REPORT OF THE 2016 ICCAT YELLOWFIN TUNA STOCK ASSESSMENT MEETING

(San Sebastian, Spain – 27 June to 1 July 2016)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the AZTI-Tecnalia Laboratory in San Sebastian, Pasaia (Spain) from 27 June to 1 July 2016. Dr Shannon L. Cass-Calay (YFT Species Group Rapporteur) opened the meeting and welcomed participants ("the Working Group") and thanked AZTI for hosting the meeting and providing all the logistical arrangements. Dr Miguel Neves dos Santos, on behalf of the ICCAT Executive Secretary, highlighted the importance of the work to be developed by the Group during the meeting aiming at the provision of management advice to the Commission, and thanked AZTI-Tecnalia for hosting the meeting. Dr Cass-Calay proceeded to review the preliminary 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 participants served as Rapporteurs:

Item 1: M. Neves dos Santos
Item 2: D. Die, M. Ortiz and J. Walter
Item 3: T. Matsumoto, K. Satoh, J. Walter, S. Cass-Calay, R. Sharma and G. Diaz
Item 4: T. Matsumoto, K. Satoh, J. Walter, S. Cass-Calay, R. Sharma and G. Diaz
Item 5. T. Matsumoto, K. Satoh, J. Walter, S. Cass-Calay, R. Sharma and G. Diaz
Item 6: J. Scott, A. Justel and S. Cass-Calay
Item 7: D. Die
Item 8: M. Ortiz

2. Summary of available data for assessment

2.1 Biology

A presentation made during the meeting (SCRS/p/2016/024) showed that average size of females (117.6 cm) is 1 cm larger than that of males (116.6 cm) in the catches of Uruguayan longliners. This difference is small compared to those reported previously to the Group, which suggest that in catches of longliners the sex ratio of large fish is dominated by males (Albaret, 1977).

Biological parameters to be used as input to assessment models were agreed during the data preparatory meeting (**Table 1**). The following main agreements were reached:

- Use a maximum lifespan of eleven years and the Then *et al.* (2014) estimator to calculate an M of 0.54 (baseline M)
- Use a Lorenzen-like function (Lorenzen, 2005) to scale mortality estimates across different ages
- Use as preferred growth parameters those from Gascuel *et al.*, 1992.

Maturity at age was agreed to follow Diaha *et al.* (2015) (**Table 2**).

SCRS/2016/116 reports the implications of these decisions in producing estimates of M for different values of growth parameters and different choices on how the baseline mortality is calculated. The authors also compared the estimates of age-dependent natural mortality to those estimated for yellowfin stocks in other oceans, and for several alternative growth curves. The Group agreed to use the vectors of M corresponding to the selected growth curve:

Based on Gascuel *et al.*, 1992:
Ages 0-11+: 1.588, 1.194, 0.748, 0.550, 0.476, 0.447, 0.435, 0.431, 0.429, 0.428, 0.428, 0.428

Based on Draganik and Pelczarski, 1984:
Ages 0-11+: 1.758, 0.889, 0.672, 0.576, 0.525, 0.495, 0.476, 0.463, 0.455, 0.450, 0.446, 0.443

The Group noted that any change in the assumptions about growth would require a re-estimation of M-at-age and discussed that the current assumption about M-at-age does not consider the possibility of senescence and that in the IOTC and the EPO assessments of yellowfin it is assumed that M does increase for older ages. To evaluate the effect of senescence, the Group proposed to conduct a sensitivity analysis. It was noted, however, that, any change in the assumptions about M requires a re-estimation of the catch at age if the method proposed by Ortiz (SCRS/2016/106) is used, because the method relies on specific assumption about M-at-age. Therefore, sensitivity analysis with senescence was only conducted with Stock Synthesis (SS3).

SCRS/2016/110 presented results of the application of SS3 to yellowfin, where three sets of growth data pairs (age, length) from Gascuel *et al*., 1992, Shuford *et al*., 2007 and SCRS/2016/049 were incorporated together to a single SS3 input file. When the SS3 model is allowed to fit all data and estimate growth parameters (a multi-stanza curve with varying *k*) the resulting predictions assign similar predicted length for ages 1-3 to those predicted by Gascuel *et al.*, 1992, but smaller predicted length for age zero and for fish older than 3 (**Figure 1** and **Table 3**). However, the primary difference when L-infinity is estimated in SS3 as compared with other externally derived growth curves is a substantially lower L-infinity. The near absence of fish at the level of L-infinity for the Gascuel *et al*., 1992 growth curve (175 cm) created substantial conflict within the SS3 models. This absence of fish could be due to a lower L-infinity or it could also be explained by U-shaped M, dome shape selectivity or a combination of the three. The Group hopes that the AOTTP programme will help further clarify growth curves, selectivity and natural mortality.

2.2 Catch, effort, size and CAS/CAA estimates

The Secretariat provided the corresponding fisheries data input of Task I nominal catch (**Table 4**, **Figure 2**), Task II catch and effort (CE), Task II catch-at-size (CAS) (**Figure 3**) and the corresponding size frequency data aggregated by year-quarter, fishing mode, main gear, and 5x5 square Lat-Long grid (**Figure 4**) before the meeting. For 2015, about 53% of the CPCs submitted preliminary estimates of yellowfin nominal catches prior to the meeting. The Group completed the 2015 total Task I by carrying over the average of the last three years (2012-2014). The agreed nominal catch for 2015 and 2016 for projections was set at 110,337 t. More detailed discussions on catch, effort and size data inputs can be found in the Report of the 2016 ICCAT Yellowfin Tuna Data Preparatory Meeting (Anon., 2016 (*in press*)).

Document SCRS/2016/107 described the estimates of the Ghanaian purse and baitboat Task I and II for 2006-2014, as recommended from the data preparatory meeting. The total catch of tropical tunas (BET, SKJ, YFT) and associated species (other species) were selected from the highest annual reports from the Ghana AVDTH database, either from the logbook reports (catch) or the sale records (landings) destined primarily to the canning companies. The logbooks reports and landings records were incomplete for 2007, thus Task I and II were not estimated for this year and prior estimates from the ICCAT database were used. Estimates of catch composition and size composition of Ghana commercial fisheries were done for each fleet component; national fleet (Fleet A) and Fleet P, assuming a homogenous composition and size distribution by a strata of year-quarter and 5°x5° square lat-lon grid. Estimated additional Task I catch was assigned to the Fleet P purse seine component operating on FADs (fishing mode) for 2006 - 2011. Sampling from within each stratum was used with priority from Ghana sampling; if not available, EU_PS sampling from the same strata was selected, if no data were available then sampling from adjacent grids were applied. The estimation provided total Task I nominal catch for YFT, catch and effort by year-month-strata, catch-at-size, and size sample frequency data for the commercial purse seine and baitboat Ghanaian fleets. The Group noted that operations from baitboat fleets, particularly in the Gulf of Guinea, may include direct baitboat fishing activities, as well collaboration fishing with purse seine operations.

Document SCRS/2016/108 summarized the yellowfin size frequency data available for model inputs. Data include sampling since 1956 to 2014, with over 4.7 million fish measured, with most of the samples coming from purse seine fleets (51%), LL (28%) and BB (17%). Spatial and temporal coverage was considered sufficient since the 1990s, however coverage in relation to catch by fishery ID varied substantially, with better information since the 1980s. The size frequency data included the actual measures from the main EU-Fleets recently provided by EU scientist, new information from the "*faux poisson*" sampling and revised data from major longline fisheries time series.

Document SCRS/2016/106 described the estimation and procedures for the estimation of the Catch-at-size (CAS) and Catch-at-age (CAA). CAS input was estimated for the complete time series 1960-2014, although sampling from 1960-1965 is very limited. New and revised size and CAS information were received from major fisheries, longline in particular, with also redistribution on mixed fisheries and new information from fisheries such as "*faux poisson*". The ageing of the CAS was done using similar protocols as in 2011, including the:

i) slicing from deterministic growth functions; ii) including variance of size at age; and, iii) an updated algorithm considering the exponential decline of numbers of fish due to overall mortality (natural and fishing mortality). Preliminary analyses that included only natural mortality indicated that declines in fish numbers with age, have significant effect in the CAA estimation. However, the Group considered that it was necessary to have more simulation studies to evaluate integrating variance of size at age and mortality in the assignment of age from growth model protocols, before accepting this protocol as the base one for ageing the CAS.

A review and update on Task II Catch and size information for yellowfin catches 1998-2012 from Uruguay was presented, including standardization to fork length measurement units using specific conversion factors (SCRS/2016/p/24) from this area (SCRS/2016/p/023). The updated size data was incorporated into the CAS and size frequency data inputs. This report indicated no differences by gender on size, which contrasts with earlier discussions of the Group.

2.3 Relative abundance estimates

2.3.1 Considerations regarding indices

For the 2016 Yellowfin Stock Assessment CPUE indices from six CPCs were documented and presented at the data workshop. Two relict purse seine indices were also considered and subjected to diagnostic evaluation, however, they were ultimately not recommended to be retained for the assessment models. In addition there were several relict CPUE indices used in the 2011 assessment (Anon., 2012). These indices were not updated for 2016 and since they could not be evaluated according to current model evaluation criteria they were not recommended for inclusion except for continuity models. **Table 5** documents the available annual indices.

The first diagnostic evaluation conducted was to determine whether the indices exhibited very high interannual variability outside of the bounds of production model behavior and while some indices did show substantial interannual fluctuations, the Group did not exclude any models from consideration on this basis. Index correlations were calculated and, where indices overlapped (early time period-1971:1992 and late time period 1993:2010), cluster analysis was conducted to attempt to find indices that exhibited similar patterns.

Overall several indices showed some severe interannual fluctuations, notable URU_W_1 and URU_W_2. Other indices showed evidence of between 10 and 52% of the observations falling outside of assumed production model dynamics. Nonetheless, with the exception of the URU indices, most of the deviations were not severe and, as this metric is most useful for identifying potential unaccounted for process error, the Group did not feel that this was a clear justification that any index should be removed. The URU_W_2 index value in 2009 was 0.03. Values approaching zero can be problematic in models. It was recommended that this value be removed from model fitting.

Negative correlations between some of the indices indicate that there is substantial conflict between many of the indices. The very high correlations between the same index in number and weight indicated that the two would be very interchangeable in models. This result coupled with previous findings (Prager and Goodyear, 2001) that indices in number or in weight gave similar results in production models resulted in the recommendation that indices be used in production models in number if they were not provided in weight.

The correlations among indices were further explored by a cluster analysis during a later time period where the indices overlapped (1993-2010). For some fleets, indices developed in both number and weight were available. In these instances, indices in number and weight could not be differentiated in the cluster analysis. When only indices in number or indices in weight were used for cluster analysis, two distinct groups emerged (**Figure 5**), primarily related to the trends of the indices in the more recent time period. One cluster of indices (Japanese LL, Venezuela LL, US LL, and Chinese Taipei 1970_1992) shows an initial early decline, and then generally varies without trend. The second cluster (URU LL, BRZ LL, and Chinese Taipei 1993_2104) shows an increase in CPUE in the mid-90s and then a subsequent decline. In the early time period the indices were in general agreement, except URU_LL_1, which appears to be a substantial outlier. Thus it is proposed to keep CH_TAI_LLN_1_70_92 in both clusters and to use URU_LL_1 in cluster 2 where the second URU index is. These clusters are as follows:

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CLUSTER1=c("CH_TAI_LLN_1_70_92" , "US_LL_W" , "VEN_LL_N","Japan_W_76_14" )
CLUSTER2=c("CH_TAI_LLN_1_70_92", "URU_W_1","URU_W_2", "BR_LL_N","CHTAI_N_93_14_M4")
CLUSTER_1_Sens=c("CH_TAI_LLN_1_70_92", "US_LL_W" , "VEN_LL_N","Japan_N_65_14" )
```

During the analysis of the indices several other issues emerged. These were the recommendations to start the Japanese longline index in 1976 due to changes in targeting that could not be accounted for in the standardization. Hence there is sensitivity on Cluster_1 which starts the Japanese longline index in 1965. The following index decisions were made as result of explorations of the indices and are outlined below:

1. Use indices in "native" units. Do not convert indices in numbers to biomass using observed average weight.
2. Do not retain indices that were developed prior to the 2011 assessment, and not updated/reevaluated since (i.e. drop Canary Islands baitboat, Brazil baitboat, Venezuelan purse seine).
3. Do not use FAD or purse seine indices for base models unless known trends in fishing power have been accounted for (through standardization or post-processing).
4. Index Weighting: Equally weighted (i.e. CV=0.2 for all indices, all years).
5. CLUSTERS as outlined above. The models were run for each index cluster. This should eliminate the conflict in indices, and test two hypotheses regarding stock dynamics, that the stock increased in the mid 90s, and then declined, or that the stock has generally varied without trend since an initial decline. This will be particularly critical for surplus production models.
6. Explore the sensitivity of the model to index selection using a "Jack-Knife Analysis".
7. Recommended indices that cause undue model degradation can be removed from provisional models at the analyst's discretion. The analyst will provide a justification to the Stock Assessment Methods Working Group.

A more complete documentation of decisions regarding index diagnostics and recommendations for inclusion in modeling can be found **Appendix 4**.

2.3.2 Index recommendations for use

The various indices proposed for incorporation in the different stock assessment models are provided in **Table 5** and are identified by index cluster (**Figure 5**). Eight indices were chosen by the Group based on meeting the criteria for inclusion and as they were fully documented. An additional index of Spanish purse seine fisheries was provided to the Group but it was lacking full documentation of methodology and assumptions. Given the complexity of defining catch per unit effort for purse seines and the noted changes in catchability that have occurred, this index could not be fully evaluated and included in the assessment models. The loss of indices from the baitboat and purse seine fleets since the 2011 assessment means that this assessment will have no CPUE information from the primary surface fleets or of fleets that are likely to capture newly recruited fish. Future work to develop or maintain indices from these fleets would be desirable.

For certain assessment models, 'relict' indices used in previous assessments and combined indices were necessary to provide continuity models. The construction and treatment of these indices are detailed in each assessment section.

3. Stocks assessment methods and other data relevant to the assessment

3.1 Production models (ASPIC)

The fleets and CPUE indices used for ASPIC model are shown in **Table 5** and **Figure 5**. The annual catches by fleet used for ASPIC are summarized in **Table 6**.

To conduct continuity runs, combined CPUEs were created using the CPUE indices shown in **Table 7**, weighted by the number of 5x5 latitude-longitude observations by quarter within a year (count of cell number with positive catch of yellowfin) (**Table 8**), which is the same protocol as that used in the last assessment. Annual improvement of catchability for purse seine fishery was assumed to be 3% or 7%. **Table 9** and **Figure 6** show the values for combined indices with those for the last assessment.

At the 2011 stock assessment, ASPIC (Prager, 1992) was used to fit production models and four ASPIC cases were selected for management advice (Runs 9, 10, 11 and 12, Anon., 2012). They all correspond to Logistic fits of the model with combined indices (1 fleet).

During the current assessment, the version 5.34 of ASPIC was used. Based on the decision at and after the yellowfin tuna data preparatory meeting in 2016, scenarios with fleet structure and indices grouped by two clusters were examined. Scenarios with combined indices were also examined for continuity runs. Thus, a number of different preliminary runs were conducted, and considered by the Group (**Table 10**).

3.1.1 Sensitivity runs

Several sensitivity analyses were conducted for two scenarios (Cluster 1, logistic and Fox model equal weighted) of ASPIC model (**Table 11**). These include scenarios with different B1/K, scenarios with longer Japanese longline CPUE and scenarios which exclude one or more CPUE indices.

3.1.2 Base case

After examining the scenarios presented, the Group decided to use one scenario for Cluster 1 (Fox model equal weighted) as the basis for providing the advice, based on retrospective patterns and values for objective function. The base case includes longline indices for Chinese Taipei (1970-1992), US (1987-2014), Venezuela (1991-2014) and Japan (1976-2014). B1/K was fixed at 0.9.

3.1.3 Retrospective analysis

Retrospective analyses were conducted by sequentially removing a single year of data and re-estimating model outputs. The purpose of this exercise was to determine how the addition of new data changes the perception of the status of the stock and to evaluate retrospective bias.

3.2 Age Structured Production Model (ASPM)

The AD model builder implemented age-structured-production-model (ASPM) software (version 3, 2014) (Nishida *et al*., 2014) was used. The ASPM software requires three types of data, catch (SCRS/2016/111; Table 2-1, 2-2, Figure 1), standardized CPUE (SCRS/2016/111; Table 3, Figure 3) and Catch-at-Age (CAA; SCRS/2016/111; Figure 2). Data source of the catch was "cdis_byFishery.csv" which was provided by the ICCAT Secretariat. Data source of the CAA was "Sum_CAAsYFT2016.xlsx". This file contains five types of CAA (see text in SCRS/2016/111). After discussion of the Group three types of CAA (01_Cont: same formulation as 2011 meeting using Gascuel 2-stanza growth model without M vector in ageing; 03_DrwithM: Draganik von Bertalanffy growth model including M vector; and, 05_GawithM: Gascuel 2-stanza growth model including M vector) were used for the ASPM analysis. The "01_Cont" was used for the base models (used to develop management advice) in order to retain similar assumptions as the stock assessment in 2011, although the ASPM analysis was not implemented for the stock previously. The data source of the standardized CPUE is "YFT_2016_CPUE.for models.6.9.16.xlsx", which contained three groups of indices (clusters 1 and 2, and sensitivity (SCRS/2016/111; Table 3, Figure 3). The fishery definitions for the ASPM analysis are described (**Table 12**). Note that the Uruguay longline standardized CPUE in the Cluster 2 was not used because the software is constrained by not allowing fleets with zero catch.

3.3 Catch statistical models: Stock Synthesis (SS3)

The model structure was based on the Multifan assessment model developed in 2011 (Anon, 2012). The platform used was Stock Synthesis (SS3), v24.f (Methot and Wetzel 2013). As in most integrated assessment, the model had a complex fishery structure that included 17 fisheries that were purse seine, baitboat, longline, rod and reel, and the other fishery categories. The model used 8 different indices of abundance primarily from the longline fleets operating by different periods. These fleets were primarily the Japanese, Taiwanese, Uruguay, Brazil, US and Venezuelan fleets. Both the Uruguay and Taiwanese fleets were split into multiple periods. Length composition data by season of 17 fleets were used (SCRS/2016/110). In addition, there were numerous assumptions based on steepness, natural mortality and growth (SCRS/2016/110). Multiple iterations of growth and natural mortality were examined until the Group noted that the models that estimated growth performed the best, subsequently growth was fixed at the model estimates obtained using age composition data.

Models were fit to different index clusters (SCRS/2016/109) with the indices input with a common CV (0.2), and diagnostic fits are summarized in detail in Section 4.3. Growth was estimated during the model development process and was useful to obtain improved model fits and to explain the observed size composition information. Models estimated growth by estimating K using the k-deviates option in SS, as well as estimating L-inf (or length at age 10+). Iterative reweighting as prescribed in Francis, 2011 was used to further adjust these length compositions through a variance multiplier on the overall Effective Sample Size (ESS) that was fixed across all fleets and time strata at 20. During the meeting an alternative weighting approach that incorporated the interannual variability in the quality of size composition samples was developed however time constraints limited its further exploration.

3.4 Virtual Population Analysis (VPA)

Tuned virtual population analyses (VPA) were conducted using the VPA-2BOX software featured in the ICCAT Software Catalog. The data inputs and several biological parameters were updated in preparation for this assessment (see Anon., 2016 (*in press*)); the Report of the 2016 ICCAT Yellowfin Tuna Data Preparatory Meeting). The Catch-at-size was fully rebuilt following the submission of new Task II size samples and CAS by the CPCs. The natural mortality function was revised to reflect an expected decline in mortality-at-age (Lorenzen, 2005). The maturity vector was also updated according to (Diaha *et al*., 2015). **Table 13** shows the parameter specifications for the VPA runs and **Table 14** the specifications for the partial CAA related to indices of abundance.

3.4.1 General specifications

Virtual Population Analyses require the following data inputs. Detailed descriptions of the VPA model inputs can be found in SCRS/2016/105.

1. Total Catch-at-Age, assumed known exactly.
2. CPUE (or index of relative fishing pressure).
3. Fleet-Specific Catch-at-Age.
4. Fleet-Specific Average Weight-at-Age.
5. Average Weight-at-Age at peak of spawning season.
6. Biological parameters:
    a. Maturity, fecundity, month of peak spawning
    b. Natural Mortality
    c. Growth Parameters

The parameter specifications used in the 2016 continuity case VPA were the same as those used in the 2011 base-case, unless otherwise noted.

The oldest age class represents 5+ age group (ages 5 and older). The fishing mortality rate (F) on that age is specified as the product of the fishing mortality rate on the next younger age (F_4) and an 'F-ratio' parameter that represents the ratio of F_5 to F_4. As in the 2011 assessment model, the F-ratio was estimated in 1970, and thereafter allowed to vary from the 1970 estimate using a random walk (standard deviation = 0.2).

The fishing mortality rates for ages 1-4 in the last year of the VPA were estimated as free parameters, but subject to a constraint restricting the amount of change in the vulnerability pattern (on ages 1 to 5+) during the most recent three years with a standard deviation of 0.4 (e.g. SCRS/2008/089). Recruitment estimates were subject to a constraint restricting the amount of change during the most recent four years with a standard deviation of 0.4.

The indices of abundance were fitted assuming a lognormal error structure and equal weighting (i.e., the coefficient of variation was represented by a single estimated parameter for all years and indices). The catchability (scaling) coefficients for each index were assumed constant over the duration of that index and estimated by the corresponding concentrated likelihood formula. All indices were weighted by a variance scalar which was estimated for the first index, then applied to the others. This parameterization weighted all indices equally.

3.4.2 Summary of VPA Model Specifications

The VPA model runs presented to the Group examined the effect of index selection on the population dynamics of yellowfin tuna. Four models were run as described below:

1) Base Model #1 1970-2014
    a) Ages 0-5+.
    b) Lorenzen M on Ages 0-5+ = 1.59, 1.19, 0.748, 0.550, 0.423.
    c) Maturity on Ages 0-5+ = 0, 0, 0, 0.38, 0.99, 1.
    d) Used CLUSTER 1 Indices: CH_TAI_LLN_1_70_92, US_LL_N, VEN_LL_N, Japan_N_76_14 weighted equally.

2) Base Model #2: Same as #1 except:
   a) Used CLUSTER 2 indices: CH_TAI_LLN_1_70_92, URU_W_1, URU_W_2, BR_LL_N, CH_TAI_N_93_14_M4.

3) Sensitivity Model #1: Same as base model except:
   a) Model start year (1965).
   b) Full time series (1965-2014) of the Japanese LL index in numbers replaced the short series.

4) Continuity Model: Updated data through 2014, fleets and indices as specified in 2011 base VPA models except:
   a) Replaced US_LL_ATL and US/MEX_GOM indices with a US_LL index developed using data from both regions.
   b) The revised indices for Uruguay and Chinese Taipei were broken into periods that indicated a change in selectivity. Decision made at the 2016 assessment differed somewhat from the previous assessment.

3.4.3 Base models diagnostics

For all base models, the VPA converged within the specified maximum iterations, and no parameter estimates were bounded. Six parameters were estimated for each model, the F ratio (F5/F4) in 1970, the F on Ages 1-4, and a single index variance. All parameters were well estimated (CV ~ 0.2) except the F on age 0, which was less well estimated (CV ~ 0.4). Fits to the CPUE series for the VPA base models are summarized in **Figures 7** and **8**. The fits to the base model that used Cluster 1 were fairly good for the U.S. longline, Japan longline, and the Chinese-Taipei longline indices; while the fit to the Venezuelan longline index was poor. For the base model that used Cluster 2, fit were degraded (relative to Cluster 1) except for the fit to the Chinese-Taipei longline index (note that the Chinese-Taipei longline index was the only index that was included in both clusters).

Retrospective analyses on Spawning Stock Biomass and Recruitment for both base models were completed by sequentially removing inputs of catch and abundance indices from the two base case models. The retrospective analyses showed no patterns in either spawning stock biomass (**Figure 9**) or recruitment for any of the base models. However, it should be noted that constraints were applied (SD = 0.4) during 2011-2014 to restrict the magnitude of change allowed.

3.4.4 Sensitivity run diagnostics

The results of the sensitivity run using the JPN longline index for the period 1965-2014 were almost identical to those of the Cluster 1 base model. **Figure 10** shows the fit to the indexes. Similarly to the Cluster 1 base case, the U.S., China-Taipei and Japan longline indexes showed a fairly good fit; while the Venezuela longline index showed a lack fit, particularly in the mid 1990s. The retrospective analyses on SSB and recruitment showed no discernable pattern and were almost identical to that of the Cluster 1 base case. Therefore, for brevity, these figures are not included.

3.4.5 Continuity case diagnostics

Figure 11 shows the fit to the 15 indexes used in the continuity case. In most cases, fits to the indexes were poor, as they had also been during the 2011 assessment.

3.5 Other methods

No other evaluation methods were presented during the meeting.

4. Stock status results

4.1 Production models (ASPIC)

4.1.1 Base case

The Group considered several ASPIC model parameterizations, and selected the base model (Cluster 1_Fox_eq) on the basis of the model diagnostics (**Table 15** and **Figure 12**). The results of the base model indicate increasing and decreasing trend for median B-ratio and F-ratio in recent years (after 2005), respectively, and currently the stock status was estimated not overfished nor overfishing, although current biomass was close to B_{MSY} level. Uncertainty in model estimates was examined using a bootstrap analysis (N=500). The 10^{th} and 90^{th} percentiles of annual estimates of B/B_{MSY} and F/F_{MSY} are shown in **Figures 12**. The Kobe Plot of 2014 stock status is shown in **Figure 13**. The uncertainty in the estimated stock status (i.e. 2014 B/B_{MSY} and F/F_{MSY}) is indicated by the cluster of blue points on the Kobe Plot.

4.1.2 Other models not selected

Point estimates for population parameters were similar among four runs for Cluster 1 including base case scenario (**Table 15, Figure 12**). No convergence or reasonable results were obtained for the scenarios that used Cluster 2 indices. The results for the scenarios of Cluster 1_sens were a bit more optimistic compared with those for Cluster 1. However, the scenarios of Cluster 1_sens include Japanese longline CPUE for 1965-2014. Based on the concern for target shift by Japanese longline during the early period, the scenarios of Cluster 1_sens were not selected for base case.

4.1.3 Continuity case

The scenarios including updated combined indices (continuity runs) indicate that population status estimates were more pessimistic compared than those for Cluster 1 (**Table 15, Figure 14**). Trend of B-ratio is flat in recent years, probably based on the trend of combined indices. **Figure 15** shows comparison of ASPIC continuity runs results (B-ratio and F-ratio) with those of 2011 assessment. The results were similar, although F-ratio for current assessment was a bit higher.

4.1.4 Sensitivity runs

Figure 16 shows the results of the sensitivity runs. For the logistic model the scenarios of B1/K = 0.8, scenarios which excluded Taiwanese longline or Venezuela longline indices, and the scenario with only the Taiwanese and Japanese longline indices resulted in unreasonable results. And the scenario which excluded the Japanese longline index showed different results compared to those from the base model. For the Fox model, the scenarios which excluded the Taiwanese longline or the Venezuela longline index, and the scenario with only the Taiwanese and the Japanese longline indices did not converge. As with the logistic model, the scenario which excluded the Japanese longline index gave somewhat different results compared to the base model.

4.1.5 Retrospective analysis

The analysis of retrospective patterns for Fox model scenario (base case scenario) indicates that F/F_{MSY} and B/B_{MSY} estimates are relatively stable for the terminal year when successive years of data are removed from the model (**Figure 17**). However, it was less stable for logistic model scenario.

4.2 Age Structured Production Model (ASPM)

4.2.1 Parameterization

Several important parameters (steepness, sigmaR, B_{1965}/B_0, plus age group) of ASPM were discussed during the meeting. In addition, the analytical period is from 1965 to 2014, thus the B_{1965}/B_0 is the initial stock condition of the first year. According to the likelihood profiles for the steepness, sigmaR and B_{1965}/B_0 (SCRS/2016/111; Figure 12) and diagnostic (fit for CPUE, fit for CAA, selectivity curve by fleet, S-R relationship SCRS/2016/111; Figures 13-17), the steepness values selected were 0.75, 0.85 and 0.95, the sigmaR was assumed equal to 0.4, and the B_{1965}/B_0 was to be estimated. The Group recommend the value of sigmaR should be determined such that the observed magnitude of recruitment was equal to the expected magnitude. This is a critical step for this particular model formulation because the value of sigmaR, if simply assumed, has a scaling effect on the actual recruitment. This analysis was completed and the results support the value of sigmaR of 0.4, or somewhat less. The Group also decided that the steepness of the base models (for management advice) would be fixed at 0.85, and the alternative steepness values were treated as sensitivity. The plus group was assumed to be age 5+.

Time blocks of selectivity were applied according to the historical residual patterns in the CAA by fleet. A time block was applied to the purse seine fleet pre- and post-1990 considering the development of FAD fishery. For similar reasons, a time block was also applied to the baitboat fleet pre- and post-1970. The Chinese Taipei longline fleet was assigned time blocks (prior 1992, and 1993 forward) because there was large change of the CAA which is not well understood. Other fisheries also used a time block (pre and post 1975) because a prominent CAA-residual distribution pattern(s). These treatments resulted in great improvement of the CAA fit (e.g. lower likelihood) in preliminary runs (detailed results not shown). Preliminary treatments that examined biological parameters (natural mortality, growth (fish body weight by age), maturity), the plus group, minus group and "pinned" group for each fleet were also presented and evaluated by the working group (SCRS/2016/111; Table 4). The minus and plus groups (lower and upper age classes) include approximately 2% of the fish relative to the most dominant age group ("pinned" age group) in CAA (Nishida *et al*., 2014).

4.2.2 Base case

The ASPM model configurations are summarized in **Table 16**. The Group selected Run_01 (Cluster 1) and Run_05 (Cluster 2) as the base models for the development of management advice. Both models used the "Continuity" CAA, developed using the methods prescribed during the 2011 stock assessment meeting.

4.2.3 Stock status

Stock status for recent years (fishing mortality in 2014, spawning biomass in the beginning of 2015) for ASPM base models (Run_01 and Run_05) are presented in **Table 17**. Historical changes in recruitment (**Figure 18**), SSB (**Figure 19**), exploited SSB (**Figure 20**), fishing mortality (**Figure 21**), SSB/SSB_{MSY} (**Figure 22**), F/F_{MSY} (**Figure 23**) and Kobe plot (**Figures 24** and **25**) were presented. The detailed results of other runs listed in the run table (**Table 17**) are presented in the sensitivity section and the document describing the ASPM analyses (SCRS/2016/111).

4.2.4 Diagnosis for base models

The goodness of model fit for standardized CPUEs (**Figure 26**), model fit for CAA (**Figure 27**), CAA residual distribution by fleet (**Figure 28**), Spawner-Recruit relationship (**Figure 29**) and selectivity curves by fleet (**Figure 30**) for both base models were presented. The retrospective patterns on SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} and fit for CPUEs were also explored, and no significant retrospective patterns were noted, except for a tendency toward overestimation of recruitment in the terminal year (**Figure 31**).

4.2.5 Sensitivity analysis

Sensitivity analyses were conducted on steepness (0.75 and 0.95), CAA type (03_DrYe and 05_GaYe) and the inclusion of the Japanese longline index before 1975. The SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} and Kobe plots of the sensitivity runs were also presented (**Figures 32** to **37**).

4.3 Stock Synthesis

4.3.1 Model and data

Models were fit to different index clusters (SCRS/2016/109), and diagnostic fits are summarized in detail below. Growth was estimated during the model development process and was useful to obtain improved model fits and to explain the observed size composition information. Models estimated growth by estimating K using the k-deviates option in SS, as well as estimating Linf (or length at age 10+). Iterative reweighting as prescribed in Francis, 2011 was used to further adjust these length compositions through a variance multiplier on the overall Effective Sample Size (ESS) that was initially fixed across all fleets and time strata at 20 but varied according to the Francis, 2011 recommended reweighting scheme. During the meeting an alternative weighting approach that incorporated the inter-annual variability in the quality of size composition samples was developed however time constraints limited its further exploration.

4.3.2 Results (sensitivity, diagnostics and advice)

Multiple models were attempted from simplistic surplus production type models to age structured surplus production models to fully integrated models with different growth characteristics. Further sensitivity analyses were carried out examining whether either dome-shaped selectivity for longlines, a 'U' shaped natural mortality vector or estimating growth were more consistent with the other input data (SCRS/2016/110). This preliminary analysis found a better fit to the composition data from estimating growth, though this finding is preliminary and in reality either or all of the three hypothesis could be operating jointly to some extent. One of the important results of the exercise of fitting growth was that it was necessary to fit the growth parameters of the multistanza model so that they were consistent with the other data inputs and assumptions of the model. It was further necessary to fix growth at the estimated values to correct for the retrospective bias patterns.

– *Likelihood Profile Analysis to inform Model specification*

Earlier versions of the model were examined (SCRS/2016/110) using Likelihood profile analysis (Edwards 1984). **Figure 38** and **39** indicate that there is a boundary of log(R0=12), below which the model cannot provide a feasible solution and the population crashes. This is influenced primarily by the requirement that the model have enough fish to produce the observed landings while the length-composition data from some fleets is forcing the model to estimate R0 to be below these values. This creates tension between not crashing and the length composition data. Freeing growth estimation reduced this tension as it explained the relative absence of fish at the size of assumed Linf from Gascuel *et al*., 1992. Furthermore, in model runs where all indices were used the conflicts between the indices made the model extremely unstable. Separating indices into clusters further improved model stability, in situations of high conflict between data sources.

Francis, 2011 suggests weighting the indices of abundance higher in these cases and down weighting the length-composition data. We followed Francis, 2011 advice by reiterating the Effective Sample Sizes for the length composition across all fleets to reconcile divergent signals in the data. As well the initial sample sizes for the length composition was substantially downweighted from the original data as fixed values of 20 were used for all years, seasons and fleets. Steepness was fixed at 0.9, as the model could not estimate steepness as determined on the basis of likelihood profiling of this parameter.

– *Retrospective patterns when growth is estimated*

Other issues that were apparent when the growth was fixed at the Gascuel growth or VB growth (Draganick and Pelczarski, 1984), with fixed steepness (i.e. model convergence issues or parameter confounding issues) were not as pronounced when these parameters were estimated. However when growth was estimated in each year of the retrospective peel, it resulted in substantial retrospective patterns (**Figures 40** and **41**). This is likely due to the effect of the model updating inference on growth parameters with each additional year of growth information and is likely particularly affected by the high numbers of age-length data added in 2012-2014 from SCRS/2016/049. We determined that removing the age composition data entirely and fixing growth at the estimated values from the full time series diminished the retrospective bias substantially. This approach was taken for the advice models (**Figure 41**).

– *Model fits to Cluster 1*

Results of the two models that were recommended by the Group are shown in (**Tables 18** and **19**) and **Figures 42** and **44** to **47**. Indices of abundance fit fairly well (**Figure 42**). Estimated selectivities (**Figure 44**) are shown only for model fit to Cluster 1 and show the spline fits to purse seine fleets, dome fits to baitboat and recreational fleets and logistic fits to longline indices. The fits to length composition by fleet (aggregated across time) are well estimated without any directional bias (**Figure 45**). Pearson residuals of the fits to annual length composition by fleet indicate that while the models have some systematic residual patterns, the fits were as best as could be obtained in the time available (**Figure 47**).

– *Model fits to Cluster 2*

These models are more pessimistic in their outlook. The model fits are slightly worse than Cluster 1 (though the number of points are different and hence likelihoods will be different, and not comparable, **Table 18**). In general model fits to indices and length composition (**Figures 43** and **46**) indicate that the model performs as well as the model using Cluster 1 data.

4.3.3 Overall discussion on Models fitting to Cluster 1 and Cluster 2

The stock recruitment relationship was imposed with a steepness of 0.9 and shows little evidence of a strong correlation between SSB and recruits (**Figure 48**). Overall recruitment dynamics are similar across both models, and while model fit to Cluster 1 (**Figure 49**) appears to give a positive outlook on the stock in recent years, with F's that may have exceeded target F values in the last 10 years, model fit to Cluster 2 (**Figure 50**) show a more pessimistic outlook on the stock primarily driven by the declining trends in CPUE used in this configuration. Comparisons show that although initial biomass is similar, the recent stock trajectories differ based on which series were fit (**Figure 51**) with the primary difference being differing inference on the levels of recent recruitment.

4.3.4 Stock Status

– *Deterministic solution based on the variance-covariance matrix*

As is evident from **Table 19** and **Figure 52** the model using Cluster 1 indicates that the stock is not overfished (SSB/SSB_{MSY}= 1.38) nor is experiencing overfishing (F/F_{MSY}=0.65). MSY levels were ~123Kt. If we use Cluster 2, the stock is overfished (SSB/SSB_{MSY}=0.81) and is experiencing overfishing (F/F_{MSY}=1.1) (**Table 19** and **Figure 53**), though the target MSY levels are the same (~123Kt). The Group noted that under Cluster 2 the stock has become overfished without experiencing substantial historical overfishing. This current model explains this as a decline in recent recruitment however this pattern could also be due to unaccounted for process error (e.g. unaccounted catches, time-varying catchability in indices, etc.) in the model. **Figures 52** and **53** both account for changes in selectivity and corresponding benchmarks; notably in the recent 15 years there has been a substantive decrease in F_{MSY} and SSB_{MSY} due to changes in the relative allocation of catches by fleets (**Figures 54** and **55**).

– *Bootstrapping to characterize uncertainty on stock status*

To characterize the uncertainty in stock status and forecasted yield advice both Cluster 1 and Cluster 2 input data was bootstrapped and then the models were re-run for each bootstrap dataset (**Figure 56**). It is evident that for Cluster 1 the median and estimate (deterministic run) are almost identical. For Cluster 2, there is some divergence (**Figure 56**), but the overall inference is identical whether we use the bootstrap median or the deterministic estimate trajectory for Cluster 1 or Cluster 2.

To estimate the models for each bootstrap it was necessary to turn off the variance re-weighting in the control file as this reweighting was already accounted for in the creation of the bootstrap files. Results of the bootstraps indicate that, for Cluster 1, the deterministic run was generally very close to the center of the bootstrap distribution (**Figure 56**). For Cluster 2 the deterministic run was closer to the upper 80% CI for F/F_{MSY} and to the lower for SSB/SSB_{MSY} indicating some divergence between the deterministic run and the bootstrap median.

It is evident from examining **Figures 52, 53** and **57** that the uncertainty characterization by using the variance covariance matrix from the original runs approximates the bootstrap variance, as is shown in **Figure 56**. This may be evidence that, for current stock status, it is adequate to use the variance-covariance matrix in estimating the uncertainty in the current stock status.

4.4 VPA

4.4.1 Base model results

The results of the two base VPA models differed. Abundance at age (**Figures 58** and **59**) for the Cluster 1 base model showed that for ages 3-5 abundance remained relatively constant after 2000, while for the same ages the Cluster 2 base model showed more of a declining trend for the same time period. Fishing mortality at age (**Figure 60**) was highest for age 4 followed by age 3; while lowest fishing mortality corresponded to age 0. While this pattern was the same for the two base models, the values of F-at-age by year were different. For example, for the base model that used Cluster 1, F at age 3, 4, and 5 showed a declining trend after 2000; while the base model that used Cluster 2 indices showed the increasing trends.

Estimated spawning stock biomass was different between the base models (**Figure 61**). Both SSB trajectories showed a decline at the beginning of the time series, the Cluster 1 base model showed an almost continuous decline until year 2000 followed by a slow increase; while the Cluster 2 model showed an increase from the mid 1980s to the mid 1990s that was followed by a sharp decrease until the end of the time series. General recruitment trends were also different between the base models (**Figure 62**). The recruitment for the Cluster 1 model, although variable, did not show a discernible trend, while for the Cluster 2 base model the time series of recruitment indicated elevated recruitment in the 1990s, and lower than average recruitment since 2005.

Results from the Cluster 1 VPA base model, *prior to the adjustment to account for changing selectivity*, indicate that the stock is currently near, or just below the overfished threshold and it is not undergoing overfishing (**Figure 63**). The *unadjusted* trajectories of relative spawning stock biomass and relative F from the Cluster 2 VPA base model were more pessimistic (**Figure 64**). They indicate that the stock is currently overfished and is also undergoing overfishing. Uncertainty in the annual estimates of relative biomass and fishing mortality was explored using 1000 bootstraps of the index residuals. The resulting 80% confidence intervals are shown in **Figures 63** and **64**.

It is generally agreed that the selectivity of fisheries that prosecute yellowfin tuna have changed over time due to an increase in the proportion of catch landed by surface fleets, and the FAD fishing fleet in particular. Therefore, trends in SSB/SSB_{MSY} and F/F_{MSY} were recomputed to account for annual changes in selectivity by allowing F_{MSY} to be estimated each year. The resulting annual estimates of SSB_{MSY} and F_{MSY}, *adjusted for selectivity*, are shown in **Figure 65**. Annual stock status estimates, adjusted for selectivity are shown in **Figure 66**. Results from the Cluster 1 VPA base model indicates that the stock is currently below the overfished threshold (SSB_{2014}/SSB_{MSY}=0.84) but it is not currently undergoing overfishing ($F_{current}/F_{MSY}$=0.98), although overfishing did occur previously. The median estimate of MSY was 122,138 t. Results from the Cluster 2 VPA base model were more pessimistic. They indicate that the stock is currently overfished (SSB_{2014}/SSB_{MSY}=0.54) and is also undergoing overfishing ($F_{current}/F_{MSY}$=1.13). The median estimate of MSY was 125,022 t. A complete summary of potential management references can be found in **Tables 20** and **21**.

Uncertainty in estimates of SSB_{2014}/SSB_{MSY} and F_{curr}/F_{MSY} (geomean 2011-2013) were examined using a bootstrap analysis (n=1000). These results were overlaid on **Figure 66**. It should be noted that for the VPA model using Cluster 2 indices, the median estimate is not located at the center of the bootstrap estimates. This likely indicates some bias in the estimates of F_{MSY} and SSB_{MSY} for that model run.

4.4.2 Sensitivity run results

The results of the sensitivity run, which started in 1965 and used the full time series (1965-2014) of the Japanese LL index in numbers, were almost identical to those of the Cluster 1 base case. **Figure 67** shows the estimated F at age, SSB, and recruitment.

4.4.3 Continuity case

A continuity model was run that used the parameter specifications, fleets and indices from the 2011 yellowfin assessment. The estimated F at age, SSB, and recruitment for the Continuity Run is shown in **Figure 68**. Although the results are somewhat different from those observed in the base cases, the observed general trends are consistent with those of both base case models.

4.5 Other methods

No other evaluation methods were considered during the meeting.

4.6 Synthesis of assessment results

Overall, all model runs that used the Cluster 1 indices suggested similar trends in SSB (decreasing through 2000, then stable or increasing somewhat) F (highest in 1990s, then declining), stock status (near stock levels that produce MSY) and estimated MSY (120,000 to 150,000 t).

The ASPIC surplus production model did not converge when Cluster 2 indices were used, likely because the trends in observed catch and CPUE are not consistent with production model dynamics. The age-structured models were able to converge using Cluster 2 indices (which suggest an increase in stock abundance in the 1990s) because they were able to estimate increased recruitment in those years. Models that used Cluster 2 indices showed similar trajectories of SSB (initial decline, a notable increase during the 1990s then declining), F (increasing in recent years) and were generally more pessimistic. SS and VPA runs suggested that the stock was both overfished and undergoing overfishing, while the ASPM run indicated a healthy stock status. The MSY estimates from Cluster 2 models ranged from 120,000 to 150,000 t.

To accommodate uncertainty in model structure and index usage, the Group agreed to develop management advice from a combination of seven runs (see Section 5.5).

5. Projections

For all assessment model projections, it was assumed that the catch in 2016 would be the same as estimated catch in 2015 (based on reported catch and carry over), and the biomass during 2015 constitutes the first projection.

5.1 ASPIC model projections

Bootstrap results from ASPIC were projected into the future for different levels of catch (from 50,000 to 200,000 t in 10,000 t steps). Projections under constant F (from 0.75*F_{2014}/F_{MSY} to 1.00*F_{2014}/F_{MSY} at 0.05*F_{2014}/F_{MSY} interval) was also conducted. Software package ASPICP ver. 3.16 was used for future projections. The projection period was 14 years (until 2029) due to limitation of software.

Projections were done for 500 bootstraps of the base case scenario. Upon examination, the median values of projected biomass ratios suggest that in order for the stock biomass to meet or exceed B_{MSY} level, catches need to be lower than 120,000 t (**Figure 69**). Similarly catch levels below 120,000 t would consistently reduce median fishing mortality ratios towards F_{MSY}.

5.2 Age Structured Production Model projections

Projections were conducted based on bootstrapping examination (1,000 times) of the base models (Run_01 and Run_05). The projection period is 10 years (2015-2024). Constant future catch with 50,000 t to 200,000 t (at 10,000 t interval) with catch proportion by fleet averaged from 2013 to 2015 was assumed. The trajectories of SSB/SSB_{MSY} and F/F_{MSY} were presented for the two base models (**Figure 70**). Projections indicate that catches of 120,000-140,000 t will allow the stock to persist at levels that support MSY.

5.3 Stock Synthesis model projections

As Task I data for 2015 are incomplete many of the catches had to be carried over from previous years. For complete records (~58%) the reported catch was used and then for incomplete catches these were carried over from previous years. As CDIS was not available for 2015, several assumptions about how to assign Task I data to SS fleets had to be made. For the baitboat fleets and the Venezuela purse seine, the following assignments were made (**Table 22**). The purse seine Task I data were split according to the average fraction of Free School to FAD catch for the years 2010-2014 (65%). For all annual landings the average fraction of landings by season for 2010:2014 was used to partition landings seasonally for each fleet. Then the 2015 estimates were carried over for 2016 with the total in each year summing to 110,337 t, the same as used in the VPA and production models.

To obtain projections at fixed quota levels from 60-150,000 t the catch by each fleet was scaled proportionally (based on 2014 catch estimates by fleet) to achieve an overall level equal to the input fixed F. Initially deterministic projections were performed and results are shown in **Figure 71**. Each of the models was projected at F_{MSY} though 2015 and 2016 catch was assumed to be 110,337 for each. This results in the initial spike in F/F_{MSY} for Cluster 2. For each model run 500 bootstraps at each quota level were run to obtain the necessary inputs for the K2SM.

To characterize how selectivity and gear allocations can change the estimated yield over time, a decline in estimated sustainable yield from 160 Kt – 110 Kt (**Figures 54** or **Figure 55**) is estimated. At the same time, the estimated amount of spawning biomass to obtain that yield increases by a substantial amount (140 Kt to 200 Kt irrespective of the cluster used). Whether we use Cluster 1 or Cluster 2, F_{MSY} target yield levels projected for 2017 vary between 140 Kt (Cluster 1) or 130 Kt (Cluster 2). However, stock status in 2022 is either at S_{MSY} levels (Cluster 1, S_{MSY}~1) or substantially below S_{MSY} levels (Cluster 2, S_{MSY}~0.6).

Note, in a projection context, depending on the cluster used, catches greater than 110-120 Kt (Cluster 2) would keep the stock below SSB_{MSY}. In case of Cluster 1, catches could exceed MSY and approach 150 Kt before the stock declines below SSB_{MSY} in 2024 (**Figure 71**).

5.4 VPA model projections

VPA projections were made using Pro-2Box software, which can be found in the ICCAT software catalog. The projections specifications were as follows:

1) Projections run from 2015-2024.
2) 1000 bootstraps of the index residuals were run to quantify uncertainty.
3) Predicted catches in 2015 and 2016 = 110,337 t.
4) Constant catch projections of 50,000 – 200,000 t, in 10,000 t increments applied 2017-2025.
5) Projected recruitment assumed to follow a Beverton and Holt function estimated using annual estimates of SSB and R from the VPA model (1970-2011). Recruitments from 2012-2013 replaced with estimates from the S/R function.
6) Projected selectivity equal to the geometric mean selectivity 2011-2013.

7) Weight of the plus group calculated using a von Bertalanffy mimic of the Gascuel *et al*., 1992 function.

VPA projections are summarized in **Figure 72** (Cluster 1) and **Figure 73** (Cluster 2). To enhance legibility, constant catches of 50,000 to 150,000 t are shown. For both VPA models, catches of 120,000 t or less maintain the spawning biomass above SSB_{MSY} and are unlikely to cause overfishing during the projection interval.

5.5 Kobe matrix for yellowfin

To accommodate uncertainty in data inputs, model structure and index usage, the Group agreed to develop management advice from a combination of seven runs:

MODEL	*Run Name*	*Bootstraps to Use*
ASPIC Cluster 1	1_Fox_eq	500
ASPM Cluster 1	Run01	500
ASPM Cluster 2	Run05	500
VPA Cluster 1	VPA – Cluster1	500
VPA Cluster 2	VPA – Cluster2	500
SS Cluster 1	Run 5	500
SS Cluster 2	Run 7	500

The Group discussed various weighting schemes, and agreed to equally weight by model run. Since there was insufficient time to complete the necessary bootstrap analyses during the meeting, the Group agreed to draft an SCRS document including the combined K2SM prior to the SCRS Species Group meeting in September. The work will be presented for adoption at that time.

6. Recommendations

6.1 Research and statistics

- The Group expressed concern that spatial and targeting shifts in longline fisheries might have affected the trends of their standardized CPUE series. Thus, the Group recommends to more fully explore better ways to incorporate spatial and targeting effects into CPUE standardization. The Group noted that more credence should be given to CPUE indices based on operational data, since analyses of these data can take more factors into account, and analysts are better able to check the data for inconsistencies and errors. Examining operational level data across the main Atlantic longline fleets taking yellowfin (Rep. of Korea, Japan, Chinese Taipei, EU-Spain, EU-Portugal, EU-France, USA, Uruguay, Brazil, Venezuela, Mexico, China, Panama, Belize, Vanuatu) will give a better idea of what is going on with the stock especially if some datasets have low sample sizes or effort in some years, and others have higher sample sizes and effort, so we have a representative sample covering the broadest areas in the Atlantic Ocean. This will also avoid having no information in certain strata if a fleet were not operating there, and avoid combining two indices in that case. As such, the Group endorses the view of the Albacore Species Group on this topic and also recommends joint analysis of operational catch and effort data from multiple fleets be undertaken under the general guidance by the *ad hoc* Working Group on Stock Assessment Methods, to further develop methods and to provide indices of abundance for Atlantic stock assessments, as is already underway in other ICCAT species groups and other tRFMOs.

- The Group continues to note that the tropical tuna fisheries are multi-species in which targeting strategies can vary depending upon the species of interest, their relative availability and their susceptibility to the gears used. It is well known that fishing directed toward one of the tropical tunas can, and often does, impact the status of other species stocks. These features are not accounted for in single species stock assessments and management advice resulting from single species stock assessments. The Group recommends making advancements on multispecies stock assessment approaches for the tropical tuna complex in the Atlantic. Additionally, the Group recommends an evaluation of management strategies designed to attempt to understand the consequences of undertaking management intended to simultaneously harvest MSY for each individual stock. This evaluation could best be conducted within an MSE framework, which should be undertaken.

- The Group noted that to conduct an MSE is an iterative process and requires the involvement of a broad range of expertise and regular dialogue. The upcoming Joint MSE Technical Working Group meeting, established under Kobe Framework, is an excellent opportunity to progress on the topic. The meeting will be held in the first week of November and the Group recommended that interested scientists be encouraged to participate in the meeting and conduct intersessional work using the *github* repository (see www.iccat-mse.github.io/albn-mse.html) and then reporting on these activities at the meeting.

- After reviewing revisions to the Ghanaian catch statistics, it was noted that assuming homogenous species compositions and size distributions across broad areas and times could have large impacts on the estimated Ghanaian (and other) fisheries catch at size, especially considering that sampling protocols used in Ghana would permit finer scale time and area strata for constructing catch at size estimates. It was further noted that the ongoing pilot study applying Electronic Monitoring Systems on board the Ghanaian purse seine vessels could well provide information for verifying total catches, species composition, and sizes of their purse seine catches. It was recommended that the Ghanaian scientists provide a review of the data available through the EMS project, comparing those data with the data coming from at-sea observers and port samplers for the 2017 SCRS.

- After examining diagnostics from some initial model fits, questions arose about the Chinese Taipei size frequency time series. As no scientists from Chinese Taipei attended the stock assessment session, it was not possible to obtain answers to the questions and concerns raised. The Group recommended that a review of the possible reasons for an abrupt change in the apparent selectivity of the Chinese Taipei longline fishery catching yellowfin in the early 2000s be provided by Chinese Taipei scientists.

- The Group noted efforts to improve upon deterministic age slicing of the yellowfin catch at size to develop catch at age needed for several forms of modeling applied at the assessment meeting. However, the behavior of the algorithms developed need to be further evaluated before their adoption can be recommended. Future outputs from the AOTTP tagging program could be used in this validation.

- The Group noted that advancing the stock assessment methodology applied for yellowfin (and other stocks) through the application of highly parameterized statistical models is welcome, particularly since less parameterized models frequently require numerous assumptions, and may lack comprehensive diagnostics. However, full evaluation of the adequacy of the fits of complex models to the data they rely upon is demanding, and generally requires more time than is usually available in a single working group meeting. The Group recommends that a standardized set of diagnostics be developed for these complicated models to facilitate a more rapid evaluation of model performance as well as training to increase the capacity for greater participation and understanding of the more complicated integrated modeling process.

- Given the continuing uncertainties regarding YFT growth and the importance of the limited aging data available for this assessment the Group recommends the routine, systematic and representative collection material and aging of YFT throughout the Atlantic.

6.2 Management

Upon completion of the combined K2SM, management recommendations will be developed and presented to the species group meeting in September. Adopted recommendations will be included in the Yellowfin Tuna Executive Summary.

7. Other matters

The Atlantic Ocean Tropical tuna Tagging Program (AOTTP) coordinator summarized the progress of the program. The program has been designed to primarily serve, the needs of the Tropical Tuna Working Group assessment work. The AOTTP coordinator mentioned progress related to the:

- purchase of tags
- development of an app for collecting data from releases and recoveries
- incorporation of data on ICCAT databases
- development of database for electronic tagging data
- development of mapping of tagging data in real time
- current calls for tenders for tag releases
- permits for operating tagging vessel on EEZ of coastal countries
- tag recovery proposals
- received proposals for tagging off Brazil and Uruguay and another one from South Africa/Namibia/St. Helena
- decision to delay acoustic tagging until its objectives and experimental design have been clearly defined

There were many comments about the balance of investment in the different types of tags and whether the balance was the best to achieve the program objectives. Comments were made about how certain technologies and brands were better than others. It was also discussed how each technology is likely to deliver different types of data and the probability of data being collected was also technology dependent. It was pointed out that electronic tagging data are complicated because of the different sensors included in the tags, and the various programming options that are available. It was suggested that electronic tagging data will need a relational database to hold the data. The AOTTP program is aware of these data management requirements.

The AOTTP should link to observer programs from each CPC, especially to those that monitor longline fleets. The program intends to use focal points as the tool to link with industry, especially longliners.

It was discussed that the AOTTP is likely to depend on sport fishers to tag fish in the central western Atlantic. Many issued were raised regarding how such a program may be made effective. For example, previous tagging efforts from sport fishing in the US have often suffered from not obtaining all the release information. It was agreed that any such effort will require training of fishers on tagging and reporting procedures. The idea that tagging may be possible around moored FADs used in the Caribbean was also briefly discussed.

There was a request for clarification on the conditions under which the data collected by the program would be available to the scientists involved in the tagging consortia and other SCRS scientists. It was emphasized that the program is designed to be for the benefit of the SCRS and that after data have been quality controlled they will be made available as quickly as possible to all SCRS scientists. The highest value of the data will be when it is aggregated for the whole Atlantic; therefore, it is imperative that the data are shared across, to all SCRS scientists. The AOTTP program will invest in limited biological sampling for a subset of the recoveries. There will also be investment in the analysis, publication and dissemination of the results.

8. 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. The synthesis of assessment results (4.6), stock synthesis projections (5.3), final VPA projections (5.4), and the Kobe Matrix (5.5) were adopted by correspondence. The remainder of the report was adopted during the meeting.

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Table 1. Summary of biological parameters accepted for use in 2016 stock assessments.

Parameter	*Yellowfin*
Natural mortality (2016 decision)	Lorenzen M based upon the Gascuel *et al.*, 1992 growth curve with t_{max}=10.
Assumed "birth date" of age 0 fish (2011)	February 14 (approximate mid-point of the peak spawning season).
Plus group (2011)	Evaluate the appropriate plus group, the group requires CAA to be through age 12
Growth rates (2016 decision)	Length at age was calculated from the Gascuel *et al.*, 1992 equation: FL (cm) = 37.8 + 8.93 * t + (137.0 – 8.93 * t) * [1 – exp(-0.808 * t)]$^{7.49}$
Weights -at-age (2011)	Average weights-at-age were based on the Gascuel *et al.*, 1992 growth equation and the Caveriviere (1976) length-weight relationship: W(kg) = 2.1527 x 10^{-5} * L(cm)$^{2.976}$
Maturity schedule (2016 decision)	Maturity will be based upon maturity at length as described in Diaha *et al.*, 2015: $P_{mature} = e^{\alpha+\beta L}/1 + e^{\alpha+\beta L}$ Maturity at age will be estimated using the appropriate growth equation

Table 2. Maturity at age estimated using the length-based model of Diaha *et al*. 2015, and the growth models of Gascuel *et al*., 1992 and Draganik and Pelczarski, 1984.

Age (years)	Gascuel	Drag&Pelc
0.00	0.000	0.000
0.25	0.000	0.000
0.50	0.000	0.000
0.75	0.000	0.001
1.00	0.000	0.003
1.25	0.000	0.008
1.50	0.000	0.022
1.75	0.001	0.056
2.00	0.003	0.137
2.25	0.012	0.296
2.50	0.044	0.528
2.75	0.143	0.748
3.00	0.377	0.887
3.25	0.688	0.954
3.50	0.889	0.982
3.75	0.967	0.993
4.00	0.991	0.997
4.25	0.997	0.999
4.50	0.999	1.000
4.75	1.000	1.000
5.00	1.000	1.000
5.25	1.000	1.000
5.50	1.000	1.000
5.75	1.000	1.000
6+	1.000	1.000

Table 3. Predicted length at age from different models used in the assessments, including the preferred growth model (Gascuel *et al*., 1992), the model of Draganik and Pelczarski, 1984, used in some sensitivity runs and the two models used in SS, a Gascuel-like and a multi-stanza model estimated with SS.

Age	*Gascuel et al.*	*Draganik and Pelczarski*	*Gascuel-like*	*Multi-stanza*
0	38	0	25	10
1	48	60	55	48
2	78	101	78	77
3	120	129	102	116
4	148	149	147	136
5	163	162	164	146
6	170	172	172	149
7	173	178	174	151
8	174	182	175	153
9	175	186	175	155
10	175	188	175	160

Table 4. Task I nominal catches of yellowfin tuna 1950-2015 ICCAT database. 2015* indicates the estimated total removals by the Group; if a CPC did not reported catches for 2015, prior to the meeting and average of the last 3 years was estimated (shaded cells), total removals for 2015 were set at 110,337 t.

SpcGearGrp	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Total	**1,200**	**1,358**	**2,787**	**3,600**	**3,407**	**4,300**	**6,597**	**23,698**	**40,581**	**57,769**	**68,493**	**58,803**	**57,523**	**64,598**	**68,928**	**67,721**	**58,736**	**60,225**	**84,323**	**94,571**	**74,455**	**74,465**	**94,628**	**95,133**	**107,141**	**124,796**	**124,960**	**131,013**	**134,044**	**127,517**	**130,743**	**156,138**	**165,243**	**165,611**
Purse seine														1,499	7,351	8,279	15,658	18,940	29,859	44,314	33,387	32,235	50,358	46,804	53,432	84,590	85,894	91,625	101,760	93,326	101,896	118,134	124,174	129,489
Longline							612	13,886	29,949	51,882	57,121	48,762	46,692	45,154	40,327	40,843	27,916	24,423	32,229	34,479	30,994	31,234	30,720	33,146	32,282	29,659	25,611	27,036	20,862	16,054	19,259	19,309	20,382	14,375
Bait boat						200	5,723	9,187	10,304	5,775	11,247	9,839	10,557	17,785	21,116	18,486	15,050	16,761	22,135	15,673	9,660	10,576	13,141	14,772	20,974	10,066	12,794	10,943	9,992	14,320	8,129	11,706	16,181	15,110
Other surf.	1,200	1,358	2,787	3,600	3,407	4,100	262	625	328	112	125	202	274	160	134	113	112	101	100	105	414	420	409	411	453	481	661	1,409	1,430	3,817	1,459	6,989	4,506	6,637
Flag	**1950**	**1951**	**1952**	**1953**	**1954**	**1955**	**1956**	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Angola	1,200	1,200	2,600	3,600	3,400	4,100	3,734	2,610	2,049	1,387	2,472	2,241	2,065	2,209	3,635	1,941	1,331	885	1,087	390	361	498	611	603	839	55	1,005	2,085	2,296	904	558	959	1,467	788
Argentina											2	25	23	78	129	100		23	139	100		150	400	129	112	108	57	43	4			8	7	
Barbados																									48	79	94	58	67	81	40	30	36	51
Belize																																		
Benin																														48	95	100	113	49
Brazil									1,740	5,920	4,700	4,400	1,400	2,400	1,624	696	464	812	812	464	812	347	233	153	232	260	715	1,302	852	1,353	1,008	2,084	1,979	2,844
Cambodia																																		
Canada																45	646	680	655	936	191	44		61			161		318					
Cape Verde																					346	296	455	445	410	360	115	104	470	581	864	5,281	3,500	4,341
Cayman Islands																															602	1,460	100	
China PR																																		
Chinese Taipei													278	399	396	183	1,243	3,023	8,884	12,202	7,990	4,938	5,317	3,000	2,630	2,669	1,962	372	384	1,038	687	867	610	539
Colombia																																	3	29
Congo																															140	50		
Côte d'Ivoire																					523	1,296	2,629	2,350	2,968	6,426	7,353	9,465	9,993	8,928	10,970	9,670	8,051	1,143
Cuba														1,700	900	754	810	2,992	1,876	1,555	1,600	2,100	3,600	4,900	3,800	2,600	3,600	3,900	3,000	3,400	5,817	4,942	3,754	2,709
Curaçao																					151	151	151	151	151	151	151	151	173	173	173	173	173	173
Dominica																																		
Dominican Republic																																		
EU.España													1,502	3,009	3,256	3,179	1,502	3,124	3,347	5,696	7,087	7,829	9,783	14,055	16,077	25,475	33,423	35,791	35,665	41,135	38,759	51,428	54,164	53,914
EU.Estonia																																		
EU.France						200	2,100	6,900	8,300	4,500	8,900	7,800	6,100	13,050	18,970	18,959	20,678	20,267	28,123	25,973	19,783	19,719	24,318	25,142	31,370	37,589	42,262	39,550	44,169	38,689	43,371	44,787	36,350	38,304
EU.Ireland																																		
EU.Latvia																																		
EU.Lithuania																																		
EU.Malta																																		
EU.Netherlands																																		
EU.Poland																																	20	
EU.Portugal																										1	3		125	185	77	208	981	1,333
EU.United Kingdom																																		
Faroe Islands																																		
FR.St Pierre et Miquelon																																		
Gabon																															47	1		
Gambia																																		
Georgia																																		
Ghana																							2	112	274	763	945	621	546	1,426	1,974	5,510	9,797	7,689
Grenada														100	100	100	100	100	100	100	100	100	100	100	100	100	100	364	166	148	487	64	59	169
Guatemala																																		
Guinea Ecuatorial																																		
Guinée Rep.																																		
Honduras																																		
Jamaica																																		
Japan							612	13,198	27,159	44,071	50,822	42,609	43,137	38,594	37,620	39,331	27,645	19,351	23,527	15,672	8,734	14,544	12,470	11,561	12,498	5,777	8,307	4,055	3,369	2,948	3,334	5,846	8,103	4,280
Korea Rep.																	297	432	2,270	5,982	11,506	9,901	11,078	13,555	17,232	18,022	12,210	17,582	12,884	10,863	7,282	7,613	6,259	3,549
Libya																																		
Maroc																									290	1,048	1,574	2,167	3,440	2,986	3,243	4,817	4,540	2,331
Mexico																															16	42	128	612
Mixed flags (EU tropical)																																	97	87
Mixed flags (FR+ES)																																319		
Namibia																																		
NEI (ETRO)																																	3,121	5,388
NEI (Flag related)																																		754
Nigeria																																		
Norway																								344										
Panama																							538	5,687	4,286	3,207	4,175	2,318	2,917	841	2,468	603	2,608	1,630
Philippines																																		
Russian Federation																																		
S. Tomé e Príncipe																										25	15	45	39	28	31	97	193	194
Senegal																241	1,272	3,083	3,227	2,500	3,817	5,054	6,897	5,872	4,207	3,094	2,009	933	1,030	245	31	628	1,461	1,163
Seychelles																																		
South Africa														71	285								54	65	57	18	6	167	281	4,595	540	178	49	456
St. Vincent and Grenadines																																		
Sta. Lucia																					48	48	48	51	51	54	69	67	67	28	27	25	26	23
Suriname																																		
Trinidad and Tobago																																		232
U.S.A.		158	187		7		151	302	283	111			17	207	126			1,136	5,941	18,791	9,029	3,781	12,342	3,590	5,621	14,335	2,252	7,208	9,747	3,182	2,167	3,160	1,731	2,553
U.S.S.R.															100	535	770	2,680	2,674	1,942	529	1,420	1,104	1,186	2,505	1,856	1,652	1,794	687	806	448	541	1,004	1,282
UK.Bermuda																										10	11	10	12	26	35	21	22	10
UK.British Virgin Islands																																		
UK.Sta Helena																					100	100	100	100	75	52	108	34	37	69	55	59	97	59
UK.Turks and Caicos																																		
Ukraine																																		
Uruguay																																67	214	357
Vanuatu																																		
Venezuela								688	1,050	1,780	1,597	1,728	3,001	2,781	1,787	1,657	1,978	1,637	1,661	2,268	1,748	2,149	2,398	1,921	1,308	662	626	827	1,306	2,811	5,397	4,500	14,426	26,576

SpcGearGrp	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015* Est
Total	**146,608**	**145,351**	**136,237**	**162,392**	**193,604**	**167,523**	**163,770**	**163,451**	**173,744**	**154,588**	**149,152**	**137,375**	**144,496**	**136,325**	**132,154**	**153,455**	**134,427**	**122,448**	**119,445**	**101,745**	**104,659**	**95,963**	**106,716**	**113,438**	**108,781**	**102,640**	**104,513**	**97,269**	**97,035**	**58,655**	**110,337**
Purse seine	95,220	93,729	80,055	114,816	135,597	114,517	113,354	111,658	112,822	96,444	99,214	91,429	92,923	80,269	80,585	102,563	93,973	80,492	62,415	59,117	58,118	51,121	73,152	78,210	76,596	70,244	74,198	68,094	71,781	40,892	80,699
Longline	24,927	20,948	28,285	25,039	29,216	23,182	23,854	20,666	26,428	24,908	26,118	22,038	25,542	27,054	27,129	22,442	17,790	19,349	27,556	21,766	21,488	27,000	21,759	20,177	18,589	17,288	18,076	17,970	13,691	7,592	14,704
Bait boat	17,722	22,218	21,842	17,002	24,366	23,052	21,371	24,854	22,746	18,793	15,925	16,970	19,776	22,093	16,776	19,349	17,154	13,732	19,507	13,592	15,185	9,348	8,139	8,755	8,315	11,429	7,405	6,134	6,669	6,229	8,391
Other surf.	8,739	8,456	6,055	5,534	4,425	6,771	5,191	6,273	11,749	14,442	7,895	6,938	6,255	6,909	7,665	9,101	5,510	8,876	9,967	7,270	9,868	8,493	3,666	6,296	5,280	3,679	4,834	5,071	4,895	3,942	6,544

Flag	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015* Est
Angola	59	51	246	67	292	510	441	211	137	216	78	70	115	170	35	34	34	34	34	111		405	98	701	520	485	191		541		244
Argentina	23	18	66	33	23	34	1						0						327	327				5	0						80
Barbados	39	57	236	62	89	108	179	161	156	255	160	149	150	155	155	142	115	178	211	292	197	154	156	79	129	131	195	188	218		201
Belize										1		3			5						143	1,164	1,160	1,365	2,108	3,284	5,929	5,355	7,105	7,132	7,132
Benin	19	3	2	7	1	1	1	1	1	1	1	3	1	1	1	1															
Brazil	1,837	2,266	2,512	2,533	1,758	1,838	4,228	5,131	4,169	4,021	2,767	2,705	2,514	4,127	6,145	6,239	6,172	3,503	6,985	7,223	3,790	5,468	2,749	3,313	3,617	3,499	2,836	3,316	2,866		3,006
Cambodia														7																	
Canada	2	40	30	7	7	29	25	71	52	174	155	100	57	22	105	125	70	73	304	240	293	276	168	53	166	50	93	74	34		67
Cape Verde	3,326	2,675	2,468	2,870	2,136	1,932	1,527	1,612	1,943	1,908	1,518	1,783	1,421	1,663	1,851	1,684	1,802	1,868	3,236	6,096	5,676	4,607	7,945	4,741	6,008	6,060	4,638	7,596	4,763		5,665
Cayman Islands																															
China PR								139	156	200	124	84	699	2,190	1,674	1,056	697	1,050	1,305	1,185	1,085	1,124	649	462	427	346	264	211	92	170	170
Chinese Taipei	1,410	902	1,848	858	7,465	4,172	4,528	4,196	6,660	4,698	6,653	4,466	5,328	4,411	5,661	4,805	4,659	6,486	5,824	3,596	1,260	1,947	1,122	1,391	824	1,768	1,071	1,260	1,047	1,220	1,220
Colombia	211	258	206	136	237	92	95	2,404	3,418	7,172	238	46	46	46	46	46	46	46	46	46	46										
Congo	20	15	15	21	22	17	18	17	14	13	12																				
Côte d'Ivoire												2			673	213	99	302	565	175	482	216	626	90	470	387	1,748	2,194	348	2,776	2,755
Cuba	3,413	2,357	1,792	794	851	676	664	542	252	266	297	309	15	15			65	65	65	65	65										
Curaçao	150	160	170	170	170	150	160	170	155	140	3,313	6,212	6,240	4,169	5,776	4,945	4,619	6,667	4,747	39	1,964	1,390	7,367	6,469	5,397	4,501	6,906	3,813	5,230		5,316
Dominica					18	12	23	30	31	9				80	78	120	169	119	81	119	65	103	124	102	110	132	119	120			
Dominican Republic													89	220	226	226	226	226	226	226	226										
EU.España	61,929	66,628	50,475	61,940	68,969	55,867	52,075	42,541	41,529	38,841	35,002	24,968	31,877	20,710	25,565	31,105	31,469	25,219	21,782	11,937	11,761	13,734	24,760	33,141	25,940	21,418	19,026	12,162	14,733	21,199	21,199
EU.Estonia						234																									
EU.France	16,564	16,842	20,580	31,024	46,102	35,770	34,997	37,618	36,929	30,641	34,291	30,624	31,442	32,078	30,703	32,555	33,062	33,101	24,546	22,915	19,067	11,363	16,167	19,248	20,916	23,093	19,265	20,778	21,849	19,357	19,832
EU.Ireland																3															
EU.Latvia						255	54	16		55	151	223	97	25	36	72	334	334	334	334	334										
EU.Lithuania						332																									
EU.Malta																													1		
EU.Netherlands																							0	1		0					
EU.Poland																															
EU.Portugal	295	278	188	182	179	328	195	128	126	231	288	176	267	177	194	4	6	4	5	167	334	953	479	1,250	653	579	447	339	71		285
EU.United Kingdom																								0	23	21	22	1		0	
Faroe Islands															1																
FR.St Pierre et Miquelon																									0				0		
Gabon								12	88	218	225	225	295	225	162	270	245	44	44	44	44										
Gambia					2	16	15																								
Georgia						25	22	10																							
Ghana	11,821	10,830	8,555	7,035	11,988	9,254	9,331	13,283	9,984	9,268	8,182	15,080	13,222	20,815	12,304	23,392	18,100	15,002	14,044	13,019	12,897	11,115	11,502	11,037	10,457	8,676	9,591	8,786	11,652	15,950	15,950
Grenada	506	186	215	235	530	620	595	858	385	410	523	302	484	430	403	759	593	749	460	492	502	633	756	630	673						
Guatemala																				2,963	5,300	3,478	3,768	2,612	3,158	2,811	2,961	4,036	3,773		3,590
Guinea Ecuatorial												1												892	892	199		2	11	9	9
Guinée Rep.																				72		66	20	67	393	682	2,435	1,970	1,283		1,896
Honduras							2			4	3	4	3																		
Jamaica											21	21																			
Japan	5,737	6,168	8,203	9,060	7,621	6,165	4,552	3,096	4,783	5,227	5,250	3,539	5,173	3,405	4,061	2,691	2,105	2,754	6,260	4,247	4,643	9,037	6,252	4,994	4,580	4,454	4,661	4,577	3,828	3,355	3,355
Korea Rep.	1,818	1,457	1,368	2,535	808	260	219	180	436	453	381	257	23	94	142	3	8	209	984	675	283	573	993	433	380	490	498	212	116		275
Libya																208	73	73													
Maroc	2,266	1,529															79	108	95	183	222	102	110	110	44	272	55	137	107	72	72
Mexico	658	33	283	345	112	433	742	855	1,093	1,126	771	826	788	1,283	1,390	1,084	1,133	1,313	1,208	1,050	943	896	961	1,220	924	1,183	1,421	1,006	1,048	970	970
Mixed flags (EU tropical)	11	156	247	259	230	998	571	744	688	876	254	452	291	216	423	42	13	298	570	292	251	416	464	467	857	1,601					
Mixed flags (FR+ES)																															
Namibia									35	14	72	69	3	147	59	165	89	139	85	135	59	28	11	1	9	90	0	6	15		7
NEI (ETRO)		2,077	3,140	5,436	12,601	4,856	10,820	9,800	8,327	8,844	9,485	6,514	7,193	5,086	5,117	9,978	7,436	4,857	3,708	1,757											
NEI (Flag related)	956	1,297	2,324	2,780	4,100	4,318	3,836	2,671	4,404	4,202	5,962	6,100	8,339	7,409	5,269	2,883	175	578													
Nigeria																									12	3	1				
Norway	813	418	493	1,787	1,790																										
Panama	7,222	5,147	3,431	2,496	4,149	10,225	10,635	10,973	12,066	13,442	7,713	4,293	2,111	1,320	1,103	574	1,022		1,887	6,325	11,486	9,767	6,442	6,199	7,236	4,459	5,058	6,057	5,548		5,554
Philippines													162	279	164	12	129	154	367	243	264	239	220	152	89	134	34	128	76		79
Russian Federation						3,200	1,862	2,160	1,503	2,936	2,696	4,275	4,931	4,359	737					4	42	211	42	33							
S. Tomé e Príncipe	180	178	298	299	164	187	170	181	125	135	120	109	124	114	122	122	122	122	134	145	137		160	165	169	173	177	182	186	301	301
Senegal	1,203	881	1,093	207	202	105	40	19	6	20	41	208	251	834	252	295	447	279	681	1,301	1,262	819	588	1,279	1,212	1,050	1,683	1,247	612	1,871	1,888
Seychelles															38		11														
South Africa	55	68	137	671	624	52	69	266	486	183	157	116	240	320	191	342	152	298	402	1,156	1,187	1,063	351	303	235	673	174	440	1,512		709
St. Vincent and Grenadines				1	40	48	22	65	16	43	49	164	76	293	2,115	1,440	1,354	625	4,265		2,781	3,198	2,630	2,350	882	963	551	352	505		470
Sta. Lucia	125	76	97	70	58	49	58	92	130	144	110	110	276	123	134	145	94	139	147	172	103	82	106	97	223	114	98	136	93	175	175
Suriname																											1,943	1,829			1,257
Trinidad and Tobago			1	11	304	543	4	4	120	79	183	223	213	163	112	122	125	186	224	295	459	615	520	629	788	799	931	1,128	1,141		1,066
U.S.A.	9,938	9,661	11,064	8,462	5,666	6,914	6,938	6,283	8,298	8,131	7,745	7,674	5,621	7,734	7,051	6,703	5,710	7,695	6,516	5,568	7,091	5,529	2,473	2,788	2,510	3,010	4,100	2,332	2,666	2,030	2,030
U.S.S.R.	1,851	1,275	3,207	4,246	3,615																										
UK.Bermuda	44	25	23	22	15	17	42	58	44	44	67	55	53	59	31	37	48	47	82	61	31	30	15	41	37	100	66	36	12	10	10
UK.British Virgin Islands																					1		0			1	1	3	10	1	1
UK.Sta Helena	82	93	98	100	92	100	166	171	150	181	151	109	181	116	136	72	9				344	177	97	104	65	163	149	53	152	178	246
UK.Turks and Caicos																			0		0	1	0					6	2		3
Ukraine						215																									
Uruguay	270	109	177	64	18	62	74	20	59	53	171	53	88	45	45	90	91	95	204	644	218	35	66	76	122	24	6	7			-
Vanuatu																			681	713	805	1,038	1,323	1,147	743	341	331	146	17		165
Venezuela	11,755	11,137	10,949	15,567	10,556	16,503	13,773	16,663	24,789	9,714	13,772	14,671	13,995	11,187	11,663	18,651	11,421	7,411	5,774	5,097	6,514	3,911	3,272	3,198	4,783	4,419	4,837	5,050	3,772	3,079	3,090

Table 5. Available CPUE indices.

	Japan_LL_65_14	CV	Japan_LL_71_14	URU_LL_1		URU_LL_2		BR_LL		VEN_LL	CV	US_LL		US_LL		CH_TAI_LL_1_70_92		CH_TAI_LL_2_93_14_M2		CH_TAI_LL_2_93_14_M3		CH_TAI_LL_2_93_14_M4	
units	number		WT	weight		weig		numbe		numb		numb		weight		number		number		number		number	
SS	YES		NO	YES		YES		YES		YES		YES		NO		YES		no		no		YES	
VPA	YES		NO	YES		YES		YES		YES		YES		NO		YES		no		no		YES	
ASPIC	sens		YES	YES		YES		YES		YES		NO		YES		YES		no		no		YES	
	scaled_i	C	scaled_ind	CV	CV	scale	CV	scaled	CV	scale	CV	scaled	CV	scaled	CV	scaled_i	CV	scaled_ind	CV	scaled_i	C	scaled_ind	CV
1965	2.76																						
1966	2.21																						
1967	4.55																						
1968	3.68																						
1969	3.14																						
1970	2.12															2.03	0.07						
1971	1.99		95.88													1.26	0.08						
1972	1.68		83.42													1.24	0.08						
1973	1.44		62.98													1.30	0.09						
1974	2.17		111.63													0.77	0.08						
1975	1.17		53.90													0.78	0.08						
1976	1.58		66.97													0.97	0.08						
1977	0.84		35.76													0.80	0.08						
1978	1.45		58.60					2.28	0.34							0.81	0.08						
1979	1.91		69.18					2.92	0.40							0.87	0.10						
1980	1.23		42.91					1.84	0.52							0.91	0.08						
1981	1.21		43.45					2.70	0.37							0.80	0.08						
1982	1.09		39.97	245.39	0.51			1.86	0.40							0.79	0.08						
1983	1.22		41.01	68.62	0.57			1.79	0.44							0.74	0.08						
1984	1.59		53.37	41.02	0.57			1.49	0.58							0.77	0.08						
1985	0.81		29.61	81.20	0.55			1.09	0.76							0.68	0.08						
1986	1.59		53.55	128.61	0.56			1.72	0.66							0.94	0.08						
1987	1.56		54.18	65.90	0.57			3.39	0.47			10.69	0.1	412.33	0.1	0.93	0.08						
1988	1.43		49.11	147.29	0.60			1.87	0.58			11.08	0.1	418.80	0.1	0.83	0.13						
1989	1.09		37.22	49.03	0.68			2.20	0.62			10.55	0.0	398.69	0.1	0.74	0.12						
1990	2.05		67.70	20.84	0.63			4.17	0.69			8.78	0.1	331.45	0.1	0.92	0.10						
1991	1.42		47.30	157.28	0.58			2.37	0.47	5.79	0.22	7.00	0.1	267.31	0.1	1.41	0.09						
1992	1.23		40.09			191.5	0.6	1.19	0.65	5.06	0.22	8.20	0.1	315.00	0.1	1.21	0.09						
1993	0.67		20.58			34.80	0.7	5.13	0.61	3.94	0.22	5.76	0.1	194.27	0.1			1.03	0.10	0.85	0.	1.24	0.20
1994	0.98		29.65			217.3	0.6	3.28	0.54	4.12	0.22	6.08	0.1	178.38	0.1			1.48	0.09	0.76	0.	2.74	0.19

1995	0.66		20.38			139.9	0.6	3.31	0.51	3.80	0.22	7.02	0.1	254.15	0.1			1.99	0.08	0.65	0.	3.46	0.18
1996	0.66		20.89			228.8	0.6	5.47	0.48	5.46	0.23	4.81	0.1	218.72	0.1			1.77	0.08	0.87	0.	1.57	0.18
1997	0.58		17.15			146.7	0.6	3.75	0.48	4.02	0.22	5.38	0.1	211.46	0.1			1.51	0.08	0.76	0.	1.08	0.19
1998	0.66		19.11			196.9	0.6	2.35	0.52	4.60	0.22	4.18	0.1	146.12	0.1			1.26	0.09	1.04	0.	1.06	0.19
1999	0.81		23.31			118.9	0.6	3.88	0.45	5.47	0.22	5.39	0.1	217.83	0.1			0.92	0.08	0.86	0.	0.72	0.19
2000	0.82		21.71			138.0	0.6	3.33	0.49	5.82	0.23	5.87	0.1	212.11	0.1			1.07	0.08	0.96	0.	0.74	0.19
2001	0.74		19.88			102.2	0.6	2.31	0.65	4.97	0.22	5.18	0.1	207.90	0.1			0.70	0.09	0.78	0.	0.39	0.20
2002	0.68		18.14			45.14	0.6	2.00	0.75	5.29	0.22	5.08	0.1	168.87	0.1			0.94	0.08	0.97	0.	0.80	0.19
2003	0.80		21.57			66.60	0.6	1.94	0.91	3.45	0.22	4.62	0.1	137.82	0.1			1.06	0.09	1.22	0.	1.67	0.19
2004	1.00		27.84			58.47	0.6	1.64	0.62	4.82	0.22	7.45	0.1	268.81	0.1			1.19	0.08	0.89	0.	1.19	0.18
2005	0.80		22.82			126.5	0.6	1.59	0.54	8.72	0.22	6.62	0.1	237.11	0.1			1.60	0.08	1.03	0.	1.47	0.18
2006	0.89		24.50			101.2	0.6	2.27	0.43	6.58	0.22	6.69	0.1	254.55	0.1			0.98	0.09	0.96	0.	0.93	0.19
2007	0.90		25.51			56.94	0.6	1.58	0.84	10.50	0.22	7.39	0.1	305.25	0.1			0.73	0.09	0.98	0.	0.56	0.19
2008	0.80		25.01			30.47	0.6	1.68	0.88	7.13	0.22	3.72	0.1	160.73	0.1			0.46	0.10	2.77	0.	0.39	0.19
2009	0.71		21.19			3.56	0.6	1.08	0.95	5.85	0.22	4.07	0.1	137.64	0.1			0.55	0.10	2.35	0.	0.51	0.19
2010	0.67		18.61			60.32	0.7	0.59	0.40	5.55	0.22	5.17	0.1	191.26	0.1			0.58	0.10	1.47	0.	0.38	0.19
2011	1.12		31.18					1.45	0.60	4.96	0.22	4.97	0.1	175.47	0.1			0.67	0.09	1.24	0.	0.47	0.19
2012	1.28		31.16					2.19	0.52	5.36	0.22	6.26	0.1	230.89	0.1			0.52	0.10	1.41	0.	0.42	0.19
2013	1.68		44.47							5.50	0.22	5.86	0.1	229.78	0.1			0.79	0.09	0.74	0.	0.44	0.19
2014	1.20		38.97							6.28	0.22	4.98	0.1	192.82	0.1			0.51	0.11	0.82	0.	0.43	0.20

Table 6. Catches (t) of yellowfin tuna for each fleet used in ASPIC models.

	Chinese Taipei LL	US LL	Venezuela LL	Japan LL	Brazil LL	Uruguay LL	Other LL (Cluster 1)	Other LL (Cluster 2)	Other LL (Cluster 1 _Sens)	Surface
1950	0	0	0	0	0	0	0	0	0	1,200
1951	0	0	0	0	0	0	0	0	0	1,358
1952	0	0	0	0	0	0	0	0	0	2,787
1953	0	0	0	0	0	0	0	0	0	3,600
1954	0	0	0	0	0	0	0	0	0	3,407
1955	0	0	0	0	0	0	0	0	0	4,300
1956	0	0	0	612	0	0	0	612	0	5,985
1957	0	0	688	13,19	0	0	0	13,886	0	9,812
1958	0	0	1,050	27,15	1,740	0	1,740	28,209	1,740	10,632
1959	0	111	1,780	44,07	5,920	0	5,920	45,962	5,920	5,887
1960	0	0	1,597	50,82	4,700	0	4,702	52,421	4,702	11,372
1961	0	0	1,728	42,60	4,400	0	4,425	44,362	4,425	10,041
1962	278	17	3,001	41,97	1,400	0	1,423	45,014	1,423	10,831
1963	399	8	2,781	37,71	2,400	0	4,249	42,355	4,249	19,444
1964	396	0	1,787	35,10	1,624	0	3,038	38,307	3,038	28,601
1965	183	0	1,657	36,91	696	0	2,085	39,964	2,085	26,878
1966	1,243	0	1,978	22,35	464	0	2,341	26,209	2,341	30,820
1967	3,023	0	1,637	12,82	812	0	6,939	20,588	6,939	35,802
1968	8,884	0	1,661	13,91	812	0	7,771	22,533	7,771	52,094
1969	12,202	0	2,268	9,966	464	0	10,043	21,813	10,043	60,092
1970	7,990	0	1,748	6,809	812	0	14,447	22,192	14,447	43,461
1971	4,938	0	2,149	10,62	347	0	13,518	25,949	13,518	43,231
1972	5,317	0	2,398	6,497	233	0	16,508	25,170	16,508	63,908
1973	3,000	0	1,921	3,803	153	0	24,422	29,993	24,422	61,987
1974	2,630	0	1,210	3,475	232	0	24,967	29,420	24,967	74,859
1975	2,669	0	563	4,192	260	0	22,235	26,730	22,235	95,137
1976	1,962	0	626	3,366	681	0	18,871	22,182	18,871	100,136
1977	372	0	827	1,467	928	0	22,903	24,269	22,903	105,444
1978	384	0	1,306	1,923	795	0	17,249	19,683	17,249	113,182
1979	1,038	0	1,000	1,986	1,076	0	12,030	13,940	12,030	111,463
1980	687	52	1,000	2,839	521	0	14,681	18,051	14,681	111,484
1981	867	45	1,000	4,145	1,159	67	13,252	17,216	13,252	136,829
1982	610	65	484	6,062	935	214	13,161	18,623	13,161	144,861
1983	539	165	1,248	2,069	887	357	10,354	12,592	10,354	151,236
1984	646	593	1,667	3,967	484	368	11,189	16,564	11,189	95,996
1985	926	738	1,626	5,308	515	354	11,677	18,480	11,677	136,342
1986	1,410	3,975	910	3,405	1,057	270	15,227	22,190	15,227	121,681
1987	902	4,888	646	3,365	653	109	11,147	19,284	11,147	124,403
1988	1,848	8,644	731	5,982	898	177	11,080	25,362	11,080	107,952
1989	858	6,247	497	6,970	1,126	64	10,467	22,991	10,467	137,353
1990	7,465	4,474	258	5,919	661	18	11,100	21,072	11,100	164,388
1991	4,172	4,141	338	4,718	582	62	9,813	18,366	9,813	144,340
1992	4,528	5,337	459	3,715	1,248	74	9,815	18,004	9,815	139,916
1993	4,196	3,886	707	3,096	1,514	20	8,777	14,932	8,777	142,785
1994	6,660	3,246	850	4,783	1,084	59	10,888	18,625	10,888	147,317
1995	4,698	3,645	687	5,227	1,312	53	10,652	18,845	10,652	129,679
1996	6,653	3,320	383	5,250	734	171	10,512	18,560	10,512	123,039
1997	4,466	3,773	381	3,539	849	53	9,878	16,670	9,878	115,337
1998	5,328	2,449	560	5,173	1,014	88	12,032	19,112	12,032	118,954
1999	4,411	3,541	504	3,405	2,930	45	15,193	19,668	15,193	109,271
2000	5,661	2,901	421	4,061	2,754	45	14,085	18,669	14,085	105,025
2001	4,805	2,200	451	2,691	4,883	90	12,295	12,664	12,295	131,013
2002	4,659	2,573	266	2,105	3,321	91	8,185	9,717	8,185	116,637
2003	6,486	2,164	323	2,754	1,940	95	7,623	10,829	7,623	103,100
2004	5,824	2,492	558	6,260	1,968	204	12,421	19,560	12,421	91,889
2005	3,596	1,746	833	4,247	4,695	644	11,349	12,836	11,349	79,980
2006	1,260	2,010	593	4,643	1,329	218	12,983	18,681	12,983	83,171
2007	1,947	2,395	613	9,037	1,552	35	13,009	23,466	13,009	68,962
2008	1,122	1,394	712	6,252	1,744	66	12,279	18,826	12,279	84,957
2009	1,391	1,686	898	4,994	1,039	76	11,208	17,671	11,208	93,259
2010	824	1,218	1,249	4,580	1,145	122	10,719	16,499	10,719	90,192
2011	1,768	1,462	1,090	4,454	1,794	24	8,513	13,701	8,513	85,351
2012	1,071	2,270	736	4,661	1,815	6	9,337	15,184	9,337	86,436
2013	1,260	1,544	738	4,577	1,584	0	9,851	15,126	9,851	79,299
2014	1,047	1,456	790	3,828	703	0	6,569	11,940	6,569	83,342

Table 7. List of CPUE indices used for creating combined CPUE for ASPIC continuity runs.

	Abbreviation	*Fleet*	*Source*
1	JPLL	Japan longline	JAP_CPUEN (column F)
2	BRLL	Brazil longline	BRA_LL (column K)
3	TLLE	Chinese Taipei longline	TAI_M1_CPUEN (column D)
4	TLLL		TAI_M4_CPUEN (column D)
5	GOLL	Gulf of Mexico longline	SCRS/2016/041 (Table 15) Stand. CPUE
6	ATLL	U.S. longline (Atl. only)	SCRS/2016/041 (Table 13) Stand. CPUE
7	ULLE	Uruguay longline	URU_LL_CPUEW (column F)
8	ULLL		URU_LL_CPUEW (column M)
9	VELL	Venezuela longline	VEN_LL_N (column H)
10	BRBB	Brazil baitboat	Relict Indices (column AS)
11	EDBB	EU Dakar baitboat	Relict Indices (column AG)
12	CIBB	Canarias Islands baitboat	Relict Indices (column AQ)
13	USRR	U.S. rod and reel recreational	Relict Indices (column F)
14	EPS3	EU purse seine 3%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (columns N)
15	EPS1	EU_PS_1%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (column O)
16	EPSF	ES_FAD_PS	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (column P)
17	EPS7	EU purse seine 7%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (columns Q)
18	VEPS	Venezuela purse seine	Relict Indices (column AR)

Table 8. Weight (number of 5x5 latitude and longitude counts with yellowfin catch) of each index listed in Table 7, for creating combined CPUE for ASPIC continuity runs.

sequencial number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fleet	JPLL	BRLL	TLLE	TLLL	GOLL	ATLL	ULLE	ULLL	VELL	BRBB	EDBB	CIBB	USRR	EPS3	EPS1	EPSF	EPS7	VEPS
1965	514																	
1966	363																	
1967	314																	
1968	304																	
1969	264										50							
1970	321		273								54							
1971	364		208								52			51			51	
1972	251		171								44			56			56	
1973	164		117								37			51			51	
1974	153		166								33			53			53	
1975	224		145								22			56			56	
1976	160		183								16			53			53	
1977	136		190								17			61			61	
1978	127		164								11			66			66	
1979	145		120								17			58			58	
1980	190		171								22	8		62			62	16
1981	244		189							17	4	8		92			92	16
1982	258		197				4			21	4	8		85			85	16
1983	198		154				4			16	20	8		102			102	22
1984	227		160				4			33	20	8		68			68	43
1985	308		187				4			32	12	8		67			67	76
1986	249	25	235				4			18	17	8	40	65			65	11
1987	232	33	180		24	98	4			25	12	8	40	60			60	10
1988	272	35	73		24	131	4			22	20	8	40	73			73	9
1989	305	28	66		24	132	4			27	16	8	40	59			59	8
1990	307	32	106		24	124	4			23	20	8	40	65			65	11
1991	350	49	229		24	97	4		6	23	12	8	40		68	68		8
1992	282	86	153		24	106		4	6	34	15	8	40		85.5	85.5		13
1993	255	145		200	24	106		4	7	27	10	8	40		87.5	87.5		13
1994	310	140		257	24	98		4	8	17	12	8	40		76	76		11
1995	308	141		248	24	114		4	8	20	15	8	40		98.5	98.5		11
1996	294	94		291	24	102		4	8	16	15	8	40		86.5	86.5		12
1997	296	98		283	24	115		4	8	10	13	8	40		72	72		9
1998	299	154		301	24	113		4	7	16	9	8	40		71.5	71.5		6
1999	271	258		333	24	74		4	30	5	12	8	40		58	58		10
2000	340	189		411	24	73		4	36	14	14	8	40		69	69		10
2001	332	190		338	24	77		4	23.5	14	12	8	40		84.5	84.5		11
2002	256	276		371	24	69		4	11	18	14	8	40		68	68		7
2003	282	142		291	24	50		4	26	36	15	8	40		70.5	70.5		9
2004	297	199		378	24	54		4	33	45	14	8	40		74	74		10
2005	292	252		363	24	144		4	45	192	14	8	40		59	59		18
2006	260	226		279	24	59		4	36	30	11	8	40		47.5	47.5		
2007	210	106		260	24	58		4	43	33	14	8	40		67.5	67.5		
2008	246	121		226	24	55		11	29	26	22	8	40		78	78		
2009	259	121		230	24	55		4	44	26	22	8	40		78	78		
2010	261	121		244	24	32		4	34	26	22	8	40		78	78		
2011	253	66		279	24	50			31		16							
2012	220	121		231	24	65			29		11							
2013	184	66		243	24	56			43		10							
2014	149	78		179	24	28			39		12							

Table 9. Combined CPUE used for ASPIC continuity runs with those for the last assessment.

Year	*2016_PS3%*	*2016_PS7%*	*2011_PS3%*	*2011_PS7%*
1965	1.9963	2.0374	2.5371	2.5806
1966	1.6014	1.6345	1.7646	1.7949
1967	3.2892	3.3570	3.4730	3.5326
1968	2.6630	2.7179	4.0188	4.1398
1969	2.0219	2.0673	3.4084	3.5290
1970	1.7313	1.7736	2.3406	2.5213
1971	1.3560	1.4459	1.7850	1.9131
1972	1.2432	1.3391	1.8943	2.0510
1973	1.1653	1.2620	1.5208	1.6543
1974	1.1563	1.2380	1.4841	1.6006
1975	0.8737	0.9249	1.2699	1.3505
1976	1.0927	1.1486	1.2444	1.3188
1977	0.8130	0.8499	1.0792	1.1379
1978	0.9484	0.9830	1.0652	1.1120
1979	1.1415	1.1684	1.3978	1.4374
1980	0.8884	0.9000	0.9281	0.9453
1981	0.9130	0.9170	1.3051	1.2835
1982	0.8259	0.8264	1.2021	1.1781
1983	0.8928	0.8800	1.1566	1.1183
1984	0.9581	0.9517	1.1754	1.1460
1985	0.7435	0.7392	1.0038	0.9802
1986	1.1176	1.1091	1.1826	1.1482
1987	1.0919	1.0820	1.1320	1.0998
1988	1.0208	0.9995	1.1687	1.1282
1989	0.8980	0.8830	1.1657	1.1313
1990	1.2525	1.2567	1.3632	1.3484
1991	1.0053	1.0243	1.0018	1.0045
1992	0.8723	0.8877	1.0250	1.0289
1993	0.8024	0.8149	0.8454	0.8517
1994	0.9698	0.9854	0.9084	0.9157
1995	0.8791	0.8932	0.8616	0.8685
1996	0.8186	0.8318	0.9601	0.9680
1997	0.6453	0.6557	0.8056	0.8122
1998	0.6181	0.6280	0.7126	0.7183
1999	0.7068	0.7182	0.7957	0.8020
2000	0.6315	0.6419	0.7447	0.7511
2001	0.4792	0.4871	0.5897	0.5947
2002	0.5382	0.5468	0.6711	0.6763
2003	0.7287	0.7405	0.7599	0.7661
2004	0.7157	0.7272	0.7978	0.8041
2005	0.6120	0.6209	0.5429	0.5459
2006	0.6403	0.6506	0.6314	0.6364
2007	0.5944	0.6042	0.7264	0.7326
2008	0.4779	0.4859	0.5634	0.5686
2009	0.4791	0.4872	0.6766	0.6827
2010	0.4507	0.4584	0.7575	0.7650
2011	0.5309	0.5400		
2012	0.6291	0.6396		
2013	0.6055	0.6157		
2014	0.5341	0.5432		

Table 10. Specification of ASPIC model runs.

Model run	*Cluster*	*B1/K*	*Production function*	*Weighting of fleets*	*Comment*
1_Fox_eq	*1*	*0.9*	*Fox*	*Equal*	***Base model***
1_Fox_cw	1	0.9	Fox	Catch	
1_Logi_eq	1	0.9	Logistic	Equal	
1_Logi_cw	1	0.9	Logistic	Catch	
2_Fox_eq	2	0.9	Fox	Equal	
2_Fox_cw	2	0.9	Fox	Catch	
2_Logi_eq	2	0.9	Logistic	Equal	
2_Logi_cw	2	0.9	Logistic	Catch	
1_sens_Fox_eq	1_sens	0.9	Fox	Equal	
1_sens_Fox_cw	1_sens	0.9	Fox	Catch	
1_sens_Logi_eq	1_sens	0.9	Logistic	Equal	
1_sens_Logi_cw	1_sens	0.9	Logistic	Catch	
JPN_7614_Logi	None	0.9	Logistic	None	1 fleet, only Japan LL CPUE (1976-2014)
JPN_7614_FOX	None	0.9	Fox	None	1 fleet, only Japan LL CPUE (1976-2014)
US_LL_logi	None	0.9	Logistic	None	1 fleet, only US LL CPUE
US_LL_FOX	None	0.9	Fox	None	1 fleet, only US LL CPUE
Comb_CPUE_PS3%_ Logi	None	0.9	Logistic	None	1 fleet, combined CPUE with PS q 3% annual increase
Comb_CPUE_PS3%_ Fox	None	0.9	Fox	None	1 fleet, combined CPUE with PS q 3% annual increase
Comb_CPUE_PS7%_ Logi	None	0.9	Logistic	None	1 fleet, combined CPUE with PS q 7% annual increase
Comb_CPUE_PS7%_ Fox	None	0.9	Fox	None	1 fleet, combined CPUE with PS q 7% annual increase

Table 11. Scenarios of sensitivity analyses for the ASPIC model runs for yellowfin tuna.

Scenario	*Abbreviation in the graph*
B1/K fix at 0.8	B1/K 0.8
B1/K fix at 1.0	B1/K 1.0
Drop index of Japan LL	no JPLL
Drop index of Taiwanese LL	no TWLL
Only with Taiwanese LL and JPN LL indices	only TWLL&JPLL
Drop index of US LL	no USLL
Drop index of Venezuela LL	no VenLL
Start year 1970	Start 1970

Table 12. Fleet descriptions and CPUE used for ASPM analysis in this study. For ease to compare the shaded right part of this table comes from worksheet "dsCDIS" of cdis_byFishery.csv. For some fleets the "time block" is applied for different selectivity period of same fleet. The original implementation of "cluster 2" included Uruguay longline (Fishery IDs 13 and 14), however they are included in other longline group in this study.

cluster 1 / sensitivity	time block	cluster 2		FisheryID	FisheryCode	Gear	School	FisheryCode2 (J.Walter)
01_PS		01_PS		1	PS-EU_early	PS	…	1_PS_ESFR2_6585 (early)
01_PS	1965-1990	01_PS		2	PS-EU_trans	PS	…	2_PS_ESFR2_8690 (transition)
01_PS	1991-2014	01_PS		3	PS-EU_fsc	PS	FSC	3_PS_ESFR2_9114 (Free school)
01_PS		01_PS		4	PS-EU_fad	PS	FAD	4_ESFR_FADS2_PS_9114
02_BB		02_BB		5	BBPS-GHA	BB+PS	…	5_BB+PS_Ghana_6514
02_BB	1965-1970	02_BB		6	BB_A2_SouthDakar	BB	…	6. BB area 2, south of Dakar
02_BB	1971-2014	02_BB		7	BB-Dakar_early	BB	…	7_BB_DAKAR_62_80
02_BB		02_BB		8	BB-Dakar_late	BB	…	8_BB_DAKAR_81_14
02_BB		02_BB		9	BB-CaAzMd	BB	…	9_BB_area1_can_AZ
03_LLJP		05_LLOT		10	LL_JPN_a1	LL	…	Japan_LL_75_14_area1
03_LLJP		05_LLOT		11	LL_JPN_a2	LL	…	Japan_LL_75_14_area2
03_LLJP		05_LLOT		12	LL_JPN_a3	LL	…	Japan_LL_75_14_area3
07_LLOT		05_LLOT		13	LL_URY_early	LL	…	URU_LL_1
07_LLOT		05_LLOT		14	LL_URY_late	LL	…	URU_LL_2
07_LLOT		03_LLBR		15	LL_BR	LL	…	BR_LL
04_LLVE		05_LLOT		16	LL_VEN	LL	…	VEN_LL
05_LLUS		05_LLOT		17	LL_US	LL	…	US_LL
06_LLTA	1965-1992	04_LLTA		18	LL_TAI_a1_early	LL	…	CH_TAI_LL_1_70_92_area1
06_LLTA	1993-2014	04_LLTA		19	LL_TAI_a1_late	LL	…	CH_TAI_LL_2_93_14_area1
06_LLTA	1965-1992	04_LLTA		20	LL_TAI_a2_early	LL	…	CH_TAI_LL_1_70_92_area2
06_LLTA	1993-2014	04_LLTA		21	LL_TAI_a2_late	LL	…	CH_TAI_LL_2_93_14_area2
06_LLTA	1965-1992	04_LLTA		22	LL_TAI_a3_early	LL	…	CH_TAI_LL_1_70_92_area3
06_LLTA	1993-2014	04_LLTA		23	LL_TAI_a3_late	LL	…	CH_TAI_LL_2_93_14_area3
07_LLOT		05_LLOT		24	LL_others	LL	…	OTHER_LL
08_OT	1965-1975	06_OT		25	RR_USA	RR (95% of oth)	…	US_RR
08_OT	1976-2014	06_OT		26	Others	oth	…	OTH_OTH

Table 13. VPA parameter specifications.

The methods of estimation include:

0 fixed constant at value given for best estimate
1 estimate as a 'frequentist' parameter
-n fix to the same value as parameter n (whether it is estimated or not)
-0.1 fix to the value of the previous estimated parameter
0.1 estimate as a random walk (a lognormal random deviation with given std. dev. and prior expectation equal to the previous parameter
0.2 estimate as a lognormal random deviation with given std. dev. and prior expectation equal to the nearest previous constant or frequentist parameter)
0.3 estimate as a lognormal random deviation with given std. dev. and prior expectation equal to the input best estimate)

TERMINAL F PARAMETERS: (lower bound, best estimate, upper bound, indicator, reference age)

1	0	0.1	2	1	0.1	first age (AGE 0 in this case)
1	0	0.5	2	1	0.1	
1	0	0.25	2	1	0.1	
1	0	0.35	2	1	0.1	
1	0	0.4	2	1	0.1	next to last age

F-RATIO PARAMETERS F{oldest}/F{oldest-1} (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
One parameter (set of specifications) for each year.

1	0.1	0.2	5	1	0.2	1970 estimated
44	0.1	0.2	5	3	0.2	1971-2010 random walk

NATURAL MORTALITY PARAMETERS: (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
One parameter (set of specifications) for each age.

1	0	1.588	1	0	0.1
1	0	1.194	1	0	0.1
1	0	0.748	1	0	0.1
1	0	0.550	1	0	0.1
1	0	0.476	1	0	0.1
1	0	0.4321	1	0	0.1

VARIANCE SCALING PARAMETER (lower bound, best estimate, upper bound, indicator, std. dev.)

This parameter scales the input variance up or down as desired.
In principal, if you estimate this you should obtain more accurate estimates of the magnitude of the parameter variances – all other things being equal.
(1 parameter so 1 set of specifications)

1	0	1.0	3.0	0	0.1	1
1	0	1.0	3.0	1	0.1	2
7	0	1.0	3.0	-0.1	0.1	3-9

Table 14. Specifications for partial catch-at-age (PCAA) for VPA Runs. VPA runs considered "base" used the "continuity" age-slicing procedure (as in 2011).

Index	*Specification*
Japanese LL	Fleet Code = JPN, Gear = LL
Chinese Taipei LL	Fleet Code = TAI, Gear = LL
United States LL	Fleet Code = USA, USA-Com, USA-Rec, Gear = LL
Venezuela LL	Fishery ID = 16, Gear = LL
Uruguay LL	Fishery ID = 13, 14, Gear = LL
Brazil LL	Fishery ID = 15, Gear = LL

Table 15. Results of the ASPIC model runs. The selected base case was model 1_FOX_eq shown in bold font.

Model run	*MSY (t)*	F_{MSY}	B_{MSY}	B_{2015}/B_{MSY}	F_{2014}/F_{MSY}	*K*	*r*
1_Fox_eq	***126,000***	***0.170***	***739,800***	***1.019***	***0.770***	***2,011,000***	***0.17***
1_Fox_cw	131,500	0.181	727,100	1.296	0.578	1,977,000	0.18
1_Logi_eq	132,400	0.168	787,100	0.908	0.827	1,574,000	0.34
1_Logi_cw	132,600	0.148	898,500	1.137	0.654	1,797,000	0.30
2_Fox_eq	No convergence						
2_Fox_cw	No convergence						
2_Logi_eq	9,651,000	1.868	5,167,000	1.995	0.005	10,330,000	3.74
2_Logi_cw	769,300	1.426	539,600	1.935	0.065	1,079,000	2.85
1_sens_Fox_eq	129,700	0.173	749,000	1.236	0.615	2,036,000	0.17
1_sens_Fox_cw	137,400	0.206	666,700	1.483	0.483	1,812,000	0.21
1_sens_Logi_eq	132,800	0.162	818,300	1.055	0.706	1,637,000	0.32
1_sens_Logi_cw	136,500	0.166	821,600	1.271	0.567	1,643,000	0.33
JPN_7614_Logi	145,000	0.338	429,500	0.978	0.723	859,100	0.68
JPN_7614_FOX	133,800	0.261	512,200	0.984	0.764	1,392,000	0.26
US_LL_Logi	126,400	0.131	965,500	0.770	1.012	1,931,000	0.26
US_LL_FOX	119,100	0.135	882,300	0.885	0.933	2,398,000	0.14
Comb_CPUE_PS3%_Logi	111,700	0.078	1,429,000	0.656	1.325	2,858,000	0.16
Comb_CPUE_ PS3%_Fox	98,040	0.065	1,500,000	0.856	1.155	4,077,000	0.07
Comb_CPUE_PS7%_Logi	114,100	0.085	1,345,000	0.654	1.302	2,689,000	0.17
Comb_CPUE_ PS7%_Fox	101,100	0.072	1,407,000	0.853	1.126	3,825,000	0.07

Table 16. Descriptions for ASPM runs regarding to important parameters of CAA (Catch-At-Age), index, sigmaR, steepness and B1965/B0, M vector and growth model.

Run	examination	CAA1	index	sigmaR	Steepness	B/B0	M vector 2	growth
Run01	base	01_Cont	cluster 1	0.4	0.85	estimated	Continuity	Ga
Run01_h075	steepness	01_Cont	cluster 1	0.4	0.75	estimated	Continuity	Ga
Run01_h095	steepness	01_Cont	cluster 1	0.4	0.95	estimated	Continuity	Ga
Run01_L	index	01_Cont	sensitivity	0.4	0.75	estimated	Continuity	Ga
Run02	M vector	01_Cont	cluster 1	0.4	0.85	estimated	Ga. related	Ga
Run03	CAA	03_Dr withM	cluster 1	0.4	0.85	estimated	Dr. related	Dr
Run04	CAA	05_Ga withM	cluster 1	0.4	0.85	estimated	Ga. related	Ga
Run05	base	01_Cont	cluster 2	0.4	0.85	estimated	Continuity	Ga
Run05_h075	steepness	01_Cont	cluster 2	0.4	0.75	estimated	Continuity	Ga
Run05_h095	steepness	01_Cont	cluster 2	0.4	0.95	estimated	Continuity	Ga
Run06	M vector	01_Cont	cluster 2	0.4	0.85	estimated	Ga. related	Ga
Run07	CAA	03_Dr withM	cluster 2	0.4	0.85	estimated	Dr. related	Dr
Run08	CAA	05_Ga withM	cluster 2	0.4	0.85	estimated	Ga. related	Ga
Run09	sigmaR	01_Cont	cluster 1	0.3	0.85	estimated	Dr. related	Dr
Run10	sigmaR	01_Cont	cluster 2	0.3	0.85	estimated	Ga. related	Ga
Run11	steepness	01_Cont	cluster 1	0.4	estimate (not converged)	estimated	Dr. related	Dr
Run12	steepness	01_Cont	cluster 2	0.4	estimate (0.585)	estimated	Ga. related	Ga

1	01_Cont: same formulation as 2011 meeting using Gascuel 2-stanza growth model without M vector in ageing, 03_DrwithM: Draganik von Bertalanffy growth model including M vector, 05_GawithM: Gascuel 2-stanza growth model including M vector
2	for age 0 to age5+ Continuity; same vector as 2011 meeing (0.8 0.6 0.6 0.6 0.6 0.6) Da related M vector; Draganik von Bertalanffy growth model related (1.758 0.889 0.672 0.576 0.525 0.495) Ga related M vector; Gascuel 2-stanza growth model related (1.588 1.194 0.748 0.550 0.476 0.447)

Table 17. ASPM estimates of the MSY and its associated quantities for yellowfin tuna for the base case models. SSB_{recent} and SSB_{MSY} are defined as the biomass of matured fish defined by the maturity vector (in thousand ton) at the beginning of 2014 and at MSY, respectively. The F_{recent} and F_{MSY} indicates the fishing mortality in 2014 and at MSY, respectively. 80 percent confidence interval (90 percentiles to 10 percentiles) are also presented if available for bootstrap examinations (1,000 replicates).

	Run_01		Run_05	
SSB_0	995.7		1024.0	
SSB_{MSY} at 2014	256.5		264.3	
MSY at 2014	150.3	(133.9-164.6)	145.5	(123.9-163.4)
Catch at 2014	97.0			
Catch at 2015	110.3			
SSB_{2014}/SSB_{MSY}	1.002	(0.775-1.240)	1.025	(0.610-1.429)
F_{2014}/F_{MSY}	0.558	(0.445-0.692)	0.625	(0.423-0.989)

Table 18. SS3 Models: table of key information for models 0-4, noting the specifications, log-likelihoods, run time, virgin and ending SSB, parameters that hit bounds, derived quantities and relative status.

	Cluster 1	*Cluster 2*
Growth Model	Multistanza est	Multistanza est
grad	6.64E-05	3.98E-05
wts	Adjusted for Fraction of catch; Francis wts	Adjusted for Fraction of catch; Francis wts
Stp	fix 0.9	fix 0.9
Index wts	= cv 0.3	= cv 0.3
Likelihoods		
TOTAL	3711.51	4010.39
Equil catch	0	0
Survey	-94.3694	175.204
Recruitment	3845.86	3863.79
Forecast Rec	-41.6811	-32.4235
Parm_priors	0.602593	2.7285
Parm softbnds	1.06562	1.06553
Parm_devs	0.0289317	0.0246453
Crash_Pen	0	0
Length comp	0	0
Age_comp	0	0

Table 19. SS3 Models: derived quantities and benchmark values.

	Run5. Cluster 1	*sd*	*Run7. Cluster 2*	*sd*
SSB_Unfished	784400	21912	789953	26782
TotBio_Unfih	1129120	31506	1137180	38530
SmryBio_Unfis	1127470	31464	1135530	38475
Recr_Unfished	141034	4127	141933	4988
SSB_Btgt	235320	6574	236986	8035
SPR_Btgt	0.319	0.0000	0.319	0.000
Fstd_Btgt	0.277	0.0039	0.275	0.004
TotYield_Btgt	122277	3060	122004	3296
SSB_SPRtgt	219632	6135	221187	7499
Fstd_SPRtgt	0.29	0.0041	0.292	0.004
TotYld_SPRtgt	122984	3088	122721	3326
SSB_MSY	197150	5389	197949	6452
SPR_MSY	0.272	0.0014	0.271	0.001
Fstd_MSY	0.320	0.0046	0.319	0.005
TotYield_MSY	123382	3114	123139	3354
RetYield_MSY	123382	3114	123139	3354
2014 catch estimate	97032		97032	
Mean catch last 5 years	100362		100362	
$F_{current}$	0.21	0.02	0.36	0.05
SSB_0	784400	21912	789953	26782
SSB_{2014}	271286	26129	160085	21385
SSB_{MSY}	197150	5389	197949	3296
SSB_{spr30}	219632	6135	221187	7499
$F_{Current}/ F_{MSY}$	0.647		1.118	
$F_{Current}/ F_{SPR30}$	0.704		0.84	
$SSB_{Current}/ SSB_{MSY}$	1.38		0.81	
$SSB_{Current}/ SSB_{SPR30\%}$	1.24		0.72	
$SSB_{Current}/ SSB_0$	0.35		0.20	

Table 20. Estimated benchmarks by the Cluster 1 VPA base model.

MEASURE	LOWER CL	MEDIAN	UPPER CL	AVERAGE	RUN 0	STD. DEV.
F at MSY	0.747	0.795	0.838	0.794	0.789	0.036
MSY	119,192	122,138	124,865	122,069	121,690	2,228
Y/R at MSY	0.642	0.657	0.672	0.657	0.655	0.012
S/R at MSY	0.782	0.792	0.800	0.791	0.793	0.007
SPR AT MSY	0.199	0.202	0.204	0.201	0.202	0.002
SSB AT MSY	145,060	147,111	148,818	147,026	147,271	1,517
F at max. Y/R	1.036	1.098	1.154	1.097	1.089	0.047
Y/R maximum	0.658	0.673	0.687	0.673	0.670	0.011
S/R at Fmax	0.463	0.483	0.498	0.482	0.483	0.014
SPR at Fmax	0.118	0.123	0.127	0.123	0.123	0.004
SSB at Fmax	79,286	83,404	86,556	83,091	83,345	2,934
F 0.1	0.611	0.644	0.674	0.644	0.641	0.024
Y/R at F0.1	0.617	0.631	0.642	0.630	0.628	0.010
S/R at F0.1	1.002	1.035	1.061	1.033	1.034	0.023
SPR at F0.1	0.255	0.263	0.270	0.263	0.263	0.006
SSB at F0.1	190,295	196,947	202,354	196,581	196,745	4,699
F 20% SPR	0.745	0.797	0.842	0.795	0.791	0.038
Y/R at F 20	0.642	0.657	0.672	0.657	0.655	0.012
S/R at F 20	0.790	0.790	0.791	0.790	0.790	0.000
SSB at F 20	146,521	146,633	146,745	146,634	146,572	81
F 30% SPR	0.538	0.572	0.601	0.571	0.568	0.025
Y/R at F 30	0.594	0.610	0.624	0.609	0.608	0.012
S/R at F 30	1.183	1.183	1.184	1.183	1.184	0.001
SSB at F 30	227,416	227,599	227,784	227,601	227,622	135
F 40% SPR	0.399	0.423	0.443	0.422	0.420	0.017
Y/R at F 40	0.530	0.545	0.557	0.544	0.543	0.011
S/R at F 40	1.575	1.577	1.578	1.577	1.578	0.001
SSB at F 40	308,307	308,588	308,835	308,578	308,801	191
F 90% max Y/R	0.529	0.559	0.586	0.558	0.555	0.022
Y 90% max Y/R	113,963	116,624	119,123	116,579	116,197	2,026
Y/R 90% max Y/R	0.592	0.606	0.618	0.605	0.603	0.010
S/R 90% max Y/R	1.191	1.212	1.228	1.211	1.214	0.015
SSB 90% max Y/R	229,252	233,516	236,841	233,274	233,837	3,071
F 75% of Fmax	0.777	0.823	0.866	0.823	0.817	0.035
Y 75% of Fmax	118,963	121,935	124,676	121,860	121,487	2,242
Y/R at 75% Fmax	0.645	0.661	0.675	0.660	0.658	0.011
S/R at 75% Fmax	0.736	0.755	0.769	0.754	0.756	0.013
SSB at 75% Fmax	135,514	139,382	142,181	139,074	139,535	2,685

Table 21. Estimated benchmarks by the Cluster 2 VPA base model.

MEASURE	LOWER CL	MEDIAN	UPPER CL	AVERAGE	RUN 0	STD. DEV.
F at MSY	0.996	1.063	1.119	1.061	1.078	0.050
MSY	122,032	125,022	127,362	124,835	125,956	2,263
Y/R at MSY	0.668	0.684	0.697	0.683	0.689	0.012
S/R at MSY	0.602	0.612	0.618	0.610	0.615	0.007
SPR AT MSY	0.153	0.156	0.157	0.155	0.157	0.002
SSB AT MSY	109,842	111,738	113,005	111,534	112,465	1,409
F at max. Y/R	1.162	1.238	1.304	1.236	1.254	0.057
Y/R maximum	0.671	0.688	0.701	0.687	0.693	0.012
S/R at Fmax	0.464	0.479	0.487	0.477	0.484	0.011
SPR at Fmax	0.118	0.122	0.124	0.121	0.123	0.003
SSB at Fmax	83,533	86,279	87,870	85,914	87,331	2,021
F 0.1	0.694	0.729	0.763	0.728	0.735	0.029
Y/R at F0.1	0.630	0.645	0.656	0.644	0.649	0.011
S/R at F0.1	0.996	1.019	1.031	1.016	1.027	0.016
SPR at F0.1	0.254	0.259	0.262	0.259	0.261	0.004
SSB at F0.1	185,051	189,438	191,621	188,742	190,888	3,084
F 20% SPR	0.836	0.892	0.935	0.888	0.906	0.041
Y/R at F 20	0.654	0.671	0.684	0.670	0.676	0.012
S/R at F 20	0.790	0.790	0.791	0.790	0.790	0.000
SSB at F 20	145,609	145,703	145,798	145,702	145,614	68
F 30% SPR	0.602	0.639	0.667	0.636	0.647	0.027
Y/R at F 30	0.606	0.621	0.632	0.620	0.626	0.011
S/R at F 30	1.183	1.183	1.184	1.183	1.184	0.001
SSB at F 30	220,606	220,756	220,909	220,758	220,847	110
F 40% SPR	0.446	0.472	0.492	0.470	0.478	0.019
Y/R at F 40	0.539	0.554	0.563	0.552	0.558	0.010
S/R at F 40	1.575	1.576	1.578	1.577	1.575	0.001
SSB at F 40	295,599	295,810	296,033	295,813	295,613	157
F 90% max Y/R	0.597	0.632	0.662	0.631	0.638	0.027
Y 90% max Y/R	112,733	115,490	117,643	115,319	116,315	2,062
Y/R 90% max Y/R	0.604	0.619	0.631	0.618	0.623	0.011
S/R 90% max Y/R	1.181	1.196	1.207	1.194	1.201	0.012
SSB 90% max Y/R	220,225	223,130	225,275	222,856	224,127	2,209
F 75% of Fmax	0.871	0.929	0.978	0.927	0.941	0.043
Y 75% of Fmax	121,208	124,214	126,557	124,034	125,139	2,253
Y/R at 75% Fmax	0.659	0.675	0.688	0.674	0.680	0.012
S/R at 75% Fmax	0.731	0.745	0.756	0.744	0.750	0.011
SSB at 75% Fmax	134,403	137,078	139,107	136,892	138,067	2,022

Table 22. Catch assignments by fleet for Stock Synthesis (SS) projection runs.

Assigned fleet	*Flag*	*SpcGearGrp*
17 (OTH_OTH	Brazil	Bait boat
8_BB_DAKAR_81_14	Cape Verde	Bait boat
6_BB_area2_Sdak	EU.España	Bait boat
6_BB_area2_Sdak	EU.France	Bait boat
6_BB_area2_Sdak	EU.Portugal	Bait boat
5_BB_PS_Ghana_6514	Ghana	Bait boat
8_BB_DAKAR_81_14	Senegal	Bait boat
17 (OTH_OTH	South Africa	Bait boat
17 (OTH_OTH	UK. Sta. Helena	Bait boat
17 (OTH_OTH	Venezuela	Bait boat
17 (OTH_OTH	Venezuela	Purse Seine

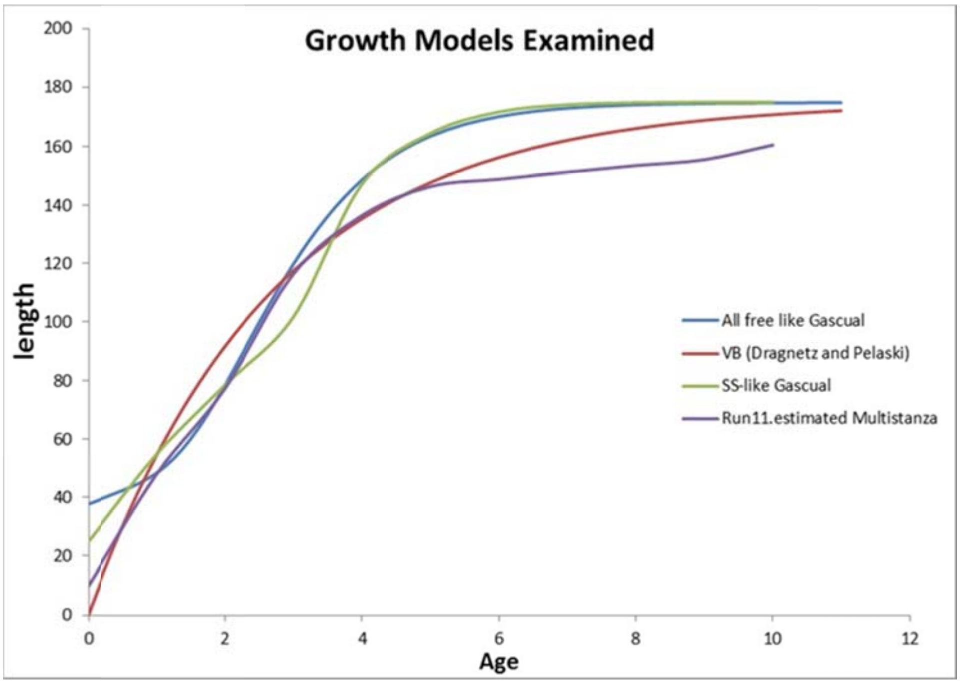

Figure 1. Growth models considered in the assessment including the preferred growth model (Gascuel *et al*., 1992), the model of Draganik and Pelczarski (1984), used in some sensitivity runs and the two models used in SS, a Gascuel-like and a multi-stanza model estimated with SS.

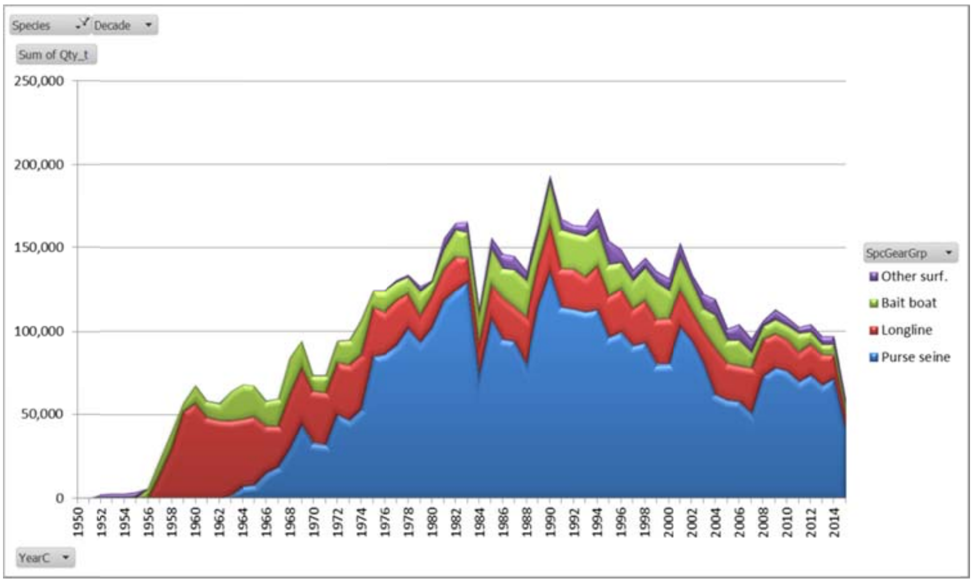

Figure 2. Nominal catch of yellowfin tuna from Task I (1950-2014) by major fishing gear types.

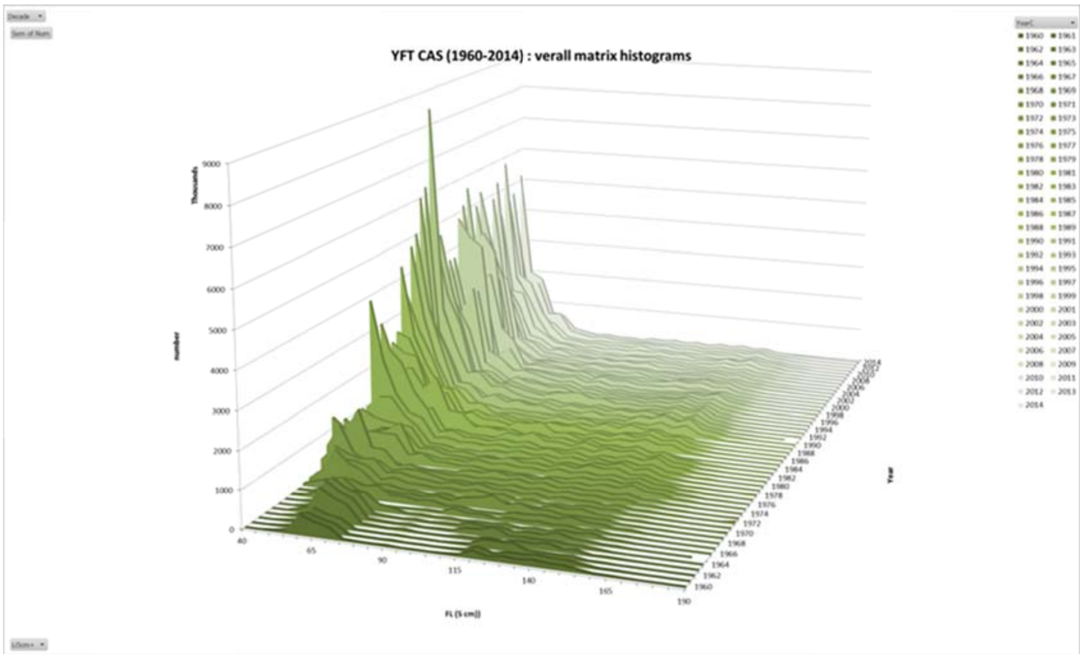

Figure 3. Estimated catch-at-size for YFT 1960-2014.

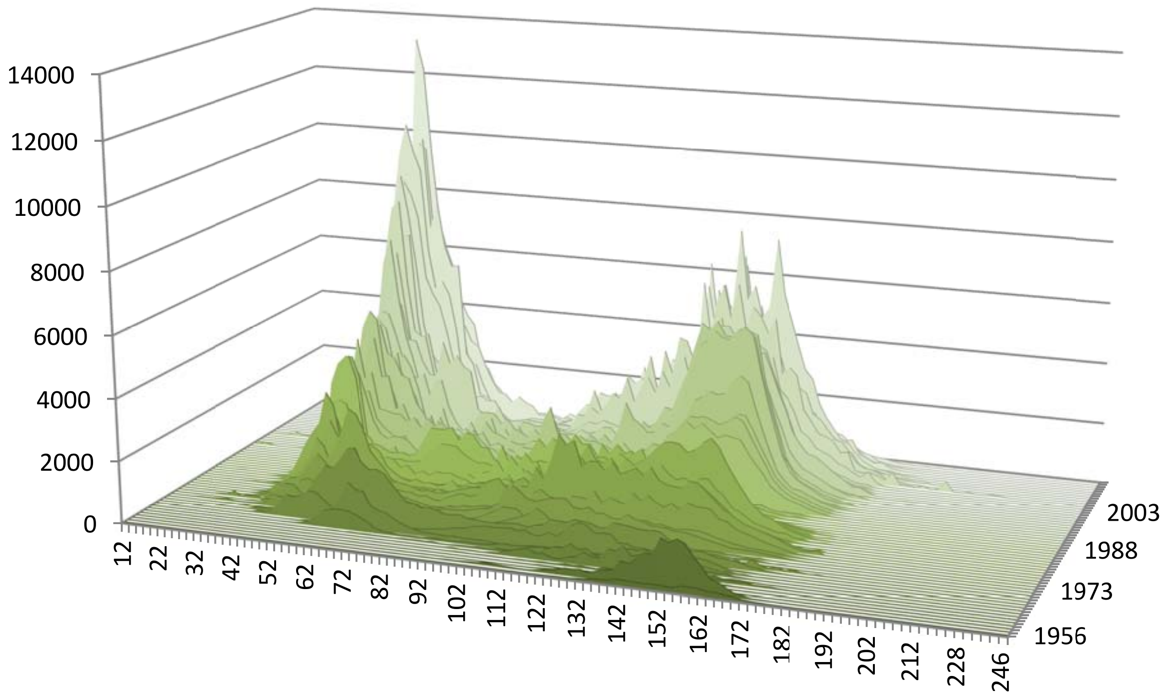

Figure 4. Size frequency distribution of yellowfin tuna catches from size sampling data 1956-2014.

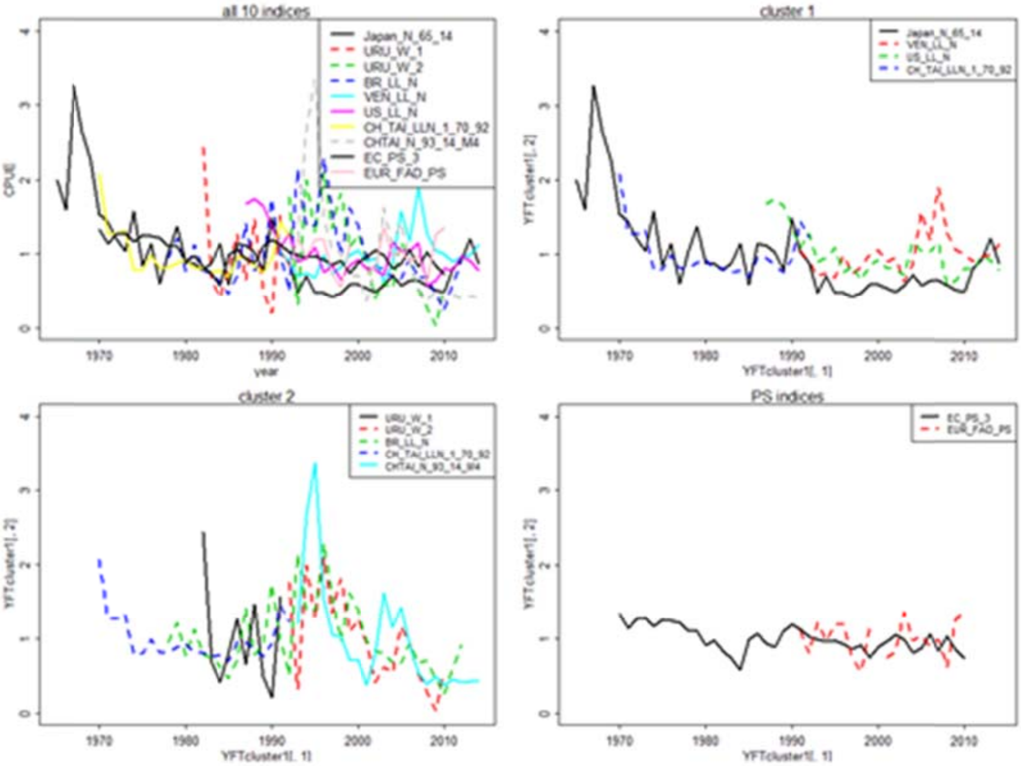

Figure 5. Indices used for stock assessment overall and by Cluster 1 and Cluster 2. Relict purse seine indices are also shown and were used in continuity case. Several other relict indices (not shown) were used in continuity model cases and previously described (Anon., 2012).

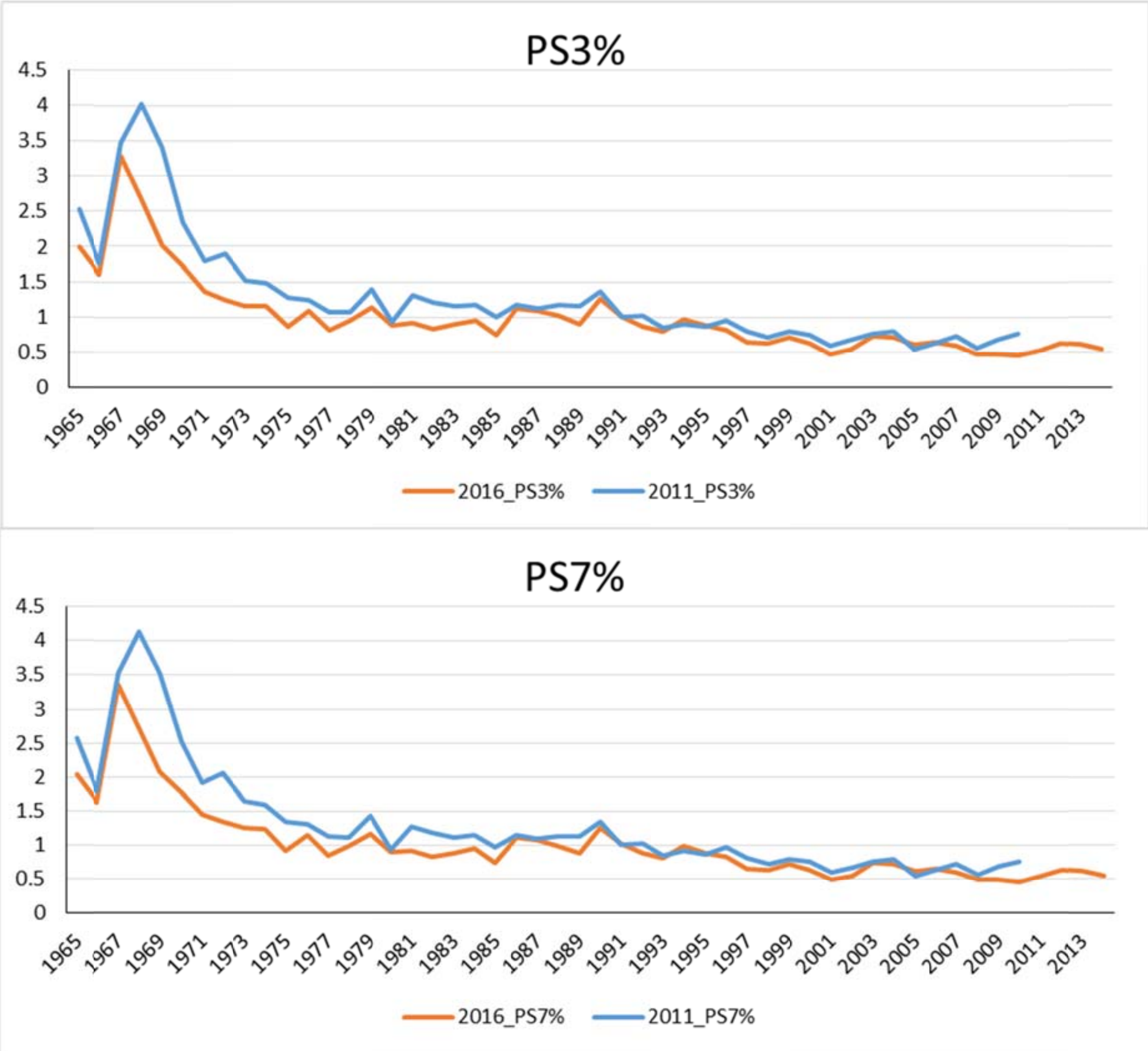

Figure 6. Trend of combined CPUEs for ASPIC model compared with those for the last assessment. Upper: annual increase in q for purse seine 3%, lower: annual increase in q for purse seine 7%.

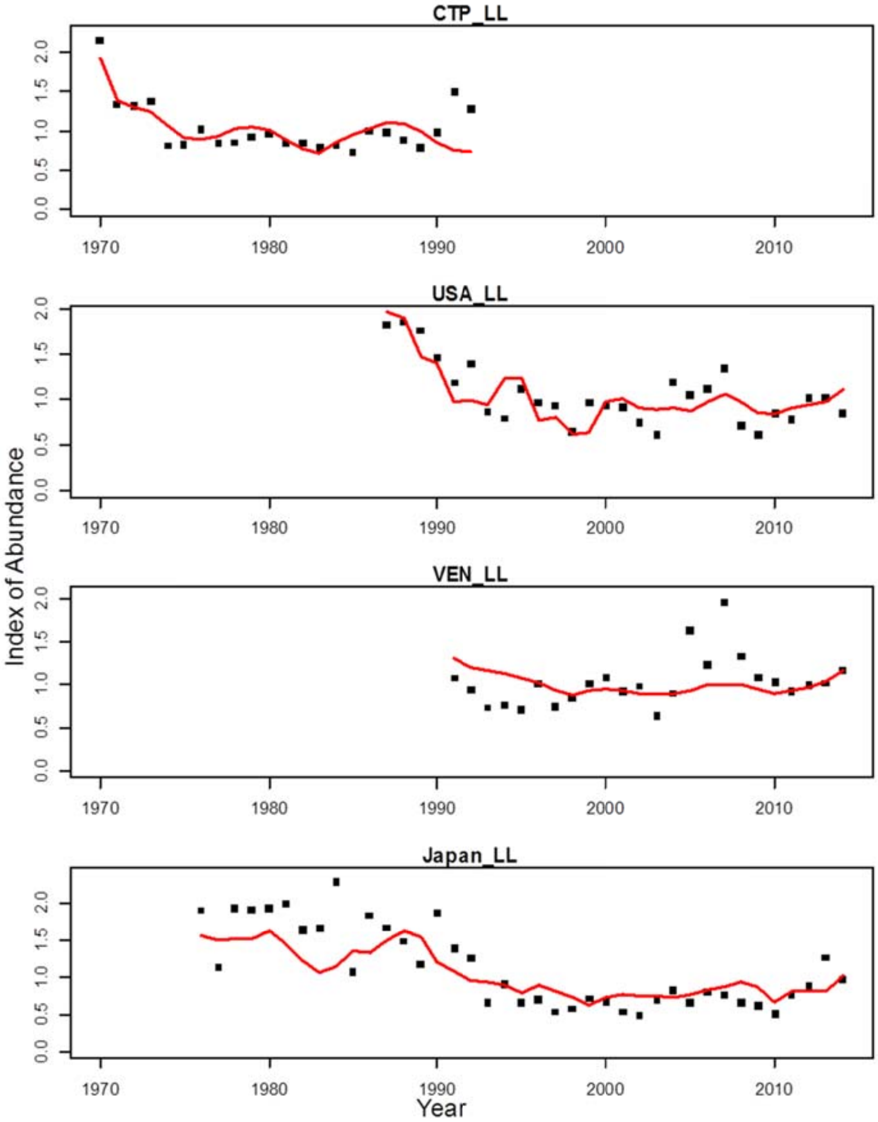

Figure 7. VPA fits to the Cluster 1 indices of abundance.

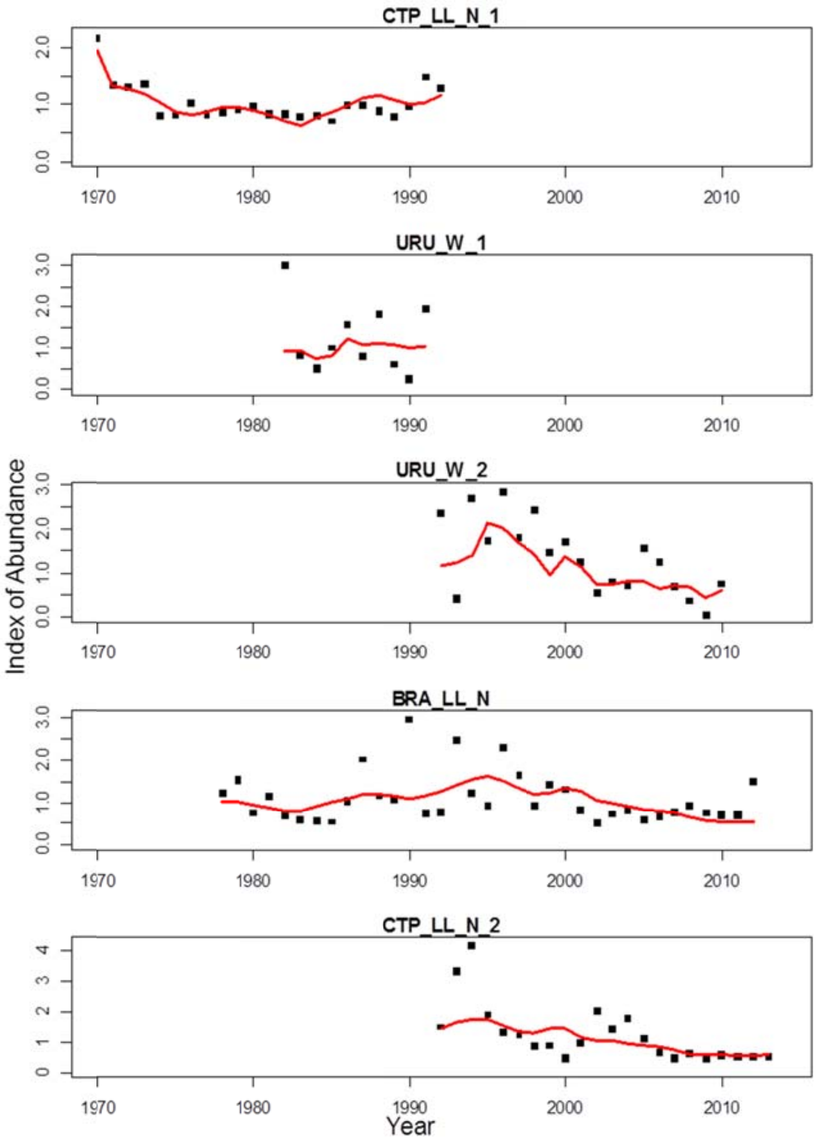

Figure 8. VPA fits to the Cluster 2 indices of abundance.

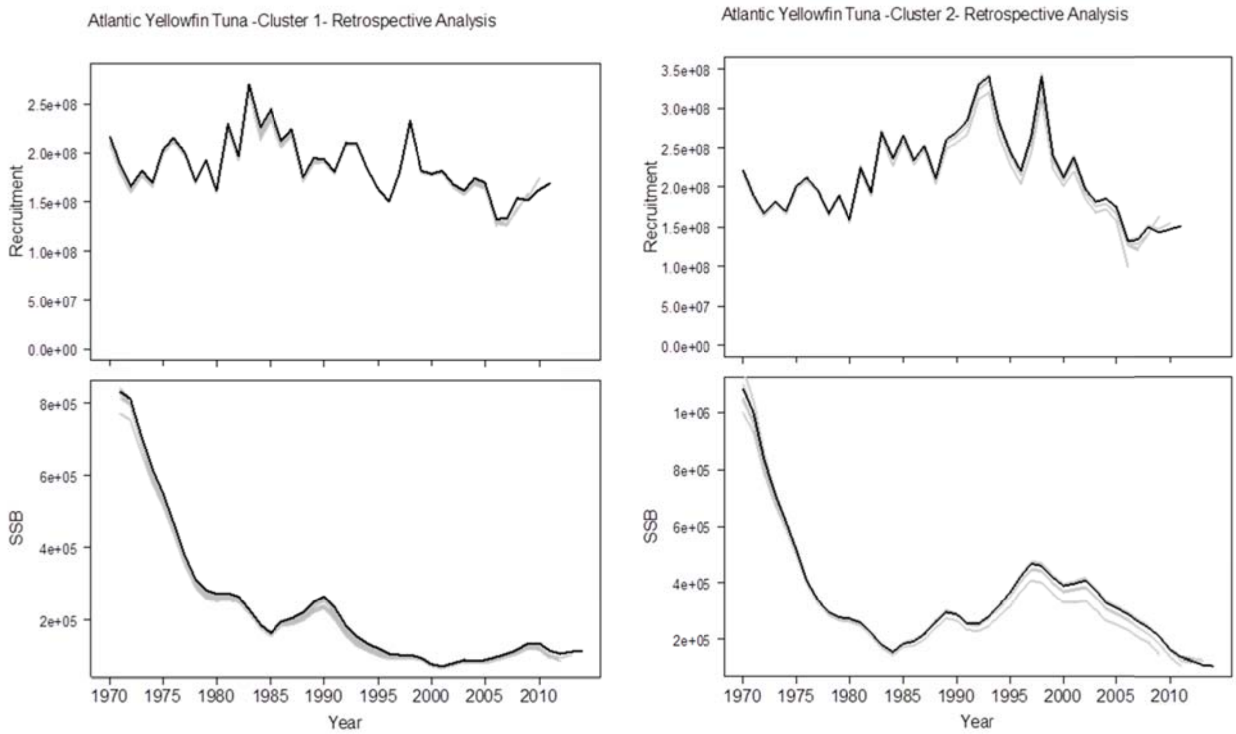

Figure 9. VPA retrospective analyses on SSB and recruitment for the Cluster 1 base model (left panels) and Cluster 2 base model (right panels).

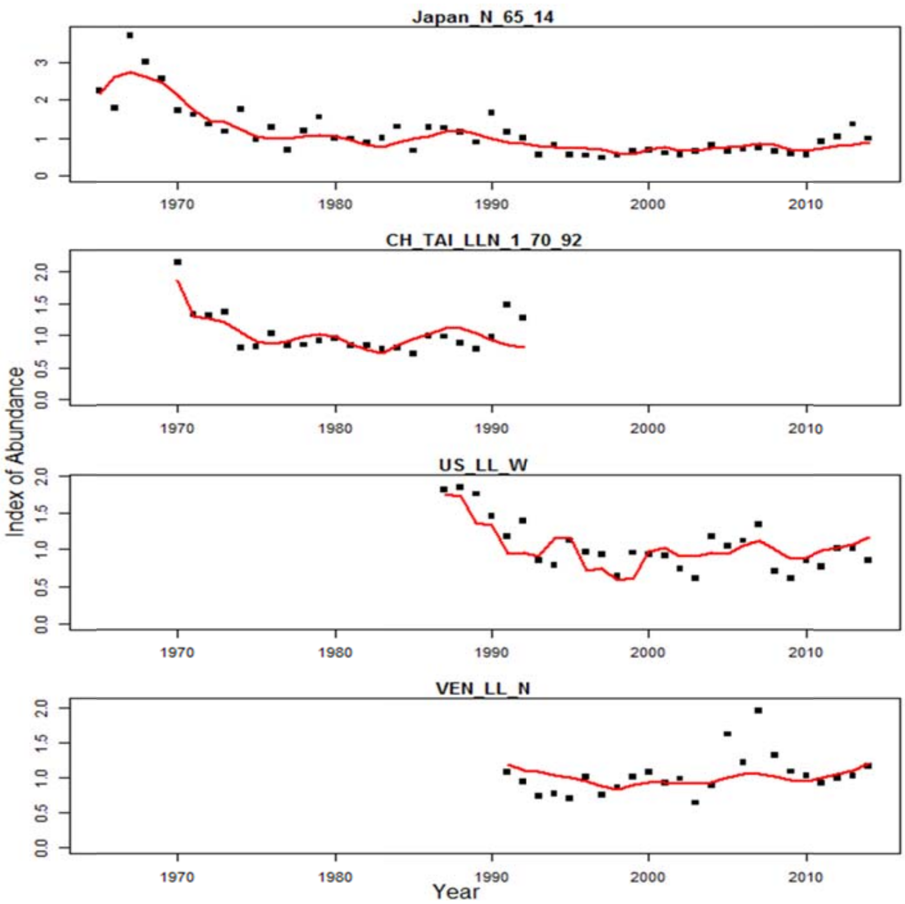

Figure 10. VPA fit to the Cluster 1 sensitivity run indexes of abundance.

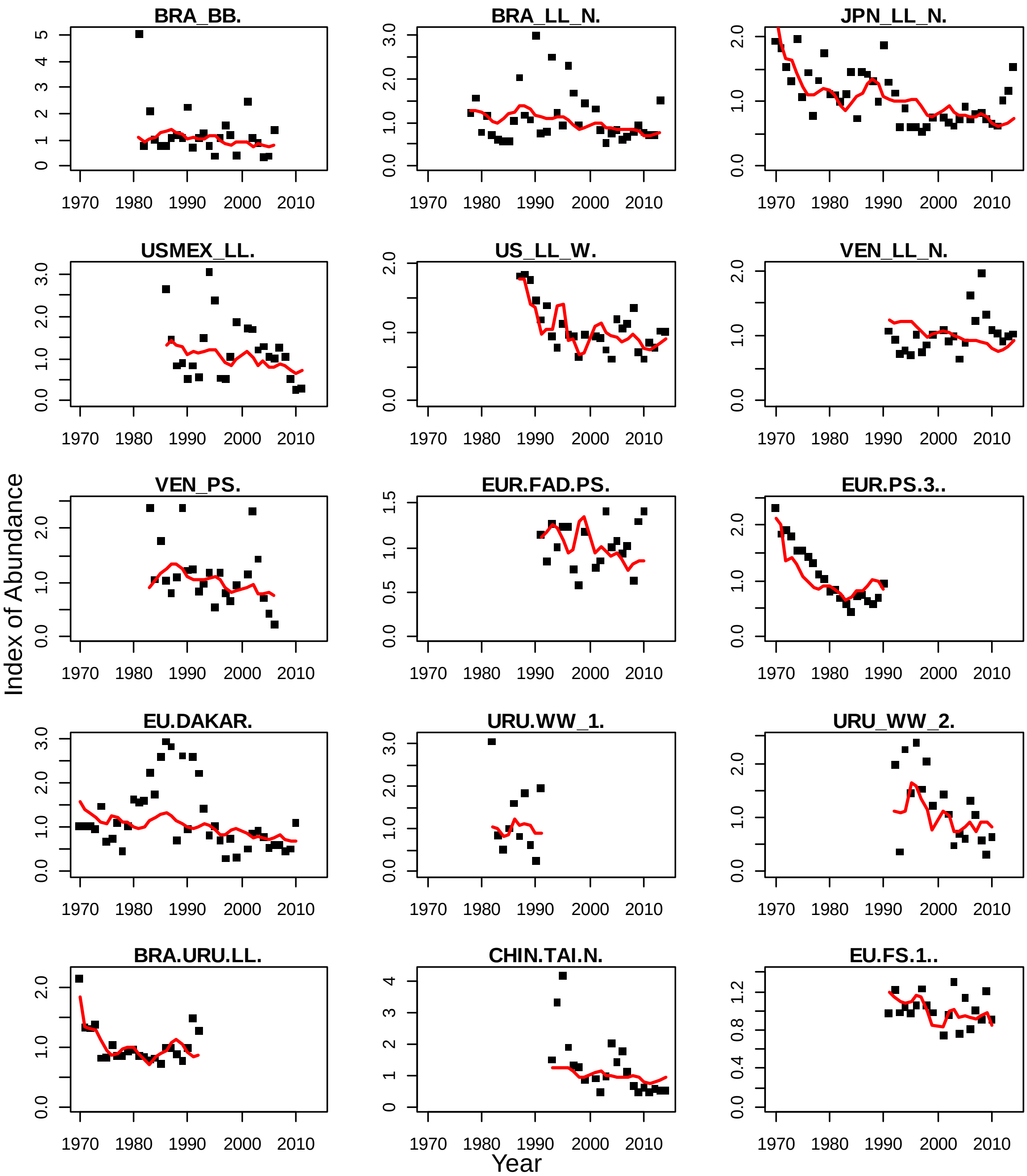

Figure 11. VPA fit to the continuity case indexes of abundance.

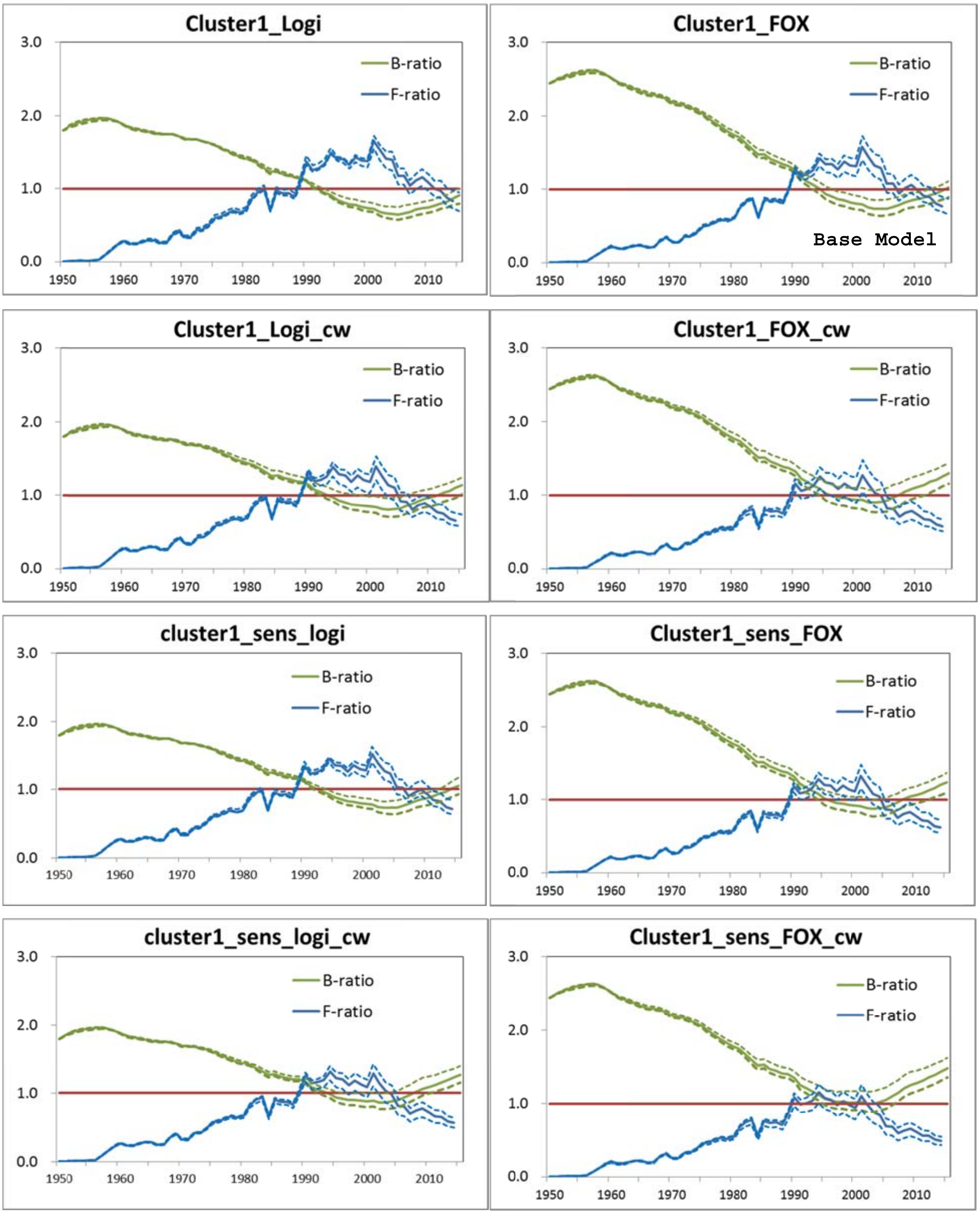

Figure 12. Trajectories of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) with 80% confidence limits (dashed lines) for ASPIC runs. The selected base case was model Cluster1_FOX where the indices were equally weighted (upper right hand panel).

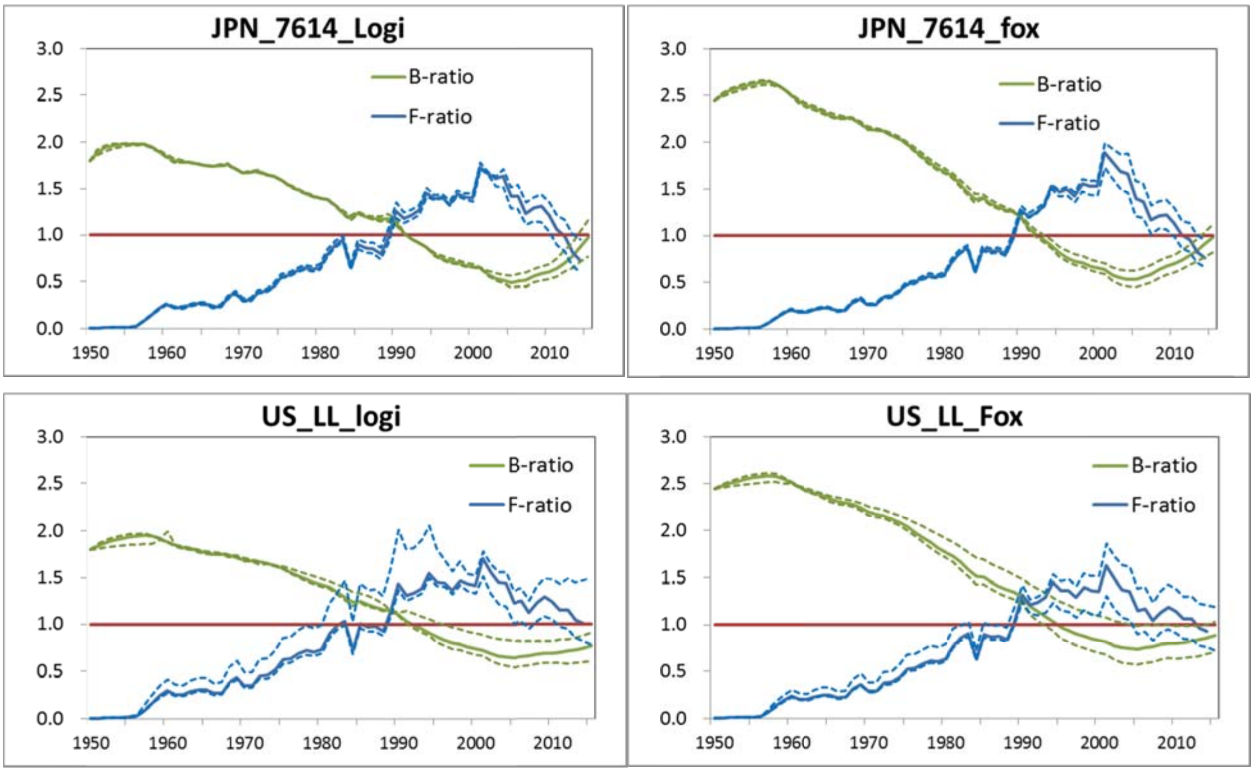

Figure 12 (continued). Trajectories of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) with 80% confidence limits (dashed lines) for ASPIC runs.

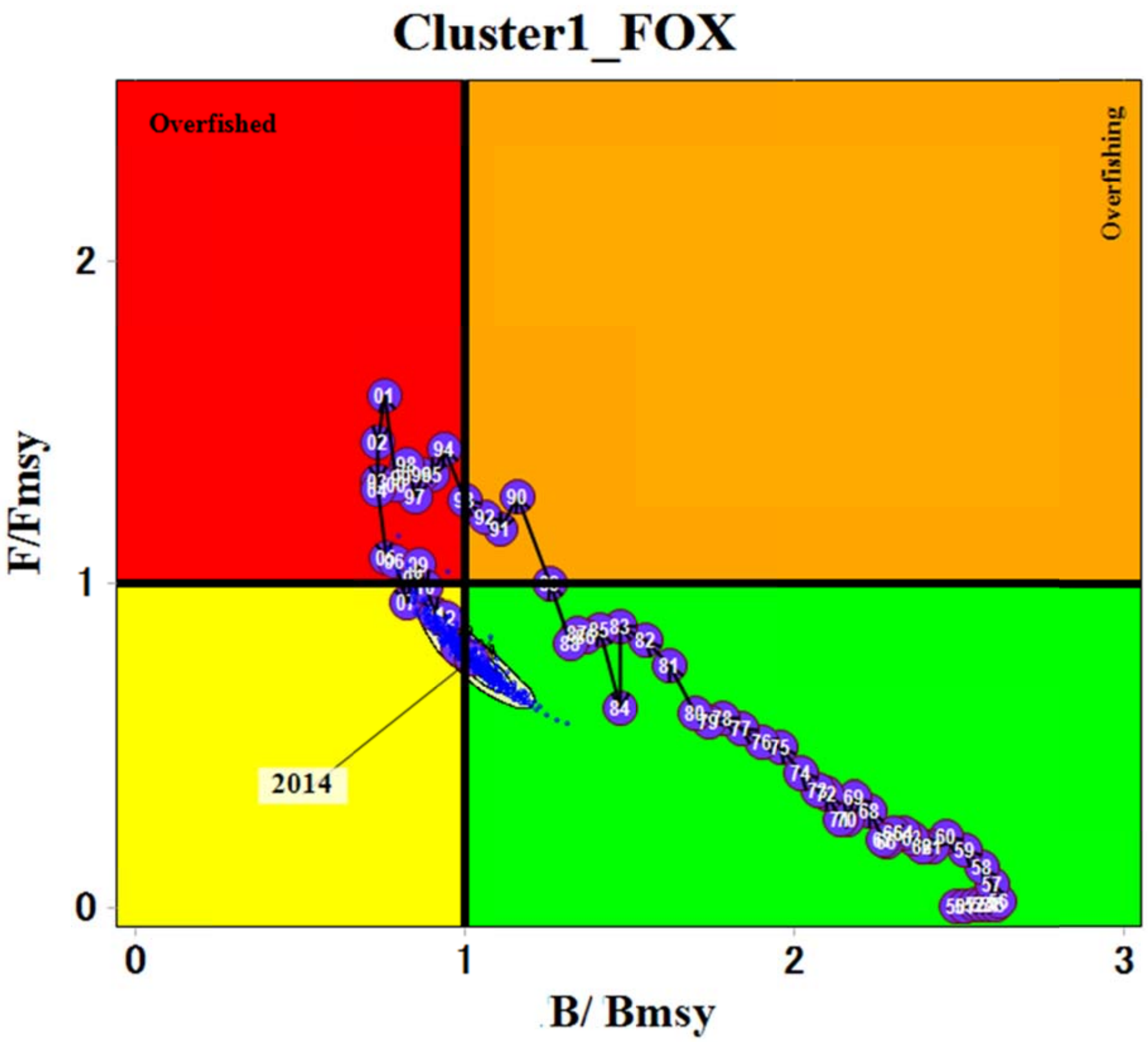

Figure 13. Kobe I plot for ASPIC base model run.

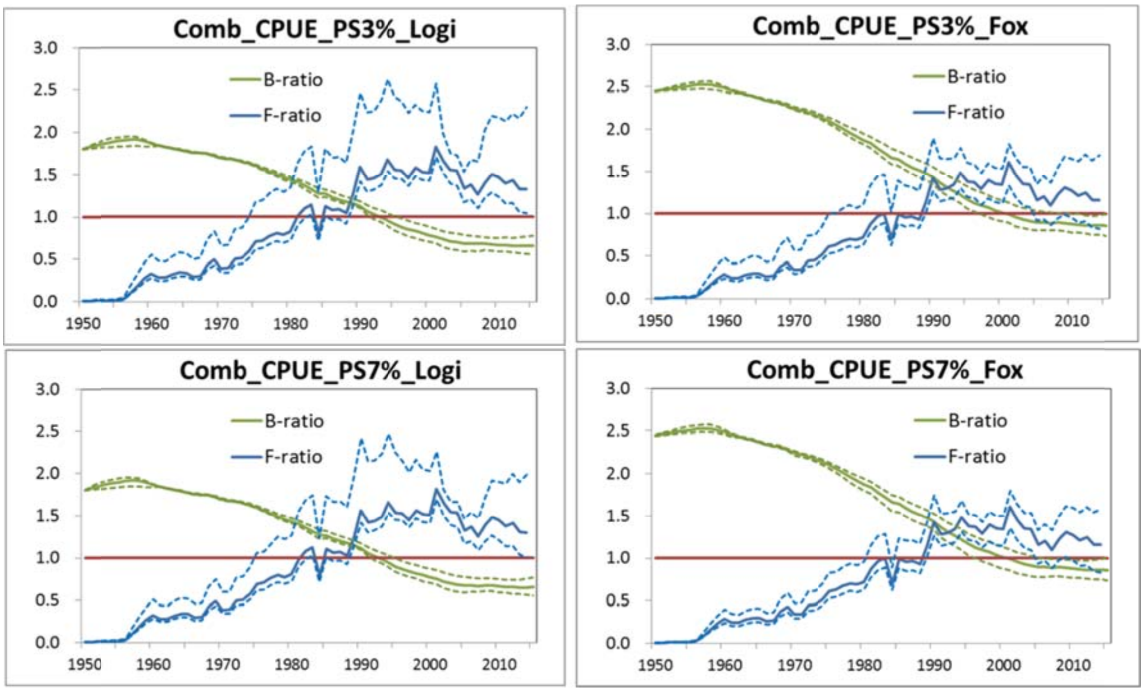

Figure 14. Trajectories of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) with 80% confidence limits (dashed lines) for ASPIC continuity runs.

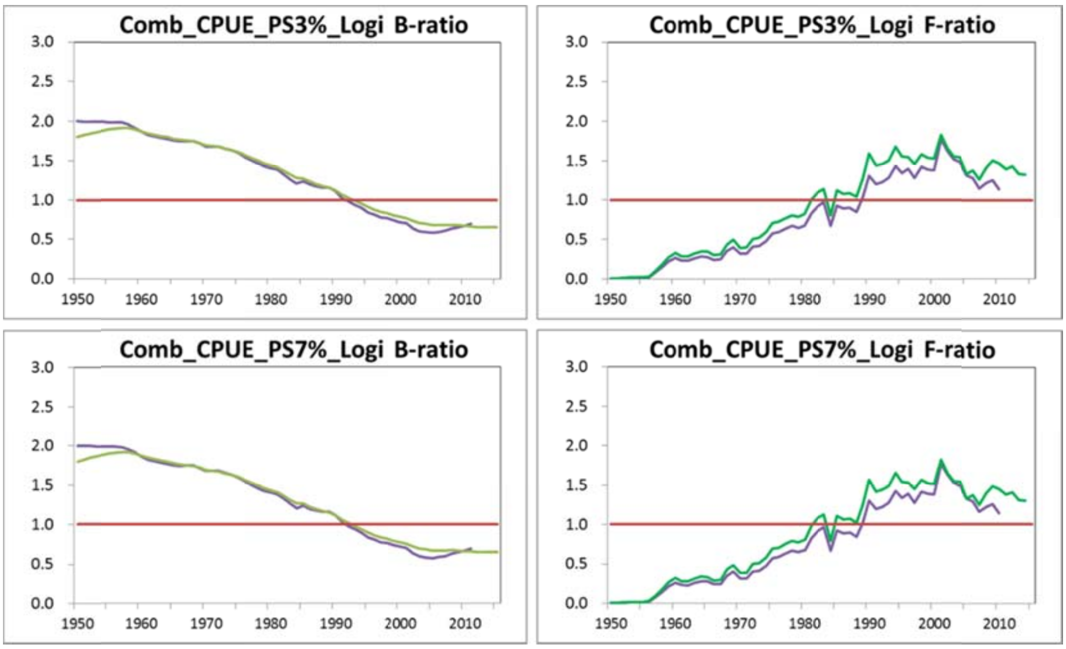

Figure 15. Comparison of ASPIC continuity runs results (B-ratio and F-ratio) with those of the 2011 assessment. Purple: 2011 assessment, green: current assessment.

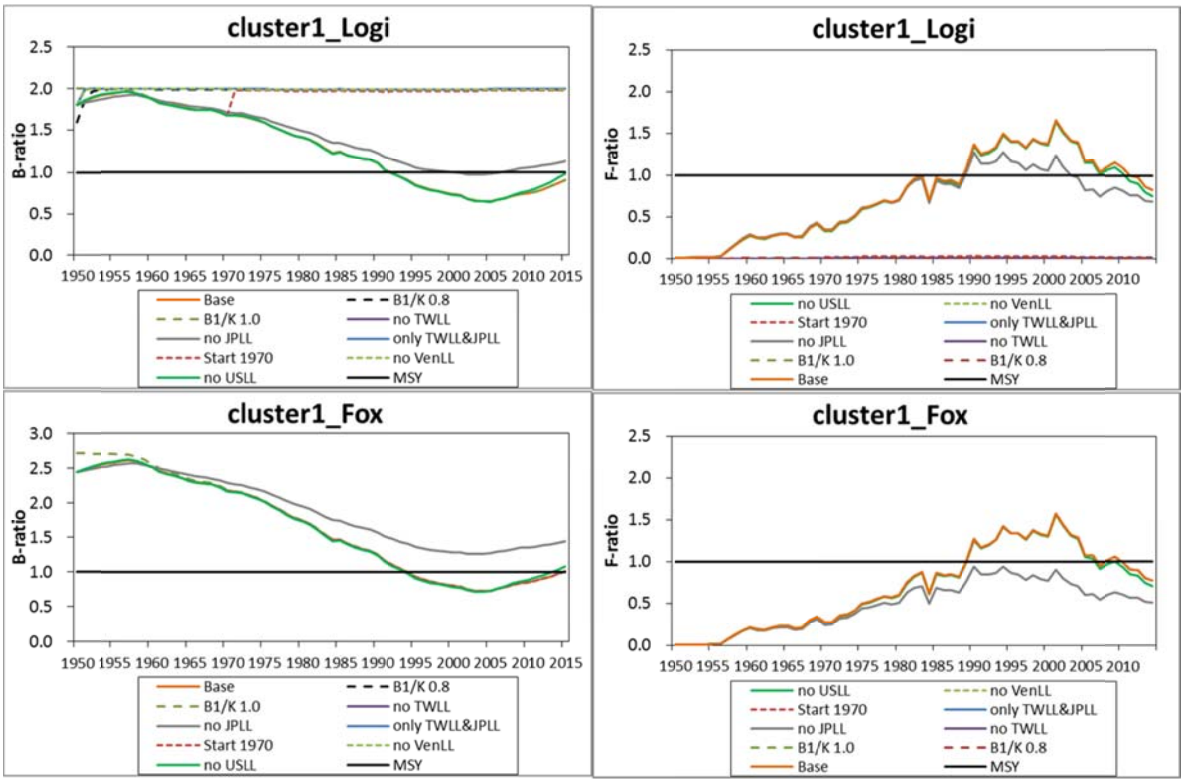

Figure 16. Results of sensitivity analyses for ASPIC model two scenarios for yellowfin tuna.

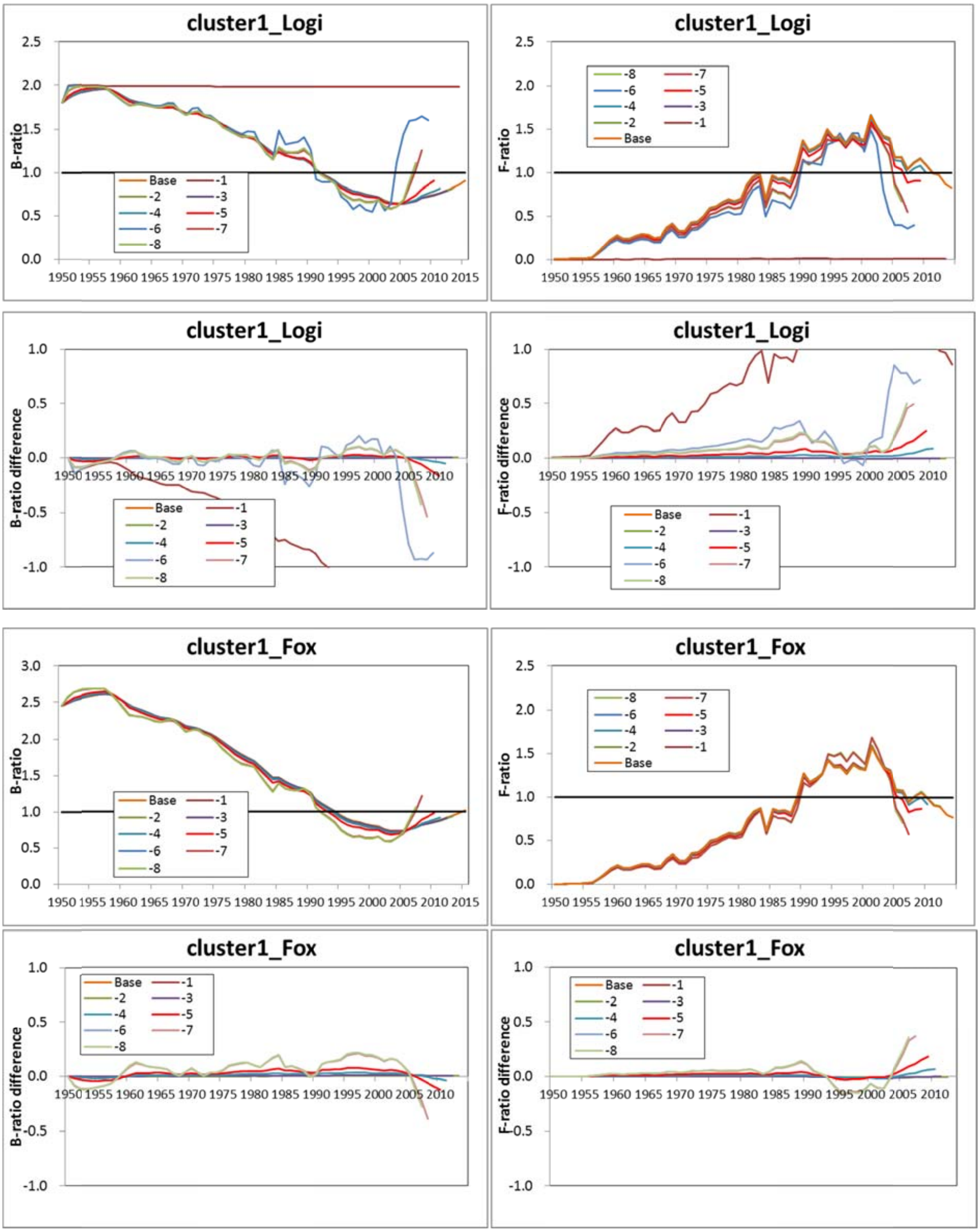

Figure 17. Results of retrospective analyses for ASPIC model for yellowfin tuna.

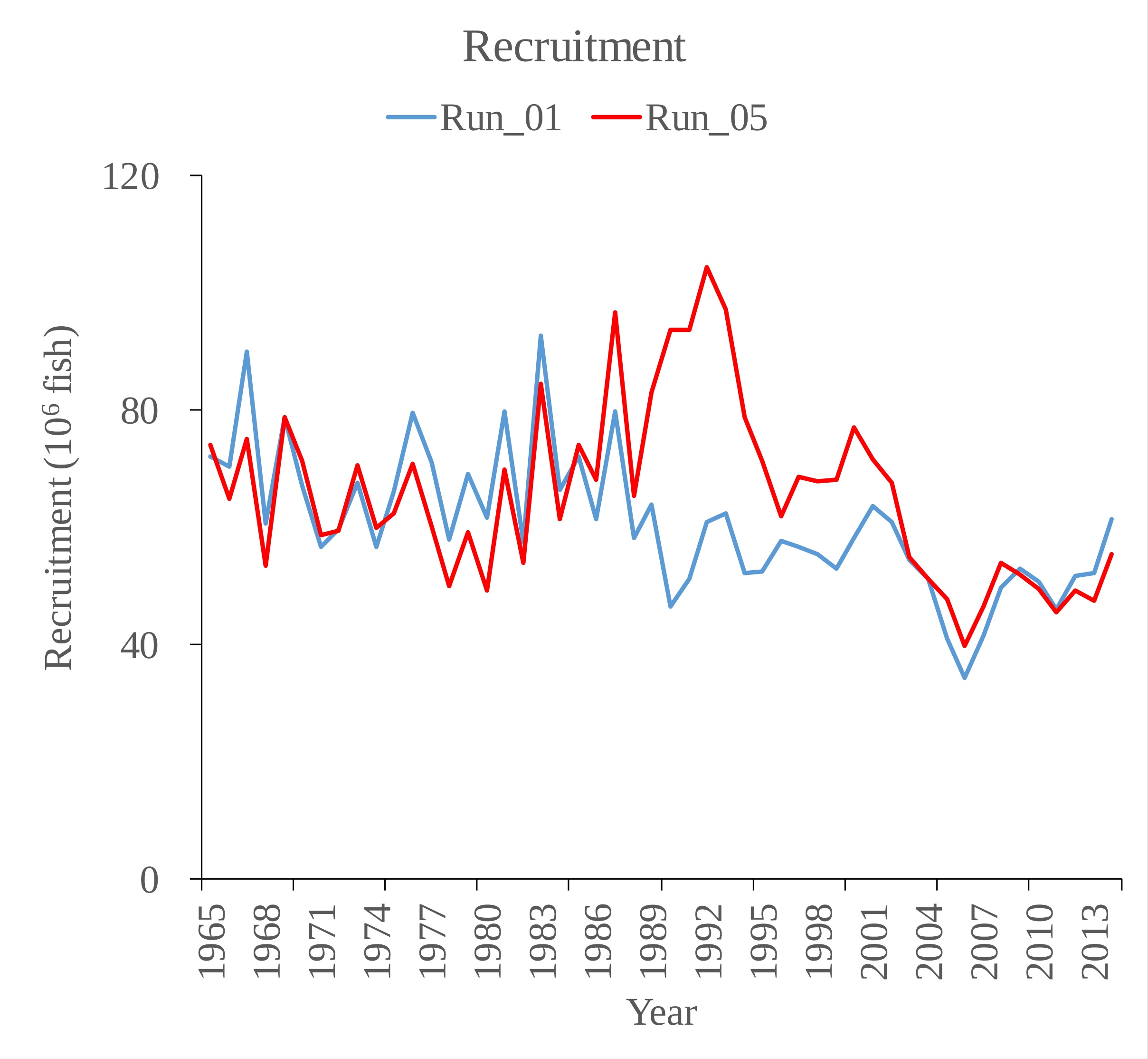

Figure 18. Recruitment for base case models (Run_01 and Run_05) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

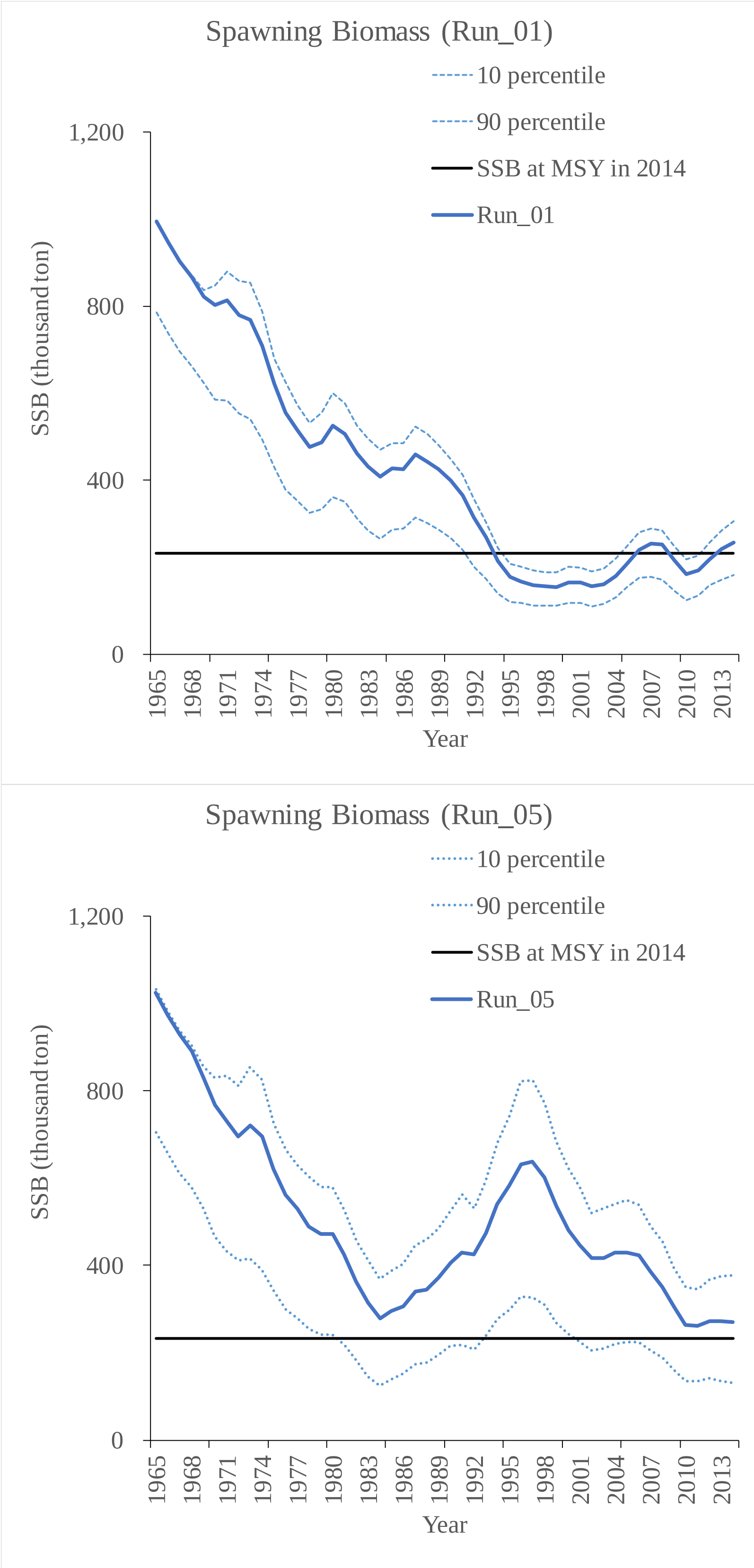

Figure 19. Spawning biomass (solid blue line) with 80 percentile confidence interval (dotted line) from bootstrap analysis (1,000 replicates) for base case models (Run_01 (cluster 1) and Run_05 (cluster2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

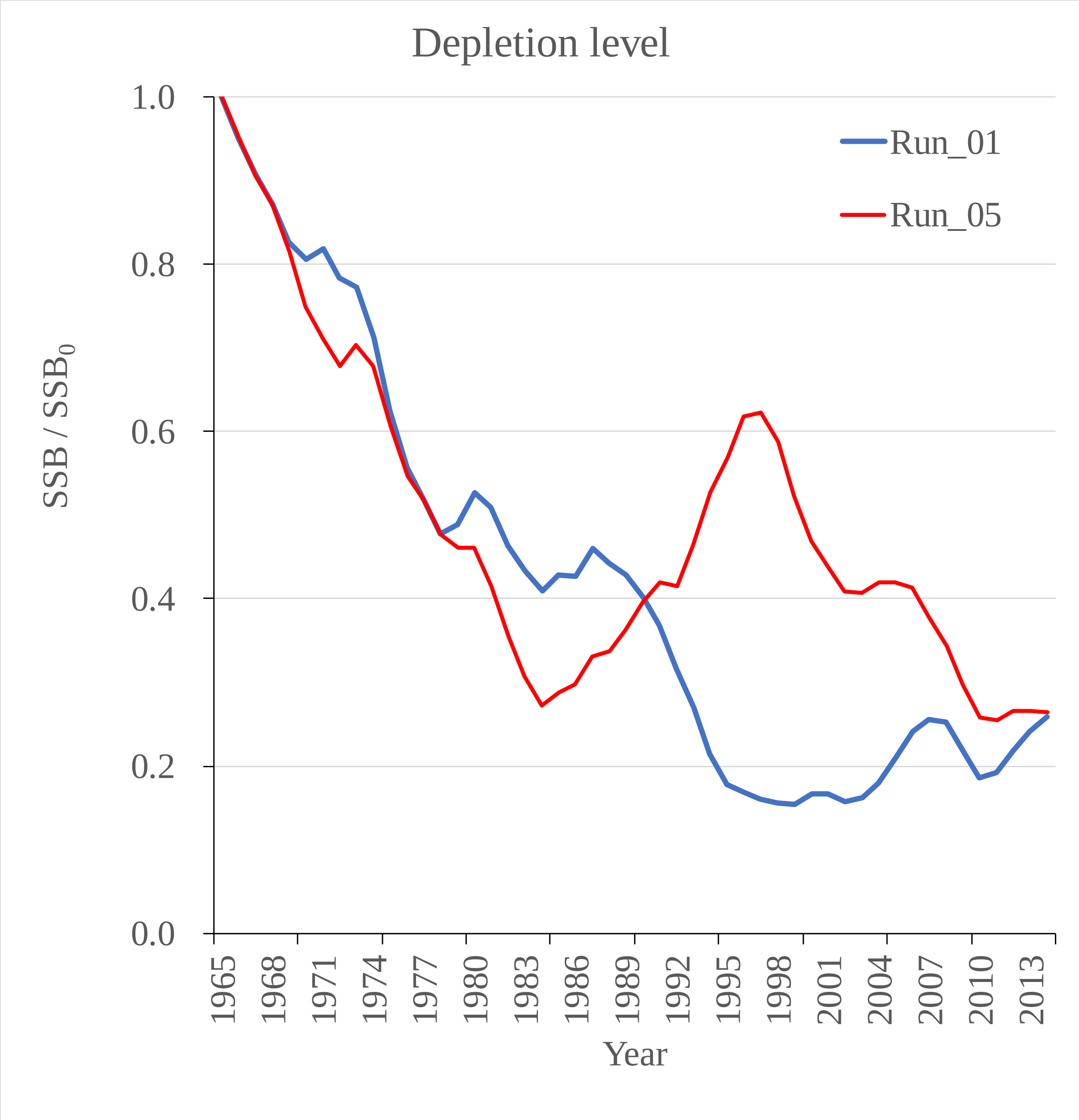

Figure 20. Ratio of exploited to unexploited spawning biomass for base case models (Run_01(cluster 1) and Run_05(cluster 2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

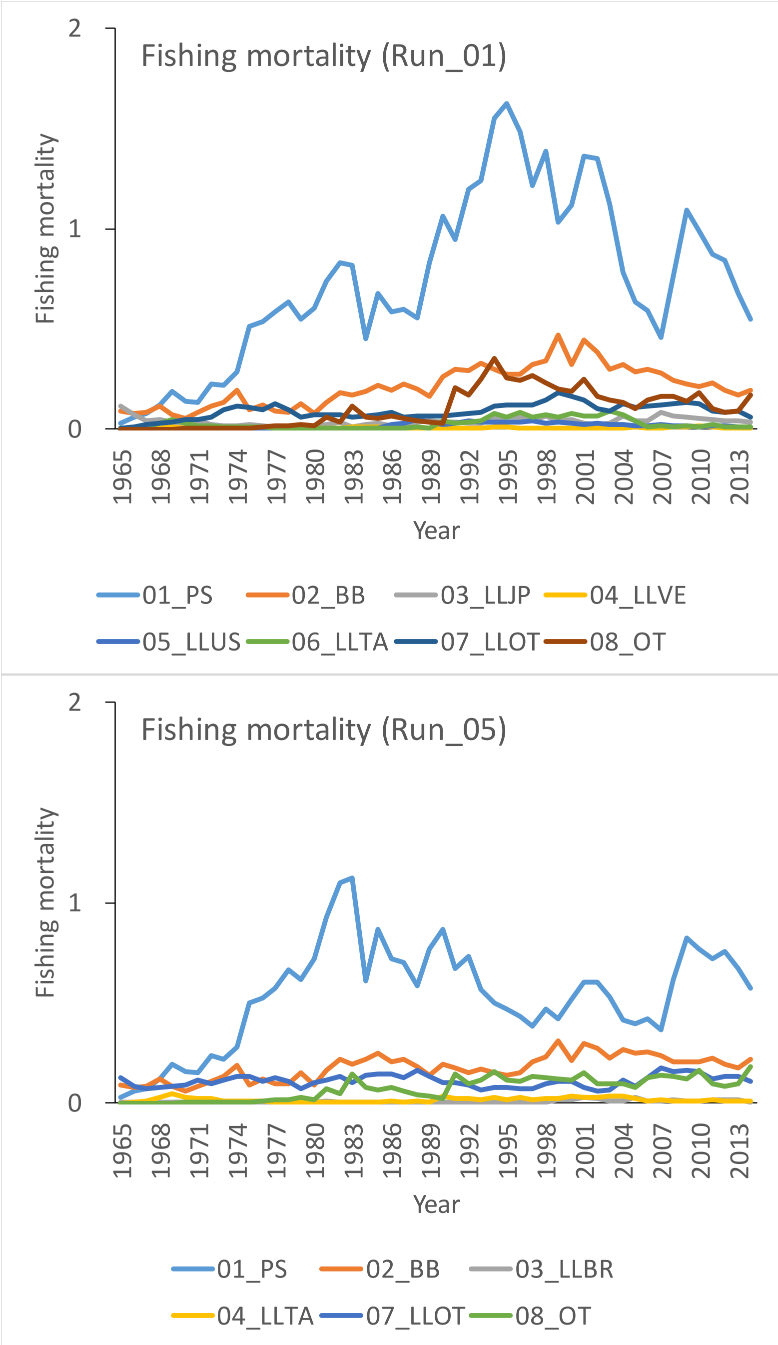

Figure 21. Fishing mortality by fleet for base case models (Run_01 (cluster 1) and Run_05 (cluster2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

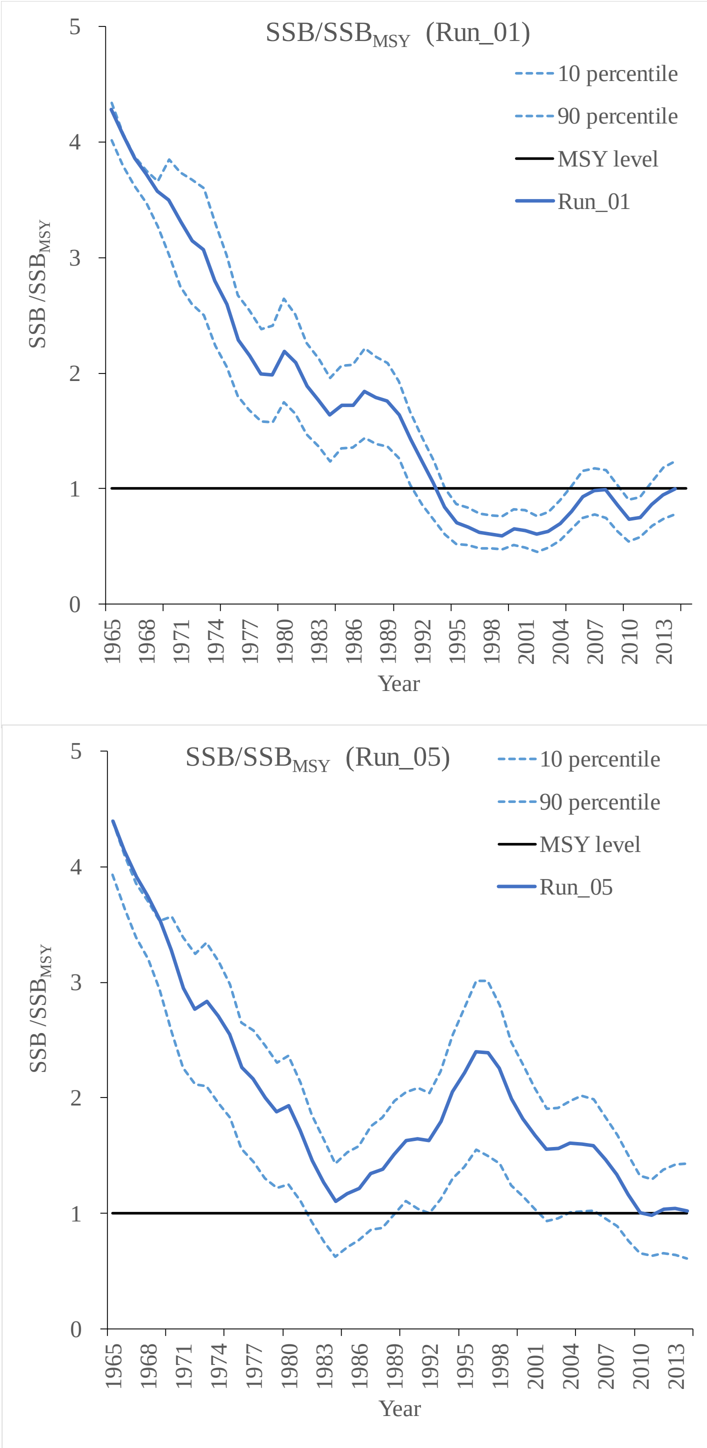

Figure 22. SSB/SSB$_{MSY}$ (solid blue line) with 80 percentile confidence interval (dotted line) from bootstrap analysis (1,000 replicates) for base case models (Run_01 (cluster1) and Run_05 (cluster 2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

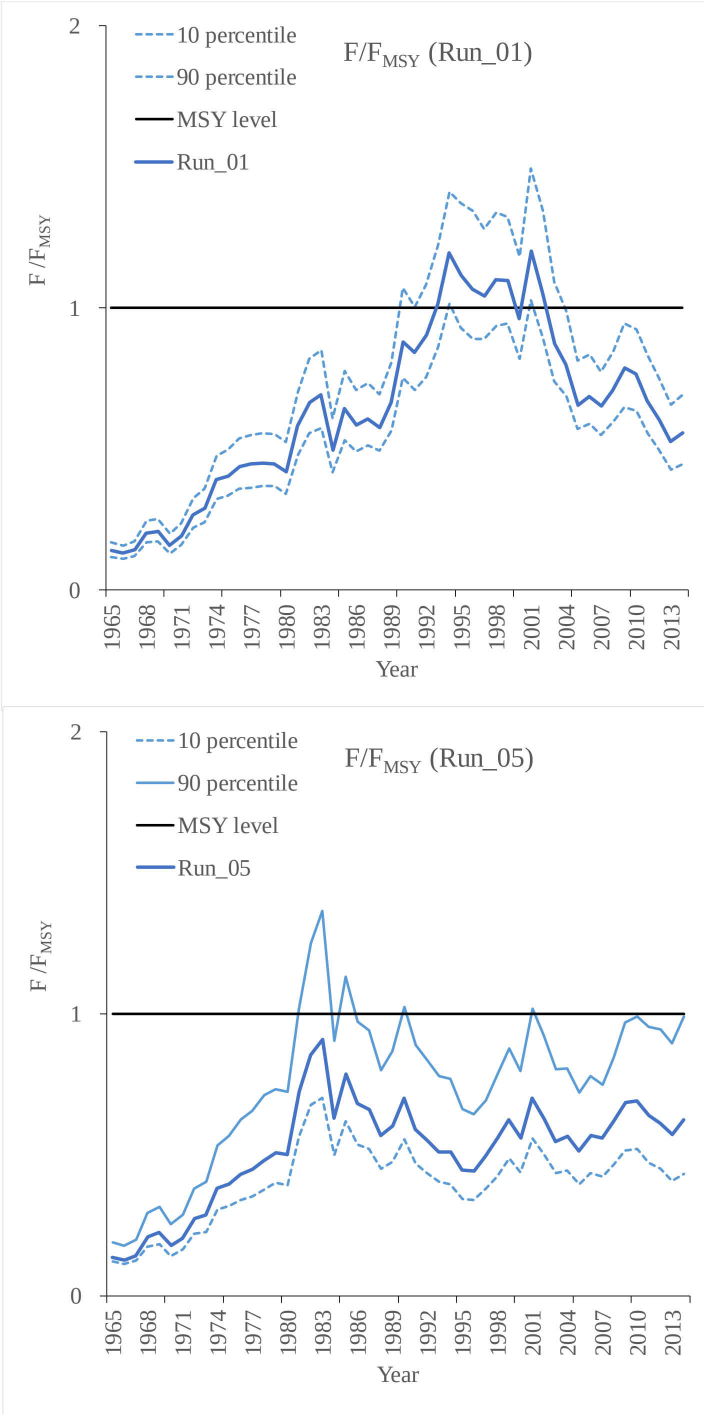

Figure 23. F/F_{MSY} (solid blue line) with 80 percentile confidence interval (dotted line) from bootstrap analysis (1,000 replicates) for base case models [Run_01 (cluster 1) and Run_05 (cluster 2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

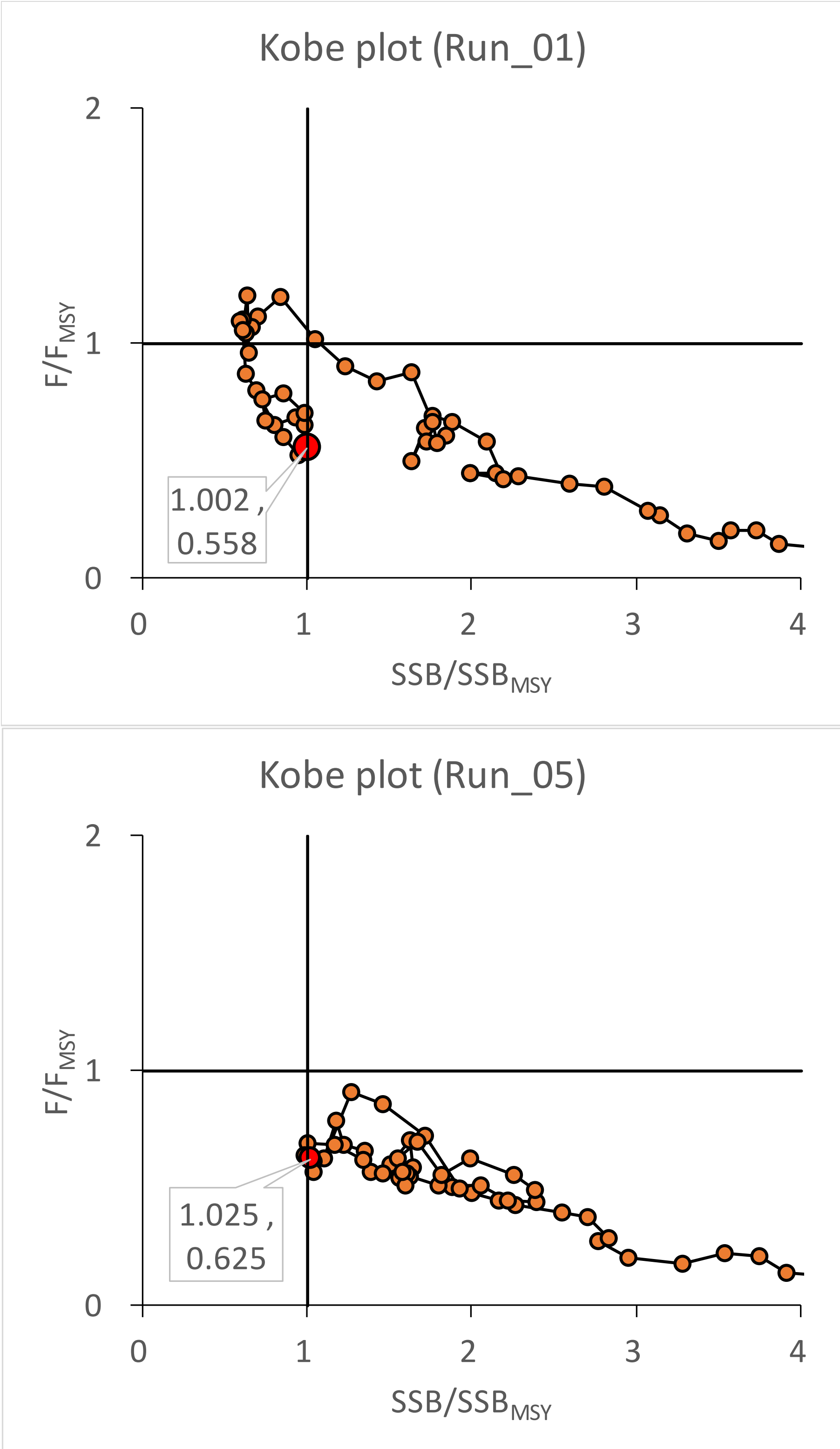

Figure 24. SSB/SSB_{MSY} and F/F_{MSY} trajectories for base case models (Run_01 (cluster1) and Run_05 (cluster 2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The large red dot indicates stock status in 2014.

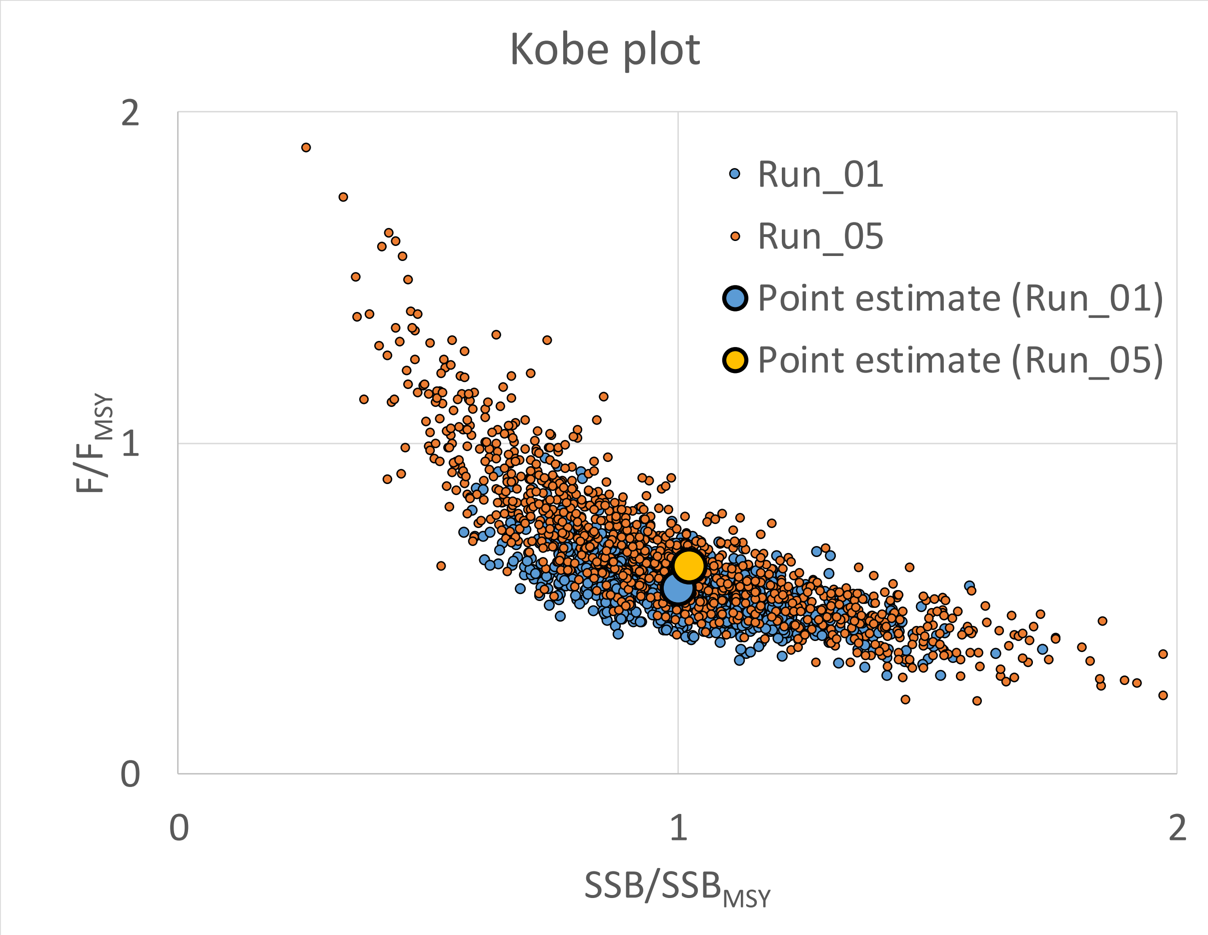

Figure 25. Distributions of SSB/SSB_{MSY} and F/F_{MSY} in 2014 from bootstrap examinations (1,000 replicates) for base case models [Run_01(cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The large blue and yellow dots indicate point estimates in 2014 of ASPM analysis for both base case models.

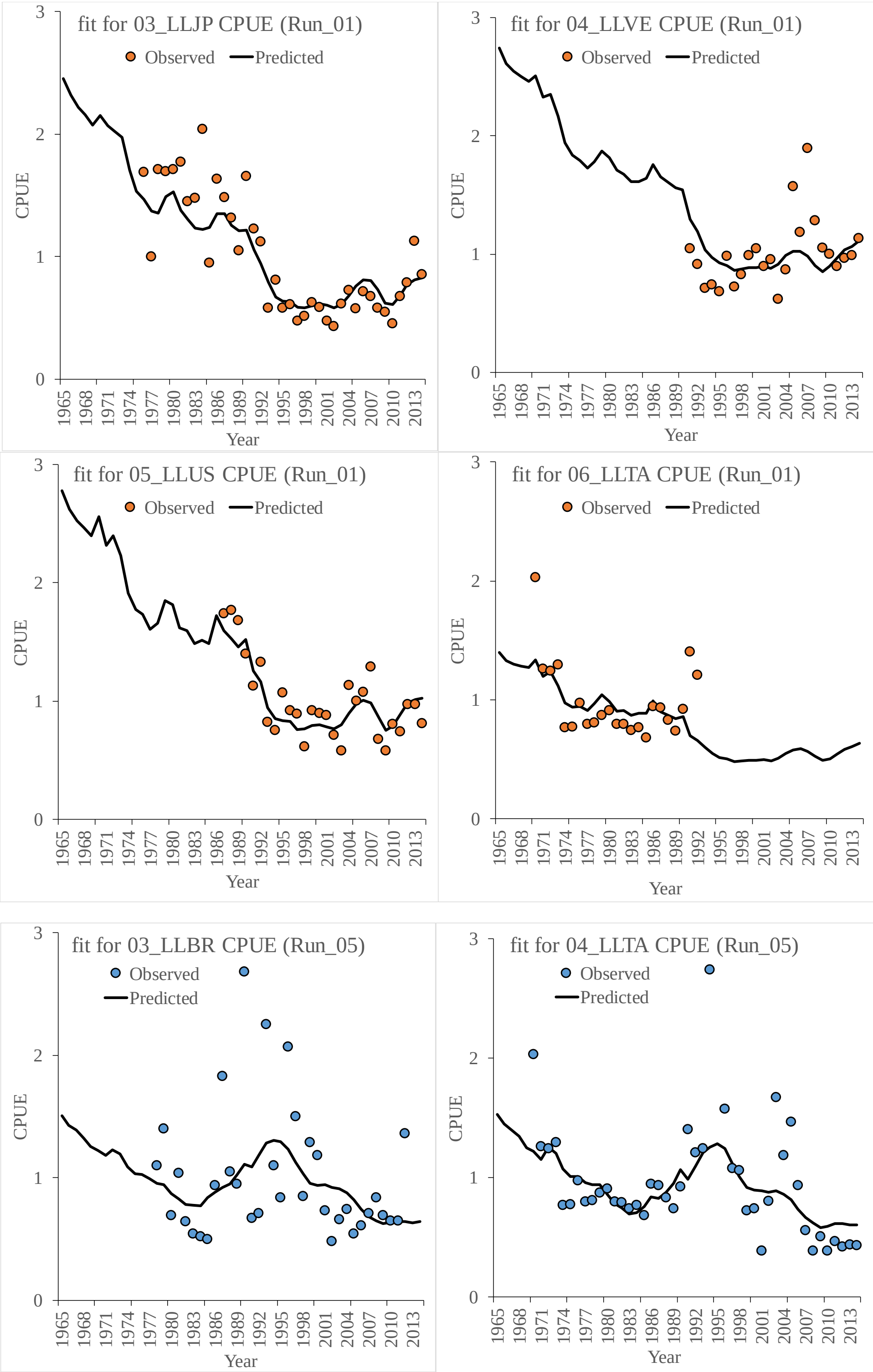

Figure 26. Model fit (black line) to the standardized CPUEs (red and blue circle) of the base case models (Run_01(cluster1) and Run_05(cluster2)) of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

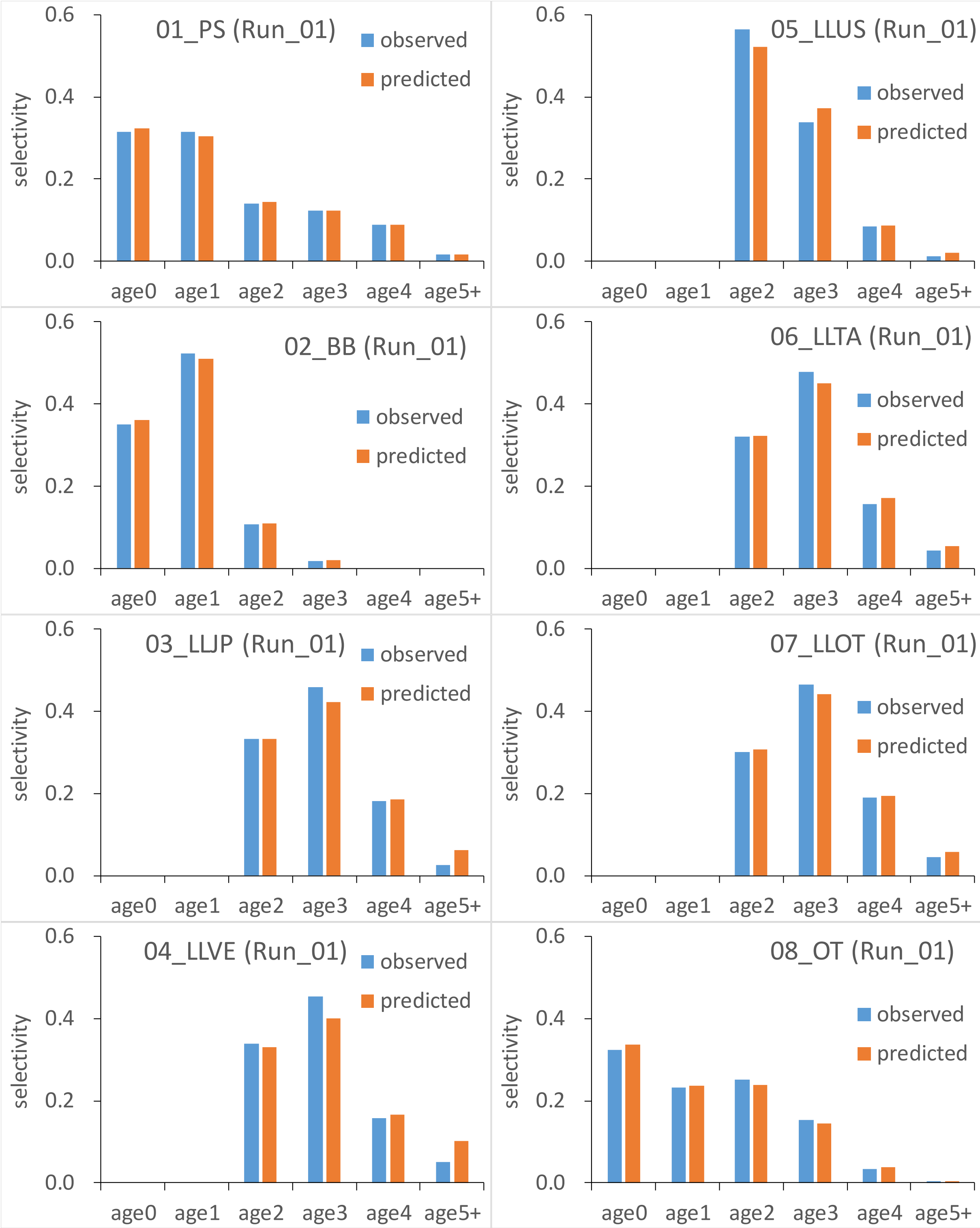

Figure 27. Model fit (orange bar) to the overall catch-at-age (blue bar) by fleet of the base case models [Run_01 (cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

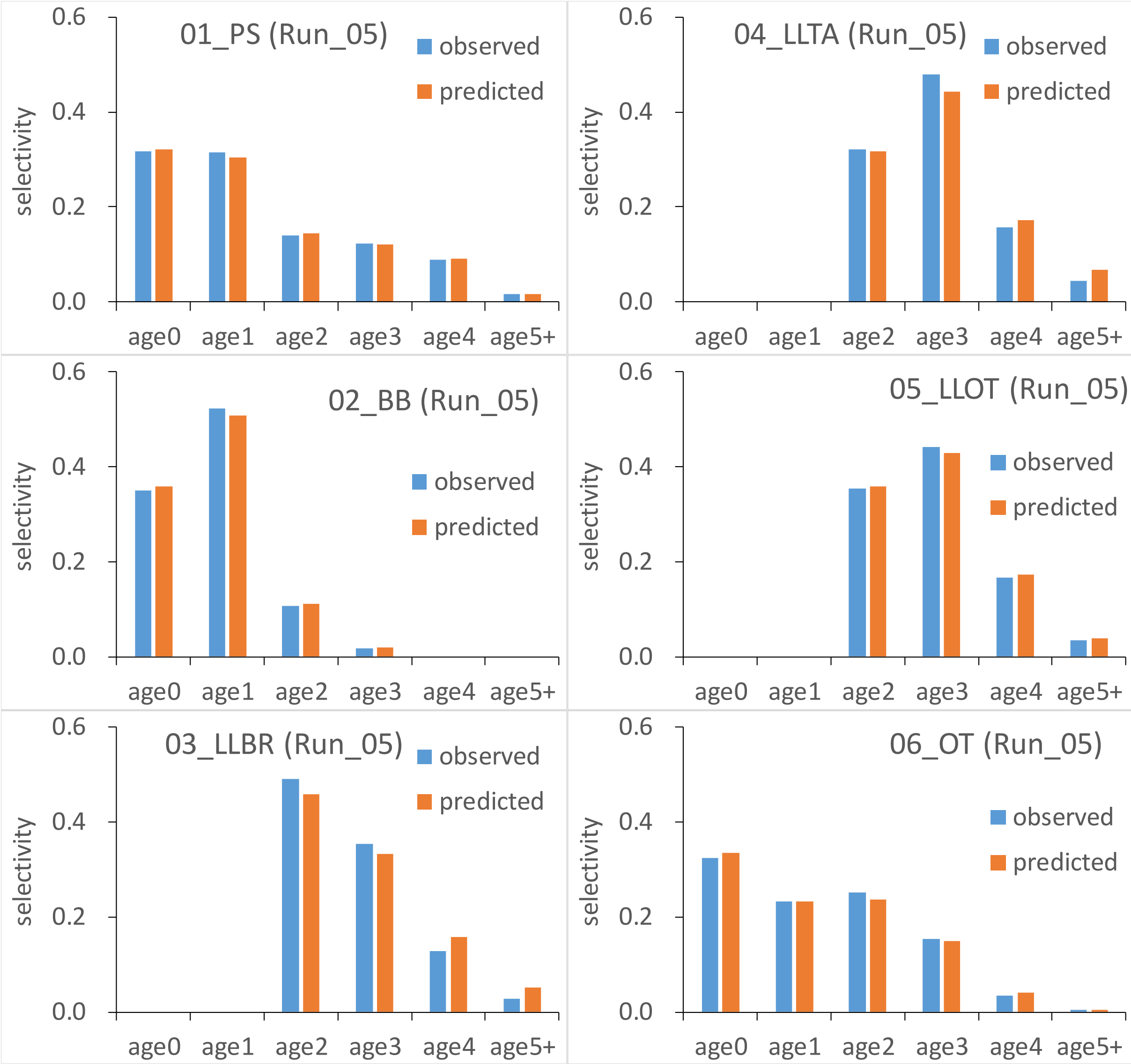

Figure 27 (continued). Model fit (orange bar) to the overall catch-at-age (blue bar) by fleet of the base case models [Run_01 (cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

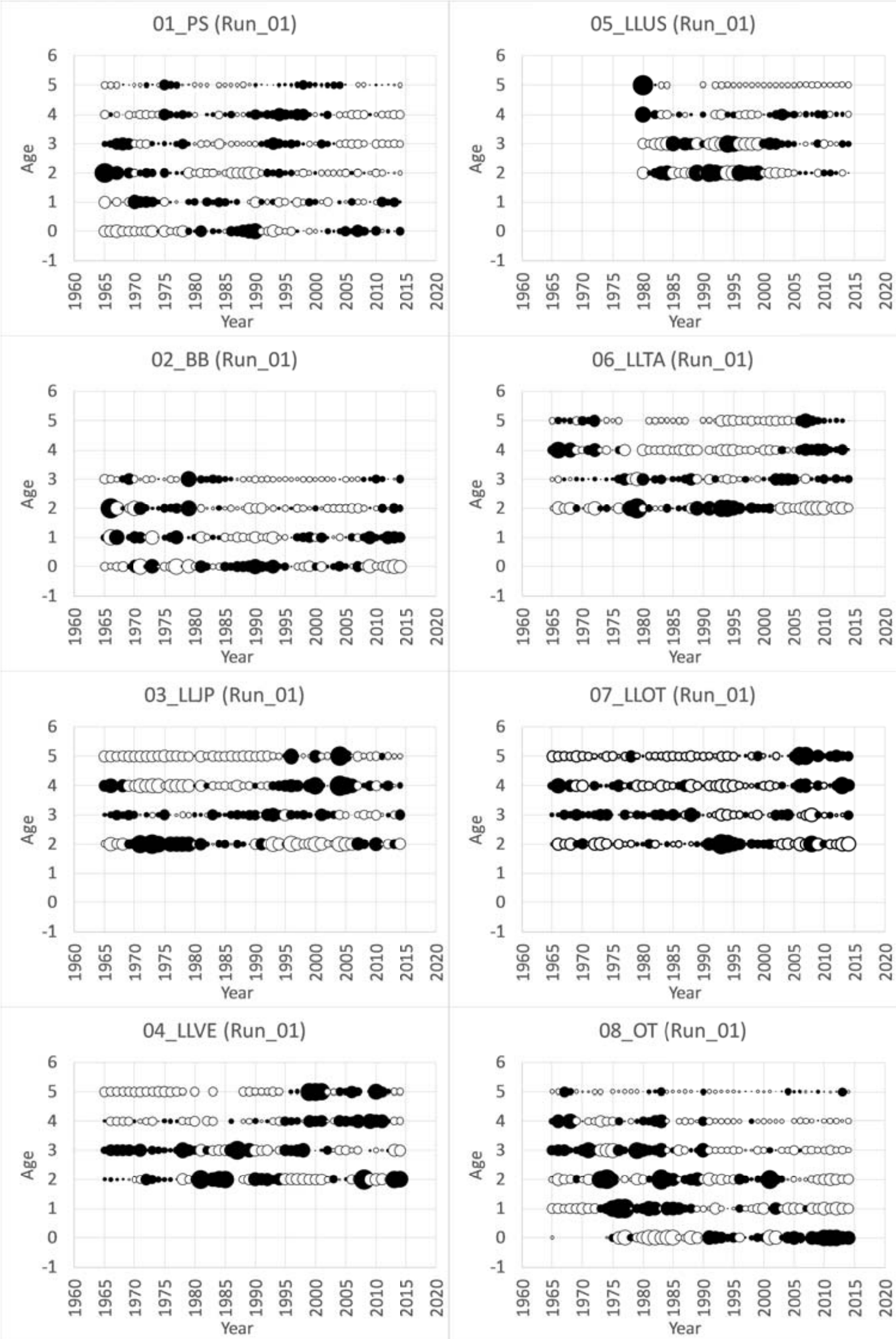

Figure 28. Historical residual pattern for catch-at-age by fleet of the base case models [Run_01(cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The positive residuals were showed as black circle (observations larger than model predictions).

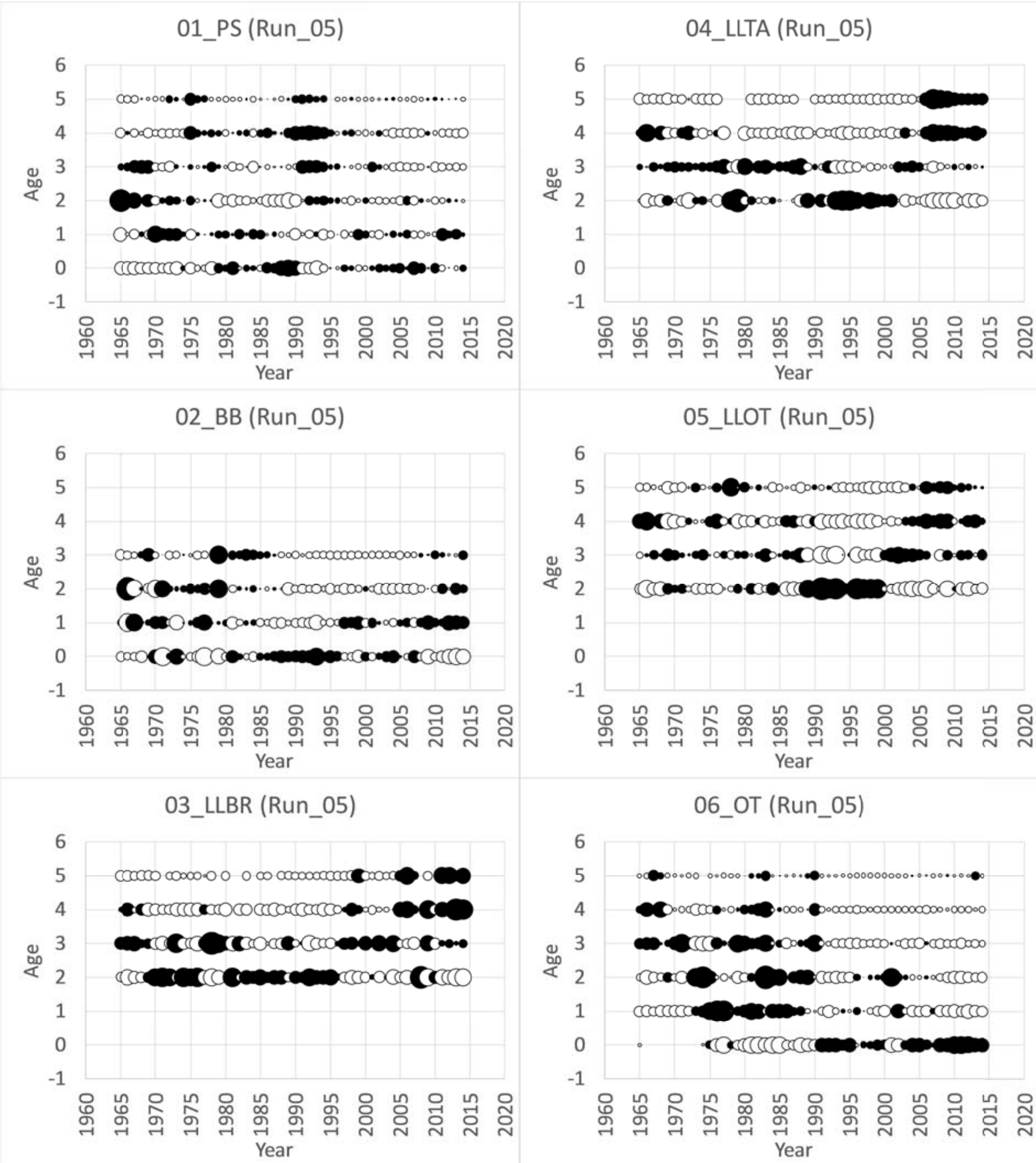

Figure 28 (continued). Historical residual pattern for catch-at-age by fleet of the base case models [Run_01(cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The positive residuals were showed as black circle (observations larger than model predictions).

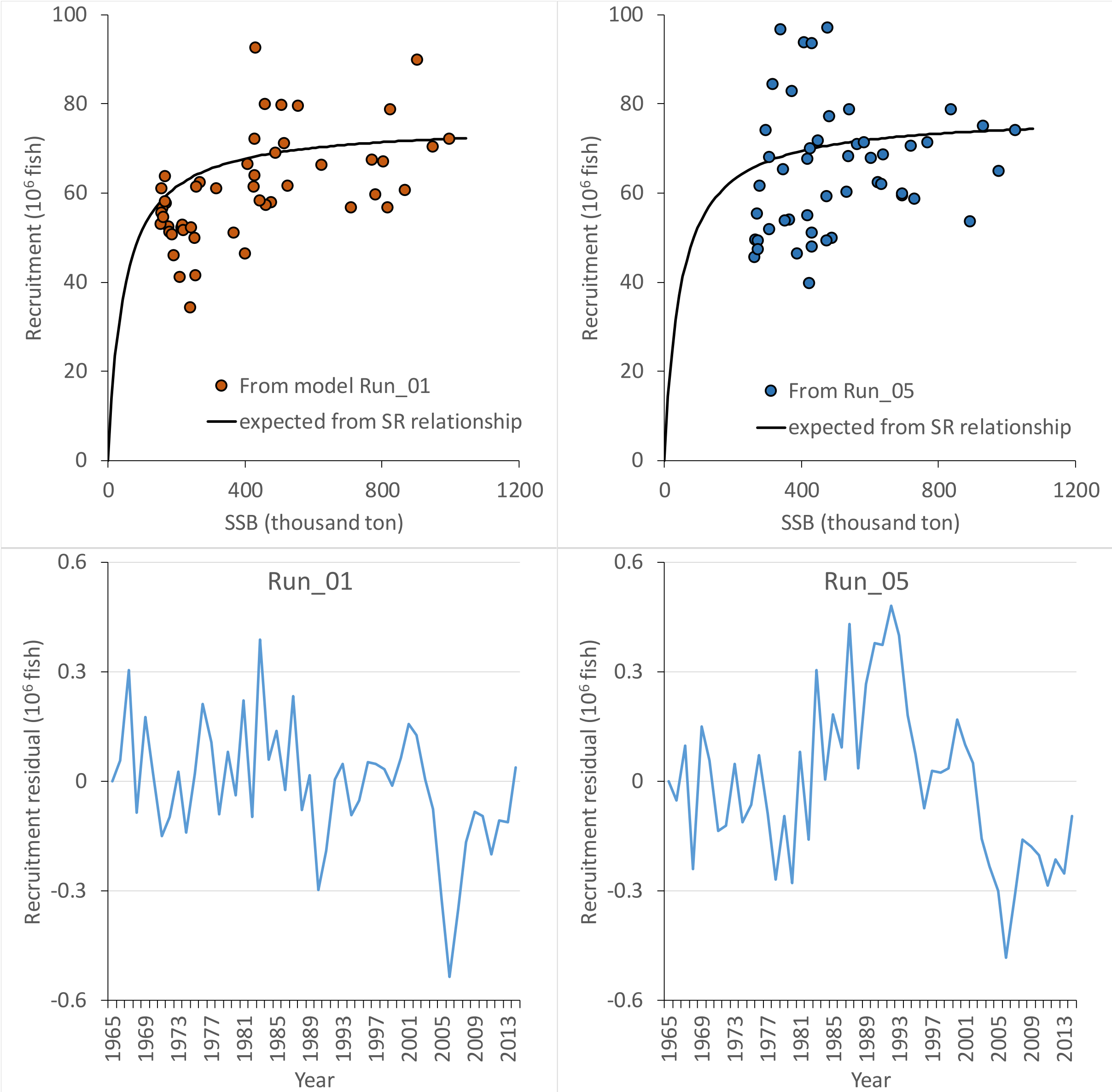

Figure 29. Stock and recruitment relationship (upper two panels) and historical recruitment residual (lower two panels) of the base case models [Run_01(cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. In the upper panels the solid black line means expected curve of Beverton-Holt stock and recruitment formulation, the red and blue circle mean point estimate from model.

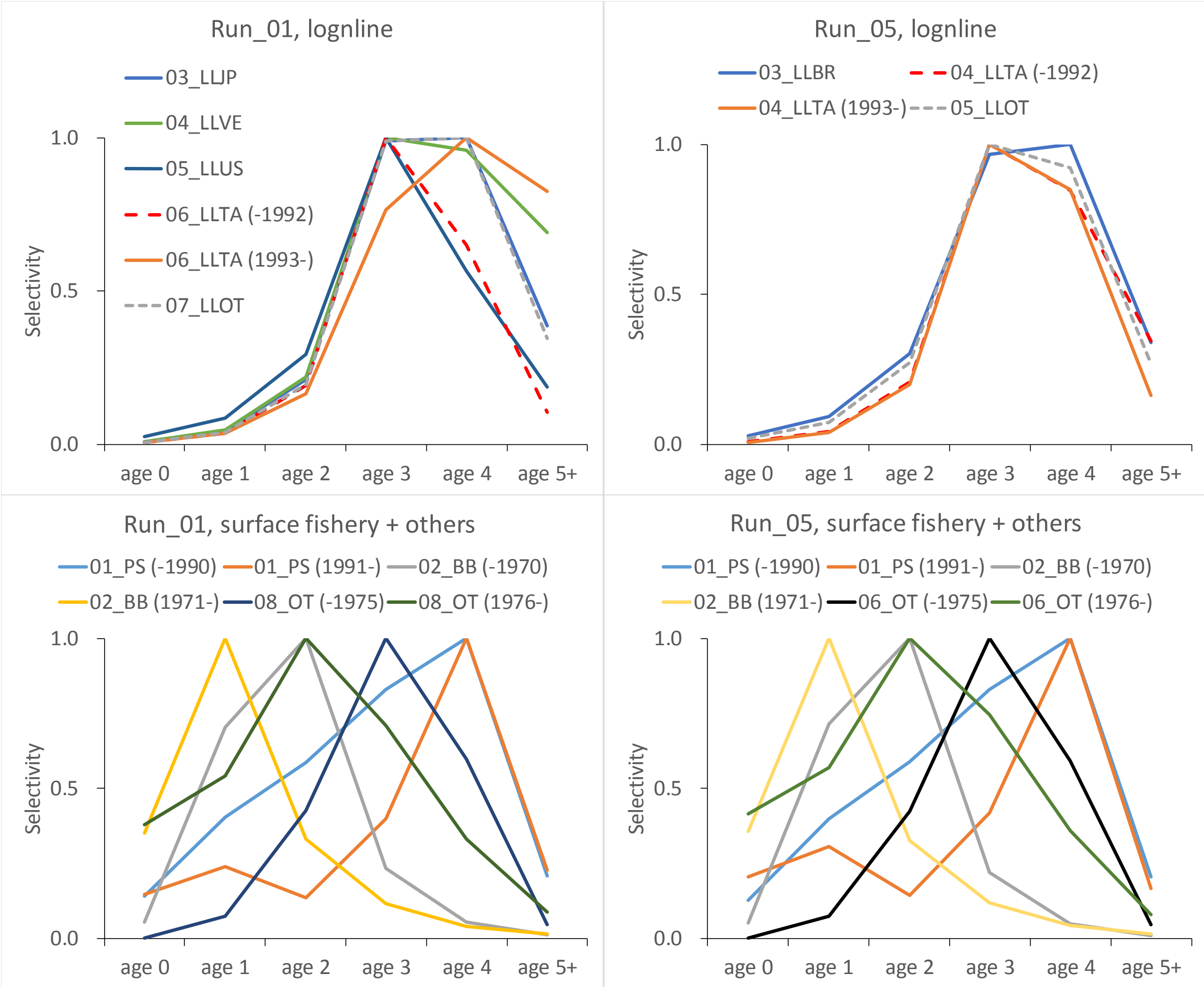

Figure 30. Selectivity curves by fleet estimated by the base case models [Run_01 (cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

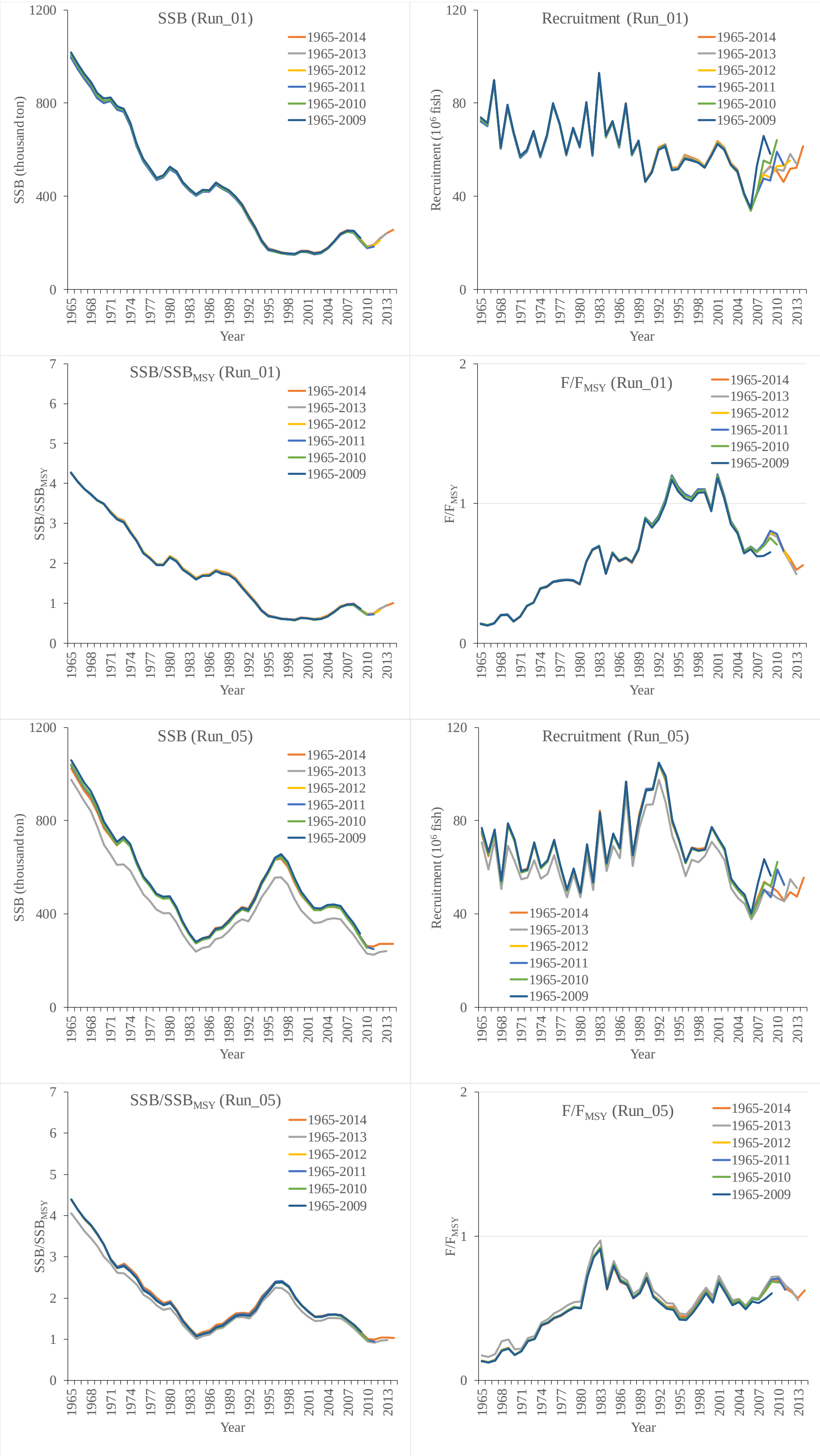

Figure 31. Retrospective patterns for SSB, recruitment, SSB/SSBMSY, F/FMSY of the base case models [Run_01 (cluster1) and Run_05 (cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

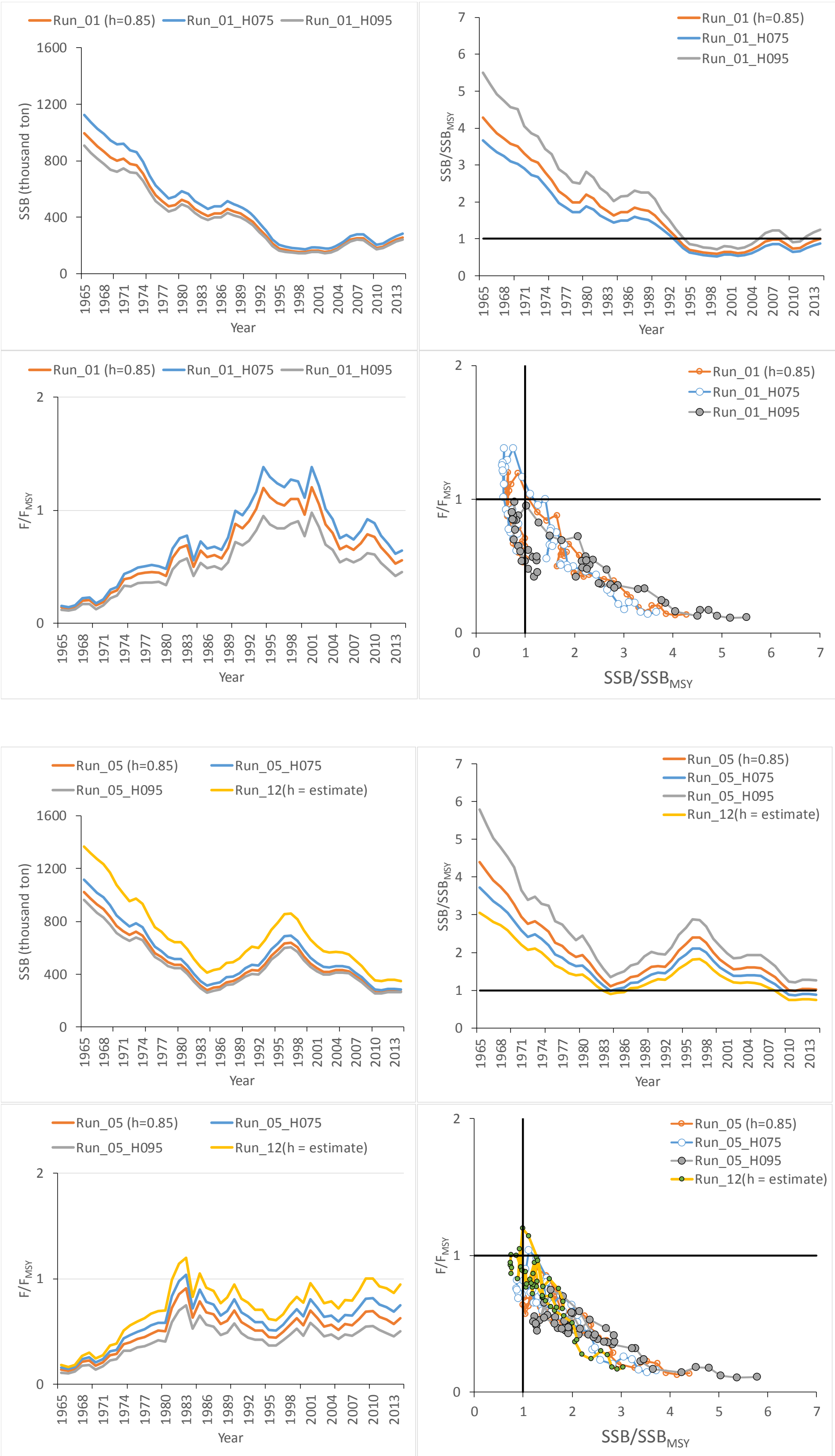

Figure 32. Sensitivity analysis on steepness for SSB, recruitment, SSB/SSB$_{MSY}$, F/F$_{MSY}$ of the base case models [Run_01 (cluster1) and Run_05 (cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

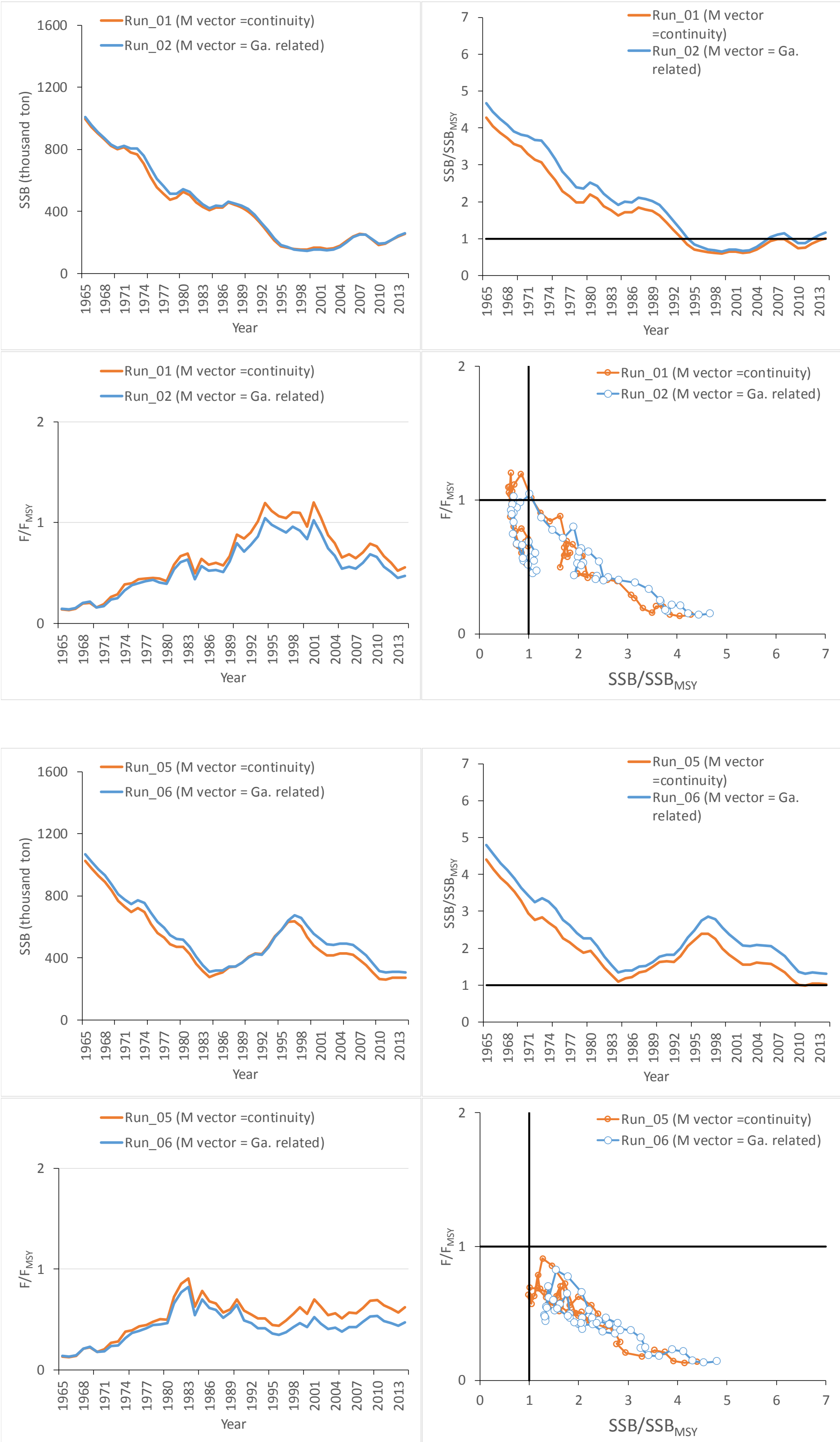

Figure 33. Sensitivity analysis on natural mortality (M) vector for SSB, recruitment, SSB/SSBMSY, F/FMSY of the base case models [Run_01 (cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

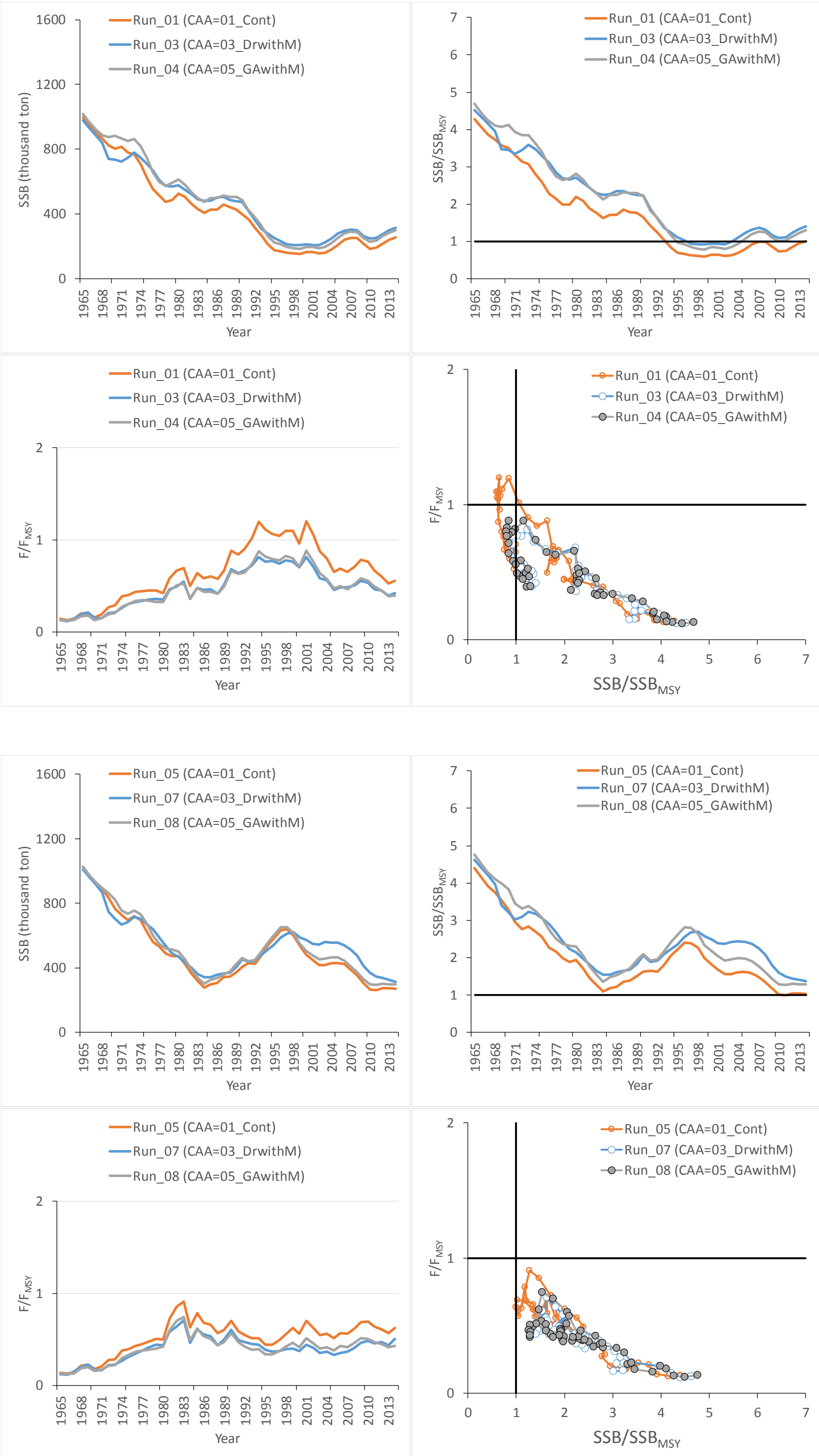

Figure 34. Sensitivity analysis on type of catch-at-age (CAA) for SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} of the base case models [Run_01(cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The types of CAA are explained as follows; 01_Cont: same formulation as 2011 meeting using Gascuel 2-stanza growth model without M vector in ageing, 03_DrwithM: Draganik von Bertalanffy growth model including M vector, 05_GawithM: Gascuel 2-stanza growth model including M vector.

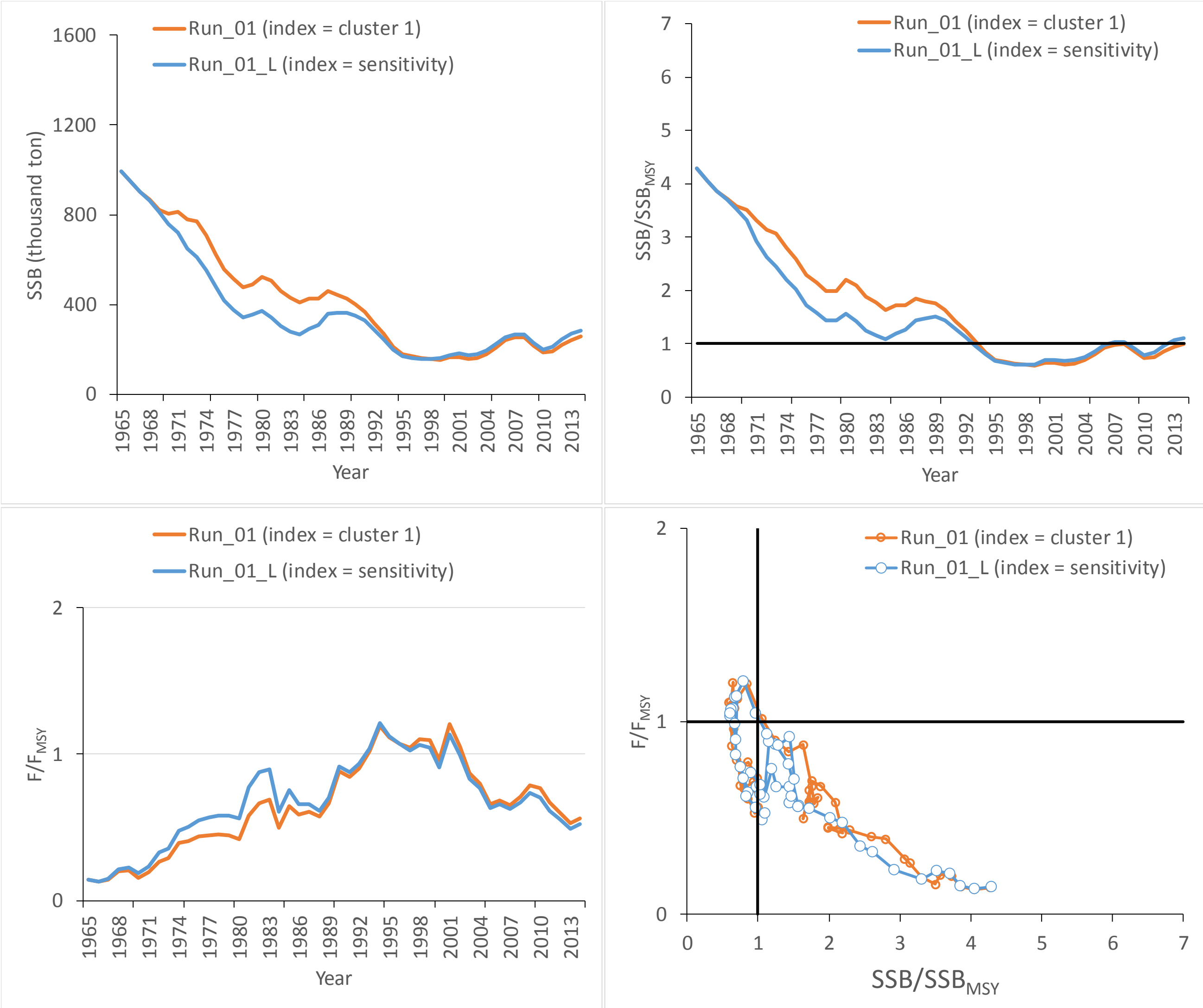

Figure 35. Sensitivity of trends in SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} to the initial year of the Japanese longline index. The comparison was made using ASPM Run_01, Cluster 1. The base model used the Japanese index developed for the period 1976-2014 (orange). The sensitivity run (blue) used a version of the Japanese longline index with a longer period (1965-2014).

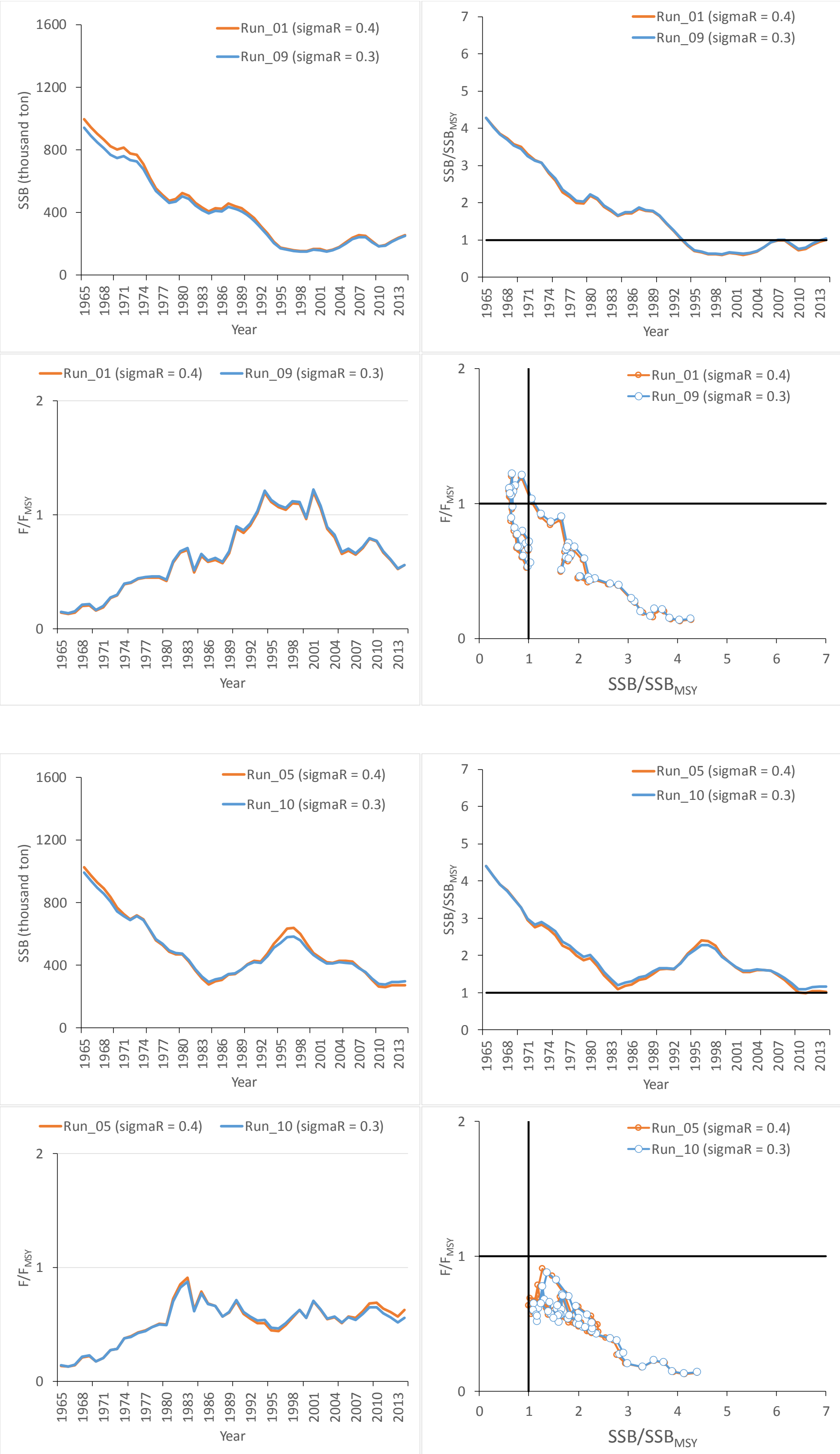

Figure 36. Sensitivity analysis on sigmaR (standard deviation for the stock recruitment fluctuations) for SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} of the base case models [Run_01 (cluster1) and Run_05(cluster2)] of ASPM analysis for yellowfin tuna in the Atlantic Ocean.

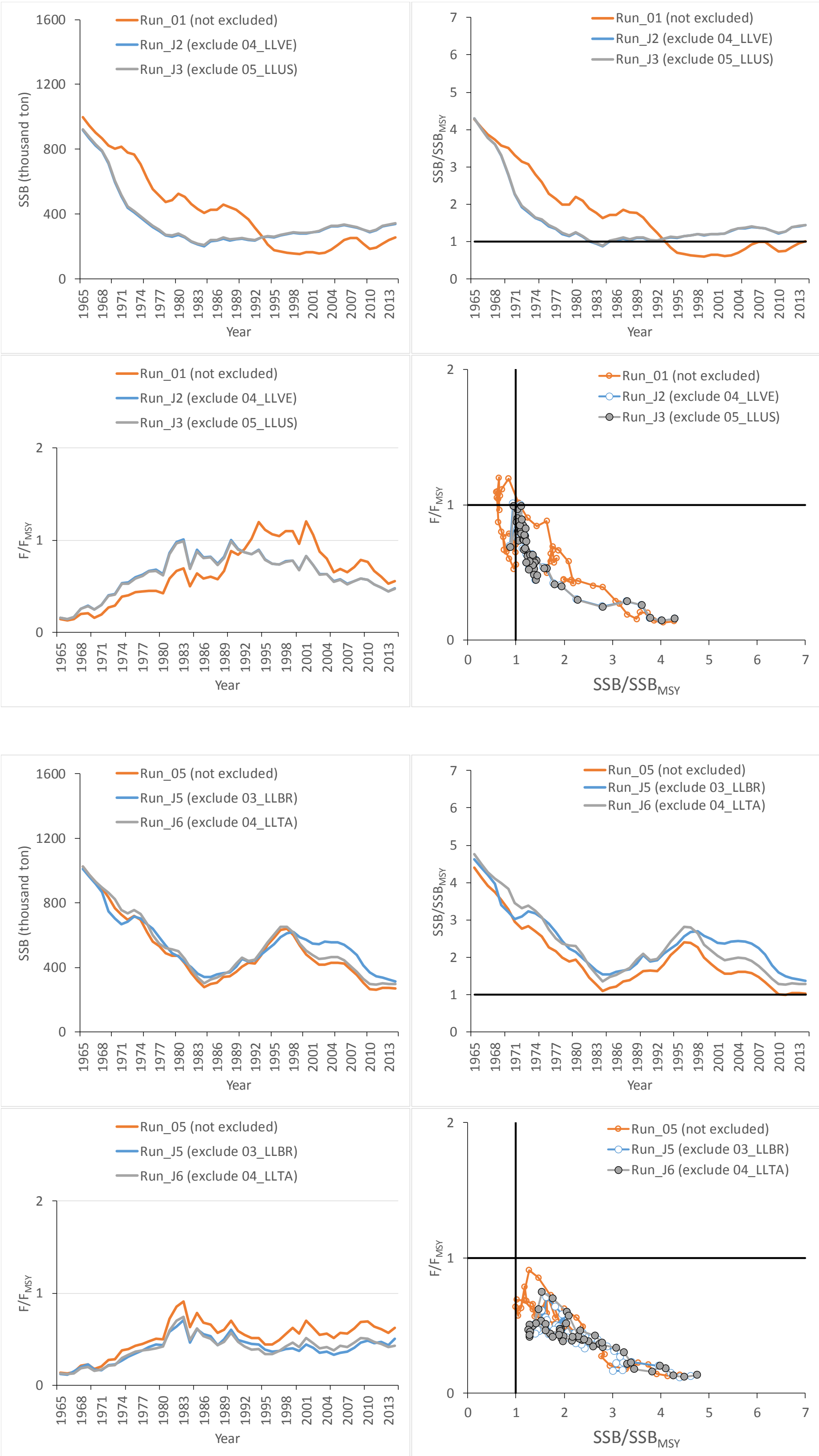

Figure 37. Sensitivity analysis (Jack-Knife Analysis) on index for SSB, recruitment, SSB/SSB_{MSY}, F/F_{MSY} of the base case models [Run_01 and Run_05] of ASPM analysis for yellowfin tuna in the Atlantic Ocean. Each run removes one index at a time from the base case models.

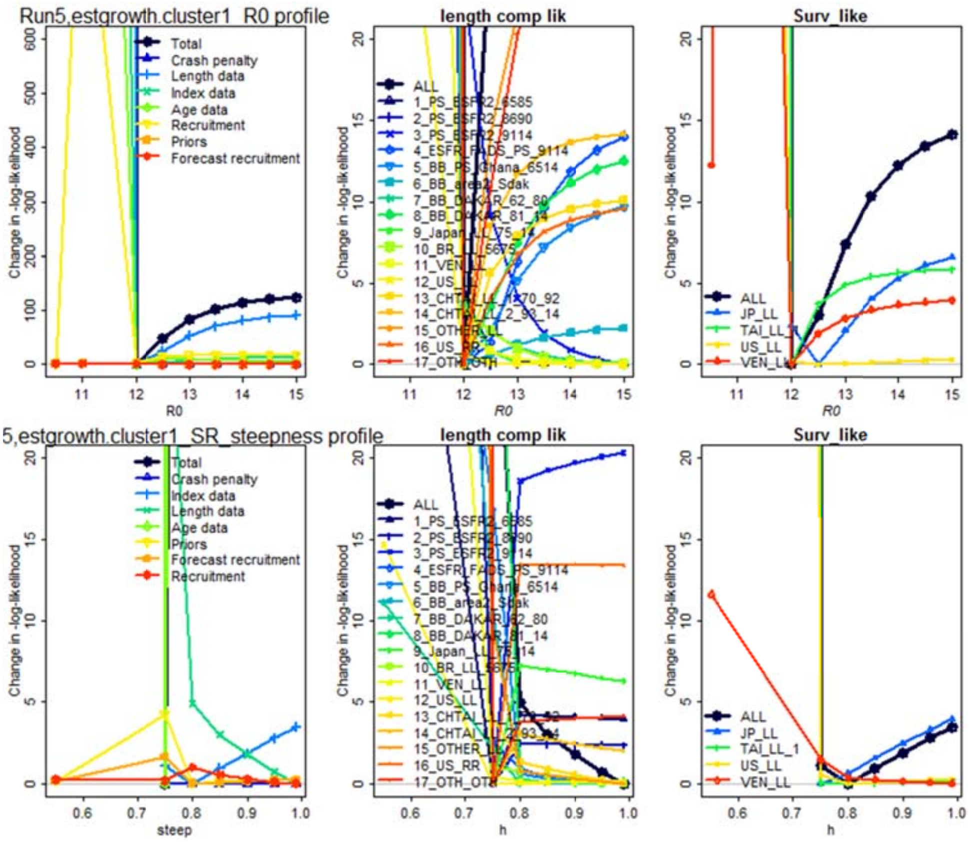

Figure 38. SS3 Model: Likelihood profiles of R0 and steepness for index Cluster 1 model.

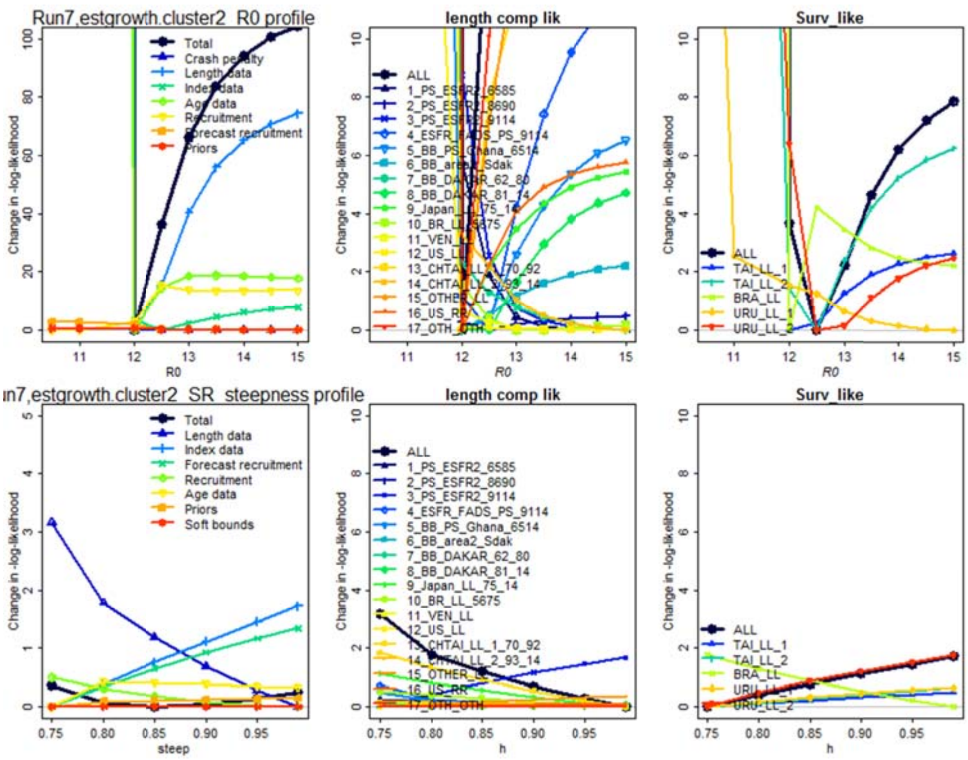

Figure 39. SS3 Model: Likelihood profiles of R0 and steepness for index Cluster 2.

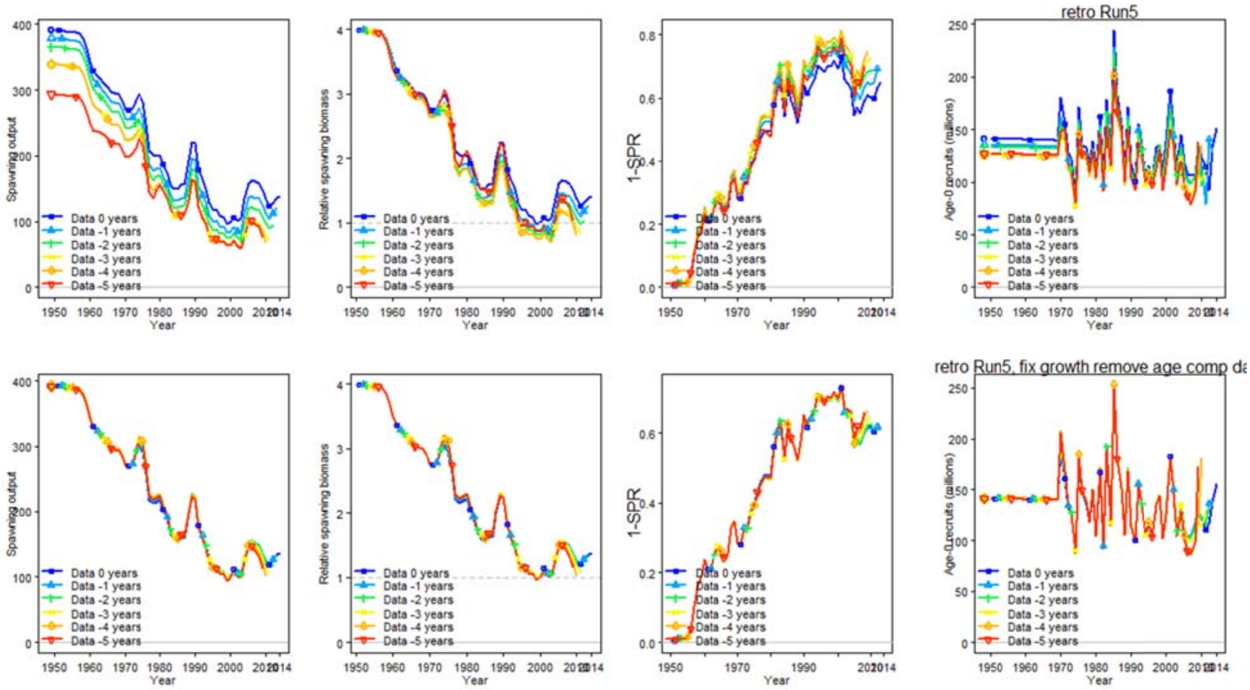

Figure 40. SS3 Model: Retrospective analysis of Cluster 1 with growth estimated (upper) and with growth fixed at estimated values and age composition data removed (lower).

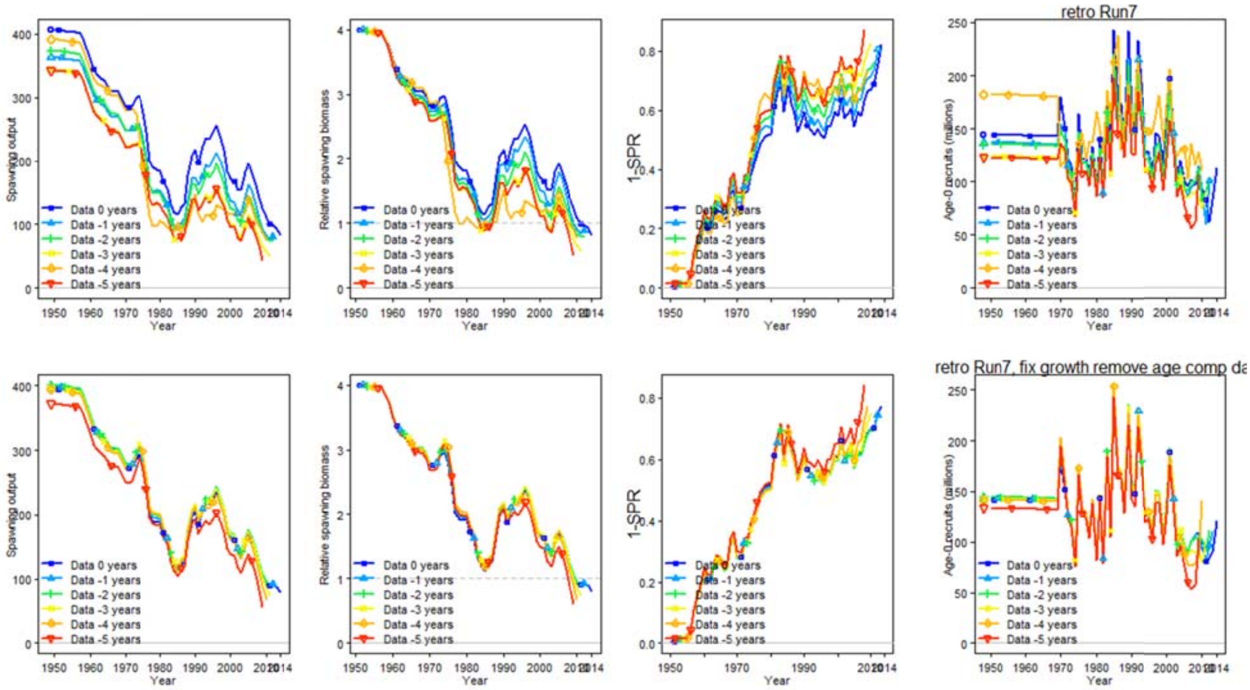

Figure 41. SS3 Model: Retrospective analysis of Cluster 2 with growth estimated (upper) and then with growth fixed at estimated values and the age composition data removed (lower).

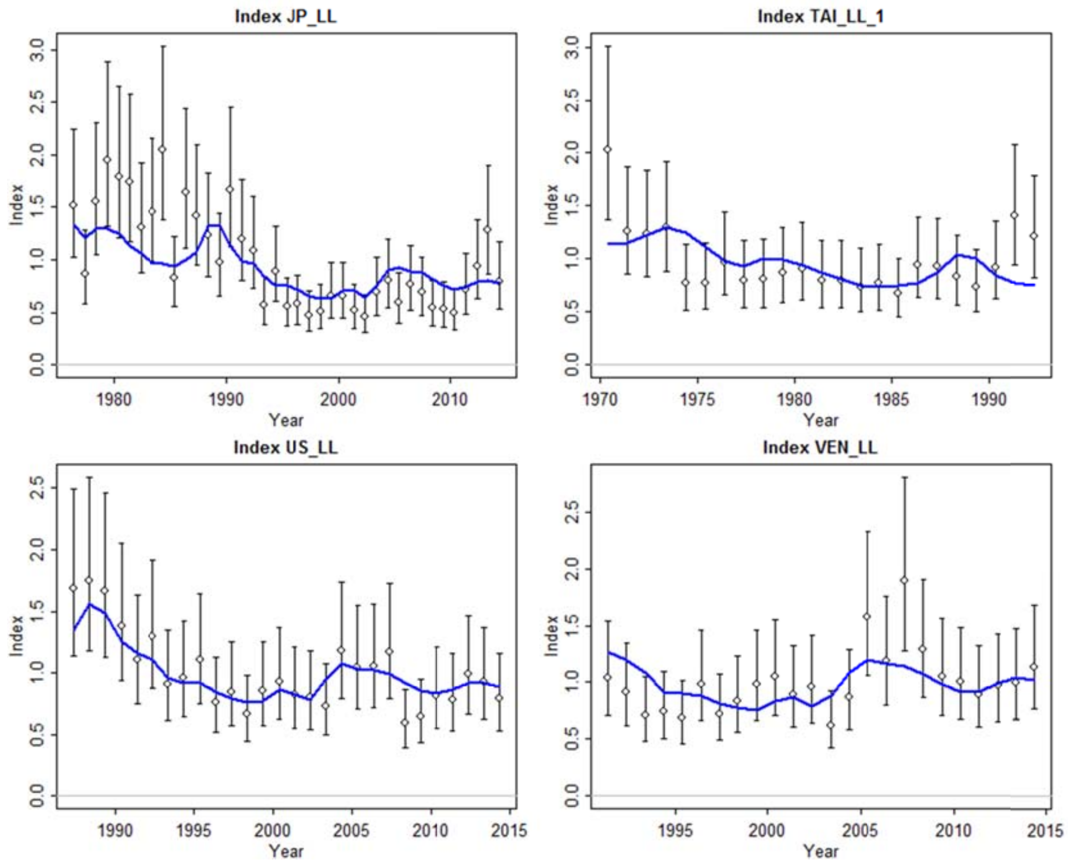

Figure 42. SS3 Model: Fits to CPUE series in Cluster 1.

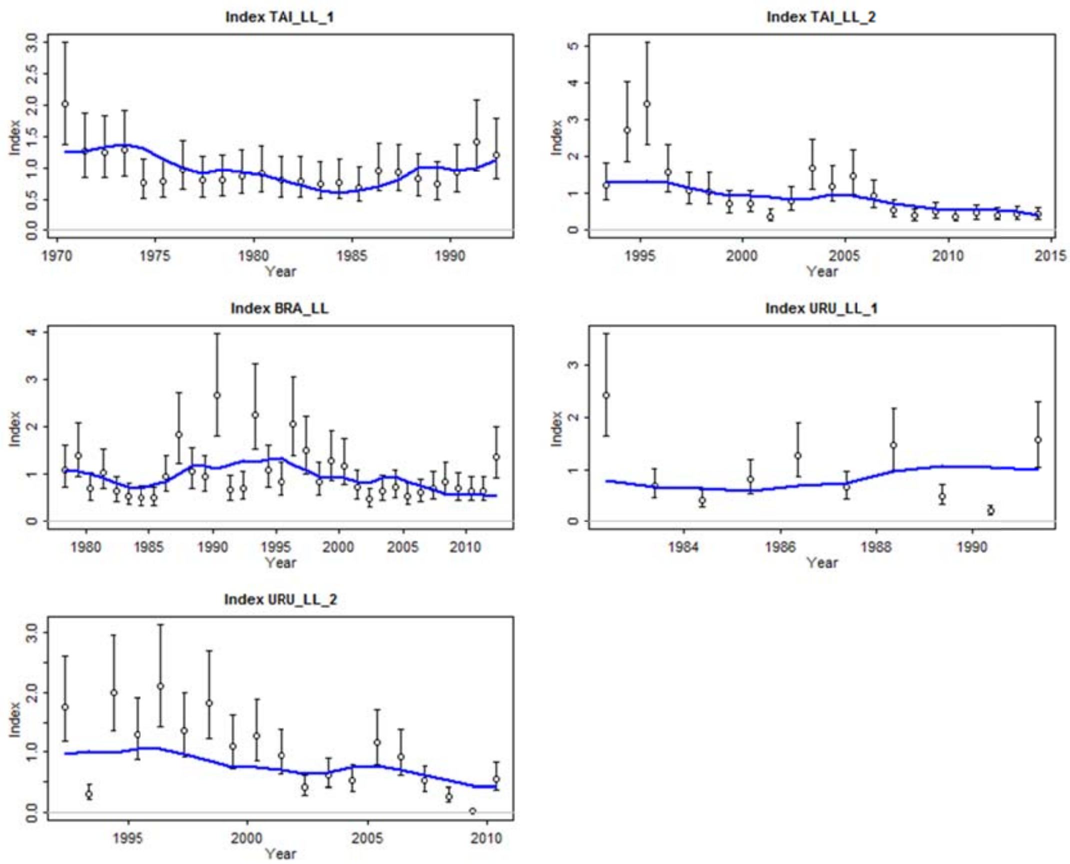

Figure 43. SS3 Model: Fits to indices for Cluster 2.

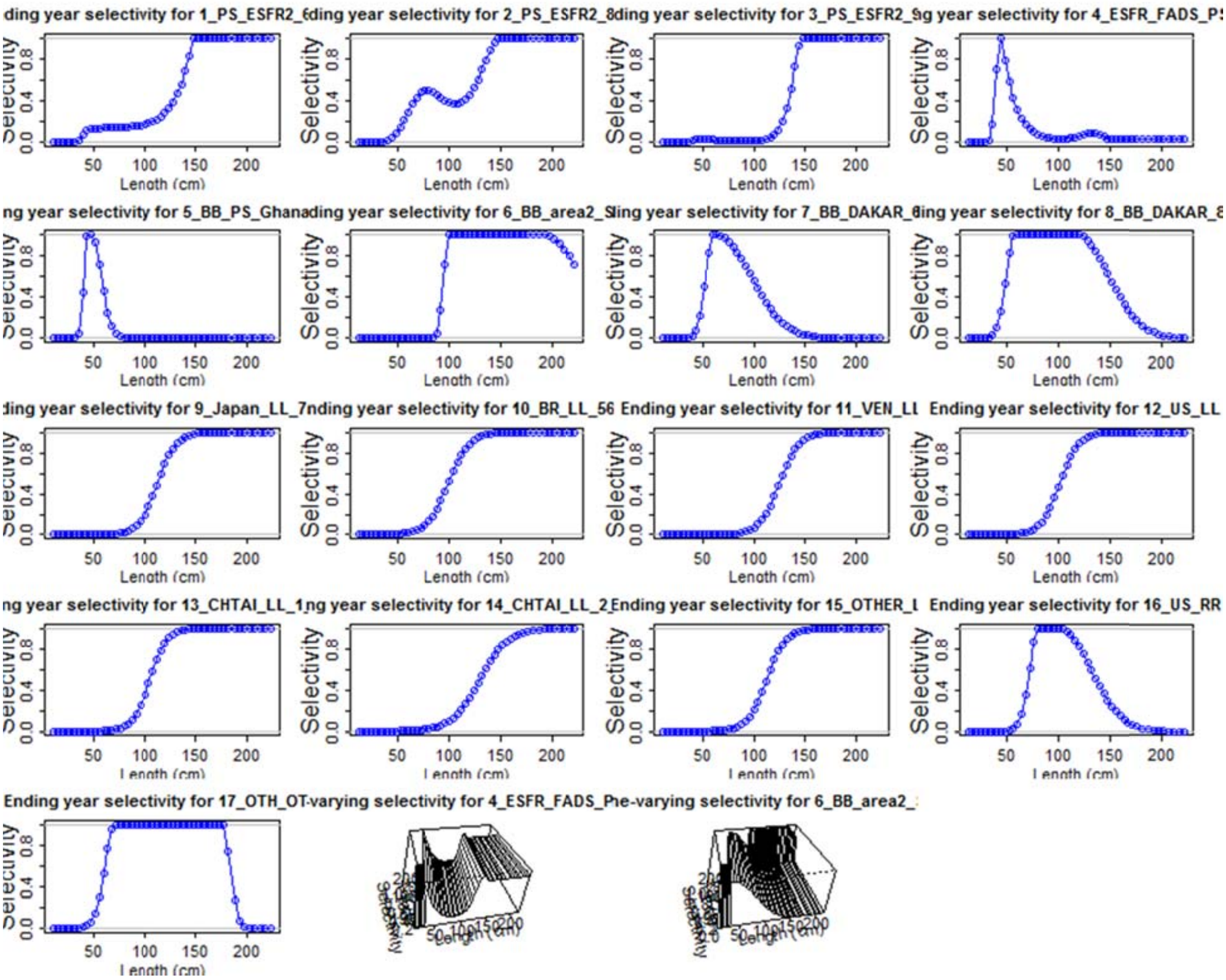

Figure 44. SS3 Model: Estimated selectivities for by fleet for Cluster 1.

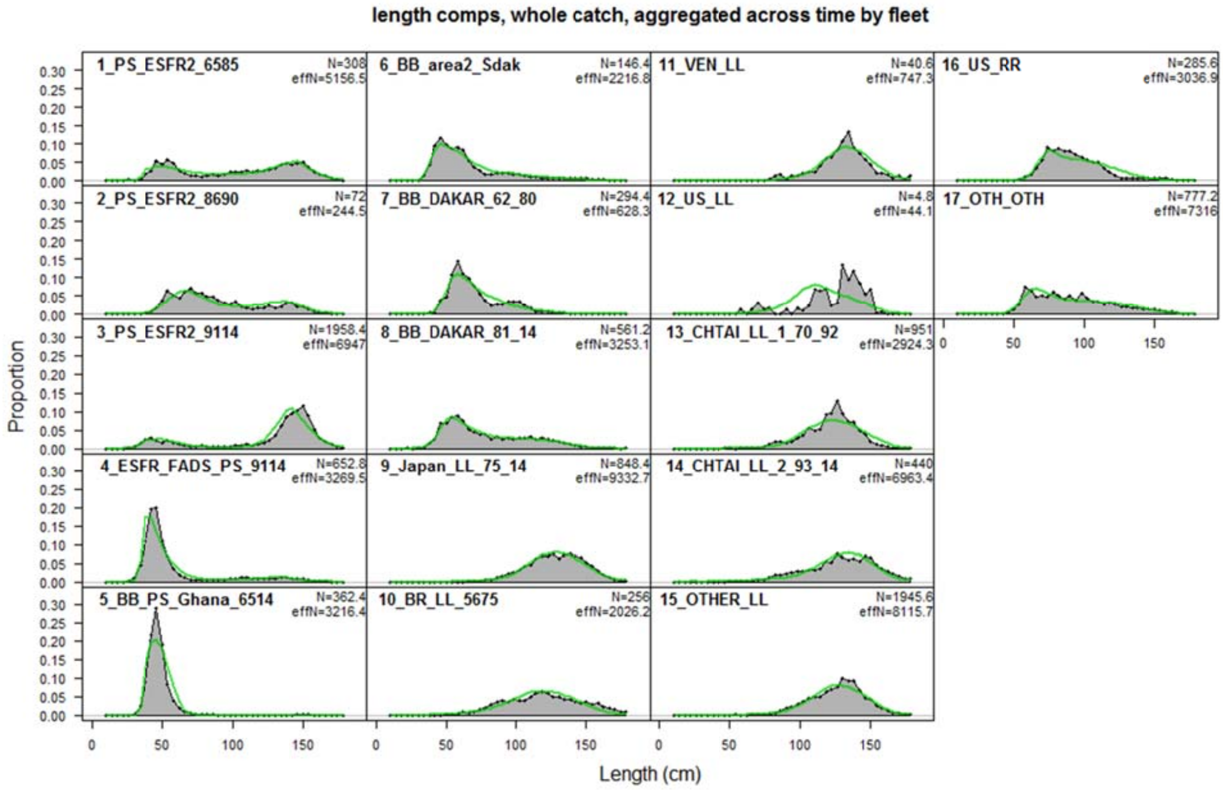

Figure 45. SS3 Model: Fits to length composition aggregated overall years for Cluster 1.

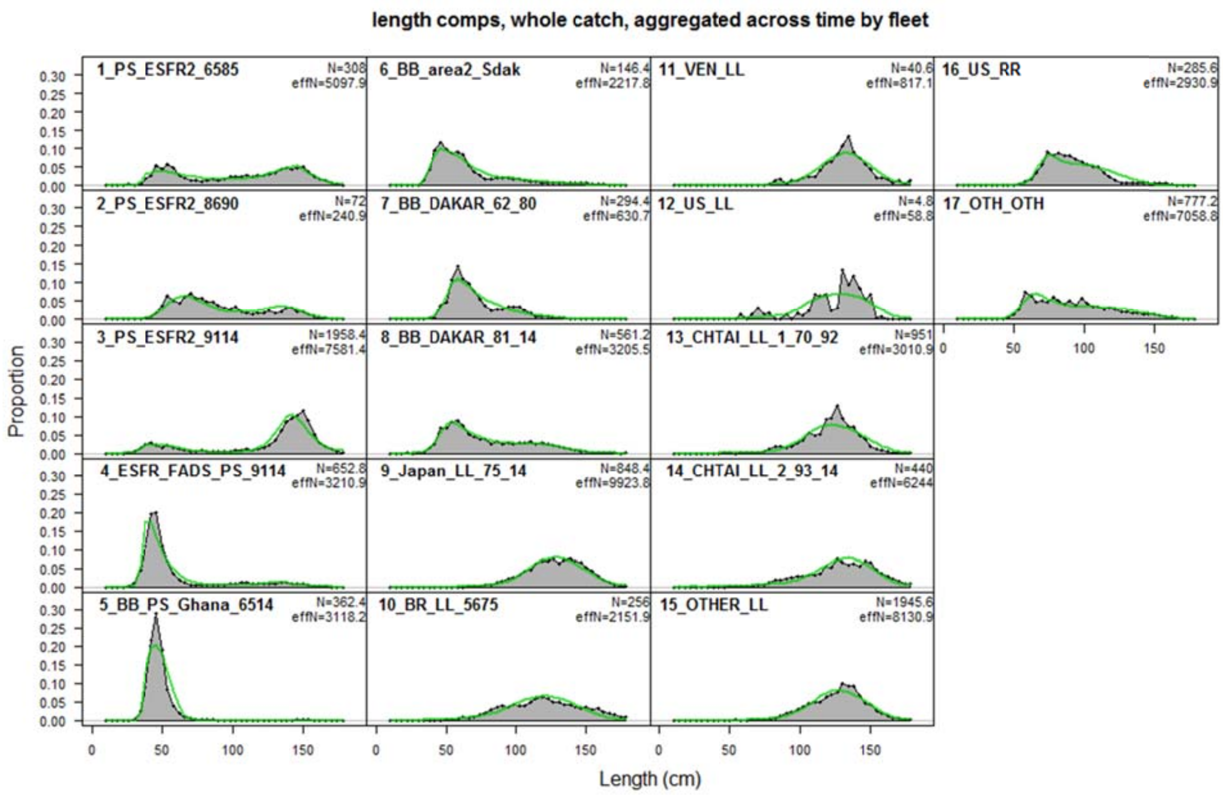

Figure 46. SS3 Model: Fits to length composition aggregated overall years for Cluster 2.

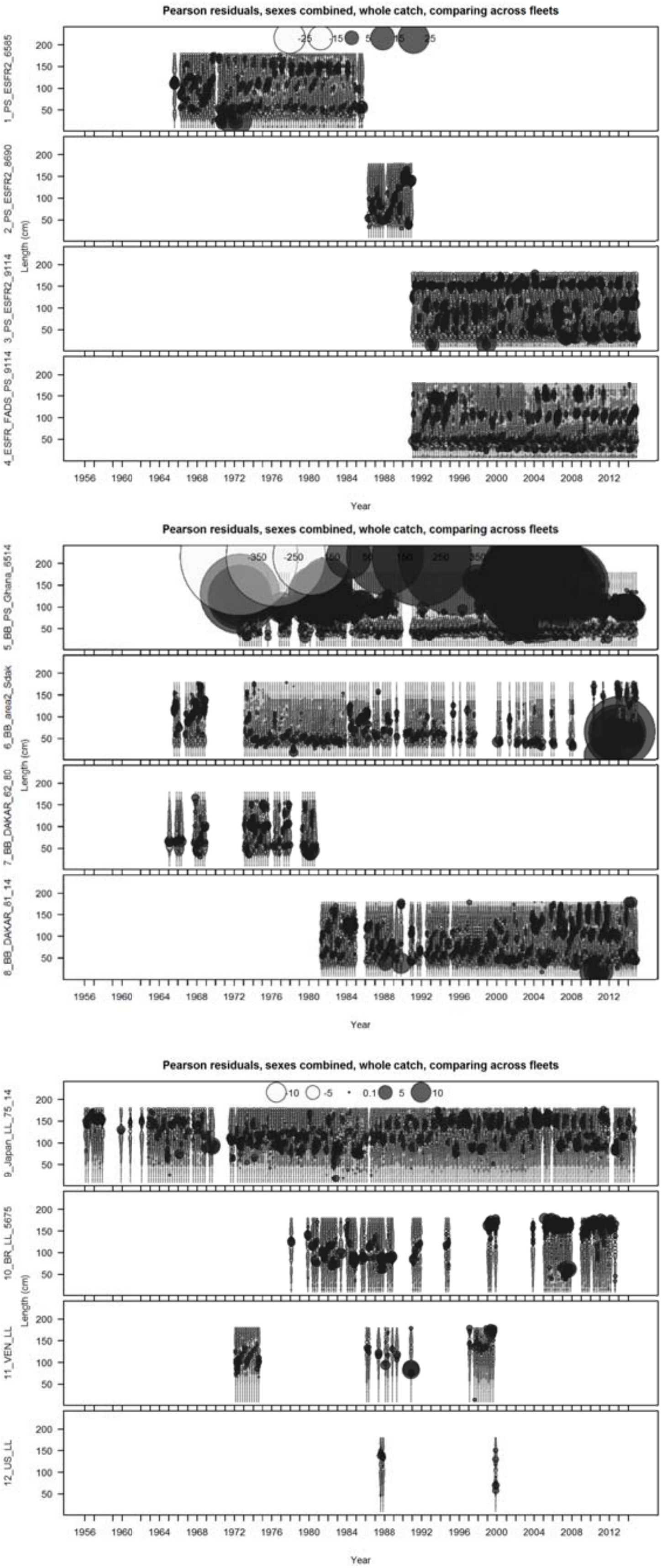

Figure 47. SS3 Model: Pearson residuals of the overall length composition by fleet and year for Cluster 1.

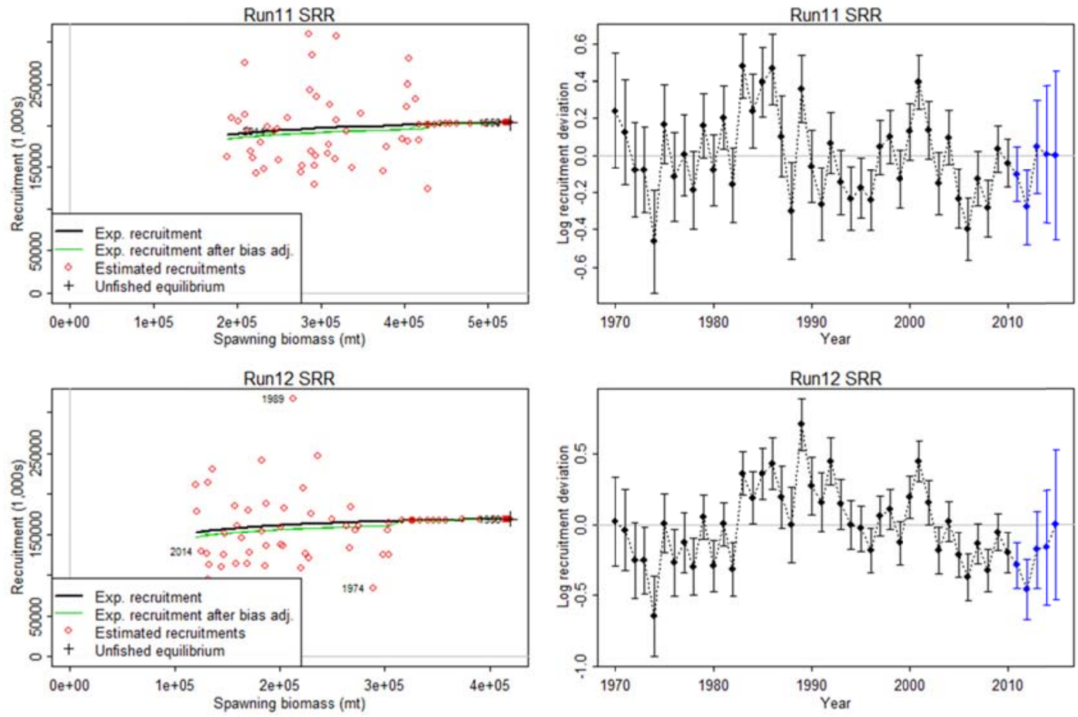

Figure 48. SS3 Model: Spawner-recruit relationship and recruitment deviations for Cluster 1 (top) and Cluster 2 (bottom). Both runs assume a steepness of 0.9. Blue points are recruitment deviations estimated with bias adjustment.

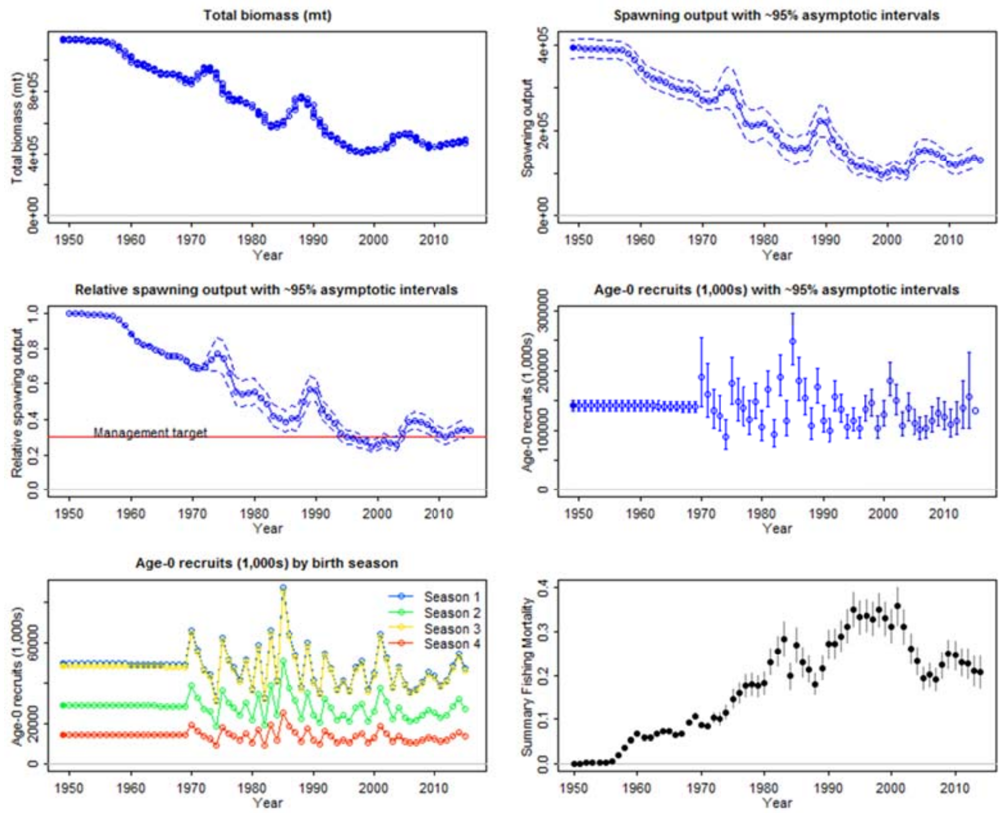

Figure 49. SS3 Model: a) Time series of total biomass, b) spawning biomass, c) spawning biomass relative to virgin, d) recruits, e) recruits by birth season and f) exploitation rate for Cluster 1.

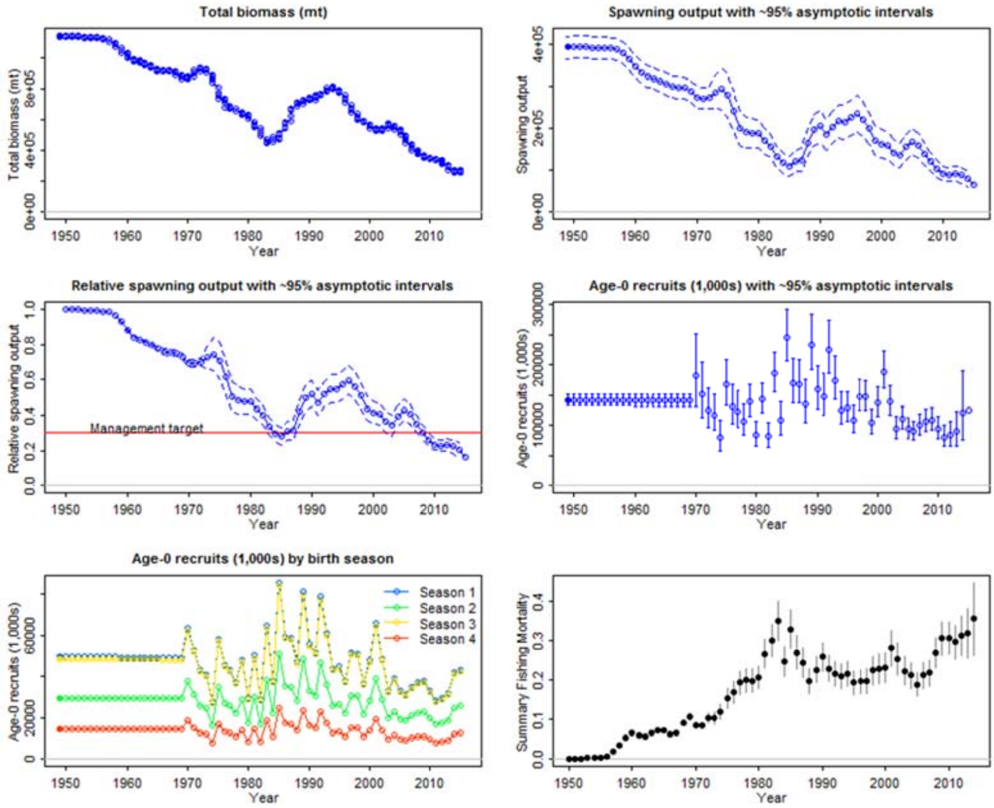

Figure 50. SS3 Model: a) Time series of total biomass, b) spawning biomass, c) spawning biomass relative to virgin, d) recruits, e) recruits by birth season, and f) exploitation rate for Cluster 2.

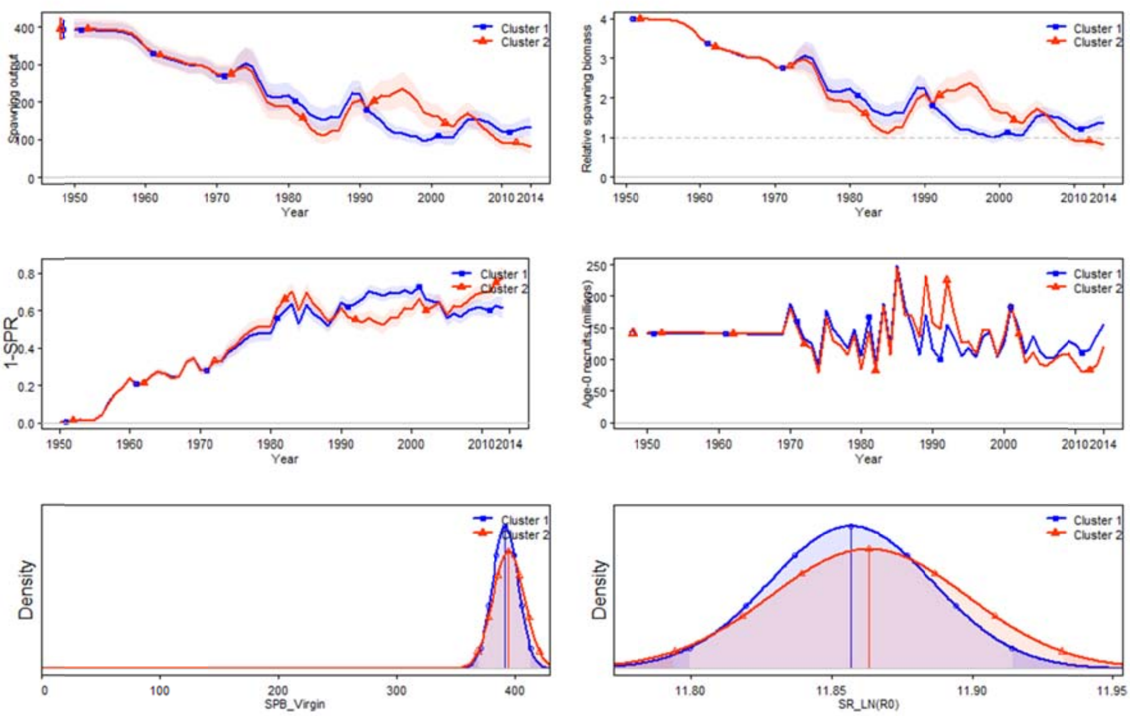

Figure 51. SS3 Model: a) Time series of total spawning biomass, b) spawning biomass relative to virgin, c) 1-SPR used as a proxy for F, d) recruits, e) recruits by birth season, and f) exploitation rate and estimated virgin spawning biomass histogram and virgin R0 for Cluster 1 and Cluster 2.

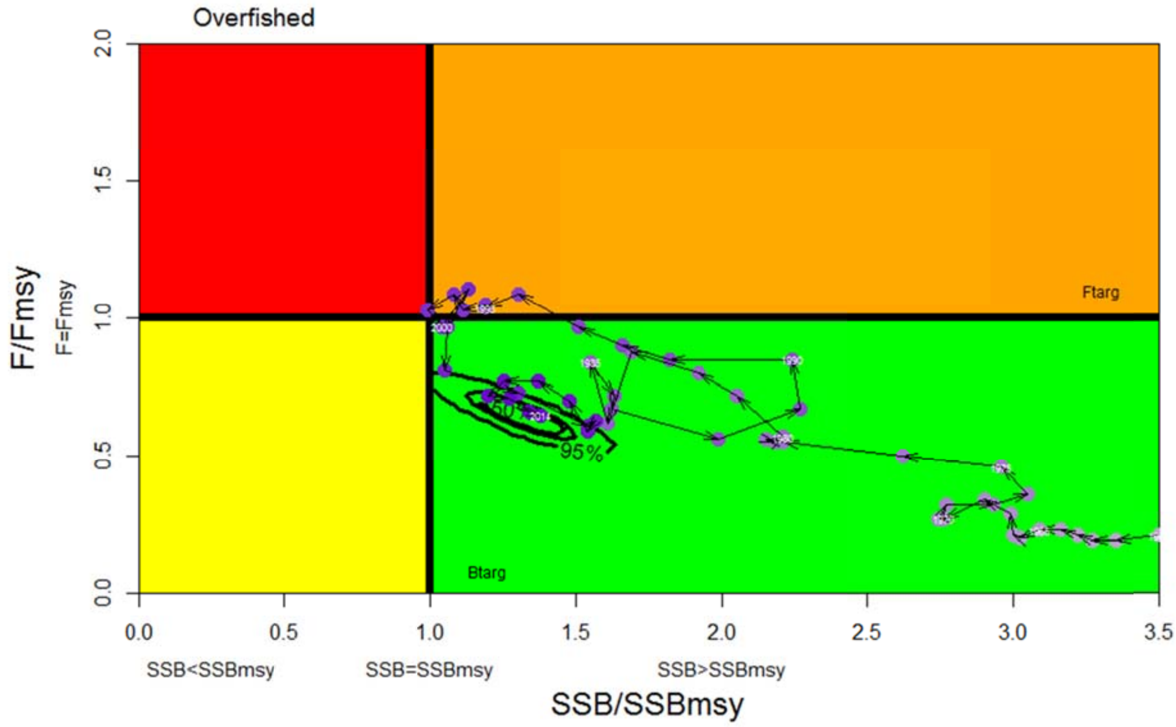

Figure 52. SS3 Model: Phase plot of SSB/SSB_{MSY} and F/F_{MSY} over the 60 year trajectory with uncertainty in the last point (uncertainty was generated using a bivariate normal distribution on F/F_{MSY} and SSB/SSB_{MSE}, and the corresponding covariance between the 2 derived management parameters).These results are predicated on Cluster 1.

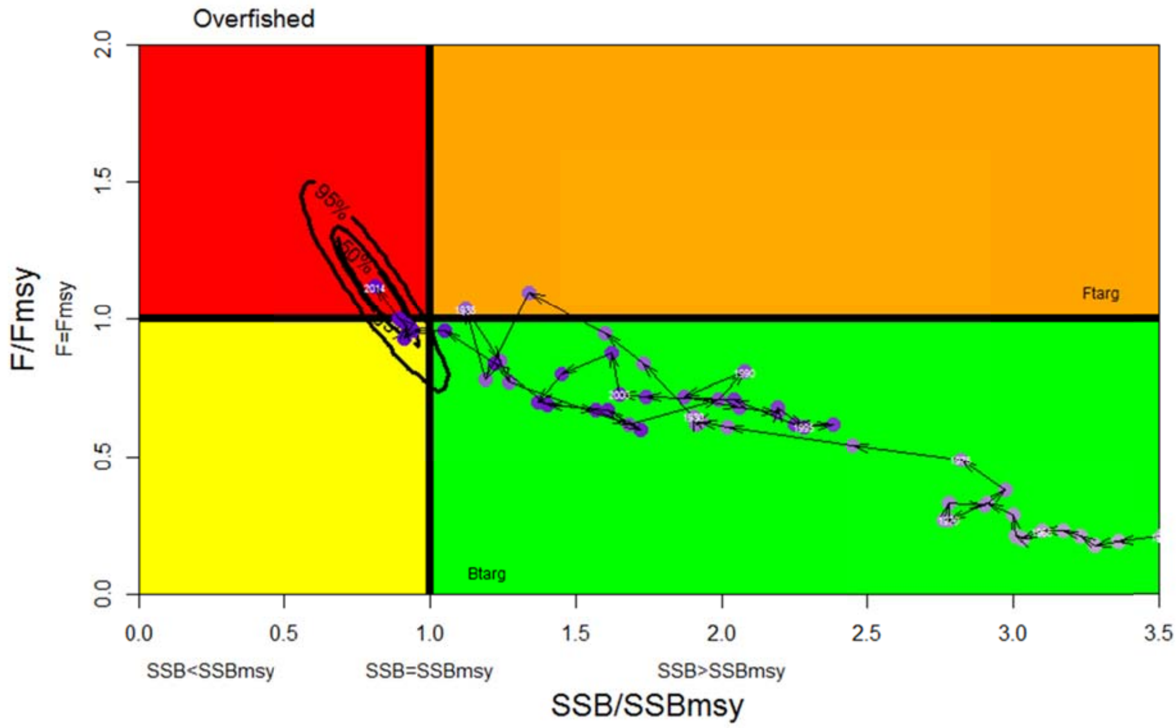

Figure 53. SS3 Model: Phase plot of SSB/SSB_{MSY} and F/F_{MSY} over the 60 year trajectory with uncertainty in the last point (uncertainty was generated using a bivariate normal distribution on F/F_{MSY} and SSB/SSB_{MSY}, and the corresponding covariance between the 2 derived management parameters). These results are predicated on Cluster 2.

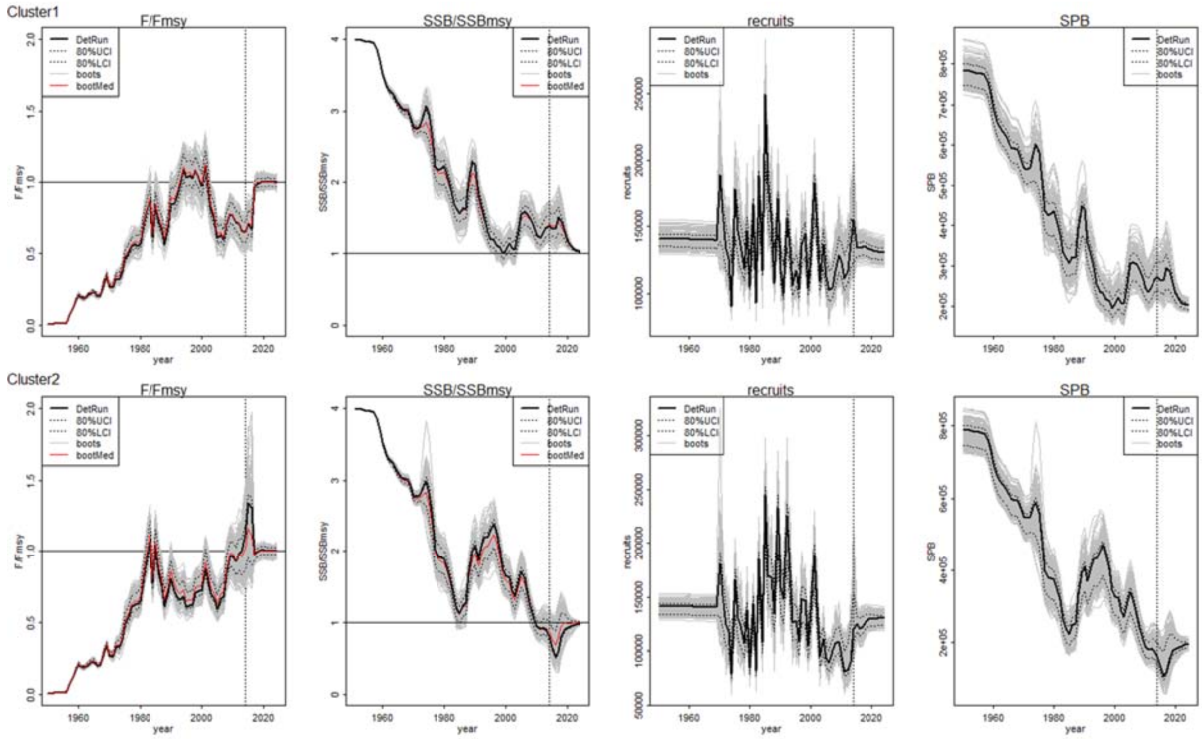

Figure 54. SS3 Model: F/F_{MSY}, SSB/SSB_{MSY}, recruits and SSB for 500 bootstraps with 80% upper and lower confidence intervals. Dark line is the deterministic run for Cluster 1 (Upper row) and Cluster 2 (lower row). Red line is the bootstrap median.

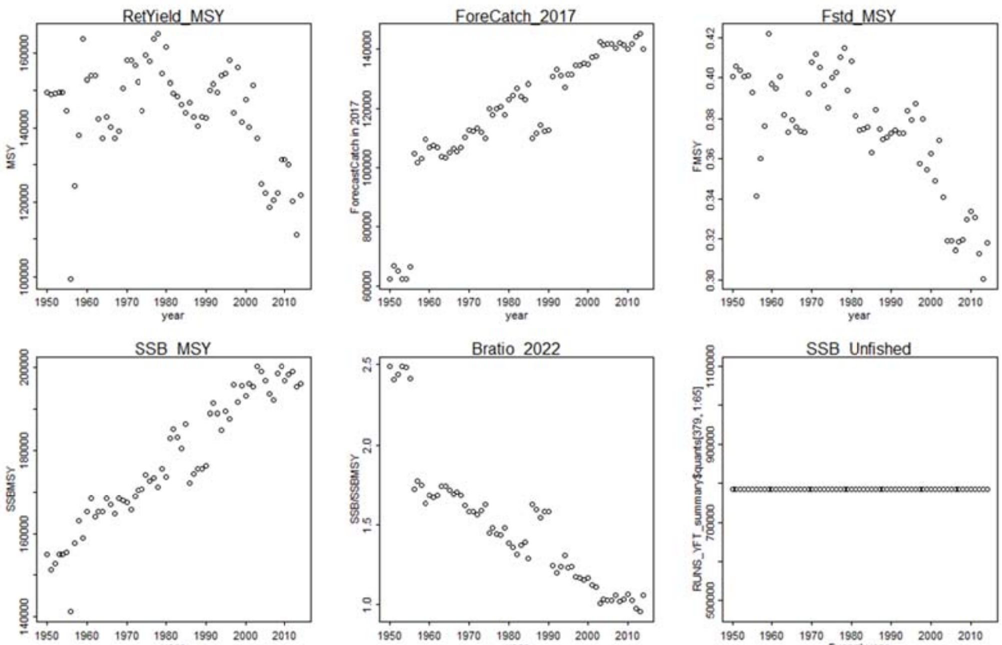

Figure 55. SS3 Models: Variation in MSY, Forecasted catch in 2017 at F_{MSY}, F_{MSY}, SSB_{MSY}, projected SSB/SSB_{MSY} in 2022 at the year-specific estimate of F_{MSY} and relative allocation of catch among fleets and SSB_{virgin} for Cluster 1 obtained from year-specific estimates of relative F and selectivity.

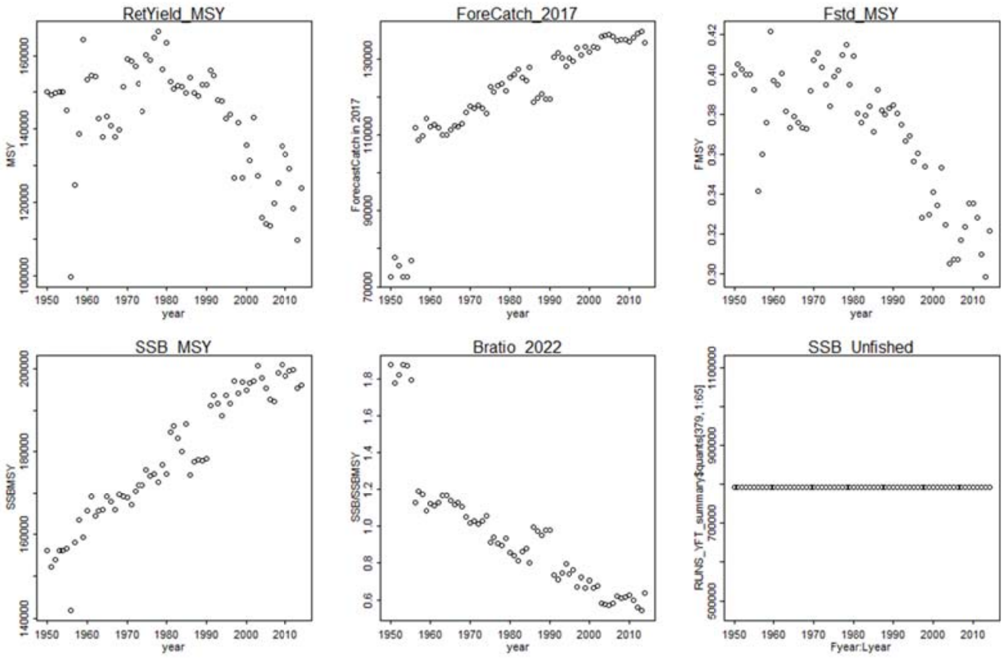

Figure 56. SS3 Models: Variation in MSY, Forecasted catch in 2017 at F_{MSY}, SSB_{MSY}, SSB/SSB_{MSY} in 2014 and SSB virgin for Cluster 2 obtained from year-specific estimates of relative F and selectivity.

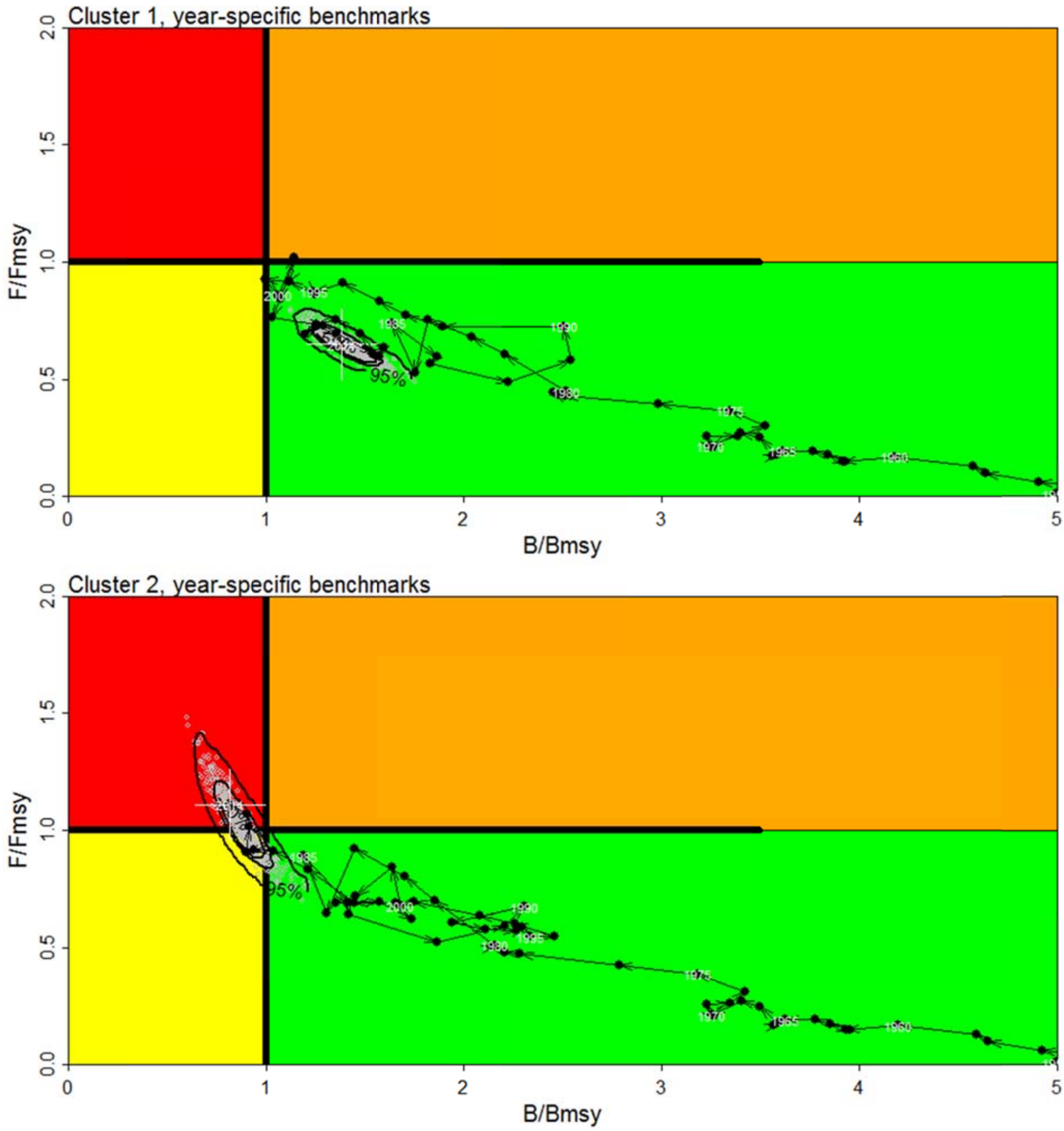

Figure 57. SS3 Model: Kobe plot for Cluster 1 and Cluster 2. Confidence intervals around the terminal year (2014) estimate are obtained from 500 bootstraps. Gray dots are bootstrap estimates for the terminal year. The trajectory is the deterministic run adjusted for each year-specific estimate of F_{MSY} and SSB_{MSY} and the white "+" denotes the deterministic terminal year estimate.

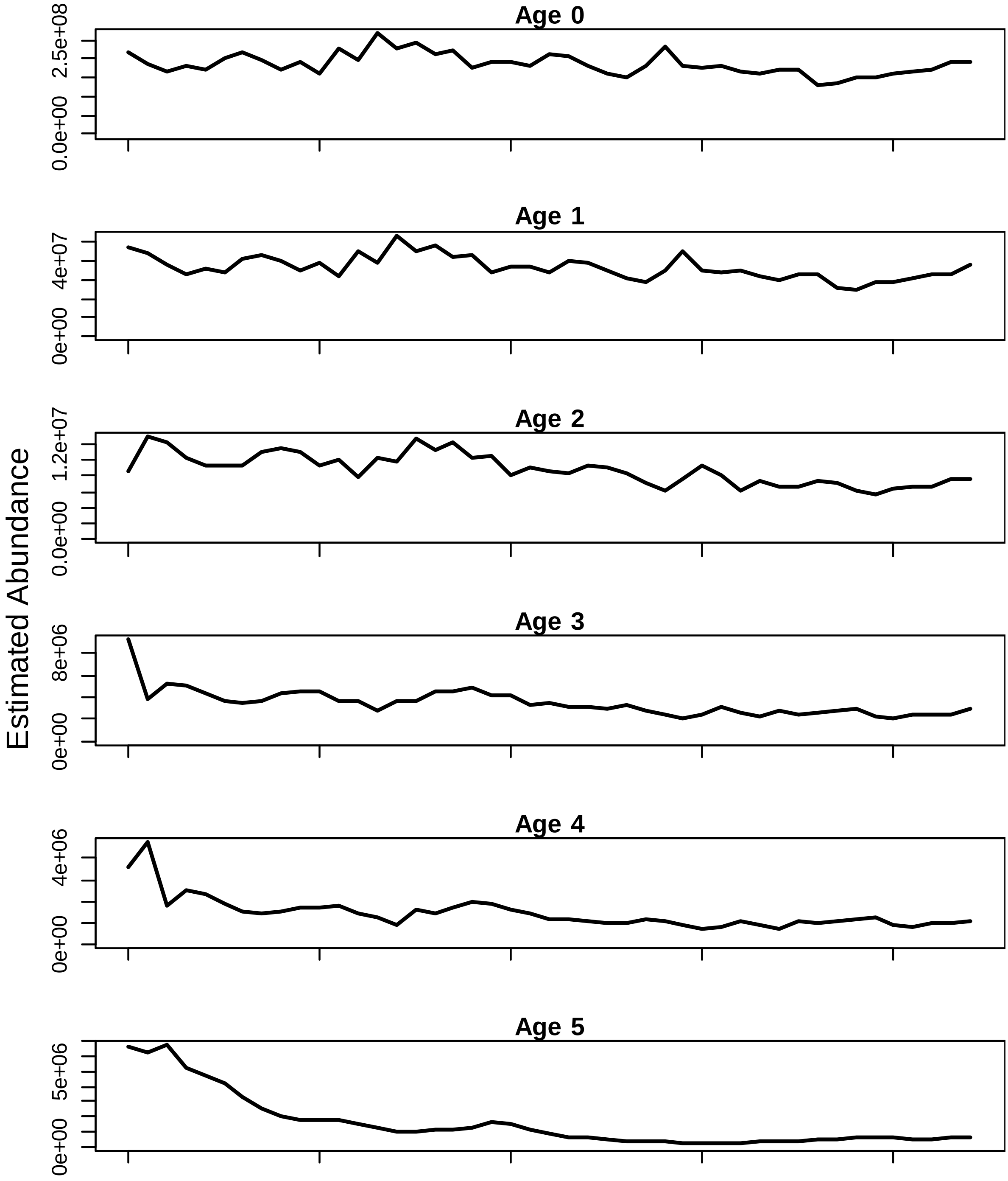

Figure 58. Estimated abundance at age by the Cluster 1 VPA base model.

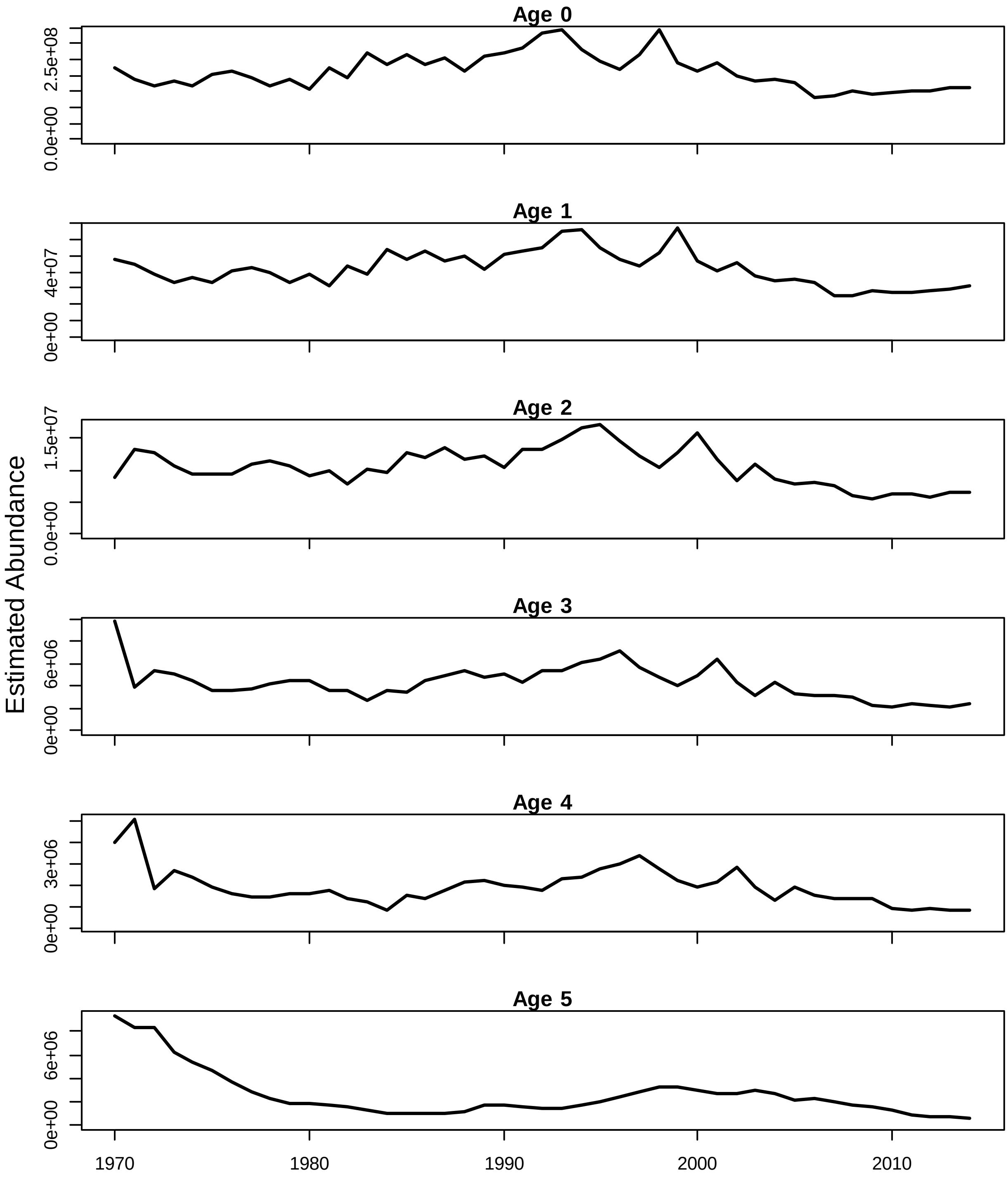

Figure 59. Estimated abundance at age by the Cluster 2 VPA base model.

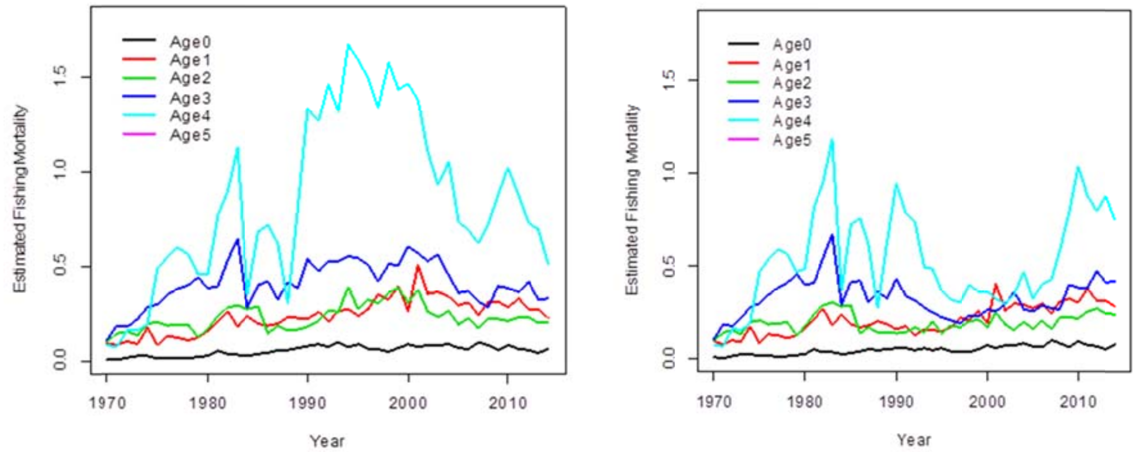

Figure 60. Estimated fishing mortality at age by the Cluster 1 (left panel) and Cluster 2 (right panel) VPA base models.

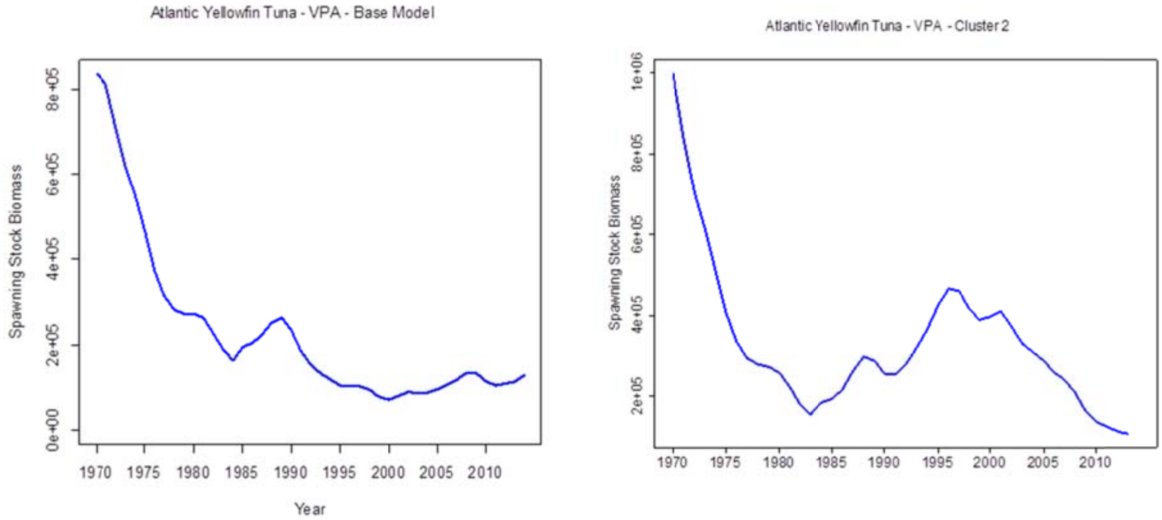

Figure 61. Estimated spawning stock biomass (SSB) by the Cluster 1 (left panel) and Cluster 2 (right panel) VPA base models.

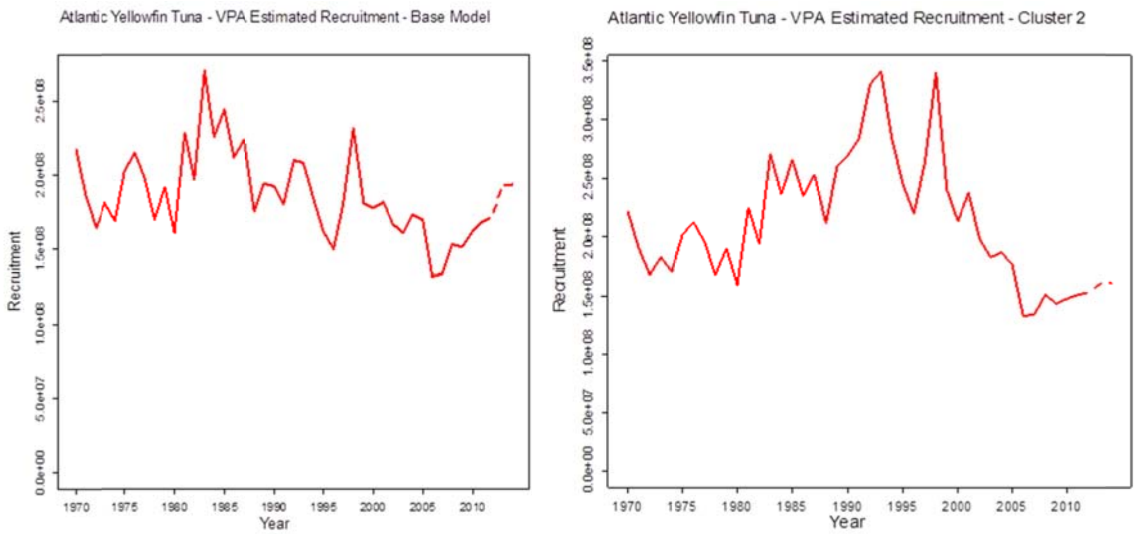

Figure 62. Estimated recruitment by the Cluster **1** (left panel) and Cluster 2 (right panel) VPA base models.

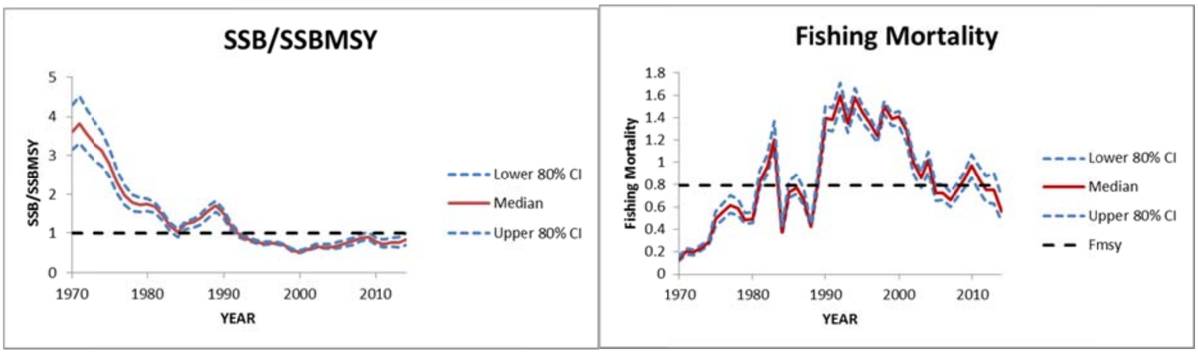

Figure 63. Trends in SSB_{2014}/SSB_{MSY} and F_{Curr} relative to F_{MSY} for VPA models using Cluster 1 indices.

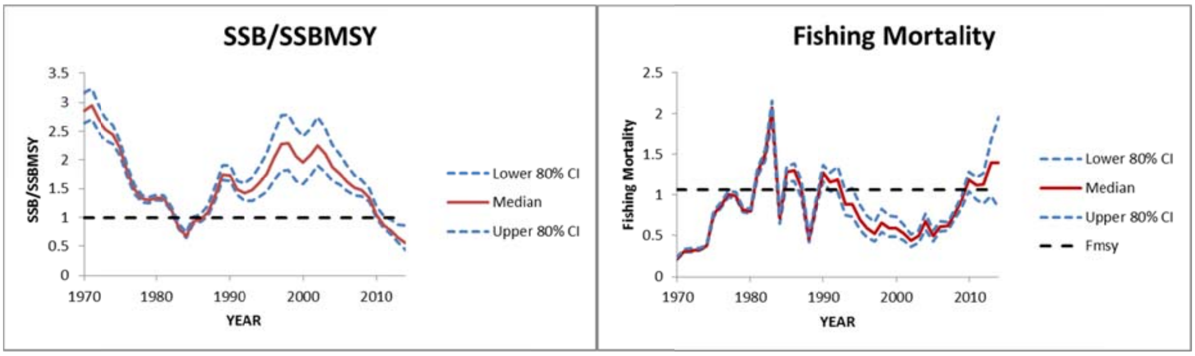

Figure 64. Trends in SSB_{2014}/SSB_{MSY} and F_{Curr} relative to F_{MSY} for VPA models using Cluster 2 indices.

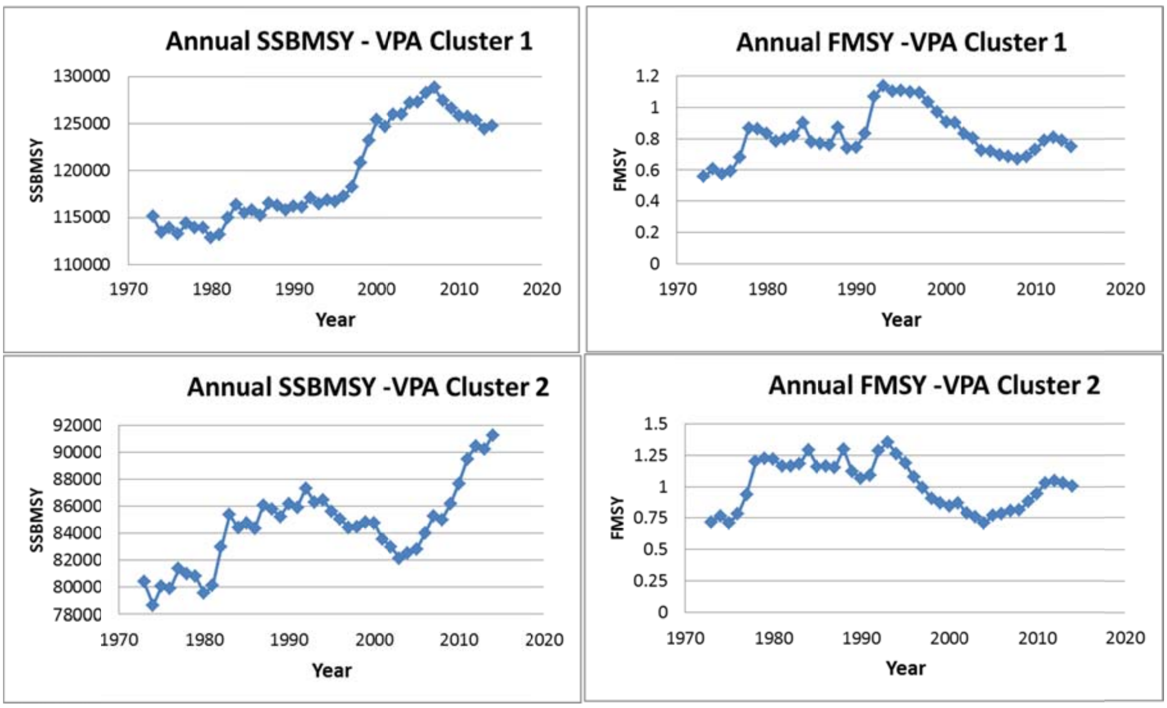

Figure 65. VPA Models: Annual estimates of SSB_{MSY} and F_{MSY} adjusted for selectivity.

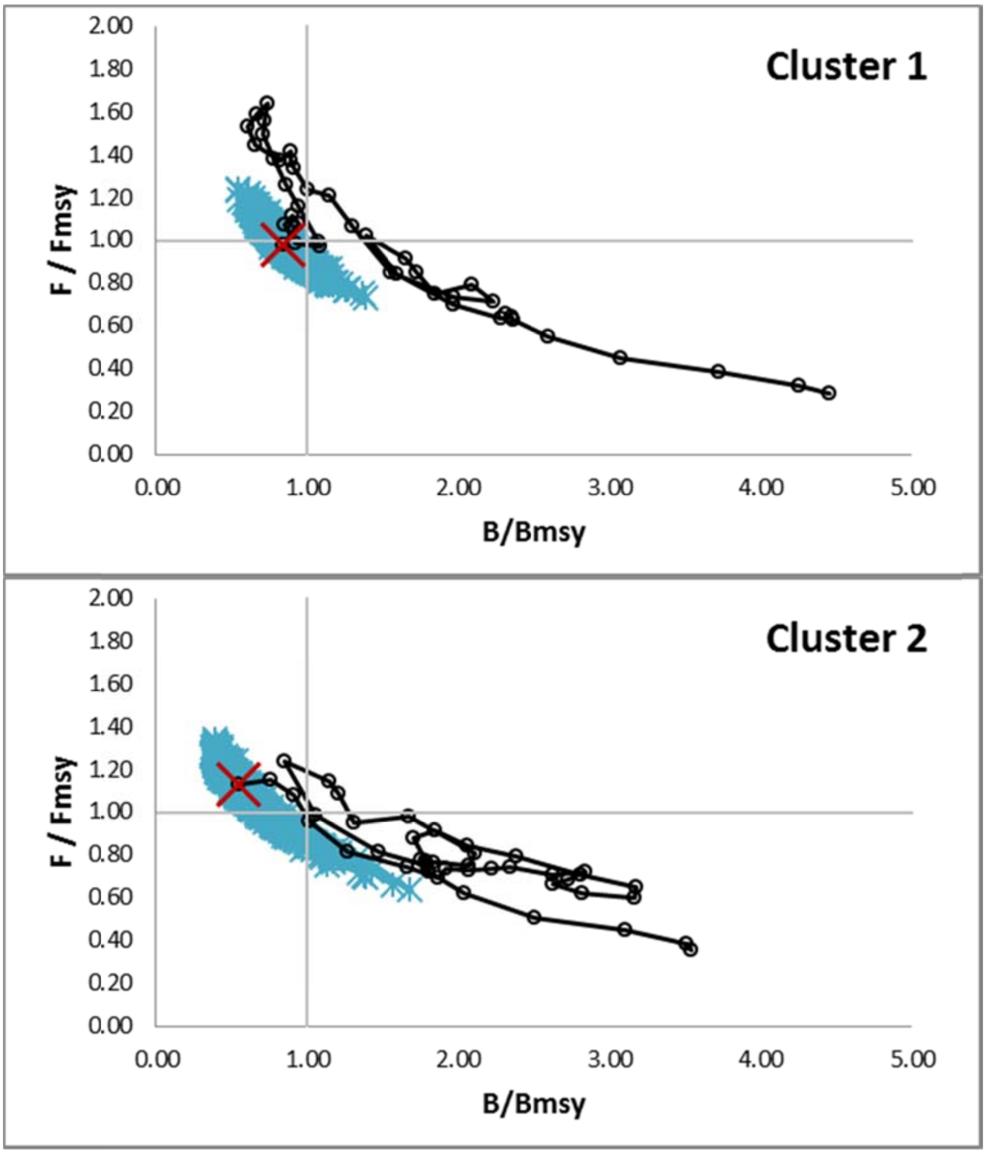

Figure 66. VPA Models: Annual stock status estimates ("Snail Tracks") adjusted for annual changes in selectivity (black line), and 1000 bootstrap estimates (blue) of terminal year stock status (SSB_{2014}/SSB_{MSY} and F_{Curr}/F_{MSY}).

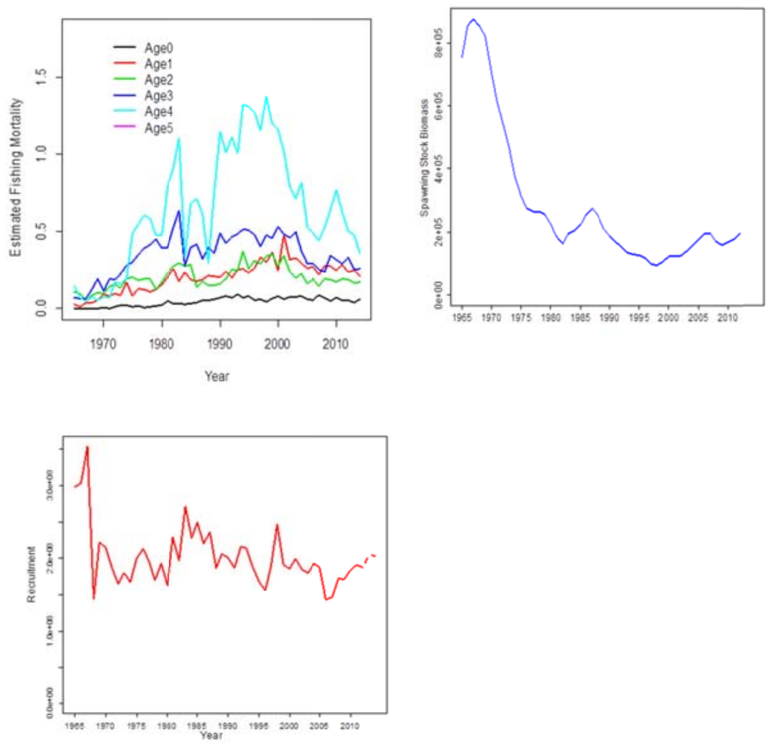

Figure 67. Estimated F at age (upper left panel), spawning stock biomass (upper right panel), and recruitment (lower panel) by the VPA sensitivity run.

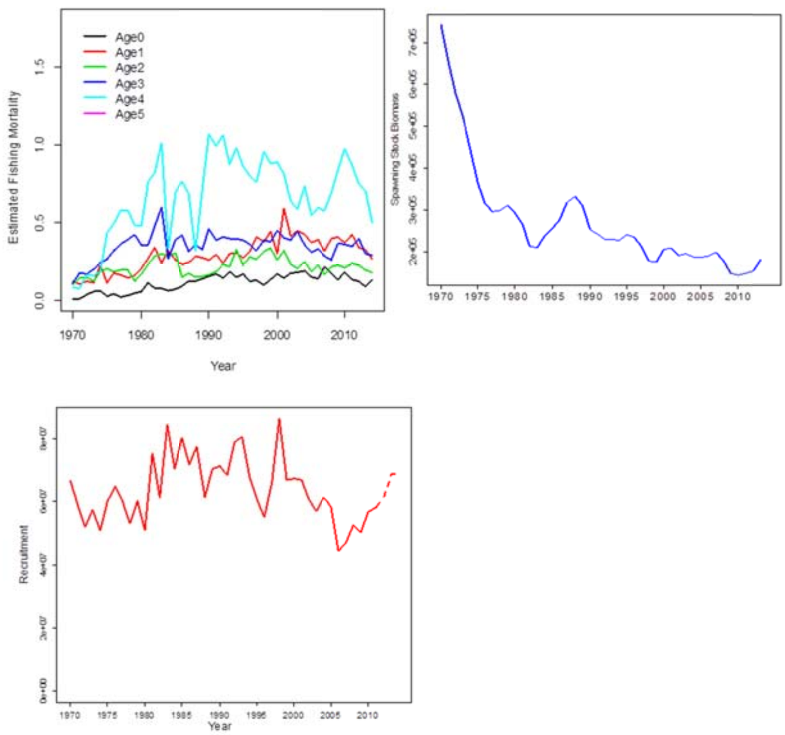

Figure 68. Estimated F at age (upper left panel), spawning stock biomass (upper right panel), and recruitment (lower panel) by the VPA continuity run.

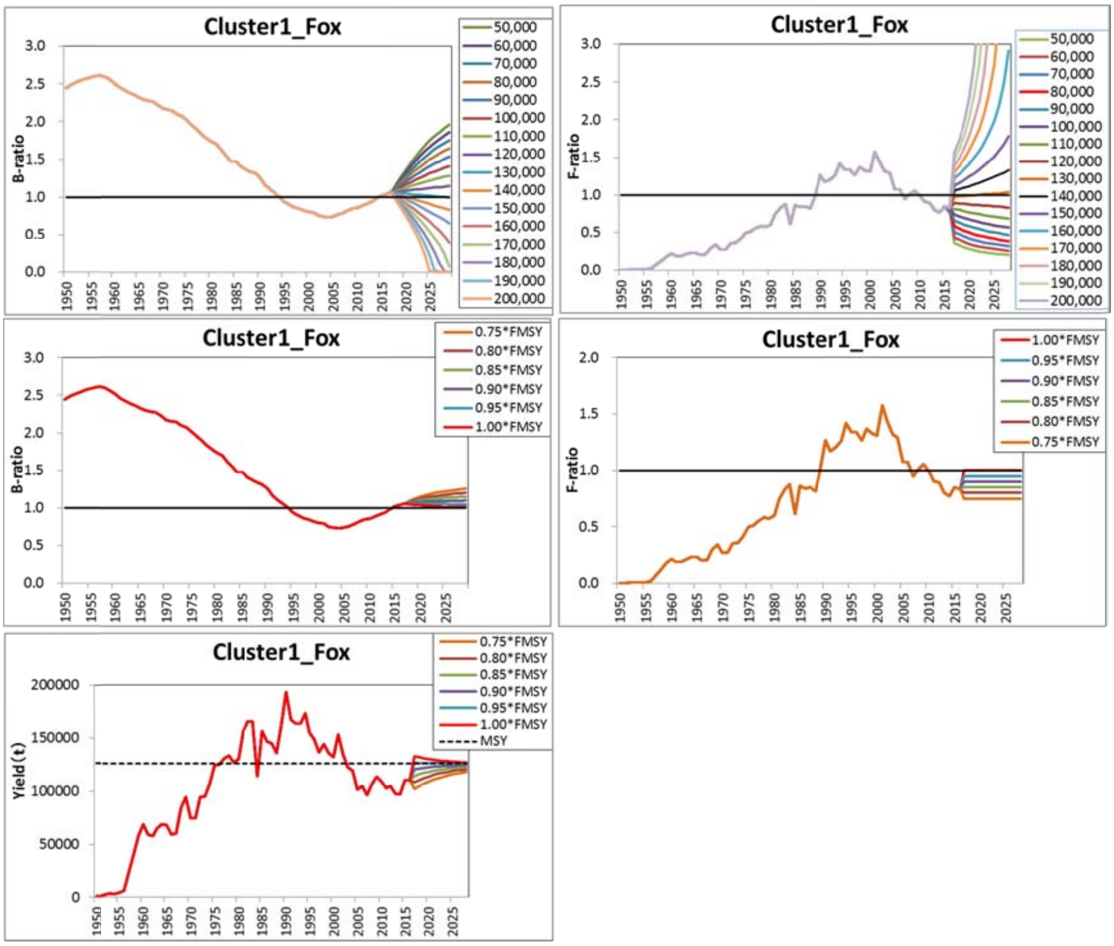

Figure 69. Future projection of B-ratio (B/B_{MSY}), F-ratio (F/F_{MSY}) and predicted yield for ASPIC base model run under constant catch or constant F.

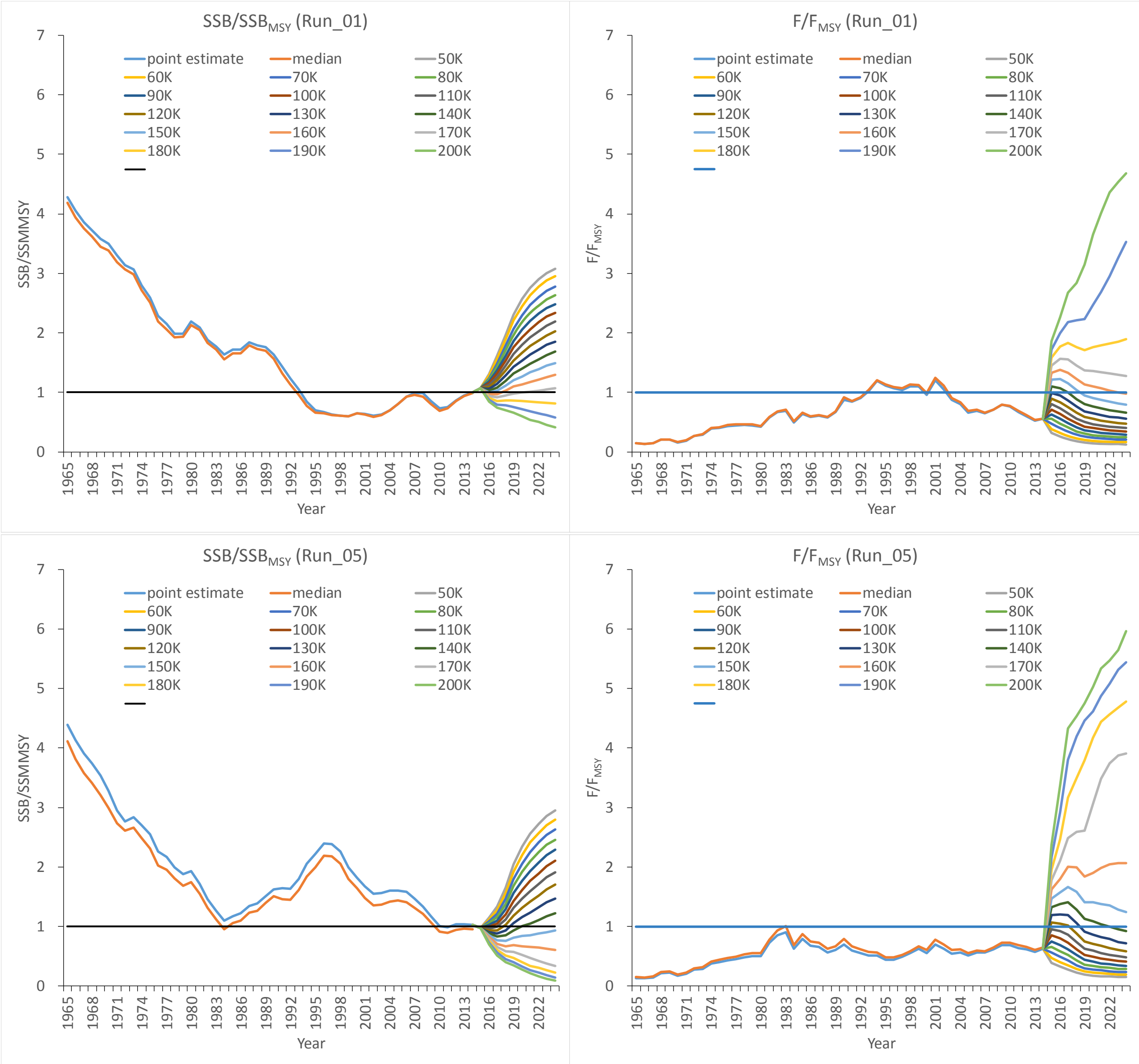

Figure 70. Future projections of the base case models (Run_01 and Run_05) of ASPM analysis for yellowfin tuna in the Atlantic Ocean. The constant catch from 50,000 (50 K) to 200,000 (200 K) t by 10,000 t and with a proportion of catch by fleet as the average of 2013 to 2015.

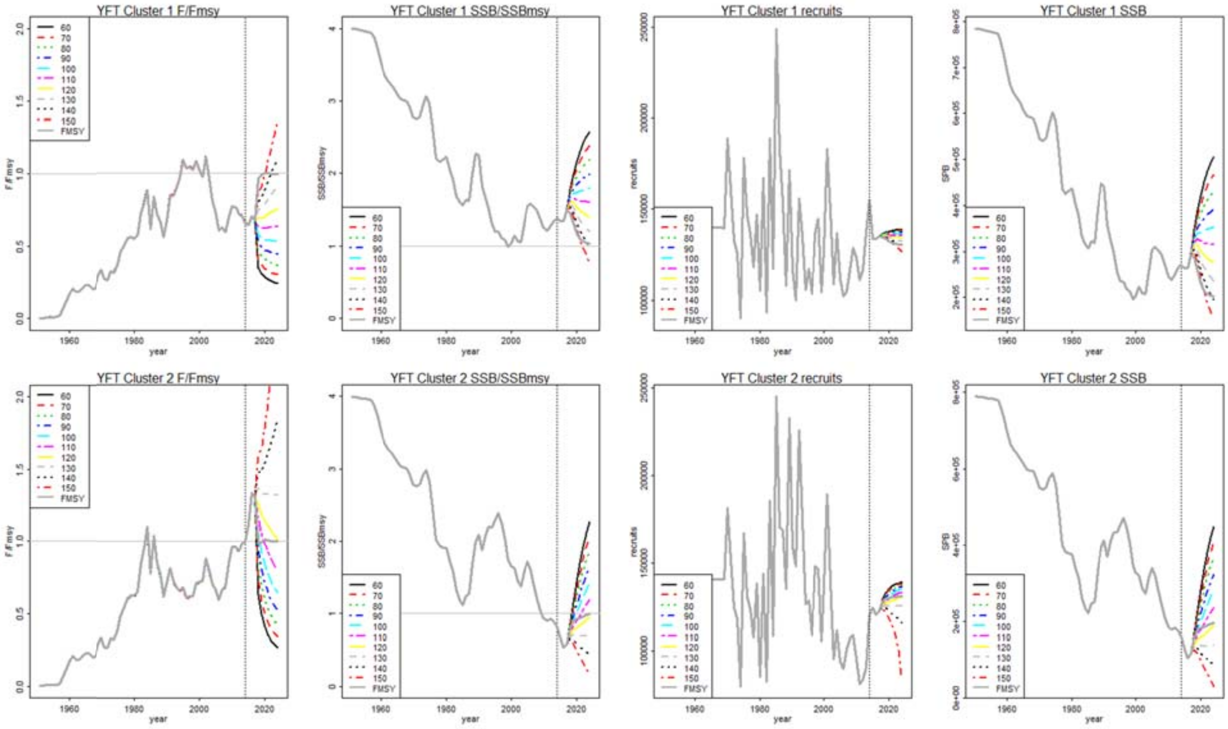

Figure 71. SS3 Models: Determinstic projections of F/F_{MSY}, SSB/SSB_{MSY}, recruits and SSB fixed quotas between 60 and 150 thousand t. Dark gray line is the deterministic run projected at FMSY for Cluster 1 (Upper row) and Cluster 2 (lower row). Catches for 2015 and 2016 were assumed to be 110,337 t.

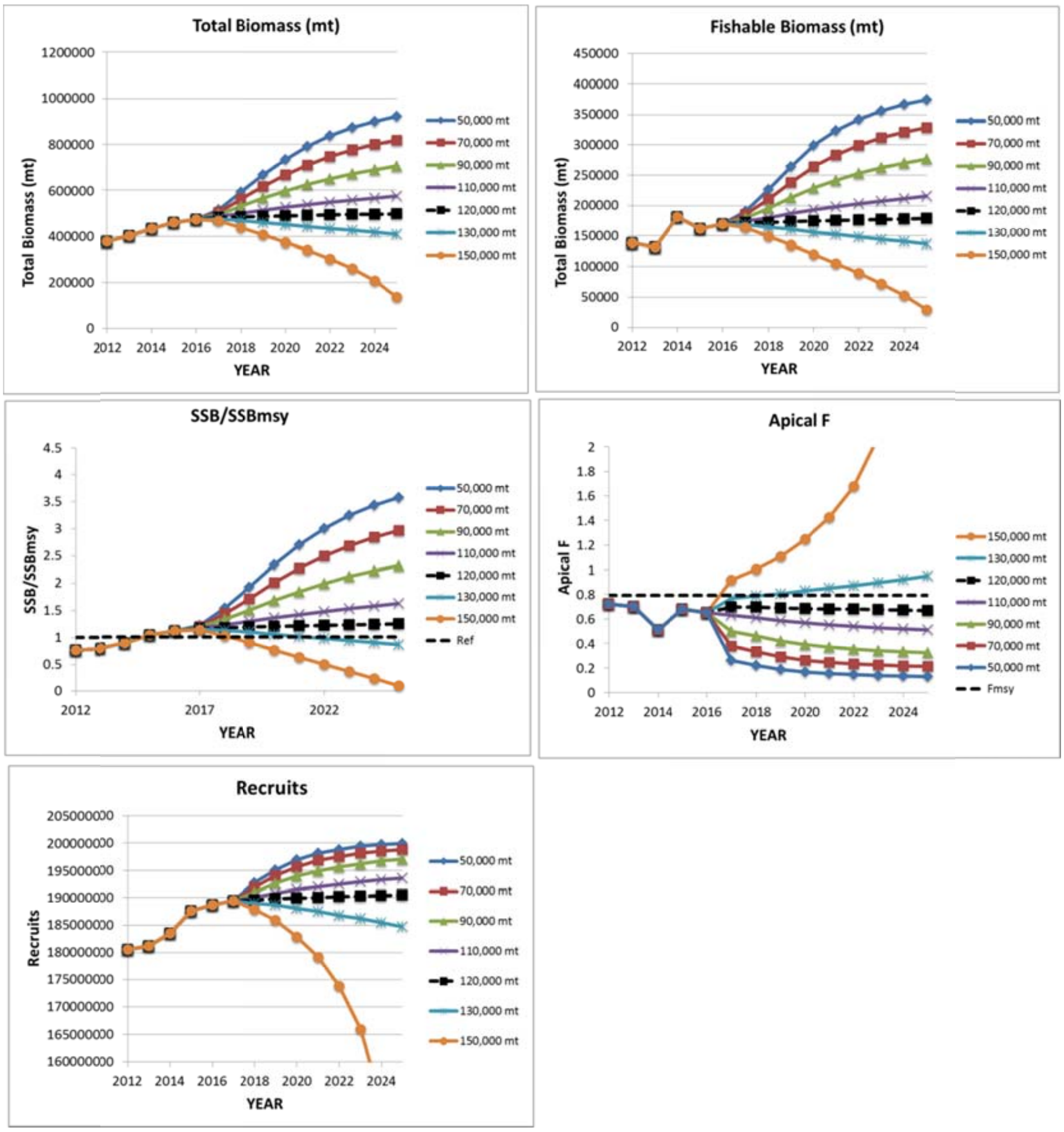

Figure 72. VPA Cluster 1: Projections of total biomass, fishable biomass, SSB/SSB_{MSY}, F relative to F_{MSY} and recruitment.

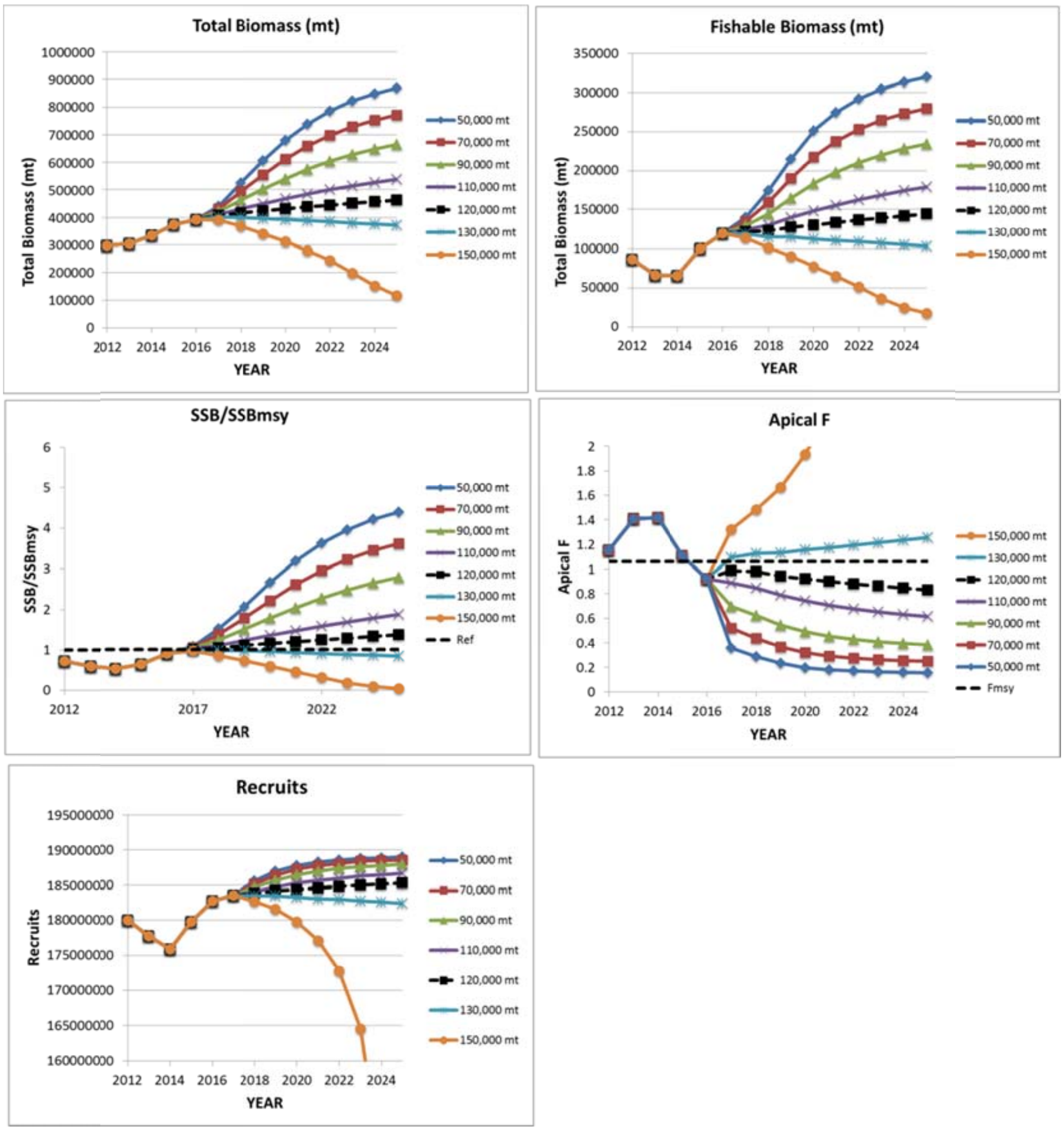

Figure 73. VPA Cluster 2: Projections of total biomass, fishable biomass, SSB/SSB$_{MSY}$, F relative to F$_{MSY}$ and recruitment.

Appendix 1

Agenda

1. Opening, adoption of Agenda and meeting arrangements
2. Summary of available data for assessment
   2.1 Biology
   2.2 Catch, effort, size and CAS/CAA estimates
   2.3 Relative Abundance estimates
3. Stocks Assessment Methods and other data relevant to the assessment
   3.1 Production models
   3.2 ASPM
   3.3 Catch statistical models: Stock Synthesis
   3.4 VPA
   3.5 Other methods
4. Stock status results
   4.1 Production models
   4.2 ASPM
   4.3 Stock Synthesis
   4.4 VPA
   4.5 Other methods
   4.6 Synthesis of assessment results
5. Projections
   5.1 ASPIC model projections
   5.2 Age Structured Production Model projections
   5.3 Stock Synthesis model projections
   5.4 VPA model projections
   5.5 Kobe matrix for yellowfin
6. Recommendations
   6.1 Research and statistics
   6.2 Management
7. Other matters
8. Adoption of the report and closure

Appendix 2

List of participants

CONTRACTING PARTIES

BRAZIL
Travassos, Paulo
Universidade Federal Rural de Pernambuco - UFRPE, Laboratorio de Ecologia Marinha - LEMAR, Departamento de Pesca e Aquicultura - DEPAq Avenida Dom Manoel Medeiros s/n - Dois Irmaos, CEP 52.171-900 Recife, Pernambuco, Brazil
Tel: +55 81 3320 6511, Fax: +55 81 3320 6515, E-Mail: p.travassos@depaq.ufrpe.br

CÔTE D'IVOIRE
Amandè, Monin Justin
Chercheur Halieute, Centre de Recherches Océanologiques de Côte d'Ivoire, Département Ressources Aquatiques Vivantes - DRAV29 Rue des Pêcheurs, BP V 18, Abidjan 01, Côte d'Ivoire
Tel: +225 05 927 927, Fax: +225 21 351 155, E-Mail: monin.amande@yahoo.fr; monin.amande@cro-ci.org

EUROPEAN UNION
Gaertner, Daniel
Center for Marine Biodiversity, Exploitation & Conservation, IRD-UMR MARBECCRH, CS 30171, Av. Jean Monnet, 34203 Sète Cédex, France
Tel: +33 4 99 57 32 31, Fax: +33 4 99 57 32 95, E-Mail: daniel.gaertner@ird.fr

Lopez, Jon
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia - Gipuzkoa, Spain
Tel: +34 634 209 738, Fax: +34 94 657 25 55, E-Mail: jlopez@azti.es

Merino, Gorka
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia - Gipuzkoa, Spain
Tel: +34 94 657 4000; +34 664 793 401, Fax: +34 94 300 4801, E-Mail: gmerino@azti.es

Murua, Hilario
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia Gipuzkoa, Spain
Tel: +34 667 174 433, E-Mail: hmurua@azti.es

Pascual Alayón, Pedro José
Centro Oceanográfico de Canarias (IEO), Darsena Pesquera, Parcela 8, S/C de Tenerife, Spain
Tel: +34 922549400/01, Fax: +34 922549495 E-Mail: pedro.pascual@ca.ieo.es

Rodríguez-Sahagún González, Juan Pablo
Gerente Adjunto, ANABAC, C/ Txibitxiaga, 24 - Entreplanta Apartado 49, 48370 Bermeo Bizkaia, Spain
Tel: +34 94 688 28 06; 627454864, Fax: +34 94 688 50 17, E-Mail: anabac@anabac.org

Rubio, Iratxe
ANABAC - Asociación Nacional de Armadores de Buques Atuneros Congeladores, Txibitxiaga, 24 - Entreplanta Apartado 49, 48370 Bermeo Bizkaia, Spain
Tel: +34 94 688 28 06, Fax: +34 94 688 50 17, E-Mail: anabac@anabac.org

Sundelöf, Andreas
Swedish University of Agricultural Sciences, Institute of Marine Resources Turistgatan, 5, SE-453 30 Lysekil, Sweden
Tel: +46 104784069, Fax: +46 5231 3977, E-Mail: andreas.sundelof@slu.se

GHANA
Ayivi, Sylvia Sefakor Awo
Ministry of Fisheries and Aquaculture Development, Fisheries Scientific Survey Division, P.O. Box BT 62, Tema, Ghana
Tel: + 233 2441 76300, Fax: +233 3032 008048, E-Mail: asmasus@yahoo.com

JAPAN
Matsumoto, Takayuki
Senior Researcher, Tuna and Skipjack Resources Division, National Research Institute of Far Seas Fisheries, Fisheries Research Agency5-7-1 Orido, Shizuoka Shimizu 424-8633, Japan
Tel: +81 54 336 6016, Fax: +81 54 335 9642, E-Mail: matumot@affrc.go.jp

Satoh, Keisuke
National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shizuoka Shimizu 424-8633, Japan
Tel: +81 54 336 6044, Fax: +81 54 335 9642, E-Mail: kstu21@fra.affrc.go.jp

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

Yokoi, Hiroki
National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shizuoka Shimizu 424-8633, Japan
Tel: +81 54 336 6045, Fax: +81 54 335 9642, E-Mail: yokoih@affrc.go.jp

MAURITANIA
Braham, Cheikh Baye
Halieute, Géo-Statisticien, modélisteur; Chef du Service Statistique, Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), BP 22 Nouadhibou, Mauritania
Tel: +222 4822 0127, E-Mail: baye_braham@yahoo.fr; baye.braham@gmail.com

SAO TOMÉ & PRÍNCIPE
Anibal, Olavio
Inspector Sanitario, Direcçao das Pescas, C.P. 59, Sao Tomé , Sao Tomé & Principe
Tel: +239 990 5019, Fax: +239 222828, E-Mail: olavoanibal@hotmail.com; etybi@yahoo.fr

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

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

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

Sculley, Michelle
University of Miami, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami FL 33149, United States
Tel: +1 305 421 4920, E-Mail: mjohnston@rsmas.miami.edu

Sharma, Rishi
SEFSC, 75 Virginia Beach Drive, Miami, Florida 33149, United States
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, United States
Tel: +305 365 4114, Fax: +1 305 361 4562, E-Mail: john.f.walter@noaa.gov

URUGUAY
Forselledo Cladera, Rodrigo
Dirección Nacional de Recursos Acuáticos - DINARA, Sección de Recursos Pelágicos de Altura Constituyente 1497, 11200 Montevideo, Uruguay
Tel: +598 2400 46 89, Fax: +598 241 32 16, E-Mail: rforselledo@gmail.com

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

INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION – ISSF
Justel, Ana
ISSF-Spain, C/ Francisco Giralte 2, 28002 Madrid, Spain
Tel: +34 91 745 3075, E-Mail: ajustel@iss-foundation.org

Scott, Gerald P.
11699 SW 50th Ct, Cooper City, Florida 33330, United States
Tel: +1 954 465 5589, E-Mail: gpscott_fish@hotmail.com

SCRS CHAIRMAN

Die, David
SCRS Chairman, Cooperative Institute of Marine and Atmospheric Studies, University of Miami, 4600 Rickenbacker Causeway, Miami Florida 33149, United States
Tel: +1 305 421 4607, Fax: +1 305 421 4221, E-Mail: ddie@rsmas.miami.edu

****

ICCAT Secretariat
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

Bear, Doug
Kell, Laurence
Santos, Miguel Neves
Ortiz, Mauricio

Appendix 3

List of Documents and Presentations

Reference	*Title*	*Authors*
SCRS/2016/083	Update on standardized catch rates for yellowfin tuna (*Thunnus albacares*) from Venezuelan pelagic longline fishery of the Caribbean Sea and Western Central Atlantic	Narváez M., Ortiz M., Arocha F., Medina M., Gutiérrez X. and Marcano J.H.
SCRS/2016/104	Stock assessment for Atlantic yellowfin tuna using a non-equilibrium production model	Matsumoto T., and Satoh K.
SCRS/2016/105	Preliminary Virtual Population Analyses of Atlantic yellowfin tuna	Cass-Calay S.L., Sculley M., and Brown C.A.
SCRS/2016/106	Update of the Ageit software to incorporate natural and fishing mortality in the estimation of catch at age from catch at size	Ortiz M.
SCRS/2016/107	Estimation of Ghana's Task I and Task II purse seine and baitboat catch 2006-2014: data input for the 2016 yellowfin stock assessment	Ortiz M. and Palma C.
SCRS/2016/108	Review and preliminary analyses of size frequency samples of yellowfin tuna (*Thunnus albacares*)	Ortiz M. and Palma C.
SCRS/2016/109	Yellowfin tuna stock assessment model CPUE evaluation	Walter J., Cass-Calay S. and Sharma R.
SCRS/2016/110	Atlantic Ocean yellowfin tuna stock assessment 1950-2014 using stock synthesis	Walter J. and Sharma R.
SCRS/2016/111	Stock assessment for Atlantic yellowfin tuna using age structured production model	Satoh K., Yokoi H., Nishida T. and Matsumoto T.
SCRS/2016/116	Scaling natural mortality rate as a function of length or weight with an application to yellowfin tuna	Walter J., Sharma R., Cass-Calay S., Ortiz M. and Brown C.

SCRS/P/2016/023	Conversiones talla-talla (largo horquilla-largo predorsal) para el atún aleta amarilla (*Thunnus albacares*)	Mas F., Forselledo R. and Domingo A.
SCRS/P/2016/024	Yellowfin tuna: review of Task II size data reported by Uruguay	Forselledo R. and Domingo A.
SCRS/P/2016/028	Updates to the yellowfin CAS and CAA estimations (1965 to 2014)	Palma C. and Ortiz M.

Appendix 4

Specific Index Recommendations

1) EU-Spain FAD Index:

This index was recently developed using a delta-lognormal standardization approach. No document or diagnostics are available presently, but are expected next week. The index does not directly account for changes in fishing power.

Advantages: The only index that references young (<10 kg) yellowfin tuna. Catches by the Spanish PS fleet on FADs are significant and occur over a large spatial area.

Disadvantages: Significant changes in catchability/fishing power are not accounted for. Unclear whether effort represents search time, fishing time or a combination.

Recommendations: DO NOT INCLUDE in any "base" models unless the indices can be adjusted to account for changes in fishing power.

2) EU-Spain Free-School Index:

No index, document or diagnostics are available presently, but are expected next week. The index is not expected to directly account for changes in fishing power.

Advantages: Catches by the Spanish PS fleet are significant and occur over a large spatial area.

Disadvantages: Significant changes in catchability/fishing power may not be adequately accounted for. Unclear whether effort represents search time, fishing time or a combination.

Recommendations: DO NOT INCLUDE in any "base" models unless the indices can be adjusted to account for changes in fishing power.

3) "Relict" PS and FAD Indices:

A number of PS/FAD indices were developed for the 2011 assessment, and changes in fishing power were considered through post-hoc adjustments.

Advantages: Catches by the EU_PS fleets are significant and occur over a large spatial area.

Disadvantages: Significant changes in catchability/fishing power may not be adequately accounted for. Unclear whether effort represents search time, fishing time or a combination.

Recommendations: DO NOT INCLUDE in any "base" models unless the indices can be adjusted to account for changes in fishing power.

4) Other "Relict" Indices (i.e. Canary Islands baitboat, Brazil baitboat, Venezuelan purse seine):

NOT UPDATED or REVIEWED at the 2016 or 2011 assessments.

Recommendations: DO NOT INCLUDE in any "base" models.

5) Japanese LL (weighted by area):

This standardized index has been further explored and revised to satisfy the YFT Species Group requests.

Advantages: Long time series, extensive spatial coverage.

Disadvantages: There is a noted shift in targeting from YFT before 1975, to BET after 1976. This change in targeting was likely accompanied by changes in gear configuration and/or fishing operations, but data describing gear configuration are not available to directly quantify the change in targeting.

Recommendation: INCLUDE this index in all stock assessment models 1976-2014. Use full time series in sensitivity runs.

6) U.S. Longline Index:

Advantages: Moderately long time series, moderately large spatial extent.

Disadvantages: Localized trends in abundance?

Recommendation: INCLUDE this index in all stock assessment models.

7) Brazilian longline:

This standardized index has been further explored to satisfy the YFT Species Group requests. Information provided by the authors since the data preparatory meeting suggests that the complex fleet characteristics have been dealt with to the extent possible.

Advantages: Moderately long time series, moderately large spatial extent.

Disadvantages: The Group noted the high inter-annual variability in the index and high variance associated with the annual indices. The Group also considered that the extensive changes of vessels and fishing strategies over time may hamper the ability of the model to achieve full standardization, absent more detailed data on vessel and gear characteristics.

Recommendation: INCLUDE this index in all stock assessment models.

8) Chinese Taipei Longline (Broken into 2 time periods):

This standardized index has been further explored and revised to satisfy the YFT Species Group requests. The author provided an index that accounted for changes in targeting as in the recent BET assessment by sub-setting the data for the period where there is information on fishing strategy.

Advantages: Long time series, extensive spatial coverage.

Disadvantages: There is a noted shift in fishing operations/size-at-age/data collection after 1992. Requires a break in the index to account for a likely change in selectivity.

Recommendation: INCLUDE both indices in "base" stock assessment models. For the latter index, use the index developed using the BET methodology to infer targeting.

9) Venezuela LL:

Advantages: Moderately long time series, moderately large spatial extent.

Disadvantages: None specifically noted.

Recommendation: INCLUDE this index in all stock assessment models.

10) Uruguay LL: (Broken into 2 time periods):

Advantages: Moderately long time series, moderately large spatial extent.

Disadvantages: Index is "broken" to account for a change in fishing operations. Index preforms poorly in a test of "biologically implausible deviations". Could suffer from larger than average process error.

Recommendation: INCLUDE this index in all stock assessment models.