0) for older (Hi) and younger (Lo) spawning from SS3 for the western stock. Right panel shows the same plots for a short time period (2000-2025). Recruitments are generated from recruitment deviations from the Beverton and Holt stock-recruitment relationship from high (2003-2012), medium (2007-2012) or low (2009-2012) years or revert to the long-term average recruitment (SRR).

Appendix 1

AGENDA

1. Opening, adoption of the Agenda and meeting arrangements.
2. Review of the scientific papers presented at the Working Group
3. Review and update data for stock assessment
   - 3.1 Biology
   - 3.2 Catch estimates
   - 3.3 Relative abundance estimates and CPUE
   - 3.4 Tagging
   - 3.5 Age composition (age-length keys)
   - 3.6 Stock composition (otolith microchemistry, genetics)
   - 3.7 Other data
4. Methods relevant to the stock assessment
   - 4.1 Methods – East
   - 4.2 Methods – West
   - 4.3 Other methods
5. Updating Stock status
   - 5.1 Stock status – East
   - 5.2 Stock status – West
   - 5.3 Stock status – alternative models
6. Projections
   - 6.1 Review of the Rebuilding Plans for the Atlantic bluefin tuna and 2016 SCRS advice
   - 6.2 Projections – East
   - 6.3 Projections – West
7. Recommendations
   - 7.1 Research and statistics – East
   - 7.2 Research and statistics – West
   - 7.3 Management – East, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment
   - 7.4 Management – West, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment
8. Other matters
9. Adoption of the report and closure

Appendix 2

LIST OF PARTICIPANTS

Bluefin tuna stock assessment session (Madrid, Spain, 20 – 28 July 2017)
Réunion d'évaluation des stocks de thon rouge (Madrid, Espagne, 20 - 28 juillet 2017)
Reunión de evaluación de los stocks de atún rojo (Madrid, España, 20 - 28 de Julio de 2017)

CONTRACTING PARTIES/PARTIES CONTRACTANTES/PARTES CONTRATANTES

ALGERIA/ALGÉRIE/ARGELIA

Kouadri-Krim, Assia
Chef de Bureau, Ministre de l'Agriculture du Developpement rural et de la Pêche, Rue des Quatre Canons, 16000
Tel: +213 21 43 31 97, Fax: +213 21 43 31 97, E-Mail: dpmo@mpeche.gov.dz; assiakrim63@gmail.com

CANADA/CANADÁ

Carruthers, Thomas
335 Fisheries Centre, University of British Columbia, Vancouver Columbia V2P T29
Tel: +1 604 805 6627, E-Mail: t.carruthers@oceans.ubc.ca

Hanke, Alexander
Scientific, St. Andrews Biological Station/ Biological Station, Fisheries and Oceans Canada, 531 Brandy Cove Road, St. Andrews New Brunswick E5B 2L9
Tel: +1 506 529 5912, Fax: +1 506 529 5862, E-Mail: alex.hanke@dfo-mpo.gc.ca

Maguire, Jean-Jacques
1450 Godefroy, Québec G1T 2E4
Tel: +1 418 688 3027, E-Mail: jeanjacquesmaguire@gmail.com

Melvin, Gary
Biological Station - Fisheries and Oceans Canada, Department of Fisheries and Oceans, 531 Brandy Cove Road, St. Andrews, New Brunswick E5B 2L9
Tel: +1 506 529 5874, Fax: +1 506 529 5862, E-Mail: gary.melvin@dfo-mpo.gc.ca

EUROPEAN UNION/UNION EUROPÉENNE/UNIÓN EUROPEA

Addis, Pierantonio
Senior Researcher in Ecology, University of Cagliari, Department of Life and Environment Science, Via Fiorelli 1, 09126 Cagliari, Italy
Tel: +39 070 675 8082, Fax: +39 070 675 8022, E-Mail: addisp@unica.it

Arrizabalaga, Haritz
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia Gipuzkoa, España
Tel: +34 94 657 40 00, Fax: +34 94 300 48 01, E-Mail: harri@azti.es

Carpi, Piera
CEFAS, Pakefield Road, Lowestoft - Suffolk, NR33 0HT, United Kingdom
Tel: +44 150 252 4447, E-Mail: piera.carpi@cefas.co.uk

Daniel, Patrick
Commission européenne - DG MARE, J-99 02/17, 1000 Bruxelles, Belgium
Tel: +32 229 554 58, E-Mail: patrick.daniel@ec.europa.eu

De Oliveira, José
CEFAS, Pakefield Road, Lowestoft - Suffolk, NR330HT, United Kingdom
Tel: +44 073 937 63048, E-Mail: jose.deoliveira@cefas.co.uk
Farrugia Drakard, Veronica
MESDC - DFA, Aquaculture Directorate, Fort San Lucjan, Triq il-Qajjenza, Marsaxlokk, Malta
Tel: +356 229 26918, E-Mail: veronica-heather.farrugia-drakard@gov.mt

Garibaldi, Fulvio
Laboratorio di Biologia Marina e Ecologia Animale Univ. Degli Studi di Genova, Dipartimento si Scienze della Terra, dell'Ambiente e della Vita (DISTAV), Corso Europa, 26, 16132 Genova, Italy
Tel: +39 010 353 8576, Fax: +39 010 357 888, E-Mail: largepel@unige.it; garibaldi.f@libero.it

Gordoa, Ana
Centro de Estudios Avanzados (CEAB - CSIC), Acc. Cala St. Francesc, 14, 17300 Blanes Girona, España
Tel: +34 972 336101, E-Mail: gordoa@ceab.csic.es

Imzilen, Taha
UMR Marbec (IRD/IFREMER/UM2), CRH - Avenue Jean Monet - CS 30171, 34203 Sète Cèdex, France
Tel: +33 651 75 87 54, E-Mail: taha.imzilen@ird.fr; imzilen.taha@gmail.com

Levontin, Polina
Consultant, Renewable resources Assessment Group Imperial College of Science, Technology & Medicine, Center of Environmental Science and Technology, Prince Consort Road, London , United Kingdom
E-Mail: polina.levontin02@imperial.ac.uk

Lino, Pedro Gil
Instituto Português do Mar e da Atmosfera - I.P./IPMA, Avenida 5 Outubro s/n, 8700-305 Olhão, Portugal
Tel: +351 289 700504, E-Mail: plino@ipma.pt

Lombardo, Francesco
Università Politecnica delle Marche, Dipartimento Scienze della Vita e dell'AmbienteVia Brecce Bianche - Ancona, Italy
Tel: +39 333 5914492, E-Mail: francescolombardo80@gmail.com

Macías López, Ángel David
Ministerio de Economía y Competitividad, Instituto Español de Oceanografía, C.O. de Málaga, Puerto pesquero s/n, 29640 Fuengirola Málaga, España
Tel: +34 952 197 124, Fax: +34 952 463 808, E-Mail: david.macias@ma.ieo.es

Navarro Cid, Juan José
Grupo Balfegó, Polígono Industrial - Edificio Balfegó, 43860 L'Ametlla de Mar Tarragona, España
Tel: +34 977 047700, Fax: +34 977 457 812, E-Mail: jnavarro@grupbalfego.com

Rodríguez-Marín, Enrique
Ministerio de Economía, Industria y Competitividad, Instituto Español de Oceanografía, C.O. de Santander, Promontorio de San Martín s/n, 39004 Santander Cantabria, España
Tel: +34 942 291 716, Fax: +34 942 27 50 72, E-Mail: rodriguez.marin@st.ieo.es

Rouyer, Tristan
Ifremer - Dept Recherche Halieutique, B.P. 171 - Bd. Jean Monnet, 34200 Sète, France
Tel: +33 (0)4 42 57 32 37; +33 (0)7 82 99 52 37, E-Mail: tristan.rouyer@ifremer.fr

Sundelöf, Andreas
Swedish University of Agricultural Sciences, Institute of Marine Research Turistgatan, 5, SE-453 30 Lysekil, Sweden
Tel: +46 703 068 775, Fax: +46 5231 3977, E-Mail: andreas.sundelof@slu.se

JAPAN/JAPON/JAPÓN

Butterworth, Douglas S.
Emeritus Professor, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701 Cape Town, South Africa
Tel: +27 21 650 2343, E-Mail: doug.butterworth@uct.ac.za

Itoh, Tomoyuki
Chief of Temperate Tuna Group, Bluefin tuna Resources Division, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 54 336 6000, Fax: +81 54 335 9642, E-Mail: itou@fra.affrc.go.jp

Kimoto, Ai
Researcher, Bluefin Tuna Resources Division, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 54 336 6000, Fax: +81 54 335 9642, E-Mail: aikimoto@affrc.go.jp

Kitakado, Toshihide
Associate Professor, Faculty of Marine Science, Tokyo University of Marine Science and Technology, Department of Marine Biosciences, 4-5-7 Konan, Minato, Tokyo 108-8477
Tel: +81 3 5463 0568, Fax: +81 3 5463 0568, E-Mail: kitakado@kaiyodai.ac.jp;toshihide.kitakado@gmail.com

Nakatsuka, Shuya
Research Coordinator, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 54 336 6000, Fax: +81 54 335 9642, E-Mail: snakatsuka@affrc.go.jp

Uozumi, Yuji
Visiting Scientist, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 54 336 6000, E-Mail: uozumi@affrc.go.jp

MAURITANIA/MAURITANIE

Braham, Cheikh Baye
Halieute, Géo-Statisticien, modélisteur; Chef du Service Statistique, Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), BP 22 Nouadhibou
Tel: +222 2242 1038, Fax: E-Mail: baye_braham@yahoo.fr; baye.braham@gmail.com

MOROCCO/MAROC/MARRUECOS

Abid, Noureddine
Responsable du programme de suivi et d'étude des ressources des grands pélagiques, Center Régional de L'INRH á Tanger/M'dig, B.P. 5268, 90000 Drabed Tanger
Tel: +212 53932 5134, Fax: +212 53932 5139, E-Mail: noureddine.abid65@gmail.com

Ben Mhamed, Abdelouahed
Ingénieur en Modélisation statistique à l'INRH, Laboratoire Approches et Méthodologies, INRH, Institut National de Recherche Halieutique, Boulevard Sidi Abderrahman Ain Diab, 20000 Casablanca
Tel: +212 614 592 144; +212 613 384 845, E-Mail: a.benmhamed@mail.com; a.benmhamed@gmail.com; ben.mhamed.abdelouahed@gmail.com

Grichat, Hicham
Chef du Service des Espèces Migratices et Aires Protegeés, Ministère de l'Agriculture et de la Pêche Maritime, Département de la Pêche Maritime, Direction des Pêches Maritimes, B.P 476 Nouveau Quartier Administratif, Haut Agdal Rabat
Tel: +212 537 68 81 15, Fax: +212 537 68 8089, E-Mail: grichat@mpm.gov.ma

Hassouni, Fatima Zohra
Chef de la Division de la Protection des Ressources Halieutiques, Division de la Protection des Ressources Halieutiques, Direction des Pêches maritimes et de l'aquaculture, Département de la Pêche maritime, Nouveau Quartier Administratif, Haut Agdal, Rabat
Tel: +212 537 688 122/21;+212 663 35 36 87, Fax: +212 537 688 089, E-Mail: hassouni@mpm.gov.ma

TUNISIA/TUNISIE/TÚNEZ

Sohlobji, Donia
Direction Générale de la Pêche et de l'Aquaculture, 32 Rue Alain Savary, 1002
Tel: +216 534 31307; +216 71 890 784, Fax: +216 71 799 401, E-Mail: sohlobji_donia@yahoo.fr; doniasohlobji@gmail.com

Zarrad, Rafik
Institut National des Sciences et Technologies de la Mer (INSTM), BP 138 Mahdia 5199
Tel: +216 73 688 604, Fax: +216 73688602, E-Mail: rafik.zarrad@instm.rnrt.tn; rafik.zarrad@gmail.com

TURKEY/TURQUIE/TURQUÍA

Erdem, Ercan
Ministry of Food, Agriculture and Livestock, General Directorate of Fisheries and Aquaculture, Eskisehir yolu 9.Km Lodumlu-Cankaya, Ankara
Tel: +903 12 258 3155, Fax: +903 12 258 3070, E-Mail: ercan.erdem@tarim.gov.tr

UNITED STATES/ÉTATS-UNIS/ESTADOS UNIDOS

Ailloud, Lisa
Virginia Institute of Marine Science, College of William & Mary, PO Box 1346 Gloucester Point, VA 23062
Tel: +1 240 253 3958, E-Mail: lailloud@vims.edu

Brown, Craig A.
Chief, Highly Migratory Species Branch, Sustainable Fisheries Division, NOAA Fisheries Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 586 6589, Fax: +1 305 361 4562, E-Mail: craig.brown@noaa.gov

Cadrin, Steven Xavier
Associate Professor, SMAST - University of Massachusetts, School for Marine Science & Technology, Department of Fisheries Oceanography, 200 Mill Road, Suite 325, Fairhaven, MA 02719
Tel: +1 774 238 6819, Fax: +1 508 910 6374, E-Mail: scadrin@umassd.edu
Díaz, Guillermo
NOAA-Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 898 4035, E-Mail: guillermo.diaz@noaa.gov

Hoenig, John
Professor of Marine Science, Department of Fisheries Science, Virginia Institute of Marine Science, PO Box 1346 (1375 Greate Rd), Gloucester Pt. VA 23185
Tel: +1 804 684 7125, E-Mail: hoenig@vims.edu

Kerr, Lisa
Gulf of Maine Research Institute, 350 Commercial Street, Portland ME 04101
Tel: +1 207 228 1639, E-Mail: lkerr@gmri.org

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

Morse, Molly
University of Massachusetts, School for Marine Science & Technology, 200 Mill Road, Suite 325, Fairhaven, MA 02719
Tel: +1 310 924 5554, E-Mail: mmorse1@umassd.edu

Porch, Clarence E.
Chief, Sustainable Fisheries Division, Southeast Fisheries Science Center, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 361 4232, Fax: +1 305 361 4219, E-Mail: clay.porch@noaa.gov

Sharma, Rishi
SEFSC, 75 Virginia Beach Drive, Miami, Florida 33149
Tel: +1 203 501 0577, E-Mail: rishi.sharma@noaa.gov

Walter, John
NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +305 365 4114, Fax: +1 305 361 4562, E-Mail: john.f.walter@noaa.gov

OBSERVERS FROM INTERGOVERNMENTAL ORGANIZATIONS/ OBSERVATEURS D'ORGANISMES INTERGOUVERNEMENTAUX/ OBSERVADORES DE ORGANIZACIONES INTERGUBERNAMENTALES

FOOD AND AGRICULTURE ORGANIZATION - FAO

Gutiérrez, Nicolás Luis
FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy
Tel: +39 06 570 56563, E-Mail: nicolas.gutierrez@fao.org

OBSERVERS FROM NON-GOVERNMENTAL ORGANIZATIONS/OBSERVATEURS D'ORGANISATIONS NON GOUVERNEMENTALES/OBSERVADORES DE ORGANISMOS NO GUBERNAMENTALES

FEDERATION OF MALTESE AQUACULTURE PRODUCERS – FMAP

Deguara, Simeon
Research and Development Coordinator, Federation of Maltese Aquaculture Producers - FMAP, 61, St. Paul Street, VLT 1212 Valletta, Malta
Tel: +356 21223515 /21226268, Fax: +356 21241170, E-Mail: simeon.deguara@um.edu.mt; dsd@aquabt.com

THE OCEAN FOUNDATION

Boustany, Andre M.
Duke University, Nicholas School of the Environment Box 90328, Durham NC 27708, United States

Tel: +1 831 402 1364, Fax: +1 919 613 8026, E-Mail: andre.boustany@duke.edu

Miller, Shana
The Ocean Foundation, 1320 19th St., NW, 5th Floor, Washington, DC 20036, United States
Tel: +1 631 671 1530, E-Mail: smiller@oceanfdn.org

WORLD WILDLIFE FUND – WWF

Buzzi, Alessandro
WWF, Via Po, 25/c, 00184 Roma, Italy
Tel: +3906 84 4971, E-Mail: abuzzi@wwfmedpo.org

SCRS CHAIRMAN/PRESIDENT DU SCRS/PRESIDENTE DEL SCRS

Die, David
SCRS Chairman, Cooperative Institute of Marine and Atmospheric Studies, University of Miami, 4600 Rickenbacker Causeway, Miami Florida 33149, United States
Tel: +1 673 985 817, Fax: +1 305 421 4221, E-Mail: ddie@rsmas.miami.edu

******

ICCAT Secretariat/ Secrétariat de l'ICCAT/ Secretaría de ICCAT

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

Neves dos Santos, Miguel
De Bruyn, Paul
Kell, Laurence
Ortiz, Mauricio

GBYP PROGRAM

Di Natale, Antonio
Tensek, Stasa
Pagá, Alfonso

Appendix 3

LIST OF DOCUMENTS AND PRESENTATIONS

Reference	Title	Authors
SCRS/2017/082	Standardized joint CPUE index for bluefin tuna (*Thunnus thynnus*) caught by Moroccan and Portuguese traps for the period 1998-2016	Lino P.G., Abid N., Mohamed M.I., and Coelho R.
SCRS/2017/083	A brief review of Atlantic bluefin natural mortality assumptions	Lauretta M.
SCRS/2017/104	An examination of bias in the East Atlantic and Mediterranean Bluefin stock assessment	Kell, L.T.
SCRS/2017/123	An exploratory data analysis of the east atlantic bluefin stock assessment dataset	Kell L.T.,Ben Mhamed A., Rouyer T., and Kimoto A.
SCRS/2017/124	An evaluation of bias and prediction skill for the east Atlantic bluefin stock assessment	Kell L.T.,Ben Mhamed A., Rouyer T., and Kimoto A.
SCRS/ 2017/131	Migratory behaviour of Atlantic bluefin tuna entering the Mediterranean Sea	Carruthers T., Di Natale A., Lauretta M., Pagá-García A., and Tensek S.
SCRS/2017/146	Eastern Bluefin Tuna stock assessment using SAM	Ben Mhamed A., Nielsen A., and Kell L.T.
SCRS/2017/149	Preliminary report of ICCAT GBYP aerial survey for bluefin tuna spawning aggregations in 2017	Di Natale A., Cañadas A., Vázquez-Bonales J.A., Tensek S., and Pagá-García A.
SCRS/2017/153	An exploration of Bluefin tuna data in the West Atlantic with ASAP	Maguire J.J., Cadrin S.X., Hanke A., and Melvin G.
SCRS/2017/164	Estimating the fraction of western Atlantic bluefin tuna that spawn by age from size frequency data collected on the Gulf of Mexico spawning grounds	Porch C., and Hanke A.
SCRS/2017/166	Review and analysis of size frequency samples of Bluefin tuna (*Thunnus thynnus*)	Ortiz M., and Palma C.
SCRS/2017/168	Preliminary 2017 stock assessment results for the eastern and Mediterranean Atlantic bluefin tuna stock	Rouyer T., Kimoto A., Kell L., Walter J.F., Lauretta M., Zarrad R., Ortiz M., Palma C., Arrizabalaga H., Sharma R., Kitakado T., and Abid N.
SCRS/2017/169	Revision of Atlantic bluefin tuna task I nominal catches from Spain	Macias D., Palma C., and Rodriguez-Marin E.
SCRS/2017/170	Direct ageing for constructing age-length keys and re-estimate the growth curve for east Atlantic and Mediterranean bluefin tuna	Rodriguez-Marin E., Quelle P., Ruiz M., Ceballos E., and Ailloud L.E.
SCRS/2017/171	Review and update of the French and Spanish purse seine size at catch for the Mediterranean bluefin tuna fisheries 1970 – 2010	Gordoa A., Rouyer T., and Ortiz M.
SCRS/2017/172	Updated Bluefin CPUE time series from the Balfegó Purse Seine Vessels	Gordoa A.
SCRS/2017/173	Western Atlantic bluefin tuna virtual population analysis (1974-2015)	Lauretta M., Kimoto A., Ortiz M., and Porch C.E.
SCRS/2017/174	Exploratory stock assessment of eastern and western population-of-origin Atlantic bluefin tuna accounting for stock composition	Cadrin S., Morse M., Kerr L., Secor D., and Siskey M.
SCRS/2017/175	Eastern Atlantic Ocean bluefin tuna stock assessment 1950-2015 using stock synthesis	Sharma R., Walter J., Kimoto A., Rouyer T., Lauretta M., Kell L.T., and Porch C.
SCRS/2017/176	Western Atlantic bluefin tuna stock assessment 1950-2015 using stock synthesis	Walter J., Sharma R., and Ortiz M.

SCRS/2017/177	Application of an Atlantic bluefin tuna operating model to generate pseudodata for stock assessment testing	Kerr L.A., Morse M.R., Cadrin S.X., and Galuardi B.
SCRS/2017/178	Simulating virtual population analysis of mixed Atlantic bluefin tuna stocks	Morse M.R, Kerr L.A., and Cadrin S.X.
SCRS/2017/179	Catch-at-age estimates using the combined forward-inverse age-length key	Ailloud L.E., Lauretta M.V., Walter J.F., and Hoenig J.M.
SCRS/2017/180	Update on CPUE bluefin tuna caught by Tunisian purse seines between 2009 and 2016	Zarrad R., and Missaoui H.
SCRS/2017/181	Bluefin tuna catch curve analyses, comparison of alternative ageing protocols	Ortiz M.
SCRS/2017/184	CPUE des palangriers japonais ayant opères dans les eaux algériennes et des thoniers senneurs nationaux	Kouadri- Krim A., and Ferhani K.

Appendix 4

SCRS Document Abstracts as provided by the authors

SCRS/2017/082 – Relative abundance indices of bluefin tuna (*Thunnus thynnus*) caught by the Moroccan and Portuguese traps in the area close to the Strait of Gibraltar were estimated for the period 1998- 2016. Data from four Moroccan and one Portuguese tuna traps were compiled and used in the analysis. The trend of the nominal CPUE series shows a relatively low and flat period between 1998 and 2009, followed by a steep increase in the more recent years. Standardized CPUEs were estimated with Generalized Linear Mixed Models (GLMMs) with Negative Binomial distribution, and using the factors year, month and trapID/location. Due to possible changes in the fishery operation patterns since the year when the quotas started to be reached, the time series and standardization models were split in 2 periods: 1998-2010 and 2011-2016. The standardized CPUEs followed in general the nominal CPUE trends, with a relatively low values and a flat period until 2009, followed by increased values for the more recent years.

SCRS/2017/083 – Survival estimates from Brownie tag return models provided an estimate of the upper limit of natural mortality, as they comprised tag removals from natural mortality, fishing mortality, and chronic tag loss (tag loss post year 1). It should be noted that tag return rate is a function of discrete tag loss, fishing mortality, reporting rate and handling mortality. Although the conventional tagging data contained considerable information on survival over time, no one hypothesis of natural mortality could be selected from the set of candidates based on the analysis. However, if the survival estimates for the period 1995 to 1999 are an accurate measure of total survival and representative of larger fish compared to other periods, then a natural mortality rate greater than 0.12 yr-1 for this group is inconsistent with the results.

SCRS/2017/104 – Stock assessment models are vulnerable to abnormal observations, which may result in biased estimates of parameters, underestimation of uncertainty, and poor prediction skill. This is especially true when the number of observations are relatively small since there are fewer cases to counter abnormalities. It is therefore advisable to identify influential points, explore their impact, and to try and find reasons for their occurrence, e.g. are they due to miscodes, exclusion of important explanatory variables, incorrect model structure, fisher behaviour, management or non-stationarity in biological processes? In this paper we use regression diagnostics, the jackknife and crossvalidation to evaluate the influence of individual observations from the catch per unit effort series used to calibrate the East Atlantic and Mediterranean bluefin Virtual Population Analysis assessment.

SCRS/2017/123 – An exploratory data analysis is conducted of the Eastern Atlantic and Mediterranean bluefin dataset prepared for the Virtual Population Analysis. These data include the catch-at-age of the whole stock, catch per unit effort and their partial catches. The analysis explored correlations and conflicts between the CPUE series, the selection patterns of the main fleets and fishing mortality of the terminal ages the main parameter estimated by VPA. The consequences for developing scenarios for use in the assessment are discussed.

SCRS/2017/124 – Stock assessment models are vulnerable to abnormal observations, which may result in biased estimates of parameters, underestimation of uncertainty, and poor prediction skill. This is especially true when the number of observations are relatively small since there are fewer cases to counter abnormalities. It is therefore advisable to identify influential points, explore their impact, and to try and find reasons for their occurrence, e.g. are they due to miscodes, exclusion of important explanatory variables, incorrect model structure, fisher behaviour, management or non-stationarity in biological processes? In this paper we use regression diagnostics, the jackknife and crossvalidation to evaluate the influence of individual observations from the catch per unit effort series used to calibrate the East Atlantic and Mediterranean bluefin Virtual Population Analysis assessment.

SCRS/ 2017/131 - This paper shows the distribution of both conventional tags and electronic tags that were deployed in the Atlantic Ocean and in the Strait of Gibraltar when they have been recovered or popped-off in the Mediterranean Sea. For better understanding the geographical distribution of those migrant fish, it was decided to divide the Mediterranean in five different areas and then asses the presence. Most of the tags are reported from the Strait of Gibraltar (47%), while the percentage in other areas (Med Gate, Balearic and Central Med) is lower, between 13 and 20%. The lowest percentage is in the eastern Med, due to many factors, including the W-E “filter” which accounts for the accumulation of fishing activities and low tag reporting rate. It is confirmed that migrant fish are able to reach every part of the Mediterranean Sea, possibly with different abundance and with interannual variability. Further analyses of the tag data will be necessary, as well as a better reporting of natural marks.

SCRS/2017/146 – The assessment of the Mediterranean and Atlantic bluefin tuna was always conducted using the VPA approaches. The uncertainties around the estimates of such approaches make difficult the provision of scientific advice. In this paper a state-space stock assessment model SAM is used as a new approaches to evaluate the impact of uncertainty. A comparison of the results of VPA and SAM was conducted based on the 2014 datasets and the preliminary 2017 datasets. To evaluate the robustness of SAM a range of diagnostics and scenarios was ran according the 2017 bluefin data preparatory meeting.

SCRS/2017/149 – The fifth ICCAT GBYP aerial survey was carried out in 2017, after the previous survey done in 2010, 2011, 2013 and 2015. The last survey included 4 areas, overlapping with the corresponding areas in previous surveys. It was carried out during the peak of the Bluefin tuna spawning period (mostly in June), by 3 companies which used 4 aircrafts. It was necessary to get a new survey design in 2017, always using the DISTANCE methodology, adopting an updated protocol. The survey reports were provided each week in real-time and the survey ended on the 3rd July and therefore the data analyses have been available for the first year in real time, according to what was set by the ToRs of the contract. The elaboration provides the estimates for each area (number of schools, number of tunas and quantities), with the usual details, comparing the results with those obtained in previous years in the same areas. The results, again, shows a high interannual variability of the quantities in total and by area, but anyway a high potential SSB, taking into account that the oceanographic situation in 2017 was again quite peculiar and different from 2015 and 2016. Possibly, we detected in real-time an important shifting in the abundance between areas. Furthermore, it is again evident that a reliable trend can be obtained only when considering various areas together.

SCRS/2017/153 – We use ASAP of the USA NOAA Toolbox to explore various combination of model configurations and length of the data series. Using the data from the 2014 assessment, ASAP provided SSB and recruitment trends similar to those in the accepted VPA in some runs but considerably higher SSB in 1970 for one of the runs. Compared with the VPA, run 4 has lower SSB in 1970 and higher SSB in 2013. Using the new catch at age for 1970 to 2013 calculated for the 2017 assessment but keeping the same stock size indices resulted in considerably higher SSB in 1970 and slightly higher SSB in 2013. Extending the catch at age to 2015 and using the updated stock size indices provides similar SSB for 1970 to 1990, but SSB increases more rapidly subsequently than when using the new catch at age to 2014. Extending the catch at age to 1960 provides even higher initial SSBs, but extending it further to 1950 suggests low SSBs in the 1950s and 1960s.

SCRS/2017/164 – The report of the 2017 ICCAT Bluefin Tuna Data Preparatory workshop recommended using two alternative vectors for the proportion of fish contributing to the spawning output of the population (spawning fraction) as a function of age. One vector essentially assumes that maturity alone determines contribution to the spawning stock and is similar to the vector currently used for the East Atlantic and Mediterranean (Corriero et al., 2005) where fish as young as three years old are considered to spawn effectively. The second vector was to be based on the approach of Diaz (2011), which infers spawning frequency from the age composition of fish caught on longlines in the Gulf of Mexico. It was pointed out, however, that the analysis of Diaz (2011) relied on cohort-slicing to infer age from size using a growth curve that has since been revised. Accordingly, the Data Preparatory workshop report recommended updating the Diaz (2011) oogive by using an age-length key rather than the cohort slicing approach.

SCRS/2017/166 – Size frequency data of Atlantic bluefin was reviewed and preliminary analysis performed for its use within the stock evaluation models. Size data is normally submitted to the Secretariat by CPCs under the Task II requirements; optionally CPCs can submit Catch at Size, size samples or both for the major fisheries catching tropical tunas. The size samples data was revised, standardized and aggregated to size frequencies samples by fishery, calendar year and quarter. Preliminary analyses indicated a minimum number of 75 fish measured per size frequency sample. For the Atlantic stocks, the size sampling proportion among the major fishing gears is not consistent with the proportion of the catch; in general purse seine is poorly sampled compared to other fisheries. The number of fish measured has increased substantially in the last decades for the Mediterranean fisheries; however some potential duplicate reporting was uncovered and appropriate corrections were done.

SCRS/2017/168 – Compared to 2014, the present assessment differs on several respects. During the 2017 data preparatory meetings, number of changes have been presented, among which the revision of the task I and task II statistics, the selection of the indices of abundance. In particular, this led to completely revisit the catch at age matrix. As a consequence, previous model specifications could not be used anymore. Whereas the 2014 assessment updated the catch and abundance index data up to 2013 and used the same model specifications as in the 2012 stock assessment, the present assessment present a complete revisitation of these. VPA2-Box was used to estimate the stock status, using a broad spectrum of settings. The resulting models were tested and compared on the basis of their diagnostics, so that the best models could be identified. In particular, different scenarios for F_{ratio}, variance scaling for indices, recruitment constraints and vulnerability were tested. This document will serve as a basis for the 2017 EBFT stock assessment.

SCRS/2017/169 – This document presents a revision of Spanish bluefin tuna nominal annual catches over the period 1950 to 2015. The revision has not affected the total catches. Changes are mainly related to gap completion, errors correction, time series improvement and reduction of unclassified gears.

SCRS/2017/170 – This paper analyzes the available direct ageing information for Atlantic bluefin tuna caught in the eastern management area. Historical fin spine readings were incorporated into the biological database, after having established that the age estimation was equivalent to that performed following the standardized methodology. This allows having a database of aged structures (otoliths and spines) from 1984 to 2013, which can be used for generating catch at age estimates. An integrated analysis of tag-recapture and age-length data was carried out in an attempt to update growth parameter estimates for the eastern stock. Neither the von Bertalanffy nor the Richards parameterization was able to adequately describe growth. The reason for the misfit was largely due to the lack of older individuals in the dataset as well as possible differences in selectivity pattern between young and old fish.

SCRS/2017/171 – Since the 1970's, Purse seiners is one of the main fisheries targeting Atlantic bluefin tuna, particularly in the Mediterranean Sea. At the beginning of the fishery, French and Spanish vessels operated near the coast and mainly targeted small young schooling bluefin tuna. At the end of the 80s the French and Spanish vessels started targeting spawner aggregations as they discovered the Balearic spawning ground. Since then, the fleet gradually adapted its capacity and technology to target bigger tuna on distant grounds. By the early 2000s, the purse seine fishery became the main provider of live fish to the developing farming operations in the Mediterranean Sea. Although this fishery represents on average more than 50% of the catch since the 1980s, basic fisheries information on size of the catch and/or its age distribution is very limited. Indeed, past assessments has identified this lack of information as one of the major sources of uncertainty in their evaluations. The present manuscript reviews and incorporates paste and new information available on size distribution of the catch of PS in the Mediterranean.

SCRS/2017/172 – This study updated the unstandardized CPUE index of the Balfegó purse seiners jointly with a new CPUE index estimated from the Balfegó joint fishing fleet. Both CPUE index are contrasted with the Japanese longline standardized CPUE series to examine its reliability. The results showed that both Balfegó CPUE series highly correlates with Japanese indices. The CPUE of the joint fishing fleet remained stable over the last three years while Japenese index and Balfegó vessels were more variable and with opposite trends in 2017. Overall these results are indicative that Balfegó vessels and fleet might be consider a reliable abundance index of the ABFT eastern population and should be taken into account. Moreover, it will correct the deficient spatial representativeness of abundance indices used to date. On the other hand, the average weight estimated from 2017 fishing sets, according to skipper estimation, did not differ from those estimated last year from stero cameras.

SCRS/2017/173 – This report documents the methods for updating the virtual population analysis of West Atlantic bluefin tuna for the period 1974 to 2015. The analysis was conducted by a joint-CPC assessment team in accordance with the specifications of the bluefin tuna work plan. The team implemented proposed changes to the model and model sensitivity analyses outlined in the 2017 ICCAT Bluefin Data Preparatory Meeting Report. The assessment files are available on the assessment meeting OwnCloud/Analysis/WBFT folder and in the attached appendices. An accompanying R script is also provided which precisely documents each modification to the continuity VPA, and the set of model sensitivities conducted by the team. These tools allow rapid integration of data modifications and replication of each model run conducted for evaluation by the Bluefin Tuna Species Workgroup at the upcoming assessment workshop.

SCRS/2017/174 – Input data from the most recent stock assessments of Atlantic bluefin tuna fisheries were revised to account for estimates of stock composition. Assessments of eastern and western fisheries were compared to assessments of eastern-origin and western-origin fish to evaluate the sensitivity of results to stock mixing, as well as to demonstrate a practical approach to operational assessments to account for stock mixing. Estimates of stock size and fishing mortality from the VPAs of both eastern- and western-origin Atlantic bluefin were generally similar to the 2014 ICCAT estimates based on eastern and western Atlantic mixed-stock fisheries, but the western VPA estimates were more sensitive to the assumption of no stock mixing than the eastern VPA.

SCRS/2017/175 – A stock assessment of the Eastern Atlantic Ocean Bluefin tuna (Thunnus thynnus, BFT) population from 1950 to 2016 using Stock Synthesis is presented here. We present initial scoping runs, base model runs, and structural uncertainty across various assumptions of steepness, growth, maturation, natural mortality, effective sample size weights on length composition data, fits to different indices of abundance, assumptions on changes in q for some LL fleets, and shape of selectivity function on the LL fisheries is tested. Diagnostics for the base model run are presented along with retrospective analysis and jack-knifes. Overall model performance appears stable across a range of assumptions though derived reference parameters can differ substantially. The current models use all available indices (other than Spanish BB as it fails to converge when we add this index) and appear unable to estimate key parameters such as steepness. The results presented here should be considered preliminary, however the model set up, data and structure will likely remain similar for final model advice.

SCRS/2017/176 – This document describes a stock assessment model using Stock Synthesis for the Western Atlantic population of Bluefin tuna. This document describes initial model set up, fleet definitions, selectivity and parameterizations. The model runs from 1950 to 2015 and was fit to length composition data, conditional length at age (otolith age-length pairs input as an age-length key), 13 indices and 12 fishing fleets. Growth was internally estimated in the model and natural mortality was scaled with a Lorenzen function. Two models with high (100% at age 13) and low age at maturity (100% at 5) are presented. Model diagnostics indicate some conflict between length and index data but generally robust diagnostic performance. A Beverton-Holt stock recruitment relationship was estimated in the model with steepness, sigmaR and R0 freely estimated. Overall fits to length composition were fairly good and the two model runs showed very similar behavior with the stock decreasing during the 1970s remaining relatively low during the 1980-2000 period and showing a pattern of steady population growth since 2000. The results presented here should be considered preliminary as benchmarks and final model specifications are still under consideration, however the model set up, data and structure will likely remain similar to what was presented in this document.

SCRS/2017/177 – We developed a simulation model to represent the spatial dynamics of Atlantic bluefin tuna and to test the performance of alternative stock assessment models. A simulation framework previously developed to explore how stock mixing affects the resource and fisheries was conditioned on the available information for Atlantic bluefin tuna and used to generate pseudodata with the same properties as the information available for stock assessment. The analytical framework was a stochastic, age-structured, stock-overlap model that was seasonally and spatially explicit with movement of eastern- and western-origin tuna informed by fishery-independent telemetry information. The operating model was conditioned with 1970 abundance at age, 1970-2013 age-1 abundance, and fishing mortality at age from the 2014 ICCAT stock assessments, which were modified to reflect decisions from the 2017 data preparatory meeting. The operating model is well-suited to test the current virtual population analyses for eastern and western Atlantic bluefin tuna fisheries and can be used to test alternative estimation models as well as the performance of alternative management procedures.

SCRS/2017/178 – The purpose of this investigation was to simulation test the performance of calibrated virtual population analysis for assessing mixed Atlantic bluefin tuna stocks. Pseudodata with the typical patterns, quantity, and quality of data available for the most recent stock assessment of Atlantic bluefin tuna were generated using a previously developed operating model framework that incorporated movement and mixing between stocks conditioned on previous Atlantic bluefin tuna stock assessments. Separate eastern and western stocks were assessed using VPA-2BOX as the estimation model, and model performance was assessed by comparing results across simulations and to the stock and population views of the operating model. The estimation model was sensitive to process error (i.e., stock mixing) and measurement error, biasing estimates of spawning stock biomass, recruitment, and apical fishing mortality. The results suggest that separate virtual population analyses of eastern and western stocks accurately reflect general stock and population trends, but absolute estimates are considerably biased and may provide misleading management advice if the simulations are realistic.

SCRS/2017/179 – Estimates of catch at age are presented for the western stock of bluefin tuna using the combined forward-inverse age-length key approach of Hoenig et al. (2002). Numerous sets of starting values were used to ensure the global maximum of the likelihood function was found. Convergence issues linked with years with little to no age data still need to be resolved. Until then, we recommend that cohort slicing catch at age estimates in the most recent years be replaced by catch at age estimates resulting from the forward-inverse age-length key analysis presented here.

SCRS/2017/180 – Bluefin catch rates of Tunisian purse seines from 2009 to 2016 were standardised. Data were analyzed following a General Linear Modelling (GLM) approach under log-normal error assumption. The GLM showed the significant effect of the factor year on the catch per unit of effort CPUE. We note some similarity in the evolution of the CPUE and the mean weight of fish. The minimum standardized CPUE was recorded in 2011 (1436 kg/day). Maximum CPUE was reached in 2014 (6554 kg/day). Higher values were recorded in the last two years 2015 (4558 kg/day) and 2016 (4778 kg/day).

SCRS/2017/181 – The current assessment of Atlantic Bluefin tuna stocks is based on age structure models (VPA), for which the CAA is estimated using a slicing ageing protocol. An alternative ageing protocol has been used for generating the CAA for the upcoming assessment, based on a statistical age at size parametric growth model. This document compares the estimated CAA using a simple catch-curve analysis by stock and main gear type. A range of estimated total mortality (Z) are presented; results show similar values of Z for the W-BFT in general for both ageing protocols, while for the E-BFT the slicing protocol indicated a larger Z compared to the parametric growth model.

SCRS/2017/184 – Les CPUE du thon rouge (*Thunnus thynnus*) réalisées par les thoniers palangriers japonais ayant opérés dans les eaux sous juridiction nationale pendant la période allantde2000 à 2006 ont été calculées ainsi que celles réalisées par les senneurs de 2012 à2016.Cependant il est important de préciser que même si la comparaison a été faite dans le cadre de ce travail, le mode opératoire est différent pour les deux types de pêche, en effet, la pêche à la palangre effectue plusieurs opérations de pêche moyennant des palangres dont le nombre d’hameçon peut varier ainsi que la longueur, à l’inverse de la senne qui cible le thon vivant peut effectuer un seul coup de senne et faire tout son quota.

Appendix 5

Control file for Western Bluefin tuna SS run 10 (high age at maturity)

For low age at maturity uncomment out line 33 and comment line 34 to change the assumed age at maturity. This **Appendix** is available as an electronic document.

Appendix 6

Control file for Western Bluefin tuna for VPA-2BOX

This **Appendix** is available as an electronic document.