REPORT OF THE 2013 ICCAT NORTH AND SOUTH ATLANTIC ALBACORE STOCK ASSESSMENT MEETING

(Sukarrieta, Spain - June 17 to 24, 2013)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at AZTI-Tecnalia in Sukarrieta, Spain June 17 to 24, 2013. Dr. Pilar Pallarés, on behalf of the ICCAT Executive Secretary, thanked AZTI for hosting the meeting and providing all logistical arrangements.

Dr. Haritz Arrizabalaga (EC-Spain), the Albacore Species Group Rapporteur, chaired the meeting. Dr. Arrizabalaga welcomed meeting participants ("the Group") and proceeded to review the Agenda which was adopted with some changes (**Appendix 1**).

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

P. Pallarés	Items 1and 7
G. Diaz, H. Arrizabalaga	Item 2
G. Scott	Item 3
P. de Bruyn, M. Schrripa, G. Merino, M. Lauretta	Item 4.1
E. Babcock, T. Matsumoto	Item 4.2
L. Kell, G. Merino	Item 5
H. Arrizabalaga, G. Scott, M. Keatinge	Item 6
H. Arrizabalaga	Item 7

2. Summary of available data for assessment

The data available for the albacore stock assessment meeting is summarized in the Report of the 2013 ICCAT North and South Atlantic Albacore Data Preparatory Meeting (SCRS/2013/013). The Group reviewed new information that was made available after the data preparatory meeting held in Madrid April 22-26, 2013.

2.1 Biology

Document SCRS/2013/113 characterized the oceanographic conditions in the albacore distribution area within the northeast Atlantic Ocean, and attempted to identify the environmental conditions that cause inter-annual fluctuations in the catches of this species. The analysis focused on those years when catches by the Basque fleet were low (i.e., 2000, 2001 and 2009, 2010) compared to other more favorable years (i.e., 2005, 2006). The study presented some preliminary results on the potential importance of the Gulf Stream index for albacore survival and recruitment, and it highlighted the relevance of parameters such as SST, meso-scale structures, and stratification of the water column in the albcore catchability.

The Group discussed the need to put the albacore CPUE from the Bay of Biscay into context given the information provided in the document. It was discussed by the Group that the document shows a series of correlations between oceanographic features and albacore catches by the Basque fleet, but the document did not provide any hypothesizes to explain most of the results. However, the Group found the negative correlation between the depth of the mix layer and albacore catchability to be useful information that could be taken into consideration when interpreting CPUEs. It was suggested that the authors explore availability of historical time-series data on mixed layer depth for possible use in standardizing CPUE.

Document SCRS/2013/103 presented preliminary results of a reproductive study of albacore in the southwestern Atlantic Ocean. A total of 14 specimens were analyzed: 10 males and 4 females. The reproductive organs (ovaries and testes) were collected and preserved in 10% formaldehyde. Histological cuts between 8 and 10 µm thick were made with a microtome and dyed with Mayer Haematoxylin and Eosin. In all the male gonads, dark acidophil zones evidencing the accumulation of genetic material (DNA) was observed, indicating that males were in spawning condition. In females, however, only oogonias and oocytes in stages I (immature) and II (resting) were observed, indicating that all females analyzed were mature, but inactive. The result from the analysis of female gonads is consistent with the hypothesis that spawning occurs at lower latitudes. The Group encouraged the authors to expand the study by increasing the sample size.

Document SCRS/2013/126 presented the results of a bibliographical review on the identification of albacore populations among and within oceanic regions (Atlantic, Pacific, and Indian Oceans, and Mediterranean Sea). This document is the first step on a global review of albacore using an international aquatic database (ASFA). The document reviewed 367 publications, mainly composed of articles (64%) but also included the revision of conference papers, proceedings and reports (24%), and books (12%). The authors concluded that, due to the divergence of the results, the concept of stock and its delimitation remains a controversial issue. The authors indicated that there is an urgent need in most regions of the world for further albacore studies to review and improve the current management units used by Regional Fishery Management Organizations.

Considering management used for albacore in the Atlantic, the Group discussed the possibility that immature albacore found in South African Atlantic waters are migrants from the Indian Ocean and, therefore, be part of that ocean's stock. The Group recognized that at present there is no quantitative information available to inform the assessment models on this issue. Therefore, any attempts to include this type of information in an assessment should be made as 'what if' scenarios to examine sensitivity of assessments to this hypothesis. The Group also discussed the potential migration of albacore from South African waters to South American waters. It was indicated that the seasonal changes in the areas of operation of the Chinese-Taipei longline fleet in the South Atlantic might be in response of this hypothesized albacore migration.

2.2 Catch, effort, size, and catch-at-age (CAA)

Document SCRS/2013/122 presented the albacore CAA prepared by the Secretariat for use in virtual population analysis (VPA). The document described the procedure used to estimate the CAA from catch-at-size, the changes made to the aging algorithm used in the 2009 stock assessment, and the differences between the CAA generated for the 2009 and the current 2013 assessments. The document described that the total number of fish estimated by the CAA was the same between the 2 assessments (2009 and 2013). However, differences were found in the number of fish at age. The author explained that these differences can be mostly, but not completely, explained by 2 main factors: (1) a change in the value of epsilon (controlling the number of iterations) used in the aging protocol, and (2) changes in the definition of the quarter (since fish are assumed to be born on April 1, the quarter April-June was defined as quarter 1). However, the author also indicated that the change in the definition of quarter can be handled with the Mean-Length-at-Age (MLAA) and it recommended that the following steps be taken:

a) Continue to use the MLAA as originally developed.
b) Use the calendar quarter and inform the VPA model that the month of birth for N-ALB is 4.
c) In all cases input the CAA, Catch, WAA, PCAA, maturity, etc. in calendar year Jan-Dec.

The estimated CAA is presented in **Table 1, Figure 1** and **Figure 2.** The MLAA are shown in **Table 2.**

2.3 Relative abundance estimates

In the data preparatory meeting, an update of the Spanish troll CPUE series was presented (SCRS/2013/053), which covered the period 1981-2011. In the process of building input files for Multifan (MFCL) analysis, this recent CPUE series was merged to two previous troll series, namely a standardized French troll CPUE series (1967-1986) and a nominal CPUE series between 1931 and 1975 (Bard 1977), to build a composite CPUE series that allowed estimating effort for Fishery 2 between 1930 and 2011. The methodology used to produce this composite series is described in Anon. (2010). In this case, a GLM controlling for source of data (fishery), quarter, and year was used to merge the three different sources to a common scale for use in MFCL analyses. In the case of assessment models using annual time scales for fitting, the GLM applied controlled for year and source of information. **Figures 3** and **4** show the resulting patterns.

The Group discussed the CPUE series corresponding to the Uruguayan pelagic longline fleet that was presented in the data Preparatory Meeting (SCRS/2013/043). After considering the changes on the target species of this fleet over time, the Group agreed to split this series into two time periods: 1982-1991 when the fleet was targeting bigeye tuna, and 1992-2012 when the target of this fleet was SWO.

During the data preparatory meeting, the Group screened the available CPUE series and decided not to use some of them as input in the stock assessment models (e.g., the transition periods for Japan and Chinese Taipei, as well as South African baitboat and Brazilian longline, see Anon 2013). Still, the Group noted that the Taiwanese and Japanese longline indices, being the main longline indices for both the north and the south, showed some contrasting trends and negative correlations (**Figures 5 and 6**). The Group noted that including both indices in the assessment models might have a confounding effect and decided to further explore the nature of these indices. In the North Atlantic, both fisheries show clear differences in their areas of operation (**Figures 7**). In latitude, both fleets overlap mostly within the 20-40ºN, but the Chinese Taipei fleet operates mostly west of 30ºW. The Group noted that the signals provided by both the Chinese Taipei and the Japanese nominal CPUEs were quite similar in this area delimited by 20ºN-40ºN and west of 30ºW (**Figure 8**). The Group expressed concern that the CPUE standardization might not have fully accounted for spatial effects. Considering that the Chinese Taipei fleet has been targeting albacore more consistently, with a high proportion of their effort having albacore as the dominant catch (**Figure 9**), and as its area of operation has not changed as much compared to the Japanese fleet, and its level of albacore catches have also remained substantially higher during the last decades, the Group decided to include the Chinese Taipei index in the base run while downweighting the Japanese longline index.

In the South Atlantic, the Group inspected the fishing areas for both fleets and observed similarity and consistency in the areas fished by Japan in the early period and Chinese Taipei in subsequent periods (**Figure 7**) when Japan reduced effective albacore fishing area (number of 5ºx5º geographical squares with at least 1 ton of albacore caught) (**Figure 10**). The Group agreed that the Chinese Taipei index might better reflect albacore abundance in the southern Atlantic given that this fleet targeted albacore more consistently throughout the period with less spatial shifts in their operations (this decision also supports scenarios where CPUEs are weighted by catch). However, the Group also noted that by-catch fisheries, in some cases, can also track population abundance and those spatial aspects needed to be further investigated in the CPUE standardization process. Thus, the Group decided, for continuity purposes, to consider both catch weighted and equally weighted scenarios in the southern Atlantic.

3. Limit and Target Reference Points and Kobe Advice Framework

Noting that the Commission has requested SCRS to identify a limit reference point for northern albacore (Rec. 11-04), SCRS/2013/120 provided examples of an approach for enhancing dialogue between SCRS and the Commission for advancing the application of Harvest Control Rules (HCR) incorporating limit and target reference points. Additionally, the approach provides advice in the Kobe Strategy Matrix framework consistent with the Commission's decision making policy for development and application of conservation and management measures (Rec. 11-13). In combination, the guiding principles in Rec. 11-13 provide a basis for design of HCRs. SCRS has recommended a generic HCR (ICCAT, 2012), upon which stock-specific robustness testing through Management Strategy Evaluation (MSE) can and will be conducted in order to fine-tune HCRs which can achieve the Commission's objectives while considering the uncertainty in assessments that SCRS can quantify.

In order to advance the Commission-SCRS dialogue, the Group agreed to provide information to the Commission on the basis of a range of interim HCR parameter values which would meet the Commission's policy based on the assessment outcomes, as paraphrased below (also see **Figure 11**):

1. For stocks in the green quadrant of the Kobe plot, management measures shall be designed to result in a **high probability** of maintaining the stock within this quadrant.
2. For stocks that are in the upper right yellow quadrant of the Kobe plot (overfishing), the Commission shall immediately adopt management measures designed to result in a **high probability** of ending overfishing in **as short a period as possible**.
3. For stocks in the red quadrant of the Kobe plot (overfishing and overfished), the Commission shall immediately adopt management measures, designed to result in a **high probability** of ending overfishing in **as short a period as possible** and the Commission shall adopt a plan to rebuild these stocks, and
4. For stocks in the lower left yellow quadrant of the Kobe plot (overfished but no overfishing), the Commission shall adopt management measures designed to rebuild these stocks in **as short a period as possible**.

The Group noted that different methods for quantifying uncertainty in stock status evaluations can result in different probability expectations (SCRS/2013/117) and, since there is not yet a unified approach across the stock assessment methods applied to quantify uncertainty, it is an important research area to focus upon and to consider in MSE. Nonetheless, the Commission expects management advice based upon the quantified uncertainties in the assessments SCRS conducts (Res. 11-14).

The Group decided to provide model probability expectations given the uncertainty the Group was able to quantify for the assessment for a range of interim HCR parameter values (**Table 3**) in the generic HCR recommended by SCRS (see **Figure 12**) to guide discussion about the policy decision points: 'high probability' and 'as short as possible'.

An **interim** biomass limit reference point of $0.4B_{MSY}$ was recommended which is consistent with robust limits recommended for a number of Pacific tuna stocks (e.g. Preece, et al. 2011) and other cases, until a fuller range of MSE testing can be conducted for other candidates. The Group recommended that management advice be provided in HCR (F) K2SMs format described in SCRS/2013/120 in order to promote dialogue on the Commission's policy choices under Rec. 11-13.

4. Stock assessment

Document SCRS/2013/036, first presented during the 2013 Meeting of the ICCAT Working Group on Stock Assessment Methods, reported a summary of methods for diagnosing abundance indices fitted as part of stock assessment models. Practical implementation of these techniques is shown in documents SCRS/2013/056 and SCRS/2013/057.

Document SCRS/2013/117 provided an evaluation of approaches for modelling uncertainty in the framework of biomass dynamic models. Those approaches included bootstrapping, jackknife, modelling uncertainty based on the covariance matrix, delta method, likelihood profiling and MCMC techniques. The document concluded that estimates of uncertainty obtained from the same data and stock assessment model vary depending on the method used to estimate the uncertainty. Therefore, further evaluations leading to 'Best Practices' are warranted.

4.1 North Atlantic albacore stock

4.1.1 SEAPODYM

Document SCRS/2013/125 presented the results of the first optimization experiment for the North Atlantic stock using the model SEAPODYM. The model configuration used a coarse grid at 2°x2º and month resolution with environmental inputs from a hindcast simulation driven by an atmospheric reanalysis (NCEP). With this reanalysis (i.e. based on observation), the coupled physical-biogeochemical simulation provided reasonable seasonal to interannual and decadal variability. Nevertheless, other configurations at higher resolution providing more realistic ocean conditions should complete this first study.

Document SCRS/2013/121 discussed various potential questions and problems related to the SEAPODYM analysis, such as stock structure, uncertainty in the asymptotic size by sex, natural mortality as a function of age, changes in fishing power of the longline fleet targeting albacore, thermal preferendum of the various ages, etc. The document suggested that some results could be more realistic than those obtained by other stock assessment models. However, there are still a wide range of uncertainties in the present analysis and results should be more carefully explored before being considered for providing advice.

The Group welcomed a modeling approach that considered spatial dynamics as well as environmental influences, since these are important elements of albacore population dynamics that are not considered in the models currently used for stock assessment. The group also agreed that the SEAPODYM model could be useful in the process of generating and testing hypotheses.

4.1.2 Multifan-CL

In document SCRS/2013/058 a preliminary stock assessment with Multifan-CL for the northern stock of Atlantic albacore with a suite of exploratory data analysis and diagnostics was presented. The document proposed applying a factorial design for scenarios to analyze the uncertainty associated with the dynamic behaviour of fishing fleets and available data. The document recommended that such designs be incorporated into 'Best Practices' in future stock assessments and MSEs.

Although preliminary results for this model were presented, further investigation into the data revealed several serious conflicts in the input data. Firstly, it was noted that several key CPUE series were developed as catch in numbers per unit of effort, whereas the total catch input into the model was in weight. As the Multifan-CL uses the standardized CPUEs and the reported total catch to calculate standardized effort, the difference in units between the CPUE and catch can cause bias in the effort estimations, particularly if the average weight of the fish in a given fishery has changed significantly over time. As a result, the effort estimations included in the preliminary model were less reliable.

In order to overcome this issue, total catch in number was requested for the longline fleets and this information was received making the CPUE and catch information consistent. For the surface fleets, this information was not available and so the catch in weight had to be converted to catch in size using an average weight of fish for each fishery per year. This information was available from the CAS database provided by the Secretariat from 1975 onwards. For fleet 1, these data were sufficient to convert the catch in weight to numbers, as the fishery initiated in 1981. For fleet 2, which started in 1930, an average of the average weight for this fleet between 1975 and 1980 was used to convert the catch into numbers prior to 1975.

Once this had been conducted, new MFCL input files were created with the same units for the catch and CPUE data. A number of model run options were then discussed, proposed and conducted (**Table 4**). Much discussion was held over the initial model parameterisation and structure. The authors of document SCRS/2013/058 proposed an initial model structure that differed from the model structure used for the 2009 assessment essentially in that the Japanese longline CPUE and the Chinese Taipei longline size frequencies were heavily down-weighted. This structure is detailed and justified in SCRS/2013/058 (see also Section 2 of this report), with the base case run outlined in that document only changing due to the changes in the input files (frq file) noted above. As this formulation differed from the previous assessment model and data structure, several sensitivity runs were conducted to assess the implications of these changes.

One of the major discussion issues was the exclusion of the Japanese CPUE series from this updated base assessment. Exploratory data analysis indicated that the Japanese and Chinese Taipei LL CPUE series were negatively correlated in certain overlapping periods. This was further discussed during the 2013 albacore data preparatory meeting which concluded that it would not be appropriate to include both Chinese Taipei and Japanese LL CPUE series in the same model as the MFCL model might not be able to resolve conflicting trends internally. As the Chinese Taipei fishery operates in the core area of the fishing area, whereas the Japanese fleet has shifted either North or South to target other species, its movement away from the core area could mean that this CPUE series no longer provides a reliable index of the population abundance in the core region and thus it was downweighted in the base model (see also agenda item 2) to address this concern. Sensitivity evaluation of the implications of downweighting the Japanese index was also conducted. Similar evaluations of other fleet CPUEs were not conducted owing to time constraints, but could be incorporated into a factorial design in future assessments.

Another area of major discussion involved the use of the Chinese Taipei LL size frequency information. In the base case model, this information was heavily downweighted as the mean length of the sampled catch from this fishery was highly variable in certain time periods, but the reasons for such variations were unclear, (F**igure 13**). Large increases in average size in the most recent years might be related to increases in sampling coverage, but potentially also to biased spatial sampling (samples coming from more equatorial regions and thus less representative of the whole area of distribution). Thus, the recent increase in fish size is probably not consistent with the albacore stock dynamics. As a consequence, the size frequency data may not be representative of the size composition of the underlying population, at least in a way the model's current spatial structure could accommodate. However, it was agreed that a sensitivity run should be conducted to include this Chinese Taipei size frequency information to assess its effect on the model outputs. In fact, these data were poorly fit assuming a logistic selectivity and additional sensitivities were conducted assuming dome shaped selectivity. Sensitivity evaluation of the implications of essentially ignoring the Chinese Taipei size frequency was also conducted.

Other sensitivity runs included considering both the Chinese Taipei size frequency and Japanese CPUE, down-weighting all the size frequency (SF) series, starting the model in a different year to test the influence the starting assumptions on the population structure had on the model outputs, considering alternative biological assumptions such as age dependent natural mortality, as well as including tagging data. In the latter case, only tagging data from release events occurring between 1988 and 1991 were considered, as this coincided with a period in which, by far, the majority of tags were released as opposed to the rather low level of tagging which has occurred outside this period.

Results of the MFCL model

Although the growth curve parameters in the Multifan-CL model were fixed (Santiago and Arrizabalaga 2005), the mean lengths of the first 2 age classes were estimated independently in order to accommodate deviations from the von Bertalanffy Growth Function (VBGF). The final growth curve is presented in **Figure 14**. **Figure 15** shows the estimated biomass trajectory for the northern albacore stock over the assessment period, according to the base case. Estimated current biomass was approximately 185980 t, with SSB/SSB_{MSY} at 0.94.

Figure 16 provides the estimated recruitments over the assessment period. Unlike the recruitment estimated during the 2009 assessment where recruitments during the first decades remained low compared to the rest of the time period, the recruitments estimated in this assessment appeared to be fairly variable, but with consistent ranges over the assessment period; time series of F by age class are presented in **Figure 17.** F is estimated to increase sharply in the 1950s, which corresponds to the first period in which size frequency data is available and so more information is available to separate the catches into age classes. This period is also when substantial increases in catch occurred immediately post WWII.

Figure 18 shows the effort deviations over time by fishery, as well as the observed and predicted CPUEs. The overall consistency of the model with the observed effort data can be examined in these plots. If the model is coherent with the effort data, an even scatter of effort deviations around zero would be expected (although some outliers can also be expected). If there was an obvious trend in the effort deviations with time, this may indicate that a trend in catchability had occurred and that this had not been sufficiently captured by the model (Hampton 2002). For the majority of fisheries there are no obvious trends in the effort deviations and although this would indicate that the model has extracted most of the information present in the data regarding catchability variation. However, this is not always the case and additional tuning of the model may be appropriate for future runs. Fleet 1 in particular appears to have mainly positive deviations.

Estimated selectivities are presented in **Figure 19.** Although most LL selectivities were constrained to be logistic, the Japanese transition period (fishery 6) and Japanese by-catch period (fishery 7) selectivities were estimated within the model. It is interesting that dome-shaped selectivities were estimated for these fisheries, possibly due to the fleets operation moving to the fringes of the core fishing area and, thus possibly increasing catch of smaller fish, although the estimates could also be the result of confounding with other model structural assumptions.

The yield analysis conducted here incorporated the stock-recruitment relationship (**Figure 20)** into the equilibrium biomass and yield estimates. The steepness was estimated to be 0.83, which is slightly different from the prior mode of 0.75. The yield curve which estimates a maximum sustainable yield of 31 680 t at an effort multiplier of 1.38 is presented in **Figure 21**. The corresponding reference points B/B_{MSY}, SSB/SSB_{MSY} and F/F_{MSY} are shown in **Figures 22, 23 and 24,** respectively. These would indicate that the current population biomass is below the biomass that can support a MSY (0.80), the spawning stock biomass is also slightly below SSB_{MSY} (0.94) while current F is below the F that would give MSY (0.72). Therefore, these results indicate that the stock is overfished, but not undergoing overfishing.

The overall model fits to the SF data are presented in **Figure 25** and the residuals in **Figure 26**. The fits to the size data are not always particularly good and this shows that the structural assumptions regarding selectivity do not fully account for shifts in SF over time or for unusually shaped SF distributions (such as bimodal distributions in the available data).

As both the input data and model specification changed substantially between the current assessment and that conducted in 2009, several sensitivity runs were performed to evaluate the effect these changes have on the model outcomes. The major changes include the downweighting or not the Japanese LL CPUE data, the downweighting or not the Chinese Taipei LL SF data and the change in standardized effort due to the use of total catch in numbers for certain fleets in the current assessment as opposed to the use of total catch in weight for those fleets in the past assessment. Run Alt8 specifically deals with the issue of catch in weight or numbers. **Table 5** shows the relative SSB/SSB_{MSY} and F/F_{MSY} benchmarks for the current base model along with the relative benchmarks for all the alternate runs. It was clear that the use of catch in weight (as done in 2009), and shown in Run Alt8, results in a more pessimistic view regarding the current stock status.

Biomass trajectories over time for the base case and all alternate runs are presented in **Figure 27,** while key model output parameters such as steepness and reference points are presented in **Table 5**. Run Alt7 is fairly similar to the model specifications of the 2009 4B model. It can be seen that the inclusion of both the Japanese LL CPUE and Chinese Taipei LL SF data result in a more pessimistic stock evaluation. This is further reinforced in runs Alt1 and Alt4 which include individually the Chinese Taipei LL SF and the Japanese LL CPUE, respectively. In Run Alt1 the Chinese Taipei LL selectivity was allowed to be non-logistic. This was conducted in order to try and capture the fact that although the selectivity had been constrained to be logistic, the absence of large fish in the SF data resulted in very poor fits to the SF data and if this change was not made the model would not have converged. This run attempted to allow the model freedom to independently calculate the shape of the selectivity curve based on the actual SF data provided to the model. In addition, the constraint that made selectivities for all fish of age 10 and over the same was removed. The new selectivities calculated for the three Chinese Taipei longline fleets by this alternate run are presented in **Figure 28**. This still resulted in a pessimistic stock evaluation.

The change in the starting year on the model (Alt2) had little effect on either the biomass trajectory or the relative benchmarks. Downweighting all the SF data (Alt3) to assess the influence this information had on the model fit resulted in a slightly more pessimistic stock evaluation, while including an age-specific vector of natural mortality (Alt5) slightly improved the stock status. This natural mortality vector is presented in **Figure 29**. The inclusion of the tagging data between 1988 and 1991 (tag), resulted in estimates of stock status very similar to the base case model. In order to see what the stock status may have been in 2009 had the corrected data been used along with the current model specification, a variation on the base case was run, but excluding the final 4 years of data (mirroring the time period used in the previous assessment). This run (Alt 6) shows that had the current corrected data and modified model parameterization been used, the stock status relative to benchmarks would have been relatively similar, but slightly more pessimistic than those estimated in 2009. We can also infer from this run that there is information in the data over the final four years (2008-2011) of the current model that indicates that the stock condition had improved since 2007.

In general, the ranges of estimated steepness vary between 0.80 and 0.88, all of which are higher than the median of the prior distribution. This would imply that there is some information in the data regarding a relationship between spawning biomass and recruitment although it may not be particularly strong. For all models, the MSY estimation was similar, ranging between 26 000 t and 35 000 t. The majority of runs as well as the base case indicated that the stock is slightly overfished, but is no longer undergoing overfishing.

Diagnostics

The group noted that the AIC was not useful to compare fits to the data across different models because not all were based on the same datasets. However, the group felt that it might be useful to have some diagnostics regarding how well the different base and sensitivity runs were fitting the different CPUE series. For this purpose, the standard deviation of the effort residuals for each of the CPUE series in each of the models was computed and tabulated (**Table 6**). While not all runs were fitting to the same indices and so diagnostics which better account for this feature would be more appropriate, this table provided a basis for comparing the relative model-data agreement across the common indices that were fitted in the different runs. This table showed that the base case is amongst runs fitting best to the common indices (the runs with age specific natural mortality and the one including tagging information also showed comparable values). Further evaluation of this kind of diagnostic could be useful in the future to assign objective weights to different runs, e.g., in an MSE approach where a large number of hypotheses are being considered. However, it should be noted that the models like MFCL not only fit to CPUE series, and thus it might be useful to develop similar diagnostics for fits to size frequency data.

Likelihood profiling was conducted for the base case run F/F_{MSY} (**Figure 30**) and SSB/SSB_{MSY} (**Figure 31**). The profiles showed a fairly wide distribution, especially for the SSB/SSB_{MSY} profile. This would indicate that the uncertainty regarding the current status of SSB/SSB_{MSY} is higher than that for F/F_{MSY}. The profile for SSB/SSB_{MSY} is also skewed to the right. The profile would however indicate that the model did converge to a global solution.

The Group did not have available pairs of F/F_{MSY} and B/B_{MSY} estimates to represent the uncertainty around the current stock status, but had available the standard deviations for parameters as well as their correlation. Thus, the Group characterized the uncertainty in a similar way to 2009 and 2007 assessments, i.e., by generating 1000 random numbers from a bi-variate normal distribution with means the last year SSB/SSB_{MSY} and F/F_{MSY} estimates, and covariance matrix:

	SSB/SSB_{MSY}	F/F_{MSY}
SSB/SSB_{MSY}	0.010404	-0.001916743
F/F_{MSY}	-0.001916743	0.00743044

The generated Kobe plot is presented in **Figure 32**, and the associated pie chart in **Figure 33**, suggesting that there is 0.2% probability for the stock to be both overfished and experiencing overfishing, 72.4% probability for the stock to be overfished but not experiencing overfishing, and 27.4% probability the stock is neither overfished or experiencing overfishing. However, the group noted that this was just an approximation to characterize the uncertainty of the current stock status, and decided to perform projections using software other than MFCL, as decided in 2009 and 2007 assessments.

4.1.3 ASPIC

ASPIC 5.34 was used to conduct stock assessment of the North Atlantic albacore.

Diagnostic of current stock status

The results of 7 scenario runs for North Atlantic albacore are presented in **Table 7**. The scenarios were built with alternative combinations of catch and CPUE series to inform the assessment model ASPIC v.5.34. All scenarios impose biomass level at the beginning of the time series at 95%K. **Table 8** and **Figures 34** and **35**, show that all the scenarios estimate that the stock is recovering with only one scenario estimating the current biomass to be lower than 60% B_{MSY} (Sc 4) and two estimating it above B_{MSY} (Sc 2 and Sc 6). Regarding the fishing mortality trend, all scenarios showed that current (2011) fishing mortality is on average below or at F_{MSY}, ranging between 45% and 89% F_{MSY}.

The Kobe plots (**Figure 35**) show that all scenarios follow the same pattern of development-overexploitation and rebuilding, with differences only on the time spent in the red quadrant (overfished and overfishing) (see Sc4) and the final stock status. Only one scenario (Sc2) showed that the Northern albacore stock is predominately in the green quadrant of the Kobe plot.

However, **Figure 36** shows the probability of the stock being currently at different areas of the Kobe plot by using the bootstrapped estimates across all 7 scenarios. According to this chart, the probability of the stock currently being in the green quadrant of the Kobe plot is 25%, the probability of being in the red quadrant is 13%, and the probability of being in the yellow quadrant is 62%.

Figure 37 shows the density plots of the estimated current status of North Atlantic albacore for the 7 scenarios tested.

These results are in agreement with those obtained with other models during the assessment session and showed that the assessment results are influenced by the choice of the CPUE series used to inform the model. However, all scenarios estimated that the stock is recovering and that current (2011) fishing mortality is near or below F_{MSY}.

Projections

Further projections complemented the contribution of this model to the assessment of North Atlantic albacore. Deterministic projections with constant catch and constant fishing mortalities are shown in **Figures 38** and **39** for all scenarios. **Figure 39** summarizes the implications of alternative quotas for the coming years in the state of exploitation of northern albacore with different ASPIC scenarios. In order to shade light on the unstable projections in scenarios 4 and 5, two additional figures show how some of the projected constant catch value could collapse the stock (**Figures 40** and **41**).

4.1.4 Stock Synthesis

Exploratory Phase

Model configurations were completed with the stock synthesis model (V3.24L) prior to the assessment meeting and were presented to the Group. The Stock Synthesis (SS) model was configured with twelve fleets, four quarter seasons, and two sexes. For the data exploration phase, the data inputs generated for use in the MFCL model were also used for the SS model. Selectivity for all fisheries was assumed to be length-based and based either on a double-normal function or assumed asymptotic. The unfished recruitment level (*R0*) and steepness (*h*) were freely estimated. Eight configurations were presented (**Table 9**), each with varying degrees of complexities and various uses of the data streams. An effort was made to construct some of the configurations with decreasing complexity so that the effects of the different levels of complexity on model results could be assessed. The primary objective of the SS modeling effort was to help verify results of the MFCL (and other) models. Results of the exploratory SS models were not formally used for management advice. As such, while some SS model (Run_1) diagnostics were presented to the Group, these diagnostics were documented here on a limited basis.

The residual mean square error (RMSE) of each of the CPUE for the ten exploratory SS was used to show the degree of fit to each of the individual series (**Table 10** and **Figure 42**). On average, the SS models had the lowest RMSE (i.e., best fit) with the Chinese Taipei late CPUE and the highest RMSE (i.e., worst fit) to the Portuguese baitboat CPUE time series. In an effort to account for fleet specific variations in RMSE, several runs used variance reweighting to increase/decrease the weighting each of the CPUE time series had on the overall model fit. The variance reweighting tended to decrease the discrepancies in some of the CPUE time series.

The range of SS model configurations all inverted the Hessian matrix (a positive attribute). Broadly speaking, removal of the length information (Run 5), while altering the trajectory of the B/B_{MSY}, did not produce a marked difference in that benchmark in the final year (**Figure 43**). Removal of the lengths tended to increase the response of the model to the annual variations in the CPUE data. The combination of the removal of the lengths and reconfiguration to an annual time step (Run 7) did have a very noticeable effect on the estimate of stock status (**Figure 44**). The perception given by this set of model runs is that, in general, the length information as whole may not be in conflict with the CPUE information as a whole. Given the time constraints of the meeting it was not possible to conclude how complex the assessment model needed to be, however, a closer examination of the various model diagnostics of the above mentioned runs may help making that determination.

Nearly all of the eight SS models reached the same conclusion that the stock was overfished, but not currently experiencing overfishing. Furthermore, all models were in agreement that the stock biomass has increased starting in around the year 2000. The exception to this outcome was the age structured production model (ASPM) configuration. The results from the ASPM were so unlike the other runs that they were deemed suspicious and in need of further work. Group discussion suggested that perhaps the model found a local minimum at may not have properly converged. This suggestion was based on experience with the ASPIC model and the same data. One conclusion could be that this model lacked the complexity necessary to adequately capture the dynamics of the fishery. Given all these characteristics, this configuration was not given any further consideration.

Post-exploratory phase configurations

The Group agreed to explore a total of eleven SS model configurations (**Table 11**). Many of these configurations were intended to mirror as closely as possible those of the MFCL alternative runs.

The majority of the post-exploratory SS configurations resulted in estimates of B/B_{MSY} in the range of 0.5 to 1.0 (**Figure 45**) and estimates of F/F_{MSY} of between 0.4 and 0.8 (**Figure 46**). While there were exceptions to this, the exceptions were considered sensitivity analysis and not the base case model. Every model configuration suggested that the stock biomass was continuing to increase and that fishing mortality was continuing to decrease.

SS Run 12 was chosen as the preferred model to discuss overall fits and diagnostics. This was a two sex model with a linear ramp on female natural mortality (**Figure 47**). The estimates of the length-based selectivities and the resulting fit to the length information across years for each of the gears are shown in **Figure 48**. In general, the information contained in the length compositions was inconsistent with regard to any type of definitive trends in recruitment signal. The Group discussed how this might be the result of the various fleets not fishing in a consistent manner through time and space over the full extent of the assessment period. Banding in some of the residual patterns suggested bimodal patterns in the frequencies and consequently some use of age based selectivity might be useful to consider in the future. It was also apparent from the residual patterns (**Figure 49**) that time varying selectivity may also be a useful consideration.

The models inability to provide good fits to the CPUE time series was evident in the examination of the fit residuals (**Figure 50**). Several sensitivity runs were conducted to determine the individual influence of the Japanese and Chinese Taipei CPUE series. The exploratory phase of runs showed that the Chinese Taipei CPUE time provided a lower RMSE than did the Japanese CPUE. This was further supported by the fact that the Japanese fleet fished more on the fringe of the stock distribution areas rather than the core areas. This provided some justification for excluding the Japanese CPUE time series from the runs used to provide management advice.

Most model configurations were consistent with their estimates of virgin recruitment and steepness. Even without the use of an informative prior the estimates of steepness remained in the range of 0.75 to 0.85 for most configurations. No trend was apparent in the pattern of recruitment deviations; however there was an unexplained positive deviation the last year of the estimate (**Figure 51**). If these model fits were used for management advice this would have been investigated in greater detail as this point would have had a very large influence on the projections.

Management benchmarks estimated from the MFCL base case and the SS models configured most like the MFCL base case (Run 17) are shown in **Figures 52** and **53**. Closer inspection of the estimates of recruitment (**Figure 54**) and spawning stock biomass (**Figure 55**) revealed differences in SSB, but not recruitment. Neither was there a difference in total biomass (**Figure 56**). This suggests that MFCL and SS, although calibrated well, are likely using different functions to estimate absolute fecundity. While this is worth noting, it does not have any impact on the management benchmarks or estimates of status of the stock.

The MFCL and SS base case model estimates of B/B_{MSY} and F/F_{MSY} from the 2009 assessment and this assessment are shown in **Figure 57**. The estimates of the management benchmarks were relatively consistent not only between modeling platforms, but also over time.

4.1.5 Virtual Population Analysis (VPA) Methods

A virtual population analysis (VPA) of North Atlantic albacore was conducted using the VPA-2Box software (Porch et al. 2001), version 4.01, for the period 1975 to 2011. Relative abundance indices and life-history parameters inputs are described in SCRS/2013/013 and catch-at-age and partial catch-at-age data are described in SCRS/2013/122. Model assumptions included a single stock with no mixing or migration, eight age-classes (age 1 through 8+ with the plus group representing ages 8 through 15), no separation of sexes, spawning period beginning May 1, constraint on vulnerability applied to the terminal 3 years, no constraints applied on recruitment or the stock-recruitment relationship, and no tagging data included. Eight indices of abundance were included in the model:

- Japan longline (Ages 3 to 8+), 1975-2011
- Chinese Taipei longline (Ages 2 to 8+), 1975-1987
- Chinese Taipei longline (Ages 2 to 8+), 1999-2011
- United States longline (Ages 3 to 8+), 1987-2011
- French troll (Ages 2 and 3), 1975-1979
- French troll (Ages 2 and 3), 1980-1987
- Spanish troll (Ages 2 and 3), 1981-2011
- Spanish baitboat (Ages 1 to 4), 1981-2011

Indices were weighted equally and a multiplicative error structure was assumed. Data sources used in this assessment differed from the previous assessment conducted in 2009 by: (1) inclusion of the Spanish baitboat data referencing ages 1 to 4, (2) splitting of the Chinese Taipei longline index into two periods (1975 to 1987 and 1999 to 2011) to account for changes in species targeting and gear configuration, (3) combining the Spanish troll data to reference ages 2 and 3, as opposed to separate indices for these two age classes, and (4) allowing for selectivity of the Spanish troll indices to be estimated rather than fixed for a single age class.

Model parameterization deviated from the 2009 assessment in that a constraint was applied on vulnerability estimates of ages 1 through 8 for the period 2009 to 2011 to penalize large deviations in fishing-mortality-at-age estimates since VPA estimates for the terminal period are generally poorly informed. This constraint was not applied in the previous assessment, and a sensitivity analysis was conducted to determine the effect of this parameterization. Based on a recommendation from the species workgroup, the spawning season was assumed to begin May 1, while the previous assessment assumed a spawning season beginning July 1. It is recommended that this assumption be evaluated in the future, as VPA model parameterization is dependent on the assumption. The base model was parameterized under these assumptions, and a bootstrap analysis (500 iterations) was applied to determine the uncertainty around base model estimates of spawning stock biomass (SSB) and fishing mortality-at-age (FAA).

Diagnostics

Model fits to indices of abundance and residual patterns were examined to determine the appropriateness of VPA fit to the various indices data. A number of alternative model runs were conducted to determine the sensitivity of the base model to various assumptions, and to estimate the effect of changing these assumptions on VPA results. Sensitivity analyses included:

- A relative abundance indices jackknife analysis in which each index was iteratively removed to determine the influence of individual indices on model estimates.
- An age-varying natural mortality analysis (Age-1 M = 0.63, Age-2 M = 0.46, Age-3 M = 0.38, Age-4 M = 0.34, Age-5 M = 0.31, Age-6 M = 0.29, Age-7 M = 0.31, Age-8+ M = 0.50) was compared to the constant natural mortality across ages equal to 0.3, assumed in the base model.
- A retrospective analysis in which data from the previous 1 to 5 years were iteratively removed to examine the influence of the most recent years on model estimates, and to compare base model estimated stock status in 2011 with a retrospective estimated stock status from 2001 projected forward to 2011.
- Addition of catch-at-age, partial catch-at-age, and relative abundance index data from the period 1959 to 1974 to determine if inclusion of this historical time series resulted in a difference in estimated stock status and benchmarks (maximum sustainable yield, spawning stock biomass (SSB_{MSY}) and fishing-mortality at maximum sustainable yield (F_{MSY})).

Results

Abundance-at-age (NAA) estimates from the VPA base model indicated a sharp decline between 1978 and 1984 (**Figures 58** and **59**) resulting from a decrease in catch of older age classes (**Figure 58**) and a decrease in catch per unit effort of the Japanese and Chinese Taipei longline fleets (**Figure 60**). Fishing mortality-at-age (FAA) estimates ranged between 0.1 and 0.8, with the highest FAA estimated for ages 2, 3, and 4. Fishing mortality on the oldest age classes peaked in 1986, 1995, and 2000, and declined steadily over the last 10 years (**Figure 61**). The base model demonstrated relatively good fit to the Japanese and Chinese Taipei (early series) longline indices, and relatively poor fit to the United States and Chinese Taipei (late series) longline data (**Figures 60** and **61**). Model fit to surface fisheries indices (troll and baitboats) were less consistent than early period longline indices, although the estimated trends between indices and model estimates were similar. Bootstrap analyses demonstrated stability in the estimated long-term trends, but illustrated uncertainty in the NAA and FAA estimates of young age classes (ages 1 to 3) during the terminal period, as well as uncertainty in NAA and FAA of the older age classes (ages 6 to 8+) during the early period (**Figures 62** and **63**). Overall, NAA and FAA estimates were least variable for younger ages (with the exception of the terminal 5 year period), and most variable for the plus group (ages 8+) across bootstrap iterations (**Figures 62** and **63**).

VPA model results were sensitive to the assumption of natural mortality (**Figure 64**), the Japanese longline indices (**Figure 65**), and the F-ratio starting parameters; and were less sensitive to terminal F parameters, variance scaling, and vulnerability constraint assumptions. Altering the assumption of natural mortality from constant-at-age (base model) to age-varying mortality resulted in an increase in the estimated magnitude of recruitment, spawner abundance, and spawning stock biomass, but did not alter the long-term population trend (**Figure 64**). Jackknife analyses demonstrated that the estimated long-term trend was most sensitive to the removal of the Japanese longline index, emphasizing the influence of that index on stock estimates (**Figure 65**). Removal of the Japanese longline index resulted in a reversal of the estimated long-term trend from stock decline to an increase in stock abundance and biomass from 1975 to 2011. The United States longline index had a large influence on the estimated stock trend in the recent time period (2000 to 2011, **Figure 65**). The Chinese Taipei and surface fleet indices were considerably less influential on stock abundance estimates. Retrospective analysis (removal of recent years catch and relative abundance data) indicated that model estimates of recruitment and SSB were not sensitive to the data from the recent time period (**Figure 66**).

The estimate of current stock status from the base model is overfished and not currently undergoing overfishing (**Table 12, Figures 67** and **68**), with an estimated probability of $SSB<SSB_{MSY}$ & $F<F_{MSY}$ of 70% (14% estimated probability of being overfished and undergoing overfishing $SSB<SSB_{MSY}$ & $F>F_{MSY}$, 15% estimated probability of not being overfished and not undergoing overfishing $SSB>SSB_{MSY}$ & $F<F_{MSY}$, and 1% estimated probability of not being overfished and undergoing overfishing $SSB>SSB_{MSY}$ & $F>F_{MSY}$). The estimated 2011 spawning stock biomass was 41,600 metric tons (80% confidence interval of 35,400 to 51,100), with an estimated apical fishing mortality in 2011 of 0.26 (80% confidence interval of 0.23 to 0.30). The estimated MSY was 36,500 metric tons (80% confidence interval of 35,600 to 37,300). Spawning stock biomass that can support maximum sustainable yield (SSB_{MSY}) was estimated to be 50,800 metric tons (80% confidence interval of 41,800 to 60,300), with an estimated F_{MSY} of 0.35 (80% confidence interval of 0.32 to 0.41). The long-term stock trajectory track (**Figure 67**) from the base model indicated that SSB was greater than SSB_{MSY} and F was less than F_{MSY} in 1975, F increased above F_{MSY} during 1976 to 2007, and SSB declined below MSY in 1985.

Stock status comparisons across the base model and the influential sensitivity runs highlighted the uncertainty in the estimated SSB_{2011} compared to SSB_{MSY} (**Table 12, Figures 67** and **68**), while estimates of median fishing mortality were more robust across model runs (**Table 12**, **Figures 67** and **68**). For example, the base model indicated that SSB_{2011} was near SSB_{MSY}, compared to the age-varying mortality and U.S. longline index jackknife runs which estimated SSB greater than SSB_{MSY} in 2011, and also when compared to the historical period run which estimated SSB_{2011} below SSB_{MSY}. In contrast, median estimates of F_{2011} were below F_{MSY} for all model runs. While removal of the Japanese longline index resulted in a different stock trend than the other model runs, fits of the stock recruitment curve to model estimated recruitment and SSB were poor, resulting in biologically implausible estimates of SSB_{2011}/SSB_{MSY} and F_{2011}/F_{MSY}. It should be noted that estimates of stock status from the Japanese index jackknife sensitivity are likely to be more optimistic than the other sensitivities. Therefore, the historical period data sensitivity run represents the most pessimistic case of current SSB compared to SSB_{MSY}. This analysis was done post-hoc of the data workshop, and the historical input data and model parameterization were less thoroughly evaluated; therefore, this run should be considered exploratory and more rigorous evaluation is necessary (e.g., accuracy of historical catch data and starting F-ratio parameters) . Due to the uncertainty in data input and model parameterization, the historical model was not projected forward.

Based on the VPA base model and sensitivities, catches of 32,000 metric tons or lower were predicted to result in decreased fishing mortality and lead to stock rebuilding, and these predictions were robust across model runs taking into account model sensitivity, excluding historical data sensitivity (**Figure 69**). In summary, while there was considerable uncertainty in the estimated SSB of north Atlantic albacore from the VPA, there was overall consistency in the predicted sustainable harvest strategies.

4.1.6 Summary of stock status

Results for all the various modeling platforms (MFCL, SS, VPA, and ASPIC) were examined for commonalities and differences. Although the range of estimated management benchmarks is relatively wide, nearly all models were in agreement that the stock was overfished, but not currently undergoing overfishing (**Figure 70**). However, the SS runs were more consistent with each other than with the MFCL base case model. Most models from all the various platforms showed a drop in stock biomass from 1930 to about 1990 and increasing trend in biomass starting in around 2000. Likewise, most models within all configurations showed a peak in fishing mortality in around 1990 with a decreasing trend thereafter (**Figure 71**). Furthermore, most models across the various platforms demonstrated more precise estimates of F/F_{MSY} than they did estimates of B/B_{MSY}. This was also demonstrated by a retrospective projection conducted with VPA over the last 10 years that suggested that F/F_{MSY} trends were more predictable than SSB/B_{MSY} trends (**Figure 72**).

4.2 South Atlantic albacore stock

4.2.1 ASPIC

Methods

Document SCRS-2013-118 presented a non-equilibrium surplus-production model for the albacore stock in the southern Atlantic Ocean using the software package ASPIC ver. 5.34. Fleet categorization (**Table 13**) was similar to that used in the 2009 assessment. Catch for each fleet (**Table 14**) was calculated based on Task I data prepared at 2013 ICCAT Atlantic Albacore Data Preparatory Meeting. **Table 15** shows CPUE indices used for the models. Several CPUE indices used for the last assessment were not used based on the decisions made at the 2013 Albacore Data Preparatory Meeting. Therefore, several fleets do not have CPUE index. Four models were examined (**Table 16**). The confidence interval of the F/F_{MSY} trajectory for Run07 presented in the document SCRS/2013/118 seemed unusual and therefore model configuration was modified during the meeting which resulted in more reasonable confidence intervals. The Group agreed that the ASPIC model should be updated with the latest catch and CPUE information.

Status and diagnostics

In general, all the models predicted that at some stage in the recent past the southern albacore stock had been undergoing overfishing and had been overfished. In these cases, except for one (Run07) model, the fishing pressure appears to have decline in recent years which translated into a subsequent increase in stock biomass.

The results based on the four base cases suggested that the exploitation level in recent years varied between cases (B_{2012}/B_{MSY} ranged from 0.813 to 0.950 and F_{2011}/F_{MSY} from 1.047 to 1.301, **Figure 82** and **Table 17**). To generate confidence intervals, 500 bootstrap trials were conducted for each model. The bootstrapped results for the four cases are shown in **Figure 83** (Kobe I plot) and **Figure 84**. (piechart). For Run07, the majority of realizations ended up in the red quadrant of the Koble plot (overfished and overfishing), while for other runs, the results were more optimistic with some of the realizations occurring in the green quadrant. MSY was estimated to range from 22,620 t to 28,060 t (**Table 17**) which was close to the total catch for 2011 (24,122t).

Several sensitivity and retrospective analyses were conducted for one scenario (Run08) of ASPIC model (**Table 18, Figure 73**). Scenarios with the Uruguay longline index separated (1981-1991 and 1992-2011) are included because this fishery targeted bigeye tuna and swordfish for the first and second period, respectively. As for sensitivity analyses, B-ratio of initial period changed for different B1/K, and using only Uruguay and Japanese (by-catch period) index made results more pessimistic and optimistic, respectively. As for retrospective analyses, large difference was observed when data for the last 6 or more years were removed.

4.2.2 Bayesian Surplus Production Model (BSP)

Document SCRS/2013/123 presented an update of the Bayesian Surplus Production (BSP) model that was applied to the South Atlantic albacore stock in the 2011 assessment using an additional two years of catch data and the CPUE series recommended by the 2013 Albacore Data Preparatory Meeting. The same informative priors were used as in 2011, as well as an alternative prior for *r* that was less informative. The alternative models were used to predict the probability of the stock achieving a biomass above B_{MSY} under a range of management scenarios. Kobe plots were also produced. Estimates of current status were strongly dependent on which method was used to weight the CPUE data points and with catch weighting being more optimistic. The choice of prior for *r* did not strongly influence the estimate of stock status, although the less informative prior produced broader credible intervals.

Methods

The Bayesian Surplus Production Model (BSP) was applied to South Atlantic albacore for the same four base case model scenarios that were used for ASPIC. The models were: (1) equal weighting of indices, Schaefer model; (2) catch weighting, Schaefer model; (3) equal weighting, Fox model with B_{MSY}/K=0.37; and (4) catch weighting, Fox model with B_{MSY}/K=0.37. For all four base case models the same Bayesian prior distributions were used as in the 2011 assessment. The prior for the biomass in 1956 relative to K was lognormal with a mean of 0.9 and a log standard deviation of 0.1 implying that the population was close to unfished in the first year of the fishery. The prior for K was uniform in log space. An informative prior for the intrinsic rate of population increase *r* was developed as shown in Babcock (2012) and the 2011 assessment, and was approximated by a t distribution with mean 0.2, variance 0.025 and df 10.

The model was fitted to catch data from 1956 to 2011. Catches in 2012 and 2013 were assumed to equal the average from years 2007-2011. The CPUE indices used were the Japanese longline early, Japanese longline late, Chinese Taipei longline, Uruguay longline early, and Uruguay longline late.

In addition to the four base case runs, sensitivity analyses were conducted to evaluate the implications of using different CPUE series and different informative priors on the model parameters (**Table 19**). Retrospective analyses were also conducted.

The BSP software, version 1, available from the ICCAT catalog of methods, was used to estimate the marginal posterior distributions using the sampling-importance resampling (SIR) algorithm. Either the priors or a multivariate-t distribution were used to integrate the posterior distribution, whichever produced adequate convergence diagnostics. A random draw of 5000 samples from the joint posterior distribution was used to estimate the median trajectory and 80% credible intervals, given a range of constant catch strategies and constant fishing mortality rate strategies. A subsample of 500 draws was used for the construction of the Kobe results.

Status and diagnostics

All four of the base case BSP models estimated a historical decline in the abundance of South Atlantic albacore, followed by an increasing trend over the last 10 years (**Figure 74**). However, the current status relative to BB_{MSY} and F_{MSY} depended on the model formulation (**Figure 82, Table 20**). The models with catch weighting were more optimistic than the models with equal weighting. The Schaeffer and Fox model formulations estimated similar trends, and similar depletion since 1956; however, because BB_{MSY}/K is lower in the Fox model, the Fox model estimated higher values of $B_{current}/BB_{MSY}$. The credible intervals of the estimates if B/BB_{MSY} and F/FB_{MSY} were quite broad, especially in the case with catch weights (**Figure 75**).

Retrospective analysis was applied to the Schaefer model cases, with both equal and catch weighting (**Figure 76**). In both cases, the projections generated from models with data through 2005 were quite similar to the current assessment, implying that the model is adequately capturing the dynamics of South Atlantic albacore.

Plots of the CPUE residuals against year show that there were trends in the residuals, especially in the early Japanese longline series and the late Uruguay series (**Figure 77**). The residuals were normally distributed according to the qq-normal plots. When CPUE series were removed from the model, the most optimistic model was the one that included only the Japanese longline fishery and the most pessimistic included both Chinese Taipei and Uruguay (**Figure 78**).

When alternative priors were used, the median biomass trajectory was the same as the base case, except for the cases with uniform priors on r and K, with catch weighting of the indices (**Figure 79 and Figure 81**). For the case with equal weighting and the Schaeffer model (**Figure 80a**), the posteriors of *r* and K had a similar mode for all three priors of K, with more informative priors providing narrow credible intervals. In contrast, the runs with catch weighting (**Figure 80b**), the posterior of K is very similar to the prior, implying that there is very little information in the data to estimate *r* and K for the catch weighting case. These results show that the data with equal weighting provide more information to estimate the model parameters. Nevertheless, the model with catch weighting may more accurately reflect the true trends, so all four models continued to be used as base cases.

4.2.3 Summary of stock status

The eight ASPIC and BSP models show fairly consistent trends in B/B_{MSY} and F/F_{MSY} over time (**Figure 82**). The estimated median current status in 2011is around B/B_{MSY}=1 and F/F_{MSY} =1 for all models (**Figure 83**). The BSP models were slightly more optimistic in the median than the ASPIC runs, but had a larger range of uncertainty. Kobe pie charts of status in 2011 vary between models (**Figure 84).** Averaging across all eight models, the probability of both $B<B_{MSY}$ and $F>F_{MSY}$ (red) is 0.57, and the probability of both $B>B_{MSY}$ and $F<F_{MSY}$ (green) is 0.30 and the probability of yellow is 0.13.

5. Projections

In this section, the results of the projections used to provide management advice are described.

5.1 North

The results shown in this section were produced by projecting forward the estimated 2011 populations presented in section 4.1.2 with alternative harvest control rules (HCR). The seven scenarios investigated in production modeling using 501 bootstrap outcomes each were projected and considered equally plausible.

The alternative harvest control rules include alternative target fishing mortalities (Ftarget=[0.7, 0.75, 0.8, 0.85, 0.9 and 1] x FB_{MSY}), threshold biomass levels of [0.6, 0.8 and 1] x BB_{MSY} and a biomass limit reference point of BB_{Lim}=0.4 x BB_{MSY}. In the forward projections, the HCR is evaluated every three years and the fishing mortality is projected assuming perfect implementation.

The outcomes of the projections are shown in **Figure 85** and **Table 21**, which indicate the projected probability of being ‘Green’ within the time-frame indicated. Expected average catch for the first 3 years, as well as cumulated catch for each future 5 year period are also shown.

5.2 South

5.2.1. ASPIC projections

Based on bootstrapping (500 times) of each scenario, future projections were conducted. Projection period is 15 years (2012-2027). Constant future catch was set at 14,000 to 36,000t (at 2,000 t interval) or constant F at $0.75{*}F_{MSY}$ to $1.00{*}F_{MSY}$ (at $0.05{*}F_{MSY}$ interval) was assumed. Catch for 2012 and 2013 was assumed to be equal to 2007-2011 average (20,937 t) for both constant catch and constant F scenarios.

Software package ASPICP ver. 3.16 was used for future projections. The results of these projections under constant catch and constant F are provided in **Figures 86** and **87**, respectively, which show the median trajectory at the different constant catch scenarios. **Figure 88** shows predicted yield under constant F scenario. Kobe II matrixes (probability of not exceeding MSY level) are shown in **Table 22** for each ASPIC run. These results would indicate that catches in excess of 26,000 t or F in excess of 0.85*F_{MSY} would result in the reduction of the resource after 15 years, in almost all model runs. The runs assuming unweighted CPUE series are in general more optimistic than the weighted CPUE series.

5.2.2 BSP projections

Basically projection scenarios are the same as those for ASPIC for south Atlantic. Under a constant catch policy, the median biomass is expected to increase above B_{MSY} within 10 years with 50% probability for TACs from 18000 to 34000 depending on the scenario (**Table 23, Figure 89**). With constant harvest rates, harvest rates below F_{MSY} allowed the population to stay above B_{MSY} with a high probability for all scenarios except the case with equal weighting and the Schaeffer model. When F is equal to F_{MSY}, the probability of achieving B_{MSY} is near zero, because the population trajectory asymptotes before reaching B_{MSY}.

5.2.3. Projections for the South Atlantic

Combining all eight ASPIC and BSP model scenarios with equal probability, the Kobe matrix probabilities (**Table 24, Figure 90**) indicate that a harvest policy of either 0.90 F_{MSY} or a TAC of 20000 would reduce F below F_{MSY} with more than 70% probability within three years. Increasing B above B_{MSY} requires greater reductions in fishing mortality. A policy of 0.75 F/F_{MSY} would have a 85% chance of $B>B_{MSY}$ by 2026. A TAC of 20000 would have 70% probability of rebuilding by 2026. The Kobe plot for the South Atlantic stock assessment is presented in **Figure 91**.

6. Recommendations

6.1 Research and statistics

- The Group recommended further elaboration of the MSE framework being developed for albacore tuna. Although advances were recognized by the Group, further work should be carried out to permit a better characterization of uncertainty in current and future stock condition.
- The Group recognizes the need to incorporate environmental studies in albacore and likewise assessments. The Group was exposed to new information suggesting that the mixed layer depth might impact catchability of surface fisheries. The Group recommends further research to confirm this, as well as to inspect sources of historical environmental information that might help integrate this information in CPUE standardizations of surface fisheries.
- The Group also recommended further research to better characterize the nature and, if possible, quantify potential mixing rates between the Atlantic and the Indian Oceans.
- The Group recommends increasing efforts to obtain French mid-water trawl and other fisheries historical series of catch, effort, catch at size, geographical distribution and other related fisheries information.
- The Group expressed concern that spatial 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 effects on CPUE standardization.
- The Group noted that the Chinese Taipei longline size sampling data showed some patterns that might not reflect changes in the population. Thus, the group requested to clarify the reasons behind the patterns in the data to the extent possible.
- Given that spatio-temporal dynamics of longline fisheries appear to affect their selectivity pattern, the group recommends to redefine the fisheries in the Multifan-CL and SS applications in the future, considering the nature of these fisheries.
- In general, the Group noted that important uncertainties remain in the biology, fisheries and modeling of North Atlantic albacore. Thus, the group continues to recommend that the Albacore Research Program be funded.

6.2 Management advice

North Atlantic

A range of time-frames and probability levels for achieving the Commission's goals established in Rec. 11-13 are provided in Table Outlook 2. Longer time frames provide more options for HCR parameters that project higher probabilities of being in the green quadrant of the Kobe Plot. The HCR projections indicate that if , for example, the Commission adopts a 'high probability' of 75% within a 10 year time-frame, then the HCR with a Biomass Threshold at B_{MSY} paired with a Target F of 0.9 F_{MSY} would provide the highest expected 10 year cumulative catch amongst options and the average catch expected from 2014-2016 would be approximately 26,200t. In contrast, if the Commission considers a 'high probability' of 60% sufficient within a 5 year time-frame, then the HCR with a Biomass Threshold at B_{MSY} paired with a Target F of 0.9 F_{MSY} would also meet that objective and provide the highest expected cumulative catch amongst options that would provide at least 60% probability within 5 years and the average catch from 2014-2016 would remain approximately 26,200 t. Consideration of implementation and other uncertainties in these projections would likely change the probability level estimates.

South Atlantic

Projections at a level consistent with the 2013 TAC (24,000 t) showed that probabilities of being in the green quadrant of the Kobe plot would exceed 50% only after 2020. Similar probabilities could be achieved earlier with lower TAC values.

With catches around 20,000 t, probabilities of 50% would be exceeded by 2015, and probabilities of 60% would be exceeded by 2018. Further reductions in catches would increase the probability of recovery in those timeframes. Likewise, increases would reduce rebuilding probabilities and extend the timeframes. Catches over the current TAC (24,000 t) will not permit the rebuilding of the stock with at least 50% probability over the projection timeframe.

7. Other matters

The Group discussed the convenience of using different approaches to assess the Atlantic albacore stocks status. According to the procedure established in ICCAT, the use of a variety of methods by the SCRS to conduct stock assessment is valuable. However, this procedure requires a significant amount of preparatory work as well as an important request of data, particularly if statistical integrated models are used. In the case of the current North Atlantic albacore assessment, the use of two statistical integrated models, VPA and production models as well as the implementation of MSE, have been only possible because a detailed and tight work plan was prepared by the Albacore Species Group, this plan was well led by the Albacore Rapporteur and strictly followed and two meetings (data preparatory and assessment) have been held. However, the implementation of the work plan has also implied an important amount of preparatory work for both the scientists involved in the assessment and the Secretariat. Taking into account the number of meetings scheduled every year for which the Secretariat must conduct preparatory and posterior work, stock assessments implying such amount of work will be difficult to assume by the Secretariat in the future.

The Group also evaluated the advantages and disadvantages of using methods, such as VPA, based in CAA when significant uncertainties in ageing exist. Regarding the statistical integrated models, the Group evaluated positively the use of two models (MFCL and SS3) as a way to test the robustness of these models in assessing the North Atlantic albacore. However, the Group agreed that it would be difficult to maintain such a complex assessment in the future and that further discussions on the best assessment models for North and South Atlantic albacore will be needed. Evaluation of different management procedures within an MSE framework could help the Group in future decisions about this issue.

Regarding future work, the Group discussed how the Data Preparatory meeting could be better used to reexamine and evaluate the previous assessment model configurations, assumptions, and the various data fit residuals. The objective of this proposal is to attempt to ensure increased useful continuity from the assessment meeting back to the next data meeting.

It was noted that residual plots to data such as length compositions could be quite useful is detecting such things as mis-specified area and/or gear assignments that may exist in the Secretariat database.

In a similar manner, residual to CPUE time series may help in the subsequent evaluation of those time series and help provide information with regard to the future inclusion or exclusion of that data. In this manner, the Data Preparatory meeting may be better characterized as a Pre-Assessment Meeting to better reflect a wider objective that could include a more directed revisit of the past assessment efforts.

8. Adoption of the report and closure

The report was adopted and the meeting adjourned.

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Table 1. Estimated CAA for N-ALB.

Year	Age_0	Age_1	Age_2	Age_3	Age_4	Age_5	Age_6	Age_7	Age_8	Age_9	Age_10	Age_11	Age_12	Age_13	Age_14	Age_15
1975	11762	477040	1476729	1403321	428884	171347	106435	77139	50028	30553	19154	12770	9125	6990	5821	5384
1976	7530	1069458	2162027	1050125	734451	409380	235539	131192	70741	37873	21074	12623	8260	5891	4580	3802
1977	5299	555836	2295220	1253662	480070	345543	233630	130969	69214	36313	20013	11988	7887	5679	4475	3793
1978	14635	2261986	2459274	1046468	397258	223112	163395	97608	50326	25154	13528	8184	5575	4200	3447	2985
1979	45142	864989	2256061	1600921	578962	252339	111964	53595	29757	18077	12237	9145	7383	6362	5819	5547
1980	9303	1665186	1626685	1137755	317302	141261	83844	52879	28285	14277	8121	5531	4280	3566	3141	2931
1981	10964	1154142	1537500	865646	319489	106636	65871	48303	32430	21265	14856	11444	9689	8887	8769	9070
1982	2005	319894	1666988	1296928	489193	143015	90754	67652	46081	30448	21267	16469	14132	13100	12969	13389
1983	9570	1078560	1617390	1385847	595854	264005	156535	94804	56040	33308	21337	14865	11154	8945	7718	7082
1984	11181	712085	1189973	864252	345454	230093	178911	129154	81106	48346	30185	21109	16791	14931	15017	16375
1985	16045	1124898	1383716	882822	311614	205586	146087	91034	55884	36403	25997	20103	16387	13817	11990	10694
1986	27579	891420	1603745	1103649	399453	211395	161298	113746	75352	51539	37102	27834	21454	16890	13674	11436
1987	4124	443870	2344578	1265790	258370	70305	44221	32264	22895	16369	12244	9646	7897	6632	5662	4810
1988	7364	1706185	2008752	888535	200526	52503	27662	17821	11903	8054	5764	4397	3518	2901	2445	2085
1989	5973	1134350	1743158	1128427	222753	65682	32296	13930	7266	4296	2711	1842	1354	1067	893	779
1990	59056	1153547	2315708	805352	275168	137548	84106	44853	24794	14460	9042	6039	4330	3354	2811	2498
1991	38468	1316900	1990461	576481	171798	108759	58039	18395	6790	3319	1943	1255	874	654	526	444
1992	14876	1291002	1786160	758447	170381	55855	56253	44180	32214	22228	14734	9825	6813	4971	3845	3105
1993	13948	1127445	1862543	1143178	337904	111711	80885	53347	30386	17238	10497	7008	5162	4166	3659	3448
1994	10297	805023	2200656	735078	219600	83426	57612	40908	25703	16201	11685	10787	11810	14189	18338	24756
1995	41328	1320844	2095899	851623	196786	136202	111908	77394	49039	29669	17975	11303	7515	5324	4127	3505
1996	9581	1461998	2150212	356531	117414	86872	71234	45440	26855	15426	9173	5875	4117	3165	2653	2325
1997	81888	1738879	1637256	692943	159463	64672	45093	32215	21056	12722	7622	4787	3250	2411	1960	1704
1998	5695	1992744	1723723	479018	132889	40962	26861	21014	14643	9354	5869	3807	2628	1953	1574	1353
1999	26218	1831244	1435806	977411	307068	106602	56472	36052	23582	14869	9270	5963	4048	2897	2172	1663
2000	8171	1028336	1628418	883153	213893	72001	104145	95383	51261	21810	9035	4177	2315	1546	1209	1032
2001	3094	512027	816461	706100	279328	142596	122536	72921	32847	13886	6397	3362	2022	1379	1060	878
2002	16130	879000	407395	273302	291221	185059	135902	83186	42816	21271	11142	6356	4007	2852	2376	2272
2003	12588	1771368	648364	400566	241757	145376	119504	75653	38875	18955	9806	5630	3598	2522	1919	1542
2004	13415	875023	1342599	547537	184744	115484	81148	49871	28340	16134	9784	6457	4646	3621	3048	2724
2005	31342	1321635	1633779	1016641	312194	132383	87553	49154	25381	13156	7155	4192	2704	1949	1598	1460
2006	23027	1286098	1952190	1084087	375769	92750	54849	35441	20727	11918	7073	4458	3040	2251	1805	1529
2007	8854	343185	1078407	805441	155363	56236	40829	28330	16979	9417	5341	3297	2313	1936	2103	2666
2008	16467	704412	1004616	509434	225008	49382	32392	22546	13637	8572	6073	4914	4417	4295	4527	5129
2009	23572	265416	658744	526662	163547	41789	22187	14519	9770	7587	6385	5427	4651	4052	3603	3262
2010	28197	576691	1207936	393936	166822	54744	34206	30357	21390	13669	8968	6381	4947	4096	3550	3138
2011	17518	995667	755105	641496	114835	59184	39787	28237	18332	11205	7156	5026	3902	3291	2963	2782

Table 2. Quarterly mean lengths at age and standard deviations used to generate length at age distributions using Kimura-Chikuni.

	Age:	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Quarter 1	**mean**	44.46	59.75	72.06	81.96	89.93	96.35	101.52	105.68	109.03	111.72	113.89	115.63	117.04	118.17	119.08	119.81
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 2	**mean**	30.61	48.60	63.08	74.74	84.12	91.67	97.75	102.65	106.58	109.75	112.31	114.36	116.01	117.35	118.42	119.28
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 3	**mean**	35.48	52.52	66.24	77.28	86.16	93.32	99.08	103.71	107.44	110.45	112.86	114.81	116.37	117.64	118.65	119.47
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 4	**mean**	40.09	56.23	69.22	79.68	88.10	94.88	100.33	104.72	108.26	111.10	113.39	115.23	116.72	117.91	118.87	119.64
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61

Table 3. Levels of Target F, Biomass threshold, and Biomass limit levels to be used to inform the Commission for its determination of 'high probability' and 'as soon as possible', subject to the decision framework of Rec. 11-13.

FTarget: $.75F_{MSY}$, $.8F_{MSY}$, $.85F_{MSY}$, $.9F_{MSY}$, $.95F_{MSY}$, F_{MSY}

BThreshold: $.6B_{MSY}$, $.8B_{MSY}$, B_{MSY}

Blimit: $.4B_{MSY}$

Table 4. MFCL model runs and specifications (all alternate runs are the same as the base run except for the changes specified.

Run	*Specifications*
Base	Model specifications provided in SCRS/2013/058
Alt1	Includes Chinese Taipei LL SF data and allows dome-shaped selectivity for this fleet
Alt2	Model starts in 1950
Alt3	All SF data down-weighted
Alt4	Japanese LL CPUE data no longer down-weighted
Alt5	Includes the Chen and Watanabe age-specific natural mortality vector (Santiago 2004)
Alt6	Excludes final 4 years of data (2008 – 2011)
Alt7	Includes equal weights for Japan and Chinese Taipei LL SF and CPUE data (similar to 2009 continuity run)
Alt8	Includes total catch in weight but effort calculated from CPUE in numbers (incorrect effort data calculation)
Tag	Includes tagging data for release events that occurred between 1988 and 1991

Table 5. Key outputs estimated by the MFCL base and alternate runs (Red values indicate the benchmark is below MSY). Values for F/F_{MSY}, B/B_{MSY} and SSB/SSB_{MSY} are averages of the values for the last 3 years of the model estimated trajectories, not including the final year.

Run	*Steepness*	*MSY*	*F/F_{MSY}*	*B/B_{MSY}*	*SSB/SSB_{MSY}*
Base	0.83	31680.00	0.72	0.80	0.94
Alt1	0.83	32780.00	0.99	0.53	0.52
Alt2	0.80	32970.00	0.77	0.72	0.82
Alt3	0.88	31970.00	0.74	0.64	0.57
Alt4	0.84	31460.00	0.78	0.67	0.67
Alt5	0.80	31940.00	0.64	0.87	1.12
Alt6	0.85	34280.00	1.04	0.76	0.50
Alt7	0.88	32780.00	0.87	0.57	0.50
Alt8	0.82	26000.00	0.92	0.66	0.75
Tag	0.82	32440.00	0.70	0.83	0.99

Table 6. Standard deviation of the effort deviates for each CPUE series for each model.

	Fishery 1	*Fishery 2*	*Fishery 3*	*Fishery 4*	*Fishery 5*	*Fishery 7*	*Fishery 8*	*Fishery 10*
Alt1	0.491	0.446	0.114	1.665			0.174	0.184
Alt4	0.481	0.461	0.126	1.653	0.428	0.446	0.159	0.180
Alt5	0.457	0.458	0.110	1.659			0.155	0.185
Alt7	0.476	0.448	0.127	1.657	0.424	0.445	0.181	0.183
Base	0.458	0.458	0.110	1.658			0.154	0.190
Tag	0.457	0.459	0.106	1.659			0.154	0.187

Table 7. Summary of the CPUE series to inform ASPIC in each scenario.

Scenario	Description
Scenario 1	Composite surface cpue only
Scenario 2	China Taiwan old and new LL only (2 q's)
Scenario 3	CT LL as one only
Scenario 4	Japanese old and new LL only (2 q's)
Scenario 5	5 fisheries (surface comp, Jap old and new LL, ChTail old and new LL
Scenario 6	Idem 5 but No Ch Tai LL
Scenario 7	Idem 5 but No Jap LL

Table 8. Estimated parameters for the Schaefer model for the 7 scenarios tested.

Scenario	*MSY*	F_{MSY}	B_{MSY}	*K*	*r*	B/B_{MSY}	F/F_{MSY}
1	34045.714	0.0579637	587362.65	1174725.3	0.11592741	0.88824294	0.68642746
2	39733.963	0.1196318	332135.45	664270.91	0.2392636	1.1724812	0.45051188
3	40066.978	0.12789948	313269.28	626538.56	0.25579896	0.93482683	0.56569929
4	43943.931	0.22127385	198595.23	397190.47	0.44254769	0.56026151	0.88679783
5	36649.974	0.08419609	435293.06	870586.11	0.16839218	0.76283489	0.74995673
6	45367.273	0.27587352	164449.54	328899.07	0.55174704	1.0326832	0.4718755
7	45787	0.1032	443680	1083195.2	0.129	0.88599875	0.65403268

Table 9. Description of exploratory Stock Synthesis runs.

Run 1
- variance adjustment lengths
- use both JPN and TWN CPUE
- Recruitment deviations start in 1970

Run 2
- Start with Run_1
- variance adjustment on lengths
- variance adjustment on all CPUE.
- use both JPN and TWN CPUE

Run 3
- Start with Run_1
- Variance adjustment lengths
- use only JPN CPUE

Run 4
- Start with Run_1
- variance adjustment length
- use only TWN CPUE

Run 5
- Start with Run_1
- Fix all selectivities to 1.0
- lambda on all lth comps = 0.0001
- Start the fishery at F = 0

Run 6
- Start with Run_5
- Start the fishery out of equilibrium
- estimate starting F with a bound of 2.0

Run 7 Annual
- Start with Run_6
- convert data to ANNUAL
- Fix male M at 0.56 from previous fits
- Estimate recruitment deviations 1970-2010
- increase penalty on recruitment deviations to 10

Run 8 Annual ASPM
- Start with Run_7
- put a prior on steepness of 0.75, SD = 0.15
- estimate of steepness went down to about 0.45
- No recruit deviations

Table 10. Residual mean square error from SS exploratory runs.

		RESIDUAL MEAN SQUARE ERROR (RMSE)								
Fleet Number	**Flt Name**	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**	**Run 8**	**Run 10**
(ALBN01	ESP_BBrec)	0.388	0.438	0.390	0.334	0.395	0.395	0.401	0.309	0.450
(ALBN02	EsFr_TR)	0.517	0.542	0.518	0.533	0.592	0.592	0.443	0.464	0.323
(ALBN03	EsFr_BBear)	0.302	0.340	0.317	0.323	0.343	0.343	0.341	0.238	0.351
(ALBN04	PRT_BB)	1.934	2.008	1.929	1.907	1.844	1.844	1.508	1.735	1.773
(ALBN05	JPN_LLtrg)	0.599	0.602	0.605	0.617	0.604	0.604	0.219	0.298	0.169
(ALBN06	JPN_LLtra)	0.705	0.632	0.743	0.705	0.686	0.686	0.481	0.394	0.629
(ALBN07	JPN_LLbyc)	0.703	0.763	0.698	0.808	0.691	0.691	0.353	0.414	0.348
(ALBN08	TAI_LL)	0.322	0.330	0.354	0.328	0.436	0.436	0.332	0.162	0.237
(ALBN09	TAI_LL)	0.450	0.406	0.470	0.520	0.517	0.517	0.402	0.374	0.320
(ALBN10	TAI_LL)	0.281	0.298	0.284	0.291	0.295	0.295	0.191	0.202	0.189
(ALBN11	KrPaCu_LL)	1.852	1.921	1.842	1.986	1.768	1.768	1.660	1.613	1.562
(ALBN12	Other_SU)	2.716	2.796	2.710	2.706	2.794	2.794	2.284	2.328	2.301

Table 11. Description of exploratory Stock Synthesis runs.

Run 12

- quarterly time step, 2 sex, change from effort to CPUE, deleted some lengths
- modified some selectivities by mirroring different fleets (11 and 12)
- Remove the JPN CPUE time series

Run 12B

- remove the CPUE variance reweighting

Run 13

- Same as model 12 except JPN CPUE is turned on and TIA CPUE turned off

Run 13B

- remove the CPUE variance reweighting

Run 14

- Same as model 12 except both JPN and TIA are turned on

Run 14B

- remove the CPUE variance reweighting

Run 15

- Start with 12B and try to make the fit more like MFCL
- Remove JPN CPUE or lengths
- No variance reweighting on CPUE
- No variance reweighting on LTHS
- Remove the TAI lengths

Run 16

- Start with Run 15
- split the TAI fishery into winter (season 1,2) and summer (season 3,4)
- put the TAI length back in
- Change divergence age for M for both sexes from 1 to 5

Run 17

- Most like MFCL base case
- 1 sex, match MFCL growth and M
- Leave out the TAI lengths
- Start recruitment deviations in 1930, no advanced options
- Fix the starting F value at 0.2
- Use the first 10 years of catch for equilibrium

Run 17B

- Start with 17 and decrease equilibrium catch to 933
- Fix initial F at 0.2

Run 17c

- Start with 17 and total remove equilibrium catch
- Start at F= 0

-

Table 12. VPA model estimates of North Atlantic albacore Beverton Holt (BH) stock recruitment parameters, maximum sustainable yield, 2011 stock status, and probability of $SSB>SSB_{MSY}$ and $F<F_{MSY}$ (green quadrant in Kobe phase diagram) from the base model and influential sensitivity runs. Note that benchmarks and stock status estimates for the Japan longline index sensitivity run are not presented due to a lack of fit of the stock recruitment curve from VPA estimates.

Run	Quantile	BH-a	BH-b	BH-σ	MSY	SSB/SSB_{MSY}	F/F_{MSY}	Pr(Green)
VPA base model	Median	1.1E+07	5.2E+03	0.21	3.65E+04	0.82	0.74	0.14
	80% CI Lower Limit	1.0E+07	6.4E+03	0.20	3.57E+04	0.66	0.51	
	80% CI Upper Limit	1.2E+07	1.4E+04	0.22	3.73E+04	1.06	1.11	
VPA USA longline indices removed	Median	1.1E+07	6.8E+03	0.20	3.60E+04	1.49	0.68	0.95
	80% CI Lower Limit	9.8E+06	2.9E+03	0.19	3.54E+04	1.11	0.41	
	80% CI Upper Limit	1.1E+07	1.1E+04	0.21	3.68E+04	2.16	1.06	
VPA age-varying mortality	Median	2.0E+07	1.3E+04	0.20	3.47E+04	1.28	0.67	0.78
	80% CI Lower Limit	1.8E+07	7.4E+03	0.19	3.36E+04	1.00	0.45	
	80% CI Upper Limit	2.3E+07	2.2E+04	0.22	3.57E+04	1.69	0.96	
VPA historical period included	Median	2.0E+07	4.7E+04	0.24	4.99E+04	0.39	0.95	0.00
	80% CI Lower Limit	1.8E+07	3.3E+04	0.22	4.76E+04	0.33	0.65	
	80% CI Upper Limit	2.2E+07	6.4E+04	0.26	5.21E+04	0.47	1.43	

Table 13. Fleet descriptions used in the ASPIC models for South Atlantic albacore.

Fleet	Fleet 1	Fleet 2 (1956 –1969) Fleet 3 (1970 –1975) Fleet 4 (1976 –2011)	Fleet 5	Fleet 6 (1956 –1998) Fleet 7 (1999 –2011)	Fleet 8
CPUE	Chinese Taipei (LL)	Japan (LL) None (1970-1975)	None	None	Uruguay (LL)
Catch	Chinese Taipei (LL) Korea (LL)	China LL E. C. Spain (LL) E. C. Portugal (LL) Japan (LL) Philippines (LL) St Vincent and Grenadier (LL) USA (LL) USSR (LL) Vanuatu (LL) Honduras (LL) Nei (LL) Côte D'Ivoire (LL) EU. United Kingdom (LL) Seychelles (LL) UK. Sta Helena (LL)	Brazil (LL, SU) Panama (LL) South Africa (LL, UN) Argentina (LL, TW, UN) Belize (LL) Cambodia (LL) Cuba (LL, UN) Namibia (LL)	Brazil (BB, GN, HL, PS, UN) E. C. Spain (PS) E. C. France (PS) E. C. Portugal (BB, PS) Japan (BB, PS) Namibia (BB) Korea (BB) Maroc (PS) Panama (PS) South Africa (BB, HL, PS, RR, SP) USA (PS) USSR (PS, SU) UK St Helena (BB, RR) Chinese Taipei (GN) Nei (PS) Netherlands (PS) Argentina (PS) Belize (PS) Cape Verde (PS) Curaçao (PS) Guatemala (PS)	Uruguay (LL)

Table 14. Catches (t) for each fleet for ASPIC for south Atlantic albacore listed in Table 13.

Year	*Fleet 1*	*Fleet 2*	*Fleet 3*	*Fleet 4*	*Fleet 5*	*Fleet 6*	*Fleet 7*	*Fleet 8*
1956		21						
1957		725						
1958		1,047						
1959		3,015			1,700			
1960		8,673			1,802			
1961		8,893			1,872			
1962		16,422			2,549			
1963		15,104			2,281			
1964	115	23,738			2,124	22		
1965	346	28,309			1,190			
1966	5,275	21,023			998			
1967	7,412	7,719			752			
1968	12,489	11,857			1,304	38		
1969	21,732	6,331			430			
1970	17,255		5,898		500			
1971	21,323		3,218		344			
1972	30,640		2,087		352	110		
1973	25,888		277		1,969	100		
1974	19,079		109		365	163		
1975	16,614		306		536	151		
1976	17,976			73	1,129	197		
1977	19,858			105	1,162	330		
1978	21,837			135	867	256		
1979	21,218			105	666	651		
1980	19,400			333	1,024	2,189		
1981	18,869			558	996	3,594		23
1982	23,363			569	1,114	4,391		235
1983	10,101			162	1,360	2,922		373
1984	8,237			224	1,061	4,551		526
1985	20,154			623	517	8,272		1,531
1986	27,913			739	1,263	7,111		262
1987	29,173			357	1,733	9,189		178
1988	20,926			405	816	7,926		100
1989	18,440			450	788	7,450		83
1990	20,461			587	638	6,973		55
1991	19,914			804	1,333	3,930		34
1992	23,068			1,001	3,374	9,089		31
1993	19,420			748	3,753	8,863		28
1994	22,576			923	1,684	10,100		16
1995	18,354			695	941	7,513		49
1996	18,974			785	1,165	7,426		75
1997	18,169			673	769	8,354		56
1998	16,113			487	3,098	10,787		110
1999	17,391			1,560	1,651		6,965	90
2000	17,239			3,041	4,027		6,989	90
2001	15,834			5,235	6,834		10,757	135
2002	17,321			1,142	3,097		10,074	111
2003	17,356			534	2,641		7,364	108
2004	13,325			703	606		7,789	120
2005	10,772			1,446	727		5,905	32
2006	12,359			2,247	3,041		6,712	93
2007	13,202			1,313	538		5,181	34
2008	10,054			2,633	478		5,640	53
2009	9,052			2,470	493		10,133	97
2010	11,105			1,693	649		5,721	24
2011	13,102			1,888	1,417		7,677	37

Table 11. Standardized CPUE series included in the ASPIC models for South Atlantic albacore.

Fleet represented	*Fleet 1*	*Fleet 2*	*Fleet 3*	*Fleet 4*	*Fleet 5*	*Fleet 6*	*Fleet 7*	*Fleet 8*
CPUE series flag	Chinese Taipei LL	Japan LL1	(None)	Japan LL3	(None)	(None)	(None)	Uruguay LL
1959		1.888						
1960		1.780						
1961		1.430						
1962		1.025						
1963		0.992						
1964		0.996						
1965		0.671						
1966		0.610						
1967	2.078	0.648						
1968	2.135	0.598						
1969	2.275	0.362						
1970	1.713							
1971	1.730							
1972	1.190							
1973	1.034							
1974	1.172							
1975	1.376			1.040				
1976	1.442			1.220				
1977	1.579			0.781				
1978	1.406			1.421				
1979	1.305			0.580				
1980	1.197			0.852				
1981	0.956			1.761				
1982	0.953			1.396				
1983	0.934			1.105				1.689
1984	1.051			1.143				1.459
1985	0.993			1.902				1.526
1986	0.977			2.212				1.509
1987	0.872			0.906				1.411
1988	0.627			0.649				1.467
1989	0.558			0.808				1.754
1990	0.597			1.111				1.148
1991	0.671			1.286				1.333
1992	0.798			0.707				0.884
1993	0.683			0.608				1.546
1994	0.869			0.878				0.690
1995	0.867			0.563				1.103
1996	0.922			0.614				1.511
1997	0.872			0.813				1.110
1998	0.753			0.793				1.532
1999	0.631			0.834				1.217
2000	0.583			1.435				0.970
2001	0.706			1.477				0.564
2002	0.570			0.950				0.455
2003	0.534			0.996				0.317
2004	0.650			1.067				0.229
2005	0.752			0.818				0.145
2006	0.574			0.438				0.561
2007	0.654			0.332				0.706
2008	0.679			0.691				0.531
2009	0.660			0.839				0.671
2010	0.749			1.039				0.589
2011	0.672			0.936				0.371

Table 16. Details of model runs in the ASPIC for South Atlantic albacore.

Run	*Weight*	B_1/K (fixed)	*Model*
2	Equal for all fleets	0.9	Logistic
6	Equal for all fleets	0.9	Fox
7	Weighted by catch	0.9	Logistic
8	Weighted by catch	0.9	Fox

Table 17. Results of the ASPIC model runs for South Atlantic albacore with those of 2011 assessment.

Results								*2011 results*			
Model run	*MSY (t)*	F_{MSY}	B_{MSY} *(t)*	B_{2012}/B_{MSY}	F_{2011}/F_{MSY}	*K (t)*	*r*	*MSY (t)*	F_{MSY}	B_{2009}/B_{MSY}	F_{2009}/F_{MSY}
Run2	28,060	0.301	93,330	0.813	1.076	186,700	0.60	27,390	0.248	0.624	1.342
Run6	25,660	0.199	128,800	0.861	1.098	350,000	0.20	25,650	0.204	0.762	1.180
Run7	22,620	0.070	323,000	0.816	1.301	646,000	0.14	23,630	0.072	0.931	1.038
Run8	24,250	0.127	191,300	0.950	1.047	520,000	0.13	24,850	0.095	1.204	0.765

Table 18. Scenarios of sensitivity analyses for the ASPIC model runs for South Atlantic albacore.

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
Uruguay index separated (-1991 and 1992-)	sep. Uruguay index
Without index of Japan LL1 (1959-69)	no JPLL1
Only with Chinese Taipei LL index	only TWLL
Only with Chinese Taipei LL and JPN LL1 indices	only TWLL&JPLL1
Only with index of Japan LL3 (1975-2011)	only JPLL3
Only with Uruguay LL indices (separated)	only Uruguay sep.

Table 19. Model specifications for South Atlantic BSP model runs. Model runs F1-F4 are the base cases. For the sensitivity analyses, specifications are the same as the base cases except where indicated.

Run name	*Weighting*	*Model*	*Series*	*End year*	*priors*	*Note*
F1	equal	Schaefer	all	2011	base	Base
F2	catch	Schaefer	all	2011	base	Base
F3	equal	Fox	all	2011	base	Base
F4	catch	Fox	all	2011	base	Base
S3	equal	Schaefer	Chinese Taipei	2011	base	cpue sensitivity
S6	equal	Schaefer	Uruguay	2011	base	cpue sensitivity
S7	equal	Schaefer	Japan	2011	base	cpue sensitivity
S8	equal	Schaefer	CHT+URU	2011	base	cpue sensitivity
S9	equal	Schaefer	CHT+JLL	2011	base	cpue sensitivity
S10	equal	Schaefer	URU+JLL	2011	base	cpue sensitivity
F1p2	equal	Schaefer	all	2011	Unif K	prior sensitivity
F2p2	catch	Schaefer	all	2011	Unif K	prior sensitivity
F3p2	equal	Fox	all	2011	Unif K	prior sensitivity
F4p2	catch	Fox	all	2011	Unif K	prior sensitivity
F1p3	equal	Schaefer	all	2011	Bo/K mean 1	prior sensitivity
F2p3	catch	Schaefer	all	2011	Bo/K mean 1	prior sensitivity
F3p3	equal	Fox	all	2011	Bo/K mean 1	prior sensitivity
F3p3	catch	Fox	all	2011	Bo/K mean 1	prior sensitivity
F1p4	equal	Schaefer	all	2011	Unif K, r	prior sensitivity
F2p4	catch	Schaefer	all	2011	Unif K, r	prior sensitivity
F3p4	equal	Fox	all	2011	Unif K, r	prior sensitivity
F4p4	catch	Fox	all	2011	Unif K, r	prior sensitivity
F1R1-F1R6	equal	Schaefer	all	2004-2010	base	retrospective
F3R1-F3R6	catch	Schaefer	all	2004-2010	base	retrospective

Table 20. Marginal posterior mean values of the parameters (CVs in parentheses) for the four BSP base cases.

Variable	*SAf 1*	*SAf 2*	*SAf 3*	*SAf 4*
K (1000)	704.25(0.56)	802.68(0.55)	843.49(0.55)	864.04(0.58)
r	0.18(0.62)	0.23(0.61)	0.23(0.83)	0.42(0.85)
MSY (1000)	23.23(0.37)	37.33(0.81)	23.58(0.66)	52.24(1.16)
Bcur (1000)	300.76(0.66)	512.97(0.75)	343.35(0.64)	543.20(0.78)
Binit (1000)	652.58(0.56)	742.42(0.55)	779.03(0.55)	797.23(0.58)
Bcur/Binit	0.47(0.32)	0.68(0.35)	0.45(0.32)	0.67(0.36)
Ccur/MSY	1.00(0.42)	0.78(0.57)	1.08(0.58)	0.75(0.82)
Bcur/Bmsy	0.87(0.32)	1.25(0.35)	1.13(0.31)	1.68(0.36)
Fcur/Fmsy	1.35(0.72)	0.89(1.25)	1.14(0.90)	0.69(1.58)

Table 21. Kobe 2 Strategy Matrix probability of being 'Green' over time for Northern albacore using the HCR parameters indicated.

	Kobe II Strategy matrix. Future probability of SSB>SSBMSY and F<FMSY for different combinations of Bthreshold and Ftarget values																			Average catch over		Cumulative catch over:		
Bthreshold	Ftarget	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	3 years	5 years	10 years	15 years	20 years
.6Bmsy	0.75Fmsy	29	32	36	49	54	57	61	65	68	70	73	75	77	78	80	81	82	84	26,969	139,100	293,575	454,716	620,434
.6Bmsy	0.8Fmsy	29	31	35	45	52	55	58	61	64	67	69	71	74	75	77	78	79	80	28,458	146,274	306,335	472,388	642,668
.6Bmsy	0.85Fmsy	29	31	33	42	47	52	55	57	59	62	64	67	69	71	72	74	76	77	29,911	153,211	318,349	488,666	662,774
.6Bmsy	0.9Fmsy	29	30	30	39	42	46	50	52	54	56	58	60	62	64	66	68	70	71	31,330	159,918	329,637	503,591	680,809
.6Bmsy	0.95Fmsy	29	29	20	36	37	39	42	44	48	50	51	52	54	55	56	58	60	61	32,715	166,398	340,221	517,205	696,835
.6Bmsy	Fmsy	29	29	0	33	33	0	33	33	0	33	33	0	33	33	0	33	33	0	34,066	172,657	350,123	529,550	710,916
.8Bmsy	0.75Fmsy	29	32	42	51	55	59	63	67	70	72	75	76	78	80	81	83	86	88	25,260	133,581	289,167	451,760	618,642
.8Bmsy	0.8Fmsy	29	32	41	50	53	56	59	62	66	69	71	73	75	77	78	80	81	83	26,655	140,496	301,820	469,532	641,152
.8Bmsy	0.85Fmsy	29	31	39	48	50	53	56	58	61	63	67	69	71	73	75	76	77	79	28,016	147,185	313,734	485,931	661,571
.8Bmsy	0.9Fmsy	29	30	35	46	48	50	51	54	56	58	60	62	64	67	69	70	72	73	29,346	153,654	324,930	500,996	679,954
.8Bmsy	0.95Fmsy	29	29	23	45	45	46	47	48	49	51	52	54	55	56	58	59	61	63	30,643	159,905	335,420	514,759	696,359
.8Bmsy	Fmsy	29	29	1	42	42	0	42	42	0	42	42	0	42	42	0	42	42	0	31,910	165,942	345,222	527,255	710,841
Bmsy	0.75Fmsy	29	35	47	58	62	68	72	75	78	80	82	84	87	90	92	94	95	96	22,639	123,151	277,783	441,651	610,569
Bmsy	0.8Fmsy	29	34	46	56	61	66	71	73	76	78	80	82	85	87	90	92	94	95	23,877	129,456	289,836	458,946	632,882
Bmsy	0.85Fmsy	29	33	45	55	59	63	69	71	74	77	78	80	82	84	87	89	91	93	25,083	135,543	301,142	474,839	653,068
Bmsy	0.9Fmsy	29	33	42	54	56	60	66	68	71	74	76	77	79	81	83	85	87	89	26,260	141,416	311,703	489,342	671,130
Bmsy	0.95Fmsy	29	32	32	52	54	57	62	64	67	70	72	73	76	77	78	80	81	83	27,407	147,079	321,520	502,449	687,030
Bmsy	Fmsy	29	31	21	50	52	11	57	57	5	62	62	5	65	65	3	67	67	2	28,525	152,534	330,547	514,046	700,587

Table 22. Kobe II risk matrix for B-ratio and F-ratio (probability of not exceeding MSY level) based on ASPIC results for south Atlantic albacore

Run02 Probability $B>B_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
14,000	23%	29%	38%	70%	90%	95%	95%	96%	96%	96%	96%	96%	96%	96%	96%	96%
16,000	23%	29%	38%	65%	86%	92%	94%	95%	95%	95%	95%	95%	95%	96%	96%	96%
18,000	23%	29%	38%	61%	81%	90%	93%	94%	94%	94%	94%	94%	94%	94%	95%	95%
20,000	23%	29%	38%	57%	72%	84%	89%	91%	92%	93%	93%	93%	93%	93%	93%	93%
22,000	23%	29%	38%	52%	63%	74%	82%	85%	87%	88%	89%	89%	89%	89%	89%	89%
24,000	23%	29%	38%	49%	54%	61%	68%	73%	75%	79%	80%	80%	80%	80%	80%	80%
26,000	23%	29%	38%	43%	47%	49%	50%	53%	55%	56%	59%	59%	60%	61%	61%	61%
28,000	23%	29%	38%	37%	35%	33%	31%	29%	28%	26%	24%	22%	21%	20%	18%	17%
30,000	23%	29%	38%	34%	28%	22%	17%	12%	9%	7%	5%	3%	1%	1%	0%	0%
32,000	23%	29%	38%	30%	22%	14%	9%	5%	3%	1%	0%	0%	0%	0%	0%	0%
34,000	23%	29%	38%	26%	17%	9%	4%	3%	1%	0%	0%	0%	0%	0%	0%	0%
36,000	23%	29%	38%	23%	12%	5%	3%	1%	1%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
0.75*FMSY	23%	29%	38%	56%	65%	70%	75%	76%	77%	78%	78%	79%	79%	79%	79%	79%
0.80*FMSY	23%	29%	38%	52%	61%	66%	68%	70%	72%	73%	74%	74%	74%	74%	74%	74%
0.85*FMSY	23%	29%	38%	51%	57%	61%	64%	66%	67%	67%	68%	68%	68%	68%	68%	69%
0.90*FMSY	23%	29%	38%	48%	53%	56%	58%	59%	60%	61%	62%	62%	62%	62%	62%	63%
0.95*FMSY	23%	29%	38%	44%	48%	50%	52%	54%	55%	55%	56%	56%	56%	56%	56%	57%
1.00*FMSY	23%	29%	38%	40%	42%	43%	44%	44%	45%	45%	45%	45%	46%	46%	46%	46%

Run02 Probability $F<F_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	71%	88%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16,000	71%	88%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
18,000	71%	88%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
20,000	71%	88%	96%	98%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
22,000	71%	88%	91%	94%	96%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%
24,000	71%	88%	74%	85%	89%	91%	92%	92%	92%	92%	91%	91%	91%	90%	90%
26,000	71%	88%	58%	60%	63%	66%	69%	71%	73%	74%	73%	74%	73%	72%	72%
28,000	71%	88%	38%	36%	34%	33%	31%	30%	28%	27%	24%	23%	22%	20%	18%
30,000	71%	88%	26%	21%	16%	11%	9%	7%	4%	3%	1%	1%	0%	0%	0%
32,000	71%	88%	16%	10%	7%	4%	3%	1%	1%	0%	0%	0%	0%	0%	0%
34,000	71%	88%	9%	6%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%
36,000	71%	88%	6%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	71%	88%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%
0.80*FMSY	71%	88%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%
0.85*FMSY	71%	88%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
0.90*FMSY	71%	88%	66%	66%	66%	66%	66%	66%	66%	66%	66%	66%	66%	66%	66%
0.95*FMSY	71%	88%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
1.00*FMSY	71%	88%	52%	52%	52%	52%	52%	52%	52%	52%	52%	52%	52%	52%	52%

Run02 Probability of being green

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	23%	29%	38%	70%	90%	95%	95%	96%	96%	96%	96%	96%	96%	96%	96%
16,000	23%	29%	38%	65%	86%	92%	94%	95%	95%	95%	95%	95%	95%	96%	96%
18,000	23%	29%	38%	61%	81%	90%	93%	94%	94%	94%	94%	94%	94%	94%	95%
20,000	23%	29%	38%	57%	72%	84%	89%	91%	92%	93%	93%	93%	93%	93%	93%
22,000	23%	29%	38%	52%	63%	74%	82%	85%	87%	88%	89%	89%	89%	89%	89%
24,000	23%	29%	38%	49%	54%	61%	68%	73%	75%	79%	80%	80%	80%	80%	80%
26,000	23%	29%	38%	43%	47%	49%	50%	53%	55%	56%	59%	59%	60%	61%	61%
28,000	23%	29%	38%	36%	34%	32%	31%	28%	27%	26%	23%	22%	20%	19%	17%
30,000	23%	29%	26%	21%	16%	11%	9%	7%	4%	3%	1%	1%	0%	0%	0%
32,000	23%	29%	16%	10%	7%	4%	3%	1%	1%	0%	0%	0%	0%	0%	0%
34,000	23%	29%	9%	6%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%
36,000	23%	29%	6%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	23%	29%	38%	56%	65%	70%	75%	76%	77%	78%	78%	79%	79%	79%	79%
0.80*FMSY	23%	29%	38%	52%	61%	66%	68%	70%	72%	73%	74%	74%	74%	74%	74%
0.85*FMSY	23%	29%	38%	51%	57%	61%	64%	66%	67%	67%	68%	68%	68%	68%	68%
0.90*FMSY	23%	29%	38%	48%	53%	56%	58%	59%	60%	61%	62%	62%	62%	62%	62%
0.95*FMSY	23%	29%	38%	44%	48%	50%	52%	54%	55%	55%	56%	56%	56%	56%	56%
1.00*FMSY	23%	29%	38%	40%	42%	43%	44%	44%	45%	45%	45%	45%	46%	46%	46%

Run06 Probability $B>B_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
14,000	24%	28%	33%	50%	73%	90%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16,000	24%	28%	33%	48%	65%	82%	93%	99%	99%	100%	100%	100%	100%	100%	100%	100%
18,000	24%	28%	33%	44%	57%	72%	84%	93%	98%	99%	99%	99%	99%	99%	100%	100%
20,000	24%	28%	33%	41%	50%	60%	72%	81%	88%	94%	96%	98%	98%	99%	99%	99%
22,000	24%	28%	33%	37%	42%	49%	54%	62%	70%	76%	82%	85%	90%	92%	93%	93%
24,000	24%	28%	33%	34%	35%	36%	39%	41%	43%	46%	48%	51%	53%	56%	59%	61%
26,000	24%	28%	33%	31%	30%	28%	27%	26%	24%	23%	22%	20%	19%	17%	17%	16%
28,000	24%	28%	33%	28%	25%	22%	18%	15%	13%	11%	8%	7%	5%	4%	4%	3%
30,000	24%	28%	33%	26%	21%	16%	13%	10%	7%	5%	3%	3%	2%	1%	1%	0%
32,000	24%	28%	33%	25%	18%	12%	9%	6%	4%	3%	2%	1%	0%	0%	0%	0%
34,000	24%	28%	33%	23%	16%	11%	6%	4%	3%	1%	1%	0%	0%	0%	0%	0%
36,000	24%	28%	33%	20%	13%	8%	5%	3%	1%	1%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
0.75*FMSY	24%	28%	33%	43%	52%	61%	69%	74%	77%	79%	81%	82%	83%	84%	84%	85%
0.80*FMSY	24%	28%	33%	41%	49%	56%	61%	67%	71%	73%	74%	76%	77%	77%	77%	78%
0.85*FMSY	24%	28%	33%	39%	46%	51%	55%	59%	62%	65%	66%	69%	70%	71%	71%	72%
0.90*FMSY	24%	28%	33%	37%	42%	47%	50%	52%	54%	56%	57%	58%	59%	59%	61%	61%
0.95*FMSY	24%	28%	33%	36%	39%	42%	45%	47%	48%	49%	49%	50%	51%	52%	52%	52%
1.00*FMSY	24%	28%	33%	34%	36%	37%	38%	39%	40%	40%	41%	41%	41%	42%	43%	43%

Run06 Probability $F<F_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	58%	68%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16,000	58%	68%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
18,000	58%	68%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
20,000	58%	68%	85%	92%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
22,000	58%	68%	66%	74%	81%	88%	92%	96%	98%	98%	99%	99%	99%	99%	99%
24,000	58%	68%	47%	49%	51%	53%	57%	60%	63%	66%	69%	73%	75%	76%	77%
26,000	58%	68%	29%	27%	26%	25%	24%	23%	21%	20%	19%	17%	16%	15%	15%
28,000	58%	68%	19%	17%	14%	12%	10%	8%	7%	5%	4%	3%	3%	2%	2%
30,000	58%	68%	13%	10%	8%	6%	4%	3%	3%	2%	1%	1%	0%	0%	0%
32,000	58%	68%	8%	6%	4%	3%	2%	1%	1%	0%	0%	0%	0%	0%	0%
34,000	58%	68%	6%	4%	2%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%
36,000	58%	68%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	58%	68%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%
0.80*FMSY	58%	68%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%
0.85*FMSY	58%	68%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
0.90*FMSY	58%	68%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
0.95*FMSY	58%	68%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
1.00*FMSY	58%	68%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%

Run06 Probability of being green

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	24%	28%	33%	50%	73%	90%	98%	100%	100%	100%	100%	100%	100%	100%	100%
16,000	24%	28%	33%	48%	65%	82%	93%	99%	99%	100%	100%	100%	100%	100%	100%
18,000	24%	28%	33%	44%	57%	72%	84%	93%	98%	99%	99%	99%	99%	99%	100%
20,000	24%	28%	33%	41%	50%	60%	72%	81%	88%	94%	96%	98%	98%	99%	99%
22,000	24%	28%	33%	37%	42%	49%	54%	62%	70%	76%	82%	85%	90%	92%	93%
24,000	24%	28%	33%	34%	35%	36%	39%	41%	43%	46%	48%	51%	53%	56%	59%
26,000	24%	28%	29%	27%	26%	25%	24%	23%	21%	20%	19%	17%	16%	15%	15%
28,000	24%	28%	19%	17%	14%	12%	10%	8%	7%	5%	4%	3%	3%	2%	2%
30,000	24%	28%	13%	10%	8%	6%	4%	3%	3%	2%	1%	1%	0%	0%	0%
32,000	24%	28%	8%	6%	4%	3%	2%	1%	1%	0%	0%	0%	0%	0%	0%
34,000	24%	28%	6%	4%	2%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%
36,000	24%	28%	4%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	24%	28%	33%	43%	52%	61%	69%	74%	77%	79%	81%	82%	83%	84%	84%
0.80*FMSY	24%	28%	33%	41%	49%	56%	61%	67%	71%	73%	74%	76%	77%	77%	77%
0.85*FMSY	24%	28%	33%	39%	46%	51%	55%	59%	62%	65%	66%	69%	70%	71%	71%
0.90*FMSY	24%	28%	33%	37%	42%	47%	50%	52%	54%	56%	57%	58%	59%	59%	60%
0.95*FMSY	24%	28%	33%	36%	39%	42%	45%	47%	48%	49%	49%	50%	51%	51%	51%
1.00*FMSY	24%	28%	33%	34%	36%	37%	38%	39%	40%	40%	40%	40%	40%	41%	41%

Run07 Probability B>B_{MSY}

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
14,000	24%	24%	24%	25%	27%	29%	32%	36%	42%	53%	63%	68%	75%	79%	82%	87%
16,000	24%	24%	24%	24%	26%	27%	28%	31%	33%	38%	42%	50%	60%	66%	70%	75%
18,000	24%	24%	24%	24%	24%	25%	26%	27%	28%	29%	31%	32%	35%	38%	41%	48%
20,000	24%	24%	24%	23%	23%	23%	24%	23%	24%	24%	24%	24%	24%	24%	25%	25%
22,000	24%	24%	24%	23%	22%	22%	21%	20%	20%	19%	18%	17%	16%	15%	14%	13%
24,000	24%	24%	24%	23%	21%	20%	19%	17%	16%	15%	13%	12%	11%	11%	10%	10%
26,000	24%	24%	24%	22%	20%	18%	16%	15%	13%	12%	11%	11%	10%	9%	8%	6%
28,000	24%	24%	24%	21%	19%	16%	14%	13%	12%	11%	10%	9%	8%	6%	5%	4%
30,000	24%	24%	24%	21%	18%	15%	13%	11%	11%	10%	8%	7%	6%	5%	3%	3%
32,000	24%	24%	24%	20%	16%	14%	12%	11%	10%	8%	7%	5%	5%	4%	3%	2%
34,000	24%	24%	24%	19%	16%	13%	11%	10%	8%	7%	5%	5%	4%	3%	2%	1%
36,000	24%	24%	24%	19%	15%	12%	10%	9%	7%	6%	5%	4%	3%	2%	1%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
0.75*FMSY	24%	24%	24%	25%	27%	29%	30%	34%	38%	42%	47%	55%	60%	65%	67%	70%
0.80*FMSY	24%	24%	24%	24%	26%	28%	29%	32%	34%	38%	41%	45%	52%	56%	60%	64%
0.85*FMSY	24%	24%	24%	24%	26%	27%	28%	29%	32%	33%	36%	39%	42%	46%	50%	55%
0.90*FMSY	24%	24%	24%	24%	25%	26%	27%	28%	29%	31%	33%	34%	36%	38%	40%	42%
0.95*FMSY	24%	24%	24%	24%	25%	26%	26%	27%	28%	29%	29%	30%	32%	32%	33%	35%
1.00*FMSY	24%	24%	24%	24%	24%	24%	25%	26%	26%	27%	28%	28%	29%	29%	29%	31%

Run07 Probability F<F_{MSY}

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	29%	29%	90%	94%	95%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%
16,000	29%	29%	79%	81%	84%	89%	92%	94%	96%	97%	98%	98%	99%	100%	100%
18,000	29%	29%	61%	65%	68%	71%	74%	77%	79%	82%	85%	88%	91%	93%	93%
20,000	29%	29%	36%	37%	38%	39%	40%	41%	43%	44%	47%	52%	56%	59%	61%
22,000	29%	29%	25%	25%	24%	24%	23%	23%	22%	21%	20%	19%	19%	18%	17%
24,000	29%	29%	17%	16%	16%	14%	14%	12%	12%	11%	11%	10%	10%	9%	8%
26,000	29%	29%	12%	11%	11%	10%	10%	9%	8%	7%	6%	6%	5%	4%	3%
28,000	29%	29%	10%	9%	8%	7%	7%	6%	5%	5%	4%	3%	3%	2%	1%
30,000	29%	29%	7%	7%	6%	5%	5%	4%	3%	3%	3%	2%	1%	1%	0%
32,000	29%	29%	6%	6%	5%	4%	3%	3%	2%	1%	1%	0%	0%	0%	0%
34,000	29%	29%	5%	5%	3%	3%	2%	2%	1%	1%	0%	0%	0%	0%	0%
36,000	29%	29%	4%	3%	2%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	29%	29%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%
0.80*FMSY	29%	29%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%
0.85*FMSY	29%	29%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
0.90*FMSY	29%	29%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
0.95*FMSY	29%	29%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1.00*FMSY	29%	29%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%

Run07 Probability of being green

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	24%	24%	24%	25%	27%	29%	32%	36%	42%	53%	63%	68%	75%	79%	82%
16,000	24%	24%	24%	24%	26%	27%	28%	31%	33%	38%	42%	50%	60%	66%	70%
18,000	24%	24%	24%	24%	24%	25%	26%	27%	28%	29%	31%	32%	35%	38%	41%
20,000	24%	24%	24%	23%	23%	23%	24%	23%	24%	24%	24%	24%	24%	24%	25%
22,000	24%	24%	24%	23%	22%	22%	21%	20%	20%	19%	18%	17%	16%	15%	14%
24,000	24%	24%	17%	16%	16%	14%	14%	12%	12%	11%	11%	10%	10%	9%	8%
26,000	24%	24%	12%	11%	11%	10%	10%	9%	8%	7%	6%	6%	5%	4%	3%
28,000	24%	24%	10%	9%	8%	7%	7%	6%	5%	5%	4%	3%	3%	2%	1%
30,000	24%	24%	7%	7%	6%	5%	5%	4%	3%	3%	3%	2%	1%	1%	0%
32,000	24%	24%	6%	6%	5%	4%	3%	3%	2%	1%	1%	0%	0%	0%	0%
34,000	24%	24%	5%	5%	3%	3%	2%	2%	1%	1%	0%	0%	0%	0%	0%
36,000	24%	24%	4%	3%	2%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	24%	24%	24%	25%	27%	29%	30%	34%	38%	42%	47%	55%	60%	65%	67%
0.80*FMSY	24%	24%	24%	24%	26%	28%	29%	32%	34%	38%	41%	45%	52%	56%	60%
0.85*FMSY	24%	24%	24%	24%	26%	27%	28%	29%	32%	33%	36%	39%	42%	46%	50%
0.90*FMSY	24%	24%	24%	24%	25%	26%	27%	28%	29%	31%	33%	34%	36%	38%	40%
0.95*FMSY	24%	24%	24%	24%	25%	25%	26%	27%	28%	29%	29%	30%	32%	32%	33%
1.00*FMSY	24%	24%	24%	24%	24%	24%	25%	26%	26%	27%	28%	28%	29%	29%	29%

Run08 Probability $B>B_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
14,000	44%	46%	49%	57%	66%	77%	88%	94%	97%	99%	99%	100%	100%	100%	100%	100%
16,000	44%	46%	49%	55%	62%	73%	81%	89%	93%	96%	98%	99%	99%	99%	99%	99%
18,000	44%	46%	49%	53%	58%	64%	74%	79%	86%	91%	94%	95%	97%	98%	99%	99%
20,000	44%	46%	49%	52%	55%	58%	63%	69%	74%	79%	83%	88%	90%	92%	95%	95%
22,000	44%	46%	49%	50%	52%	55%	56%	57%	59%	63%	66%	69%	71%	74%	77%	79%
24,000	44%	46%	49%	49%	49%	48%	48%	48%	48%	48%	47%	47%	47%	47%	46%	46%
26,000	44%	46%	49%	47%	45%	44%	41%	40%	38%	37%	36%	34%	30%	28%	25%	23%
28,000	44%	46%	49%	46%	42%	38%	37%	34%	31%	28%	25%	21%	18%	16%	14%	11%
30,000	44%	46%	49%	44%	39%	35%	33%	29%	25%	21%	17%	14%	11%	9%	8%	6%
32,000	44%	46%	49%	43%	36%	33%	29%	24%	19%	14%	12%	10%	8%	6%	4%	3%
34,000	44%	46%	49%	41%	35%	30%	24%	20%	15%	12%	9%	6%	5%	4%	3%	2%
36,000	44%	46%	49%	40%	33%	28%	22%	15%	12%	9%	6%	5%	4%	3%	2%	1%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
0.75*FMSY	44%	46%	49%	54%	58%	61%	66%	71%	74%	76%	78%	81%	83%	84%	85%	85%
0.80*FMSY	44%	46%	49%	52%	56%	58%	62%	65%	67%	71%	74%	74%	75%	76%	78%	78%
0.85*FMSY	44%	46%	49%	51%	54%	56%	58%	60%	62%	63%	65%	67%	69%	70%	71%	72%
0.90*FMSY	44%	46%	49%	50%	53%	54%	55%	56%	57%	58%	59%	60%	61%	61%	62%	62%
0.95*FMSY	44%	46%	49%	49%	50%	51%	52%	54%	54%	55%	55%	55%	55%	55%	56%	56%
1.00*FMSY	44%	46%	49%	49%	49%	49%	49%	49%	49%	49%	50%	50%	49%	50%	49%	50%

Run08 Probability $F<F_{MSY}$

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	65%	69%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16,000	65%	69%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
18,000	65%	69%	93%	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
20,000	65%	69%	82%	86%	90%	93%	96%	97%	98%	99%	100%	100%	100%	100%	100%
22,000	65%	69%	63%	67%	71%	74%	76%	79%	82%	85%	88%	90%	91%	93%	94%
24,000	65%	69%	50%	50%	50%	50%	51%	51%	51%	50%	50%	49%	49%	49%	48%
26,000	65%	69%	38%	36%	35%	34%	33%	31%	30%	28%	25%	22%	21%	19%	17%
28,000	65%	69%	30%	28%	26%	24%	22%	19%	15%	14%	12%	11%	9%	8%	6%
30,000	65%	69%	24%	21%	19%	15%	13%	11%	9%	8%	6%	5%	4%	3%	3%
32,000	65%	69%	19%	15%	13%	11%	9%	7%	5%	4%	4%	4%	2%	2%	1%
34,000	65%	69%	14%	12%	10%	7%	5%	4%	4%	3%	2%	2%	1%	1%	1%
36,000	65%	69%	12%	8%	6%	5%	4%	4%	3%	2%	2%	1%	1%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	65%	69%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%
0.80*FMSY	65%	69%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%
0.85*FMSY	65%	69%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
0.90*FMSY	65%	69%	64%	64%	64%	64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
0.95*FMSY	65%	69%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
1.00*FMSY	65%	69%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%

Run08 Probability of being green

Catch (t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14,000	44%	46%	49%	57%	66%	77%	88%	94%	97%	99%	99%	100%	100%	100%	100%
16,000	44%	46%	49%	55%	62%	73%	81%	89%	93%	96%	98%	99%	99%	99%	99%
18,000	44%	46%	49%	53%	58%	64%	74%	79%	86%	91%	94%	95%	97%	98%	99%
20,000	44%	46%	49%	52%	55%	58%	63%	69%	74%	79%	83%	88%	90%	92%	95%
22,000	44%	46%	49%	50%	52%	55%	56%	57%	59%	63%	66%	69%	71%	74%	77%
24,000	44%	46%	49%	49%	49%	48%	48%	48%	48%	48%	47%	47%	47%	47%	45%
26,000	44%	46%	38%	36%	35%	34%	33%	31%	30%	28%	25%	22%	21%	19%	17%
28,000	44%	46%	30%	28%	26%	24%	22%	19%	15%	14%	12%	11%	9%	8%	6%
30,000	44%	46%	24%	21%	19%	15%	13%	11%	9%	8%	6%	5%	4%	3%	3%
32,000	44%	46%	19%	15%	13%	11%	9%	7%	5%	4%	4%	4%	2%	2%	1%
34,000	44%	46%	14%	12%	10%	7%	5%	4%	4%	3%	2%	2%	1%	1%	1%
36,000	44%	46%	12%	8%	6%	5%	4%	4%	3%	2%	2%	1%	1%	0%	0%

F	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75*FMSY	44%	46%	49%	54%	58%	61%	66%	71%	74%	76%	78%	81%	83%	84%	85%
0.80*FMSY	44%	46%	49%	52%	56%	58%	62%	65%	67%	71%	74%	74%	75%	76%	78%
0.85*FMSY	44%	46%	49%	51%	54%	56%	58%	60%	62%	63%	65%	67%	69%	70%	71%
0.90*FMSY	44%	46%	49%	50%	53%	54%	55%	56%	57%	58%	59%	60%	60%	61%	62%
0.95*FMSY	44%	46%	49%	49%	50%	51%	52%	54%	54%	55%	55%	55%	55%	55%	55%
1.00*FMSY	44%	46%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%

Table 23. Kobe II strategy matrices for each BSP model run.

(a) Run 1

Probability $F<F_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
14000	0.724	0.744	0.762	0.770	0.770	0.776	0.780	0.786	0.794	0.794	0.794	0.800	0.800	0.802	0.806
16000	0.606	0.614	0.642	0.648	0.656	0.666	0.680	0.704	0.714	0.714	0.726	0.736	0.736	0.738	0.744
18000	0.534	0.536	0.552	0.556	0.564	0.578	0.584	0.588	0.590	0.602	0.606	0.614	0.618	0.626	0.626
20000	0.444	0.456	0.472	0.478	0.484	0.502	0.502	0.502	0.506	0.514	0.522	0.524	0.524	0.524	0.542
22000	0.358	0.376	0.376	0.378	0.386	0.394	0.394	0.404	0.404	0.422	0.422	0.422	0.422	0.424	0.424
24000	0.286	0.290	0.304	0.318	0.326	0.326	0.326	0.330	0.326	0.326	0.326	0.330	0.330	0.332	0.338
26000	0.226	0.222	0.222	0.222	0.222	0.220	0.220	0.220	0.226	0.230	0.226	0.226	0.226	0.226	0.226

28000	0.192	0.182	0.178	0.178	0.170	0.160	0.160	0.158	0.156	0.150	0.142	0.142	0.136	0.132	0.130
30000	0.150	0.136	0.130	0.116	0.110	0.100	0.100	0.090	0.084	0.084	0.074	0.072	0.068	0.068	0.066
32000	0.114	0.098	0.082	0.076	0.074	0.068	0.064	0.062	0.060	0.056	0.054	0.050	0.050	0.050	0.050
34000	0.108	0.098	0.088	0.080	0.074	0.068	0.064	0.060	0.054	0.046	0.046	0.044	0.042	0.040	0.040

Probability $B>B_{MSY}$

Harvest	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
0.75 Fmsy	0.308	0.338	0.408	0.448	0.508	0.520	0.548	0.578	0.598	0.634	0.648	0.678	0.694	0.710	0.742
0.8 Fmsy	0.298	0.328	0.370	0.422	0.456	0.508	0.522	0.548	0.562	0.584	0.628	0.634	0.652	0.680	0.692
0.85 Fmsy	0.298	0.314	0.332	0.384	0.422	0.448	0.498	0.512	0.532	0.558	0.564	0.580	0.620	0.634	0.646
0.9 Fmsy	0.292	0.300	0.318	0.332	0.366	0.404	0.438	0.448	0.484	0.512	0.512	0.536	0.558	0.564	0.578
0.95 Fmsy	0.290	0.292	0.298	0.308	0.318	0.330	0.340	0.362	0.402	0.422	0.440	0.448	0.468	0.490	0.508
1.0 Fmsy	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
14000	0.312	0.378	0.406	0.462	0.474	0.512	0.540	0.558	0.586	0.594	0.602	0.624	0.638	0.654	0.668
16000	0.296	0.356	0.394	0.416	0.466	0.470	0.500	0.520	0.538	0.538	0.578	0.582	0.588	0.594	0.600
18000	0.290	0.322	0.362	0.384	0.408	0.426	0.458	0.458	0.478	0.502	0.508	0.522	0.530	0.534	0.568
20000	0.286	0.308	0.346	0.358	0.364	0.384	0.394	0.406	0.416	0.440	0.444	0.448	0.468	0.468	0.478
22000	0.280	0.288	0.306	0.310	0.350	0.352	0.354	0.358	0.368	0.382	0.382	0.384	0.390	0.390	0.390
24000	0.280	0.280	0.278	0.288	0.292	0.298	0.298	0.320	0.320	0.330	0.340	0.338	0.336	0.340	0.340
26000	0.268	0.268	0.264	0.258	0.258	0.256	0.256	0.254	0.248	0.242	0.240	0.248	0.252	0.252	0.252
28000	0.268	0.256	0.244	0.240	0.236	0.232	0.218	0.218	0.218	0.210	0.202	0.202	0.198	0.190	0.188
30000	0.256	0.244	0.230	0.224	0.212	0.202	0.192	0.170	0.158	0.152	0.138	0.126	0.120	0.116	0.112
32000	0.252	0.236	0.220	0.206	0.170	0.156	0.140	0.130	0.118	0.114	0.096	0.090	0.088	0.080	0.076
34000	0.272	0.246	0.204	0.184	0.154	0.130	0.112	0.108	0.102	0.092	0.090	0.080	0.080	0.074	0.070

Probability of being green

Harvest	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
0.75 Fmsy	0.308	0.338	0.408	0.448	0.508	0.520	0.548	0.578	0.598	0.634	0.648	0.678	0.694	0.710	0.742
0.8 Fmsy	0.298	0.328	0.370	0.422	0.456	0.508	0.522	0.548	0.562	0.584	0.628	0.634	0.652	0.680	0.692
0.85 Fmsy	0.298	0.314	0.332	0.384	0.422	0.448	0.498	0.512	0.532	0.558	0.564	0.580	0.620	0.634	0.646
0.9 Fmsy	0.292	0.300	0.318	0.332	0.366	0.404	0.438	0.448	0.484	0.512	0.512	0.536	0.558	0.564	0.578
0.95 Fmsy	0.290	0.292	0.298	0.308	0.318	0.330	0.340	0.362	0.402	0.422	0.440	0.448	0.468	0.490	0.508
1.0 Fmsy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14000	0.310	0.376	0.404	0.460	0.472	0.510	0.538	0.556	0.584	0.592	0.600	0.622	0.636	0.654	0.668
16000	0.294	0.354	0.392	0.414	0.464	0.468	0.498	0.520	0.538	0.538	0.578	0.582	0.588	0.594	0.600
18000	0.284	0.316	0.356	0.380	0.404	0.424	0.456	0.456	0.476	0.500	0.506	0.520	0.528	0.532	0.566
20000	0.280	0.304	0.342	0.354	0.362	0.382	0.392	0.404	0.414	0.438	0.444	0.448	0.468	0.468	0.478
22000	0.272	0.280	0.298	0.304	0.344	0.346	0.350	0.354	0.364	0.378	0.378	0.380	0.386	0.386	0.386
24000	0.262	0.262	0.260	0.270	0.274	0.280	0.280	0.302	0.302	0.312	0.322	0.322	0.322	0.326	0.326
26000	0.226	0.222	0.222	0.222	0.222	0.220	0.220	0.220	0.218	0.218	0.214	0.222	0.226	0.226	0.226
28000	0.192	0.182	0.178	0.178	0.170	0.160	0.160	0.158	0.156	0.150	0.142	0.142	0.136	0.132	0.130
30000	0.150	0.136	0.130	0.116	0.110	0.100	0.100	0.090	0.084	0.084	0.074	0.072	0.068	0.068	0.066
32000	0.114	0.098	0.082	0.076	0.074	0.068	0.064	0.062	0.060	0.056	0.054	0.050	0.050	0.050	0.050
34000	0.108	0.098	0.088	0.080	0.074	0.068	0.064	0.060	0.054	0.046	0.046	0.044	0.042	0.040	0.040

(b) Run 2

Probability $F<F_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
14000	0.884	0.890	0.890	0.896	0.898	0.898	0.902	0.906	0.906	0.906	0.906	0.908	0.896	0.902	0.902
16000	0.818	0.828	0.828	0.838	0.844	0.844	0.846	0.848	0.848	0.846	0.846	0.846	0.848	0.848	0.848
18000	0.752	0.762	0.786	0.786	0.786	0.786	0.790	0.790	0.794	0.794	0.794	0.800	0.800	0.804	0.804
20000	0.608	0.628	0.628	0.638	0.640	0.662	0.666	0.680	0.686	0.686	0.686	0.686	0.696	0.696	0.710
22000	0.528	0.532	0.536	0.536	0.536	0.540	0.540	0.544	0.544	0.544	0.544	0.544	0.548	0.548	0.548
24000	0.424	0.418	0.416	0.420	0.414	0.414	0.414	0.414	0.414	0.412	0.418	0.428	0.428	0.428	0.428
26000	0.370	0.370	0.362	0.360	0.356	0.352	0.352	0.350	0.350	0.350	0.350	0.348	0.348	0.348	0.348
28000	0.322	0.320	0.314	0.314	0.312	0.298	0.296	0.296	0.296	0.294	0.276	0.262	0.260	0.254	0.254
30000	0.296	0.296	0.282	0.262	0.244	0.242	0.238	0.218	0.210	0.186	0.178	0.172	0.166	0.152	0.144
32000	0.260	0.242	0.234	0.210	0.178	0.168	0.150	0.136	0.128	0.124	0.118	0.110	0.108	0.100	0.094
34000	0.212	0.176	0.166	0.154	0.130	0.122	0.110	0.102	0.084	0.082	0.072	0.064	0.062	0.056	0.052

Probability $B>B_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75 Fmsy	0.612	0.664	0.722	0.762	0.802	0.818	0.846	0.852	0.862	0.900	0.902	0.932	0.938	0.938	0.944
0.8 Fmsy	0.602	0.660	0.700	0.730	0.762	0.802	0.818	0.846	0.848	0.852	0.894	0.900	0.902	0.932	0.938
0.85 Fmsy	0.596	0.626	0.664	0.712	0.730	0.762	0.786	0.818	0.830	0.846	0.846	0.852	0.876	0.894	0.900
0.9 Fmsy	0.564	0.602	0.628	0.660	0.688	0.716	0.742	0.762	0.774	0.800	0.828	0.836	0.846	0.846	0.850
0.95 Fmsy	0.560	0.564	0.598	0.604	0.622	0.646	0.688	0.698	0.702	0.720	0.734	0.760	0.774	0.774	0.804
1.0 Fmsy	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
14000	0.610	0.664	0.720	0.780	0.812	0.822	0.846	0.846	0.856	0.870	0.870	0.870	0.884	0.886	0.888
16000	0.598	0.636	0.652	0.716	0.752	0.780	0.806	0.810	0.832	0.832	0.832	0.836	0.842	0.848	0.848
18000	0.598	0.614	0.632	0.644	0.656	0.698	0.736	0.762	0.772	0.784	0.808	0.808	0.814	0.814	0.802
20000	0.580	0.596	0.610	0.630	0.634	0.626	0.636	0.636	0.650	0.640	0.628	0.636	0.650	0.654	0.670
22000	0.568	0.570	0.570	0.574	0.572	0.584	0.578	0.572	0.560	0.560	0.564	0.564	0.564	0.550	0.550
24000	0.548	0.548	0.536	0.524	0.514	0.514	0.480	0.474	0.474	0.474	0.454	0.454	0.458	0.454	0.448
26000	0.528	0.502	0.482	0.468	0.468	0.428	0.428	0.426	0.412	0.404	0.408	0.404	0.400	0.400	0.400
28000	0.520	0.482	0.458	0.444	0.428	0.398	0.386	0.372	0.366	0.342	0.332	0.326	0.326	0.320	0.312
30000	0.488	0.462	0.428	0.420	0.374	0.360	0.322	0.304	0.286	0.274	0.264	0.258	0.246	0.230	0.220
32000	0.488	0.442	0.402	0.386	0.330	0.306	0.280	0.254	0.236	0.204	0.192	0.178	0.166	0.160	0.144
34000	0.476	0.432	0.406	0.370	0.306	0.254	0.222	0.186	0.176	0.168	0.152	0.148	0.134	0.112	0.108

Probability of being green

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
14000	0.598	0.652	0.708	0.768	0.800	0.810	0.834	0.834	0.844	0.858	0.858	0.858	0.860	0.862	0.864
16000	0.574	0.612	0.628	0.692	0.728	0.756	0.782	0.786	0.810	0.806	0.806	0.810	0.816	0.822	0.822
18000	0.554	0.570	0.588	0.600	0.612	0.654	0.694	0.720	0.730	0.742	0.766	0.776	0.790	0.790	0.790
20000	0.520	0.536	0.550	0.570	0.576	0.576	0.586	0.586	0.600	0.600	0.600	0.614	0.628	0.632	0.648
22000	0.484	0.496	0.496	0.510	0.510	0.528	0.532	0.534	0.534	0.534	0.538	0.538	0.536	0.536	0.536
24000	0.408	0.412	0.410	0.416	0.410	0.410	0.410	0.410	0.410	0.408	0.408	0.408	0.412	0.412	0.412

26000	0.370	0.370	0.362	0.360	0.356	0.352	0.346	0.344	0.344	0.344	0.350	0.348	0.348	0.348	0.348
28000	0.322	0.320	0.314	0.314	0.312	0.298	0.296	0.296	0.296	0.294	0.276	0.262	0.260	0.254	0.254
30000	0.296	0.296	0.282	0.262	0.244	0.242	0.238	0.218	0.210	0.186	0.178	0.172	0.166	0.152	0.144
32000	0.260	0.242	0.234	0.210	0.178	0.168	0.150	0.136	0.128	0.124	0.118	0.110	0.108	0.100	0.094
34000	0.212	0.176	0.166	0.154	0.130	0.122	0.110	0.102	0.084	0.082	0.072	0.064	0.062	0.056	0.052

(c) Run 3

Probability $F<F_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
14000	0.876	0.882	0.888	0.892	0.894	0.894	0.898	0.898	0.898	0.898	0.898	0.904	0.904	0.904	0.906
16000	0.826	0.832	0.838	0.838	0.838	0.850	0.866	0.870	0.872	0.872	0.876	0.878	0.878	0.878	0.882
18000	0.796	0.800	0.804	0.806	0.806	0.808	0.810	0.810	0.810	0.810	0.812	0.816	0.816	0.816	0.816
20000	0.748	0.750	0.754	0.756	0.762	0.774	0.774	0.774	0.776	0.776	0.782	0.788	0.788	0.788	0.792
22000	0.712	0.714	0.714	0.714	0.718	0.720	0.722	0.724	0.724	0.726	0.726	0.726	0.726	0.728	0.732
24000	0.676	0.678	0.684	0.688	0.688	0.688	0.688	0.688	0.684	0.684	0.684	0.684	0.684	0.684	0.686
26000	0.632	0.632	0.630	0.632	0.632	0.632	0.632	0.630	0.628	0.632	0.630	0.630	0.630	0.630	0.630
28000	0.590	0.588	0.586	0.586	0.582	0.580	0.578	0.576	0.574	0.572	0.556	0.552	0.552	0.550	0.548
30000	0.570	0.552	0.548	0.538	0.532	0.524	0.524	0.520	0.514	0.508	0.498	0.488	0.488	0.482	0.476
32000	0.530	0.522	0.518	0.500	0.492	0.476	0.472	0.468	0.458	0.450	0.448	0.434	0.432	0.432	0.424
34000	0.522	0.508	0.502	0.488	0.474	0.462	0.448	0.440	0.428	0.418	0.410	0.408	0.406	0.398	0.390

Probability $B>B_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75 Fmsy	0.718	0.738	0.758	0.770	0.794	0.798	0.818	0.830	0.838	0.844	0.846	0.852	0.860	0.866	0.880
0.8 Fmsy	0.708	0.732	0.754	0.762	0.772	0.790	0.798	0.814	0.824	0.832	0.840	0.844	0.848	0.854	0.860
0.85 Fmsy	0.708	0.724	0.736	0.754	0.762	0.772	0.786	0.794	0.806	0.814	0.818	0.830	0.840	0.844	0.844
0.9 Fmsy	0.706	0.712	0.724	0.736	0.752	0.756	0.766	0.772	0.778	0.790	0.794	0.802	0.814	0.814	0.828
0.95 Fmsy	0.704	0.706	0.708	0.718	0.724	0.730	0.742	0.750	0.756	0.764	0.770	0.772	0.776	0.778	0.784
1.0 Fmsy	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700
14000	0.698	0.724	0.734	0.754	0.768	0.782	0.798	0.802	0.812	0.814	0.814	0.816	0.828	0.834	0.842
16000	0.692	0.722	0.730	0.738	0.754	0.760	0.776	0.786	0.794	0.794	0.800	0.808	0.812	0.812	0.812
18000	0.688	0.710	0.722	0.728	0.736	0.742	0.752	0.752	0.764	0.774	0.774	0.788	0.790	0.794	0.800
20000	0.678	0.696	0.716	0.720	0.718	0.724	0.726	0.734	0.736	0.740	0.742	0.744	0.754	0.754	0.764
22000	0.676	0.686	0.698	0.698	0.714	0.714	0.712	0.710	0.716	0.718	0.718	0.720	0.722	0.722	0.722
24000	0.674	0.676	0.674	0.680	0.680	0.686	0.686	0.692	0.694	0.698	0.702	0.702	0.702	0.706	0.704
26000	0.672	0.672	0.664	0.662	0.660	0.660	0.660	0.658	0.652	0.654	0.650	0.650	0.652	0.652	0.646
28000	0.672	0.658	0.650	0.648	0.640	0.640	0.630	0.628	0.624	0.612	0.606	0.600	0.596	0.590	0.590
30000	0.662	0.650	0.640	0.630	0.626	0.612	0.598	0.586	0.568	0.558	0.550	0.548	0.540	0.540	0.534
32000	0.658	0.644	0.630	0.618	0.592	0.574	0.554	0.550	0.534	0.516	0.508	0.502	0.492	0.478	0.474
34000	0.686	0.672	0.658	0.622	0.594	0.578	0.548	0.532	0.524	0.504	0.486	0.478	0.472	0.458	0.452

Probability of being green

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75 Fmsy	0.718	0.738	0.758	0.770	0.794	0.798	0.818	0.830	0.838	0.844	0.846	0.852	0.860	0.866	0.880
0.8 Fmsy	0.708	0.732	0.754	0.762	0.772	0.790	0.798	0.814	0.824	0.832	0.840	0.844	0.848	0.854	0.860
0.85 Fmsy	0.708	0.724	0.736	0.754	0.762	0.772	0.786	0.794	0.806	0.814	0.818	0.830	0.840	0.844	0.844
0.9 Fmsy	0.706	0.712	0.724	0.736	0.752	0.756	0.766	0.772	0.778	0.790	0.794	0.802	0.814	0.814	0.828
0.95 Fmsy	0.704	0.706	0.708	0.718	0.724	0.730	0.742	0.750	0.756	0.764	0.770	0.772	0.776	0.778	0.784
1.0 Fmsy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14000	0.696	0.722	0.732	0.752	0.766	0.780	0.796	0.800	0.810	0.812	0.812	0.814	0.826	0.834	0.842
16000	0.690	0.720	0.728	0.736	0.752	0.758	0.774	0.786	0.794	0.794	0.800	0.808	0.812	0.812	0.812
18000	0.684	0.706	0.718	0.724	0.732	0.740	0.750	0.750	0.762	0.772	0.772	0.786	0.788	0.792	0.798
20000	0.670	0.688	0.708	0.712	0.712	0.718	0.720	0.728	0.730	0.734	0.738	0.740	0.750	0.750	0.760
22000	0.664	0.674	0.686	0.688	0.704	0.704	0.704	0.704	0.710	0.712	0.712	0.714	0.716	0.716	0.716
24000	0.656	0.656	0.656	0.662	0.662	0.668	0.668	0.674	0.672	0.676	0.680	0.680	0.680	0.684	0.684
26000	0.632	0.632	0.630	0.630	0.630	0.630	0.630	0.628	0.624	0.626	0.624	0.626	0.630	0.630	0.630
28000	0.590	0.588	0.586	0.586	0.582	0.580	0.578	0.576	0.574	0.572	0.556	0.552	0.552	0.550	0.548
30000	0.570	0.552	0.548	0.538	0.532	0.524	0.524	0.520	0.514	0.508	0.498	0.488	0.488	0.482	0.476
32000	0.530	0.522	0.518	0.500	0.492	0.476	0.472	0.468	0.458	0.450	0.448	0.434	0.432	0.432	0.424
34000	0.522	0.508	0.502	0.488	0.474	0.462	0.448	0.440	0.428	0.418	0.410	0.408	0.406	0.398	0.390

(d) Run 4

Probability $F<F_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
14000	0.950	0.950	0.952	0.952	0.952	0.954	0.954	0.954	0.954	0.954	0.954	0.954	0.954	0.954	0.954
16000	0.932	0.936	0.938	0.940	0.940	0.942	0.942	0.944	0.944	0.944	0.944	0.944	0.944	0.944	0.944
18000	0.926	0.926	0.928	0.926	0.926	0.926	0.924	0.924	0.924	0.924	0.924	0.924	0.922	0.922	0.922
20000	0.894	0.896	0.896	0.896	0.896	0.898	0.898	0.898	0.898	0.900	0.900	0.900	0.902	0.902	0.902
22000	0.870	0.870	0.870	0.874	0.874	0.878	0.870	0.870	0.872	0.872	0.872	0.872	0.872	0.874	0.874
24000	0.826	0.826	0.830	0.826	0.826	0.826	0.826	0.822	0.822	0.822	0.822	0.816	0.818	0.818	0.814
26000	0.800	0.794	0.792	0.788	0.788	0.786	0.786	0.786	0.786	0.782	0.784	0.778	0.772	0.772	0.772
28000	0.766	0.766	0.764	0.760	0.752	0.750	0.750	0.746	0.746	0.746	0.746	0.736	0.736	0.730	0.730
30000	0.750	0.746	0.744	0.740	0.730	0.726	0.720	0.714	0.704	0.698	0.696	0.688	0.684	0.680	0.674
32000	0.732	0.728	0.720	0.706	0.696	0.686	0.676	0.664	0.642	0.626	0.612	0.598	0.590	0.576	0.568
34000	0.638	0.628	0.612	0.594	0.574	0.556	0.530	0.516	0.498	0.486	0.480	0.474	0.470	0.462	0.458

Probability $B>B_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75 Fmsy	0.818	0.840	0.862	0.878	0.890	0.892	0.900	0.910	0.922	0.938	0.948	0.948	0.950	0.950	0.956
0.8 Fmsy	0.814	0.838	0.854	0.864	0.878	0.890	0.892	0.900	0.902	0.922	0.922	0.936	0.948	0.948	0.948
0.85 Fmsy	0.812	0.828	0.842	0.854	0.862	0.876	0.878	0.890	0.894	0.898	0.902	0.920	0.920	0.934	0.940
0.9 Fmsy	0.808	0.814	0.832	0.842	0.854	0.860	0.864	0.876	0.880	0.890	0.894	0.896	0.902	0.906	0.914
0.95 Fmsy	0.798	0.810	0.818	0.826	0.832	0.836	0.842	0.852	0.854	0.862	0.862	0.868	0.878	0.884	0.886
1.0 Fmsy	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.796	0.796	0.794	0.796
14000	0.894	0.902	0.916	0.922	0.930	0.934	0.936	0.938	0.938	0.938	0.940	0.948	0.948	0.948	0.948

16000	0.892	0.902	0.910	0.916	0.922	0.926	0.930	0.932	0.932	0.930	0.934	0.934	0.934	0.934	0.936
18000	0.888	0.900	0.902	0.910	0.914	0.916	0.914	0.914	0.922	0.922	0.922	0.928	0.928	0.930	0.930
20000	0.878	0.884	0.894	0.894	0.892	0.894	0.904	0.904	0.904	0.904	0.906	0.908	0.908	0.908	0.908
22000	0.878	0.880	0.884	0.882	0.884	0.888	0.890	0.890	0.890	0.890	0.892	0.896	0.896	0.896	0.896
24000	0.876	0.870	0.870	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.864	0.864	0.864	0.860	0.854
26000	0.870	0.870	0.866	0.862	0.862	0.862	0.854	0.850	0.844	0.832	0.832	0.822	0.820	0.812	0.804
28000	0.870	0.870	0.854	0.844	0.836	0.828	0.822	0.814	0.804	0.800	0.784	0.766	0.758	0.756	0.752
30000	0.870	0.858	0.834	0.828	0.820	0.804	0.790	0.784	0.762	0.754	0.736	0.732	0.724	0.718	0.710
32000	0.864	0.840	0.832	0.818	0.800	0.778	0.758	0.734	0.714	0.704	0.694	0.684	0.658	0.646	0.642
34000	0.802	0.770	0.752	0.718	0.704	0.670	0.640	0.626	0.596	0.590	0.550	0.536	0.518	0.514	0.506

Probability of being green

Harvest	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
0.75 Fmsy	0.818	0.840	0.862	0.878	0.890	0.892	0.900	0.910	0.922	0.938	0.948	0.948	0.950	0.950	0.956
0.8 Fmsy	0.814	0.838	0.854	0.864	0.878	0.890	0.892	0.900	0.902	0.922	0.922	0.936	0.948	0.948	0.948
0.85 Fmsy	0.812	0.828	0.842	0.854	0.862	0.876	0.878	0.890	0.894	0.898	0.902	0.920	0.920	0.934	0.940
0.9 Fmsy	0.808	0.814	0.832	0.842	0.854	0.860	0.864	0.876	0.880	0.890	0.894	0.896	0.902	0.906	0.914
0.95 Fmsy	0.798	0.810	0.818	0.826	0.832	0.836	0.842	0.852	0.854	0.862	0.862	0.868	0.878	0.884	0.886
1.0 Fmsy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14000	0.890	0.898	0.912	0.918	0.926	0.930	0.932	0.934	0.934	0.934	0.936	0.944	0.944	0.944	0.944
16000	0.888	0.898	0.906	0.912	0.918	0.922	0.926	0.928	0.928	0.930	0.934	0.934	0.934	0.934	0.936
18000	0.884	0.896	0.898	0.904	0.908	0.910	0.908	0.908	0.916	0.916	0.916	0.922	0.920	0.922	0.922
20000	0.862	0.868	0.878	0.878	0.880	0.882	0.892	0.892	0.892	0.892	0.894	0.896	0.896	0.896	0.896
22000	0.856	0.858	0.862	0.864	0.866	0.870	0.864	0.864	0.864	0.864	0.866	0.870	0.870	0.870	0.870
24000	0.824	0.824	0.824	0.822	0.822	0.826	0.826	0.822	0.822	0.822	0.822	0.816	0.816	0.816	0.812
26000	0.800	0.794	0.792	0.788	0.788	0.786	0.786	0.786	0.786	0.782	0.782	0.776	0.770	0.772	0.772
28000	0.766	0.766	0.764	0.760	0.752	0.750	0.750	0.746	0.746	0.746	0.746	0.736	0.736	0.730	0.730
30000	0.750	0.746	0.744	0.740	0.730	0.726	0.720	0.714	0.704	0.698	0.696	0.688	0.684	0.680	0.674
32000	0.732	0.728	0.720	0.706	0.696	0.686	0.676	0.664	0.642	0.626	0.612	0.598	0.590	0.576	0.568
34000	0.638	0.628	0.612	0.594	0.574	0.556	0.530	0.516	0.498	0.486	0.480	0.474	0.470	0.462	0.458

Table 24. Kobe II matrices for the 8 scenarios combined in the South Atlantic

(a) Probability $F<F_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
14000	0.909	0.914	0.919	0.922	0.923	0.924	0.926	0.928	0.929	0.929	0.930	0.932	0.931
16000	0.857	0.863	0.871	0.874	0.878	0.882	0.887	0.892	0.895	0.897	0.899	0.901	0.902
18000	0.799	0.808	0.819	0.825	0.830	0.834	0.838	0.841	0.843	0.846	0.848	0.851	0.852
20000	0.680	0.698	0.708	0.719	0.728	0.740	0.746	0.753	0.759	0.765	0.772	0.776	0.781
22000	0.590	0.603	0.610	0.618	0.626	0.634	0.637	0.644	0.648	0.654	0.656	0.659	0.662
24000	0.506	0.511	0.519	0.526	0.530	0.534	0.537	0.540	0.541	0.542	0.545	0.547	0.550
26000	0.414	0.413	0.414	0.414	0.415	0.415	0.417	0.418	0.419	0.419	0.420	0.419	0.418
28000	0.339	0.332	0.325	0.322	0.316	0.311	0.306	0.304	0.301	0.299	0.292	0.287	0.284

30000	0.286	0.272	0.261	0.247	0.236	0.227	0.221	0.213	0.207	0.200	0.193	0.188	0.185
32000	0.240	0.220	0.206	0.192	0.182	0.175	0.170	0.166	0.161	0.157	0.154	0.149	0.148
34000	0.201	0.182	0.171	0.165	0.157	0.151	0.144	0.140	0.133	0.129	0.126	0.124	0.123

(b) Probability $B>B_{MSY}$

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75 Fmsy	0.470	0.539	0.598	0.637	0.678	0.700	0.728	0.753	0.778	0.809	0.824	0.841	0.851
0.8 Fmsy	0.465	0.526	0.576	0.610	0.641	0.675	0.693	0.717	0.735	0.755	0.782	0.796	0.810
0.85 Fmsy	0.464	0.510	0.547	0.584	0.609	0.634	0.658	0.676	0.696	0.712	0.723	0.738	0.757
0.9 Fmsy	0.459	0.490	0.522	0.548	0.570	0.592	0.610	0.625	0.642	0.658	0.671	0.681	0.694
0.95 Fmsy	0.457	0.475	0.493	0.513	0.526	0.542	0.557	0.568	0.581	0.591	0.600	0.609	0.618
1.0 Fmsy	0.451	0.459	0.464	0.471	0.475	0.480	0.482	0.487	0.490	0.493	0.496	0.499	0.500
14000	0.477	0.581	0.643	0.696	0.734	0.762	0.790	0.815	0.836	0.848	0.855	0.864	0.872
16000	0.472	0.562	0.615	0.660	0.700	0.724	0.750	0.767	0.788	0.802	0.822	0.833	0.840
18000	0.471	0.541	0.590	0.623	0.650	0.678	0.703	0.719	0.737	0.750	0.763	0.775	0.787
20000	0.465	0.519	0.564	0.592	0.610	0.627	0.644	0.658	0.671	0.680	0.688	0.696	0.709
22000	0.463	0.495	0.529	0.549	0.570	0.583	0.591	0.599	0.606	0.615	0.623	0.628	0.635
24000	0.460	0.475	0.488	0.501	0.511	0.522	0.524	0.534	0.538	0.542	0.544	0.548	0.551
26000	0.455	0.453	0.451	0.449	0.449	0.444	0.443	0.443	0.439	0.436	0.437	0.437	0.438
28000	0.454	0.432	0.412	0.398	0.384	0.372	0.361	0.352	0.347	0.337	0.327	0.321	0.316
30000	0.447	0.409	0.373	0.350	0.326	0.308	0.285	0.269	0.253	0.242	0.231	0.226	0.218
32000	0.445	0.386	0.342	0.307	0.265	0.239	0.221	0.209	0.201	0.193	0.187	0.182	0.176
34000	0.442	0.368	0.308	0.257	0.224	0.205	0.191	0.182	0.175	0.169	0.160	0.155	0.151

(c) Probility of green status ($B>B_{MSY}$ and $F<F_{MSY}$).

Harvest	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0.75 Fmsy	0.469	0.538	0.597	0.637	0.677	0.699	0.728	0.753	0.778	0.809	0.824	0.841	0.851
0.8 Fmsy	0.465	0.525	0.575	0.610	0.641	0.675	0.693	0.717	0.735	0.755	0.782	0.796	0.810
0.85 Fmsy	0.464	0.509	0.547	0.583	0.609	0.634	0.658	0.676	0.696	0.712	0.723	0.738	0.757
0.9 Fmsy	0.458	0.489	0.522	0.547	0.570	0.592	0.610	0.625	0.642	0.658	0.671	0.681	0.694
0.95 Fmsy	0.456	0.474	0.492	0.513	0.526	0.541	0.557	0.568	0.581	0.591	0.600	0.609	0.618
1.0 Fmsy	0.160	0.169	0.174	0.181	0.186	0.190	0.193	0.197	0.201	0.203	0.207	0.209	0.211
14000	0.474	0.578	0.641	0.693	0.731	0.760	0.788	0.812	0.833	0.846	0.853	0.861	0.868
16000	0.468	0.557	0.610	0.656	0.695	0.720	0.746	0.763	0.785	0.798	0.819	0.829	0.837
18000	0.463	0.533	0.583	0.615	0.642	0.672	0.697	0.713	0.730	0.744	0.757	0.770	0.783
20000	0.454	0.508	0.553	0.581	0.601	0.618	0.635	0.650	0.663	0.673	0.682	0.692	0.704
22000	0.446	0.480	0.514	0.536	0.558	0.572	0.580	0.590	0.598	0.608	0.615	0.620	0.627
24000	0.428	0.445	0.459	0.475	0.484	0.496	0.503	0.513	0.517	0.521	0.526	0.529	0.532
26000	0.394	0.395	0.399	0.400	0.402	0.403	0.405	0.406	0.407	0.409	0.411	0.412	0.413
28000	0.336	0.329	0.324	0.321	0.315	0.309	0.305	0.302	0.300	0.298	0.291	0.285	0.283
30000	0.286	0.272	0.261	0.247	0.236	0.227	0.221	0.213	0.207	0.200	0.193	0.188	0.185
32000	0.240	0.220	0.206	0.192	0.182	0.175	0.170	0.166	0.161	0.157	0.154	0.149	0.148
34000	0.201	0.182	0.171	0.165	0.157	0.151	0.144	0.140	0.133	0.129	0.126	0.124	0.123

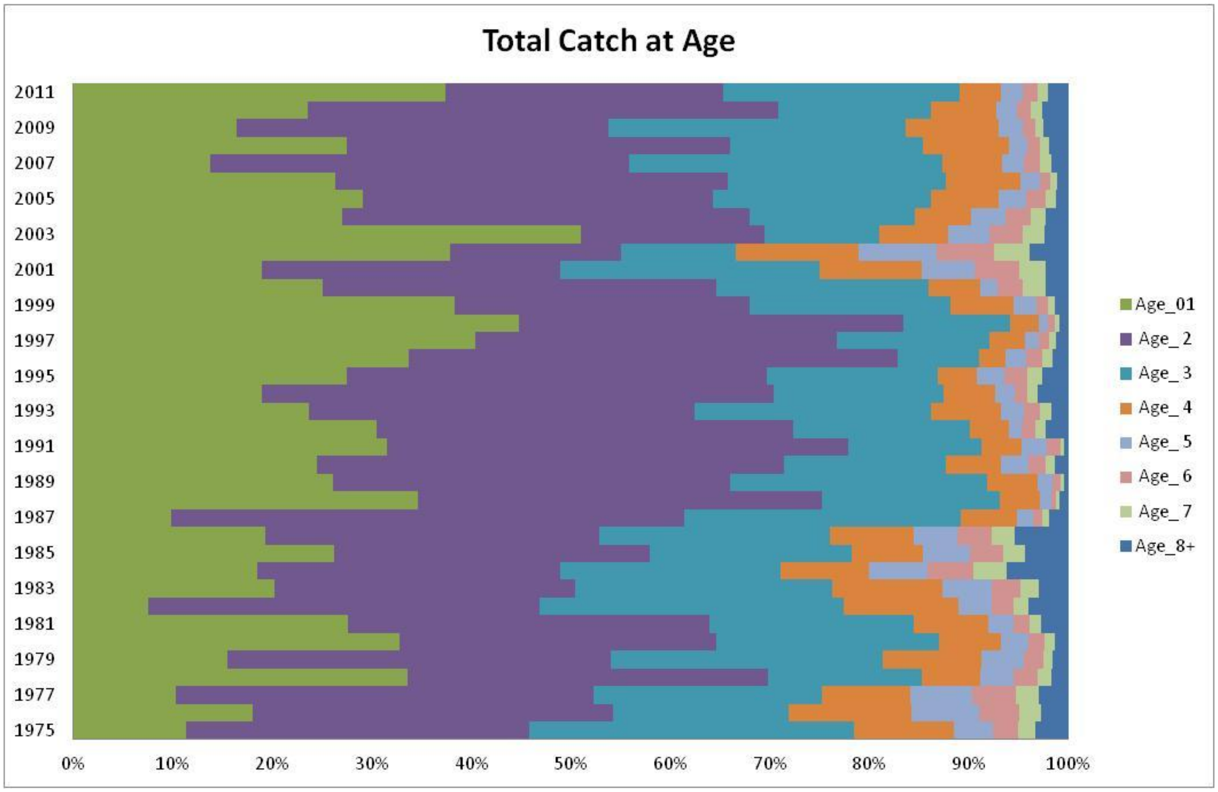


Figure 1. Total N-ALB catch-at-age (CAA).

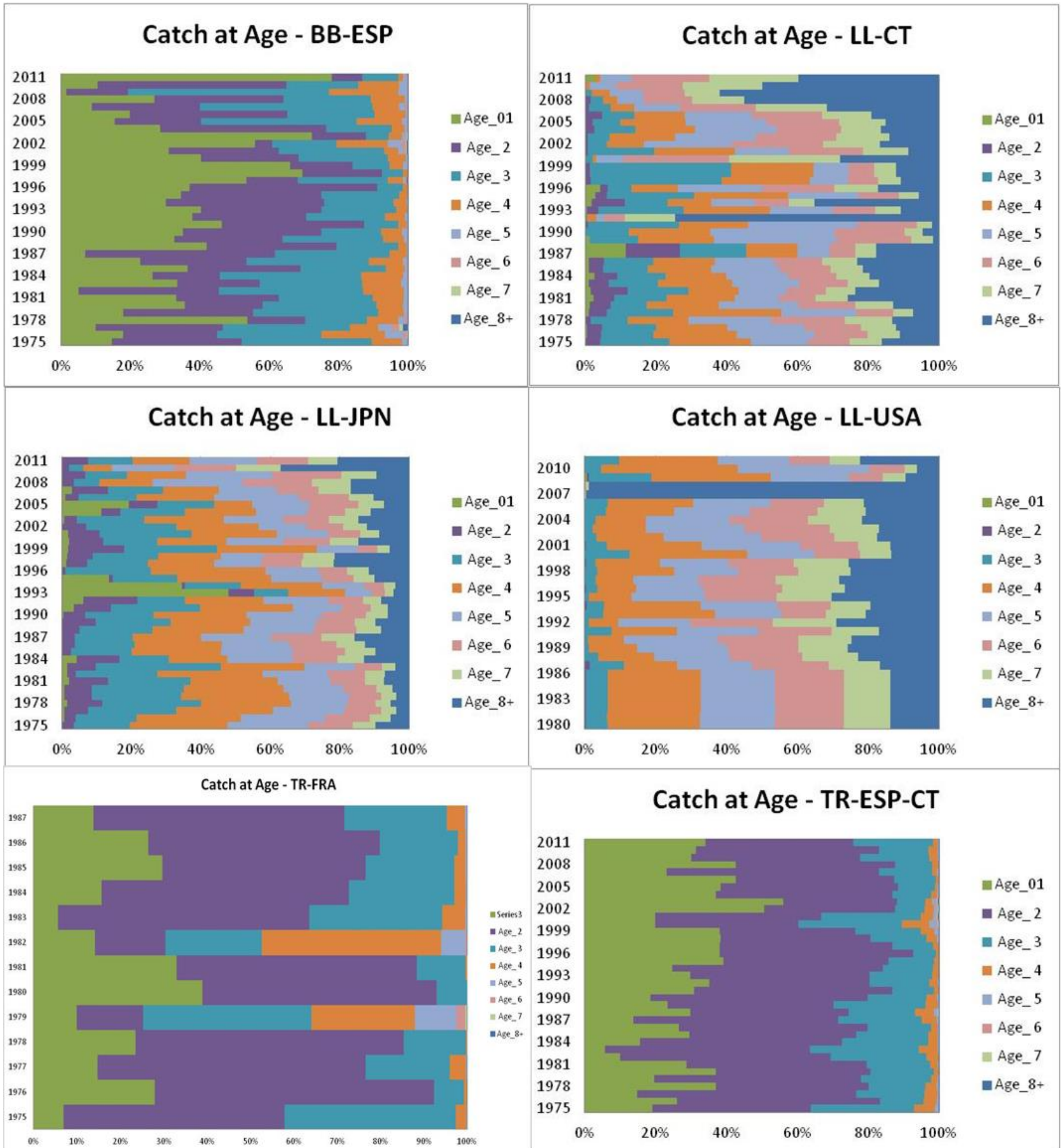


Figure 2. Partial catch-at-age by fleet.

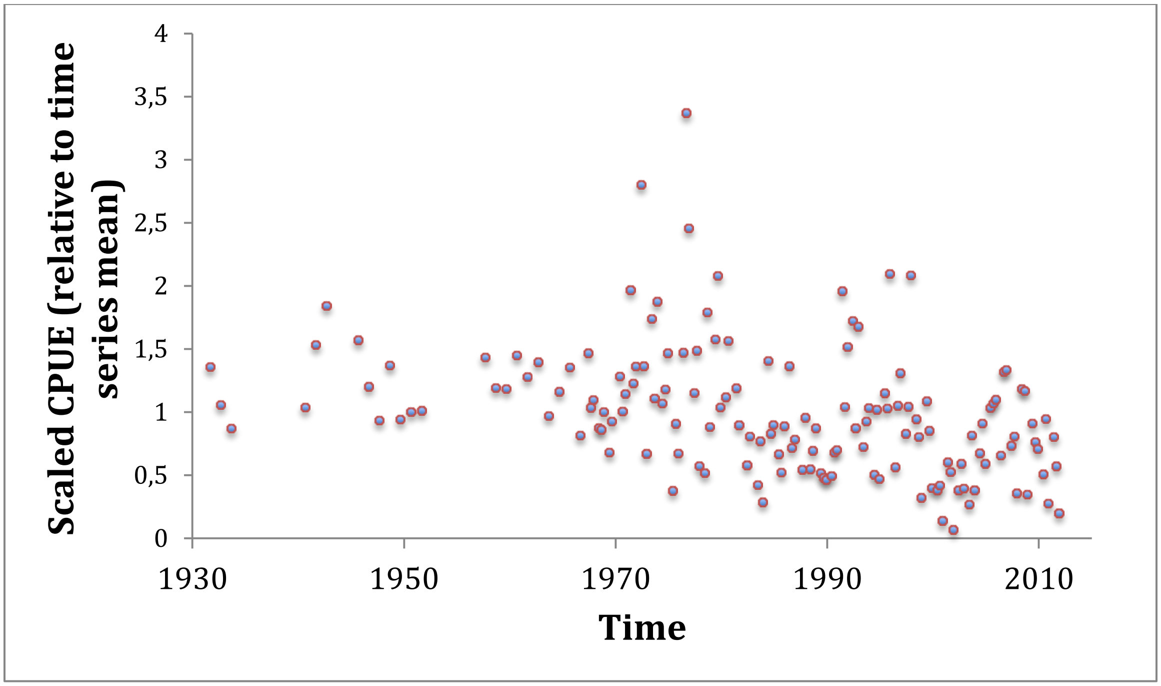


Figure 3. Composite troll CPUE on a quarterly time step constructed using the methodology applied in Anon (2009), but using a GLM to adjust for overlapping time periods.

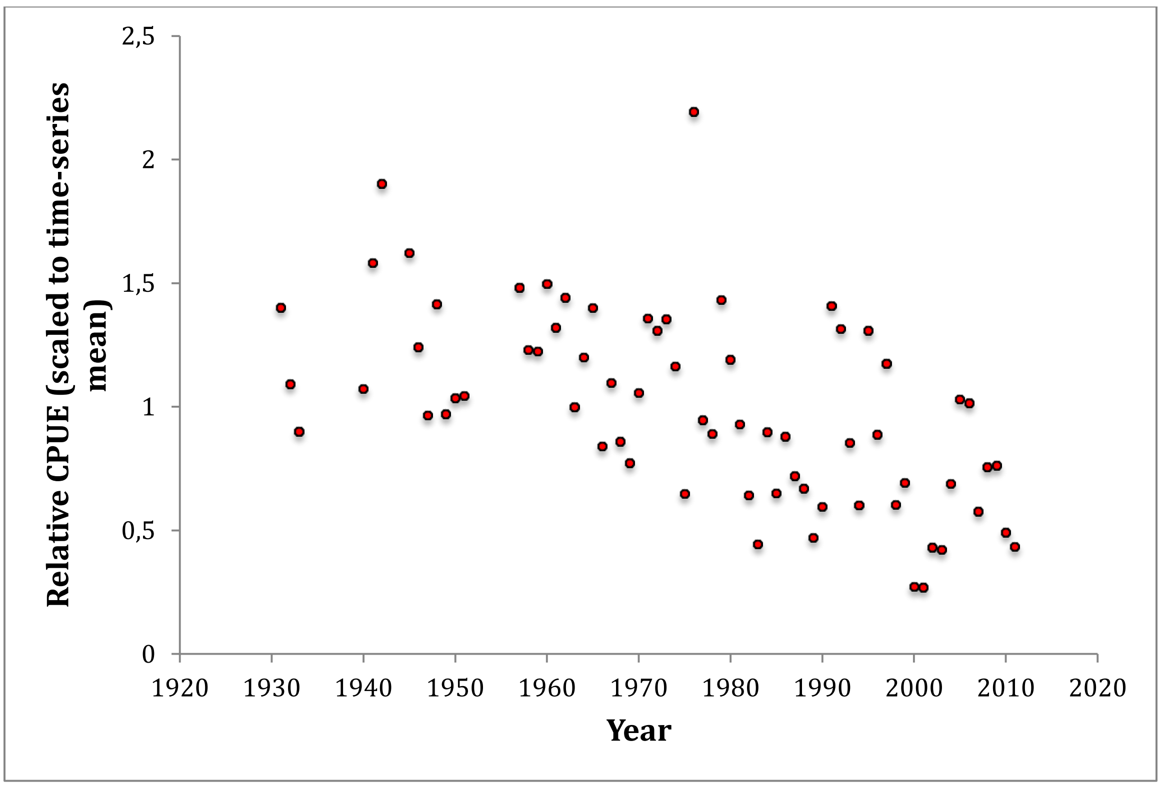


Figure 4 Composite troll CPUE on an annual time step constructed using the methodology applied in Anon (2009), but using a GLM to adjust for overlapping time-periods.

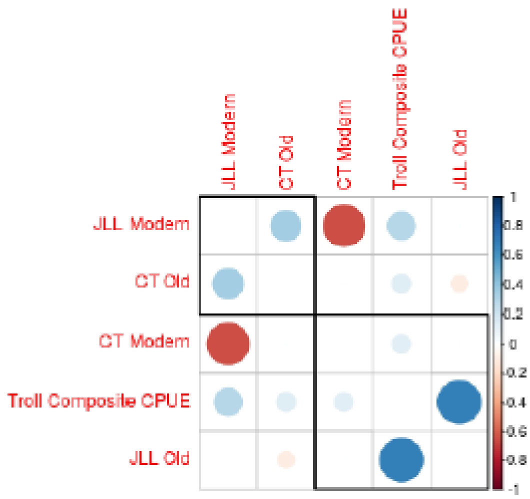


Figure 5. Correlation matrix for the northern stock indices. Blue indicates a positive correlation and red, a negative correlation. The order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities for the indices being clustered.

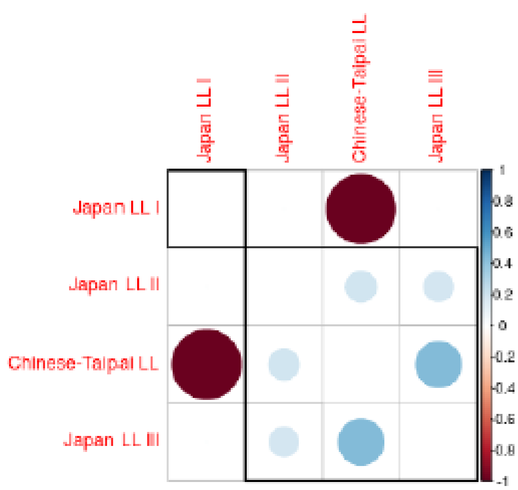
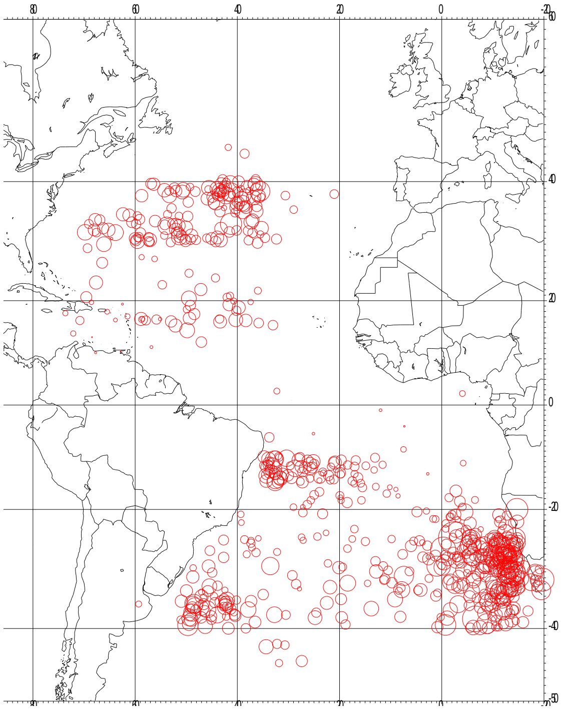
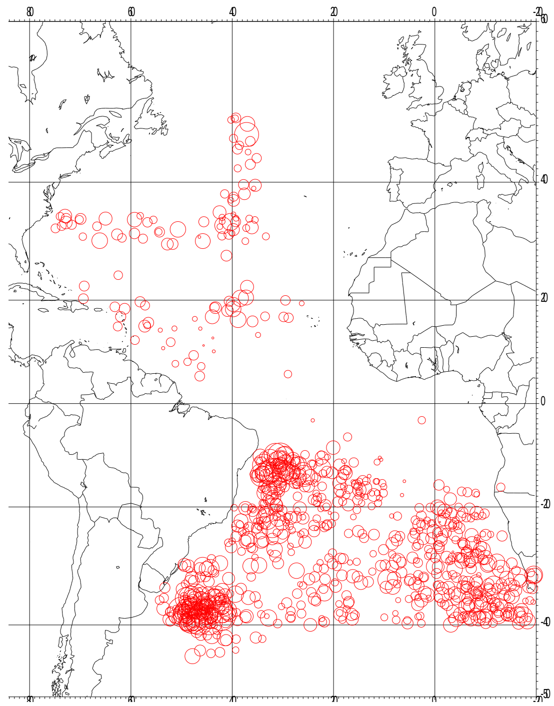


Figure 6. Correlation matrix for the southern stock indices. Blue indicates a positive correlation and red, a negative correlation. The order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities for the indices being clustered.

a)

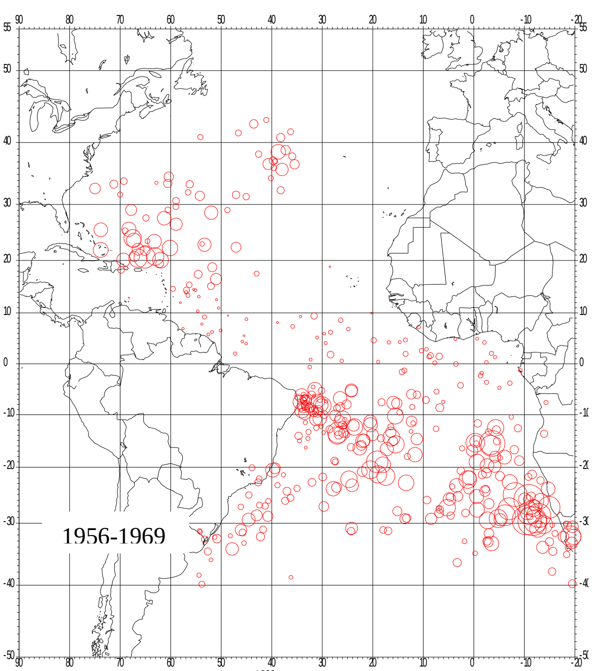


1967-1986

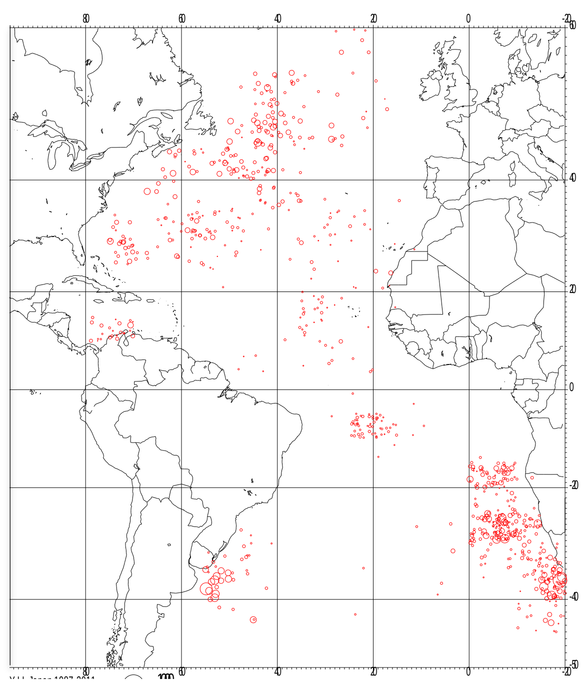


1987-2011

b)



1956-1969



1987-2011

Figure 7. Map of the 3 best monthly catches of albacore (1) during the early period, and (2) during recent years showing the approximate main areas of major ALB catches of the (a) Chinese Taipei, and)b) Japanese longline fleets in the North and South Atlantic (all the albacore monthly catches of each period are randomly plotted within each 5° square).

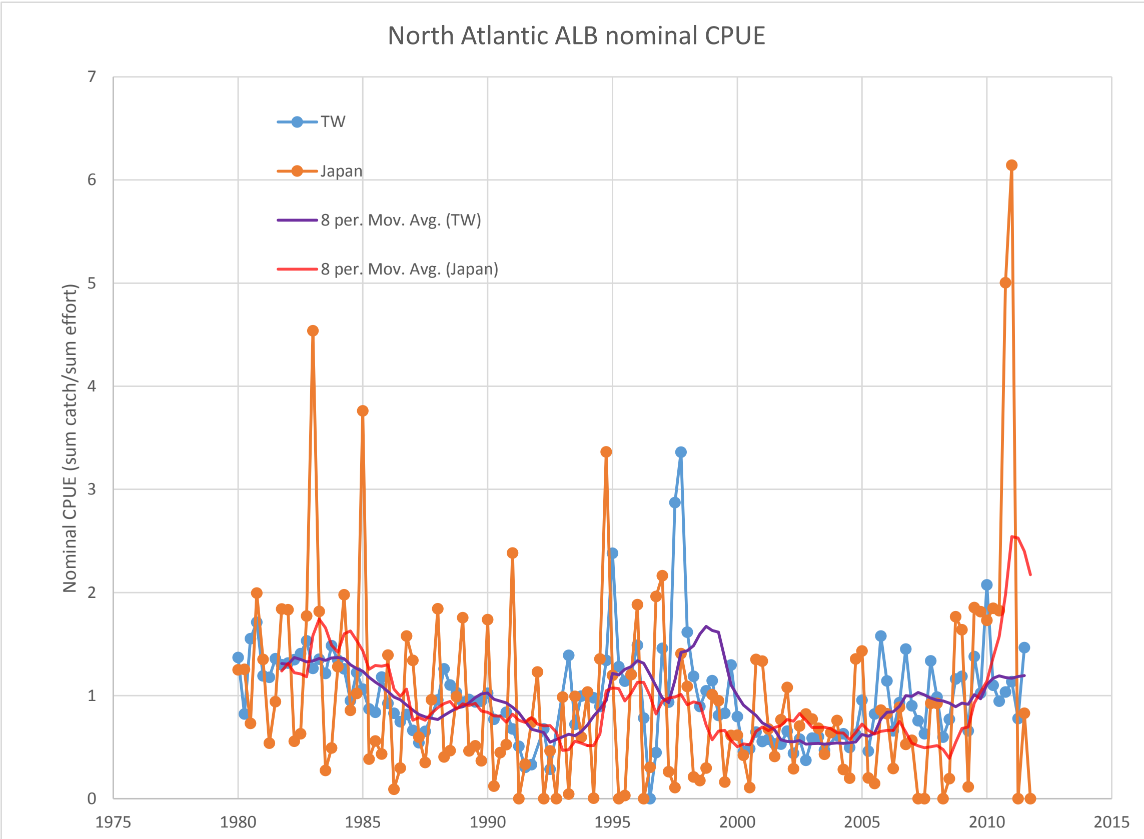
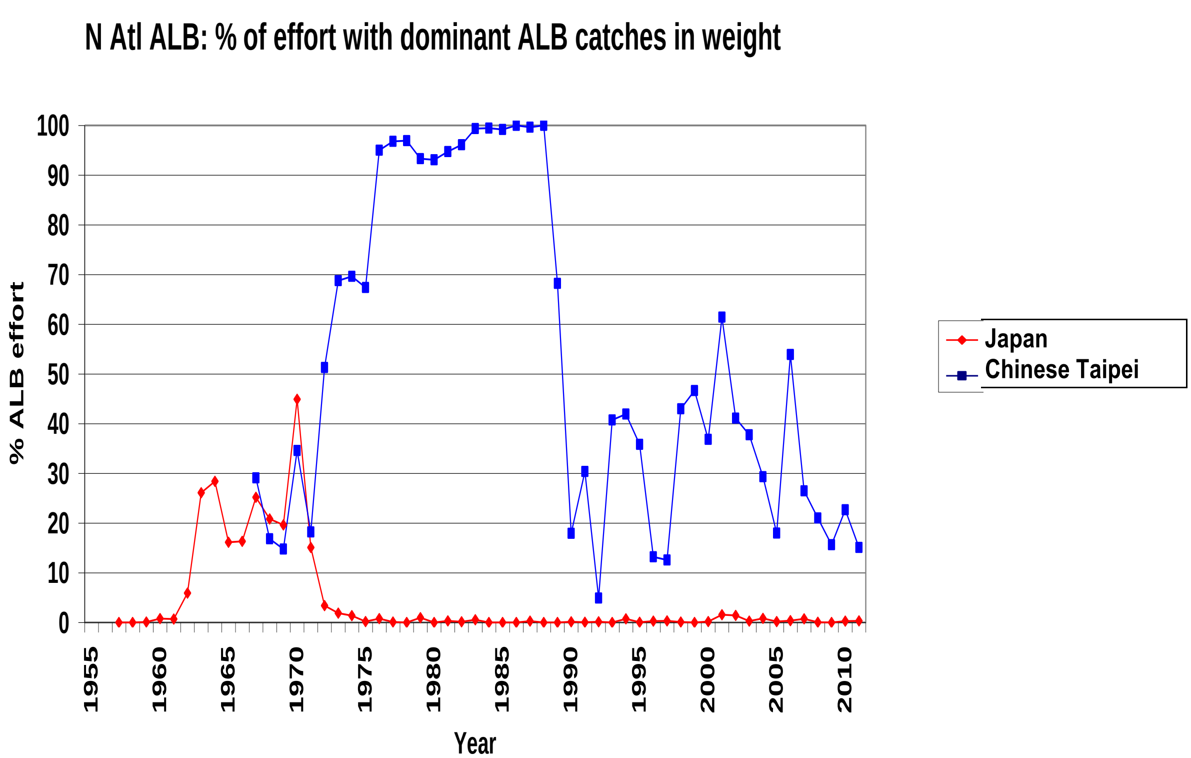


Figure 8 Nominal CPUE for Chinese Taipei and Japan between 20ºN-40ºN and west of 30ºW.



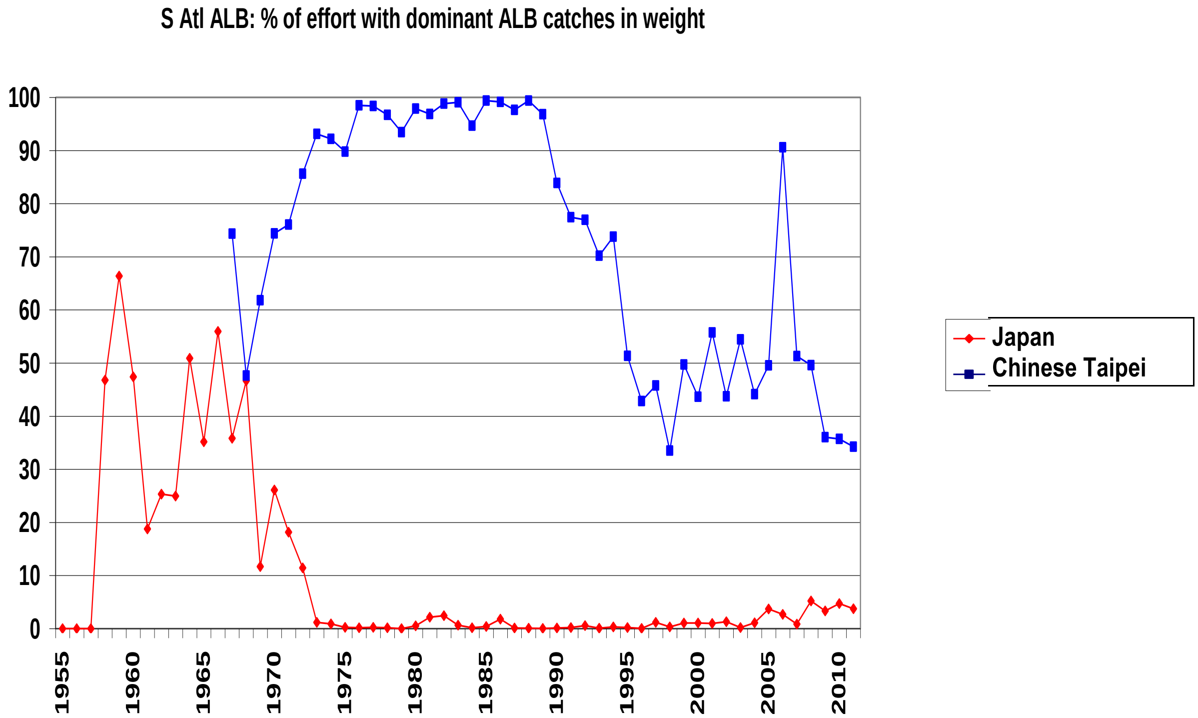


Figure 9. Percent of fishing effort with more than 50% ALB catch for the North (9a) and South (9b) Atlantic stocks.

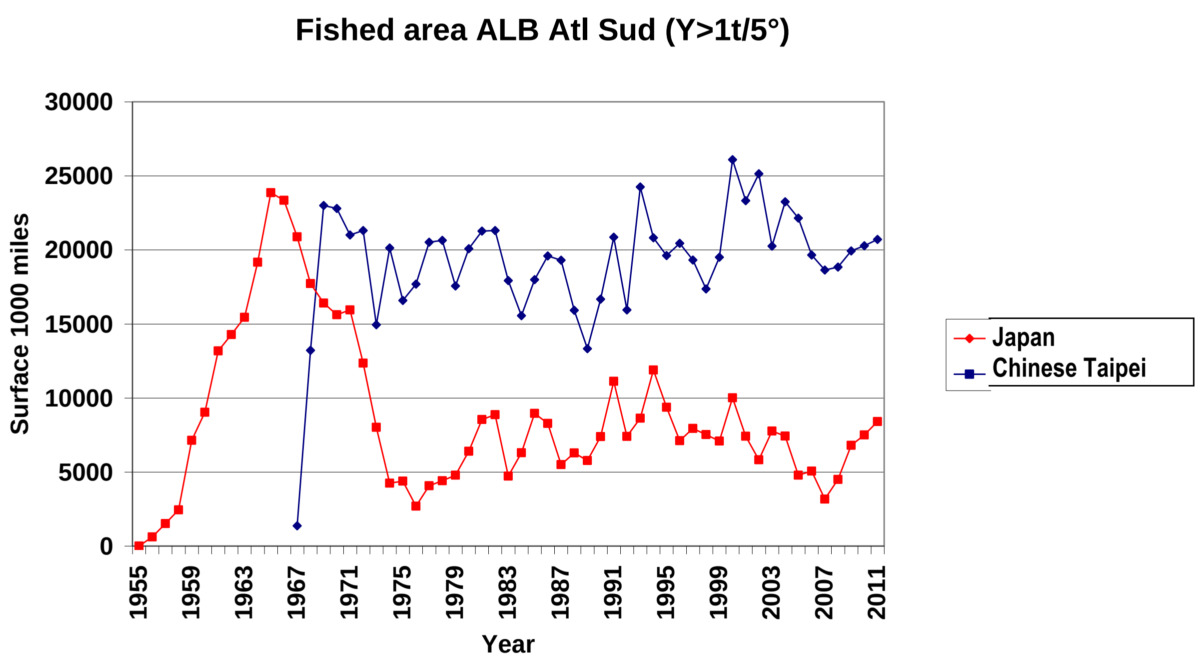


Figure 10. Sizes of the areas fished for albacore by longliners in the northern and southern Atlantic: number of 5x5 quadrants with at least 1 t of ALB catch in a month for the South Atlantic stock, for the Chinese Taipei and Japanese longliners.

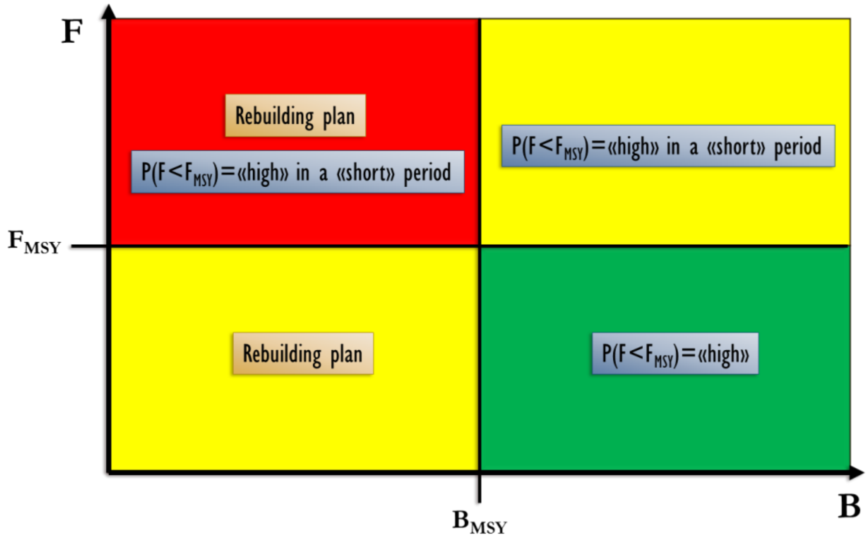


Figure 11 Schematic representation of the key elements of the Recommendation by ICCAT on the principles of decision making for ICCAT conservation and management measures (Rec. 11-13).

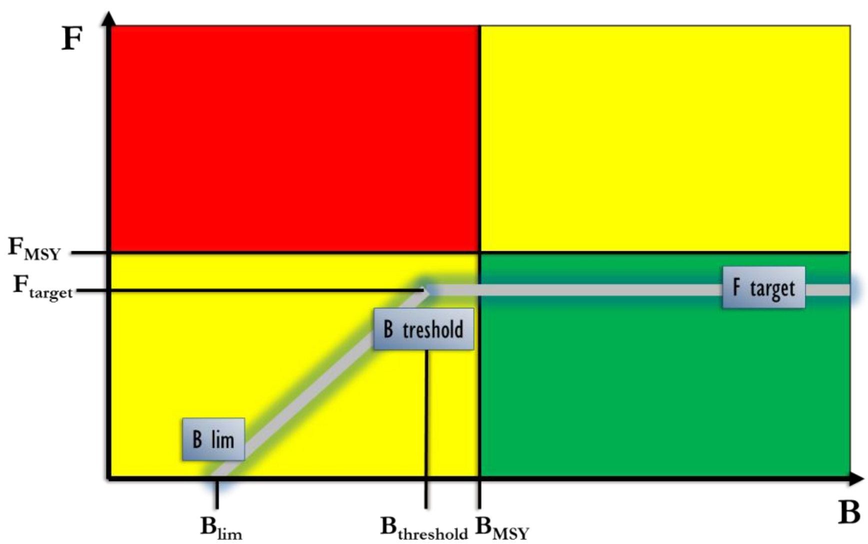


Figure 12. Generic form of the HCR recommended by SCRS (SCRS, 2011). Blimit is the limit biomass reference point, BThreshold is the biomass point at which increasingly strict management actions should be taken as biomass decreases and Ftarget, the target fishing mortality rate to be applied such that it is lower than FMSY with 'high probability' (Rec [11-13]).

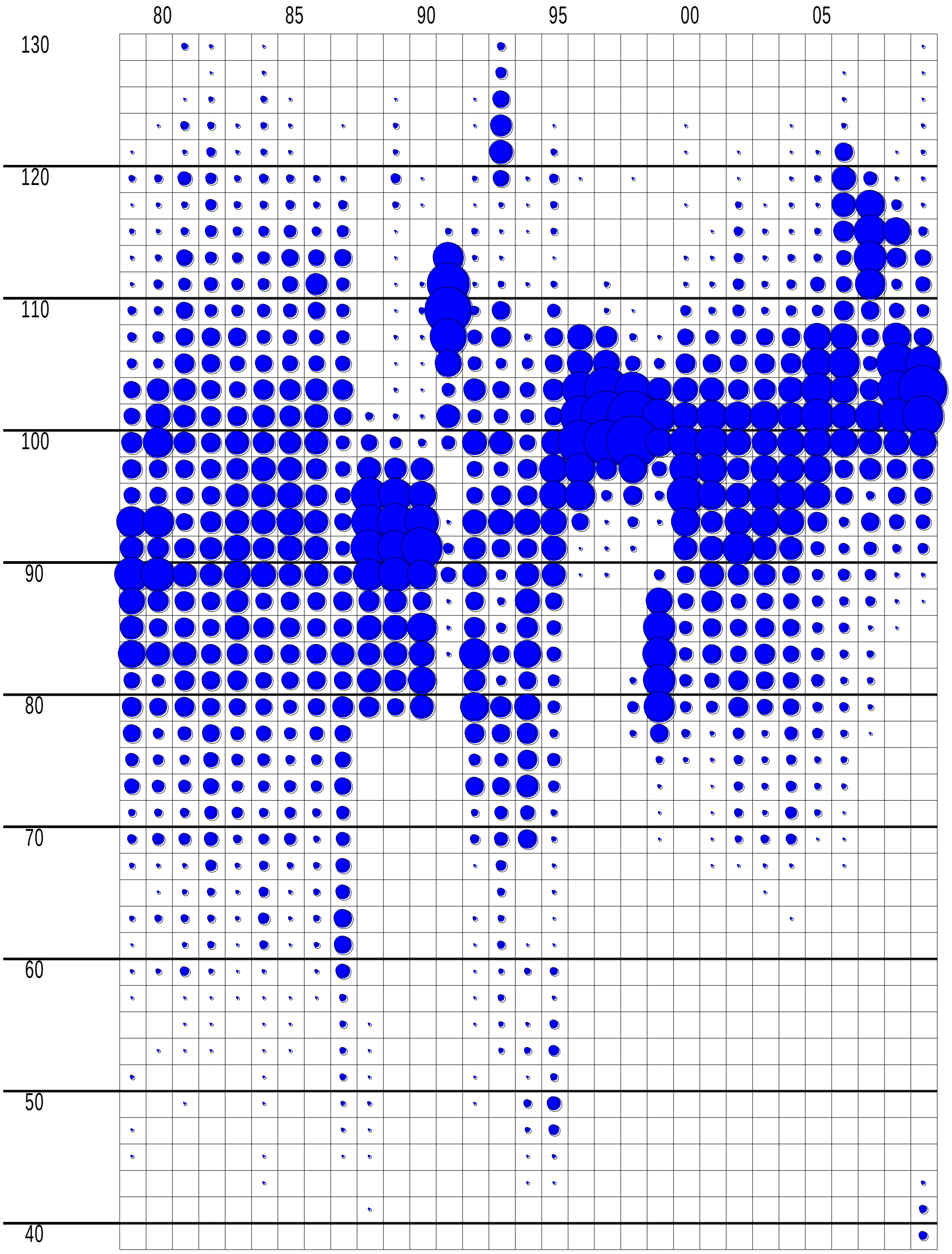


Figure 13. Change in size distributions (Y axis, in cm.) of catch in the Chinese Taipei fleet over time (X axis, in years).

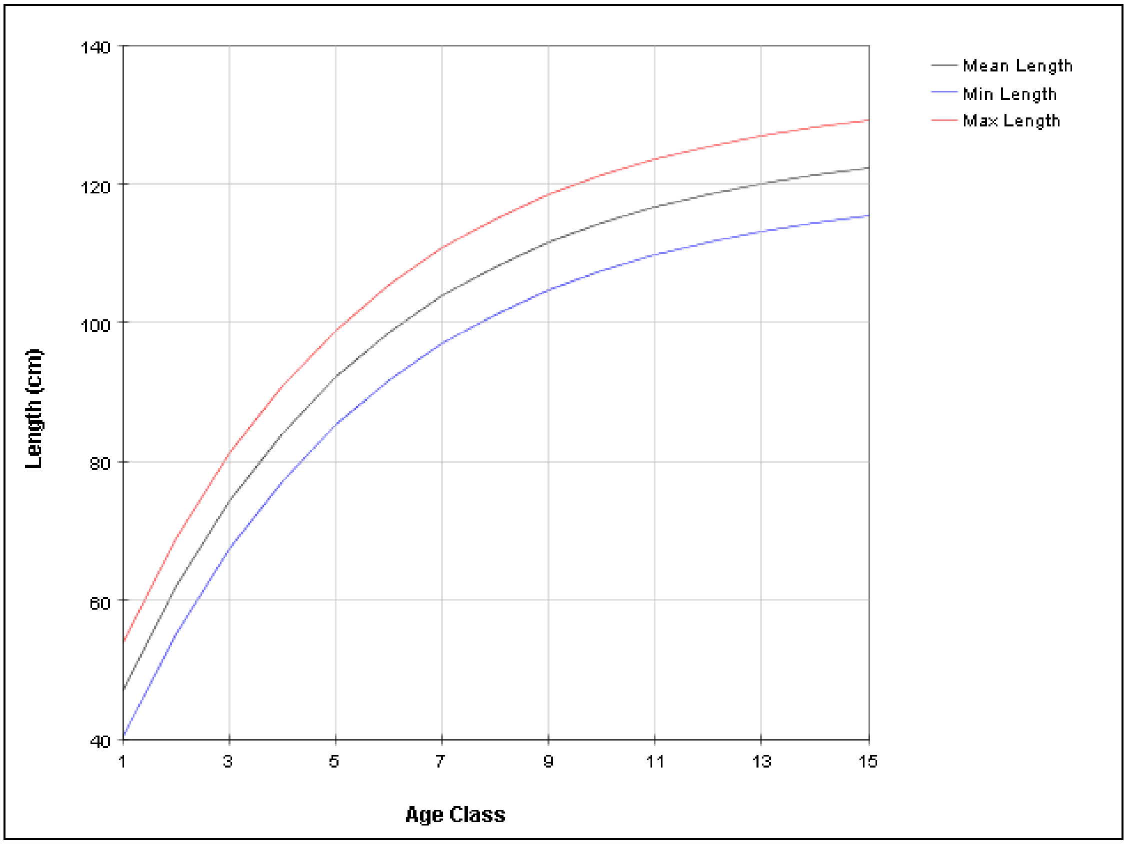


Figure 14. Growth curve used in the MULTIFAN-CL base model.

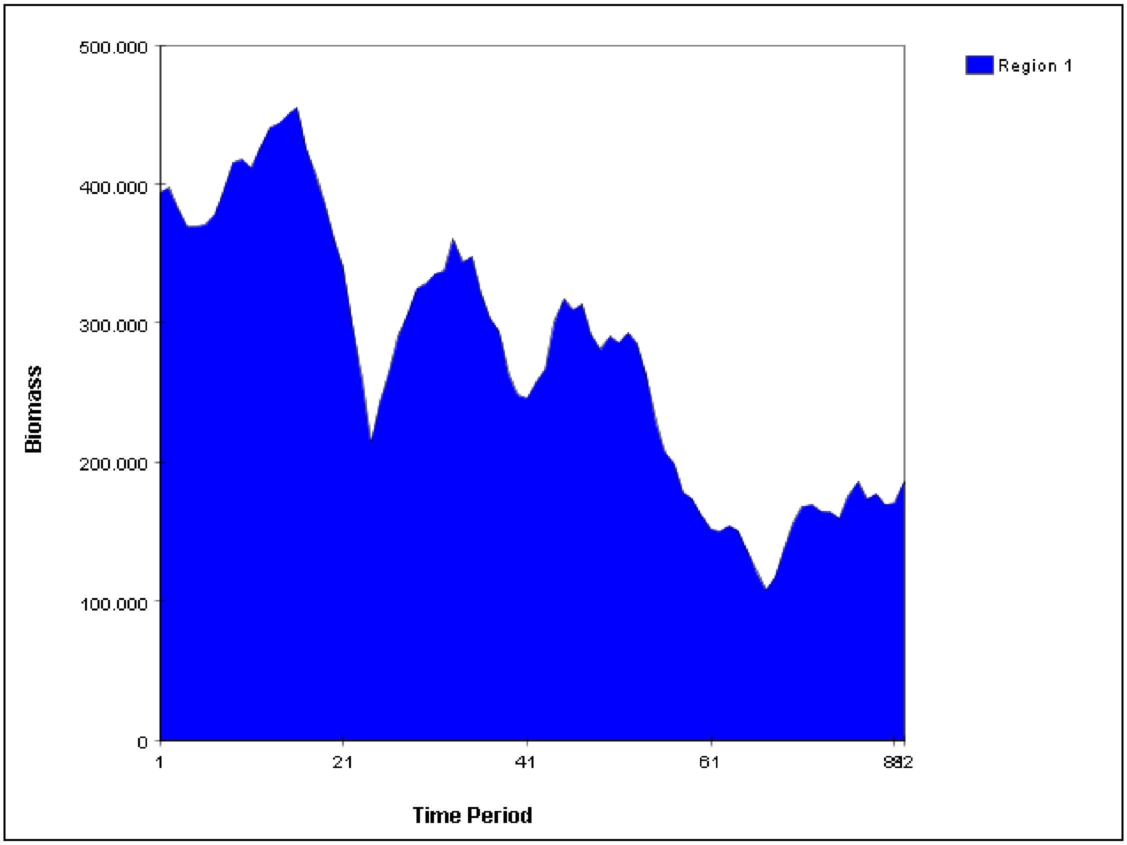


Figure 15. MFCL base model estimated biomass over time.

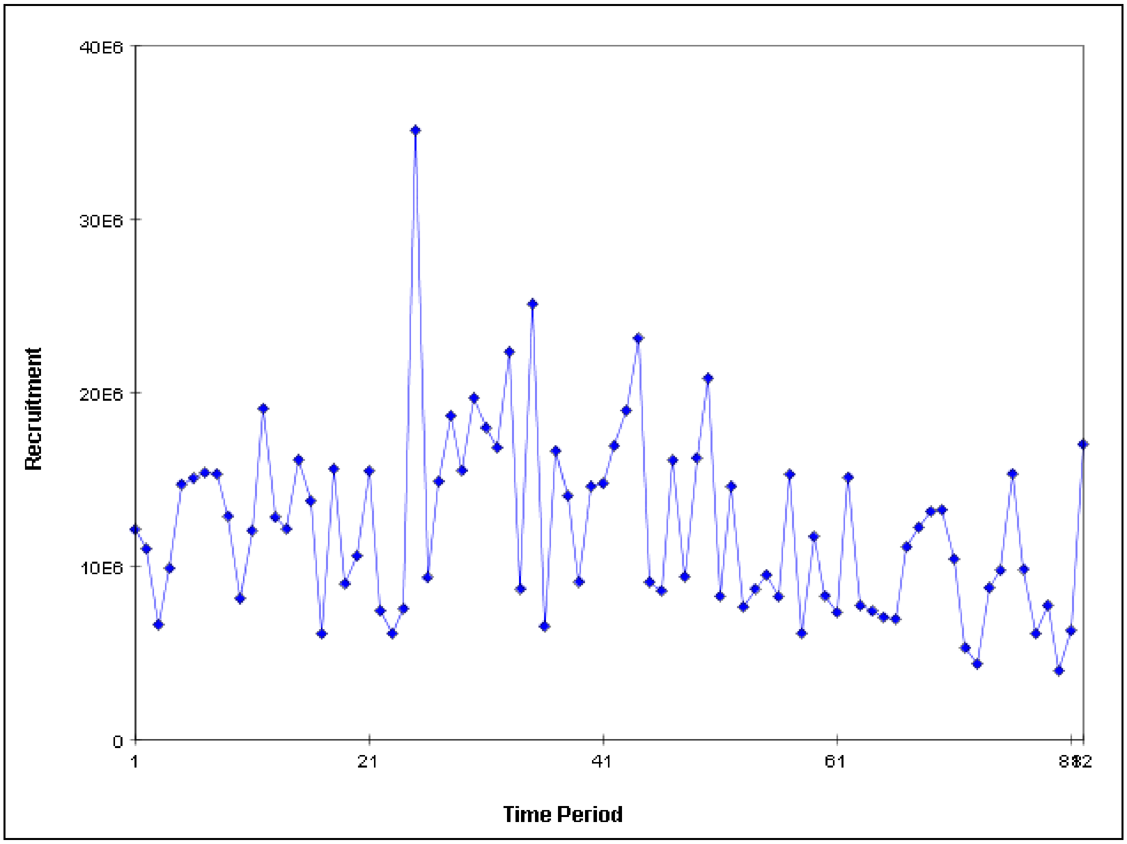


Figure 16. MFCL base model estimated recruitment over time.

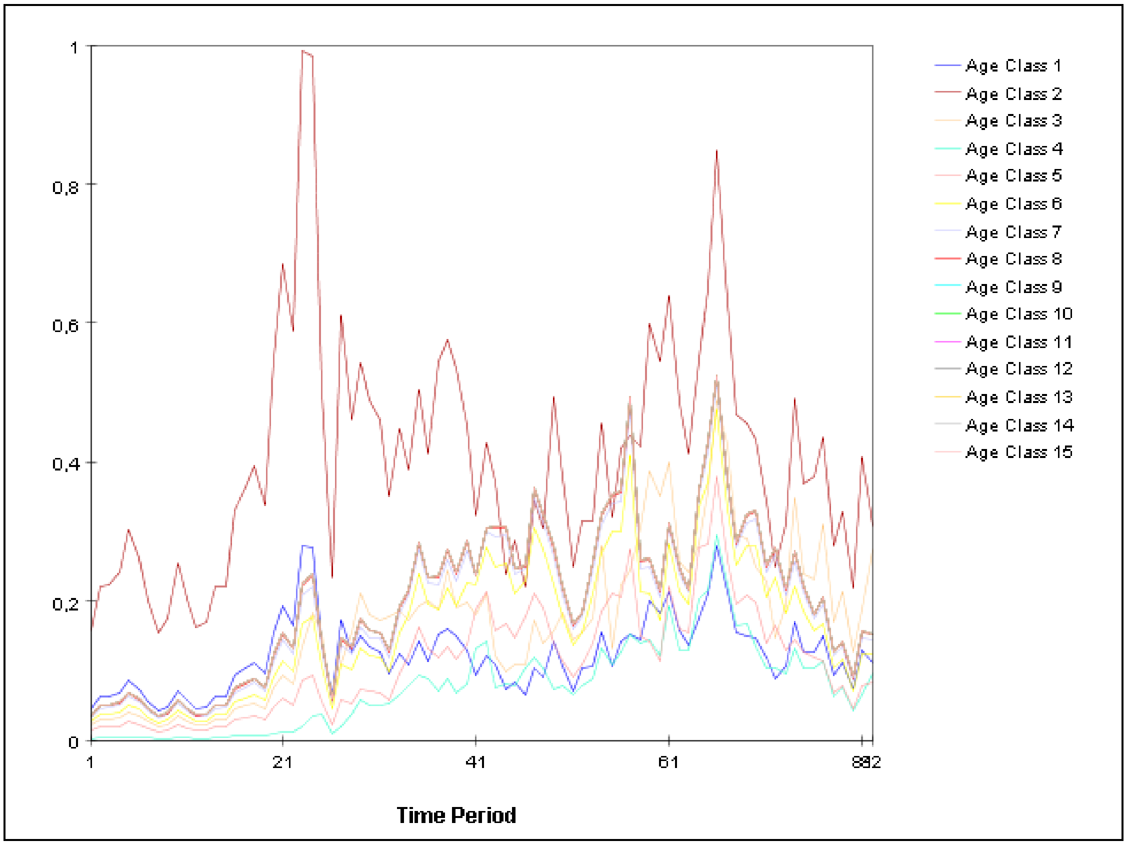
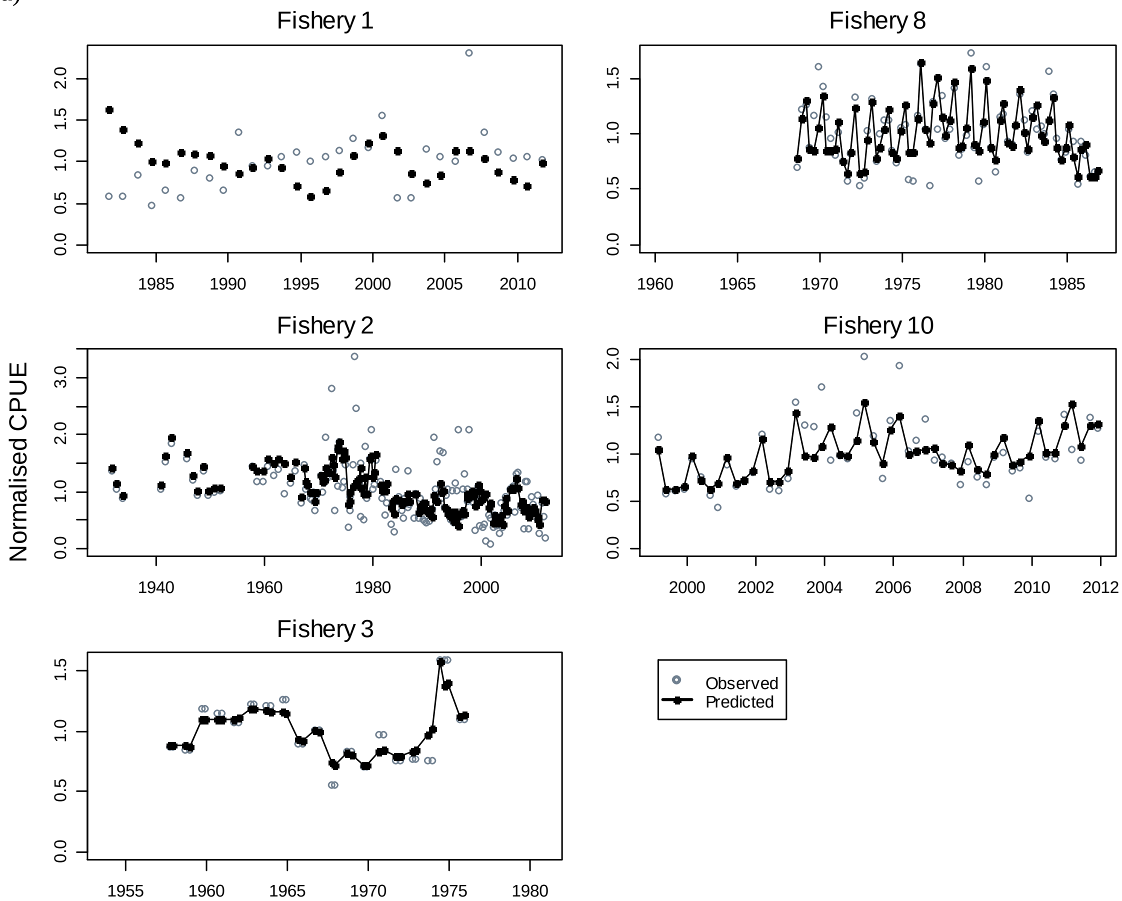


Figure 17. MFCL base model estimated F per age group over time.

a)


Fishery 1
Fishery 8
Fishery 2
Fishery 10
Fishery 3
Normalised CPUE
Observed
Predicted

b)


Fishery1
Fishery8
effort deviations
Year

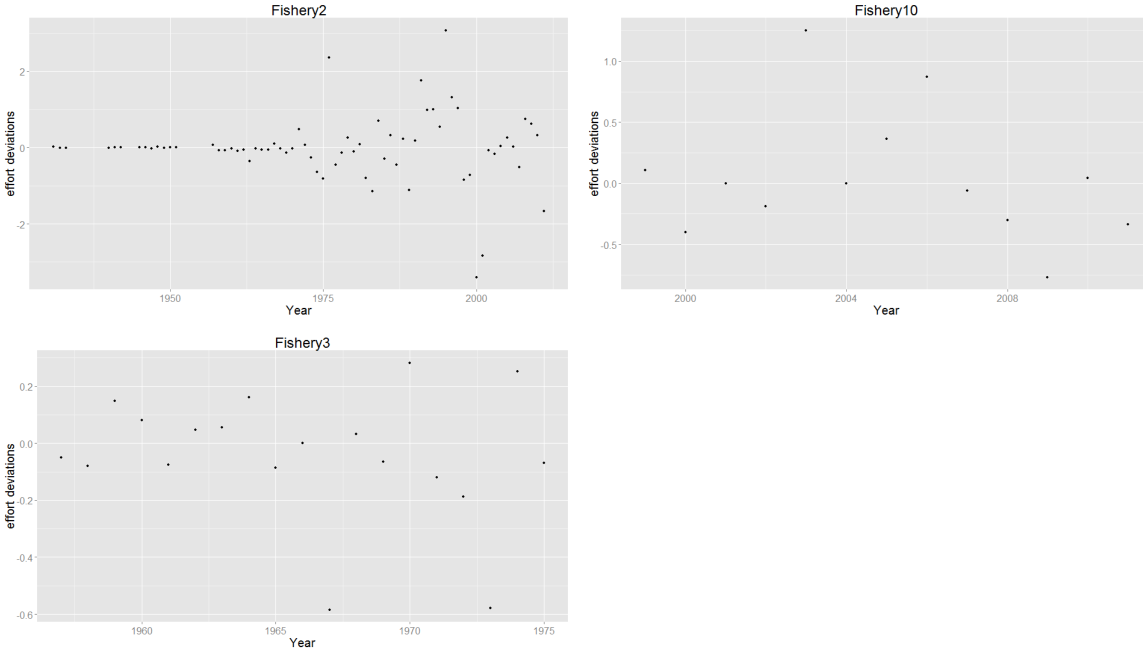
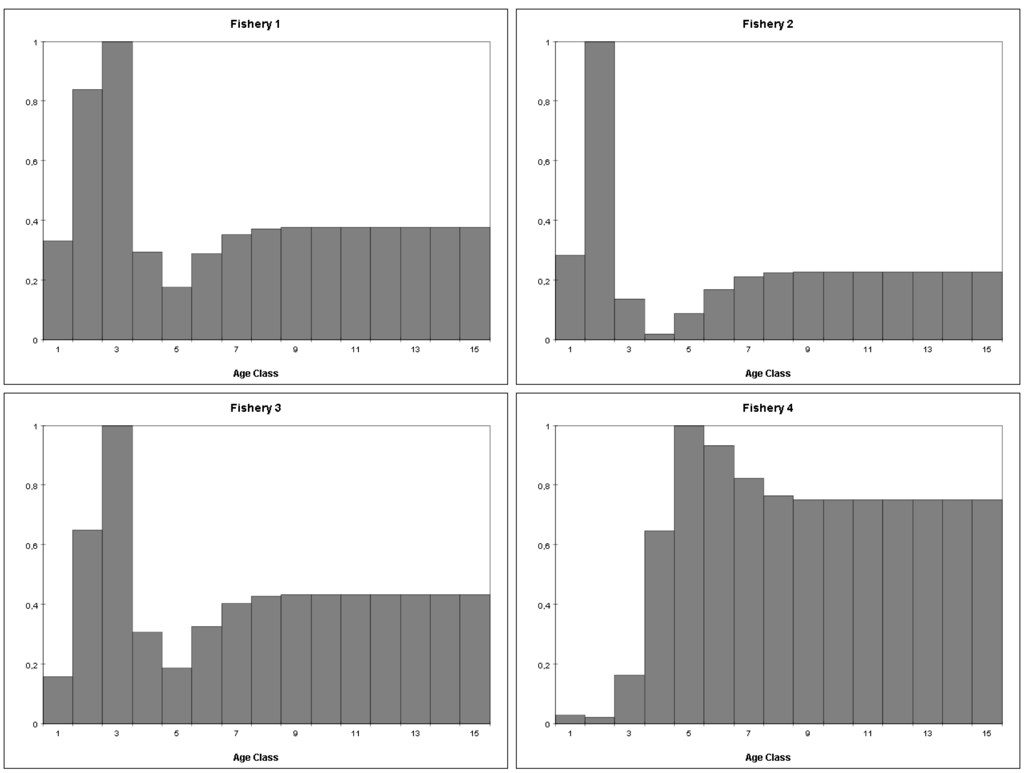


Figure 18. MFCL base model a) normalised CPUE and b) effort deviations for fleets used in the model fitting.



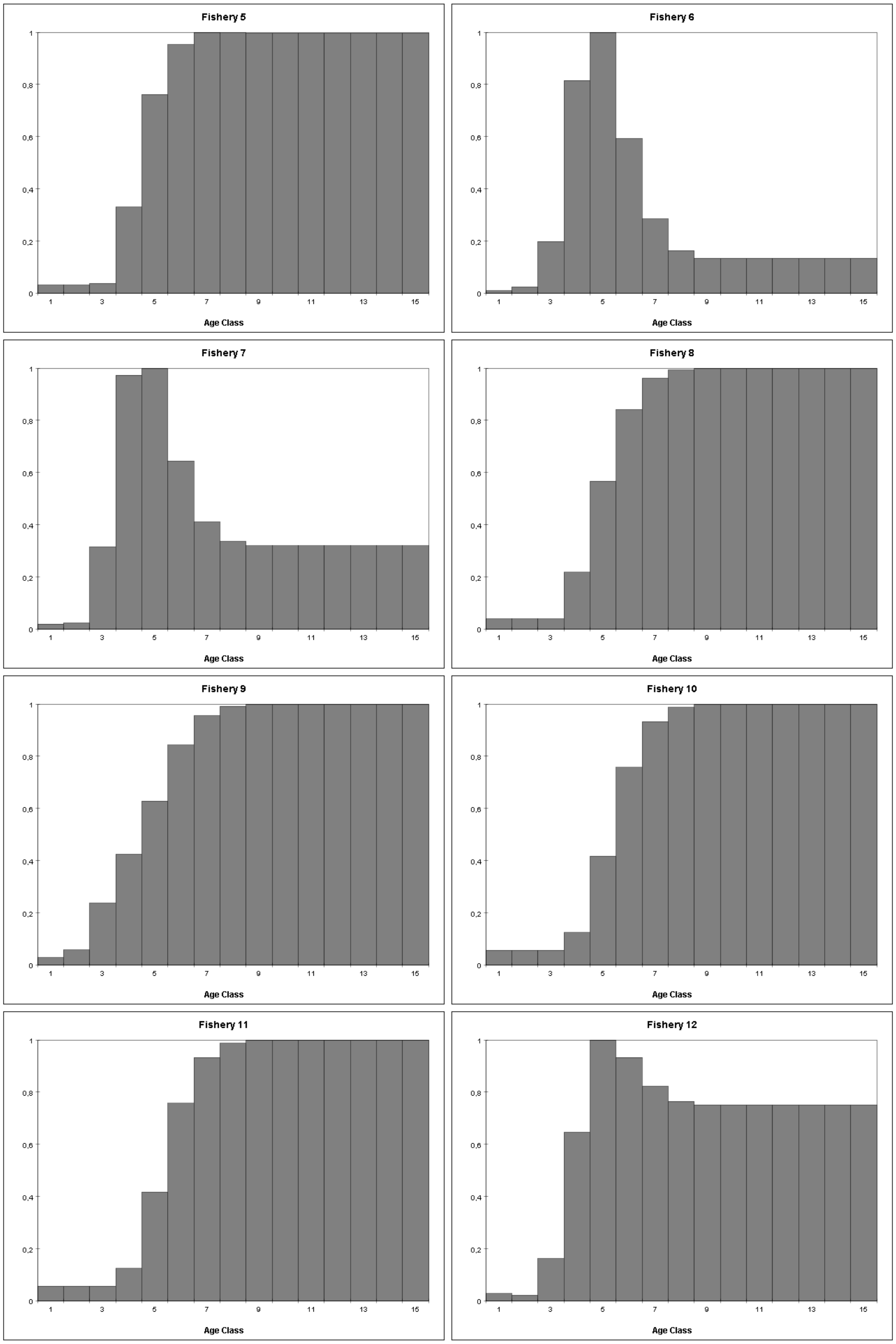


Figure 19. MFCL base model estimated selectivities for each fishery.

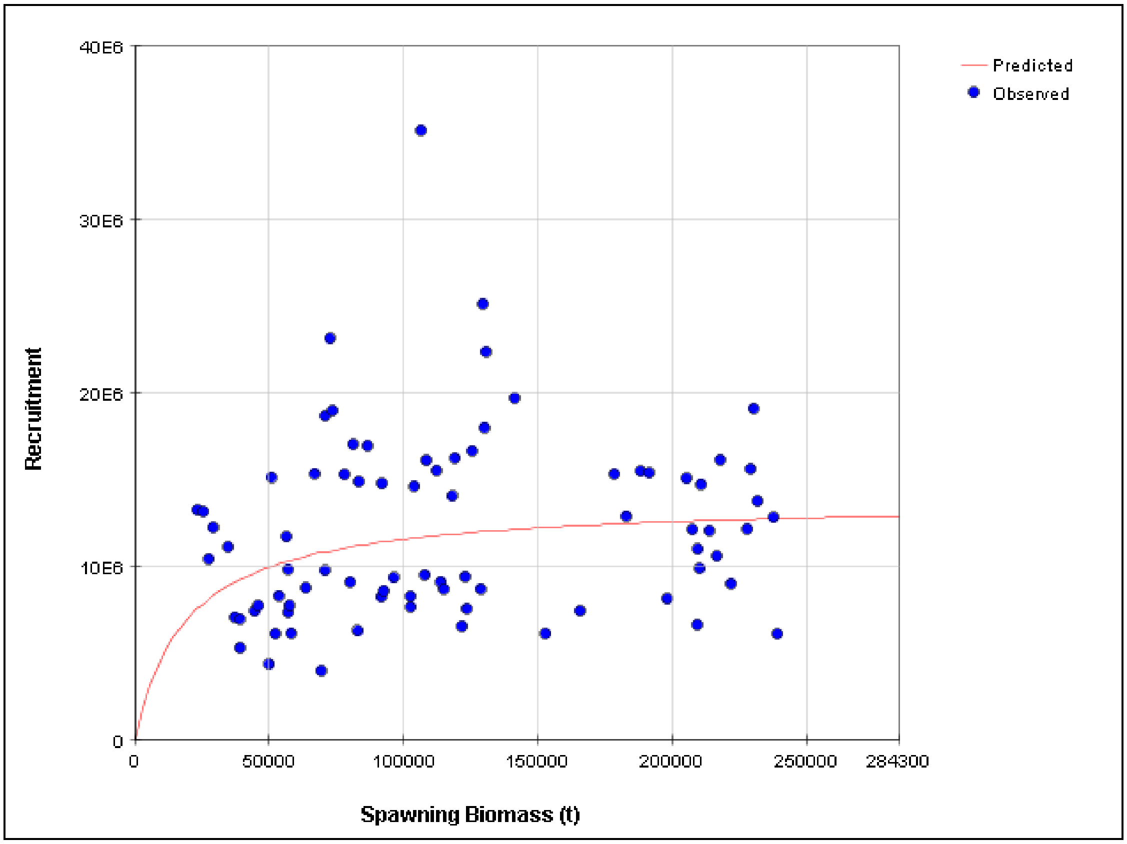


Figure 20. MFCL base model estimated Stock recruitment relationship.

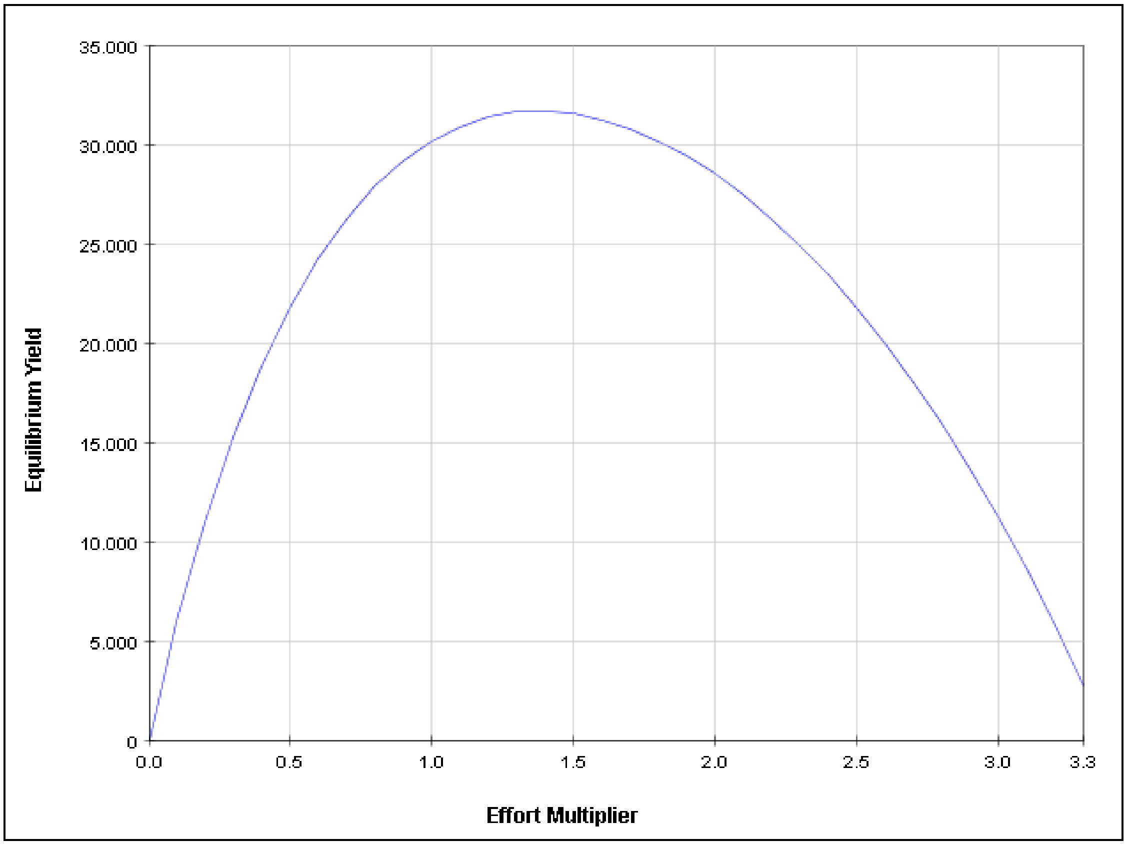


Figure 21. MFCL base model estimated yield curve.

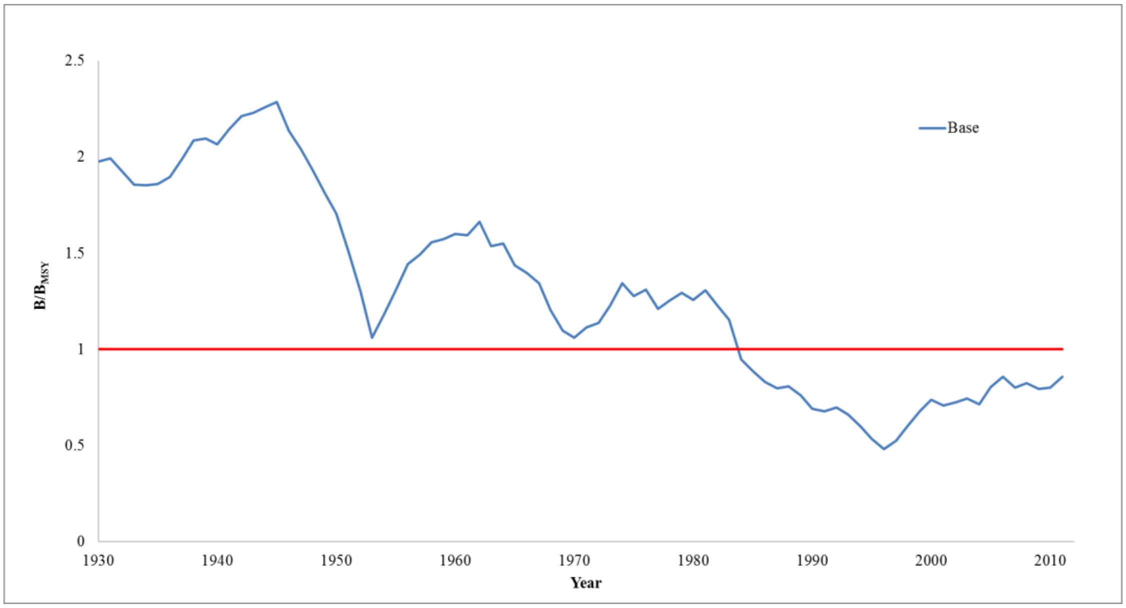


Figure 22. Current biomass relative to biomass at MSY.

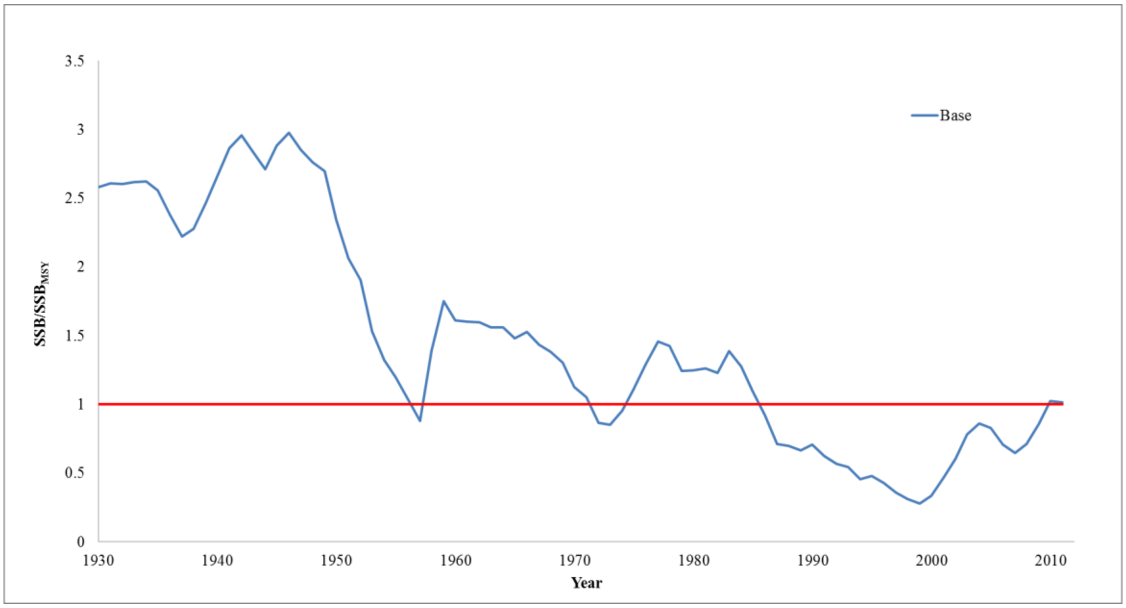


Figure 23. Current spawning stock biomass relative to spawning stock biomass at MSY.

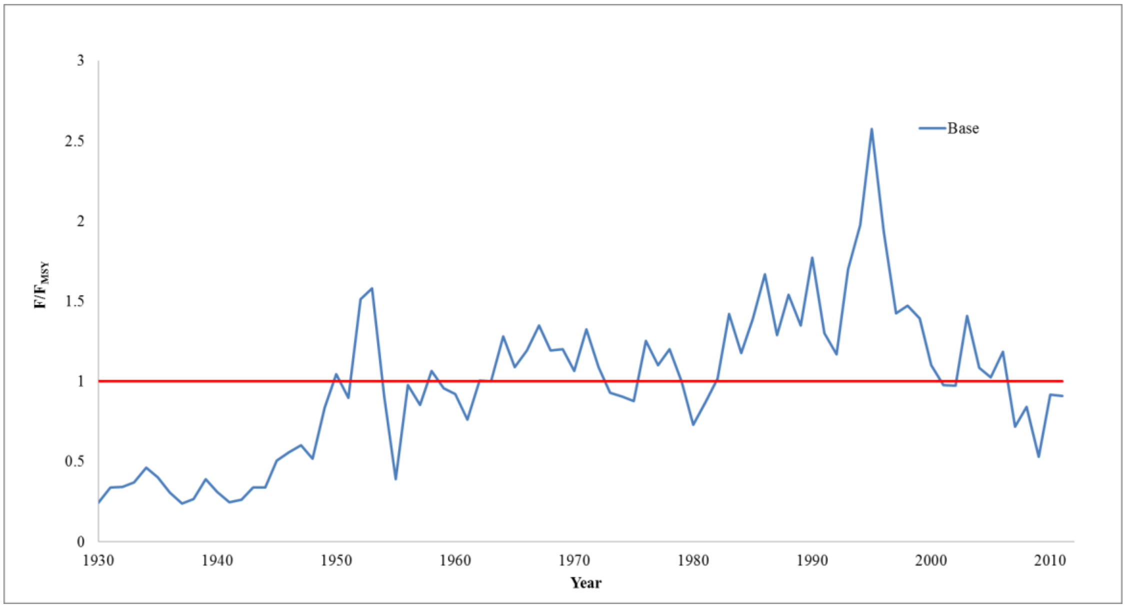


Figure 24. Current F relative to F at MSY.

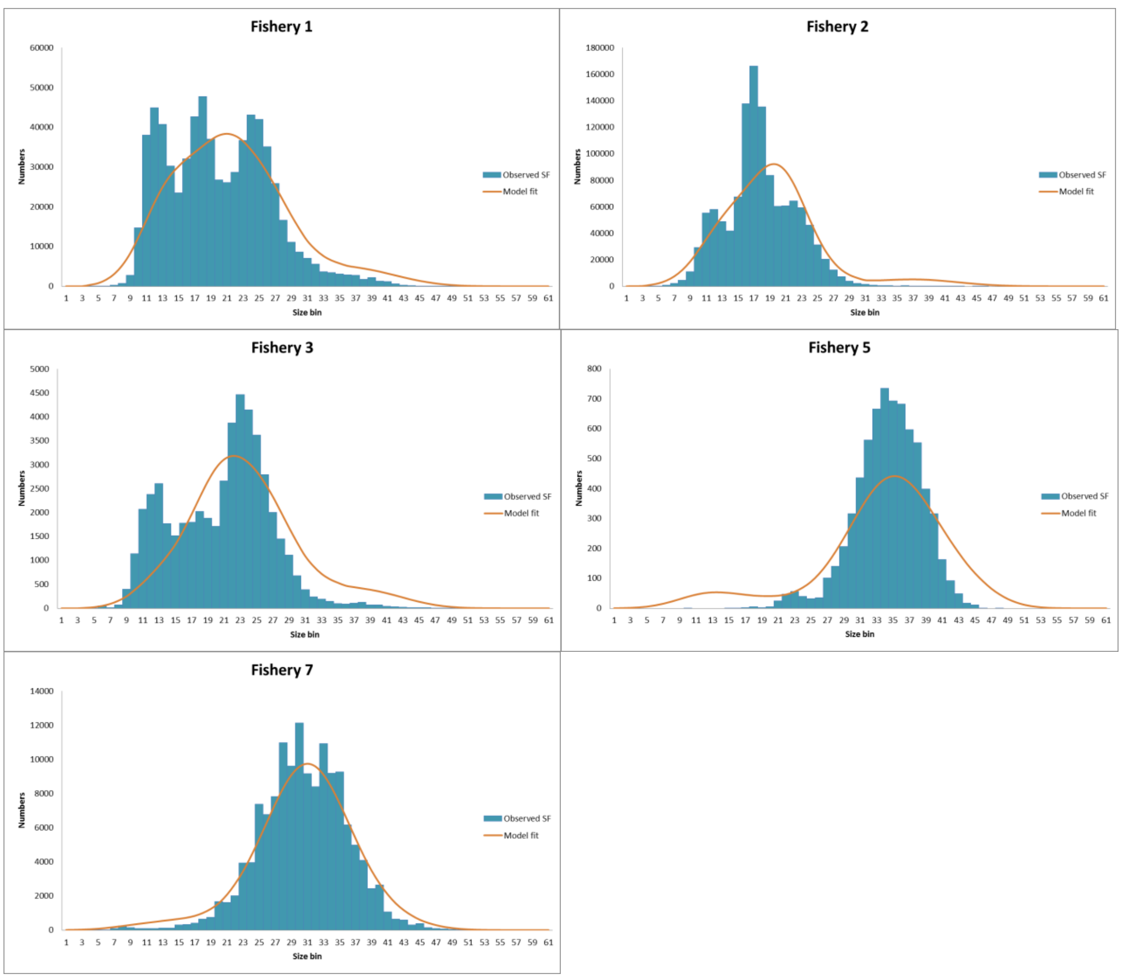


Figure 25. Base case model fit to the length frequency data by fishery.

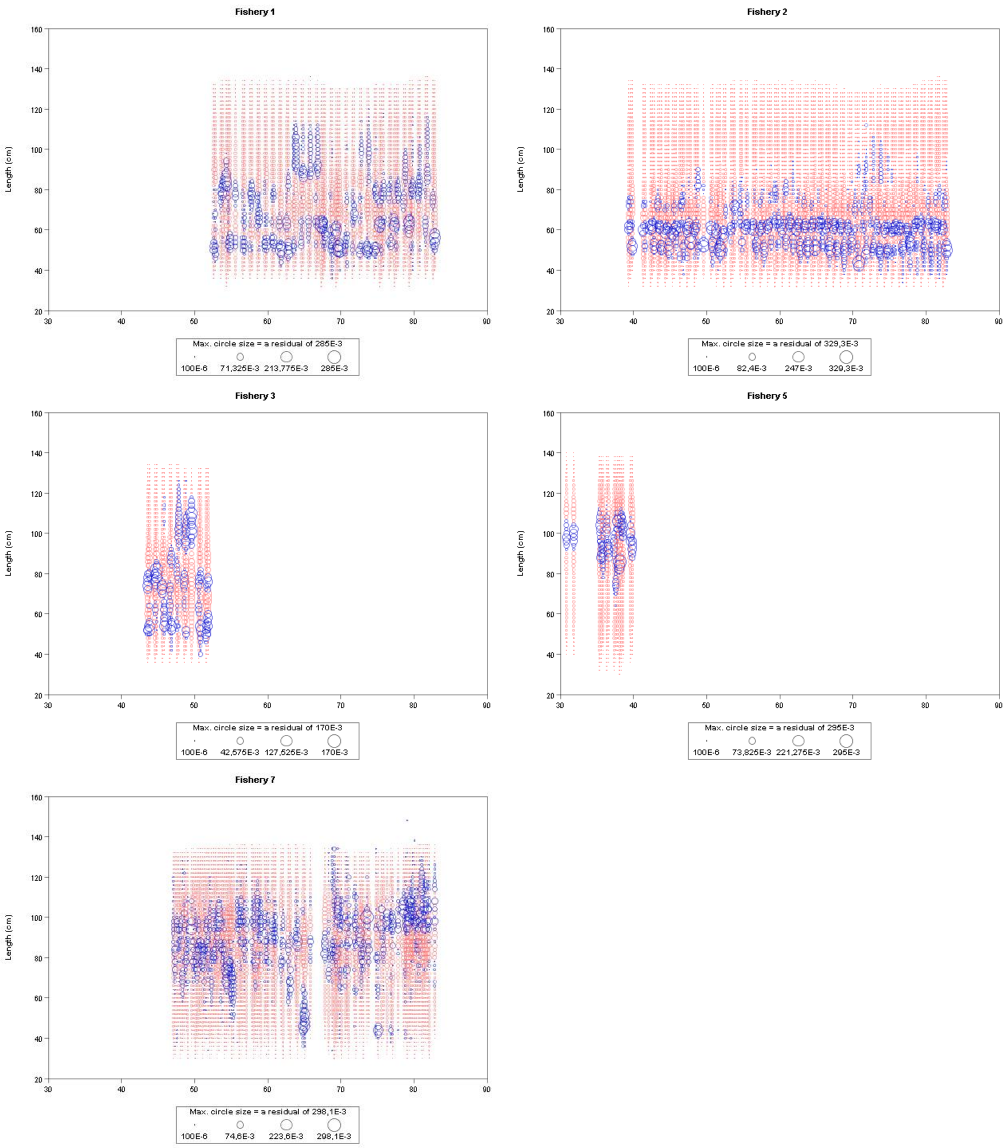


Figure 26. Base case model residuals for the fit to the length frequency data by fishery.

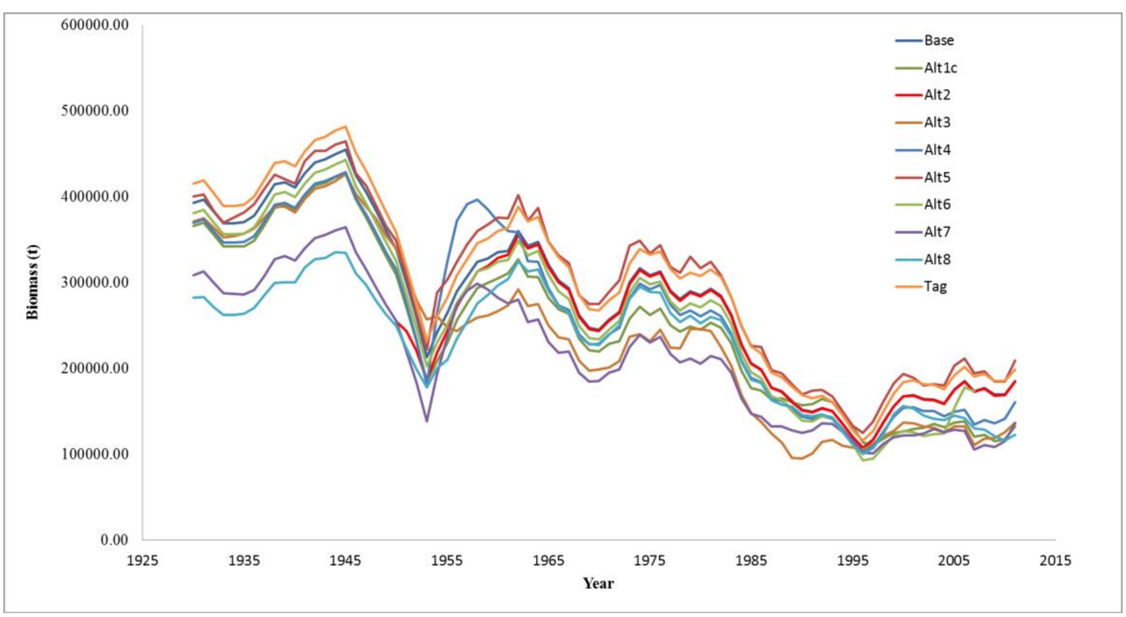


Figure 27. Model estimated biomass trajectories over time for the base case and alternate runs.

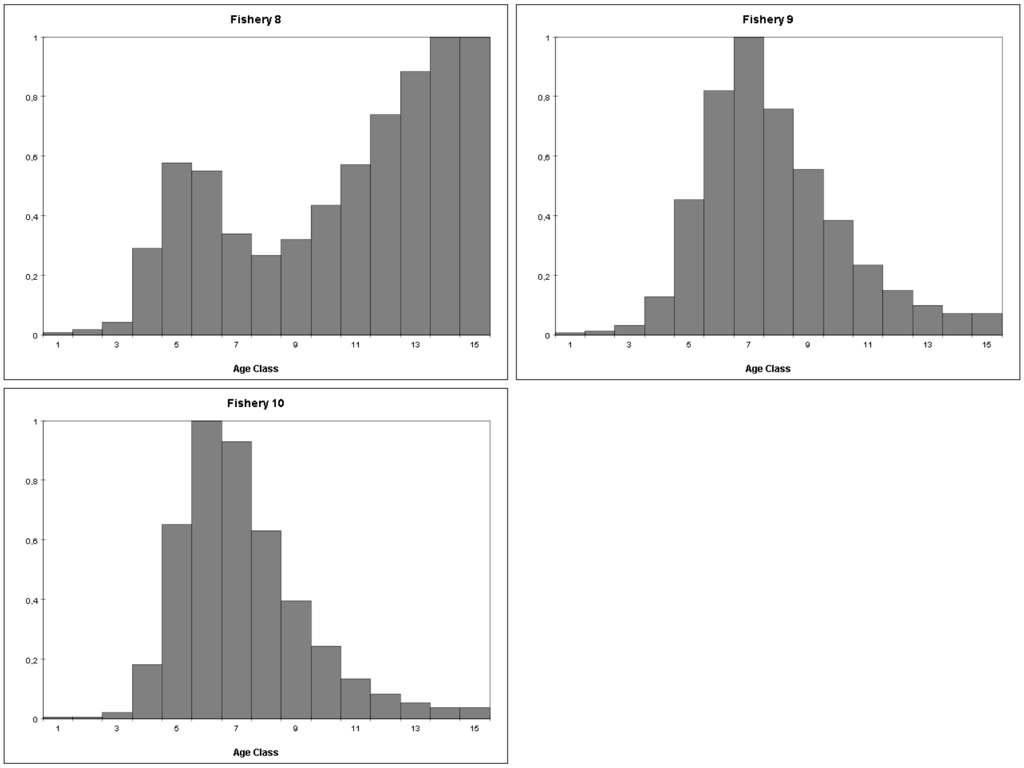


Figure 28. MFCL alt1 model estimated selectivities for the three Chinese Taipei LL fisheries.

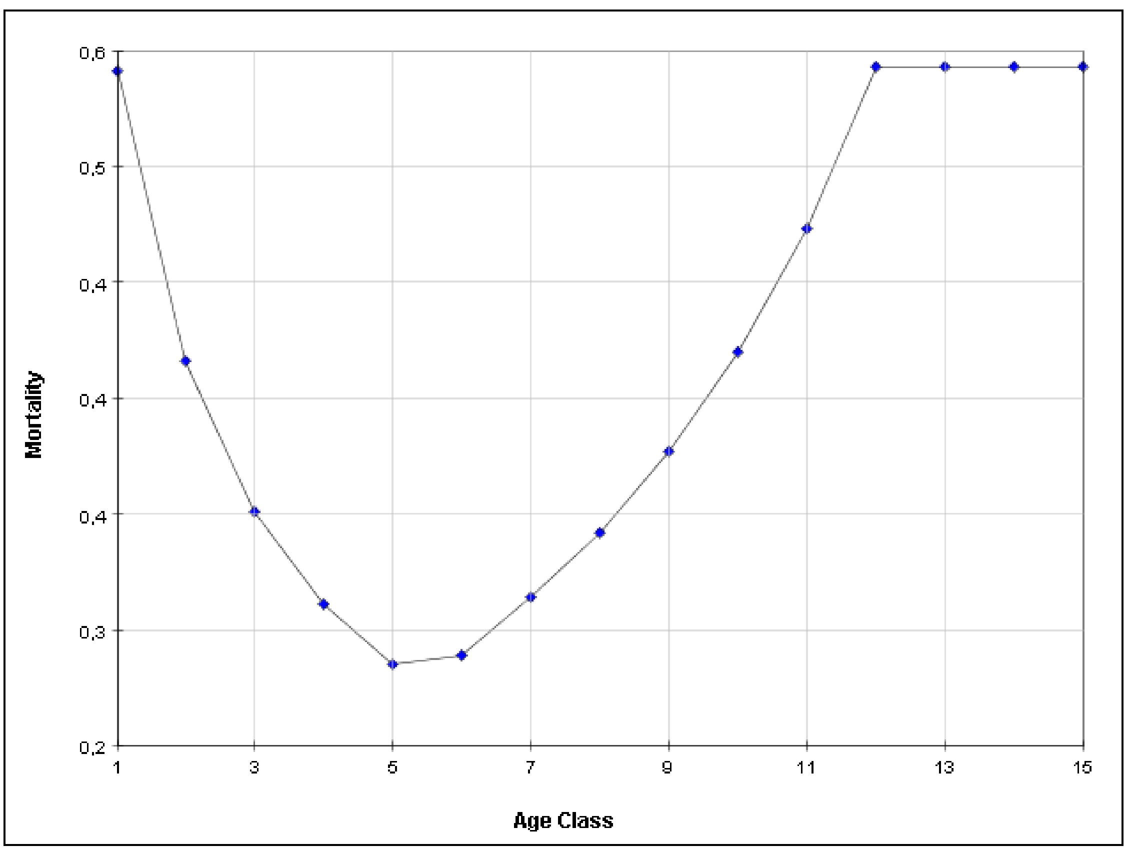


Figure 29. Age specific vector of natural mortality included in run alt5.

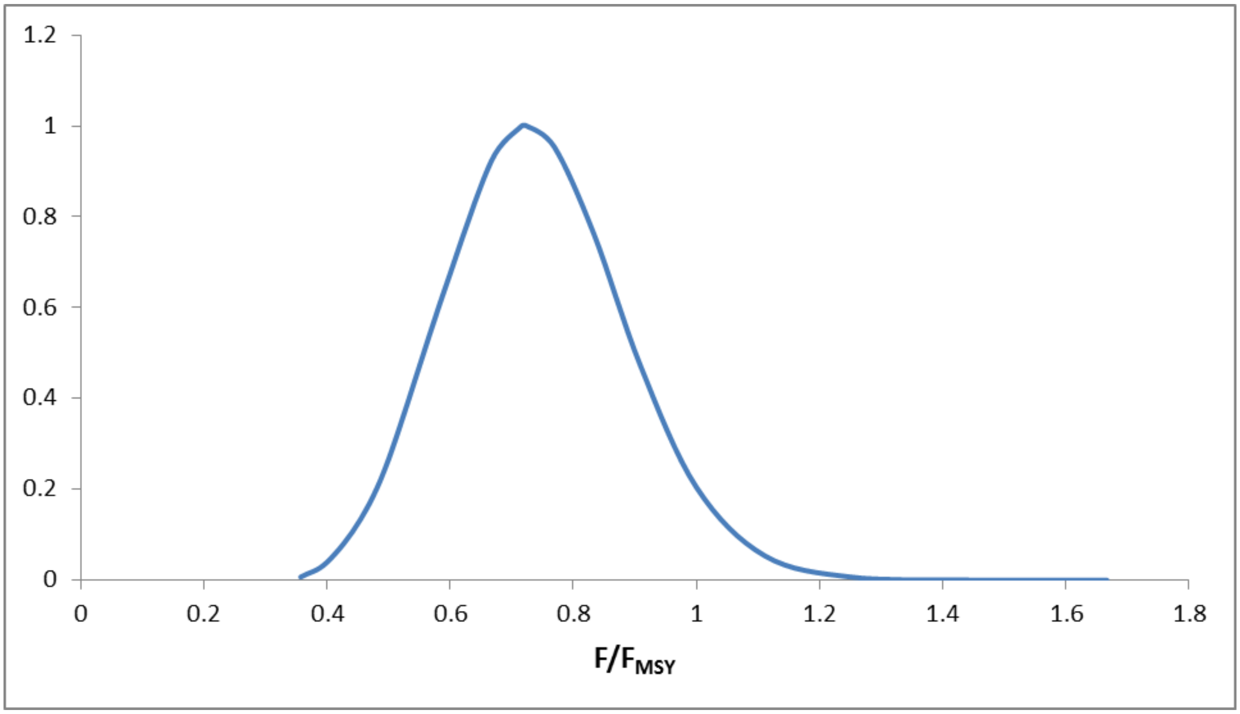


Figure 30. F/F_{MSY} likelihood profile for the MFCL base case.

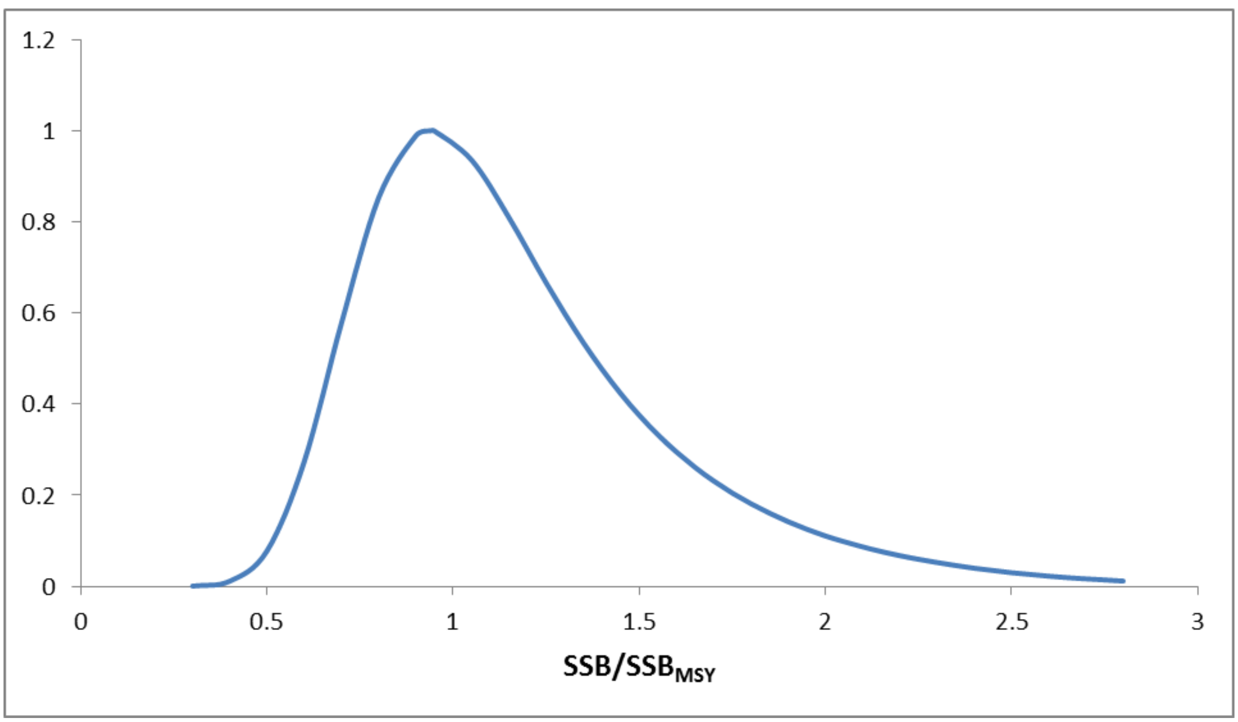


Figure 31. SSB/SSB_{MSY} likelihood profile for the MFCL base case.

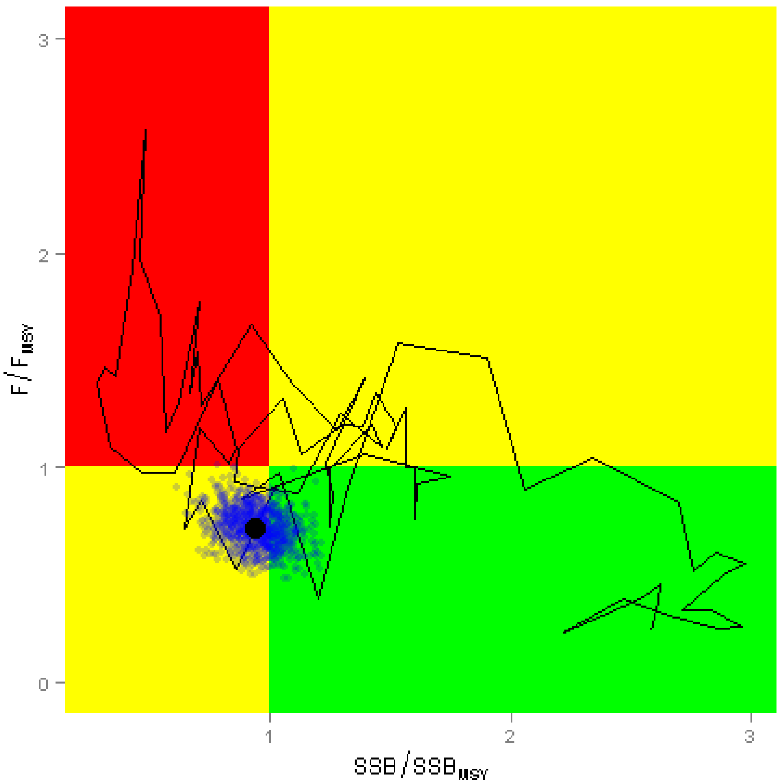


Figure 32. The Kobe plot generated from the base case MFCL model. The black dot indicates the most recent model estimated benchmarks while the blue cloud of points represent the uncertainty around the current estimate.

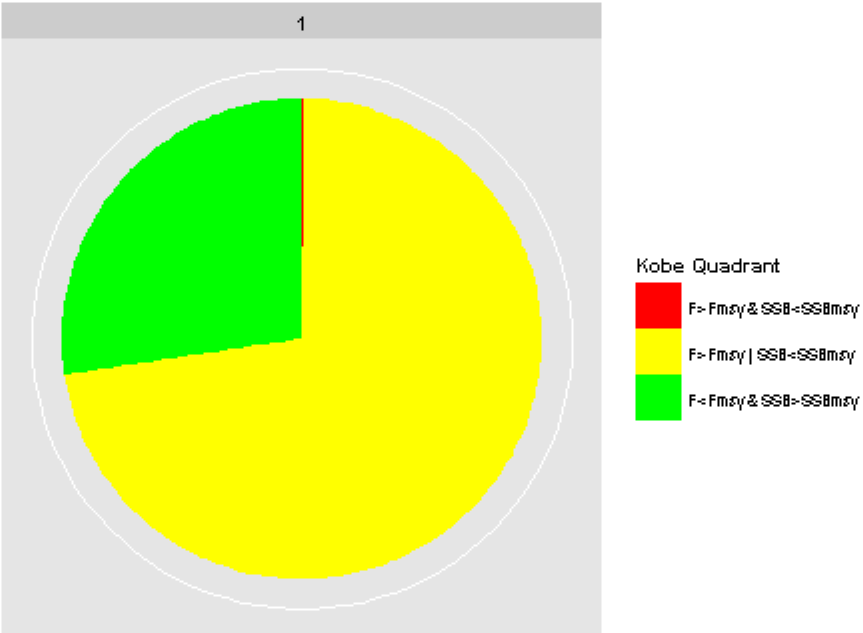


Figure 33. The Kobe pie chart, characterizing the probability that current stock status is within each of the Kobe plot quadrants.

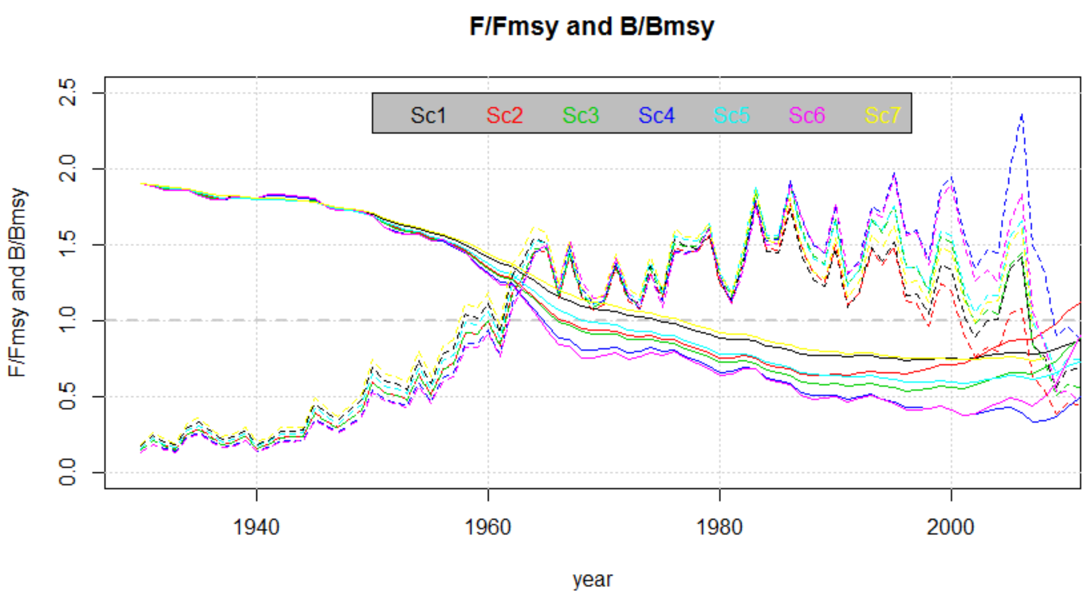


Figure 34. Estimated B/B_{MSY} and F/F_{MSY} for the 7 scenarios tested.

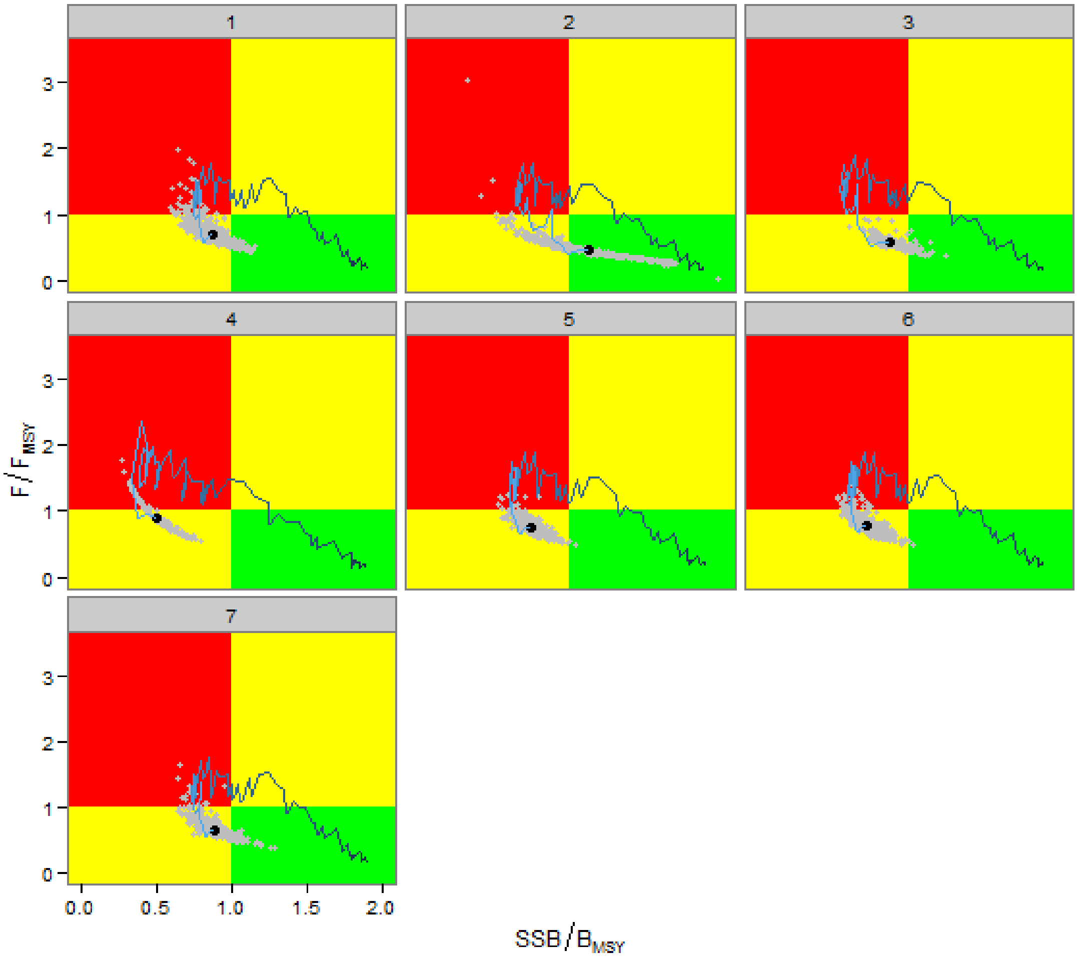


Figure 35. In blue: Estimated trends in B/B_{MSY} and F/F_{MSY} with the 7 scenarios tested. In grey: Bootstrapped 2011 B/B_{MSY} and F/F_{MSY} coordinates

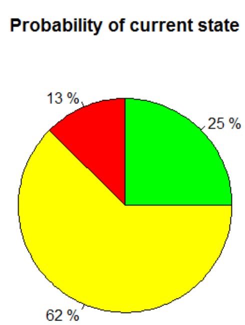


Figure 36. Probability of being in different zones in the Kobe plot for bootstrapped estimates of the 7 tested scenarios.

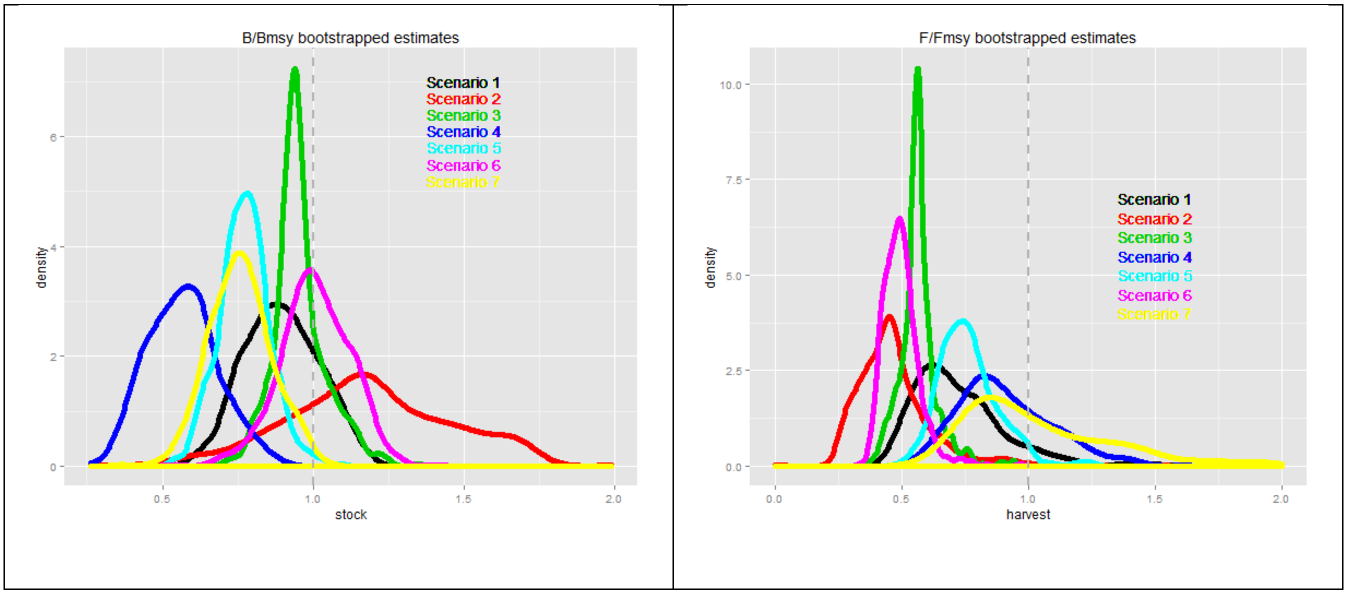


Figure 37. Density plots of the bootstrapped B/B_{MSY} and F/F_{MSY} with the 7 scenarios tested.

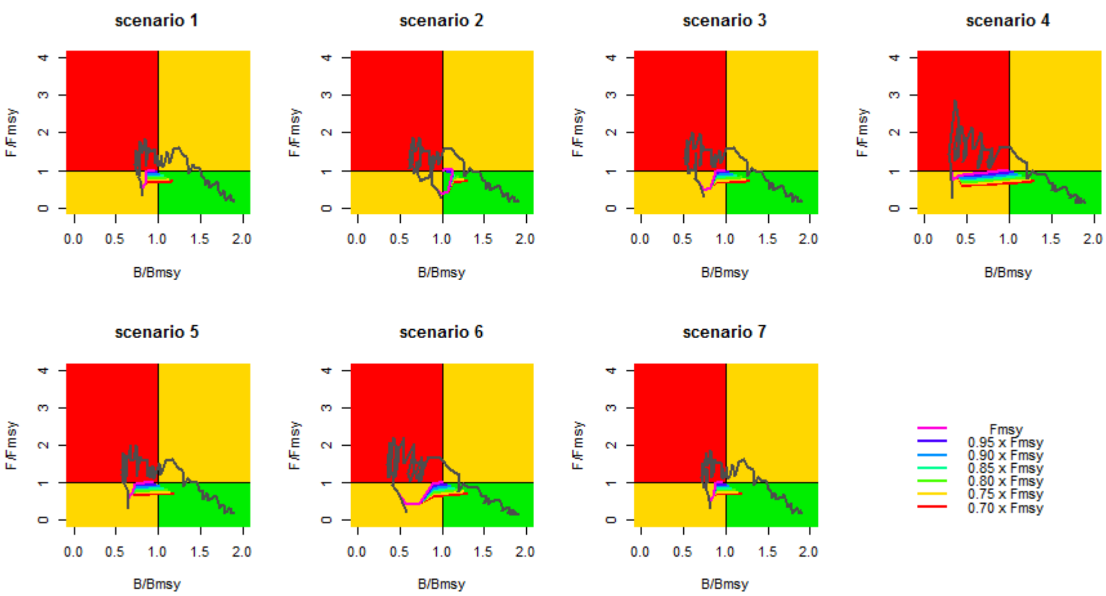


Figure 38. Constant fishing mortality 20 year projections for the 7 scenarios considered.

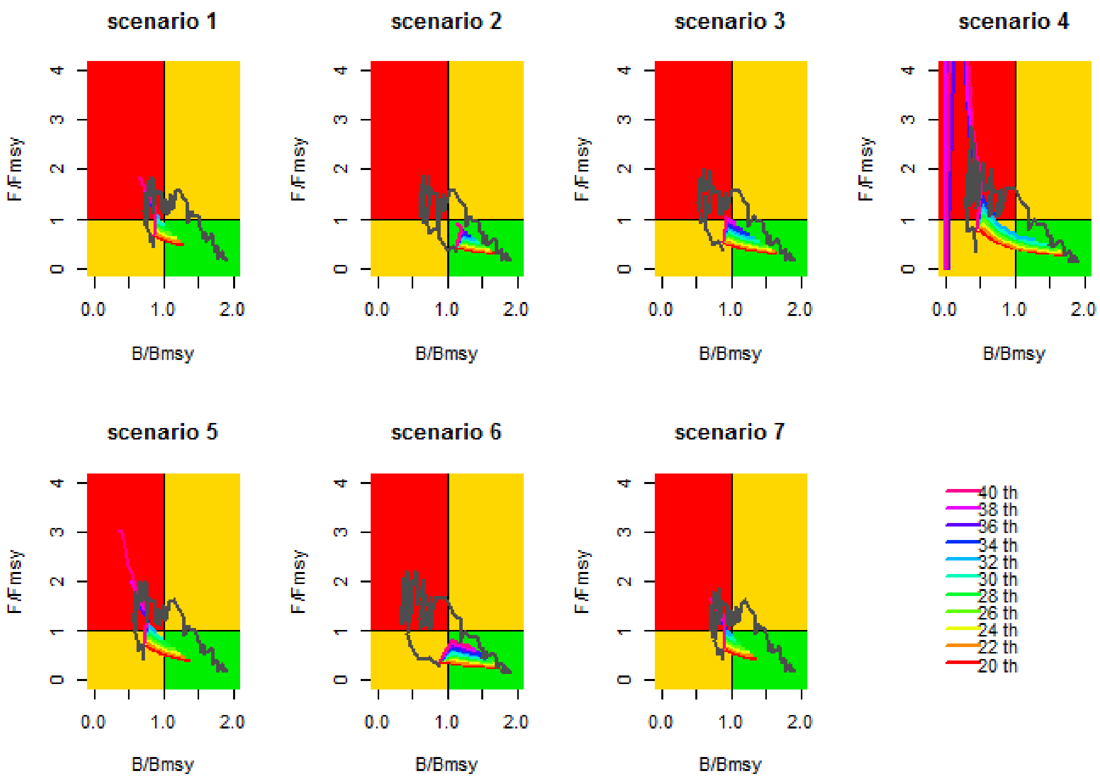


Figure 39. Constant catch 20 year projections for the 7 scenarios considered.

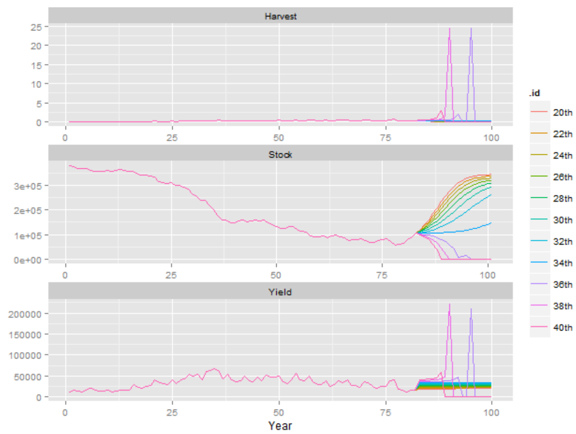


Figure 40. Constant catch projections for scenario 4.

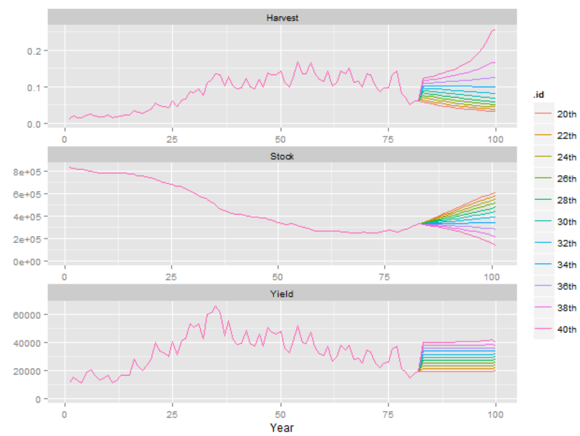


Figure 41 Constant catch projections for scenario 5.

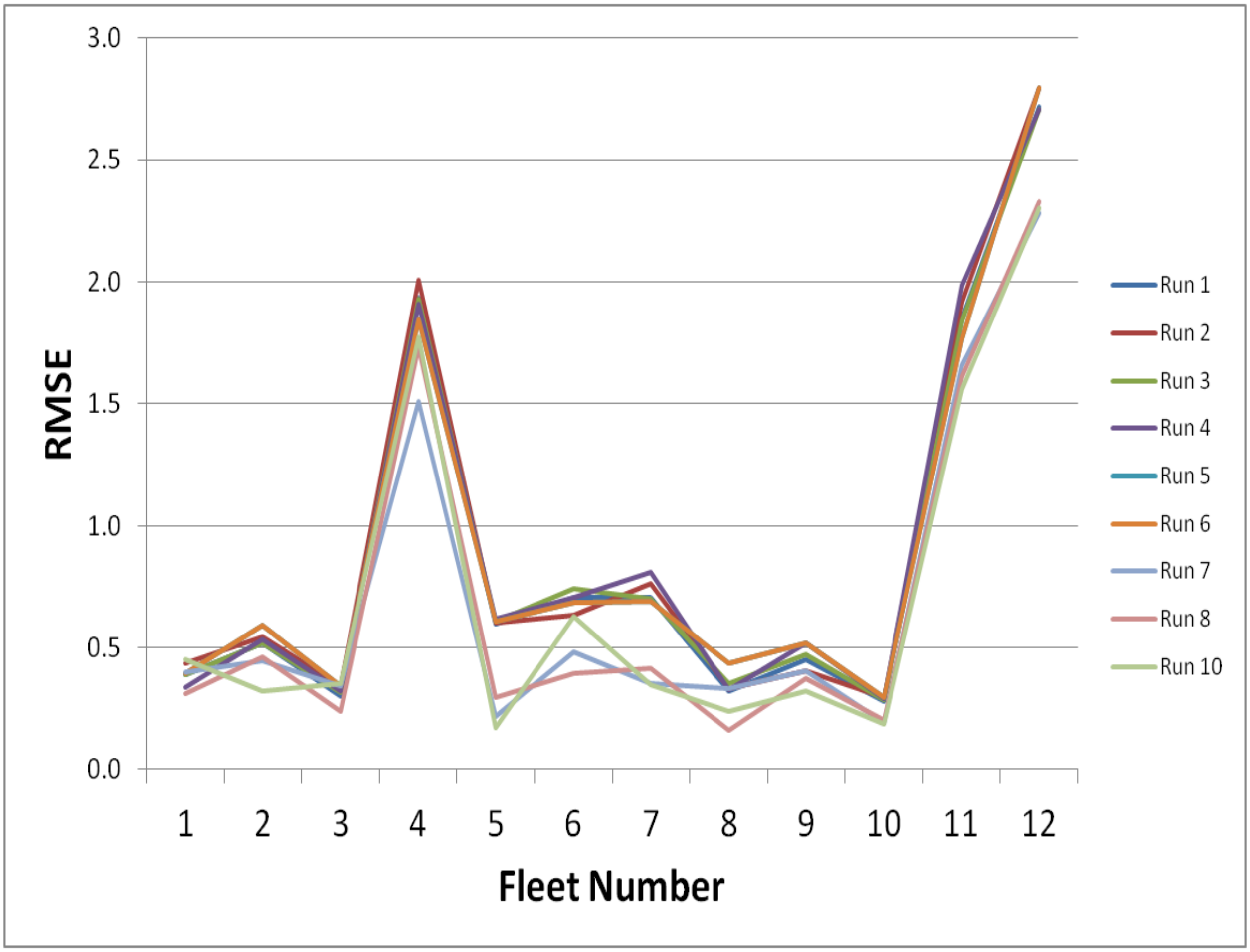


Figure 42. Residual mean square error (RMSE) for the CPUE time series used in the SS exploratory runs (note that CPUEs of fleets 11 and 12 were not used).

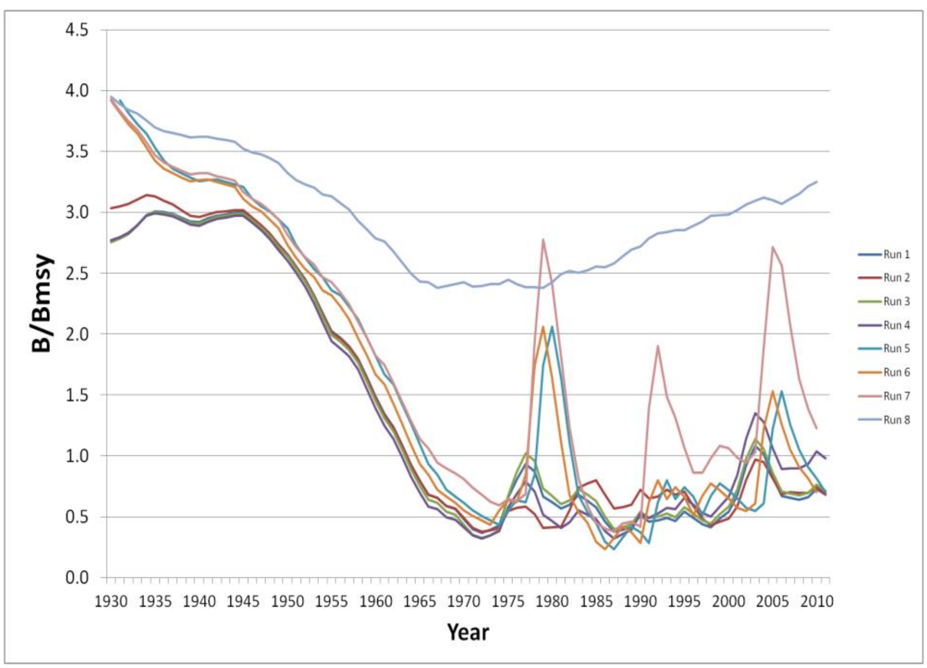


Figure 43. Management benchmark B/Bmsy for the ten SS exploratory runs

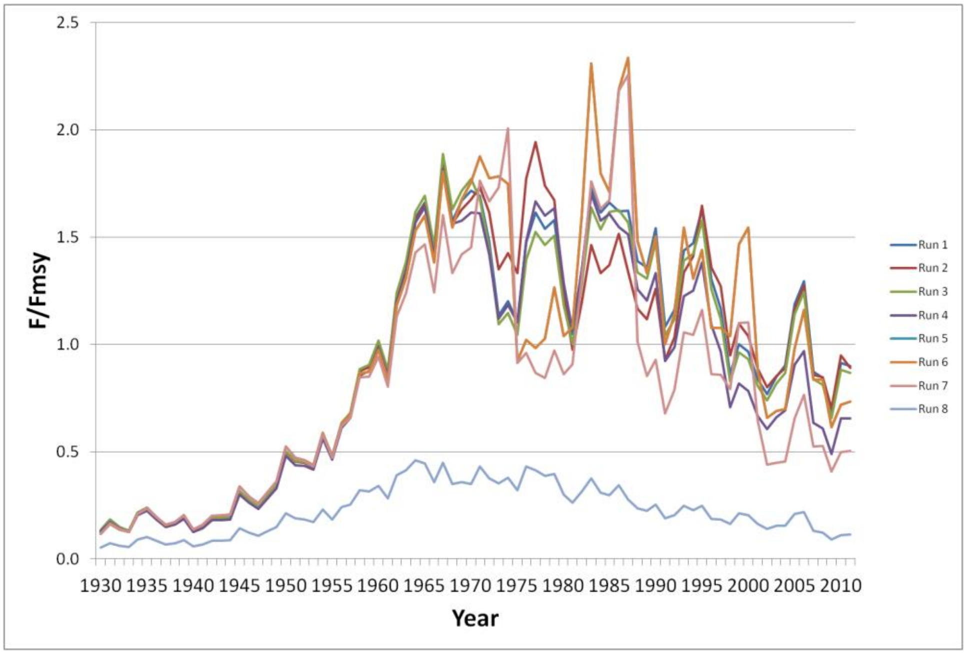


Figure 44. Management benchmark F/F_{MSY} for the ten SS exploratory runs.

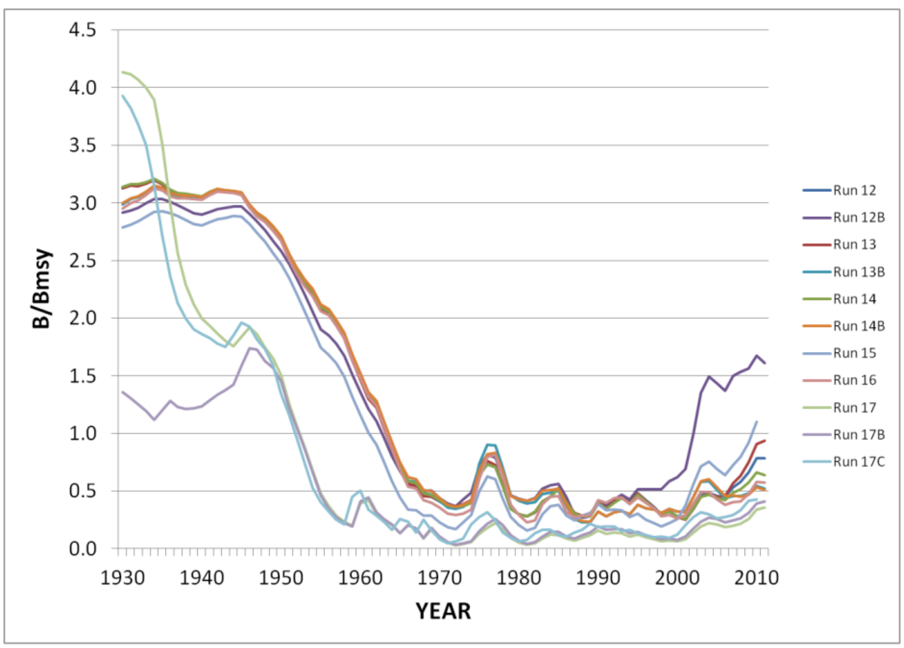


Figure 45. Management benchmark B/B_{MSY} for the eleven post exploratory SS configurations.

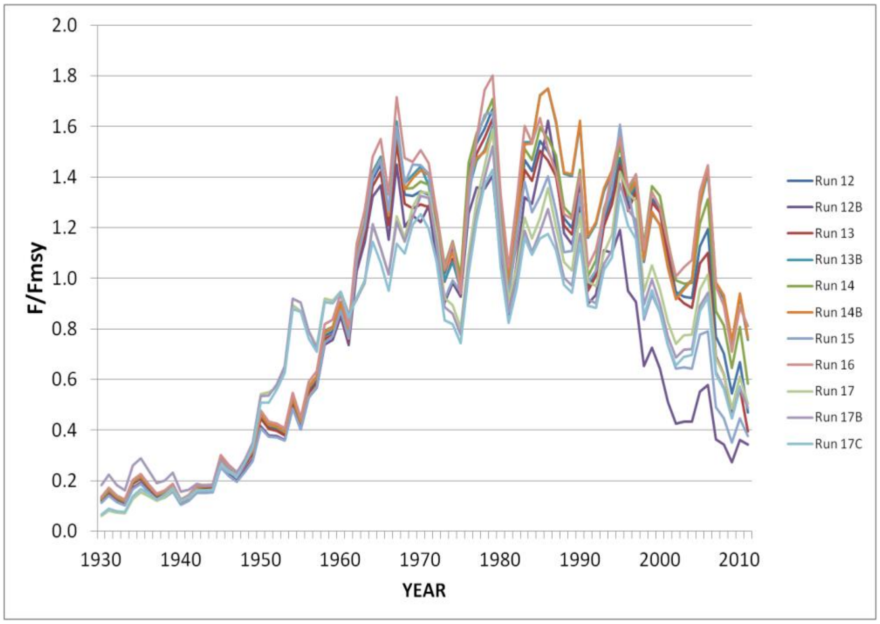
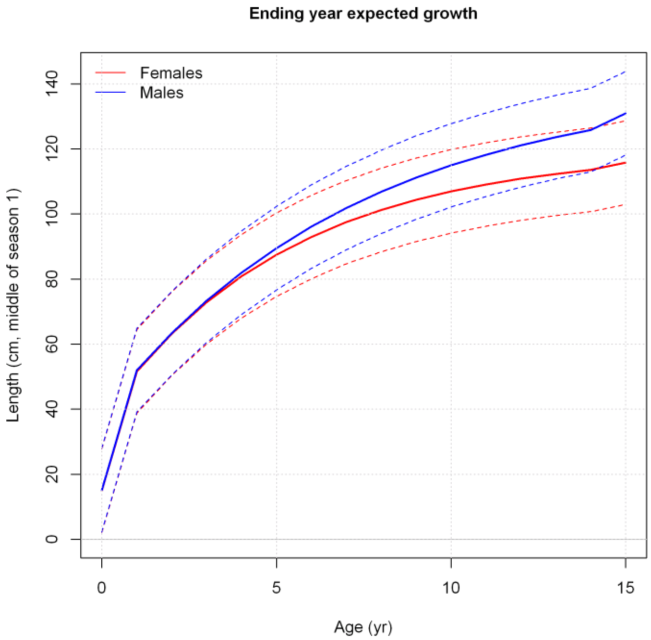


Figure 46. Management benchmark F/F_{MSY} for the eleven post exploratory SS configuration.



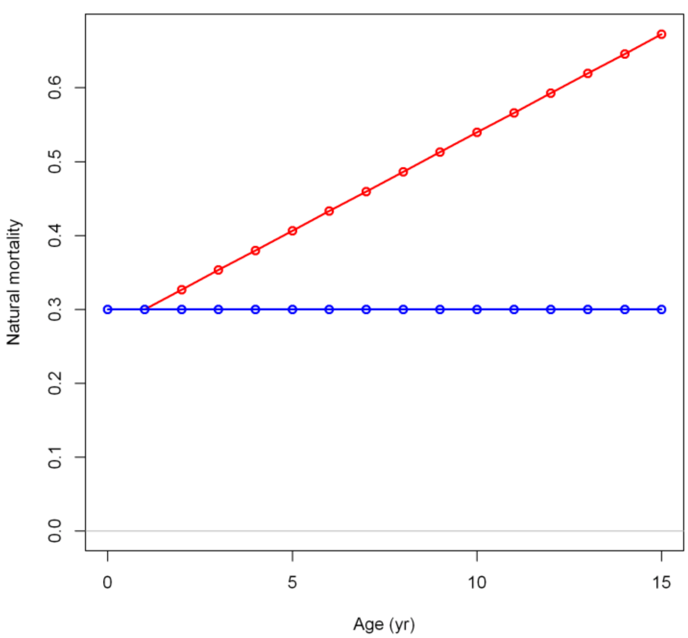


Figure 47. Growth and natural mortality used for SS Run 12.

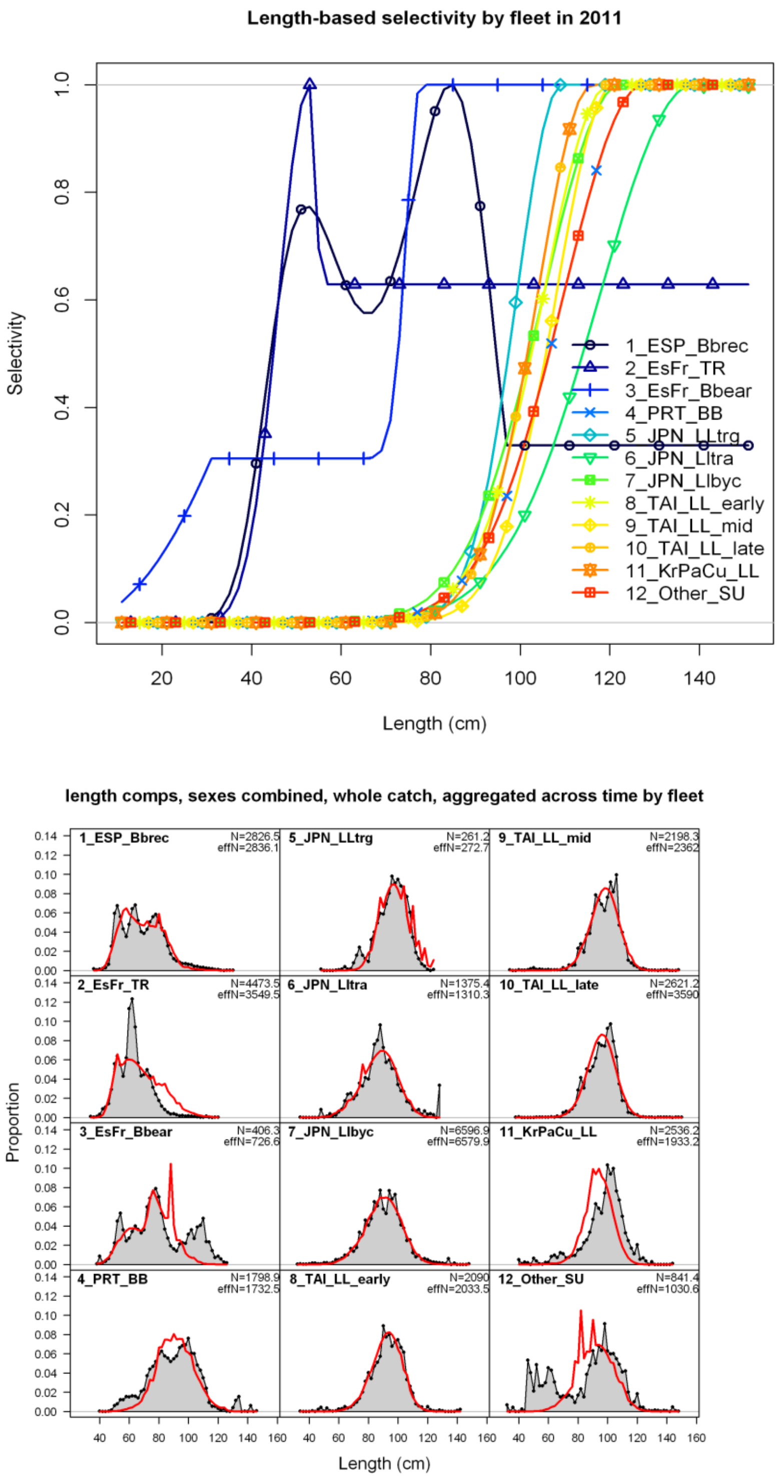


Figure 48. Estimated selectivities and resulting fit to overall length compositions, sexes combined, for SS Run 12. Note that fleets 11 and 12 were not included in the model fit.

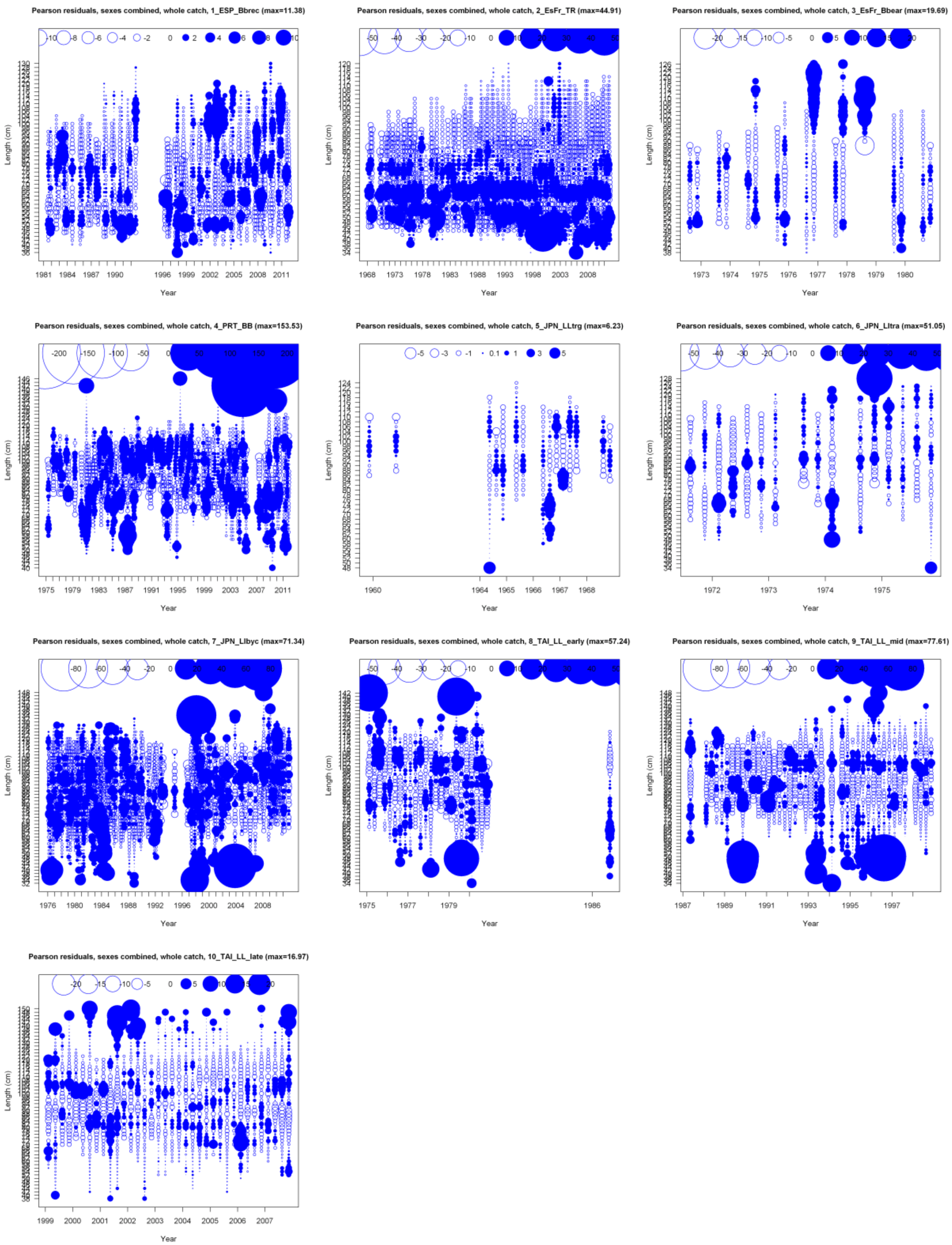


Figure 49. Pearson residuals, sexes combined, for SS Run 12.

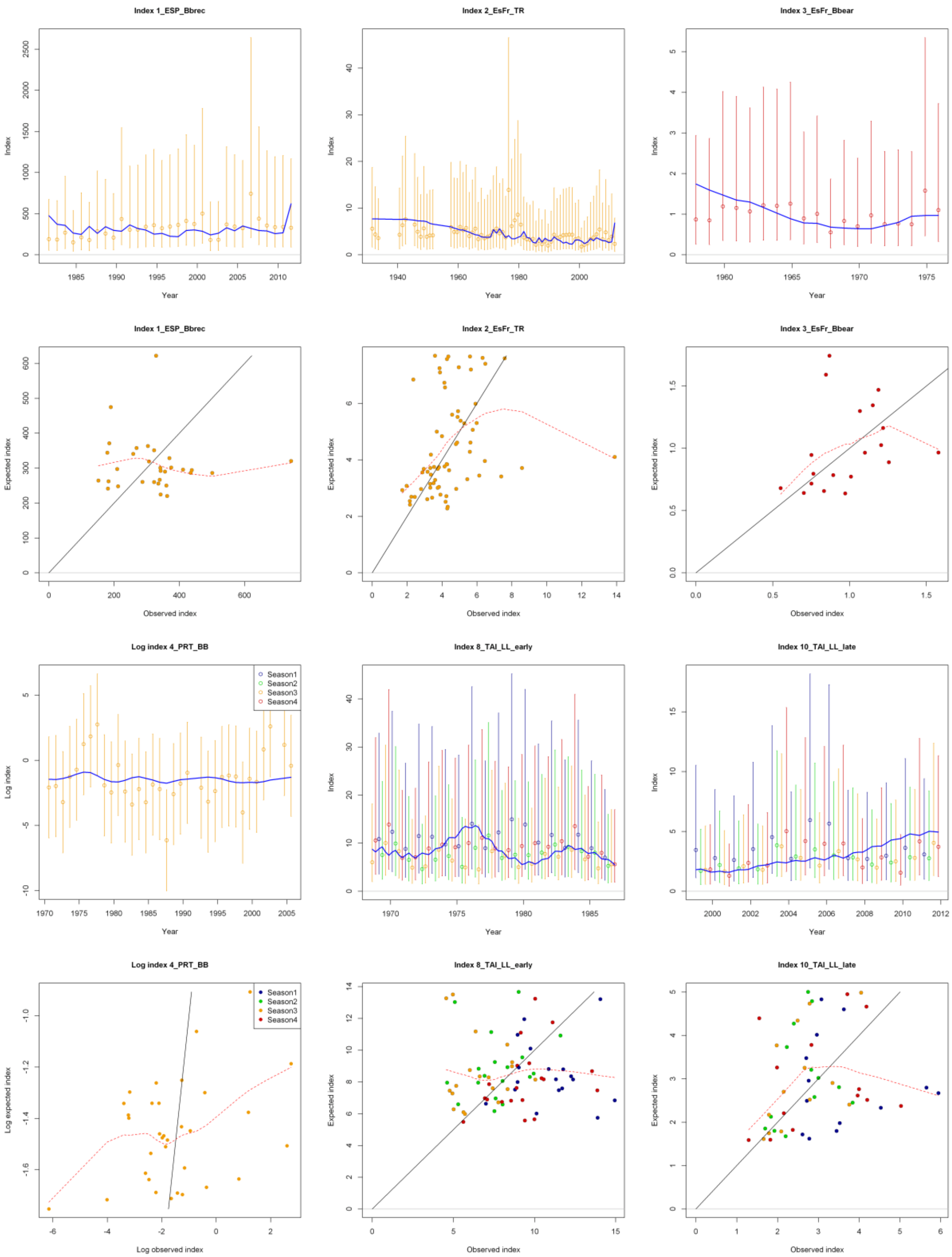


Figure 50. Fit to CPUE time series used in SS Run 12.

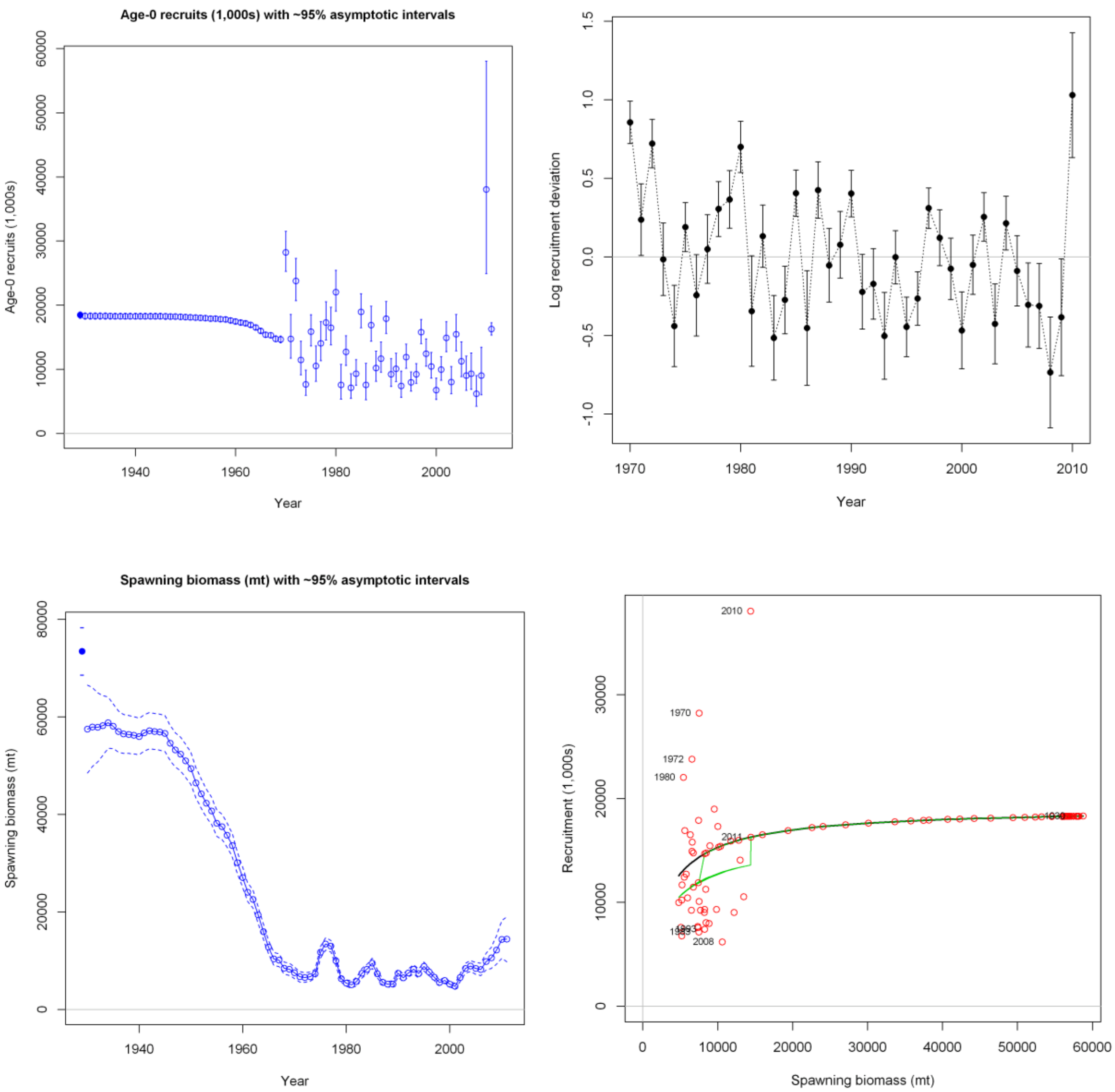


Figure 51. Spawning stock biomass (lower left), recruitment (upper left), stock-recruitment function (lower right), and recruitment residuals (upper right) for SS Run 12.

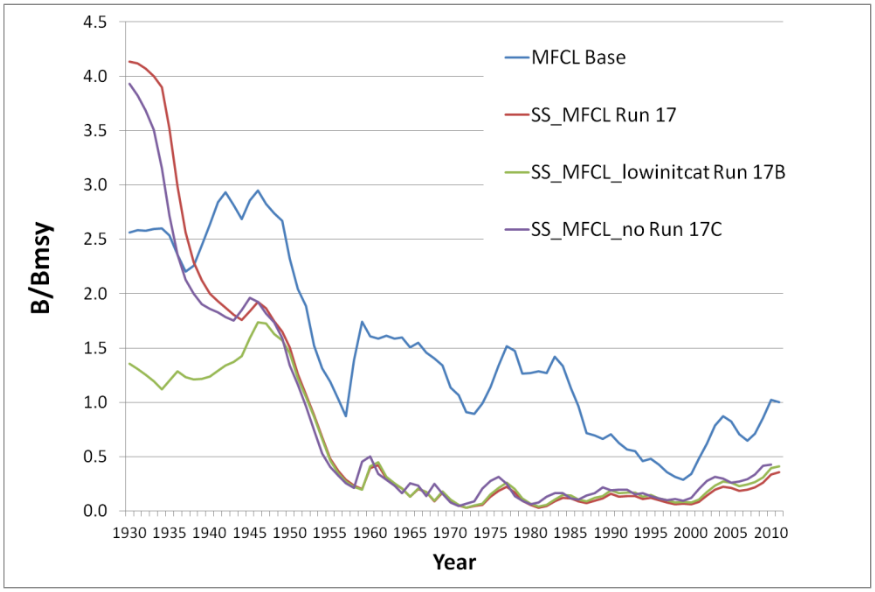


Figure 52. Estimates of B/B_{MSY} for the MFCL base case and SS Runs 17, 17B, and 17C.

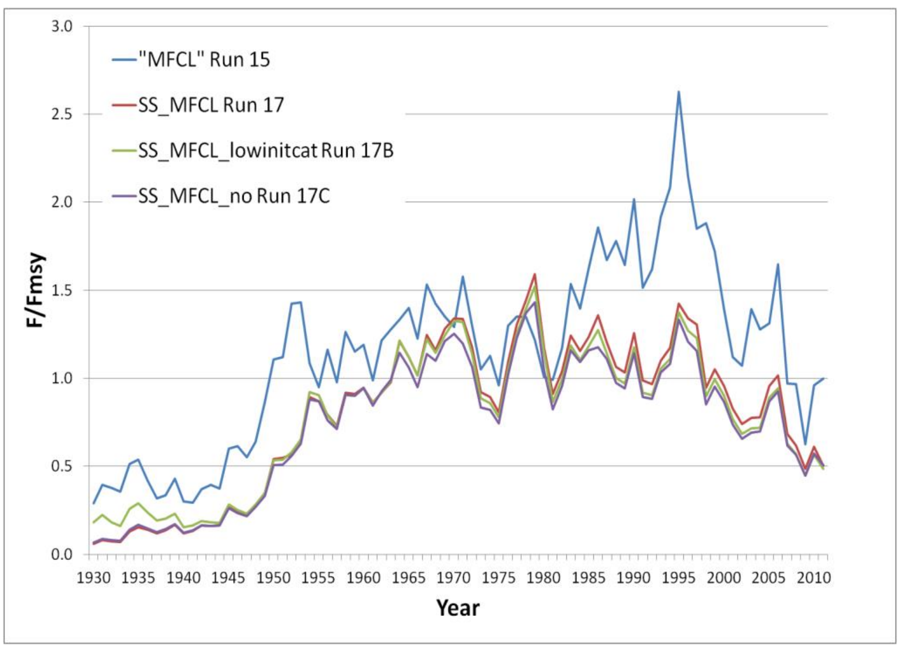


Figure 53. Estimates of F/F_{MSY} for SS Run 15 (the SS "MFCL-like" run), and SS Runs 17, 17B, and 17C.

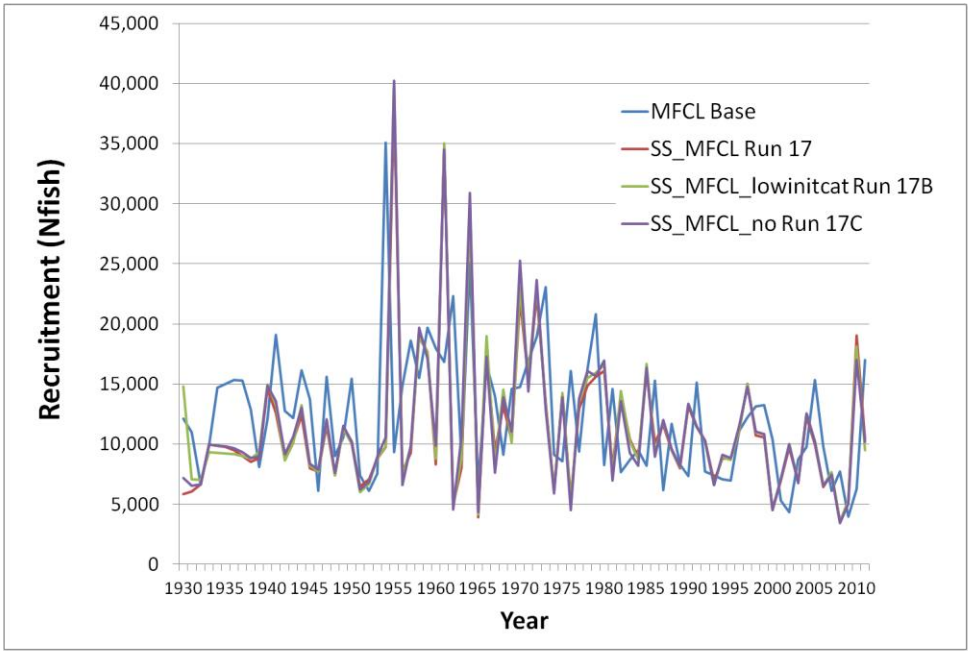


Figure 54. Estimates of recruitment for the MFCL base case and the SS Runs 17, 17B, and 17C.

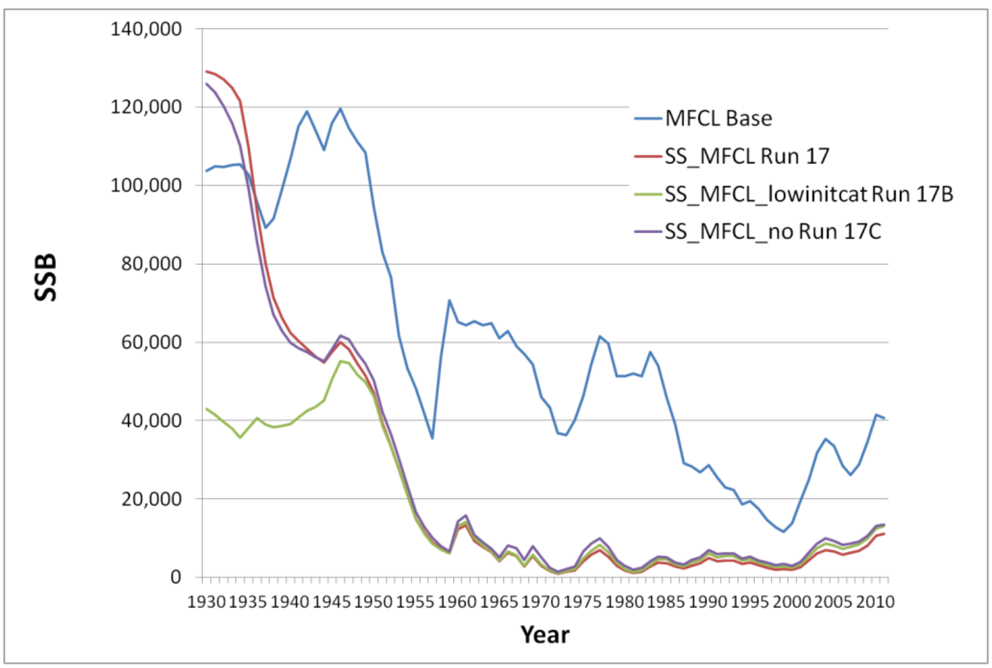


Figure 55. Estimates of spawning stock biomass for the MFCL base case and the SS Runs 17, 17B, and 17C.

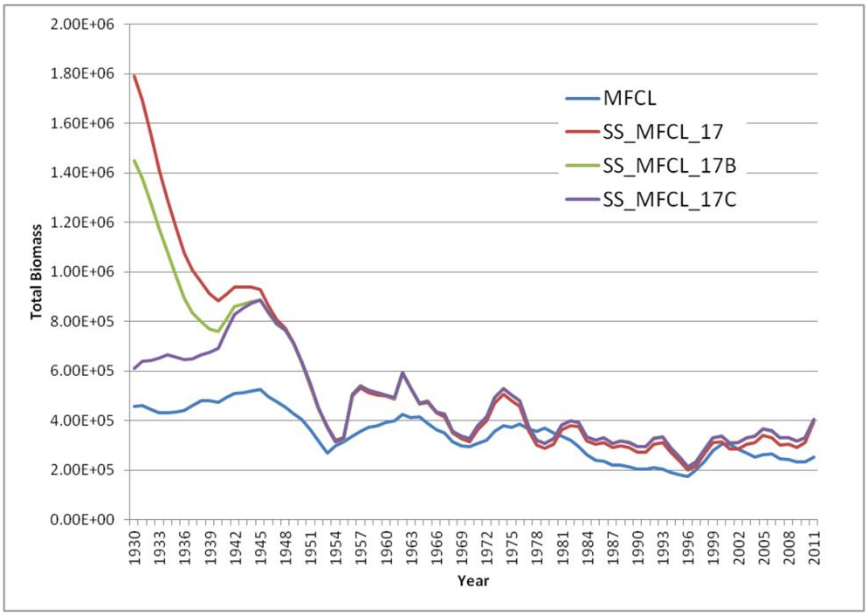


Figure 56. Estimates of total stock biomass for the MFCL base case and the SS Runs 17, 17B, and 17.

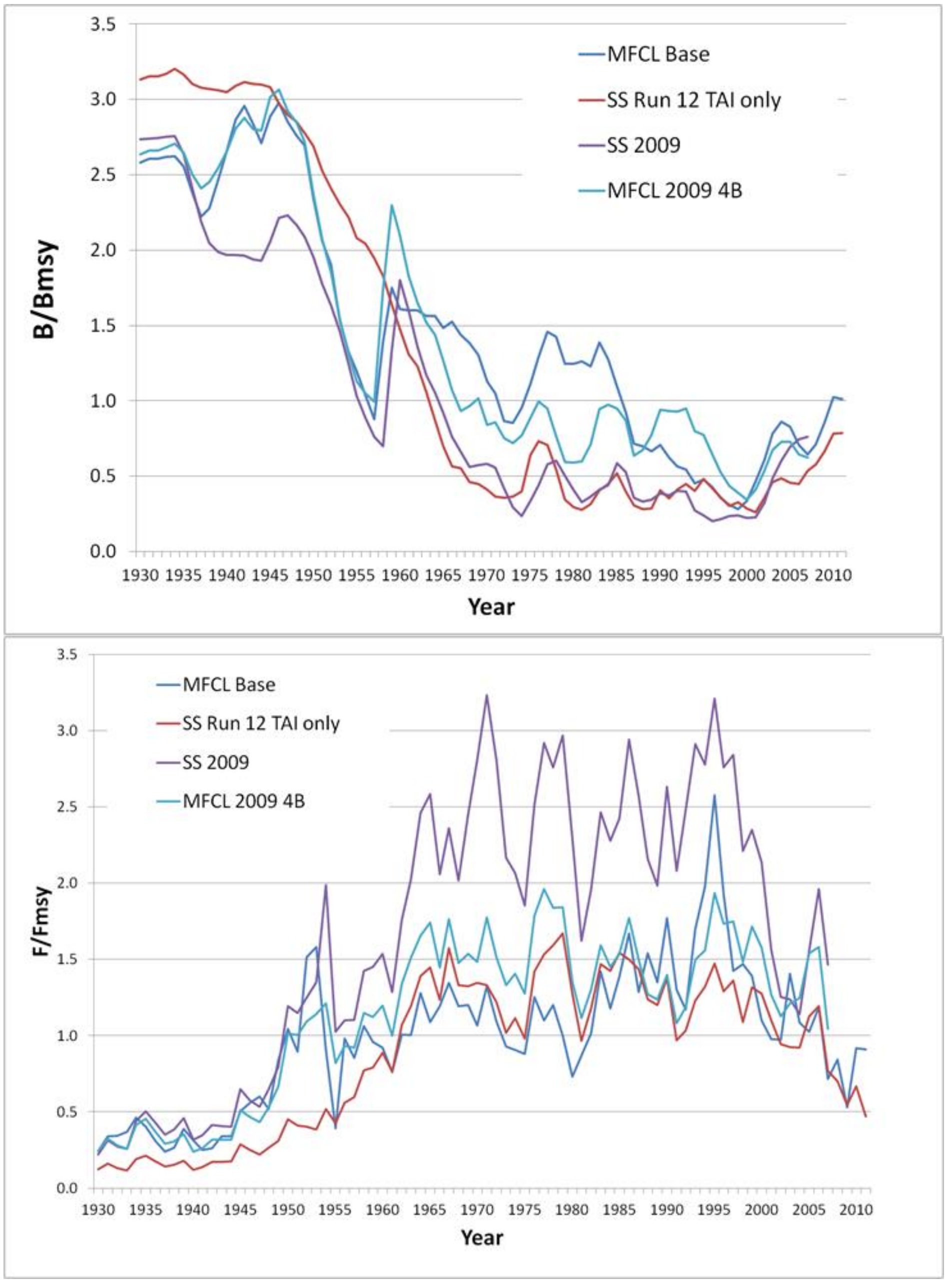


Figure 57. Comparison B/B_{MSY} (top) and F/F_{MSY} (bottom) of the SS MFCL base case, SS Run 12, SS from the 2009 assessment, and MFCL from the 2009 assessment. These represent the final runs considered from SS and MFCL in 2009 and 2013.

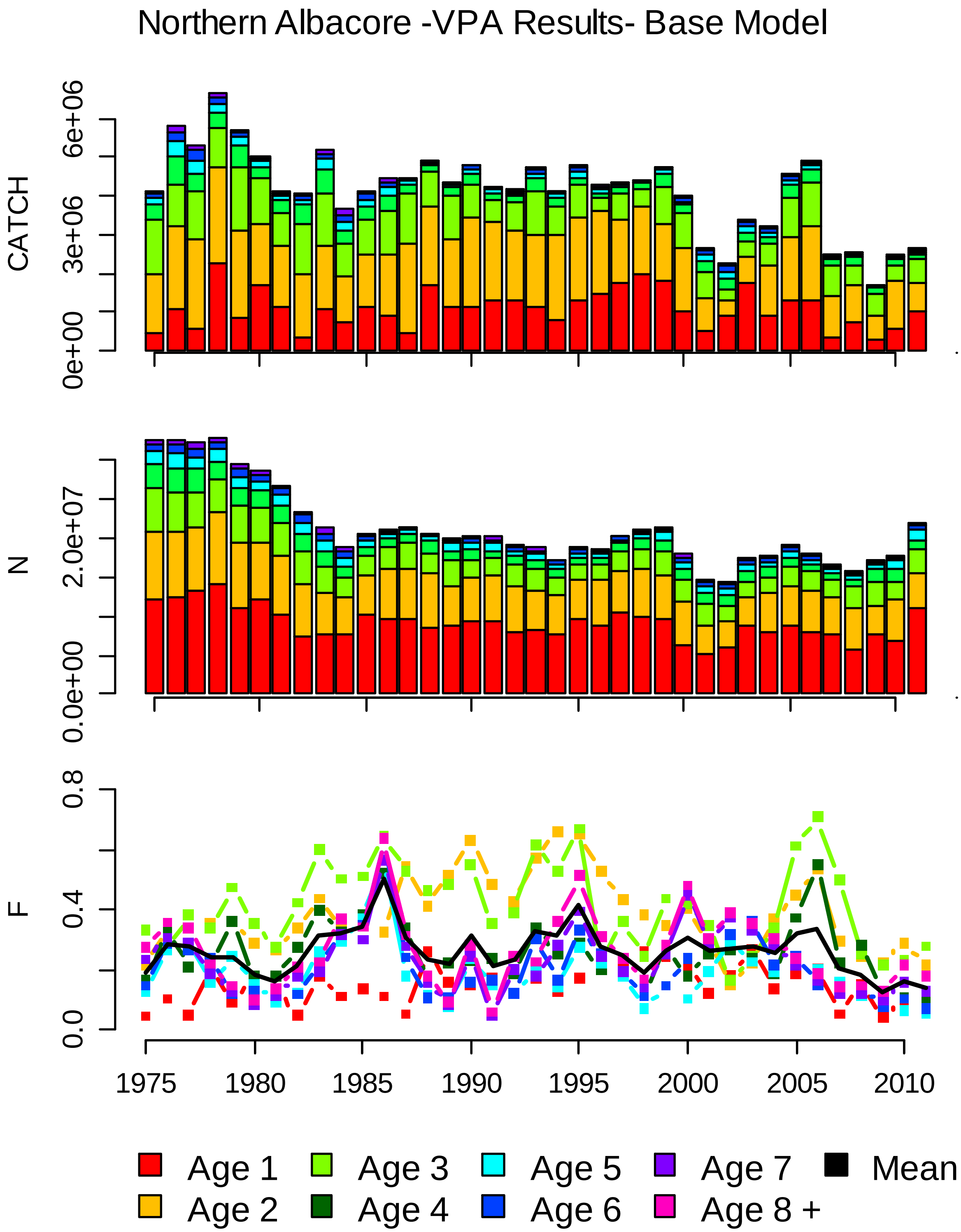


Figure 58. Catch-at-age data, estimated abundance-at-age, and estimated fishing mortality-at-age from the base model virtual population analysis of North Atlantic albacore.

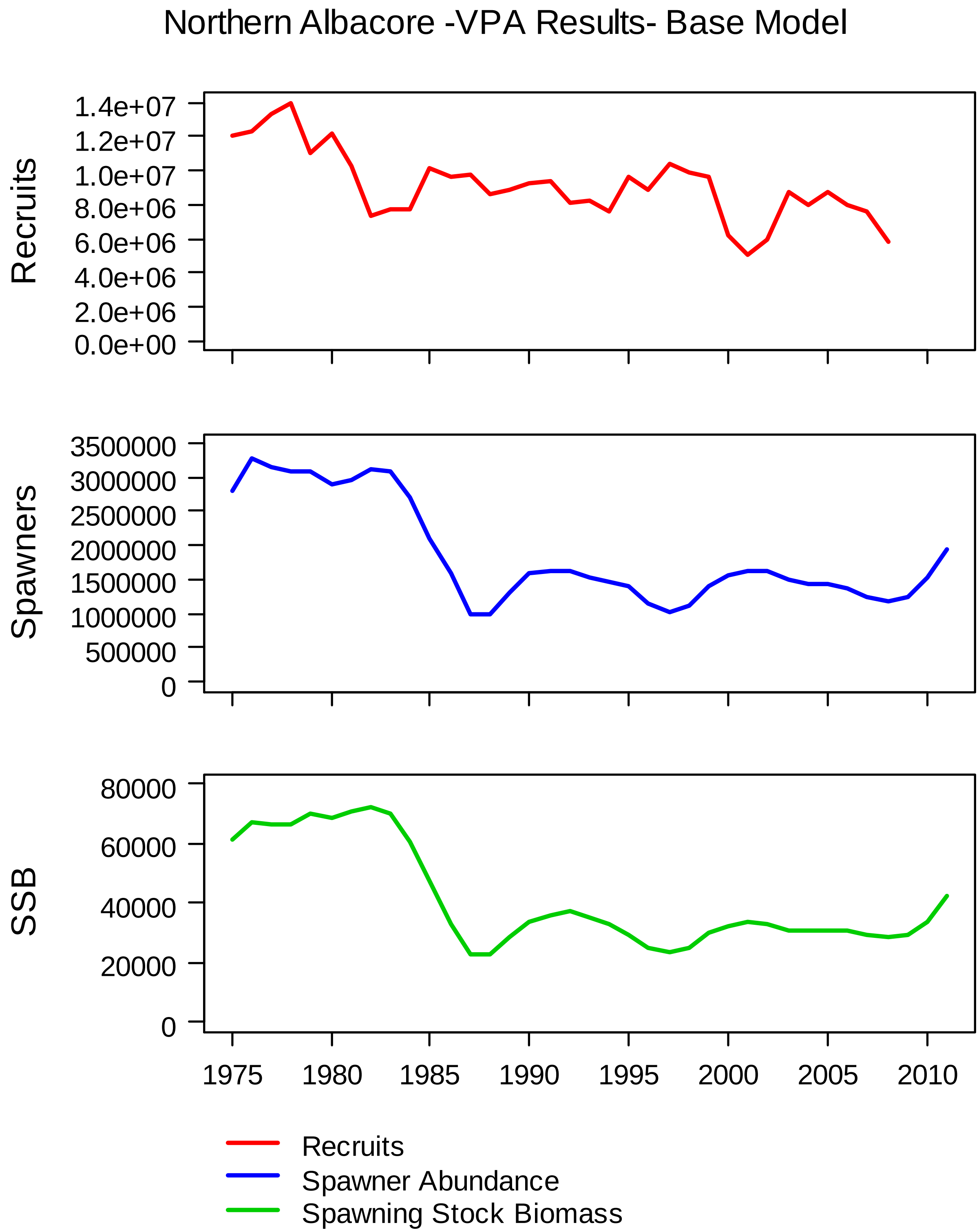


Figure 59. Estimated recruitment, spawning stock abundance, and spawning stock biomass from the virtual population analysis base model of North Atlantic albacore.

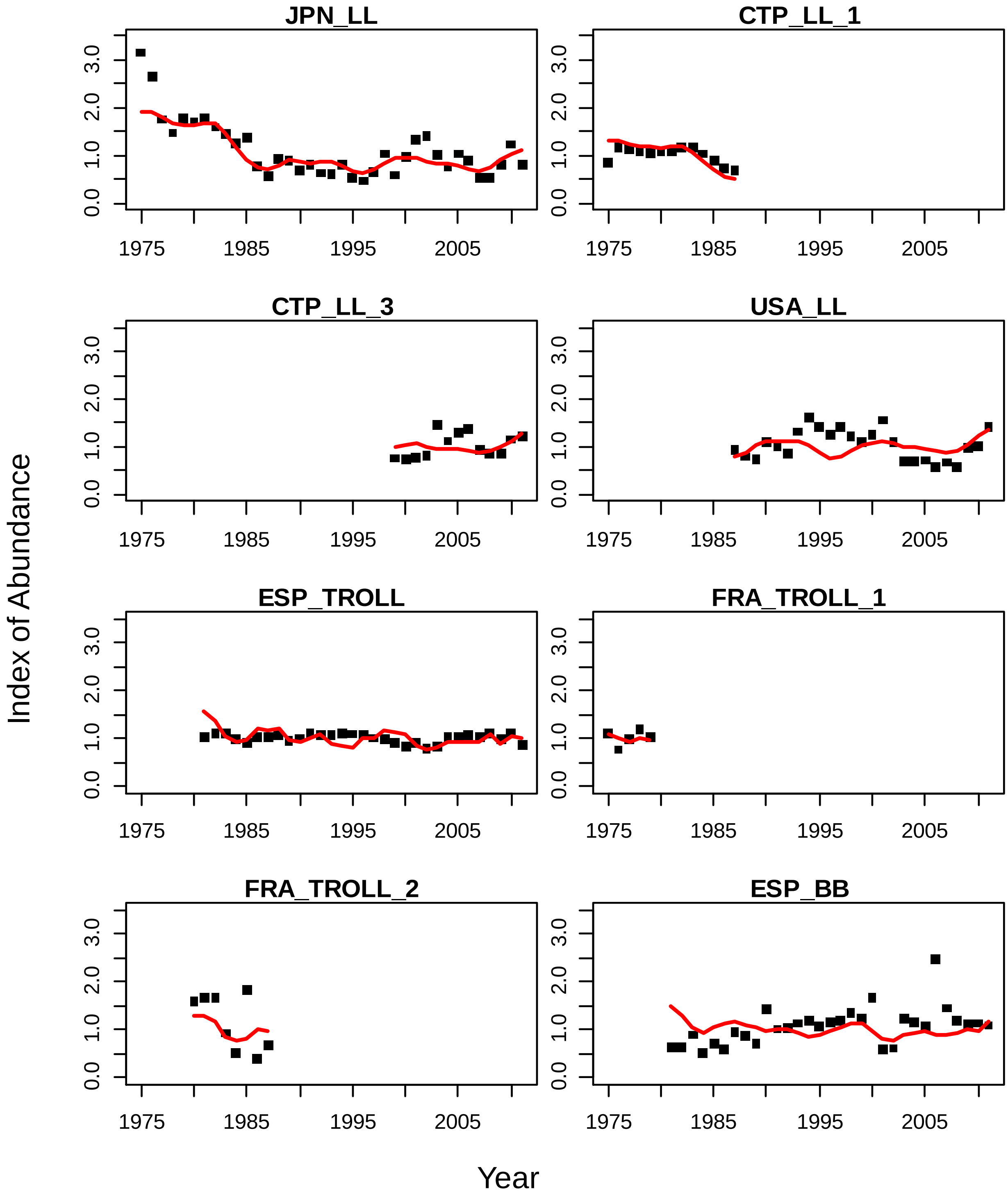


Figure 60. Virtual population analysis base model fits to indices of abundance of north Atlantic albacore. JPN_LL = Japan longline, CTP_LL_1 = Chinese Taipei longline period 1, CTP_LL_3 = Chinese Taipei longline period 3, USA_LL = United States longline, ESP_TROLL = Spain troll, FRA_TROLL = French troll, ESP_BB = Spain baitboat.

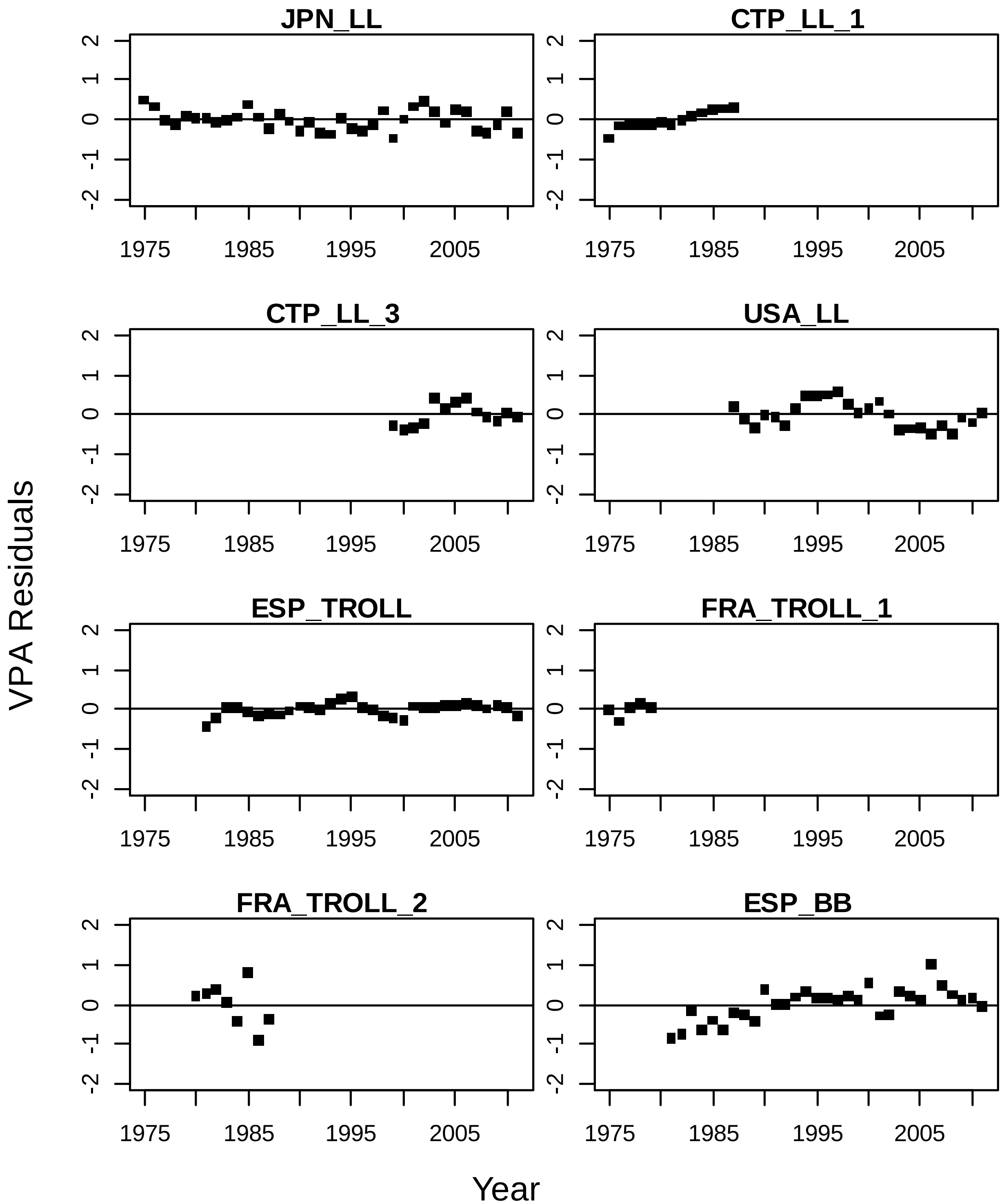


Figure 61. Residual error to VPA base model fits to indices of abundance.

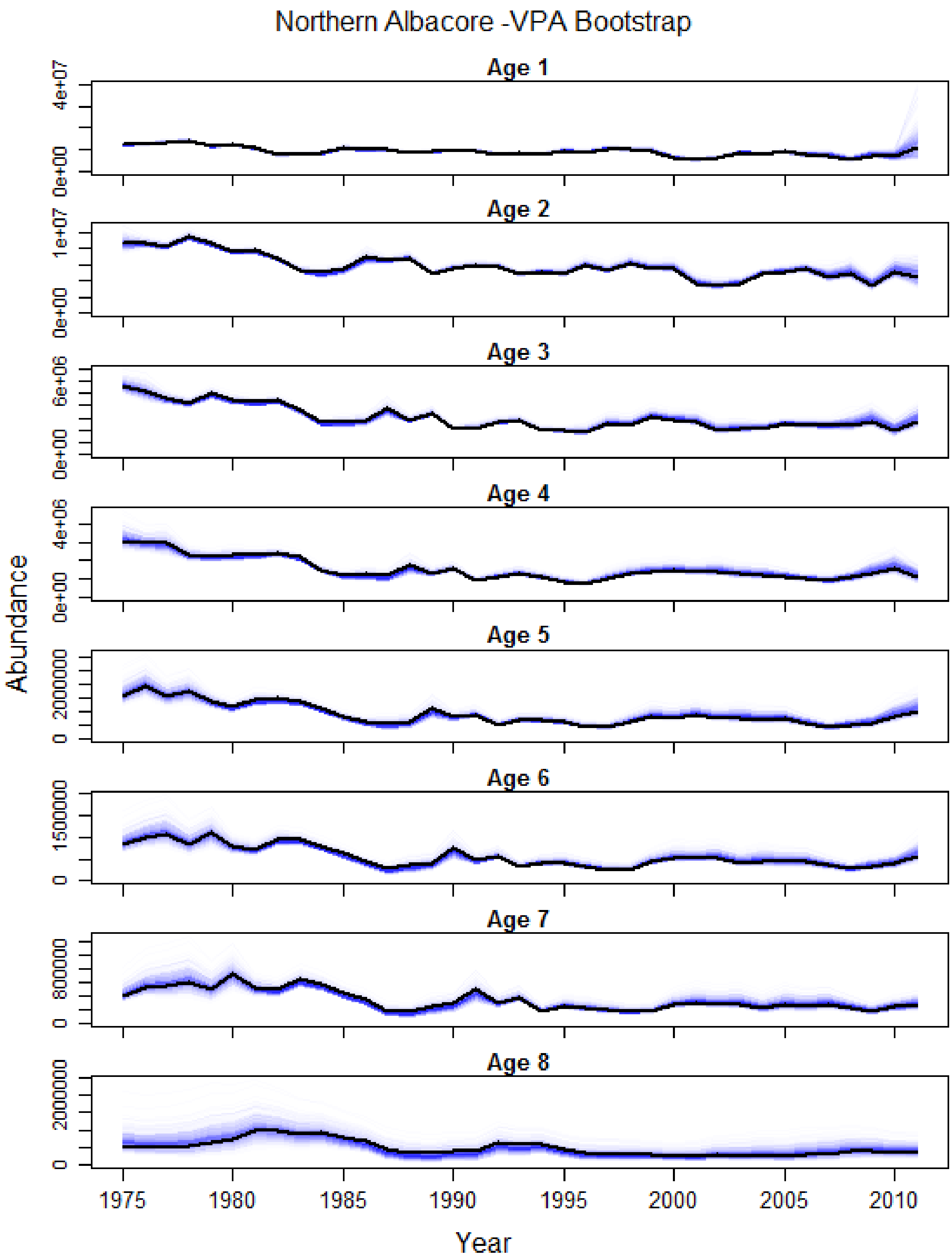


Figure 62. Bootstrap analysis of North Atlantic albacore VPA base model estimates of abundance-at-age. Black line shows the deterministic run, bootstraps are shown as blue lines.

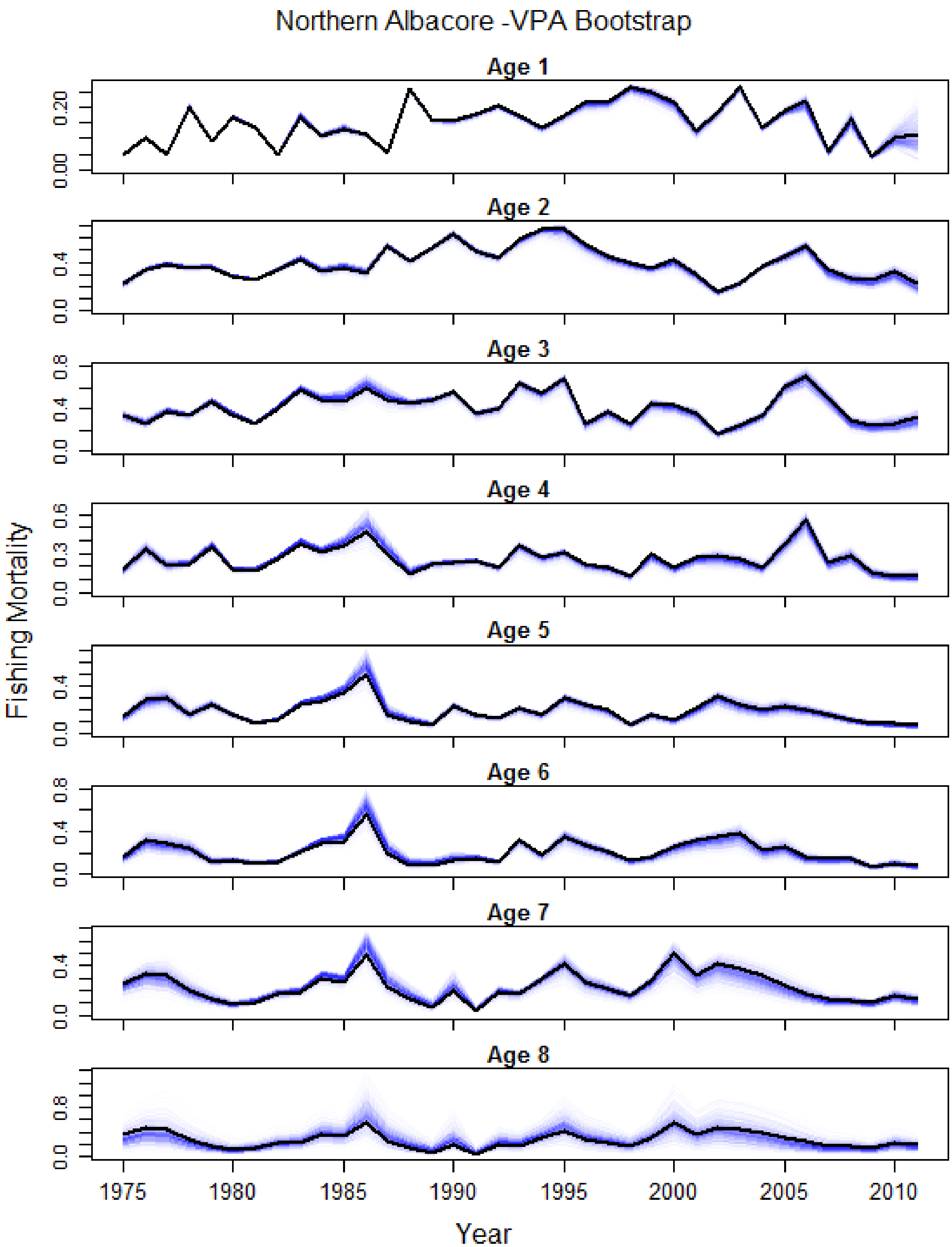


Figure 63. Bootstrap analysis of North Atlantic albacore VPA base model estimates of fishing mortality-at-age. Black line shows the deterministic run, bootstraps are shown as blue lines.

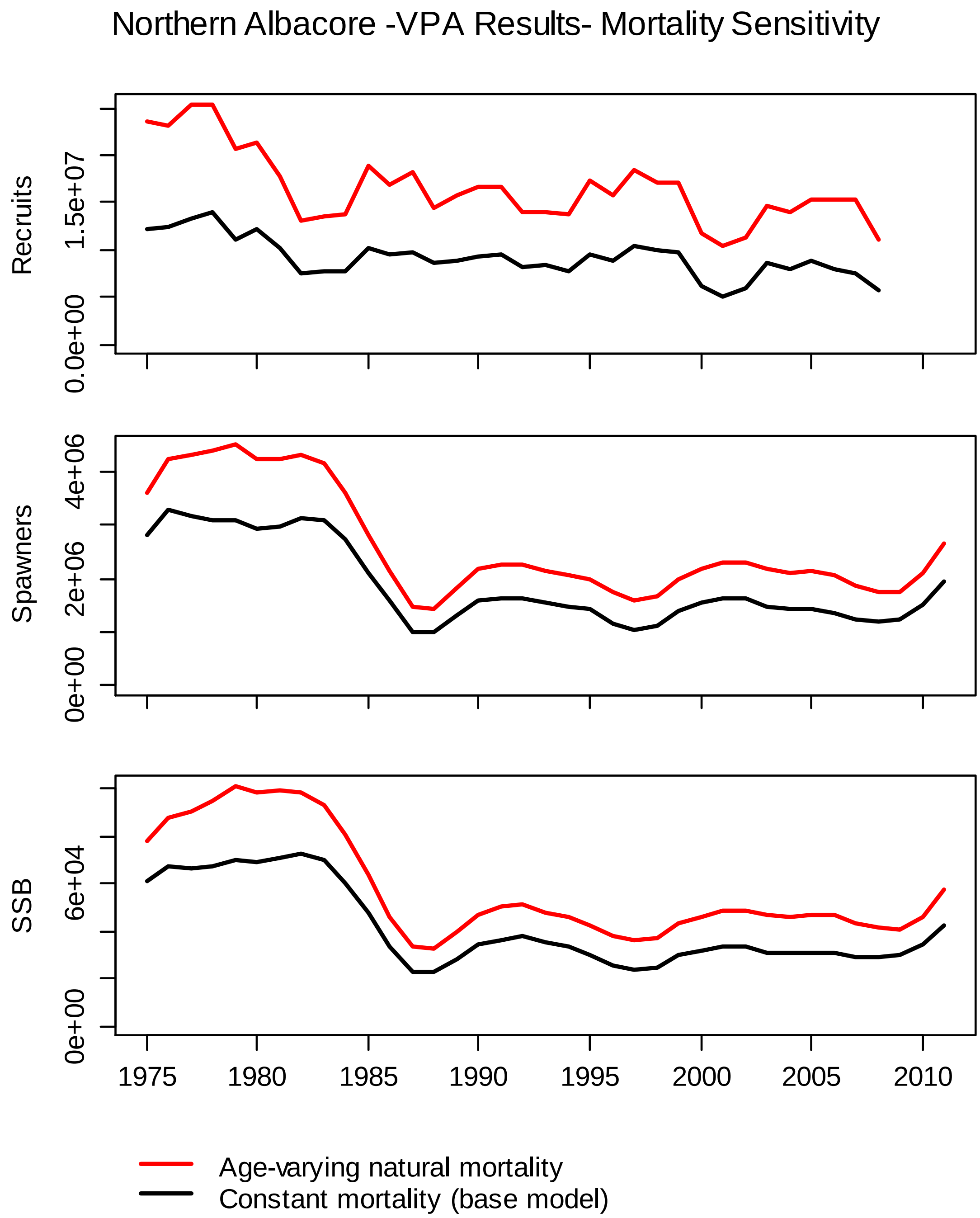


Figure 64. Virtual population analysis of North Atlantic albacore natural mortality sensitivity analysis. Age-varying mortality: Age-1=0.63, Age-2=0.46, Age-3=0.38, Age-4=0.34, Age-5=0.31, Age-6=0.29, Age-7=0.31, Age-8+=0.50; constant natural mortality = 0.3 across ages.

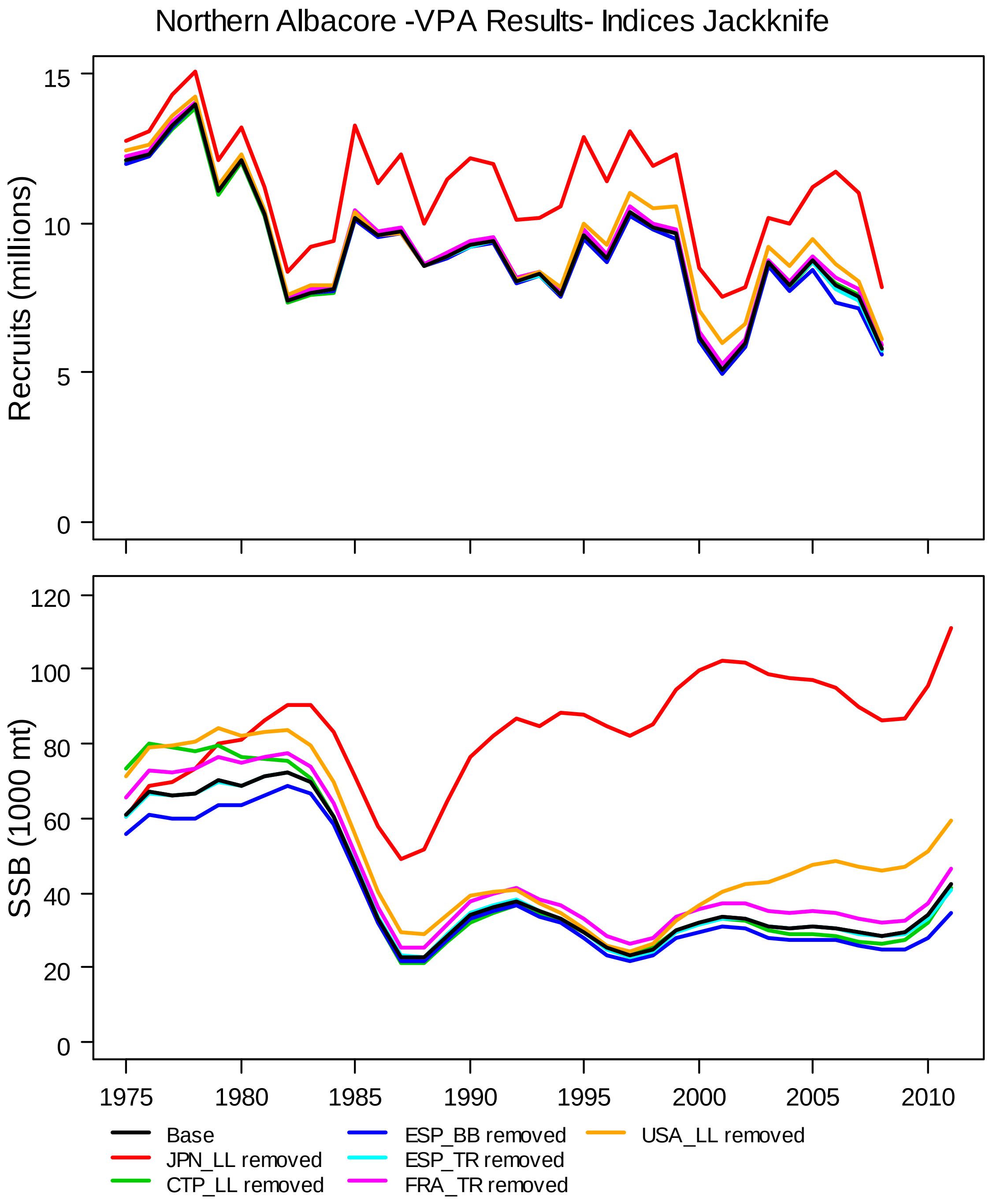


Figure 65. Virtual population analysis of North Atlantic albacore indices sensitivity analysis. JPN_LL = Japan longline, CTP_LL = Chinese Taipei longline, USA_LL = United States longline, ESP_TROLL = Spain troll, FRA_TROLL = French troll, ESP_BB = Spain baitboat.

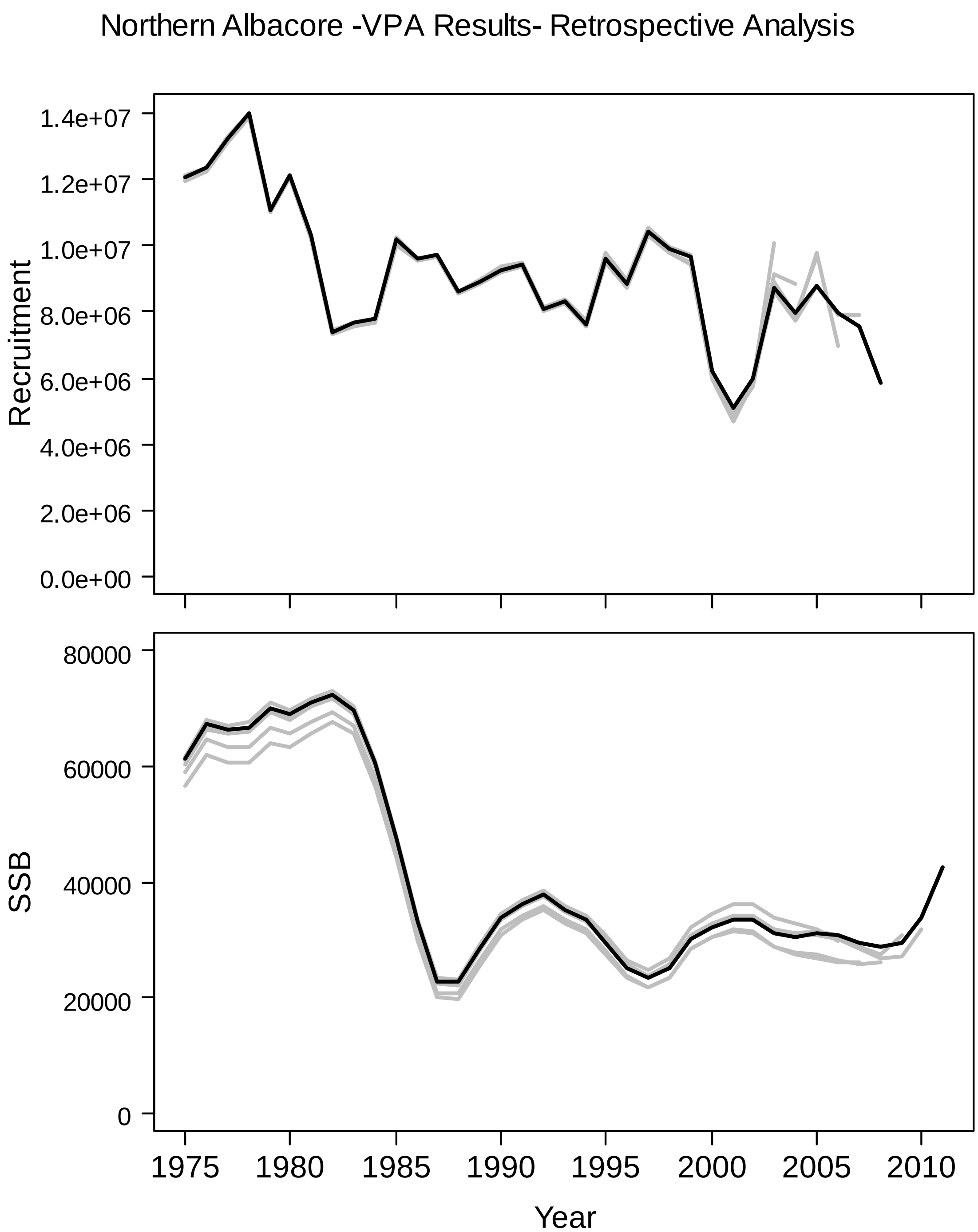


Figure 66. Retrospective sensitivity analysis of estimated recruitment and spawning stock biomass (SSB) from the VPA base model of North Atlantic albacore, iteratively removing 1 to 5 most recent years of data.

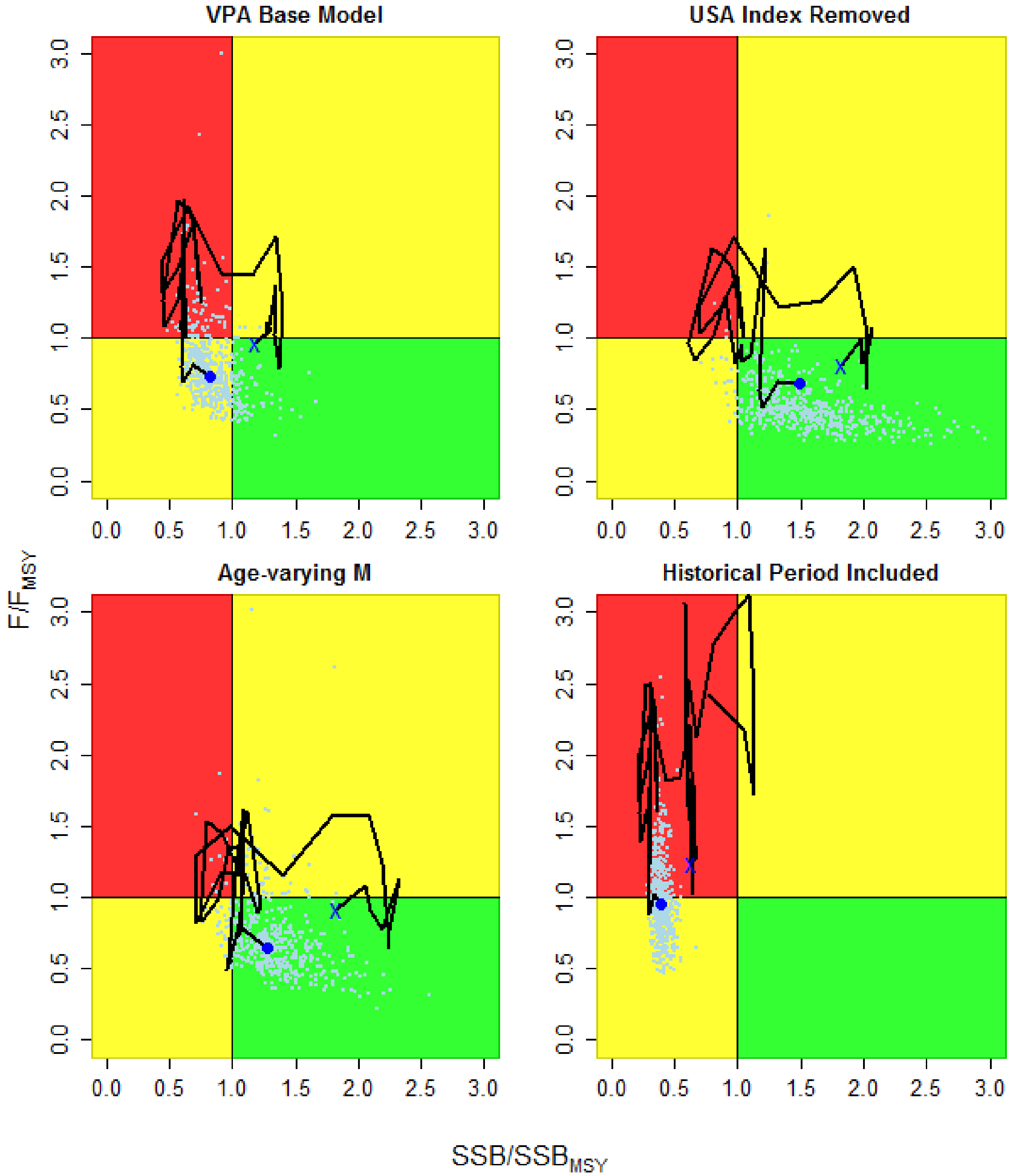


Figure 67. Kobe phase plot of North Atlantic albacore stock status from the VPA model. The blue "X" indicates the stock status at the beginning of the time series, the blue point indicates the stock status in 2011, and the light blue points show the stock status estimates from bootstrap iterations.

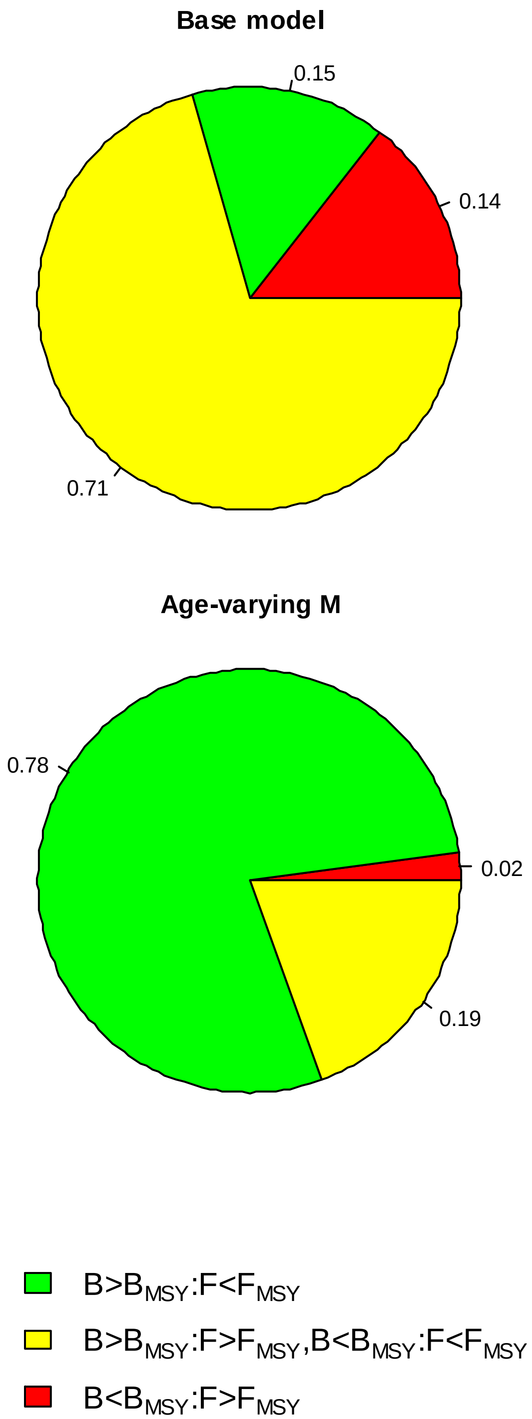


Figure 68. Kobe phase chart illustrating the relative probability of the stock status of North Atlantic albacore from the VPA model.

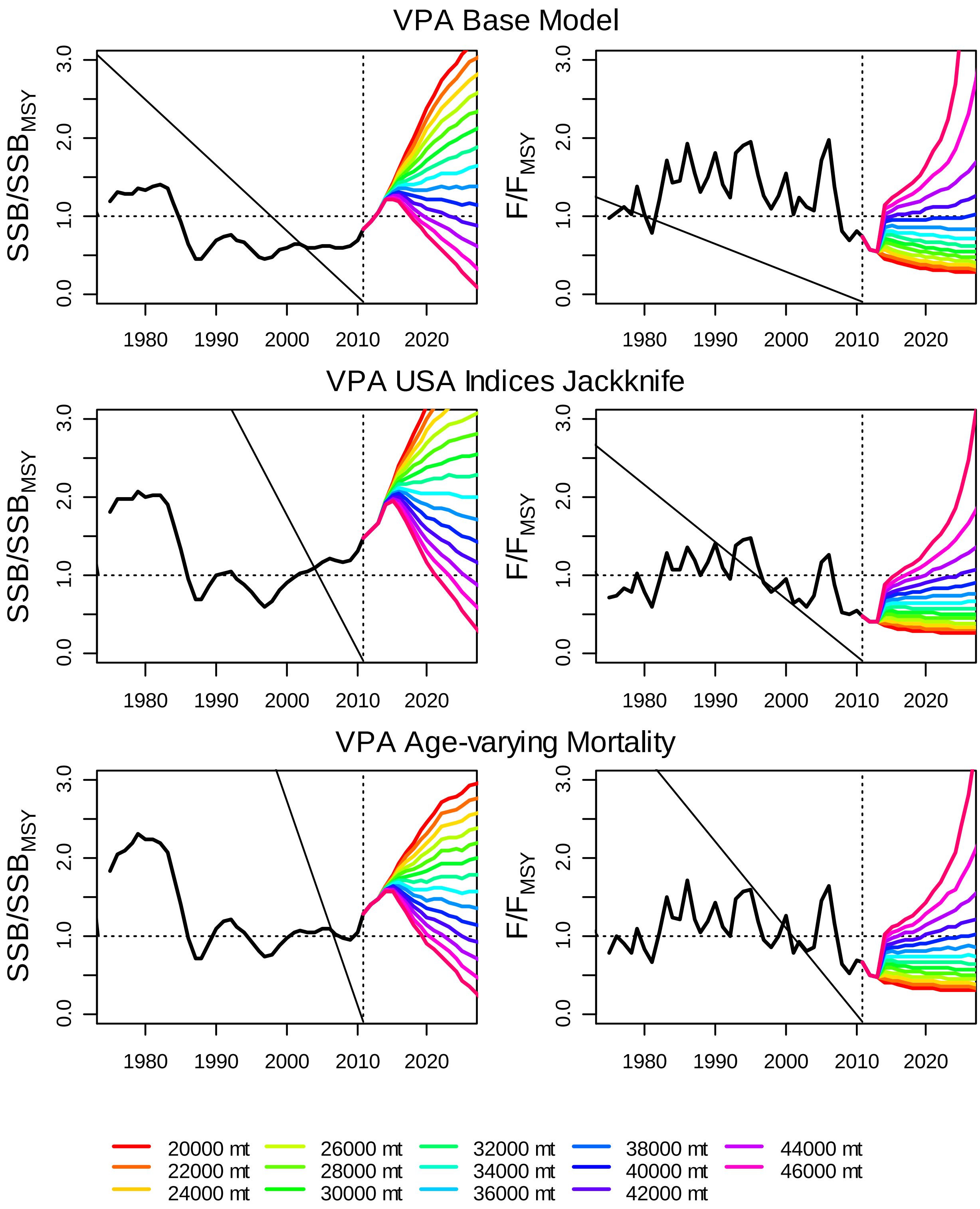


Figure 69. Projections of North Atlantic albacore stock status from the VPA models. From top to bottom: base model, base model with the U.S. longline indices removed, and base model with age-dependent natural mortality.

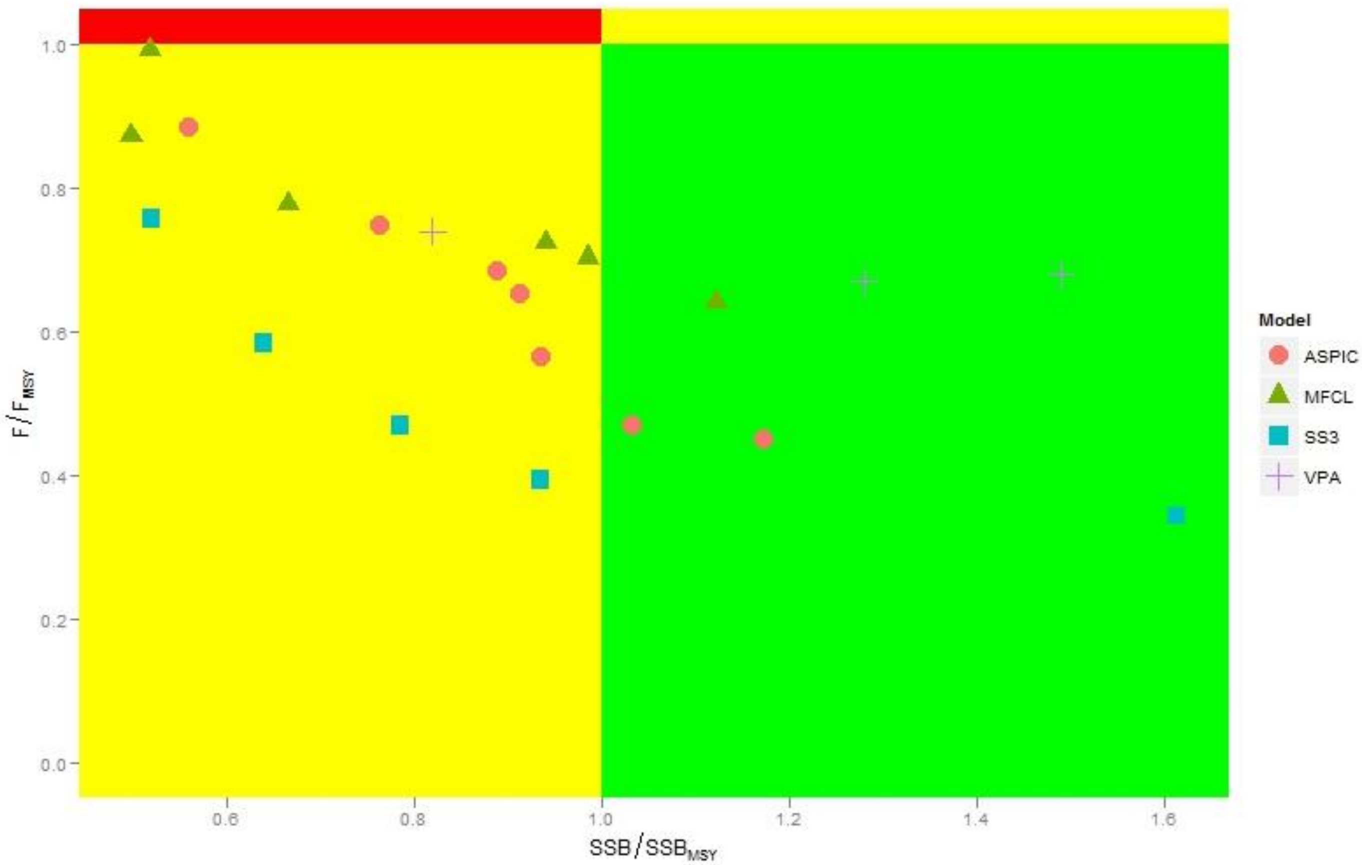


Figure 70. Summary of stock status estimates using different models and runs.

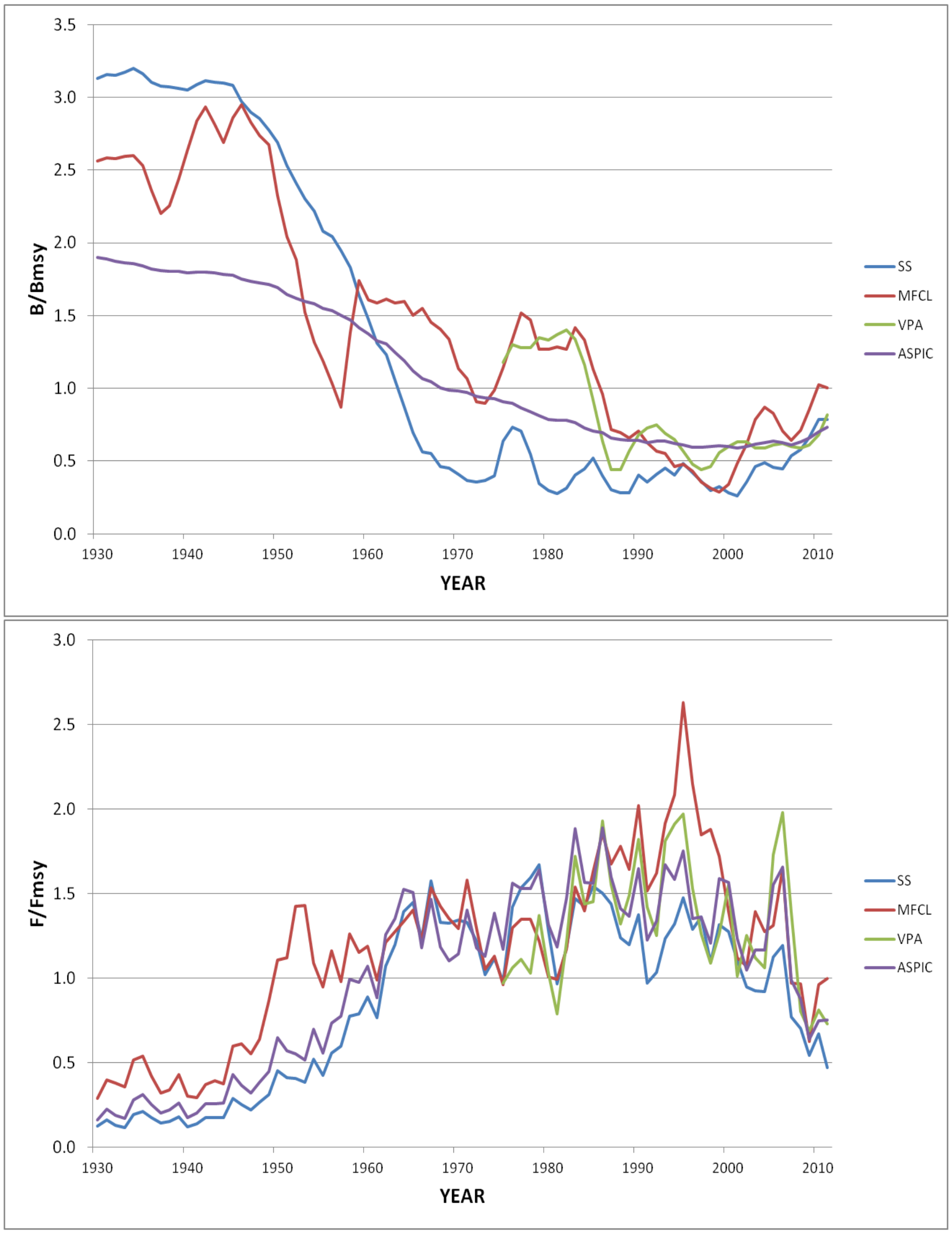


Figure 71. Comparison SSB/SSB_{MSY} (top) and F/F_{MSY} (bottom) of the base case models from the four modeling platforms. In the case of ASPIC, run 5 is represented, which includes all CPUE series.

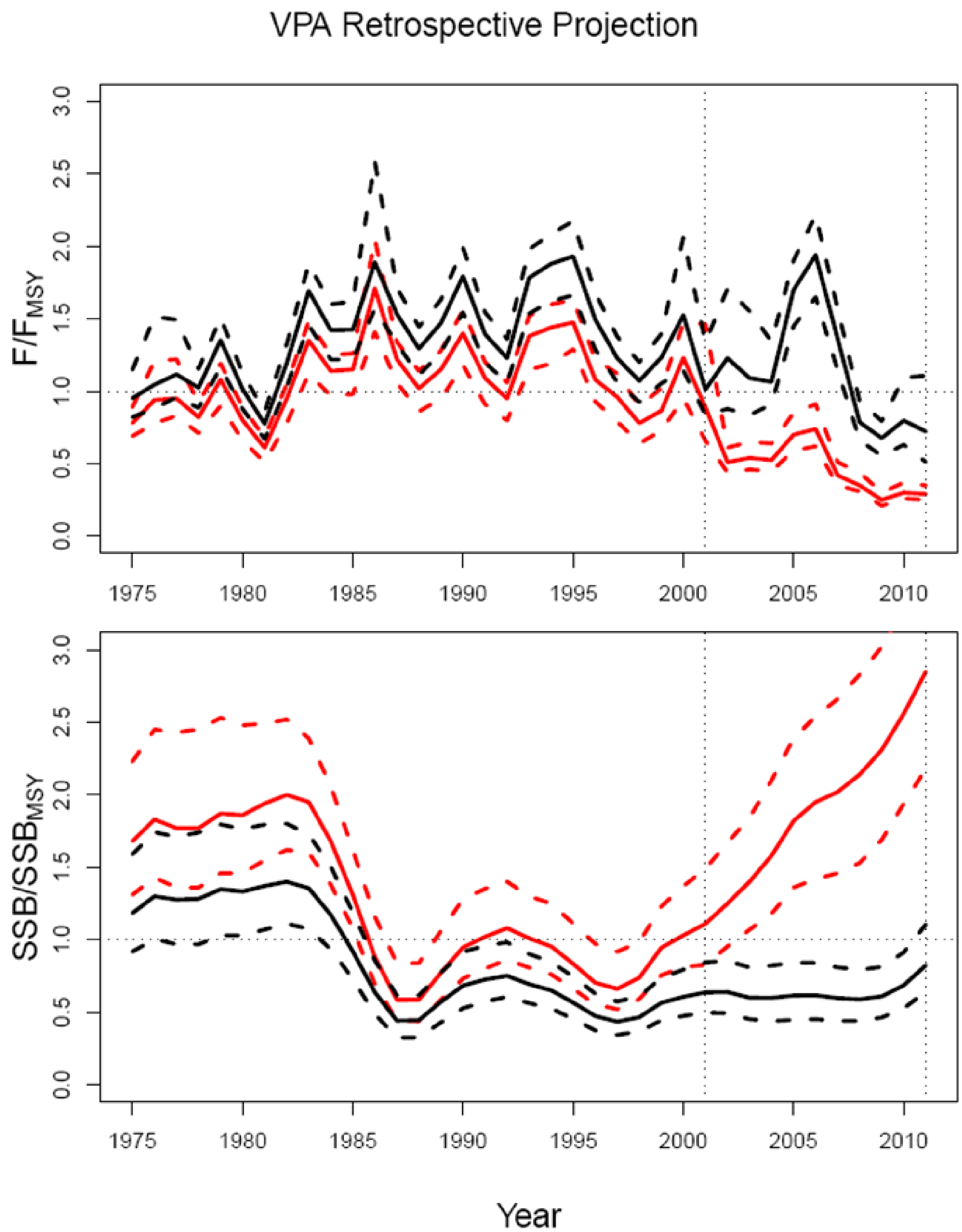


Figure 72. Retrospective projection from VPA analysis.

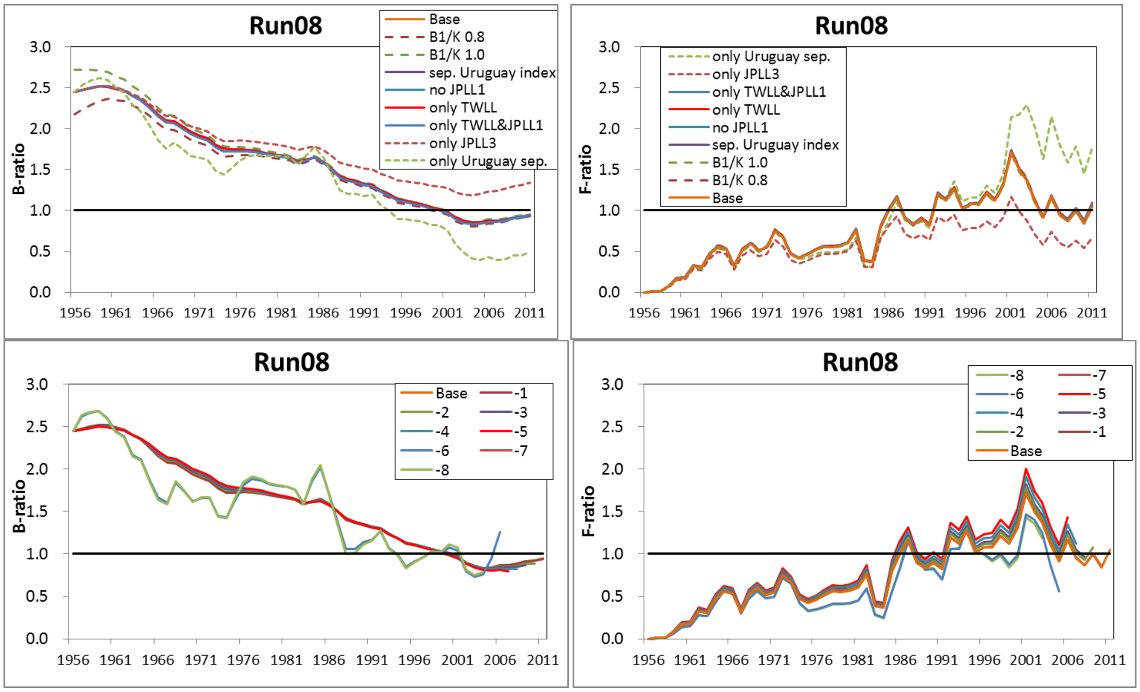


Figure 73. Results of sensitivity and retrospective analyses for ASPIC Run08 for South Atlantic albacore.

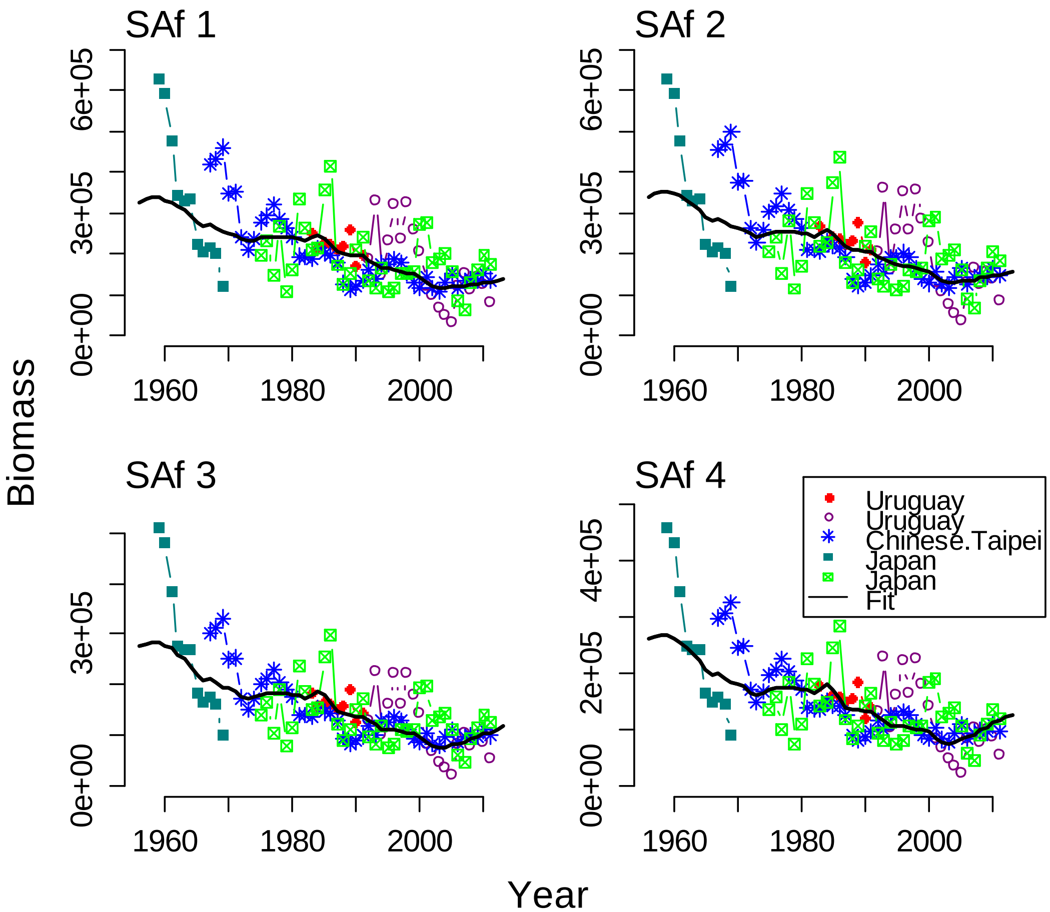


Figure 74. Fit of the BSP model to the four base case scenarios.

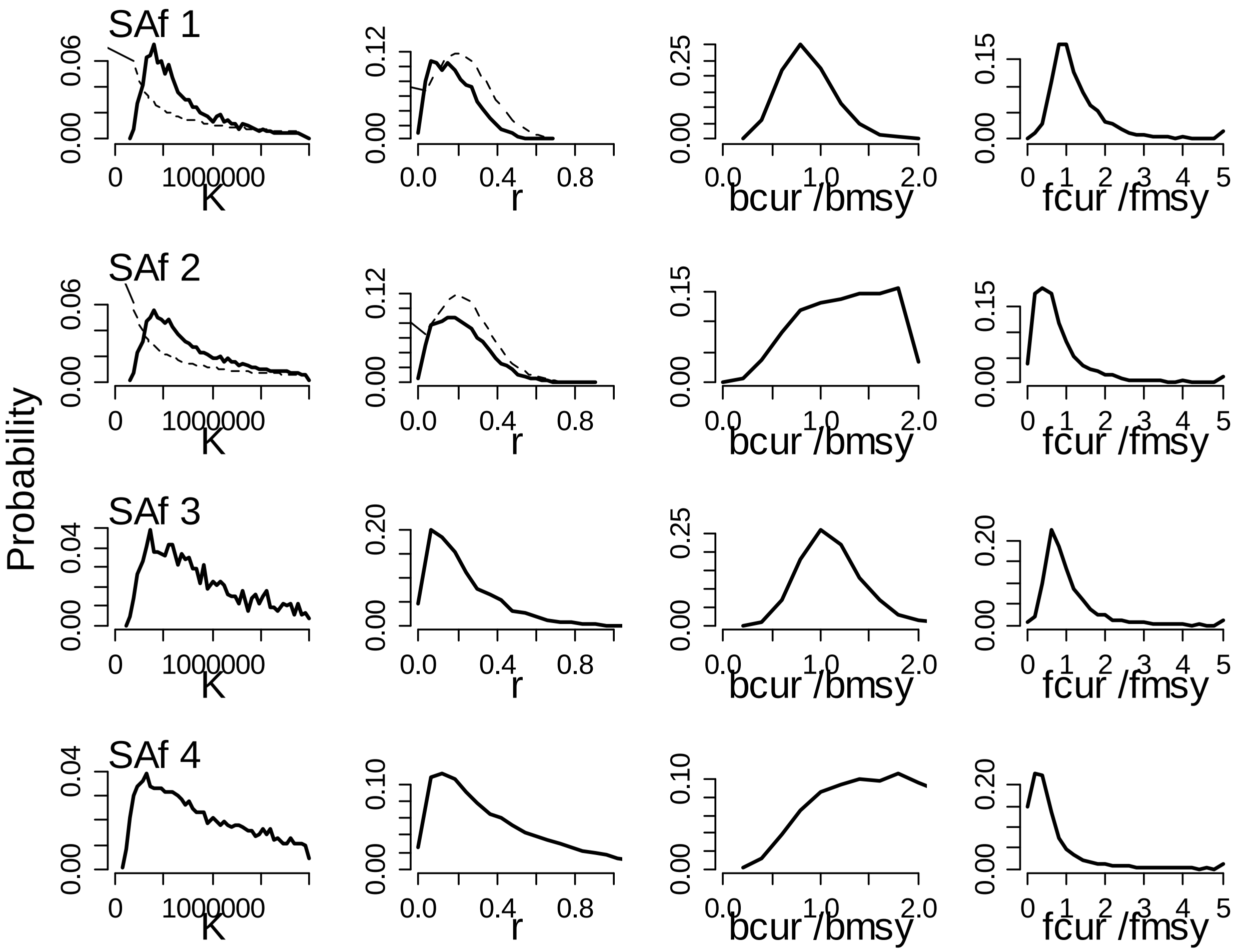


Figure 75. Posterior (solid) and prior (dashed) distributions from the four base case BSP model runs for the South Atlantic.

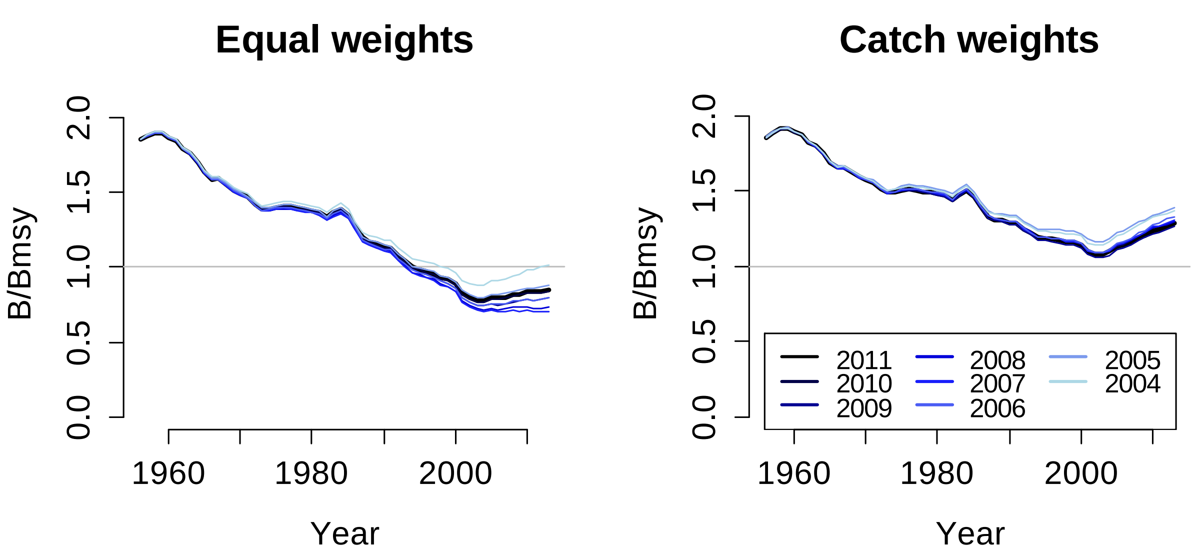


Figure 76. Retrospective analysis, with projection after the last year of data using real catches, for the Schaeffer model (run F1 left, F2, right) of BSP for South Atlantic albacore.

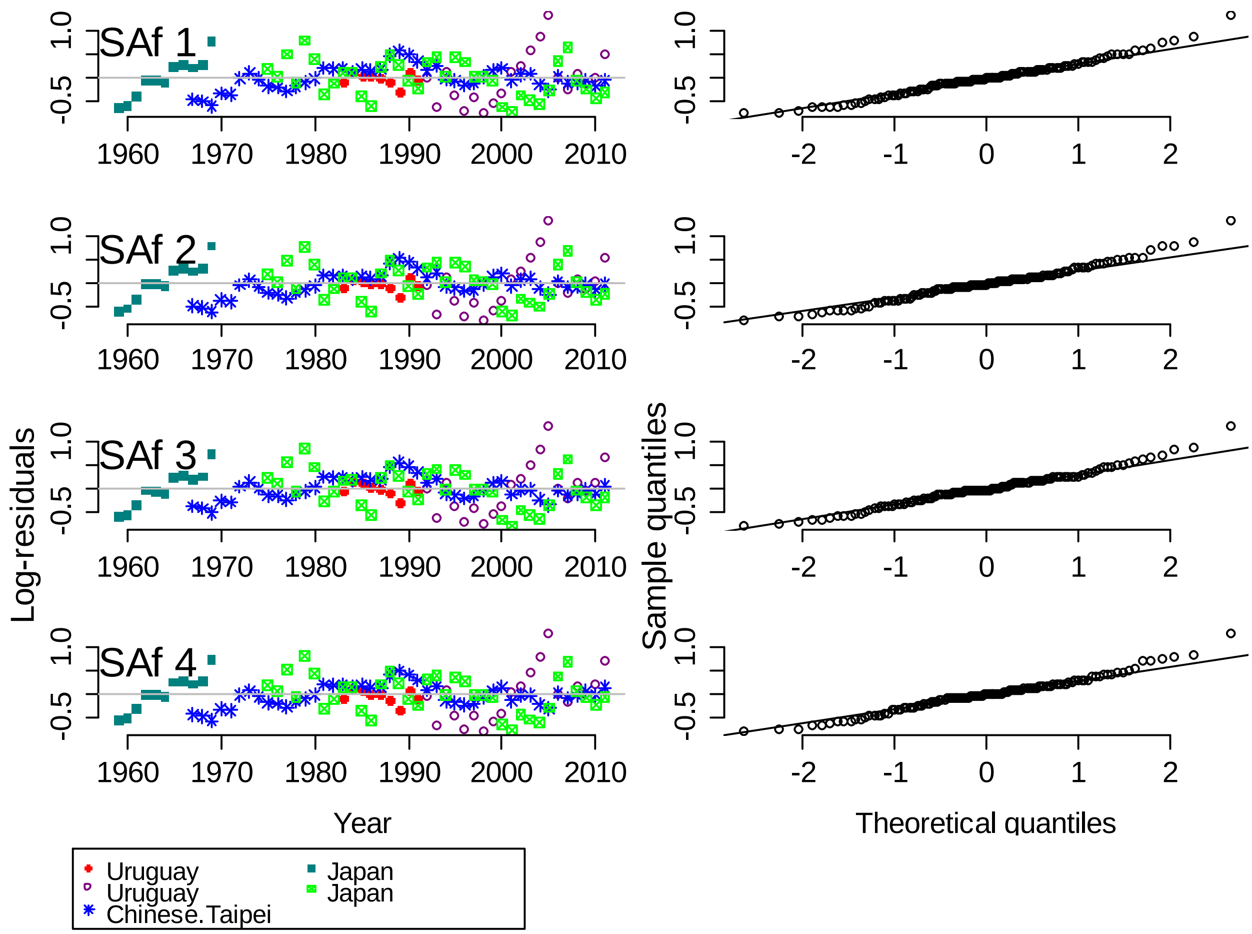


Figure 77. CPUE residuals (left) and residual qq-normal plots (right) for the four BSP base case runs for the South Atlantic.

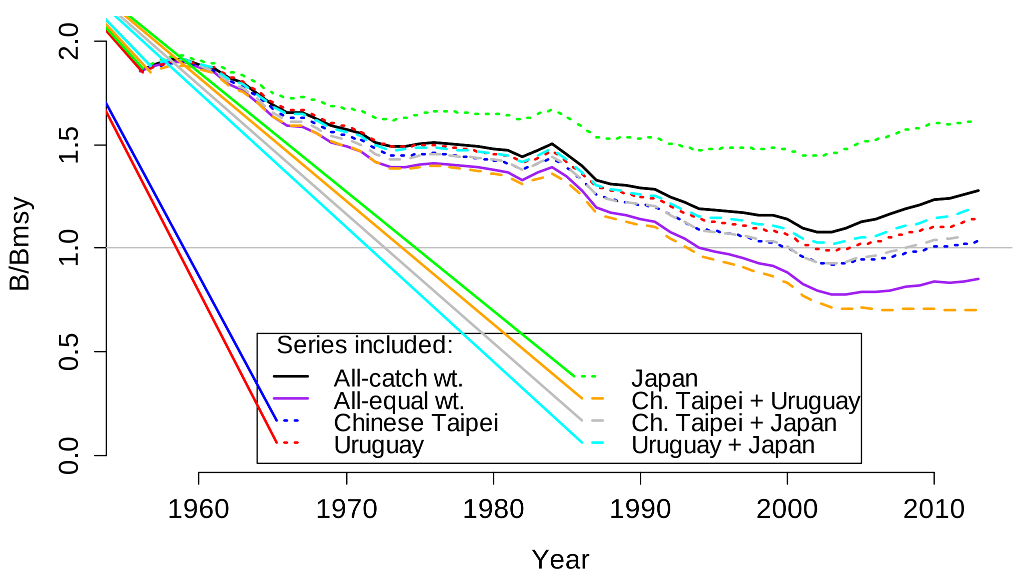


Figure 78. BSP South Atlantic sensitivity analyses removing some CPUE series, compared to the base cases with equal or catch weighting. The Schaeffer functional form was used in all cases.

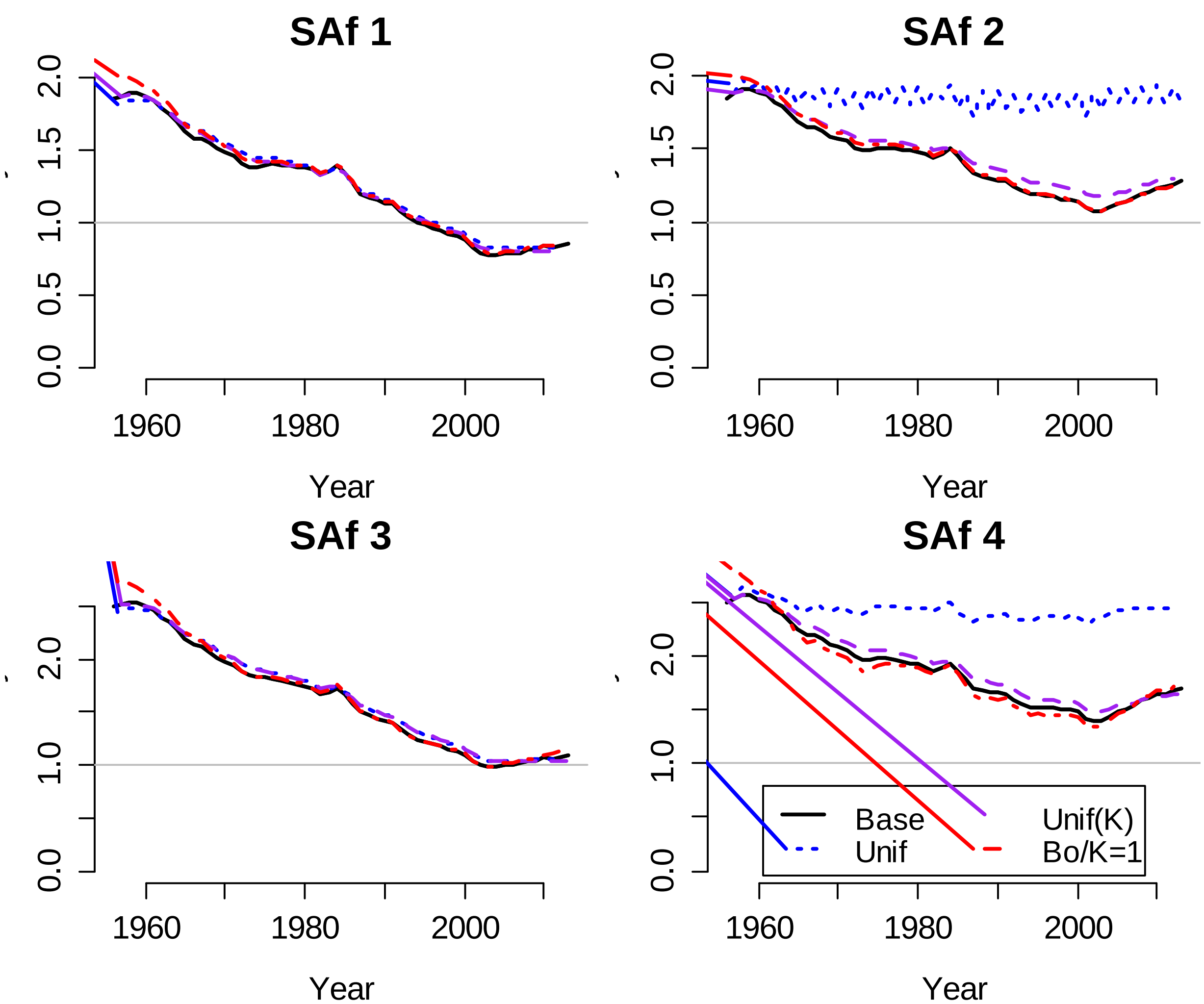
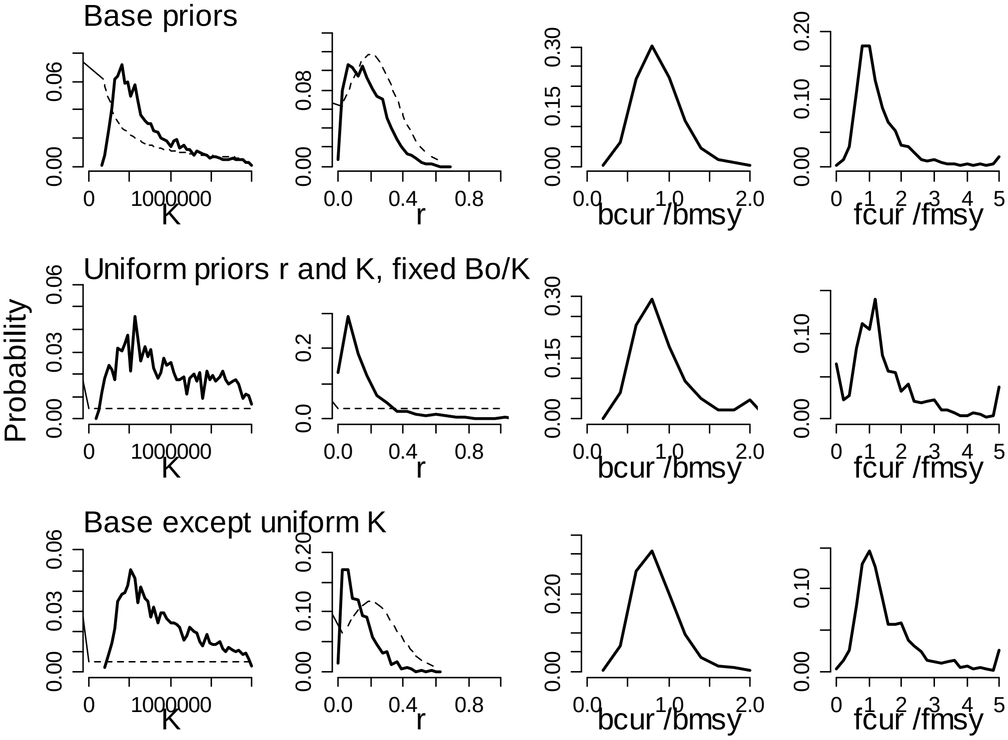


Figure 79. Median biomass trajectories for the BSP South Atlantic model runs with alternative priors. “Base” is the base case. “Unif” is uniform priors on r and K, and Bo/K fixed at 0.9, similar to the ASPIC runs. “Unif(K)” has uniform prior on K.

(a) Run F1 (Schaeffer model, equal weighting)



(b) Run F2 (Schaeffer model, catch weighting)

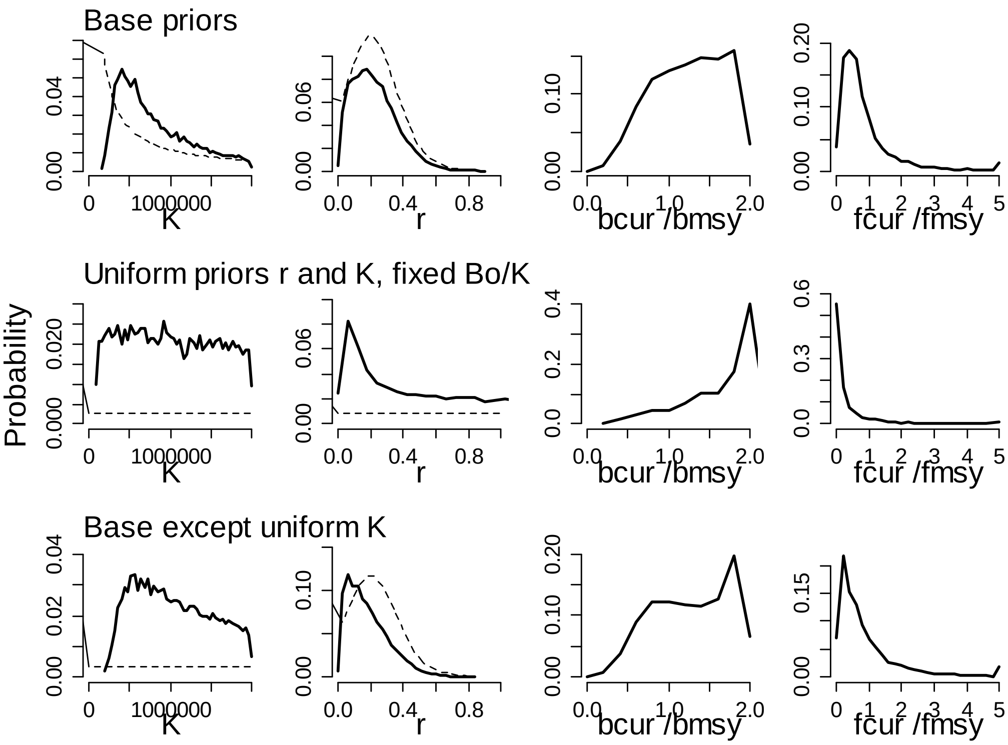


Figure 80. Priors and marginal posteriors for r and K for alternative prior formulations, and current B/B_{MSY} and F/F_{MSY} for runs with alterative priors.

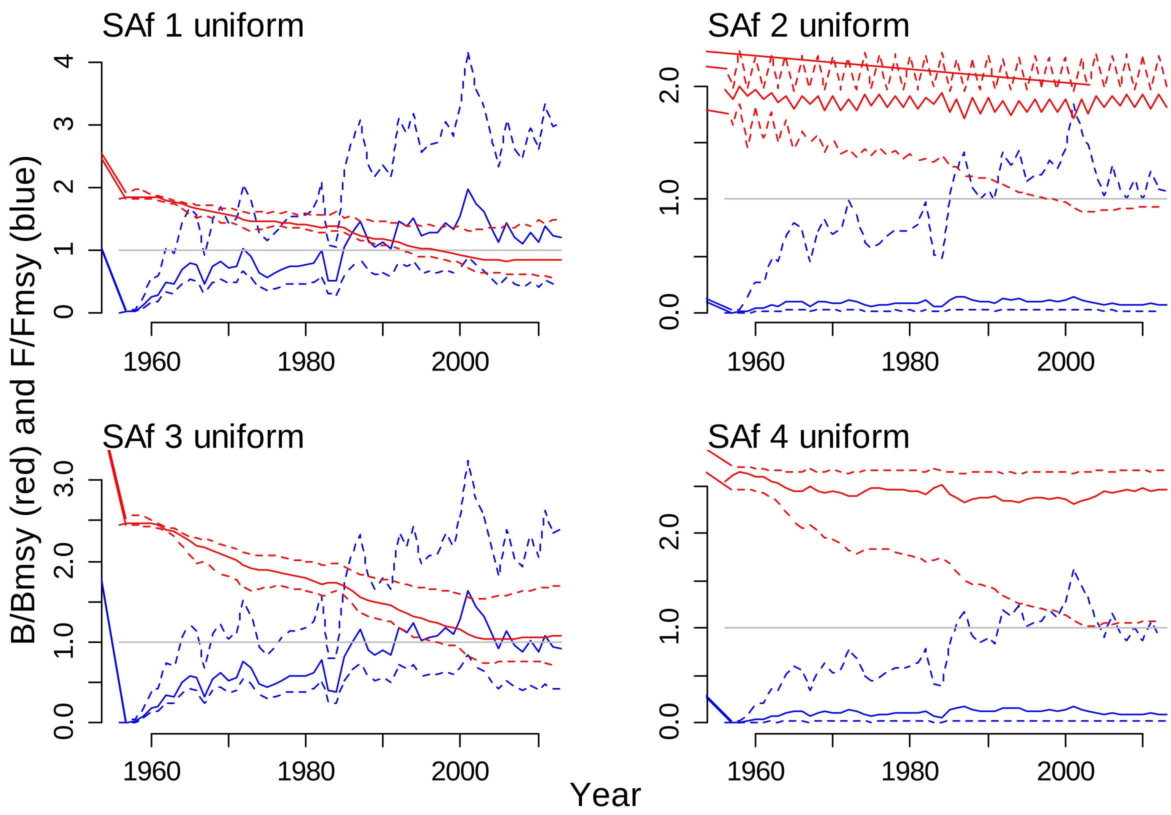


Figure 81. Median trajectories with 80% credible intervals, from the four alternative prior cases of the BSP model with uniform priors on r and K, and Bo/K fixed at 0.9 for South Atlantic albacore.

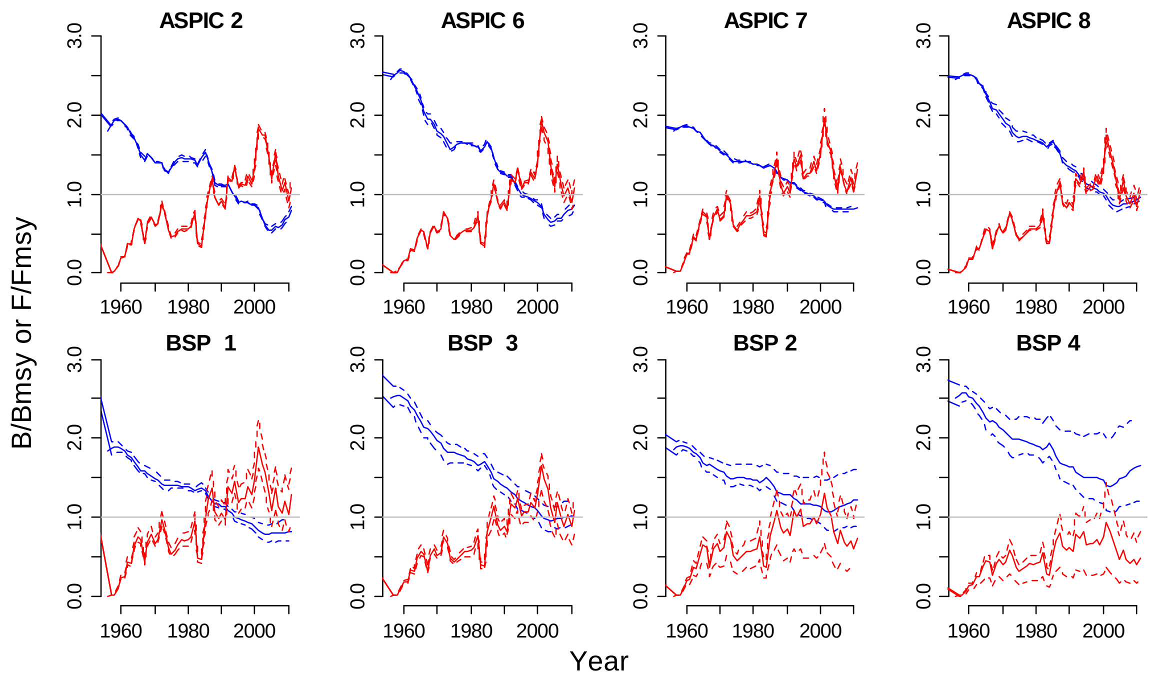


Figure 82. Biomas and fishing mortality rate trajectories for South Atlantic albacore.

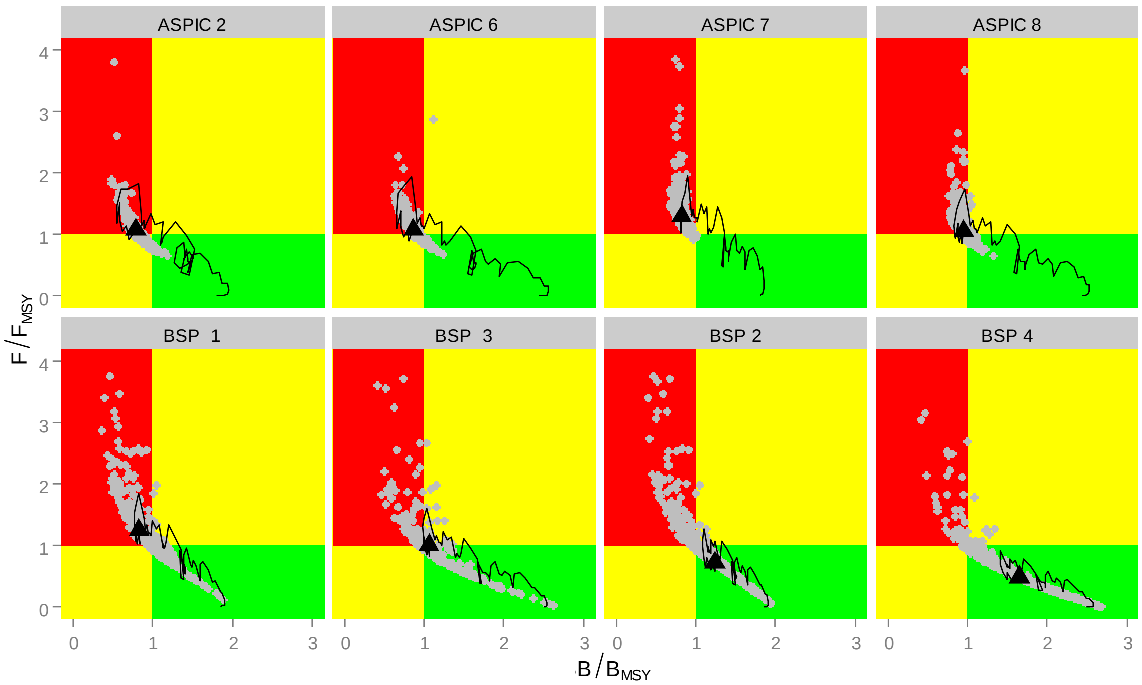


Figure 83. Kobe phase plots for South Atlantic albacore. End year is 2011 (black triangle).

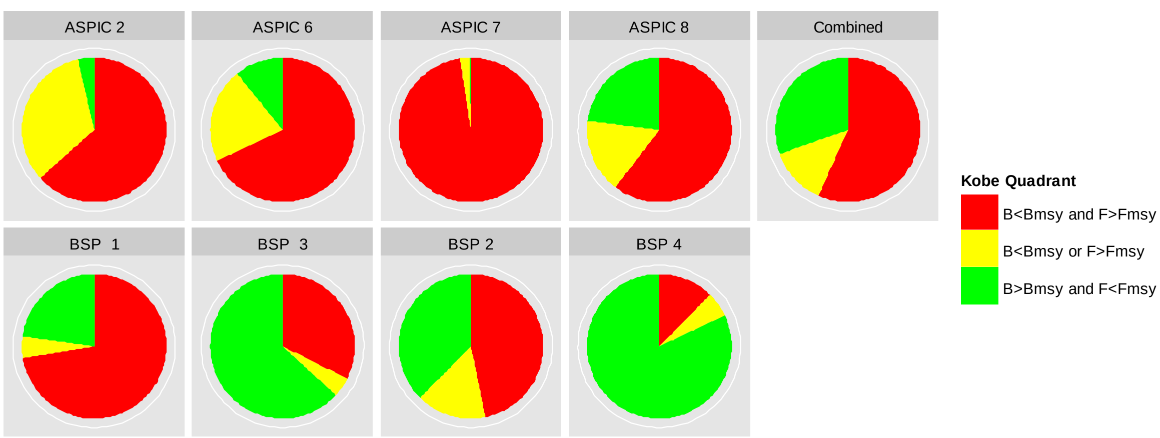


Figure 84. Kobe pie charts of status in 2011, for all eight models separately, and for all models combined for South Atlantic albacore.

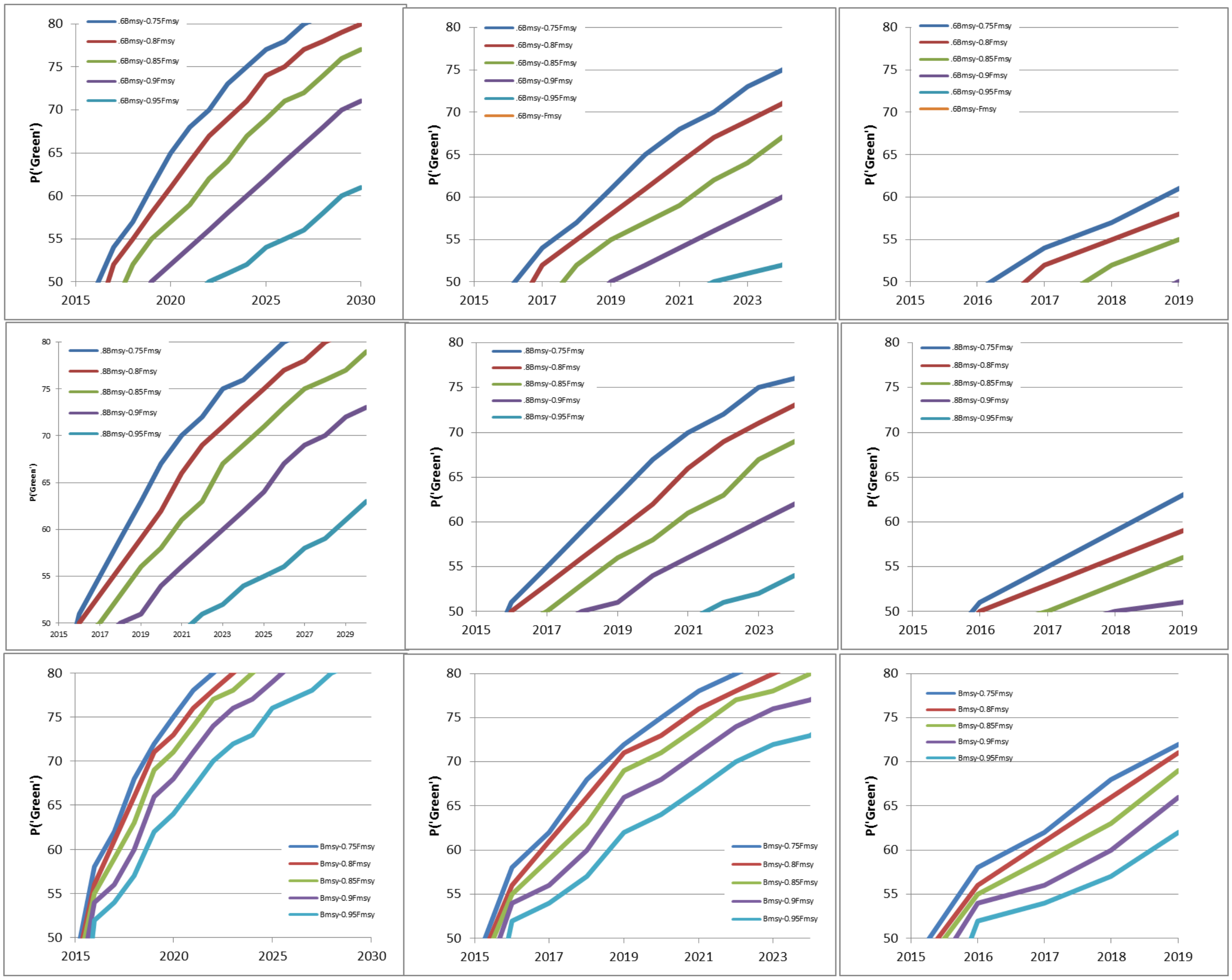


Figure 85. Projected probability of being 'Green' within different time scales for various combinations of HCR parameters, as indicated. The left column represents a 20 year time frame (1 mean Generation + 10 years – a value sometimes used for heavily depleted stocks). The center column, a 9 year time-frame (1 mean generation), and the rightmost column, a 5 year time-frame. The rows represent Bthresh levels (0.6 B_{MSY}, 0.8 B_{MSY} and B_{MSY} for top, middle and bottom raws, respectively).

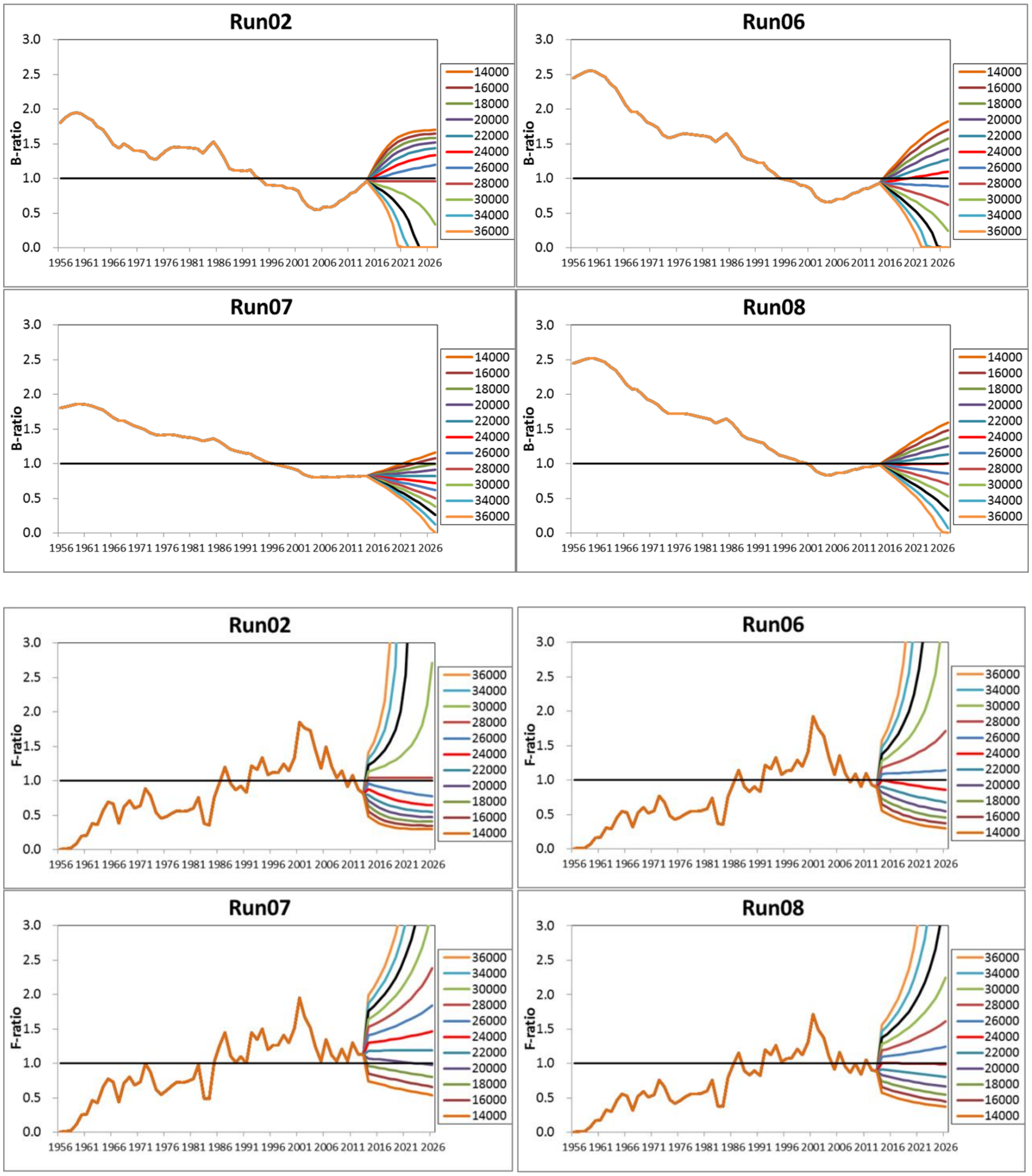


Figure 86. Future projection (15 years) of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) for 4 ASPIC runs for South Atlantic albacore under constant catch.

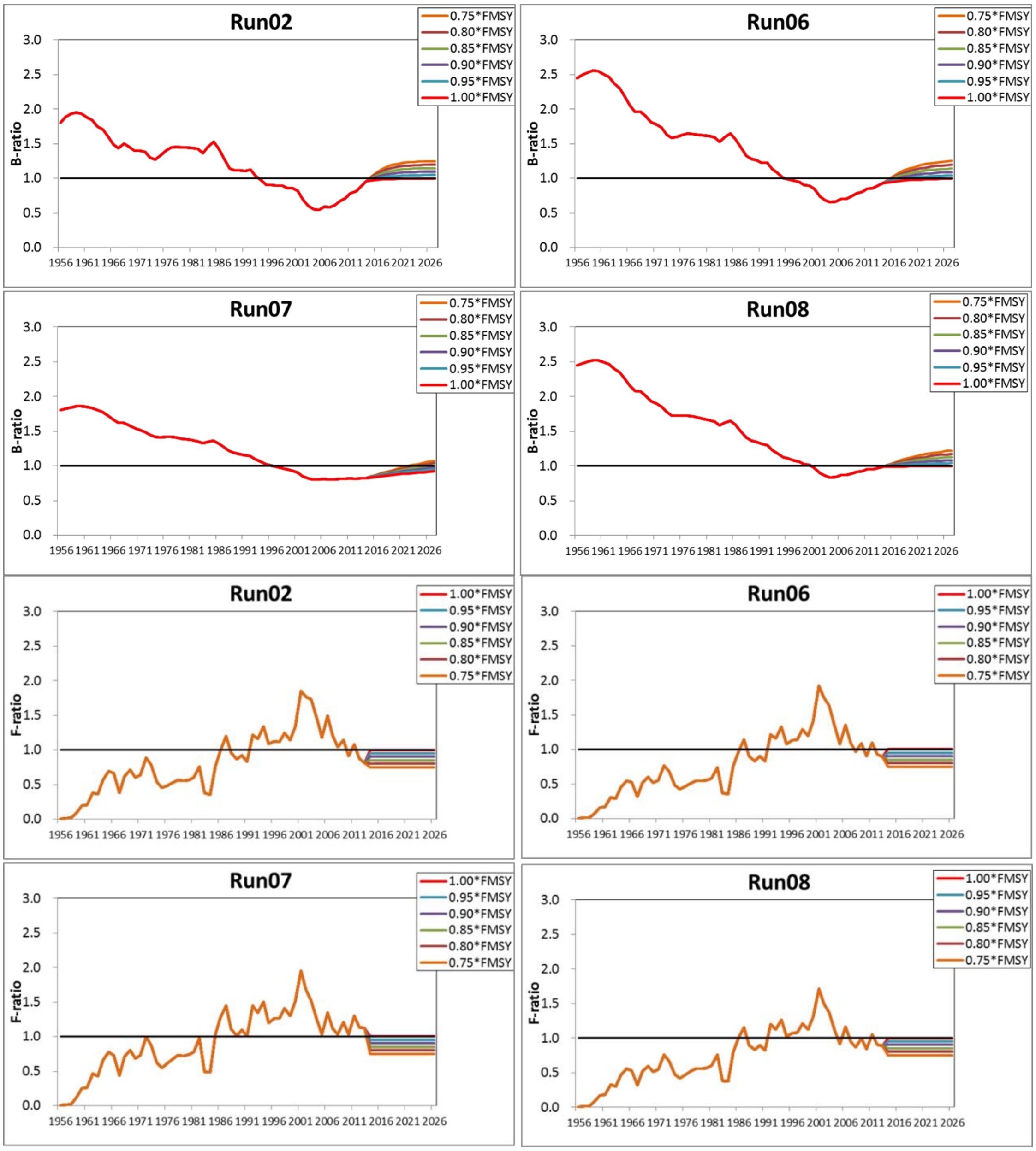


Figure 87. Future projection (15 years) of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) for 4 ASPIC runs for south Atlantic albacore under constant F.

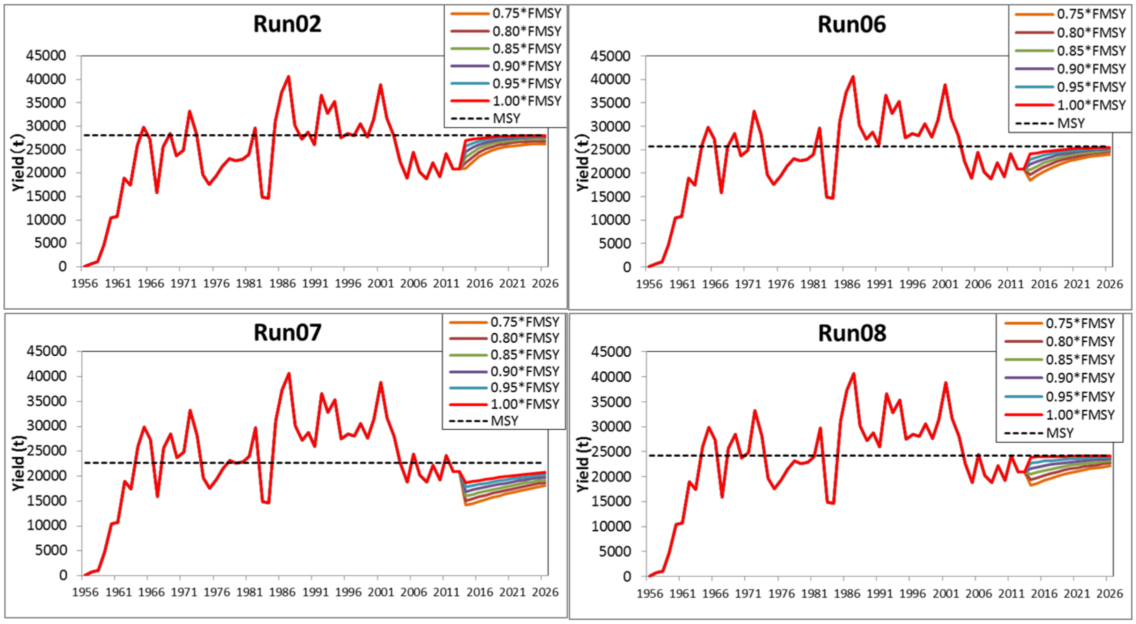


Figure 88. Predicted yield for future projection (15 years) for 4 ASPIC runs for South Atlantic albacore under constant F.

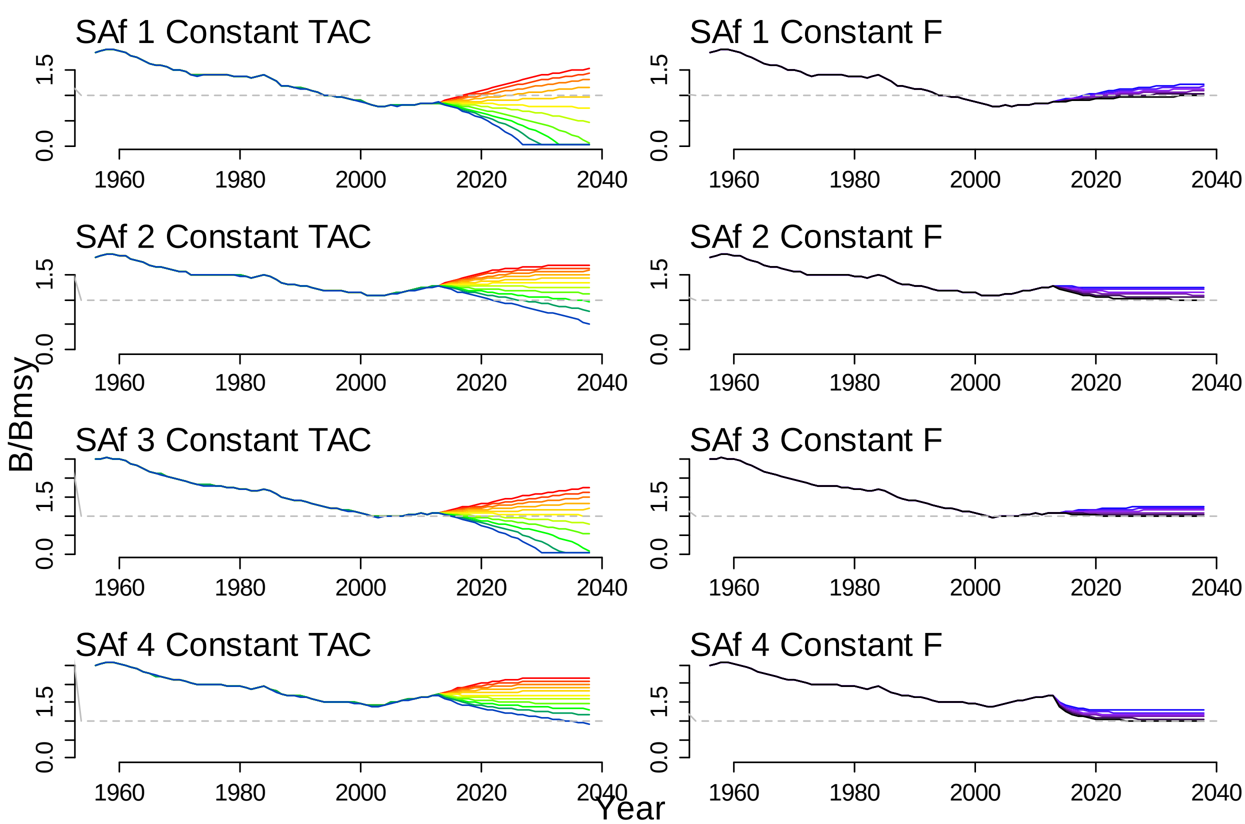


Figure 89. Median projections with the four base case BSP runs for South Atlantic albacore, with either a constant catch or a constant F harvest policy.

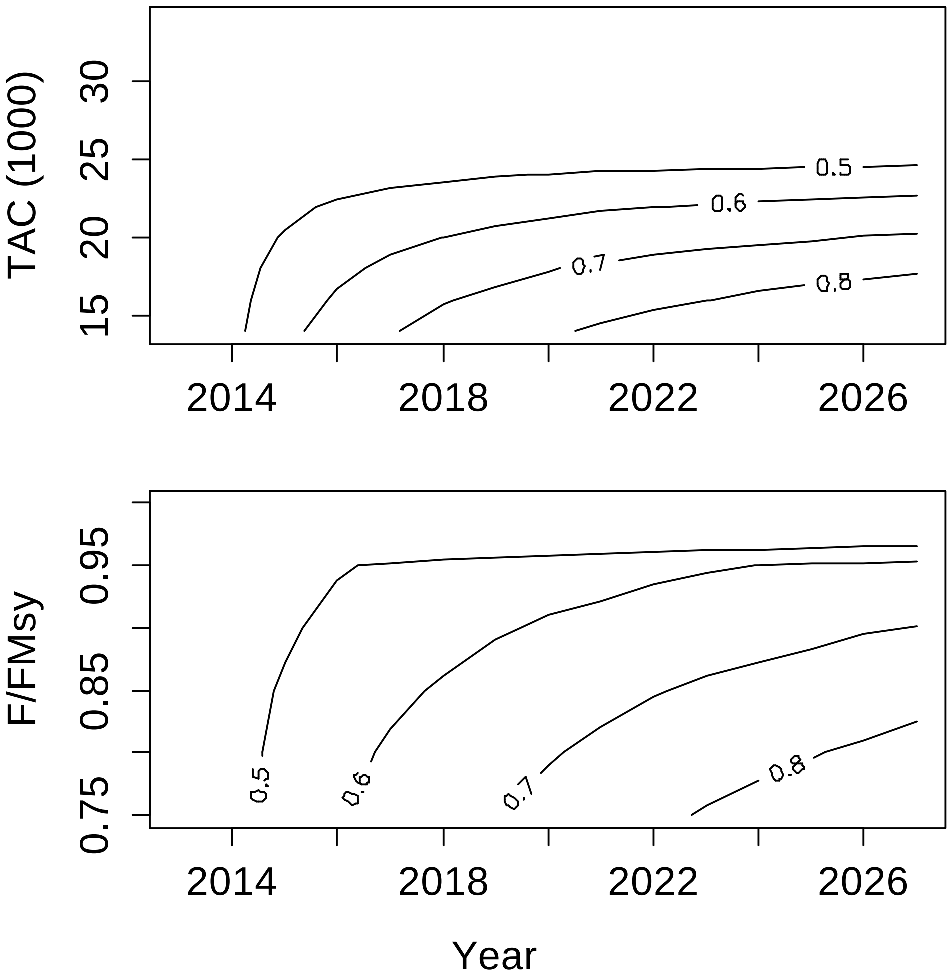


Figure 90. Probability of being green ($B>B_{MSY}$ and $F<F_{MSY}$), for the 8 scenarios combined in the South Atlantic.

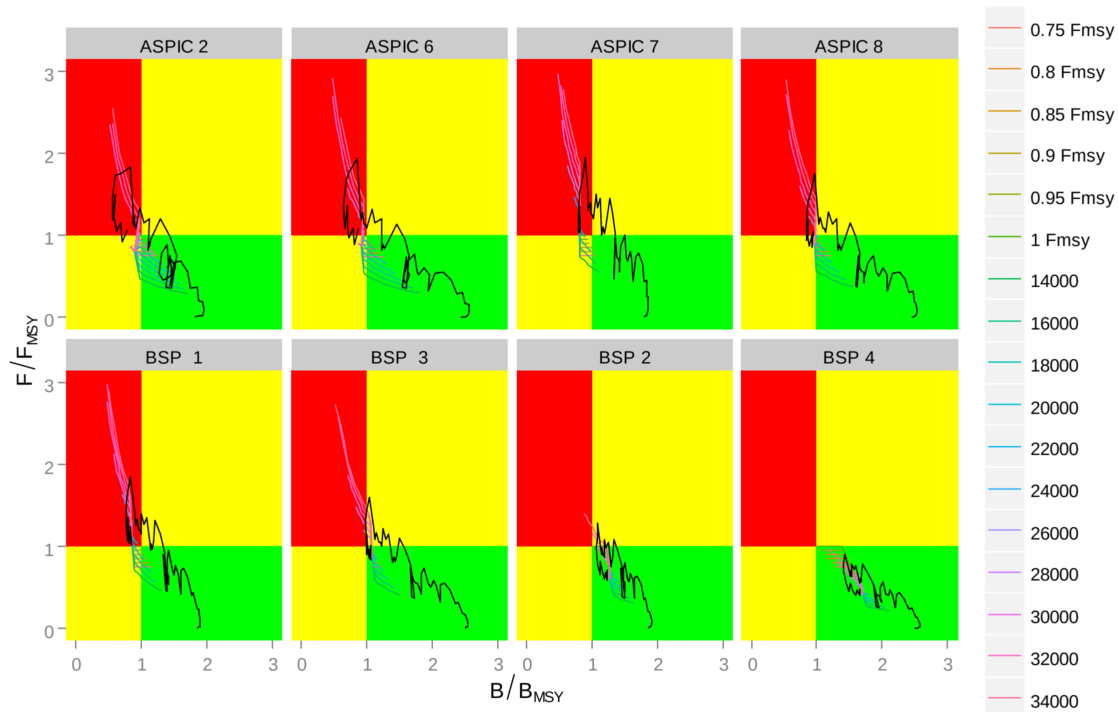


Figure 91. Kobe projections for the South Atlantic for the ASPIC and BSP models.

Appendix 1

AGENDA

1. Opening, adoption of the Agenda and meeting arrangements.
2. Summary of available data for assessment
   - 2.1 Biology
   - 2.2 Catch, effort, size and CAA estimates
   - 2.3 Relative abundance estimates
3. Limit and Target Reference Points and Kobe Advice Framework
4. Stock Assessment Methods, Diagnostics and Stock Status
   - 4.1 North
     - 4.1.1 SEAPODYM
     - 4.1.2 Multifan-CL
     - 4.1.3 ASPIC
     - 4.1.4 Stock Synthesis
     - 4.1.5 VPA
     - 4.1.6 Summary of stock status
   - 4.2 South
     - 4.2.1 ASPIC
     - 4.2.2 BSP
     - 4.2.3 Summary of stock status
5. Projections
   - 5.1 North
   - 5.2 South
6. Recommendations
   - 6.1 Research and Statistics
   - 6.2 Management
7. Other matters
8. Adoption of the report and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2013/103	Aspectos reproductivos del Albacora en el Atlántico sud Occidental. Domingo A., Bessonart M. and Forselledo R.
SCRS/2013/113	Influence of oceano-meteorological conditions on the behaviour, distribution and abundance of the northeast Atlantic albacore. Goikoetxea N. et al.
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