REPORT OF THE 2016 SAILFISH STOCK ASSESSMENT

(Miami, USA – 30 May to 3 June 2016)

1. Opening, adoption of Agenda and meeting arrangements

The Meeting was held at the Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, USA from 30 May - 3 June 2016. Local arrangements were made by Dr. David Die with financial support of NOAA through the Cooperative Institute of Marine and Atmospheric Studies (CIMAS). Dr. Paul de Bruyn, on behalf of the ICCAT Executive Secretary, thanked the University of Miami for hosting the meeting and providing all logistical arrangements.

Dr. Freddy Arocha, the Billfish Species Group Rapporteur, chaired the meeting. Dr. Arocha welcomed the meeting participants (hereinafter “the Group”) and proceeded to review the Agenda which was adopted with minor changes (**Appendix 1**).

The List of Participants is included as **Appendix 2**. The List of documents presented at the meeting is attached as **Appendix 3.**

The following participants served as Rapporteurs for various sections of the report:

Section	*Rapporteurs*
1	P. de Bruyn
2	J. Hoolihan, P. de Bruyn, G. Diaz, H. Perryman
3	M. Schirripa, R. Sharma, M. Lauretta, M. Fitchett, E. Babcock, B. Mourato
4	R. Sharma, C. Brown
5	F. Forrestal, J. Costa, F. Arocha
6	M. Perez Moreno, F. Arocha
7	P. de Bruyn

2. Summary of available data for assessment

2.1 Biology

2.1.1 Genetics

SCRS/2016/P/025 described preliminary results of a study investigating genetic differentiation among groups of Atlantic sailfish. Mitochondrial DNA was compared using a 645 base pair sequence from the control region. So far, analyses have been undertaken on samples from the western North Atlantic (Florida), Senegal, and Brazil (**Figure 1**). An AMOVA comparison indicated a moderate to strong ($\Phi st = 0.1020$, $p = 0.011$) differentiation between northern and southern hemispheres, and moderate differentiation ($\Phi st = 0.0783$, $P = 0.010$) between eastern and western Atlantic samples. In pairwise comparisons, the largest population differentiation was observed between the western North Atlantic (Florida) and African (Senegal) groups, and the smallest differentiation between the Brazil and African (Senegal) groups (**Table 1**). Preliminary results suggest genetic stock structure between both the eastern and western Atlantic, and northern and southern hemispheres. Further work is needed to elucidate and confirm the presence of stock structure. Additional collection and analyses of samples from Côte d’Ivoire, EU-Portugal, E-U-Spain, d Uruguay and Venezuela, are anticipated.

2.1.2 Distribution

SCRS/2016/099 used general additive models (GAMs) to predict the spatial distribution of sailfish across the Gulf of Mexico (GOM) using data from the U.S. PLL Observer Program (2005-2010).

A delta approach fitting a Bernoulli GAM with binomial data, and a Gamma GAM with zero-truncated catch rate data (fish/100 hooks) was used. Model factors included year, season, day/night, sea bottom depth, altimetry, sea surface temperature, and minimum distance from a front. Results indicated that both the probability of catching a sailfish and the CPUE are most influenced by sea bottom depth and sea surface temperature. Seasonal distribution profiles were developed across the GOM by predicting across grids of NCEI and AVISO environmental data (**Figure 2**). Profiles indicated a seasonal flux, with increased sailfish CPUE between April and September, and higher catch rates associated to fronts.

2.1.3 Age, Growth, Natural Mortality and Maturity at size

The Group reviewed and compared growth parameters based on relevant information compiled from sailfish age and growth studies conducted in the Atlantic and Pacific Oceans. Discussion and comparison of growth curve estimates (**Table 2**, **Figure 3**) resulted in the Group's conclusion that the growth trajectory estimated by Cerdenares-Ladrón *et al.* (2011) was the most plausible, and agreement to use the following growth parameters in the exploratory assessment model runs: Linf = 206.83; K = 0.36; T0 = -0.24.;

The Group discussed the estimate of M. It was noted that appropriate methods to estimate M based on tag-recapture and maximum age were those described in Hoenig (1983) and in Then *et al.* (2015). Considering that the estimates of M were high, the Group considered applying the estimate of M obtained using the method by Hoenig (1983) and to be consistent with prior billfish stock assessments (BUM). Therefore, an estimate of M = 0.35 (based on Hoenig equation from 1983) and a mean maximum age of 12 years was selected based on information available from age and growth, and tagging information reviewed during the meeting.

It was noted to the Group that a new estimate of maturity at size was presented and discussed in the 2014 Intersessional meeting of the 2014 Billfish Species Group held in Mexico (Anon. 2015), and during the 2015 SCRS Species Groups meeting (Anon. 2016), which resulted in an new L50 estimate of 142.12 cm LJFL (@ 3 years) by the combination of Brazilian and Venezuelan reproductive samples to produce the new L50 estimate for west sailfish.

2.2 Catch, effort, and size

The Task I nominal catch (T1NC) statistics of sailfish by stock, flag and gear, are presented in **Table 3** and by stock in **Figure 4**. The Secretariat informed the Group that updates were made to the historical catch series for Venezuela (Longline artisanal).

The Group noted that for two key fisheries, data was either absent (Grenada) or the reported catches were extremely low (Mixed flags (FR+ES)) in recent years. In the case of Grenada, the Group decided that for the assessment, an average of the catch reported between 2007 and 2009 (the final three years of reported data from that CPC) would be carried over for the years 2010 to 2014 (191t per year). For the Mixed flags fleet, estimates of the eastern stock of sailfish caught as by-catch in the EU tropical tuna purse seine fleet were made by the Group using the stratified ratio estimator method and the EU Purse Seine observer database. The observed sailfish by-catch were linearly related to the observed tuna catch in both FAD and free sets. Observed sets and the tropical tuna catch from the Task II database were stratified by year and fishing mode. By-catch ratio estimators for sailfish were calculated using the mean observed sailfish by-catch in each stratum divided by the mean observed tuna catch for each stratum. This ratio estimator was then applied to the total reported tuna catch for each stratum, yielding total estimates of sailfish by-catch. The results from this analysis are presented in **Tables 4a and b** for FAD and free school catches, respectively. The Group noted that this analysis indicates that the catches reported in the Task I data are almost certainly lower than the true catches. As such, the Group decided for assessment purposes to use the average of the catches reported between 2008 and 2010 as a carry over for the years 2011 to 2014 (275 t per year).

The Group noted the strong decline in total reported sailfish catches since 2010. Although it was not clear how accurate total captures were prior to this period, several potential factors may have resulted in decreased reporting in recent years. For example, these reduced captures could potentially be a product of management actions or changes in fishing operations (such as switches in targeting for many commercial longline vessels). With regards to management, there may have been some reduction in sailfish captures due to the Billfish rebuilding plan which was enacted in 2005. It was noted that this plan was only focused on marlin species but there was speculation that this may have had an effect on sailfish catches as well. Related to this management action, the Group noted that live release information is not provided and, thus, if management has discouraged retaining any billfish catches, these potential releases have not been recorded. Very few fleets report any dead discard information for sailfish and this makes the quantification of these potential captures impossible. The Group considered the possibility that the recent decline of catches could be a result of increased, but unrecorded live releases and dead discards. Overall, the Group expressed its concern that high uncertainty still remains with respect to total removals.

During the 2009 Sailfish Stock Assessment Session (Anon. 2010), it was reported that the catch and effort data from Ghana used in the standardization of CPUE for the gillnet fishery had very different patterns in the relationships between CPUE, trips and number of canoes when you compared data prior or after 1992. Such differences led the Group in 2009 to exclude the Ghana CPUE data prior to 1992. Such pattern was also seen again when the data were standardized in preparation for the current assessment (SCRS/P/2016/027). Furthermore, catch levels prior and after 1990 are very different and prior to 1992 the species composition of billfish landings reported by Ghana is very different to that prior to 1989. The Group concluded that catches of sailfish for Ghana between 1956 and 1989 may have been incorrectly estimated.

To test the sensitivity of assessment results to the estimates of sailfish catch from Ghana, an alternative catch series of sailfish catches for Ghana for the period 1957-1989 was developed during the meeting (**Appendix 4**).

The data catalogues for sailfish regarding Task II catch and effort (T2CE) and Task II size information (T2SZ), were presented to the Group for the Atlantic West and East stocks. This information is presented in **Tables 5a** and **5b** respectively. The Group noted that many gaps exist in these datasets which limits the ability of the Group to use integrated stock assessment models. The Group noted, however, that much data regarding size information exists (especially for Venezuela) from the Enhanced Program for Billfish Research and the JDMIP (Arocha *et al.* 2016) and this data is being compiled for inclusion in the ICCAT database even though it is not official Task II data submitted by the CPC. In addition, the Task II CE data is not often used in sailfish stock assessments as CPCs usually provide standardised CPUE indices using more comprehensive data than is available in the Task II dataset.

The sailfish conventional tagging data available in the ICCAT database is presented in **Table 6**. There are a total of 115,743 sailfish individuals released between 1950 and 2011. The total number of individuals recovered is 2,020, which represents on average a recovery ratio of about 1.7%. The apparent movement (straight displacements between release and recovery positions) shown in **Figure 5** (complemented by the release and recovery density maps of **Figure 6**) indicates that the largest amount of the sailfish tagging took place in the western Atlantic. The Group acknowledged the important work (national scientists and the Secretariat) behind the ICCAT tagging database on sailfish and noted the large number of individuals that had been tagged. The Group recommended in the future exploring methodologies to include this important information into the stock assessments framework.

2.3 Relative Indices of Abundance

The following documents with indices of abundance for the western stock were presented to the Group during the meeting:

Document SCRS/2016/075 indicated that catches of sailfish (*Istiophorus albicans*), white marlin (*Tetrapturus albidus*) and blue marlin (*Makaira nigricans*) and effort data were available from the recreational rod and reel fishery based at the Playa Grande Yacht Club, Central Venezuela, from 1961 to 2001. Data were also available from an artisanal drift-gillnet fishery in the same area from 1991 to 2014. Each dataset was standardized independently using a generalized linear mixed model (GLMM). The two datasets were also combined in a GLMM analysis that included the year, season, fishery and some two-way interactions as potential explanatory variables. The combined analysis produced a CPUE index of abundance that runs from 1961 to 2014. The index shows a decline followed by a period of stability for both sailfish and white marlin.

The Group inquired if trips with no catches were included in the analysis. It was indicated that the data for both gears (recreational rod and reel and gillnet) corresponded to monthly summaries and that nearly all the monthly summaries have positive catches. It was also discussed that since both fisheries are conducted in an area considered to be a ‘hot spot’, the possibility of trip with no sailfish catch was extremely low. The Group noticed that some of the model diagnostics showed some deviance from the assumptions. It was discussed that adding a constant value to the model might have created the pattern seen in the residuals. Following the advice from the authors, the Group agreed to use the individual indices instead of the combined index, as it was initially suggested in Babcock and Arocha, 2015.

Document SCRS/2016/093 presented an index of abundance for sailfish from the United States recreational billfish tournament fishery for the period 1972-2014 and for non-tournament recreational fisheries for the period 1981-2014. Tournament catch-per-unit-effort (number of fish caught per 100 hours fishing) was estimated from catch and effort data submitted by recreational tournament coordinators and U.S. National Marine Fisheries Service observers under the Recreational Billfish Survey program. A selection process was applied to restrict the data to tournaments that primarily target sailfish, using live bait only, along the Florida East coast. Non-tournament recreational data was compiled from the Marine Recreational Fisheries Statistical Survey (MRFSS). The catch per unit effort standardization procedure included the variables year, area, and season. Standardized indices were estimated using Generalized Linear Mixed Models under a Delta lognormal model approach.

The authors explained that the data from MRFSS covered a larger area (the data included covered from the State of North Carolina through Texas) than the tournament data, and therefore it was used to see if there was any indication of the stock moving or expanding further north as it has been hypothesized for North Atlantic swordfish. However, the authors indicated that there was no evidence of this being the case. The Group discussed the difficulties in identifying the target species in the MRFSS data, which could affect the number of trips with zero catches included in the analysis. It was also noted by the Group that the model diagnostics for the MRFSS index showed strong evidence that the assumption of normality was violated. Therefore, the Group supported the decision made in the 2009 Sailfish Stock Assessment Session (Anon. 2010) of not including the MRFSS index in the 2016 Sailfish Stock Assessment and only including the tournament index.

Document SCRS/2016/092 catch and effort data from 73,810 sets done by the Brazilian tuna longline fleet, including both national and chartered vessels, in the equatorial and southwestern Atlantic Ocean, from 1978 to 2012, were analyzed. The fished area was distributed along a wide area of the equatorial and South Atlantic Ocean, ranging from 3º W to 52º W of longitude, and from 11º N to 40º S of latitude. The CPUE of the sailfish was standardized by a Generalized Linear Mixed Model (GLMM) using a Delta Lognormal approach. The factors used in the model were: year, fishing strategy, quarter, area, sea surface temperature, and the interactions year:strategy, year:quarter and year:area. The standardized CPUE series of the sailfish showed a gradual decreasing trend, particularly after the year 2000.

The Group asked the author how was the SST data used in the standardization obtained and it was indicated that it was from satellite data. The Group also suggested that it is preferably to incorporate SST data into the models as a categorical variable (bins) instead of as a continuous variable because many species have a range of preferred temperatures and their response to temperature is not linear. As it was the cases with other species groups, the Group held an extensive discussion with regard to the methodology used to define the three fishing strategies (FS). The Group was concerned that the FS:Year interaction was significant which means that the catchability of those 3 FS changed with time. It was discussed that such effect might be masking true changes in stock abundance. As a potential fix, the Group suggested to estimate individual CPUEs for each FS, or to do so only for the FS with the highest mean CPUE. Alternatively, the Group also suggested to exclude the FS:Year interaction from the model. If the nominal and the standardized CPUEs are similar then keeping the interaction in the model should not raise much of a concern.

- The following documents with indices of abundance for the eastern stock were presented to the Group during the meeting:

Presentation SCRS/P/2016/026 introduced a standardized index of abundance for the artisanal fishery in Senegal for the period 1981-2015. The main gears in the fishery are troll, handline, and gillnet which incidentally catches sailfish. The catch and effort data used corresponded to monthly summaries of catch and effort (n=1076). The standardized index was estimated using a GLMM. The main factors tested in the model were year, area, month and gear. Two models were considered, one with only the main factors and a second one with the main factors and the interactions. Model selection was based on the AIC. The final model used to estimate the standardized index included the factors year, area, gear, and month and the interactions year:area, year:gear, area:gear, and gear:month. The estimated standardized index showed no discernible trend in the first 20 years of the time series and a declining trend after year 2000.

The Group noted that monthly aggregated data was used in the analysis and the data used in the model corresponded to the positive observations (N=1072 positive observations). The examination of the mean CPUE by factor showed a consistency among the results and what is known about the fishery. More specifically, troll gear has higher catches than seine gear (which targets sardines), and that highest catches occur during the upwelling months. The significant Year:Month interaction supports the anecdotal observation that the length of the period when sailfish are present in the area of the study has shortened. The Group noted that the estimated

CPUE for years 2013 and 2014 were significantly lower than the rest of the time series and the author indicated that was the result of new management regulations. Therefore, the Group requested that the index be re-estimated without including the last two years of data (2014-2015). A new estimated index without the last two years of data was provided by the author during the meeting.

Presentation SCRS/P/2016/027 introduced a standardized index of abundance for the Ghanaian drift gillnet artisanal fishery for the period 1974-2013. The data used corresponded to monthly summaries of catch and effort data. No data for years 1983 and 2010 were included as part of the time series. The standardization procedure used a GLM. The factors tested in the model were year, quarter, fishing season, number of canoes, and the interactions Year:Quarter and Year:Fishing Season. The factors included in the final model were year, quarter, and the interaction year:quarter. Although variable, highest CPUE values were observed in the late 80s and in the 90s. The index values for the last three years of the time series (2011-2013) were the lowest since 1991. The Group requested that a new split index for the periods 1974-1990 and 1991-2013 be estimated. Such indices were provided during the meeting.

Document SCRS/2016/098 analyzed the catch, effort, and standardized CPUE trends for the eastern stock of Atlantic sailfish (*Istiophorus albicans*) captured by the Portuguese pelagic longline fleet between 1999 and 2015. Nominal annual CPUEs were calculated as kg/1000 hooks and were standardized with Generalized Linear Models (GLM) with Tweedie distribution and using year, quarter, area, and targeting effects (ratios) as explanatory variables. Model goodness-of-fit was determined with AIC and the pseudo coefficient of determination, and model validation was analyzed with residual analysis. The final standardized CPUE series shows a general decrease in the initial years, between 1999 and 2010, followed by a general increase in the more recent years, until 2015, with some inter-annual oscillations. This paper presents the first index of abundance for Atlantic sailfish estimated from captures from the Portuguese pelagic longline fleet in the east Atlantic and can be used for future stock assessments of the species.

It was recommended by the Group that future versions of this index also include the estimated mean CPUE for each factor in the model.

- The following documents with indices of abundance for both the eastern and western stocks were presented to the Group during the meeting:

Document SCRS/2016/071 introduced standardized catch rates of the sailfish (*Istiophorus albicans*) obtained from 10,615 trip observations of EU-Spain surface longline fishing targeting swordfish during the period 2001-2014. In roughly 28% of these trips at least one individual belonging to this species was found. Because of the low prevalence of this species in this fishery, the standardized CPUE was developed using a Generalized Linear Mixed Model assuming a delta-lognormal error distribution. The results obtained indicate that the overall trend of the standardized CPUE was similar for the total Atlantic areas and for the East and West stocks. An overall increasing trend was identified for the total Atlantic areas and for the East and West stock for the whole 2001-2014 period with some fluctuations in the most recent years.

The Group inquired what was the rationale used to define the different areas used in the CPUEs standardization. It was pointed out that the areas defined were similar to those used for the analysis of the same fleet for target and other species, and they represent an approximation of the sea temperatures at 50 m depth. Other elements that were also taken into consideration to define the spatial structure for the analysis included the current stock boundaries assumed by ICCAT for this species, and environmental conditions in the surface layers between East and West areas as well as North and South were also considered. Moreover, the distribution of the fleet in the respective areas throughout the year and observations available also plays an important role in deciding the spatial-temporal definitions for analysis. The Group agreed to use in the assessment the individual indices presented for each stock (East and West) instead of the index also presented for the entire Atlantic.

Document SCRS/2016/094 presented estimated standardized CPUEs for sailfish caught by Japanese tuna longline fishery in the western and eastern Atlantic Ocean using logbook data during 1994-2014. Delta lognormal model was used to standardize the nominal CPUEs. Annual changes in the standardized CPUEs for the western Atlantic stock showed a large fluctuation. The time series had a slight decreasing trend from 1994 to 2007 and after that the time series had sharply increased and maintained at higher values. Annual changes in the standardized CPUEs for the eastern Atlantic stock were considerably stable. The time series had a slight decreasing trend during 1994 and 2001, while the time series showed an increasing trend since then. The 95% confidence intervals were not wide for the western and eastern Atlantic sailfish stocks. These results suggest that the current adult stock level of sailfish in the western and eastern Atlantic increased in recent years compared with those in the 1990s and 2000s.

It was indicated by the authors that the use of the habitat model should be dismissed due to the lack of vertical distribution information for sailfish. However, the Group noted that vertical distribution information has been available since 2009 and recommended that this information be incorporated in the future. The Group noted that the standardized index for the western stock was below the nominal index for the entire time series. It was discussed that the indices start in 1994 because prior to that year the data did not separate catches of sailfish and spearfish. In the 2009 Sailfish Stock Assessment Session (Anon. 2010), a JPN index that covered the period 1960-2007 was included in the analysis. It was indicated to the Group that such index was developed during the assessment meeting using CATDIS data and the estimated sailfish/spearfish ratios in the catch. The Group inquired if the presence of spearfish in the estimated ratios was significant and it was informed that in some areas up to 30-40% of the catches were spearfish. The Group noted that in eastern Atlantic, the Japanese longline fleet of yellowfin catches in numbers were higher than bigeye catches when less than 15 hooks–between-float were used, while the opposite was true when more than 15 hooks–between-float were used. However, the same trend was not evident in the western Atlantic. The Group discussed the implication of these observations, but it was agreed that there was not enough information available to interpret this particular results. The Group agreed to use in the assessment the newly estimated index for each stock for the period 1994-2014 and use (as a separate index) the historical CPUE estimated by the Group in the 2009 Sailfish Stock Assessment Session (Anon. 2010), only for the period 1960-1993. The Group noted that the strong year:area interaction and notably an apparent increase of catches in the western Caribbean might require a finer spatial partitioning than the current coarse areas used in the model; this could be the areas chosen by the adaptive partition method originally proposed in the document. To address this concern, the index was split into two different periods in the stock synthesis model (see Section 3.2.3 for details).

Document SCRS/2016/102 introduced catch and effort data of sailfish (*Istiophorus platypterus*) collected and analyzed for the Chinese-Taipei distant-water longline fishery in the Atlantic Ocean for the period 2009-2015. Catch in number observed in logbooks and that estimated using catch ratio of sailfish over the two species (sailfish and spearfish *Tetrapturus pfluegeri*) were used to calculate nominal CPUE (catch per unit of effort), and then CPUE was standardized using generalized linear models (GLMs). Two separate eastern and western stocks of sailfish were considered in the standardization, with information on operation type (i.e., hooks per basket) included as a potential effect in the models. All of the main effects were statistically significant in the GLM analyses, except for month and longitude in the standardization of the western stock. However, relative abundance indices showed similar and consistent trends for the two scenarios on catch data. The standardized CPUE of eastern Atlantic sailfish increased from 2009 to a higher level but then dropped in recent two years (2014-2015), while for the western stock the CPUE showed a decreasing trend during 2010 and 2014 with a slightly increase in 2015.

The Group noted that the data used did not include observations with zero catches. The author indicated that about 19% of the observations had sailfish positive catches and that the percentage was fairly constant. The Group inquired how stable was the ratio sailfish-spearfish. It was indicated that the ratio was very variable since catches for these species are a rare event. The author indicated that Logbook data was used to estimate the ratios by area and it was assumed that the ratios remained constant with time. The Group indicated that the ratios might not have been constant throughout the entire time series. However, with that assumption it should be possible to use the ratios to estimate CPUE series prior to 2009.

The Group discussed the possibility of combining the data from the EU-Spain and EU-Portugal longline fisheries to estimate a combined index for eastern sailfish, and potentially expand this approach to combine data from other fleets. This approach of combining data from different fleets to estimate indexes of abundance is currently being explored for other species like bluefin tuna. The Group acknowledged the importance of having standardized indices from the artisanal fisheries of Senegal and Ghana, and those from EU-Spain and EU- Portugal longline fisheries. The Group thanked the authors of these documents and their significant contribution to the assessment process.

The Group also have available other indices of abundance that were presented at the 2014 Intersessional meeting of the Billfish Group (Anon. 2015) and the 2015 SCRS Species Groups meeting (*Madrid, 21-25 September 2015*). **Tables 7 and 8** (and **Figures 7 and 8**) show the indices of abundance used for the western and eastern stocks, respectively.

3. Stock Assessment

3.1 Eastern stock

3.1.1 Bayesian production models

Methods

For the eastern Atlantic population, Bayesian production models were run using both the BSP model that is available from the ICCAT catalog of methods (BSP-VB, Babcock 2007, McAllister and Babcock 2003) and a JAGS version of the same model based on Millar and Meyer (1999, BSP-JAGS). See **Appendix 5** for details on model specification, diagnostics and sensitivity analyses.

For all model runs, the prior for biomass in the first year relative to K (Bo/K) was lognormal with mean of 1 and a CV of 0.2, except for a sensitivity that fixed Bo/K at 1. The prior for K was uniform on log(K) between log(10) and log(1E6). The prior for r was calculated using the demographic method of Carruthers and McAllister (2011), as shown in **Appendix 6**. Because the annual time step was used, the input parameters were a mean of 0.57, and CV of 0.3. In a sensitivity analysis, the mean was set equal to 0.3 with a CV of 0.3. Uninformative priors were used for the catchability coefficient for each CPUE index (q), using a uniform distribution in BSP-VP and an inverse gamma distribution in BSP-JAGS. The same priors were used for the residual variance, in cases where sigma was estimated.

None of the BSP-VB models included process error. For the BSP-JAGS models, process error was fixed at 0.05, except in sensitivity runs in which sigma was set to either 0.00001 or 0 to evaluate the effect of removing process error. The models varied in which indices were included, how the indices were weighted, and the priors for r and Bo/K (**Table 9**). The indices included were either those that had an increasing trend (Chinese Taipei, EU- Japan-early, Japan-late, Spain) or those that had decreasing trend (Côte d'Ivoire, EU-Portugal, Ghana, Japan-early, Senegal). Indices were weighted equally with an estimated variance, or weighted by catch (input precision equal to the fraction of the total catch associated with each index), or each index had its own estimated residual variance.

Results

The BSP-VB models without process error did not converge well, particularly for the case with an estimated variance for each series. The Hessian estimate of variance for some parameters was near zero, although the importance sampling estimated very wide distributions for the parameters indicating that the model may not have accurately estimated the mode of the posterior distribution. The model posteriors were very similar to the priors for both K and r, even though K had an uninformative prior. Thus, the mean values of K were orders of magnitude higher than the values from other models applied to the same dataset. Because the model was unable to find any information in the data, these model results are not credible. See **Appendix 5** for details.

The BSP-JAGS models with process error provided better convergence diagnostics. The catch weighted models gave posterior distributions for r that were quite similar to the priors (see **Appendix 5**), probably because the data were given very low weights relative to the priors. Because of this, the results were highly uncertain, and the 95% confidence intervals for B/B_{MSY} included a range from near zero to more than 4 for some years (**Table 10**, **Figure 9**). The models that estimated residual variance provided more narrow credible intervals for B/B_{MSY} and F/F_{MSY}. All the models other than the catch-weighted ones estimated a posterior mean of r that was higher than the prior; these high r values may not be biologically realistic.

All of the models estimated a starting biomass that was below B_{MSY}, probably because the models attempted to fit the large variability in the Japanese longline series in the 1960s combined with very low catches. All the runs were similar during the early part of the time series, but the runs with increasing versus decreasing indices diverged in recent years as the median biomass trajectory follows the indices. Estimates of MSY were between 5,000 t and 13,000 t, and the current stock status was below B_{MSY} in all runs. That the population was depleted despite the fact that catches were never above MSY was surprising, but may be explained by the fact that the process error allowed the model to follow the decreasing trend in the indices despite the relatively low catches. Incorporating process error implies that biomass is allowed to vary randomly, without necessarily following the catch time series exactly. Thus, the population estimates could decline if the indices are declining, even if reported catches are low. Three possible scenarios that may explain this are: (1) that the reported catches are lower than real catches, (2) there is a decline in abundance not caused by catch, and/or (3) the actual MSY may be lower than the model estimate due to data uncertainty.

Current fishing mortality is below F_{MSY} in some of the runs with increasing indices, and far above F_{MSY} in the models with decreasing indices. In general, the BSP-JAGS runs are consistent with a population that has declined, and may or may not be rebuilding depending on which indices, if any, are tracking abundance. However, these results are highly uncertain.

3.1.2 ASPIC

During the 2009 assessment ASPIC 5.0 was used for fitting production models for sailfish in the eastern Atlantic. In this assessment, ASPIC 7.0 was used. Although ASPIC 7.0 allows for input of priors for initial parameters, this option was not used in the present assessment for sailfish in the eastern Atlantic.

After examining the different indices available for the assessment of the eastern stock the Group agreed, similarly to the approach used for the western stock, to group the indices into two different scenarios. One scenario contains the indices that showed positive trends in the last years of the time series and the other scenario the indices that showed negative trends. Additionally the Group agreed that the relative abundance index for Ghana should be split into two series Ghana1 (1974-1987) and Ghana2 (1992-2014).

The following scenarios of CPUE indices were used in ASPIC runs:

- E1) Recent trends in indices is negative: Japan1, Ghana1, Ghana2, Senegal, Côte d'Ivoire, EU-Portugal ('Neg')
- E2) Recent trends in indices is positive: Japan1, Japan2, Ghana1, EU-Spain, Chinese Taipei ('Pos')
- E3) All indices: Chinese Taipei, Côte d'Ivoire, EU-Spain, Ghana1, Ghana2, Japan1, Japan2, Portugal, Senegal
- E4) Like E1 but with a recalculated catch for Ghana prior to 1990
- E5) Like E3 but with a recalculated catch for Ghana prior to 1990
- E6) Like E1 but with the Ghana CPUE as a single uninterrupted series

In all cases, CPUE indices were given equal weighting in the fit. As part of model diagnostics, retrospective patterns were run by using data up to 2013, 2011, 2009 and 2007. Uncertainty was assessed by running 500 bootstraps in ASPIC.

Results

Estimates for F_{MSY}, MSY, and K appear highly sensitive to the CPUE trends used, Therefore, results for different scenarios were significantly different (e.g. E1 vs E2). ASPIC fits better the scenarios that omit data for the period1988-1990 from the Ghana1 index and separate the Ghana series into two indices (E1-E5). ASPIC have problem converging, or didn't converge, for the scenarios with a single Ghana series (E6).

Runs that use CPUE with positive trends yielded different estimates of current biomass and exploitation than runs that use CPUE with negative trends or all indices combined. However, fits and parameter estimates for F_{MSY}, K, and MSY with positive trajectories were highly sensitive to which catch series was used (Task 1 or alternative Task I series) and fit observed indices quite poorly. Runs with alternative catch either did not converge or bounded out at the upper limit of F_{MSY} (1.5). Runs that use CPUE with negative trends and both Ghana series appeared the least sensitive to the use of different catch series and exhibited the highest value of contrast in ASPIC. Furthermore, historical trends of B/B_{MSY} and F/F_{MSY} for the period up to 2007 for scenarios are consistent with results from the previous 2009 assessment.

Scenarios (E2 and E5) with recent positive trends did not fit the model and solutions kept hitting the upper constraint of F_{MSY} (1.5) (**Table 11**). It was considered that such high values are not biologically plausible and, therefore, results for these scenarios were not considered any further.

The other two scenarios (E1 and E4) allowed the model to converge and both suggested that the stock is overfished and is undergoing overfishing. Scenario E4 is more optimistic and suggested that in the last two years overfishing is not occurring; while Scenario E1 indicated that overfishing continues.

For scenarios E2 and E5, deterministic results suggest the stock was previously overfished in prior decades and is not presently undergoing overfishing, ASPIC Run E3 suggests that overfishing may have stopped over the last two years and the stock is recovering.

Unfortunately, scenario E3 was not able to be bootstrapped so the only bootstrap results available are those for E1. Retrospective analyses for E1 show what is expected from the addition of the recent CPUE data that show increases in the index and catch data that show decreases (**Figure 10**). As data are added the Biomass estimates become larger and the fishing mortality smaller. Boostraps for E1 converged for 100% of runs and yielded reasonable intervals for parameters (**Table 12**).

E3 exhibits a retrospective pattern with great inconsistencies in the use of all indices for the recent 7 years. The ASPIC run E3 produced results consistent to E1; however, using all indices create issues with consistency for estimates of F_{MSY}, B/B_{MSY}, and F/F_{MSY} (**Figure 11**).

3.2 Western stock

3.2.1 ASPIC

Production models were fitted for western sailfish using different combinations of the available indices of abundance. The first model included all indices and was run with both ASPIC 5 and ASPIC 7 using the least squares estimation method. Both software versions solved to the same solution; however, the estimates of F_{MSY} were not biologically plausible ($F_{MSY}>1.2$). ASPIC 7 was used for all other model runs, using maximum likelihood estimation or maximum a posterior with priors. Uniform priors were included for MSY and fleet catchabilities across a range of logical values. A beta prior was included on F_{MSY} (alpha=2, beta=8; **Figure 12**), based on the prior developed for the Bayesian Surplus Production model for r. Multiple model runs were conducted using this parameterization, which included multiple scenarios of selected indices: (1) all indices, (2) those which showed an increasing trend in recent period, versus (3) those that showed a decreasing trend in the recent period, and (4) catch weighting versus (5) equal indices weighting. A base model was selected by the Group which included all available indices except the Brazilian rod and reel which was excluded due to concerns about extremely low samples sizes in 2009. Multiple sensitivity runs were conducted on the base model, including an indices jackknife, model bootstrap, and retrospective analysis. An additional run was made with the Japan longline index split at 2008 to account for a change in spatial distribution (see section 2.3), consistent with the stock synthesis assessment model.

The base deterministic model runs showed poor model fit to the indices and a lack of convergence without prior on F_{MSY}, hitting the upper bounds on either F_{MSY} or MSY. To better understand model convergence, the negative log-likelihood objective function was profiled across the range of hypothesized MSY (200 to 4,000 t) and F_{MSY} (0.01 to 1.0) values. The profile surface indicated a flat contour at the upper ranges of MSY, and little gradient across the range of F_{MSY} (**Figure 13**). This profile across the range of logical parameter values demonstrated that the ability to estimate F_{MSY} was poor, and that values of MSY greater than 1,400 t are plausible. The scaled likelihood surface (**Figure 13**) indicated the maximum likelihood at the upper bound of F_{MSY}, which believed to be biologically implausible.

Estimates of MSY and F_{MSY} varied greatly between the different model runs, with little agreement between the base model and alternative positive and negative indices models. Estimates of current stock status were also highly variable with no agreement across models. Bootstrap estimates of parameter uncertainty were evaluated to determine the quality of the fit of the base model. Many bootstrap runs bounded at the upper limit of MSY or F_{MSY}; however, these runs were overwritten with runs that solved within the bounds, until 500 valid bootstraps were completed. Overall convergence was approximately 72% of trials. The resulting bootstrap estimate of F_{MSY} and MSY showed a wide distribution across the range of parameter bounds (**Figure 14**), indicating poor model performance and lack of convergence to a stable solution. It was concluded that the ASPIC model for western sailfish did not produce reliable estimates of F_{MSY} or current stock status. The information in the data did indicate that MSY is not likely to be less than 1,400 t; however, the determination of stock status was highly uncertain.

3.2.2 Bayesian state space surplus production model

SCRS/2016/103 presented initial results of the stock assessment of the western Atlantic sailfish. The assessment model was implemented in JAGS (Just Another Gibbs Sampler) and consisted of fitting a Bayesian state-space surplus production model to CPUE data for western Atlantic sailfish. The catch time series is derived from the Task I table in the 2015 SCRS Report (Anon. 2016) and relative abundance indices consisted of standardized catch-per-unit effort (CPUE) for Brazil, Chinese Taipei, EU-Spain, Japan, United States and Venezuela, including longline, recreational and gillnet fisheries. One run that included all input CPUE series (9 indices) and prior mean values was developed. The full specifications of the initial model presented are detailed in this SCRS document. Based on model outputs the western Atlantic sailfish population biomass has slightly declined over the available time series but it is above B_{MSY} and has remained stable since middle 1980s. The estimated harvest rate in 2014 was 0.025, which is lower than the estimated H_{MSY} of 0.065.

Several assumptions regarding data weighting, including equal weights, weights proportional to the catches and weights developed by applying the Francis method (Francis, 2011) were considered. However, none of the models could converge. A model with all indices together (except Brazilian recreational rod and reel fishery) was also tested, but it did not converge either. This lack of convergence might be related to the presence of conflicting trends in the CPUE. Thus, additional runs were performed to address the conflicting trends in the CPUEs in a similar way as agreed for the Stock Synthesis model (see Section 3.2.3) which also resulted in a lack of convergence in all runs. Also, the Group noted that the available data did not provide sufficient information for any of these models to reliably estimate the model parameters.

3.2.3 Stock Synthesis (ASPM) 3 parameters, steepness, R0 and M

The initial model was presented (SCRS/2016/100) with the following details. Comparisons were made with the old and new models on data used in the previous assessment and what was used in current years. In the 2009 assessment of the western stock, a composite index that was averaged across all series (weighted by-catch and area) was used. In the current examination of the Age Structured Production Model (ASMP), 11 fleets were modelled assuming full selectivity. It was noted that the CPUE series had conflicting trends, as five of the series were increasing, and five were decreasing. This would cause conflicting results based on alternative trends. In the model presented, no Brazilian Rod & Reel catches were available in recent years. A combined index was generated based on catches and landings across fisheries (so larger fisheries got more weight). Four models/approaches were examined, (1) unweighted CPUE with no recruitment deviates, (2) use all CPUEs with no recruitment deviates, (3) add catch weighted with no recruitment deviates, and (4) add catch weighted CPUE and recruitment deviates. It was noted that the results of model 1, 2 and 3 were not convincingly plausible, and model 4 results were more consistent with the known history of the fishery. Likelihood profiling approaches were used, and the data were found to be non-informative on natural mortality or steepness. It was noted that the Japanese and Spanish CPUE’s were informative, though steepness very large or very low if it were fit to those series. Possible reasons for this are that the CPUE data are not informative, and mostly a one way trip is evident. A new set of length/age structured models were used, where the growth was modified as Priors, and size at age 1 was fixed at 100 cm LJFL. However, trying to introduce more uncertainty with growth, provided an unrealistic answer.

Additional work was accomplished following that described in SCRS/2016/100. With the length composition data, five models were examined that combined CPUE weighted by catch, 3 gears selectivity, gillnet, rod and reel and longline, with bias correction to the stock-recruitment function used. The Dome shaped selectivity was used for gillnet, the longline and rod and reel was fixed as a logistic. As per the 2009 assessment, one CPUE series was generated where the combined CPUE was applied across all fisheries. The Length Composition data resulted in a better fit to the gillnet fleet than longline fleet, due mostly to the larger sample size of the gillnet fishery which resulted in that data series getting a higher weighting (based on the Francis weighting scheme; Francis, 2011). Mean length fits to the gillnet gear and longline gear were acceptable, but not so much for the Rod & Reel fishery (again because of the low sample size). Profiling on steepness indicated the overall data/model ‘preferred’ a very high steepness and natural mortality values (M). In addition, the posteriors were similar to MLE’s analyzed.

The Group discussed the different inputs of the model and particularly whether the western sailfish catches were recorded completely and/or accurately. In addition, it was noted that in previous sailfish meetings the Group have not adopted growth and M estimates, and that additional time should be used by the Group to decide on an appropriate estimate of M and a growth curve. It was also noted that fixing M and steepness (*h*) would have a strong influence on the outcome of the estimates of stock productivity. As a result, the posteriors distributions of the –MCMC may be misleading and should be viewed with appropriate skepticism. For example, the steepness appeared to be estimated at the upper bound. In addition, all information on ASPM comes from the CPUE’s.

Given the conflicting CPUE time series and no means to objectively discern which of the trends were more accurate, it was suggested that two separate models for the two separate scenarios (alternative hypothesis) be constructed, one represented by only the CPUE’s with increasing trends (Model_1) and another by only the CPUE’s with decreasing trends (Model_2). While the size frequency data was seen as informative, improving the fit was not a worthwhile pursuit. The Group agreed that the use of a combined index (across all conflicting CPUE time series) would be hiding the uncertainty associated to the different CPUEs trends and that models should be constructed that use data across all CPUE series, rather than one series, and be transparent with the datasets being used.

A long discussion ensued and the Group agreed to group the CPUEs based on the prevailing trend in the time series, which resulted in the following groupings (**Figure 15**):

1. Those with increasing trends:
    a) Japan longline, 1994-2015
    b) US rod and reel tournaments
    c) Venezuela gillnet
    d) Spanish longline

2. Those with decreasing trends:
    a) Brazil rod and reel
    b) Brazil longline
    c) US longline (observer)
    d) Venezuela longline
    e) Chinese Taipei recent (2009-2014)

3. Those used in both data sets based on being the only long term time series:
    a) Japan longline 1960-1993
    b) Venezuela Rod and Reel

The input biological population parameters for the SS model are those discussed and agreed in Section 2.1 under the item on Age, Growth, Natural Mortality and Maturity at Size.

Model_1.0 and Model_2.0

The Group examined two scenarios, one based on positive (Model_1.0) and another on negative (Model_2.0) trending CPUEs. The standard deviation on the steepness prior was tightened from 20% to 10%. Both scenarios were considered plausible with different datasets. It was noted that the fits to the survey index (CPUEs) were comparable across the two different scenarios (**Figure 15**). Estimated and observed mean lengths from gillnet and rod and reel fisheries were comparable, but were better for the longline fishery from Model_1 (**Figure 16**). It was noted that the average size of fish in the gillnet fishery declined (**Figure 17**). A larger sample and less variable sizes were observed and as such, created tighter fits of the selectivity to the length information. Longline fleets changing selectivity over time are a possible reason why the model was not fitting the data very well.

It was noted that the two models agreed in the stock biomass trend fairly well up until the year 2005. This was because the last few data points of the CPUE time series had a large influence on biomass trajectories. One model (Model_1) suggests a high fishing mortality and lower biomass, and the other (Model_2) vice-versa (**Figure 18**). As a mean to further differentiate between the two scenarios a retrospective analysis was suggested for each as a diagnostic. An examination of the retrospective analysis showed no retrospective pattern or bias apparent for Model_1. However, Model_2 showed a strong difference in biomass estimates when excluding data after 2010. However, it was noted that recent upward trend in Model_1 was being driven by the Japanese (recent) CPUE as well as the U.S. rod and reel index. The recent declining trend in Model_2 was being driven almost entirely by the Brazilian rod and reel index (**Figure 19**).

Model_1.1 and Model_2.1

Given the strong influence on the current perception of stock status driven by the Japanese longline index (Model_1.0) and the Brazilian rod and reel index (Model_2.0) the Group revisited the fundamentals of these two CPUE time series.

Model_1.1. Two observations were made regarding the Japanese CPUE times series. The first observation was that there was a marked increase in the index between 2007 and 2008. The second observation was that the CV’s associated with the second stanza of this index (2008-2014) were much smaller than the first stanza (1994-2007). These two aspects resulted in the assessment model making a large jump in the estimates of biomass between 2007 and 2008. The small CV’s for the second stanza accentuated the fit to this jump. The Group determined that it would be appropriate to let catchability change between the two periods by using time blocks in CPUE series for the Japanese series (in effect breaking it into two surveys). Effects of having a catchability change indicates that the models performed better than the previous models, and recruitment deviates are not exceedingly large (**Figure 20**).

Model_2.1. The Group then discussed the sudden drop in biomass in recent years as estimated by the Brazilian rod and reel index. Closer examination of this index revealed that the 2009 data point was being estimated from only three sampling days. The Group concluded that this point was unlikely to be representative and also influenced the standardization of the other annual estimates of relative biomass. In addition, the Group was unable to estimate an alternative index excluding the 2009 data during this meeting and, therefore, decided to exclude the entire index from further analysis. Once removed, no retrospective patterns or bias was evident (**Figure 21**). Furthermore, the two scenarios were much more in agreement with each other, at least with regard to the current status of the stock (**Figure 20**). The Group made a final examination of the four candidate models (Model_1, 2, 1.1, and 2.1), and made the determination to adopt Model_1.1 and Model_2.1 as two plausible scenarios to represent the current status of the stock.

In an effort to further refine the plausibility of the two candidate models chosen above, MCMC analysis was conducted on each of the estimated parameters and the deterministic estimate of stock status (i.e. F/F_{MSY} and B/B_{MSY}) compared to the distribution of stock status evaluations from the MCMC analysis. A total of 501,000 MCMC runs were made with the first 1,000 runs being discarded as a “burn in” period. The remaining runs were thinned by 1,000 resulting in a total of 5000 runs for analysis. Examination of the MCMC distributions of Model_1.1 showed that the median of the posterior values of the steepness parameter was being estimated considerably higher (approximately 0.90) than the informative prior value used (0.70) (**Figure 22**). The distribution of the posteriors was rather tight relative to the distribution of the prior, suggesting a strong signal in the data for a higher steepness value. Three of the gillnet selectivity parameters were well estimated, as evidenced from the “normal” shape of the posterior distributions, while two were not, either resulting in a uniform distribution (parameter number 1) or one highly skewed to the left (parameter number 6). The resulting Kobe plot from Model_1.1 showed that while the point estimates of stock status were in the green zone (neither overfished or under going over fishing), the MCMC cluster of points were 87% in the red zone (both overfished and under going over fishing) (**Figure 23**). This disparity in results makes any perception of stock status highly uncertain.

Examination of the MCMC distributions of Model_2.1 posteriors suggested that the median value of steepness was closer (approximately 0.8) to that of the prior (0.7) and had a shape that would be expected from that parameter (beta-like) (**Figure 24**). The estimates of the gillnet selectivity parameters were similar to those of Model_1.1. The resulting Kobe status plot had more desirable diagnostics than Model_1.1 in that the point estimate of the 2014 status was within the 95% confidence intervals of the MCMC, however not within the 75% confidence intervals (**Figure 25**). The point estimate of stock status from Model_2.1 suggested the stock is neither overfished or under going over fishing; however, the centroid of the MCMC cluster suggests the stock is in the red zone (both overfished and under going over fishing) (**Figure 24**). This disparity in results makes any perception of stock status from Model_2.1 also uncertain.

3.3. SRA Section (Catch-MSY Methods)

In standard stock assessments conducted in the Atlantic, indices of abundance are essential elements to capture trends in biomass over time. For Sailfish in the Atlantic, CPUE data showed conflicting trends in both the eastern and the western stocks and, therefore, the Group attempted a catch only method. The primary method used is a technique called Stock reduction Analysis (Zhou *et al.* 2012, Walters *et al.* 2006, Martell and Froese 2012, Kimura and Tagart 1982) which required assumptions about initial biomass, biomass level at the middle of the time series, and what the biomass depletion levels range for the last year. The technique builds on simple surplus production models (like Shaefer, 1954), that use removal data and some estimate of carrying capacity and *r*. Ideally, these models should have some measure of the changes in abundance over time, but as shown in Martell and Froese (2012) and Walters *et al.* (2006), a narrow range of r-K parameter can be obtained through simulation techniques that maintain the population, so that it neither collapses nor exceeds the carrying capacity K. This is the primary basis of the method that was developed and used during the assessment.

Methods

This method of Martell and Froese (2012) is based on catch data and does not require fishing effort or CPUE data. The method involves several steps. It applies a simple population dynamics model, starts with wide prior ranges for the key parameters, and includes the available catch data in the model. The model systematically searches through possible parameter spaces and retains feasible parameter values. Mathematically and biologically unfeasible values are excluded from the large pool of data. The model progressively derives basic parameters and carry out stochastic simulations using these base parameters to get biomass trajectories and additional parameters. This simple model has two unknown parameters, r and K. The Group set reasonably wide prior range, for example, K between C_{max} and 500 * C_{max}. The Group used the approach proposed in Martell and Froese (2012) for "resiliency" estimates that tied to the productivity parameter *r* (low resiliency levels indicated r between 0.05-0.5, medium resiliency indicated a *r* between 0.2-1, and high between 0.5-1.5). These were compared to values obtained in the literature and alternative methods.

The Group run model (1) to find all mathematically feasible r values by searching through wide range of Ks for all depletion levels. If the feasible choice of r and K chosen meets the intermediate (0.1 and 1 level of depletion in 1980), and last point depletion levels (the range specified was 0.3-0.7 level of depletion for these billfish stocks) it is kept. The summary of all runs which meet these criteria are then used, and geometric mean values are reported to be the better representation of yield targets (Martell and Froese 2012). Biological parameters, including K, r, MSY, are derived from the retained pool of [r, K] values. The geometric mean values of these are then used to assess the stock dynamics over time and reported using a plot.

SRA West

The catch only method for western sailfish estimates an MSY equal to 1,317 t (95% confidence interval is 1,130 to 1,534) and F_{MSY} equal to 0.18 (95% confidence interval was 0.09 to 0.33). **Figure 26** shows the posterior distributions of r, K, and MSY. A summary of the parameter estimates is provided in **Table 13**. Stock status was estimated to be overfished (B_{2014}/B_{MSY} =0.46, 95% confidence interval of 0.23 to 0.61) and overfishing occurring (F_{2014}/F_{MSY}=1.37, 95% confidence interval of 0.69 to 2.45). The large uncertainty in current fishing status is noted, while the confidence intervals of biomass status were below 1 indicating that the stock is currently overfished. The catch and overall stock biomass trajectory is shown in **Figure 27**.

SRA East

The catch only method for eastern sailfish estimated MSY equal to 1,977 t (95% confidence interval was 1,812 to 2,157) and F_{MSY} equal to 0.13 (95% confidence interval was 0.10 to 0.18). **Figure 28** shows the posterior distributions of r, K, and MSY. A summary of the parameter estimates is provided in **Table 14**. Stock status was estimated to be overfished (B_{2014}/B_{MSY} =0.49, 95% confidence interval of 0.22 to 0.70), but overfishing not occurring (F_{2014}/F_{MSY}=0.96, 95% confidence interval of 0.16 to 2.42). Similar to western sailfish, it was noted that the estimates of stock biomass status were much less uncertain the fishing mortality rate in relation to F_{MSY}. The catch and overall stock biomass trajectory is shown in **Figure 29**.

3.4 Summary of assessment results

Both the eastern and western stocks of sailfish may have been reduced to stock sizes below B_{MSY} in recent years, but there is considerable uncertainty, as many models examined had convergence problems, and the maximum likelihood surfaces were flat and not well defined.

Western Atlantic Ocean

In the ASPIC models examined in the west was heavily influenced by the priors used in the models. They couldn't provide stock status due to large uncertainty in estimates of benchmarks, and general poor model convergence. The BSPM model did not converge in the western Atlantic Ocean. Integrated models were equally inconclusive as the ASPIC and BSPM models as to the status of the stock. Although the MLE estimates indicated that the stock was not overfished nor overfishing was occurring, the MCMC diagnostics indicated otherwise. Alternative models using data limited methods suggested that the stock in the western Atlantic was overfished with overfishing occurring. There is a large uncertainty in these results, and these results should be interpreted with caution.

Eastern Atlantic Ocean

The BSPM, ASPIC and SRA models in the east showed similar trends in biomass trajectories and fishing mortality levels; trends in abundance suggest that the eastern stocks suffered their greatest declines in abundance prior to 1990. Different model runs indicate a declining/increasing trend in recent years depending on the CPUE series selected. The majority of the models examined in the BSPM/ASPIC/SRA indicate that the stock is overfished, but overfishing status is uncertain.

4. Management recommendations

Considerable uncertainty still remains in the assessments of both the eastern and western stocks. Available abundance indices demonstrate conflicting trends for both stocks, and there are concerns that reported catches, including dead discards, may be incomplete. Nevertheless, it should be noted that there have been significant improvements since the last assessment. There are more abundance indices available, and the standardizations have seen general improvement, fostered in part by the CPUE workshop held in advance of this meeting. In addition, this assessment incorporated new data and new modelling approaches. As it was the case during the 2009 Sailfish Stock Assessment Session (Anon. 2010), the results for the eastern stock were more pessimistic than the western stock in that more of the results indicated recent stock biomass below B_{MSY}.

4.1 Eastern stock

East Atlantic sailfish appear to have declined markedly since the 1970s, reaching a low in the early 1990s. There is broad agreement across model results that the stock is currently overfished. Since 2010, catches appear to have declined substantially. However, models disagree over whether or not overfishing is occurring and whether the stock is recovering. Based on the assessment results, and considering the associated uncertainty, the Group recommends at a minimum that catches should not exceed current levels. Furthermore, taking into account the possibility that overfishing may be occurring, the Commission may consider reductions in catch levels.

4.2 Western stock

The assessment models agreed on MSY estimates between 1,200 – 1,400 t. Although current catches are well below this level, it is possible that the biomass is below B_{MSY} – in which case overfishing could be occurring. Based on the assessment results, and considering the associated uncertainty, the Group recommends that the West Atlantic sailfish catches should not exceed current levels. One approach to reduce fishing mortality could be the use of non-offset circle hooks as terminal gear. Recent research has demonstrated that in some longline fisheries the use of non-offset circle hooks resulted in a reduction of marlin mortality, while the catch rates of several of the target species remained the same or were greater than the catch rates observed with the use of conventional J hooks or offset circle hooks. Currently, three ICCAT Contracting Parties (Brazil, Canada, and the United States) already mandate or encourage the use of circle hooks on their pelagic longline fleets.

5. Recommendations on research and statistics

1. The Group examined available life history parameters, and noted that several new life history parameters have been estimated in recent years. The Group recommended that the sailfish section in the ICCAT Manual reflect those new estimates.

2. The Group noted that robust growth estimates for Atlantic sailfish are not available. The Group recommended that growth parameters be estimated for the Atlantic sailfish stocks.

3. The Group recommended that new information about stock structure be considered prior to future assessments.

4. The Group examined the available tagging data for sailfish, and noted that over 118,000 tag releases are documented for the species. The majority of releases have occurred off the east coast of the U.S., but tagging has also occurred off Venezuela and Brazil. The Group recommended that the data be further evaluated prior to the next assessment to determine if the data can be formatted for inclusion in Stock Synthesis models for western sailfish.

5. The Group continues to express concern regarding the quality and completeness of the Task I and II data. Therefore, the Group recommends that all CPCs report dead discards as well as complete landings, and representative size samples from all their fisheries.

6. The Group recommended that sailfish catches reported by Ghana be reviewed due to differences in time periods.

7. The Group recommended that future assessments of billfish stock status include combined indices of fleets with similar operational characteristics.

8. Noting the severe difficulties in interpreting and fitting indices within stock assessment model, the Group recommends work to consider how to reconcile divergent CPUE patterns that may be a function of changes in fleet spatial distribution, oceanography, or targeting.

6. Other matters

Document SCRS/2016/095 (The Caribbean Billfish Management and Conservation Plan) was available to the Group since the deadline for document submission to the ICCAT Secretariat. Due to time constraint during the assessment meeting, the document was not presented during the meeting. Any comments and information on the document can be addressed to the author.

7. Adoption of the report and closure

The report was adopted during the meeting. The Rapporteur thanked the local organizers for the excellent meeting arrangements and the participants for their efficiency and hard work. The Secretariat reiterated it’s thanks to the hosts for the exceptional organization of the meeting and for the warm support provided to participants. The meeting was adjourned.

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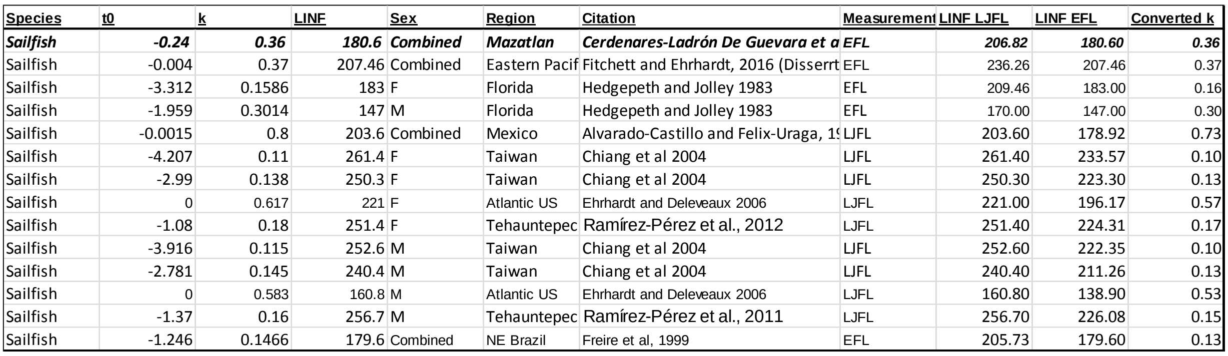
Table 1. Mitochondrial DNA differentiation among Atlantic sailfish groups showing pairwise F_{st} values (below diagonal) and respective *p* values (above diagonal).

	NW Atlantic (Miami)	*Brazil*	*Africa (Senegal)*
NW Atlantic (Miami)	–	0.8823	0.00430
Brazil	0.04049	–	0.10523
Africa (Senegal)	0.14204	0.02774	–

Table 2. Different growth studies published on sailfish used to assess likely parameter structure.



Species	t0	k	LINF	Sex	Region	Citation	Measurement	LINF LJFL	LINF EFL	Converted k
Sailfish	***-0.24***	***0.36***	***180.6***	***Combined***	***Mazatlan***	***Cerdenares-Ladrón De Guevara et a***	***EFL***	***206.82***	***180.60***	***0.36***
Sailfish	-0.004	0.37	207.46	Combined	Eastern Pacif	Fitchett and Ehrhardt, 2016 (Disserrt	EFL	236.26	207.46	0.37
Sailfish	-3.312	0.1586	183	F	Florida	Hedgepeth and Jolley 1983	EFL	209.46	183.00	0.16
Sailfish	-1.959	0.3014	147	M	Florida	Hedgepeth and Jolley 1983	EFL	170.00	147.00	0.30
Sailfish	-0.0015	0.8	203.6	Combined	Mexico	Alvarado-Castillo and Felix-Uraga, 1	LJFL	203.60	178.92	0.73
Sailfish	-4.207	0.11	261.4	F	Taiwan	Chiang et al 2004	LJFL	261.40	233.57	0.10
Sailfish	-2.99	0.138	250.3	F	Taiwan	Chiang et al 2004	LJFL	250.30	223.30	0.13
Sailfish	0	0.617	221	F	Atlantic US	Ehrhardt and Deleveaux 2006	LJFL	221.00	196.17	0.57
Sailfish	-1.08	0.18	251.4	F	Tehauntepec	Ramírez-Pérez et al., 2012	LJFL	251.40	224.31	0.17
Sailfish	-3.916	0.115	252.6	M	Taiwan	Chiang et al 2004	LJFL	252.60	222.35	0.10
Sailfish	-2.781	0.145	240.4	M	Taiwan	Chiang et al 2004	LJFL	240.40	211.26	0.13
Sailfish	0	0.583	160.8	M	Atlantic US	Ehrhardt and Deleveaux 2006	LJFL	160.80	138.90	0.53
Sailfish	-1.37	0.16	256.7	M	Tehauntepec	Ramírez-Pérez et al., 2011	LJFL	256.70	226.08	0.15
Sailfish	-1.246	0.1466	179.6	Combined	NE Brazil	Freire et al, 1999	EFL	205.73	179.60	0.13

Table 3. Estimated catches (t) of Atlantic sailfish (*Istiophorus albicans*) by area, gear and flag.

			1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL			0	0	0	0	0	0	1	95	99	9	226	523	581	585	798	1776	1189	1541	1792	1714	1886	2160	1675	1319	4326	6011	6250	2357	3308	4097	2910	3050	3838	4892	3596	3274	3316	3746	3252	2762	3550	2701	3239	3228	2292	2445	3023	2604	2975	2922	3976	4603	4411	4137	4335	4058	3854	4137	3962	3753	2897	2411	2393	1825	1585	204
	ATE		0	0	0	0	0	0	0	71	32	4	50	173	218	230	264	797	540	848	920	962	628	916	870	670	3573	5278	5398	1457	2529	3230	2069	2082	2796	3706	2445	2269	2065	2553	2109	1710	2315	1476	1780	1815	1172	1234	1881	1337	1362	1342	1978	2761	2313	2625	2587	2194	1901	2542	2196	2062	1821	1241	1258	1042	920	50
	ATW		0	0	0	0	0	0	1	24	66	5	176	350	364	354	533	979	649	693	871	752	1258	1243	804	649	753	732	852	900	779	867	841	968	1042	1186	1151	1004	1252	1193	1143	1052	1235	1225	1459	1413	1120	1211	1142	1267	1613	1580	1998	1842	2098	1512	1748	1864	1953	1595	1765	1691	1076	1170	1134	783	665	153
Landings	ATE	Longline	0	0	0	0	0	0	0	71	32	4	50	173	218	228	260	793	529	754	808	835	474	711	605	376	191	174	351	133	96	57	121	153	229	238	177	89	99	99	93	112	109	47	104	256	151	189	196	206	275	273	195	269	354	322	261	294	566	555	596	555	483	454	485	431	458	47
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	4	11	18	36	46	67	93	143	150	3275	4982	4858	1164	2290	3066	1623	1432	1999	2962	2107	1940	1394	1870	1479	1153	1249	1000	983	1111	954	910	1504	644	859	883	1231	1725	1862	2022	2106	1756	1289	1798	1488	927	895	651	710	489	452	
		Sport (HL+RR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	76	81	87	112	122	144	107	122	189	160	143	107	325	497	568	506	161	240	571	584	537	445	957	429	692	448	67	135	182	488	228	186	551	767	98	282	219	143	46	189	113	580	443	136	58	117	9	3
	ATW	Longline	0	0	0	0	0	0	1	24	66	5	65	217	217	195	356	788	444	482	653	516	998	976	533	376	460	436	476	363	263	342	294	320	395	310	442	417	460	473	406	405	392	268	491	619	407	425	360	427	765	731	1275	1368	1382	1066	1098	1492	1504	1130	1246	1220	978	1049	941	664	539	153
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	28	28	28	38	38	110	198	178	175	179	87	173	141	173	274	295	187	208	238	514	521	599	498	468	410	482	433	553	615	602	402	603	440	642	368	442	452	502	457	92	101	154	86	106	
		Sport (HL+RR)	0	0	0	0	0	0	0	0	0	0	111	133	147	159	177	191	205	211	218	236	232	239	243	245	255	258	266	339	338	350	368	561	475	735	536	313	496	491	472	352	267	371	333	233	217	348	230	350	267	163	76	60	106	0	0	0	2	6	7	4	2	10	19	20	9	
Discards	ATE	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	1	
	ATW	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	57	57	62	64	36	63	28	29	69	57	27	72	45	11	7	5	7	3	5	8	9	10	4	10	20	13	11	
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
Landings	ATE	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	
		Benin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	48	51	53	50	25	32	40	8	21	20	21	20	20	20	19	6	4	5	5	12	2	2	5	3	3	4	0	0	0	0	0	0	0	
		Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	5	9	4	5	11	4	4	8	16	8	1	4	5	2	4	1	1	
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	1	11	54	421	333	122	370	252	226	36	11	29	8	2	5	1	3	19	6	2	3	0	1	2	3	5	4	80	157	38	58	24	56	44	66	45	50	62	49	15	25	36	109	121	80	21	51	54	42	51	
		Cuba	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20	43	31	371	56	52	42	21	13	42	96	110	185	65	69	40	79	79	158	200	115	19	55	50	22	53	61	184	200	77	83	72	533	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	40	40	66	55	58	38	69	40	54	66	91	65	35	80	45	47	65	121	73	93	78	52	448	74	24	108	192	80	99	
		EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	7	4	7	9	19	28	14	0	13	3	42	8	13	42	38	15	20	8	150	210	183	148	177	200	192	206	280	174	154	201	203	302	
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	2	1	2	27	53	11	3	8	13	19	31	136	43	49	103	170	121	70	109	33	
		EU.United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
		Gabon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	110	218	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	
		Ghana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3040	4726	4517	764	1885	2691	1191	891	1426	2408	1658	1485	925	1392	837	465	395	463	297	693	450	353	303	196	351	305	275	568	592	566	521	542	282	420	342	358	417	299	201	220	191	
		Guinea Ecuatorial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	3
		Honduras	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Japan	0	0	0	0	0	0	0	71	32	4	50	173	216	215	238	745	458	229	293	124	42	54	40	20	5	11	1	5	3	8	13	17	16	23	32	41	32	16	26	26	31	6	15	27	45	52	47	19	58	16	26	6	20	22	70	50	62	144	199	94	115	142	157	71	59	47
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	23	86	26	311	257	253	246	43	36	29	108	29	13	4	27	17	23	2	24	20	2	8	11	12	12	22	2	2	5	5	11	4	0	0	0	0	0	0	0	0	0	0	1	0	5	0	6	10	
		Liberia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	85	43	136	122	154	56	133	127	106	122	118	115	0	0	0	0	0	0	0	
		Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	
		Mixed flags (FR+ES)	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	4	11	18	36	46	67	93	143	148	235	256	327	400	405	375	432	504	521	499	354	364	403	394	408	432	595	174	150	182	160	128	97	110	138	131	353	400	365	413	336	264	274	205	251	308	265	56	0	0	0	
		NEI (BIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	269	408	213	55	1	105	43	20	11	0	0	0	0	0	
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	51	57	69	86	127	120	77	43	3	2	16	7	8	10	0	0	0	0	0	0	0	
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	31	9	7	41	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
		S. Tomé e Príncipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	86	97	84	78	81	88	92	96	139	141	141	136	136	136	136	515	346	292	384	114	119	121	124	127	131	134	
		Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	76	81	87	112	122	144	107	122	189	160	143	107	325	498	572	510	163	241	572	596	587	552	1040	466	860	462	162	167	240	560	260	238	786	953	240	673	567	463	256	737	446	630	484	174	247	165	37	
		Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	
		South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		St. Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	5	0	0	0	0	0	0	0	
		Togo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	22	36	23	62	55	95	135	47	31	71	0	0	0	0	0	0	0	
		U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		U.S.S.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	14	13	14	11	14	39	14	9	7	1	13	5	0	0	37	0	0	0	0	2	5	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATW	Aruba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	20	20	30	30	30	30	30	30	30	30	30	23	20	16	13	9	5	10	10	10	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	45	29	42	50	46	74	25	71	58	44	44	42	26	27	26	42	58	42	0	0	18	36	36	39	44	
		Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	12	0	0	52	8	0	4	0	
		Brazil	0	0	0	0	0	0	0	0	0	0	0	159	91	46	46	46	46	23	57	27	21	43	64	37	78	76	186	287	246	201	231	64	153	60	121	187	292	174	152	147	301	90	351	243	129	245	310	137	184	356	598	412	547	585	534	416	139	123	268	433	78	137	108	38	57	
		China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	9	4	3	1	0	1	0	0	0	1	2	1	1	1	0	1	
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	14	74	60	80	34	94	7	37	36	9	29	1	3	6	11	25	7	9	14	12	20	9	92	86	42	37	17	112	117	19	19	2	65	17	11	33	31	13	8	21	5	14	10	11	6	9	26	6	9	
		Cuba	0	0	0	0	0	0	0	0	0	0	0	0	0	13	29	59	44	151	258	19	58	30	17	58	133	152	122	91	51	151	119	134	181	28	169	130	50	171	78	55	126	83	70	42	46	37	37	40	28	196	208	68	32	18	50	72	47	56	0	0	0	0	0	0	0	
		Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	28	28	28	28	28	28	28	21	21	21	21	21	21	21	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Dominica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	0	1	0	3	3	4	2	0	2	0	0	0	
		Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	50	49	46	18	40	44	44	40	31	98	50	90	40	40	101	89	27	67	81	260	91	144	165	133	147	0	0	0	0	0	0	0	
		EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	13	13	19	36	5	30	42	7	14	354	449	196	181	113	148	248	393	451	306	233	239	229	244	
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	2	12	12	110	19	53	101	48	19	9	4	0	0	
		Grenada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	37	40	31	36	27	37	66	164	211	104	114	98	218	316	310	246	151	119	56	83	151	148	164	187	151	171	112	147	159	174	216	183	0	0	0	0	0	
		Japan	0	0	0	0	0	0	1	24	66	5	65	21	63	105	244	586	234	58	117	125	205	234	93	60	78	90	103	14	4	4	3	26	85	15	23	16	8	2	5	12	12	27	0	1	8	2	4	17	3	10	12	3	3	10	5	22	4	1	33	43	36	13	16	7	11	12
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	45	64	83	176	253	249	241	54	45	44	45	45	10	12	30	28	8	18	24	33	10	1	1	12	16	1	2	3	4	4	12	4	0	0	0	0	0	0	0	0	0	0	1	0	45	4	1	1	
		Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	19	19	10	9	65	40	118	36	34	45	51	55	41	46	45	48	34	32	51	63	42	
		NEI (BIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	297	268	0	0	0	0	68	81	252	17	0	0	0	0	0	
		NEI (ETRO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	27	30	36	46	67	64	41	23	1	1	9	4	4	6	0	0	0	0	0	0	0	
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	44	13	9	0	18	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		St. Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	4	4	2	1	3	0	1	0	2	164	3	86	73	59	18	13	8	7	4	4	3	4	
		Sta. Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	2	3	2	3	
		Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	58	14	25	35	24	10	7	3	3	1	2	1	4	10	25	37	3	7	6	8	10	9	17	13	32	16	16	38	72	34	29	
		U.S.A.	0	0	0	0	0	0	0	0	0	0	111	126	142	157	173	188	194	201	207	214	220	227	233	240	248	254	261	308	308	308	308	533	452	734	495	282	462	454	451	324	242	343	294	202	179	345	231	349	267	163	76	58	103	0	0	0	0	0	3	3	0	0	7	3	2	
		UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Venezuela	0	0	0	0	0	0	0	0	0	0	0	44	68	33	40	96	72	123	90	111	440	338	101	91	84	60	59	56	66	93	58	72	57	119	81	81	117	127	94	113	99	175	205	341	223	180	255	279	515	367	261	249	277	327	509	607	1042	549	382	416	498	590	543	341	210	142
Discards	ATE	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	1	
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATW	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	57	57	62	64	36	63	28	29	69	57	27	72	45	11	7	5	7	4	5	7	10	10	4	10	19	11	11	

Table 4. Estimates of the eastern stock of sailfish caught as bycatch in the EU tropical tuna purse seine fleet for a) FAD and b) free school sets

a)

FAD Sets	*Sets*	*Obs. (mt)*	*Est. (mt)*	*SD*
2003	-	-	-	-
2004	-	-	-	-
2005	5	0.27	12.50	5.44
2006	3	0.65	11.40	8.06
2007	4	0.14	4.20	1.93
2008	3	1.17	24.77	16.67
2009	5	0.19	4.97	2.56
2010	4	0.14	2.11	1.13
2011	4	0.17	6.26	4.01
2012	7	0.24	8.29	3.48
2013	7	0.17	2.82	1.19

b)

Free Sets	*Sets*	*Obs. (mt)*	*Est. (mt)*	*SD*
2003	16	0.86	98.57	37.45
2004	-	-	-	-
2005	8	0.72	38.06	18.86
2006	7	1.40	56.37	30.41
2007	15	4.99	98.64	48.81
2008	19	1.00	11.54	3.14
2009	22	1.46	34.35	9.18
2010	46	3.22	30.81	7.95
2011	43	6.36	131.84	38.55
2012	43	3.69	113.44	42.73
2013	32	2.38	223.89	88.24

Table 5. Data catalogues for Task II data for the a) Western and b) Eastern Sailfish stocks.

a)

Species	Stock	Status	FlagName	GearGrp	DSet	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SAI	ATW	CP	Venezuela	LL	t1	94	129	170	271	148	139	167	165	333	227	190	186	188	233	387	476	907	363	269	320	409	498	404	262	112	142
SAI	ATW	CP	Venezuela	LL	t2	-1	b	ab	ab	ab	ab	ab	ab	ab	ab	a	-1	-1	a	a	a	a	a	a	a	a	a	a	a	a	-1
SAI	ATW	CP	Brazil	LL	t1	98	65	285	201	60	97	76	69	106	278	531	412	325	347	208	415	82	59	75	73	76	135	106	25	57	
SAI	ATW	CP	Brazil	LL	t2	a	a	ab	a	a	a	a	a	a	ab	ab	ab	a	a	a	ab	ab	ab	ab	ab	ab	ab	ab	a	a	
SAI	ATW	CP	EU.España	LL	t1	0	8	13	13	19	36	5	30	42	7	14	354	449	196	181	113	148	248	393	451	306	233	239	229	244	
SAI	ATW	CP	EU.España	LL	t2	-1	-1	-1	b	b	-1	b	b	-1	b	b	b	b	b	-1	b	b	-1	b	b	b	-1	-1	-1	-1	
SAI	ATW	CP	U.S.A.	RR	t1	242	341	290	201	179	342	230	349	267	163	76	58	103		0	0	0	0	3	3	0	0	7	3	2	
SAI	ATW	CP	U.S.A.	RR	t2	ab	ab	ab	ab	ab	b	ab	b	ab	b	b	-1	b	b	b	b	b	b	b	ab	b	b	b	b	b	
SAI	ATW	CP	Venezuela	GN	t1		41	25	60	65	41	88	114	182	140	71	64	88	93	122	131	135	186	113	96	89	92	139	79	98	
SAI	ATW	CP	Venezuela	GN	t2		ab	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	
SAI	ATW	NCO	Grenada	UN	t1	218	316	310	246	151	119	56	83	151	148	164	187														
SAI	ATW	NCO	Grenada	UN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1														
SAI	ATW	NCO	Dominican Republic	SU	t1	40	31	98	50	90	40	40	101	89	27	67	81	260	91	144	165	133	147								
SAI	ATW	NCO	Dominican Republic	SU	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1								
SAI	ATW	NCO	Grenada	LL	t1													151	171	112	147	159	174	216	183						
SAI	ATW	NCO	Grenada	LL	t2													-1	a	a	a	a	a	a	-1						
SAI	ATW	CP	Brazil	SU	t1	184		33	21	41	143	224	67	78	78	67				326	0										
SAI	ATW	CP	Brazil	SU	t2	-1		-1	-1	-1	-1	-1	-1	-1	-1	-1				-1	-1										
SAI	ATW	CP	Brazil	UN	t1													222	238			58	60	193	360	1	0	0			
SAI	ATW	CP	Brazil	UN	t2													-1	-1			-1	-1	-1	-1	-1	-1	-1			
SAI	ATW	NCO	Cuba	UN	t1		83	70	42	46	37	37	40	28	196	208	68	32	18	50	72	47	56								

SAI	ATW	NCO	Cuba	UN	t2		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1									
SAI	ATW	CP	Mexico	LL	t1				2	19	19	10	9	65	40	118	36	34	45	51	55	42	47	45	48	34	32	51	63	42	
SAI	ATW	CP	Mexico	LL	t2				a	a	-1	a	a	a	a	a	-1	-1	a	a	a	a	abc	a	a	a	a	a	a	a	
SAI	ATW	CP	Barbados	LL	t1						74	25	71	58	44	44	42	26	27	26	42	58	42			16	29	25	35	37	
SAI	ATW	CP	Barbados	LL	t2						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			-1	a	a	a	a	
SAI	ATW	NCO	NEI (BIL)	LL	t1											297	267						81	59	17						
SAI	ATW	NCO	NEI (BIL)	LL	t2											-1	-1						-1	-1	-1						
SAI	ATW	CP	U.S.A.	LL	t1	62	66	40	64	29	30	69	57	27	72	45	11	7	5	7	3	5	7	9	10	4	10	18	11	11	
SAI	ATW	CP	U.S.A.	LL	t2	a	a	a	a	a	a	a	a	a	ab	a	a	ac	a	a	a	a	a	a	a	ab	ab	ab	ab	ab	
SAI	ATW	NCC	Chinese Taipei	LL	t1	42	37	17	112	117	19	19	2	65	17	11	33	31	13	8	21	5	14	10	11	6	9	27	7	9	
SAI	ATW	NCC	Chinese Taipei	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	-1	-1	a	ab	ab	ab	ab	ab	ab	a
SAI	ATW	CP	St. Vincent and Grenadines	LL	t1												2	164	3	86	73	59	18	13	8	7	4	4	3	4	
SAI	ATW	CP	St. Vincent and Grenadines	LL	t2												-1	a	a	a	-1	a	a	a	a	a	a	a	a	a	
SAI	ATW	CP	EU.Portugal	LL	t1											7	0	2	12	12	110	19	53	101	48	19	9	4			
SAI	ATW	CP	EU.Portugal	LL	t2										a	a	-1	-1	a	a	a	a	a	ab	a	a	ab	ab	ab	ab	
SAI	ATW	NCO	NEI (ETRO)	LL	t1				15	27	30	36	46	67	64	41	23	1	1	9	4	4	6								
SAI	ATW	NCO	NEI (ETRO)	LL	t2				-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1								
SAI	ATW	CP	Trinidad and Tobago	LL	t1	4	1		1	2	1	4	10	25	37	3	7	6	7	10	9	17	13	32	16	16	32	60	28	23	
SAI	ATW	CP	Trinidad and Tobago	LL	t2	-1	-1		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	a	a	a	a	a	a	
SAI	ATW	CP	Japan	LL	t1	12	27	0	1	8	2	4	17	3	10	12	3	3	10	5	22	4	1	33	43	36	13	16	7	11	12
SAI	ATW	CP	Japan	LL	t2	b	-1	b	-1	a	a	a	a	ab	ab	ab	a	ab	a	ab	a	ab	ab	ab	ab	ab	ab	a	a	a	-1

b)

Sp.	Stock	Status	FlagName	Gear Grp	D Set	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SAI	ATE	CP	Ghana	GN	t1	395	463	297	693	450	353	303	196	351	305	275	568	592	566	521	542	282	420	342	358	417	299	201	220	191	
SAI	ATE	CP	Ghana	GN	t2	-1	-1	-1	-1	a	-1	-1	b	ab	b	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	a	a	a	
SAI	ATE	CP	Senegal	HL	t1	957	429	692	448	67	135	182	488	228	186	551	767	98	282	219	143	46	189	108	497	357	122	30	114	5	
SAI	ATE	CP	Senegal	HL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ab	ab	ab	ab	ab	a	-1	-1	b	b	-1	a	
SAI	ATE	NCO	Mixed flags (FR+ES)	PS	t1	595	174	150	182	160	128	97	110	138	131	353	400	365	413	336	264	274	205	251	308	265	56				
SAI	ATE	NCO	Mixed flags (FR+ES)	PS	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1				
SAI	ATE	CP	Senegal	TR	t1	53	27	141	11	90	29	52	59	24	44	213	155	123	337	343	296	177	512	158	18			104	25		
SAI	ATE	CP	Senegal	TR	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ab	-1			b	b	a	
SAI	ATE	CP	EU.España	LL	t1	0	13	3	42	8	13	42	38	15	20	8	150	210	183	148	177	200	192	206	280	174	154	201	203	302	
SAI	ATE	CP	EU.España	LL	t2	-1	-1	-1	b	b	b	b	b	b	b	b	b	b	b	b	b	b	-1	-1	-1	b	b	-1	-1	b	
SAI	ATE	CP	S. Tomé e Príncipe	TR	t1						92	96	139	141	141	136	136	136	136	515	346	292	384	8	8	10					
SAI	ATE	CP	S. Tomé e Príncipe	TR	t2						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1					
SAI	ATE	CP	Côte d'Ivoire	GN	t1	58	38	69	40	54	66	91	65	35	80	45	47	65	121	73	93	78	52	448	74	24	108	192	80	99	
SAI	ATE	CP	Côte d'Ivoire	GN	t2	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	-1	-1	a	-1	-1	-1	a	a	a	ab	
SAI	ATE	CP	Japan	LL	t1	31	6	15	27	45	52	47	19	58	16	26	6	20	22	70	50	62	144	199	94	115	142	157	71	59	47
SAI	ATE	CP	Japan	LL	t2	b	b	-1	-1	a	ab	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	ab	ab	ab	ab	ab	ab	-1
SAI	ATE	NCC	Chinese Taipei	LL	t1	5	4	80	157	38	58	24	56	44	66	45	50	62	49	15	25	36	109	121	80	21	52	59	46	53	
SAI	ATE	NCC	Chinese Taipei	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	-1	-1	a	ab	ab	ab	ab	ab	ab	a
SAI	ATE	CP	Liberia	GN	t1						33	85	43	136	122	154	56	133	127	106	122	118	115								
SAI	ATE	CP	Liberia	GN	t2						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1								
SAI	ATE	NCO	Cuba	UN	t1		184	200	77	83	72	533																			
SAI	ATE	NCO	Cuba	UN	t2		-1	-1	-1	-1	-1	-1																			

SAI	ATE	CP	EU. Portugal	LL	t1									27	42	6	1	2	10	6	11	136	43	49	84	142	96			68	108	33
SAI	ATE	CP	EU. Portugal	LL	t2									-1	a	a	a	a	a	a	a	a	a	ab	a	a	ab	ab			ab	ab
SAI	ATE	NCO	NEI (BIL)	SU	t1												255	365	162	53												
SAI	ATE	NCO	NEI (BIL)	SU	t2												-1	-1	-1	-1												
SAI	ATE	CP	S. Tomé e Príncipe	PS	t1																			101	106	106	124			127	131	134
SAI	ATE	CP	S. Tomé e Príncipe	PS	t2																			-1	-1	-1	-1			-1	-1	-1
SAI	ATE	NCO	NEI (ETRO)	LL	t1				27	51	57	69	86	127	120	77	43	3	2	16	7	8	10									
SAI	ATE	NCO	NEI (ETRO)	LL	t2				-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1									
SAI	ATE	CP	Senegal	GN	t1	30	10	14	2	3	3	6	3	5	0	8	28	19	15	1	22	27	28	180	35	45	38			85	21	26
SAI	ATE	CP	Senegal	GN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	-1	-1	b	b			b	a
SAI	ATE	NCO	Togo	GN	t1								9	22	36	23	62	55	95	135	47	31	71									
SAI	ATE	NCO	Togo	GN	t2								-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1									
SAI	ATE	CP	S. Tomé e Príncipe	UN	t1	97	84	78	81	88																						
SAI	ATE	CP	S. Tomé e Príncipe	UN	t2	-1	-1	-1	-1	-1																						
SAI	ATE	CP	Gabon	GN	t1				3	3	110	218	2				0		4													
SAI	ATE	CP	Gabon	GN	t2				-1	-1	-1	-1	-1				-1		-1													

Table 6. Tag releases and recaptures by year in the ICCAT tagging database.

			Years at liberty									
Year	*Releases*	*Recaptures*	*< 1*	*1 - 2*	*2 - 3*	*3 - 4*	*4 - 5*	*5 - 10*	*10+*	*15+*	*ERROR*	*% recapt**
1950	2	1		1								50.0%
1951	1	1	1									100.0%
1952	2	2	2									100.0%
1953	1	1			1							100.0%
1954	3	0										
1955	13	2		2								15.4%
1956	2	1			1							50.0%
1957	59	2	1	1								3.4%
1958	31	2	1	1								6.5%
1959	252	1		1								0.4%
1960	926	5	3	2								0.5%
1961	1303	7	5	2								0.5%
1962	1497	10	7	3								0.7%
1963	1423	8	8									0.6%
1964	1305	6	6									0.5%
1965	1316	9	8	1								0.7%
1966	1277	17	13	2	1		1					1.3%
1967	877	13	12	1								1.5%
1968	847	10	8	2								1.2%
1969	819	7	5	1		1						0.9%
1970	632	2	1		1							0.3%
1971	1074	4	2	1	1							0.4%
1972	920	6	3	3								0.7%
1973	914	17	7	8		1			1			1.9%
1974	870	10	4	4	2							1.1%
1975	1017	17	14	3								1.7%
1976	1464	22	15	7								1.5%
1977	1391	32	24	4	1	2		1				2.3%
1978	1549	32	18	11	2				1			2.1%
1979	1860	37	23	4	5	2	1			2		2.0%
1980	2125	49	24	9	2	1	1		11	1		2.3%
1981	1853	43	34	4	4	1						2.3%
1982	1643	32	20	7	2	2	1					1.9%
1983	1824	13	8	4	1							0.7%
1984	2212	32	16	7	4	2	1	2				1.4%
1985	1912	41	26	8	3		2	2				2.1%
1986	2238	44	32	8	4							2.0%
1987	1999	46	24	10	6	3		3				2.3%
1988	2487	50	30	7	4	4	2	3				2.0%
1989	2183	50	24	18	7		1					2.3%
1990	3403	85	48	23	6	6	1	1				2.5%
1991	4912	140	75	41	17	2	3	2				2.9%
1992	5878	147	87	41	13	2	1	3				2.5%

1993	5540	124	80	29	11		1	3				2.2%
1994	5708	93	57	16	9	7	1	3				1.6%
1995	6512	96	57	23	7	6	1	2				1.5%
1996	4933	118	63	31	17	2	3	2				2.4%
1997	5454	106	58	26	13	5	2	2				1.9%
1998	5021	106	56	30	12	5	1	1			1	2.1%
1999	7174	127	83	24	12	5	1	2				1.8%
2000	5148	54	36	9	7						2	1.0%
2001	3866	43	27	8	2	2	3				1	1.1%
2002	4186	31	21	6	1	2					1	0.7%
2003	2977	17	12	4	1							0.6%
2004	447	17	8	7	1						1	3.8%
2005	448	23	17	6								5.1%
2006	8	8	7								1	100.0%
2011	5	1	1									20.0%
Grand Total	**115743**	**2020**	**1222**	**471**	**181**	**63**	**28**	**32**	**13**	**3**	**7**	**1.7%**

Table 7. Indices of abundance used for the assessment of SAI western stock: US-LL (US longline estimated from observer data), US-RR (US rod and reel, recreational tournaments), VEN-RR (Venezuela recreational rod and reel), VEN-GILL (Venezuela gillnet), VEN-LL (Venezuela longline), BRA-LL (Brazil longline), BRA-RR (Brazil recreational rod and reel), JPN-LL1 (Japan longline 1994-2014), JPN-LL2 (Japan longline 1960-1993), SPA-LL (E.U. Spain longline), CH-T-LL (China-Taipei longline).

	US-LL	*US-RR*	*VEN-RR*	*VEN-GILL*	*VEN-LL*	*BRA-LL*	*BRA-RR*	*JPN-LL1*	*JPN-LL2*	*SPA-LL*	*CH-T-LL*
Units	*number*	*number*	*number*	*weight*	*number*	*number*	*number*	*number*	*number*	*weight*	*number*
Source	*SCRS/2015/185*	*SCRS/2016/093*	*SCRS/2014/065*	*SCRS/2016/075*	*SCRS/2015/084*	*SCRS/2016/092*	*SCRS/2015/209*	*SCRS/2016/094*	*2009 assessment*	*SCRS/2016/071*	*SCRS/2016/102*
1960									0.804		
1961			0.33						1.103		
1962			0.27						1.397		
1963			0.12						1.355		
1964			0.16						1.525		
1965			0.18						1.867		
1966			0.38						1.973		
1967			0.22						2.215		
1968			0.3						3.308		
1969			0.3						2.272		
1970			0.25						2.159		
1971			0.37						1.435		
1972		0.49	0.31						1.182		
1973		0.97	0.26						1.397		
1974		0.55	0.25						1.377		
1975		1.4	0.15						0.75		
1976		1.02	0.2						0.754		
1977		1.39	0.09						1.665		
1978		1.4	0.06			0.35			1.252		
1979		1.29	0.06			0.501			1.145		
1980		1.41	0.09			0.411			0.925		
1981		1.13	0.08			0.389			1.291		
1982		0.35	0.04			0.232			1.305		
1983		0.36	0.12			0.435			1.35		
1984		0.54	0.21			0.153			1.001		
1985		0.4	0.17			0.089			0.752		
1986		0.77	0.1			0.13			0.844		
1987		0.62	0.17		5.627	0.334			0.926		
1988		0.61	0.09		2.118	0.277			0.69		
1989		0.5	0.12		1.575	0.483			0.506		
1990		0.67			0.931	0.094			0.376		
1991		0.62	0.04	16.04	0.899	0.296			0.611		
1992	1.965	0.6	0.07	29.02	0.742	0.213			0.519		
1993	1.645	0.73		24.03	0.271	0.476			0.467		
1994	0.913	1.12	0.08	22.21	0.759	0.081		0.079			
1995	0.681	0.94	0.05	23.24	0.664	0.258		0.029			
1996	0.707	1.09	0.02	20.16	0.75	0.236	0.19	0.053			
1997	0.906	1.06	0.01	29.17	0.676	0.246	0.38	0.127			
1998	0.666	1.11	0.02	28.55	0.933	0.225	0.29	0.075			
1999	1.854	0.66	0.01	28.92	2.397	0.16	0.17	0.152			

2000	2.689	0.61	0.06	23.83	0.693	0.218	0.45	0.094		
2001	1.002	0.74	0.06	22.42	0.431	0.304	0.23	0.017	0.61356	
2002	0.661	0.83		20.51	0.507	0.154	0.26	0.047	0.78549	
2003	0.456	0.94		19.74	0.314	0.241	0.42	0.098	0.68082	
2004	0.791	0.99		21.12	0.347	0.213	0.29	0.046	0.35385	
2005	1.011	0.97		25.17	0.405	0.443	0.43	0.118	0.66841	
2006	0.521	1.14		28.43	0.726	0.186	0.58	0.082	0.62019	
2007	0.608	0.97		31.02	1.84	0.152	0.62	0.017	0.81285	
2008	1.105	1.57		31.75	0.462	0.077	0.46	0.227	1.18685	
2009	0.796	1.74		32.35	0.526	0.271	0.02	0.223	1.40152	0.054
2010	0.877	1.79		31.56	0.511	0.05	0.16	0.213	1.39395	0.083
2011	0.768	2.03		37.75	0.724	0.179	0.11	0.272	1.238	0.068
2012	1.087	2.08		36.13	0.946	0.033	0.14	0.122	1.22106	0.086
2013	0.631	1.45		37.8	0.784		0.19	0.105	1.86786	0.058
2014	0.658	1.33		40.24	0.442		0.07	0.234	1.15559	0.027

Table 8. Indices of abundance used for the assessment of SAI eastern stock: CIV-ART (Cote d'Ivoire artisanal), SEN-ART (Senegal artisanal), GHA-ART (Ghana artisanal), JPN-LL1 (Japan longline 1994-2014), JPN-LL2 (Japan longline 1960-1993), SPA-LL (E.U. Spain longline), CH-T-LL (China-Taipei longline), POR-LL (E.U. Portugal longline).

	CIV-ART	*SEN-ART*	*GHA-ART*	*JPN-LL1*	*JPN-LL2*	*SPA-LL*	*CH-T-LL*	*POR-LL*
Units	*number*	*weight*	*weight*	*number*	*number*	*weight*	*number*	*weight*
Source	*Konan et al. 2010*	*SCRS/P/2016/026*	*SCRS/P/2016/027*	*SCRS/2016/094*	*no current paper*	*SCRS/2016/071*	*SCRS/2016/102*	*SCRS/2016/098*
1960					0.736			
1961					5.036			
1962					1.080			
1963					0.778			
1964					2.405			
1965					2.028			
1966					1.951			
1967					0.660			
1968					1.799			
1969					2.846			
1970					4.269			
1971					1.086			
1972					1.007			
1973					0.579			
1974			0.211895562		0.470			
1975			0.861368814		0.449			
1976			0.957747662		0.612			
1977			0.112948668		0.375			
1978			0.163621417		0.686			
1979			0.212812227		0.262			
1980			0.180083326		0.527			
1981		0.748	0.086482684		0.325			
1982		1.104	0.935583116		1.078			
1983		0.695			0.421			
1984		0.480	0.201801942		1.147			
1985		0.975	0.175561492		0.635			
1986		1.127	0.509489735		0.670			
1987		1.526	0.262844857		0.485			
1988	0.610	1.268	4.668112227		0.483			
1989	0.300	1.904	0.028988173		0.398			
1990	0.350	1.479	1.526036311		0.250			
1991	0.400	1.491	3.314307472		0.198			
1992	0.180	1.293	1.931277986		0.212			
1993	0.180	0.780	1.863091017		0.379			
1994	0.240	0.335	1.626846167	0.046				
1995	0.120	0.612	0.775487009	0.048				
1996	0.110	1.263	2.386733581	0.040				
1997	0.190	1.892	1.294619842	0.028				
1998	0.160	1.244	0.823348625	0.038				
1999	0.250	0.951	0.564210346	0.029				3.980

2000	0.110	1.133	0.36950505	0.037				1.520
2001	0.180	1.847	0.93782419	0.013		0.136		1.400
2002	0.200	1.448	1.756970257	0.029		0.725		2.120
2003	0.100	2.116	2.219196392	0.035		0.483		0.740
2004	0.200	0.692	0.818136506	0.072		0.471		1.280
2005	0.200	0.811	1.327515512	0.078		0.574		1.180
2006	0.200	0.523	0.70223582	0.062		0.672		0.410
2007	0.250	0.609	0.645313986	0.094		0.812		0.470
2008		0.741	0.611763543	0.115		1.066		0.290
2009		0.556	1.526725834	0.071		1.187	0.054	0.370
2010		0.382		0.073		0.874	0.050	0.080
2011		0.296	0.496332575	0.122		0.773	0.056	0.900
2012		0.412	0.712631818	0.104		1.408	0.078	0.830
2013		0.269	0.200548261	0.114		2.339	0.090	0.710
2014				0.076		2.480	0.056	1.770

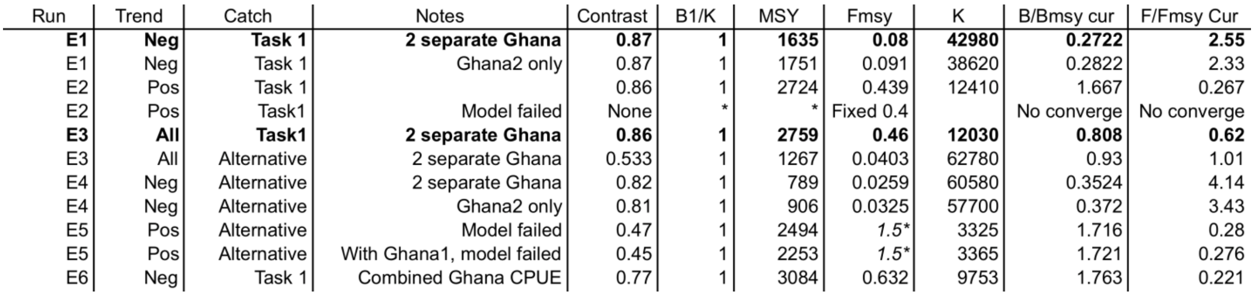
Table 9. Bayesian production model runs in the East.

Number	*Index trend*	*Weighting*	*Software*	*Process error*	*Bo/K*	*r prior mean*	*converged*
1a	up	equal	BSP-VB	0	prior	0.54	yes
1b	up	catch	BSP-VB	0	prior	0.54	yes
1c	up	by series	BSP-VB	0	prior	0.54	no
2a	down	equal	BSP-VB	0	prior	0.54	yes
2b	down	catch	BSP-VB	0	prior	0.54	yes
2c	down	by series	BSP-VB	0	prior	0.54	no
1a	up	equal	JAGS	0.05	prior	0.54	yes
1b	up	catch	JAGS	0.05	prior	0.54	yes
1c	up	by series	JAGS	0.05	prior	0.54	yes
2a	down	equal	JAGS	0.05	prior	0.54	yes
2b	down	catch	JAGS	0.05	prior	0.54	yes
2c	down	by series	JAGS	0.05	prior	0.54	yes
3a	down, 2 GHN	equal	JAGS	0.05	prior	0.54	yes
3b	down, GHN 92+	equal	JAGS	0.05	prior	0.54	yes
1d	up	equal	JAGS	0.05	prior	0.3	yes
2d	down	equal	JAGS	0.05	prior	0.3	yes
1e	up	equal	JAGS	0.05	fixed=1	0.54	yes
2e	down	equal	JAGS	0.05	fixed=1	0.54	yes
1f	up	equal	JAGS	1E-06	prior	0.54	yes
1g	up	equal	JAGS	0	prior	0.54	no

Table 10. Means and CVs of parameters from BSP-JAGS models in the east.

Model	K (1000)	r	Bo/K	MSY (1000)	Bcur/ Bmsy	HRcur/ HRmsy
E-up-equal wt	23.41 (0.96)	1.23 (0.22)	0.45 (1.1)	6.8 (0.75)	0.67 (0.43)	0.33 (0.33)
E-up-catch wt.	66.35 (1.18)	0.59 (0.31)	0.45 (1.57)	8.98 (1.1)	0.4 (2.07)	2.85 (2.44)
E-up-series wt.	27.04 (0.48)	1.17 (0.22)	0.45 (1.12)	7.67 (0.41)	0.41 (0.38)	0.45 (0.29)
E-down-equal wt.	15.7 (0.77)	1.39 (0.24)	0.44 (1.07)	5.08 (0.57)	0.71 (0.86)	0.61 (0.81)
E-down-catch wt.	71.94 (1.27)	0.59 (0.31)	0.43 (1.56)	9.6 (1.16)	0.36 (1.61)	2.85 (2.51)
E-down-series wt.	18.94 (0.5)	1.28 (0.22)	0.46 (1.08)	5.79 (0.42)	0.32 (0.94)	1.35 (1.19)
E-down-equal-2 GHN	24.23 (2.99)	1.6 (0.2)	0.40 (1.13)	8.58 (2.36)	0.41 (0.62)	0.61 (0.52)
E-down-equal-GHN 92+	20.94 (1.58)	1.42 (0.21)	0.42 (1.1)	7.03 (1.21)	0.41 (0.62)	0.62 (0.55)
E-up-prior.3	91.08 (2.14)	0.7 (0.27)	0.56 (1.17)	13.48 (2.01)	0.52 (0.59)	0.51 (0.37)
E-down-prior.3	62.43 (2.22)	0.63 (0.28)	0.61 (1.15)	8.58 (2.08)	0.14 (2.46)	63.97 (3.23)
E-up-Bo=K	21.68 (0.37)	1.22 (0.22)	1	6.4 (0.33)	0.66 (0.4)	0.34 (0.33)
E-down-B0=K	17.25 (0.82)	1.21 (0.25)	1	4.83 (0.6)	0.29 (2.16)	38.58 (3.74)
E-up-low process	22.73 (0.62)	1.22 (0.22)	0.46 (1.1)	6.65 (0.49)	0.66 (0.42)	0.34 (0.33)

Table 11. Results for sailfish eastern Atlantic with varying catch scenarios, indices used, separation of Ghana series (Ghana1 and Ghana2), and omission of 1988-1990 from Ghana index.



Run	Trend	Catch	Notes	Contrast	B1/K	MSY	Fmsy	K	B/Bmsy cur	F/Fmsy Cur
E1	**Neg**	**Task 1**	**2 separate Ghana**	**0.87**	**1**	**1635**	**0.08**	**42980**	**0.2722**	**2.55**
E1	Neg	Task 1	Ghana2 only	0.87	1	1751	0.091	38620	0.2822	2.33
E2	Pos	Task 1		0.86	1	2724	0.439	12410	1.667	0.267
E2	Pos	Task1	Model failed	None	*	*	Fixed 0.4		No converge	No converge
E3	**All**	**Task1**	**2 separate Ghana**	**0.86**	**1**	**2759**	**0.46**	**12030**	**0.808**	**0.62**
E3	All	Alternative	2 separate Ghana	0.533	1	1267	0.0403	62780	0.93	1.01
E4	Neg	Alternative	2 separate Ghana	0.82	1	789	0.0259	60580	0.3524	4.14
E4	Neg	Alternative	Ghana2 only	0.81	1	906	0.0325	57700	0.372	3.43
E5	Pos	Alternative	Model failed	0.47	1	2494	*1.5**	3325	1.716	0.28
E5	Pos	Alternative	With Ghana1, model failed	0.45	1	2253	*1.5**	3365	1.721	0.276
E6	Neg	Task 1	Combined Ghana CPUE	0.77	1	3084	0.632	9753	1.763	0.221

Table 12. Bootstrap results for ASPIC runs for ASPIC Run E1 with CPUE Indices Exhibiting a Negative Trend.

Parameter	*Estimate*	*80% lower*	*80% upper*	*50% lower*	*50% upper*	*Interquartile range*	*Relative IQ Range*
B1/K	1.00	NA	NA	NA	NA	NA	NA
MSY	1657.00	1152.00	1951.00	1448.00	1855.00	406.80	0.25
Fmsy	0.08	0.03	0.13	0.06	0.11	0.05	0.70
Ye(2015)	780.30	518.10	1260.00	685.10	1040.00	354.50	0.45
Y.(Fmsy)	464.60	291.50	849.70	388.50	655.00	266.50	0.57
Bmsy	21480.00	14900.00	33580.00	16800.00	26150.00	9343.00	0.44
B./Bmsy	0.27	0.16	0.43	0.21	0.34	0.14	0.51
F./Fmsy	2.55	1.41	3.92	1.86	3.00	1.15	0.45
Ye./MSY	0.47	0.30	0.68	0.37	0.57	0.20	0.43

Table 13. Key parameters associated with the stock production analysis for SAI_west.

Parameter	*Lower 80% CI*	*Geometric Mean*	*Upper 80% CI*
r	0.18	0.35	0.67
K	10233	15250	25592
MSY	1130	1317	1534
B_{MSY}	18727	36470	71025
B_{2014}/B_{MSY} *	0.23	0.42	0.61
F_{2014}/F_{MSY} *	0.69	1.37	2.45

*Based on Shaefer models

Table 14. Key parameters associated with the stock production analysis for SAI_east.

Parameter	*Lower 80% CI*	*Geometric Mean*	*Upper 80% CI*
r	0.194	0.263	0.356
K	18727	36470	71025
MSY	1812	1977	2157
B_{MSY}	9363	18235	35513
B_{2014}/B_{MSY} *	0.22	0.49	0.70
F_{2014}/F_{MSY} *	0.16	0.96	2.42

*median est (other pars Gem. Mean)

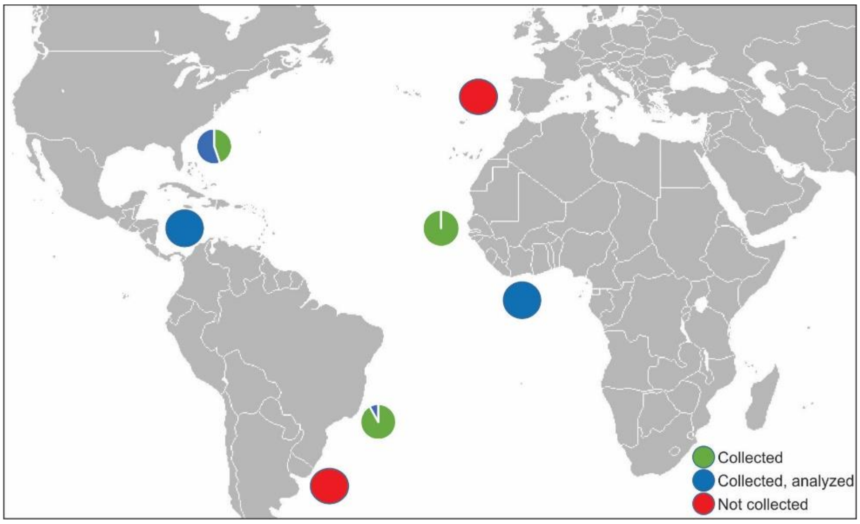


Figure 1. Spatial distribution of sailfish mitochondrial DNA sampling.

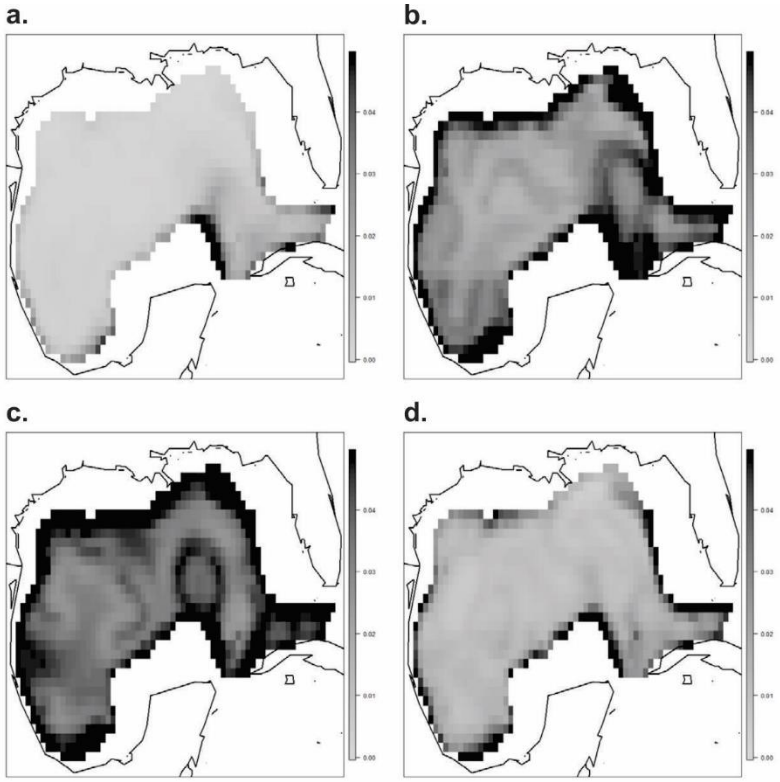


Figure 2. Sailfish abundance indices predicted from the fitted delta generalized additive models for Jan. – Mar. (a), Apr. – Jun. (b), Jul. – Sep. (c), and Oct. – Dec. (d). Predictions were generated from data fishnets (0.1° latitude by 0.1° longitude) representing seasonal averages of numerical model descriptors for the year 2010. Fishnets were generated using data from NCEI and NOAA. Plots were generated from the daytime fishnets (nighttime fishnets displayed similar patterns with slightly larger abundance indices).

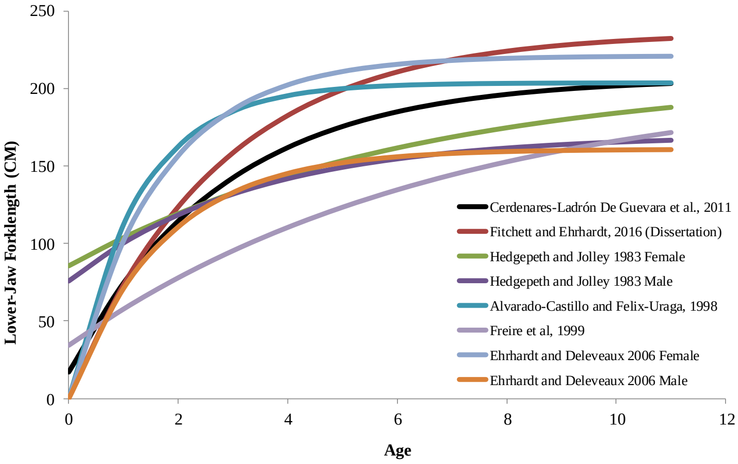


Figure 3. Von Bertalanffy growth plots examined to determine appropriate sailfish growth parameters to be used in assessment.

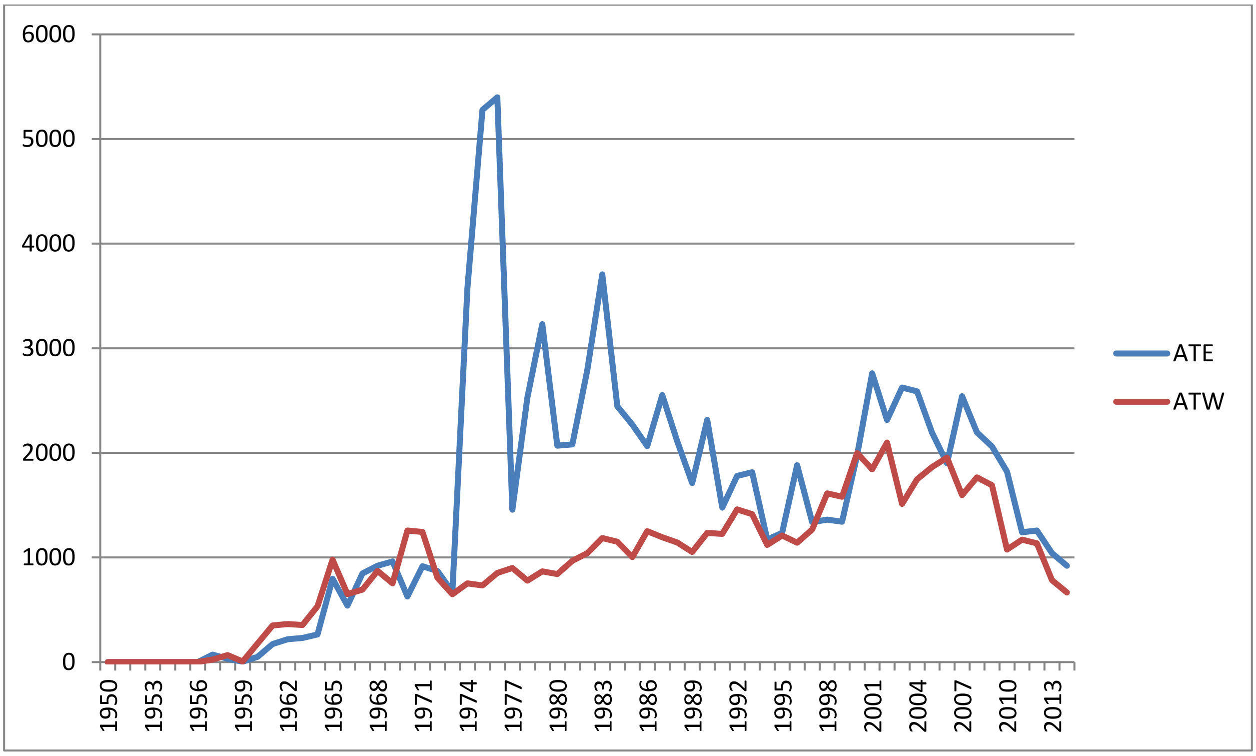


Figure 4. Sailfish Task I nominal catches (t) by year for western (red line) and eastern stock (blue line).

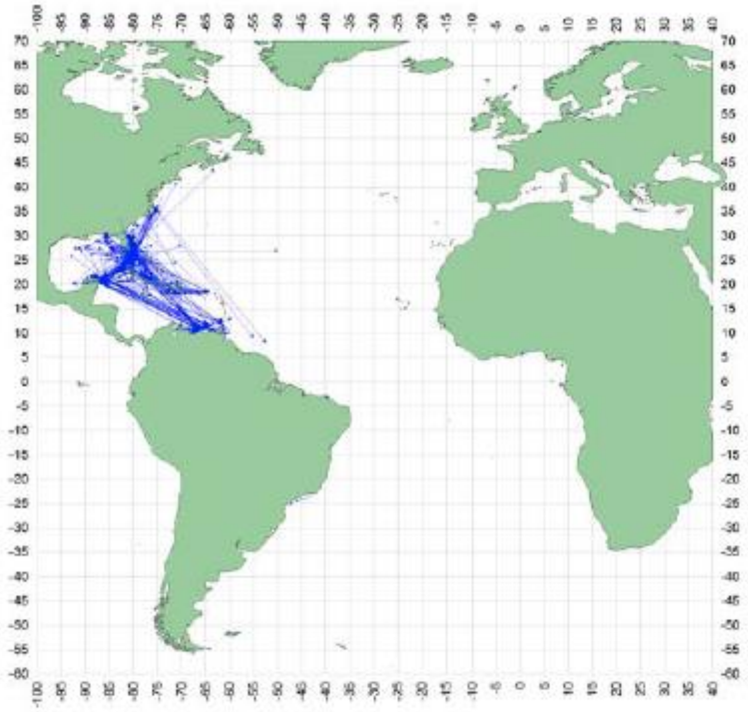


Figure 5. Straight displacements between release and recovery positions (apparent movement), from conventional tagging of sailfish.

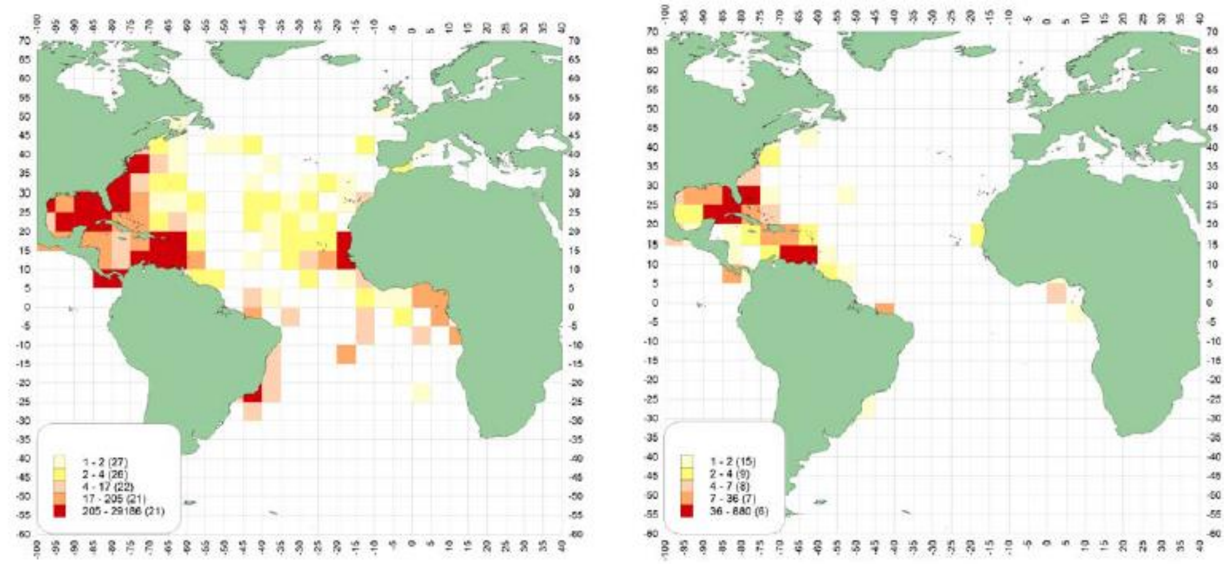


Figure 6. Density (5 by 5 degrees squares) of SAI releases (left) and recoveries (right).

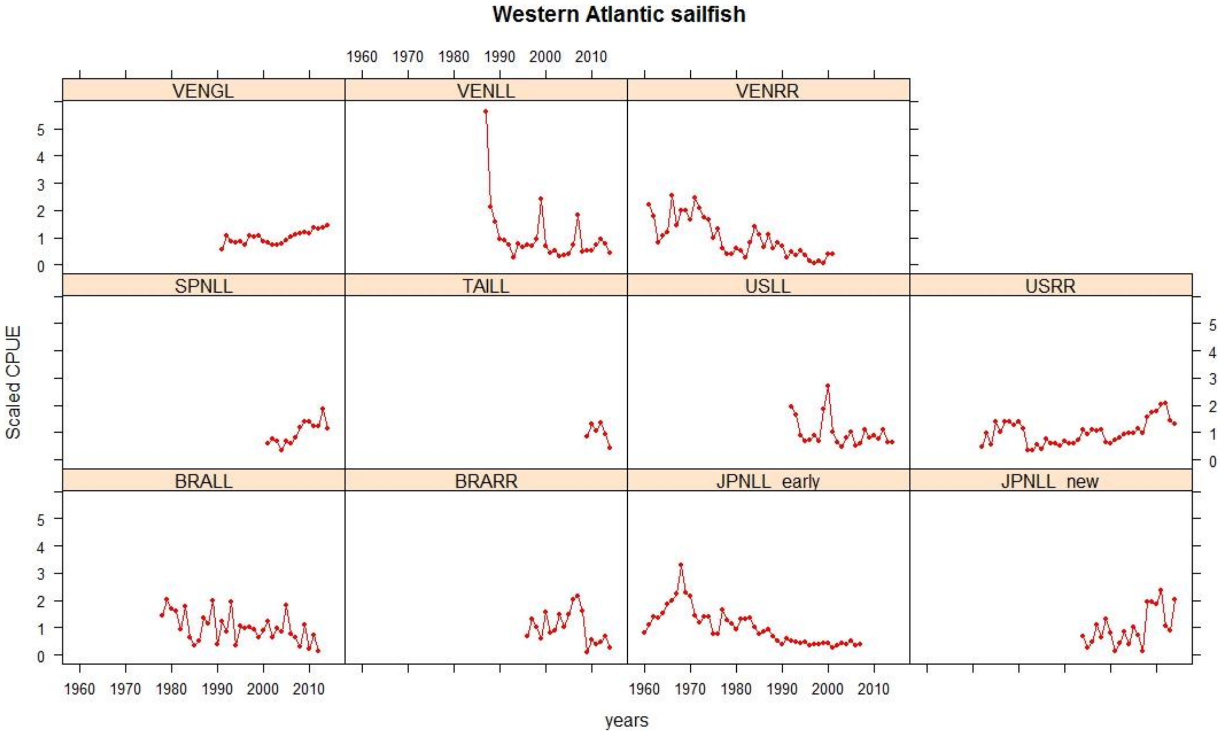


Figure 7. Indices of abundance used for the western sailfish stock.

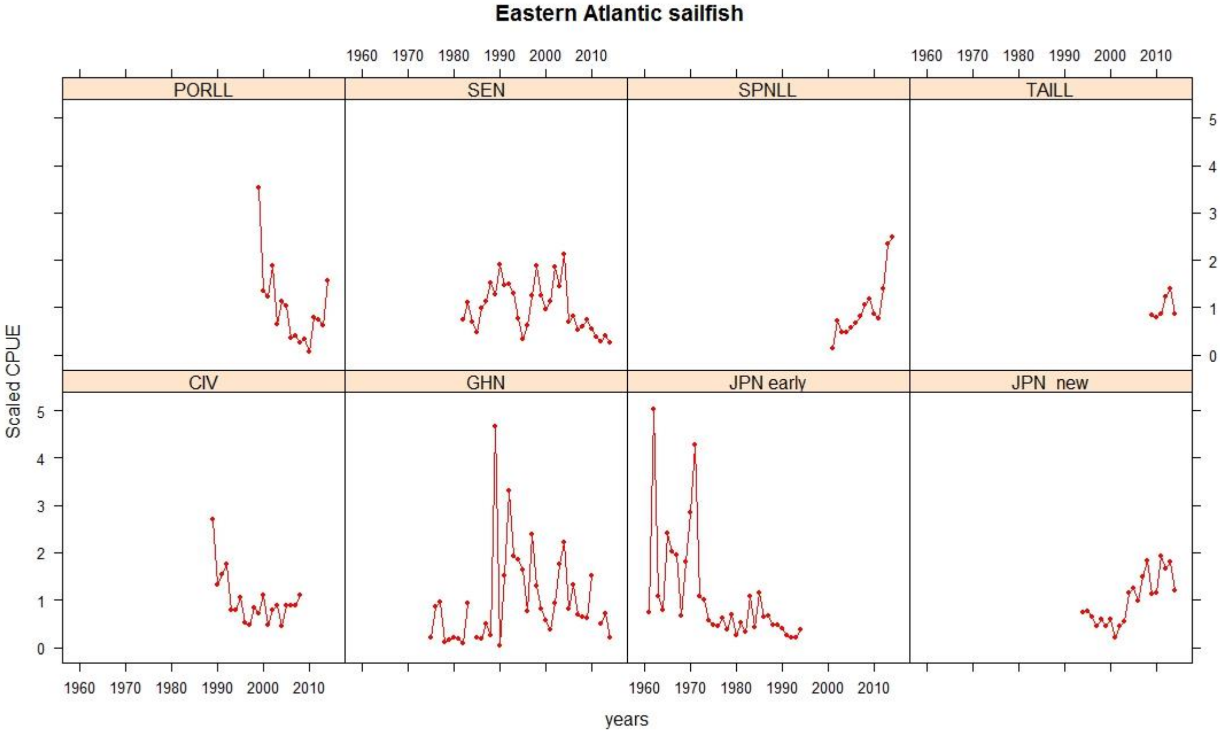


Figure 8. Indices of abundance used for the eastern sailfish stock.

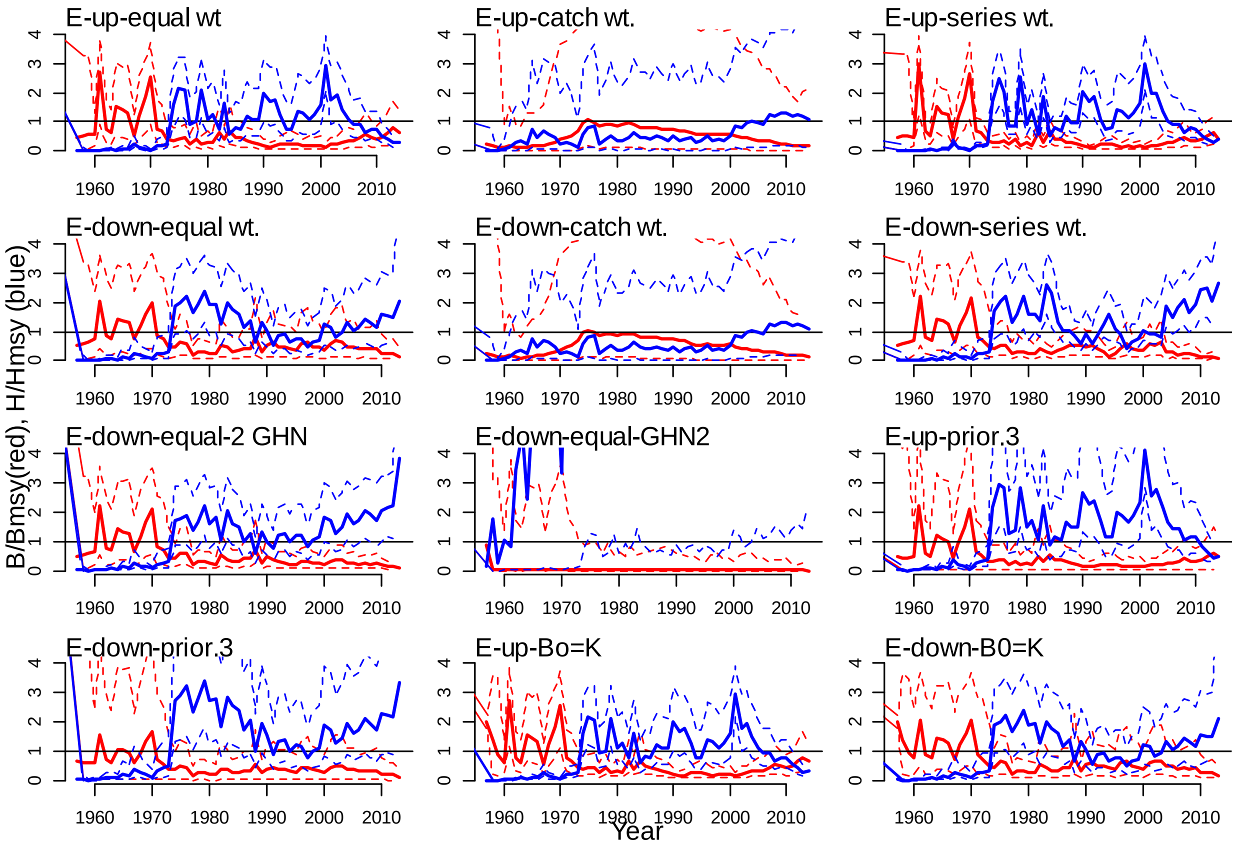


Figure 9. Biomass and harvest rate trajectories for the BSP-JAGS models in the east.

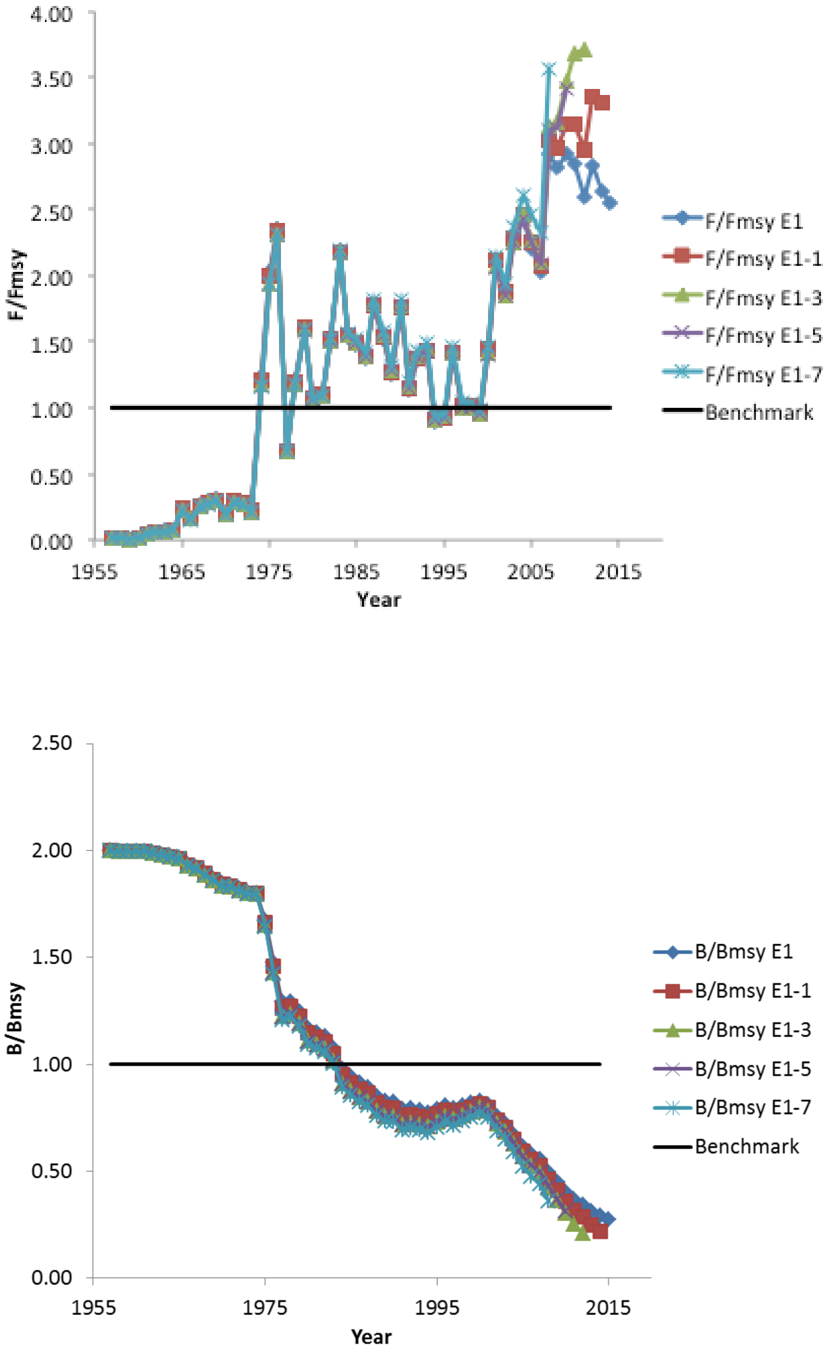
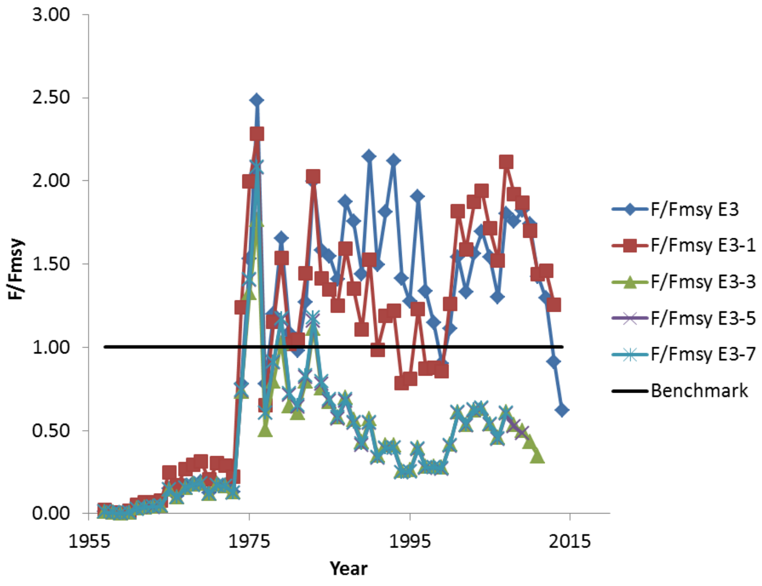


Figure 10. Retrospective Analyses for ASPIC run E1 for F/F$_{MSY}$ (upper panel) and B/B$_{MSY}$ (lower panel).



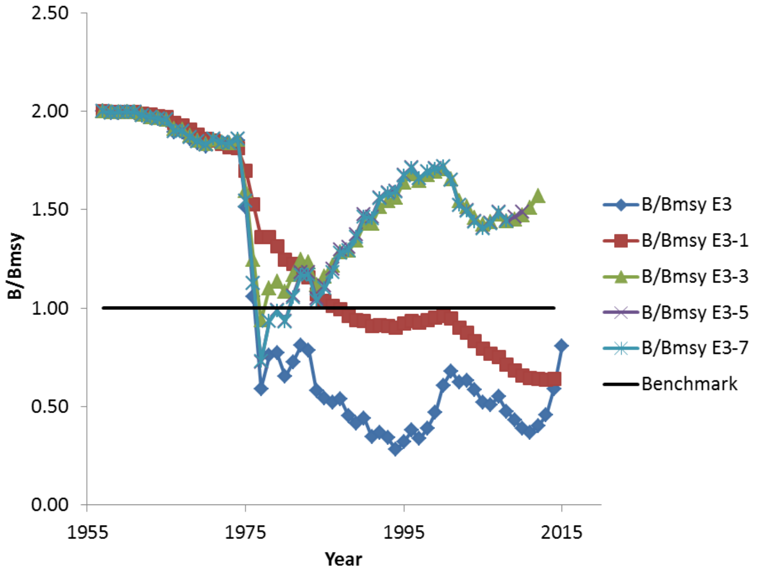


Figure 11. Retrospective Analyses for ASPIC run E3 for F/F$_{MSY}$ (upper panel) and B/B$_{MSY}$ (lower panel).

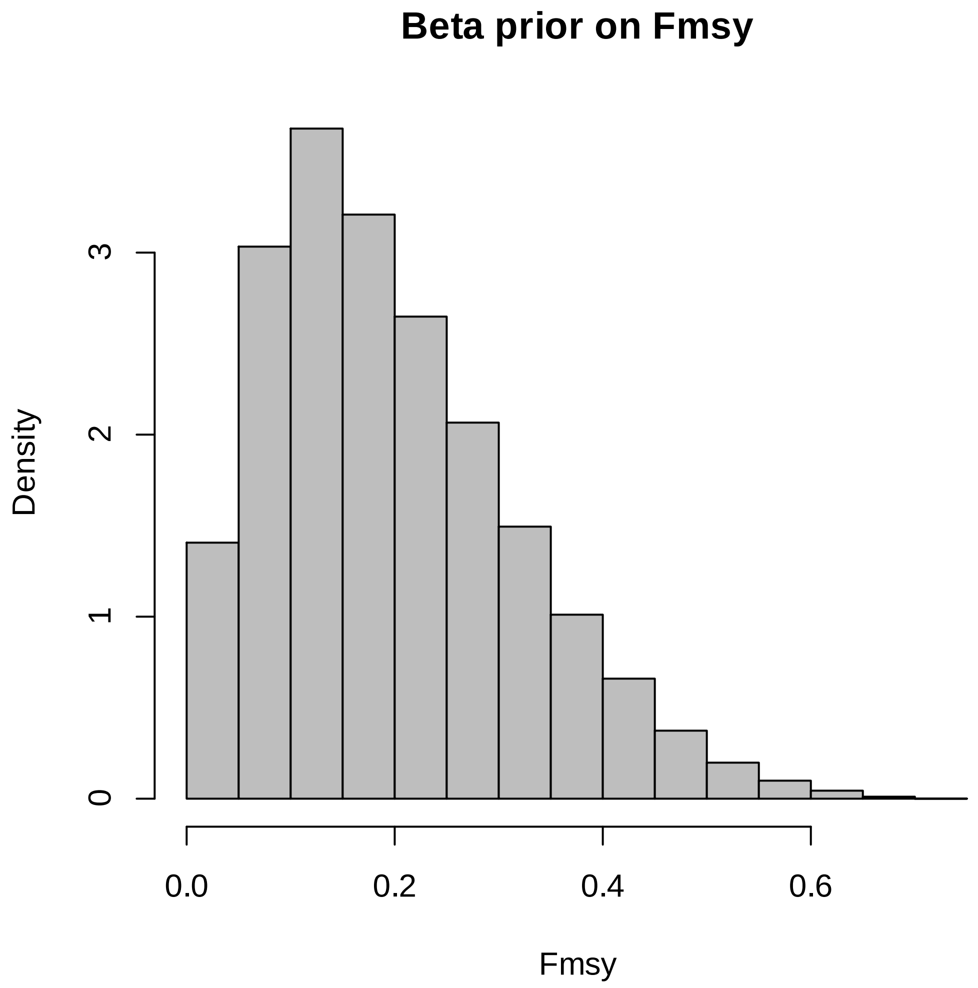
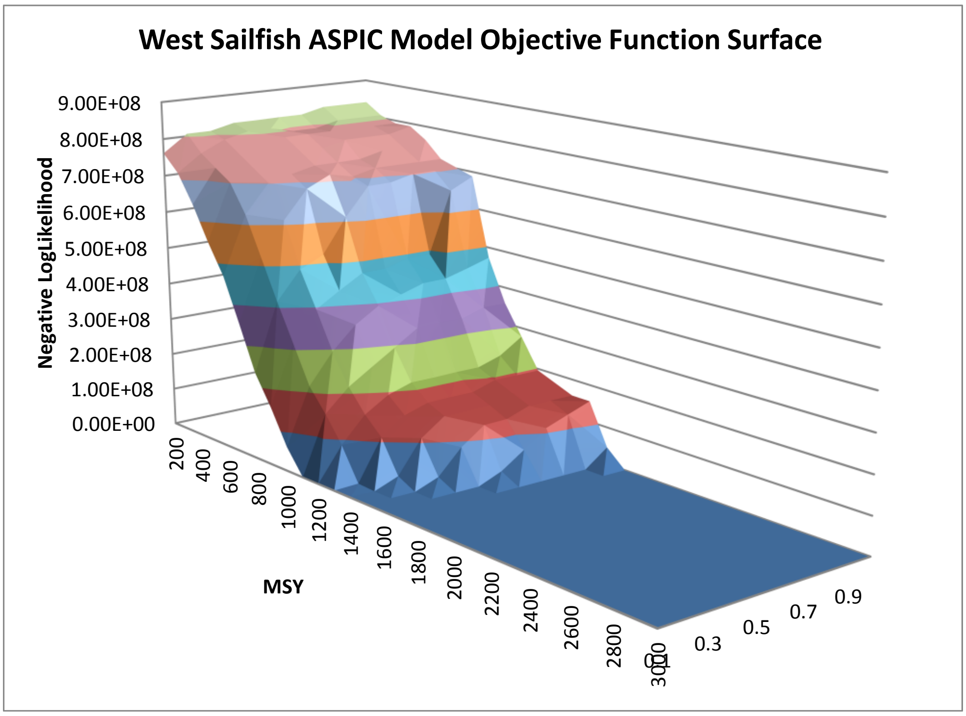


Figure 12. Prior on F_{MSY} for ASPIC surplus production model of western Atlantic sailfish.



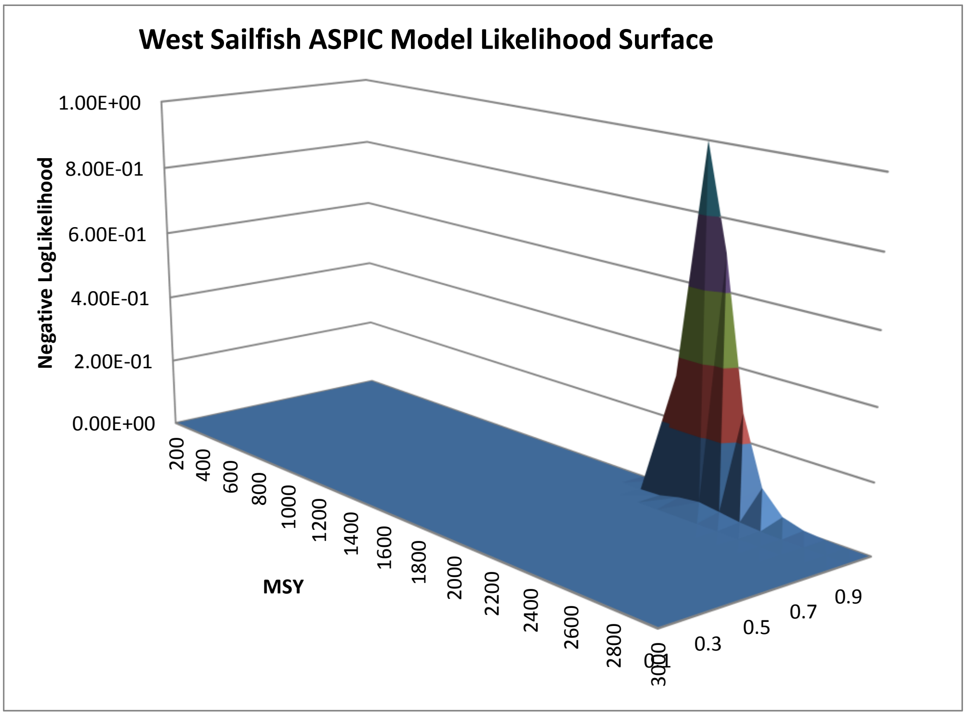


Figure 13. Upper panel: Surface profile of the objective function for the ASPIC base model of western sailfish. The contour flattens at a MSY of approximately 1,600 t across the full range of hypothesized F_{MSY}. Lower panel: Likelihood profile scaled to the maximum likelihood showing the model convergence to the upper bound on F_{MSY}.

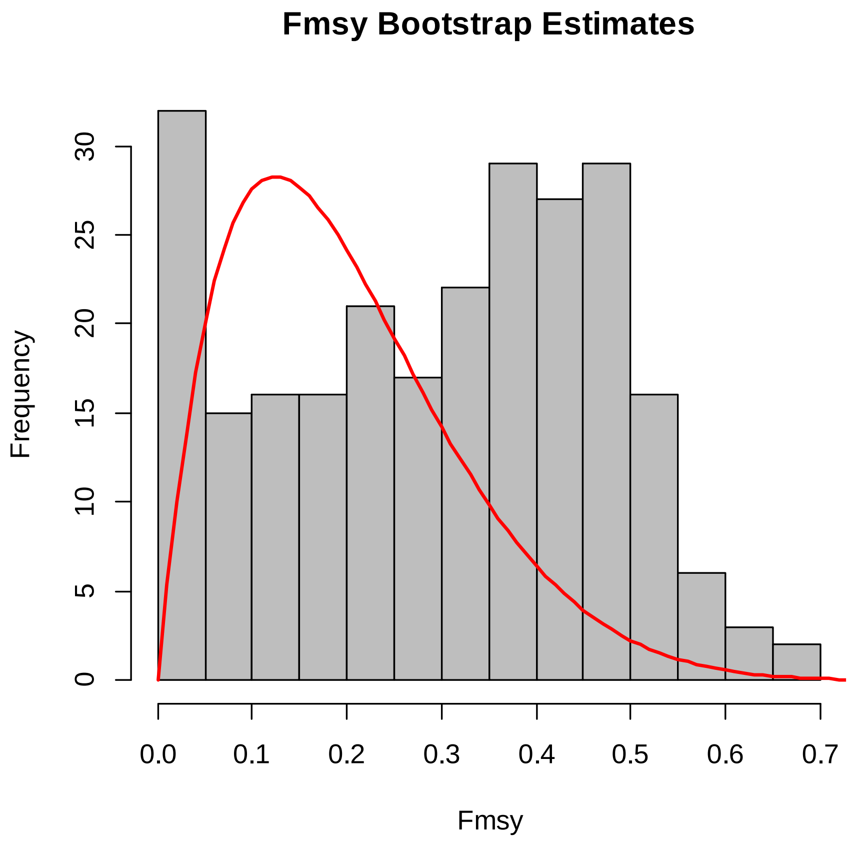


Figure 14. Bootstrap estimates of F_{MSY} from the ASPIC base model for western sailfish. The distribution of estimates is spread across the lower (0.01) and upper bounds (0.8) defined in the model.

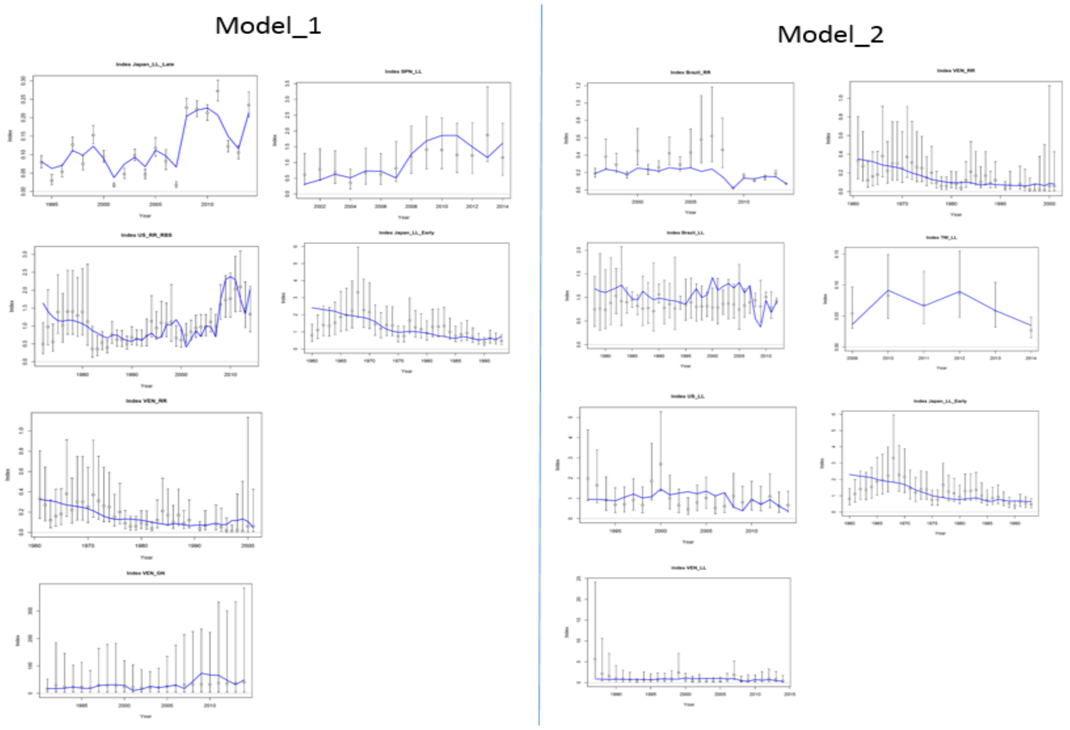
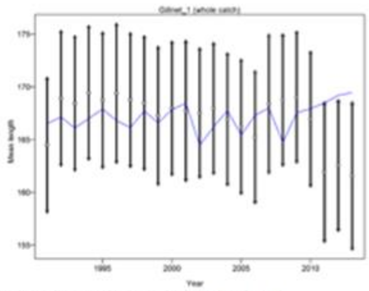
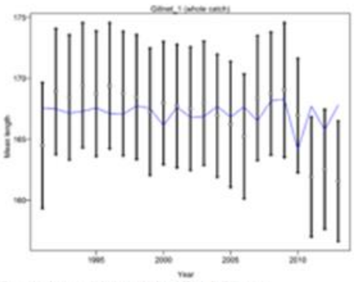


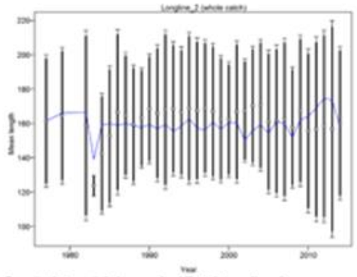
Figure 15. Fit to indices of abundance used in each of Model_1 (left) and Model_2 (right).



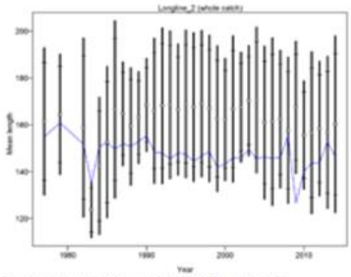
Francis data weighting method TA1.8 Gillnet_1
Suggested sample size adjustment (with 95% interval) for len data from Gillnet_1:
1.0592 (0.6981-3.3956)



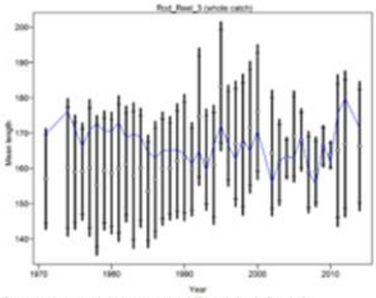
Francis data weighting method TA1.8 Gillnet_1
Suggested sample size adjustment (with 95% interval) for len data from Gillnet_1:
1.0295 (0.6393-3.2897)
file: comp_lenfit_data_weighting_TA1.8_Gillnet_1.png



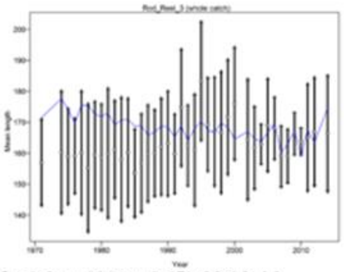
Francis data weighting method TA1.8 Longline_2
Suggested sample size adjustment (with 95% interval) for len data from Longline_2:
0.88 (0.3462-7.55)
file: comp_lenfit_data_weighting_TA1.8_Longline_2.png



Francis data weighting method TA1.8 Longline_2
Suggested sample size adjustment (with 95% interval) for len data from Longline_2:
1.555 (0.8533-4.6563)
file: comp_lenfit_data_weighting_TA1.8_Longline_2.png



Francis data weighting method TA1.8 Rod_Reel_3
Suggested sample size adjustment (with 95% interval) for len data from Rod_Reel_3:
1.2879 (0.9984-1.934)
file: comp_lenfit_data_weighting_TA1.8_Rod_Reel_3.png



Francis data weighting method TA1.8 Rod_Reel_3
Suggested sample size adjustment (with 95% interval) for len data from Rod_Reel_3:
1.0726 (0.7305-1.9627)
file: comp_lenfit_data_weighting_TA1.8_Rod_Reel_3.png

Figure 16. Observed (bars) and expected (blue line) mean weight of catch from the three gear types for Model_1 (left) and Model_2 (right).

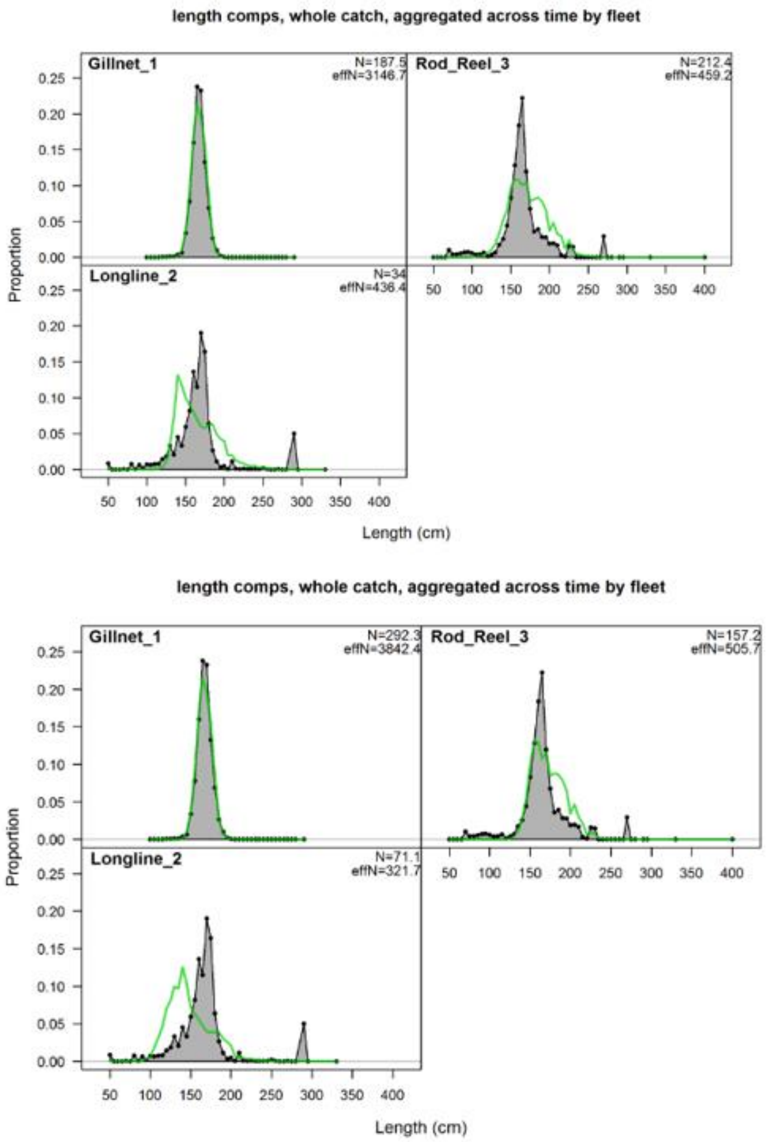


Figure 17. Overall fit to length composition data from each of the three gear types for Model_1 (top) and Model_2 (bottom).

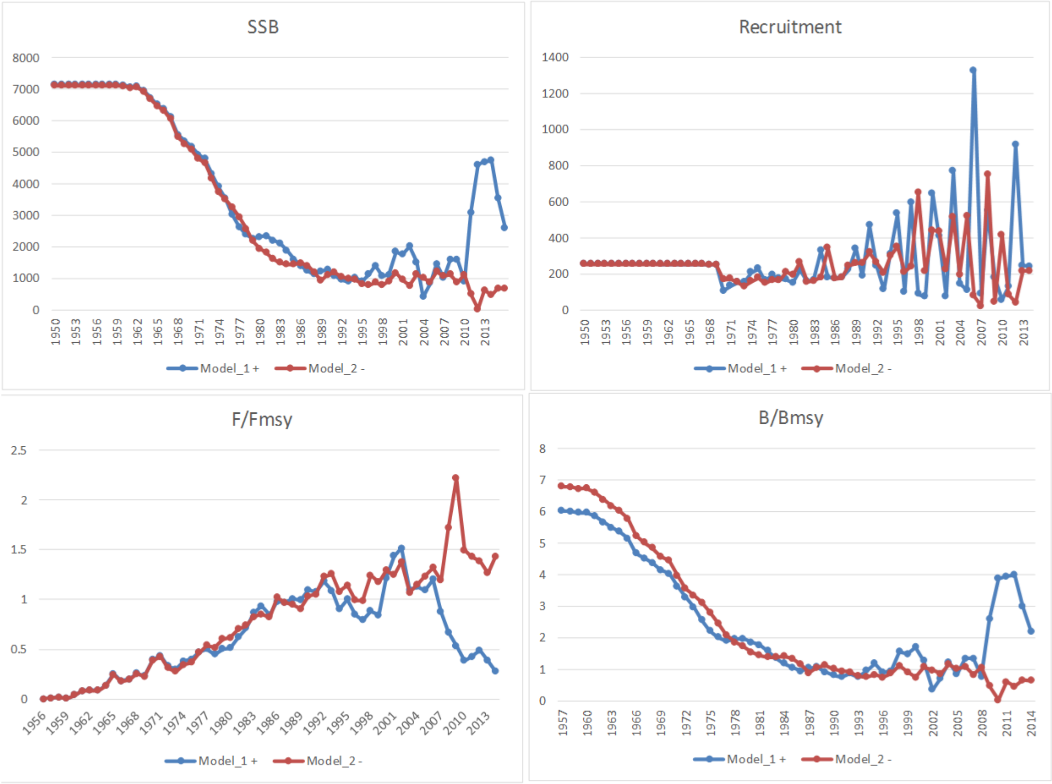
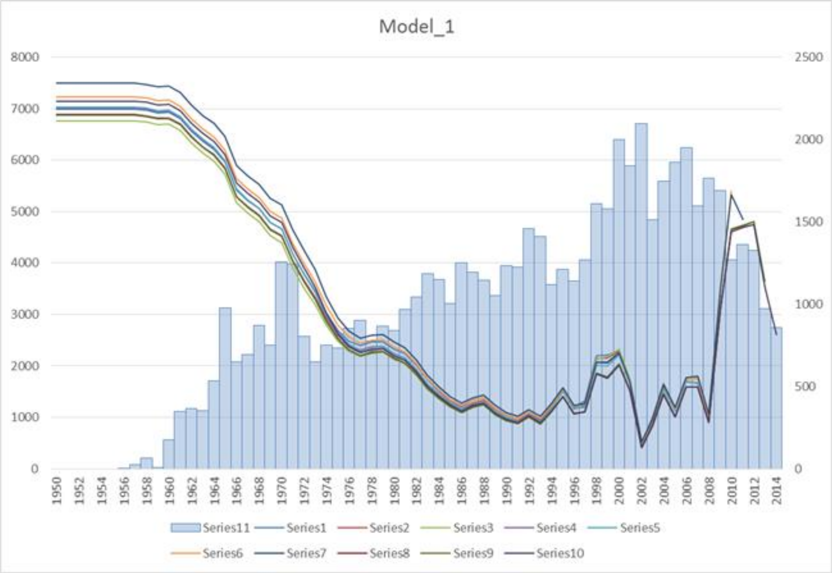


Figure 18. Estimated historic trends in spawning stock biomass (upper left), recruitment (upper right), F/F$_{MSY}$ (lower left) and B/B$_{MSY}$ (lower right) for Model_1 (blue) and Model_2 (red).



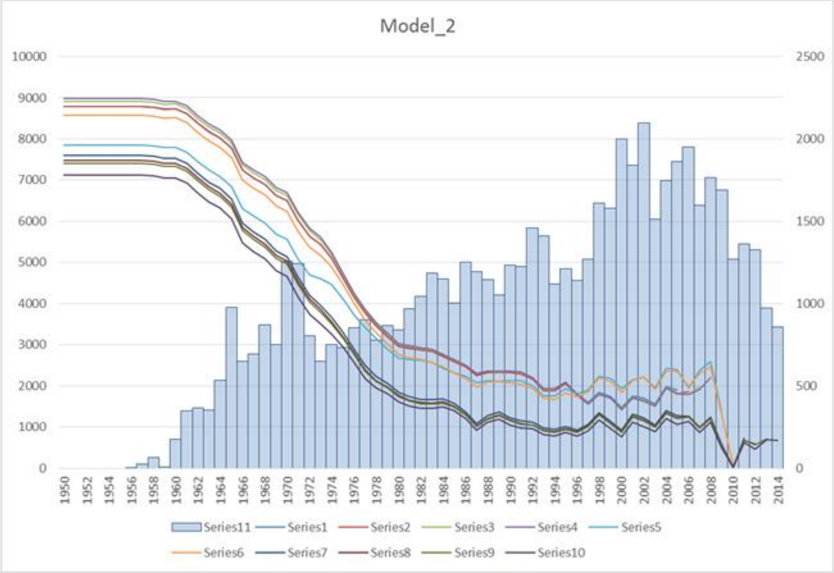


Figure 19. Retrospective analysis Model_1 (top) and Model_2 (bottom).

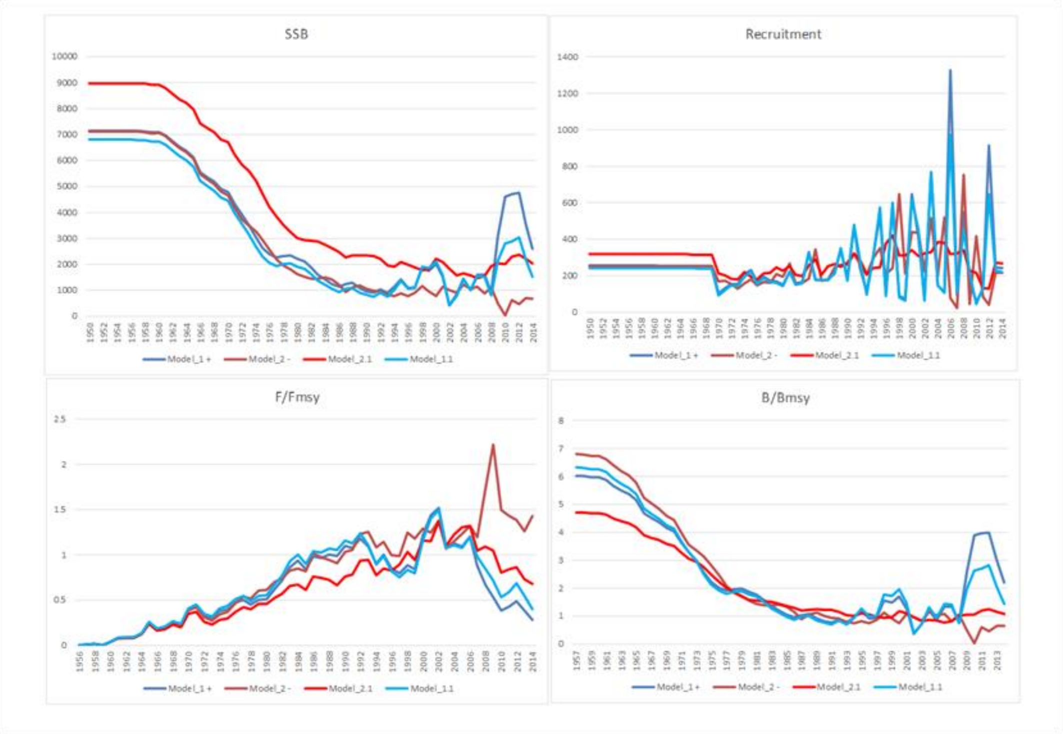


Figure 20. Estimated historic trends in spawning stock biomass (upper left), recruitment (upper right), F/F$_{MSY}$ (lower left) and B/B$_{MSY}$ (lower right) for Model_1 (dark blue) and Model_2 (dark red), Model_1.1 (light blue) and Model_2.1 (light red).

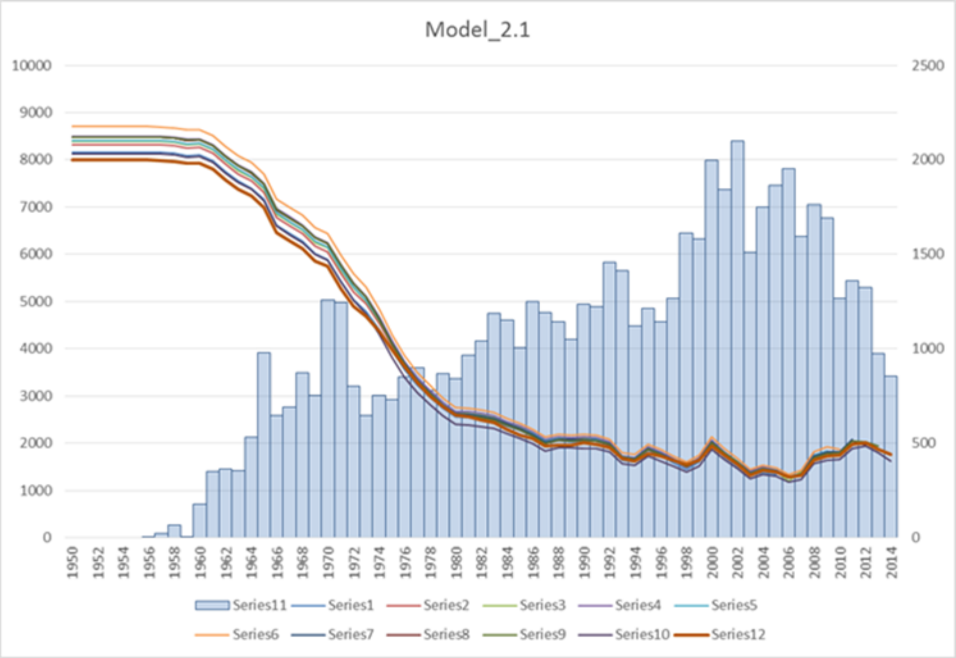


Figure 21. Retrospective analysis for Model_2.1.

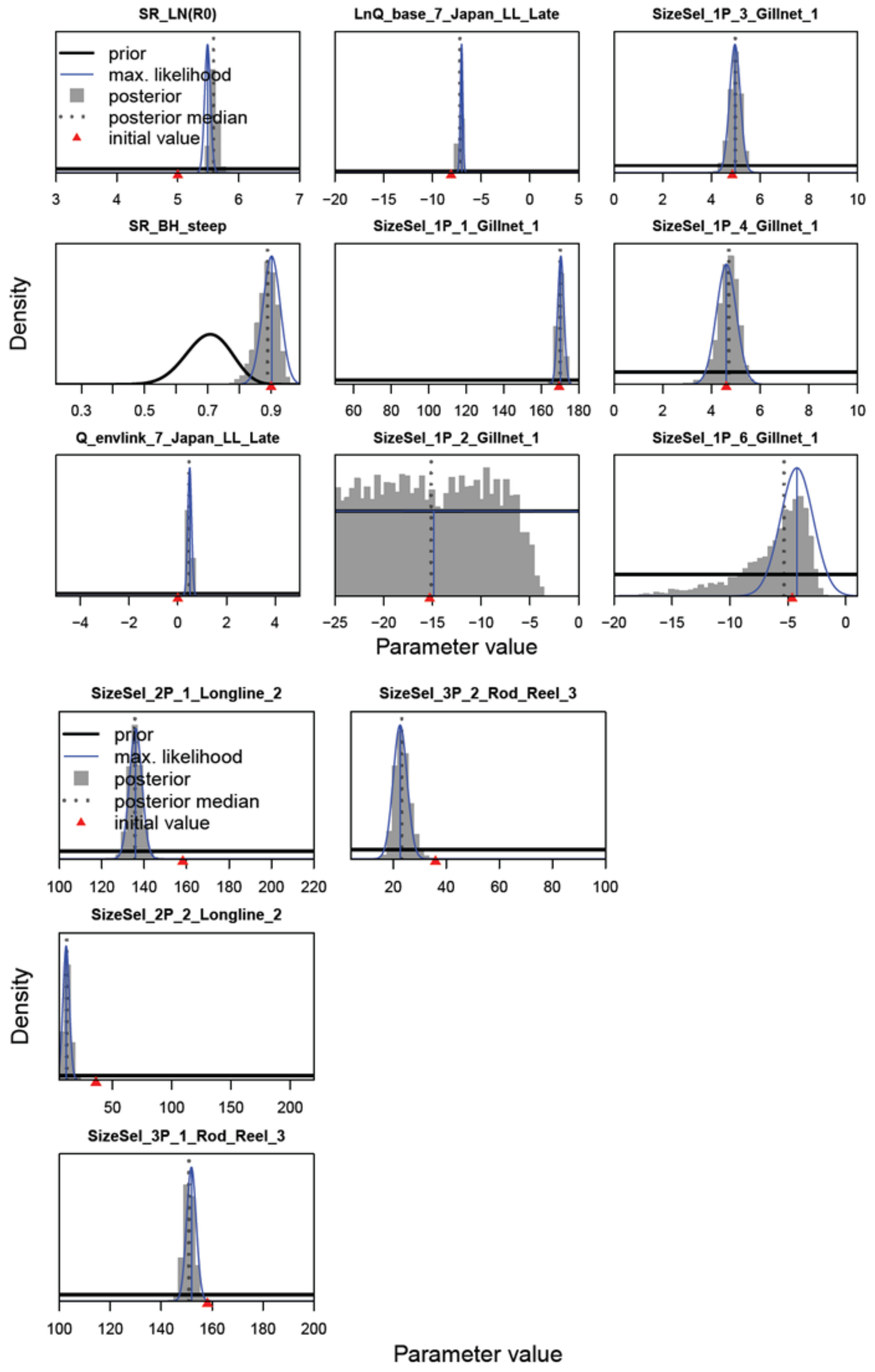


Figure 22. Prior, maximum likelihood, and posterior distributions from MCMC analysis of Model_1.1. Red triangle represents the starting value and the dotted line the posterior median value.

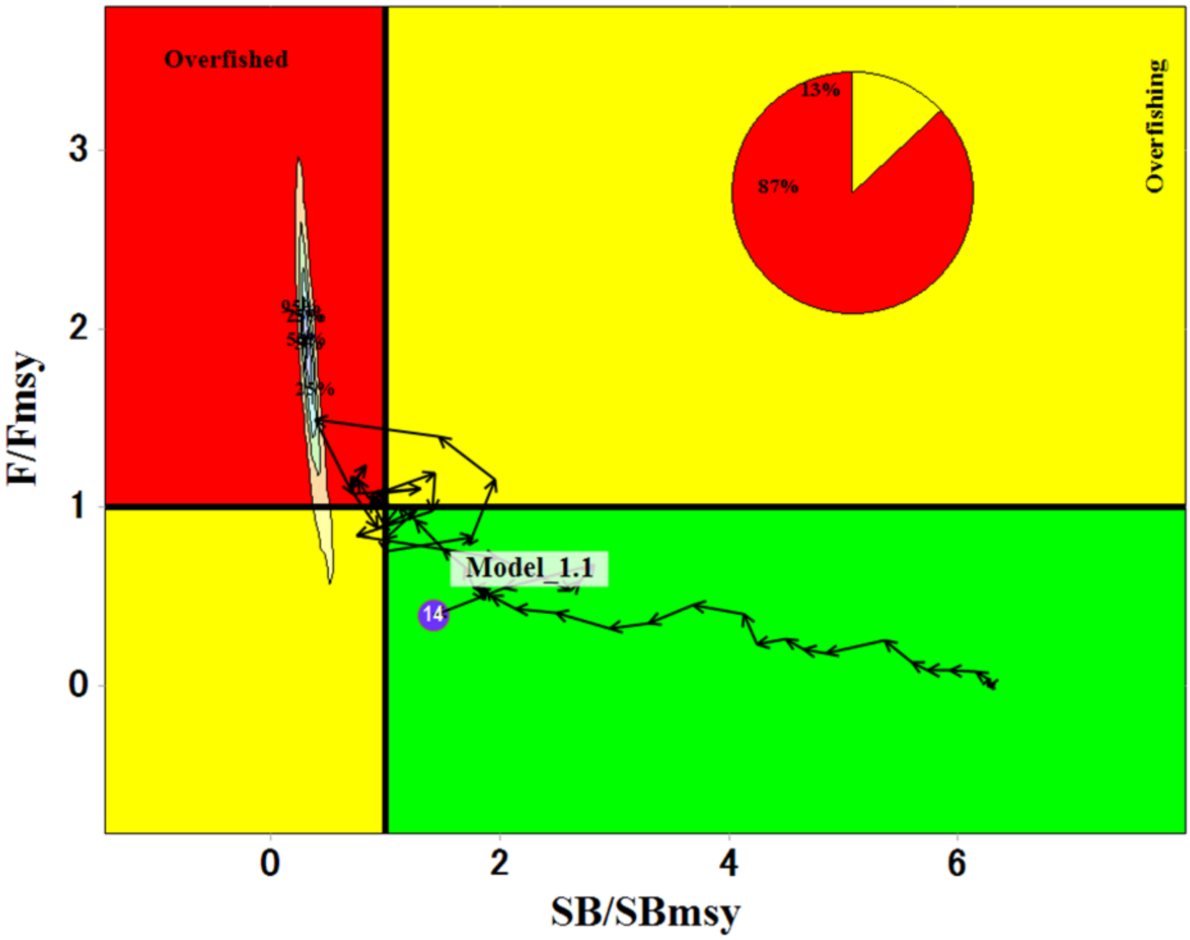


Figure 23. Kobe status plot for Model_1.1

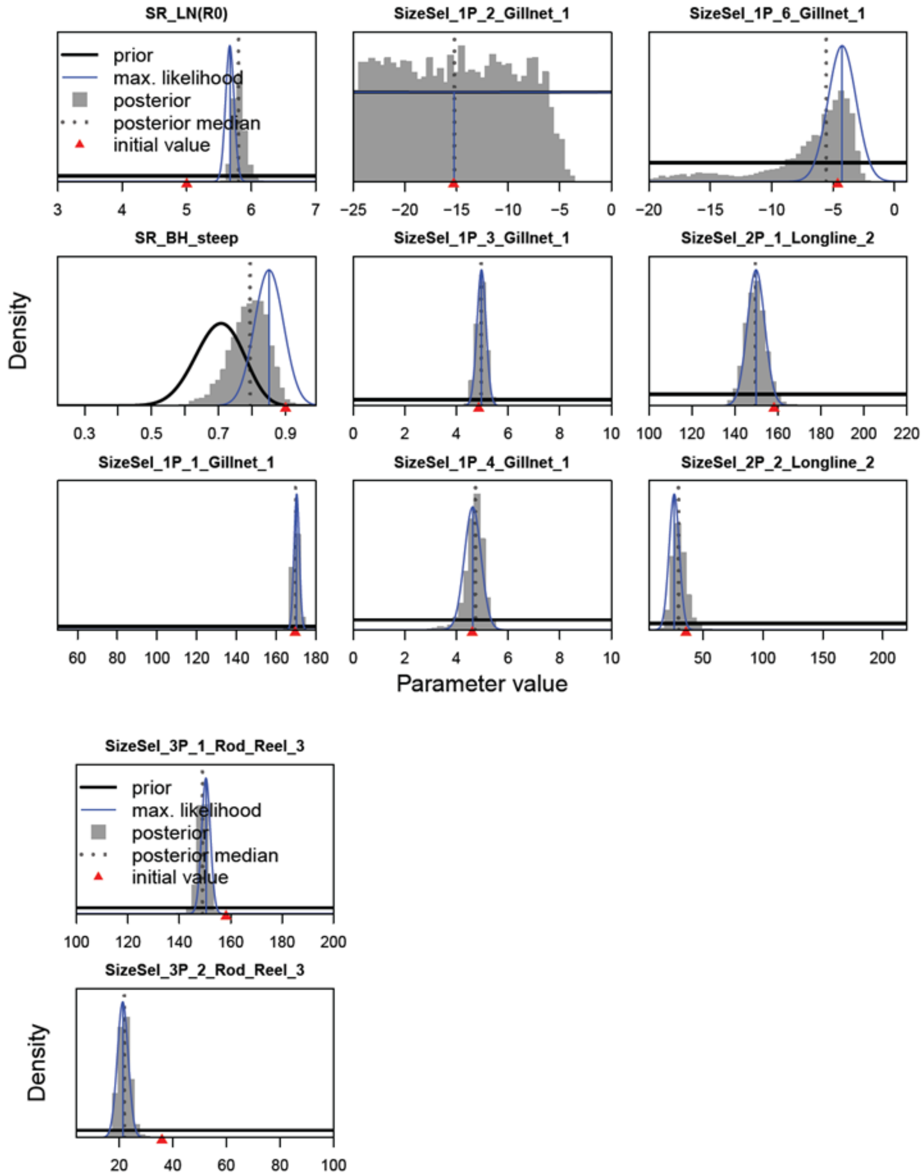


Figure 24. Prior, maximum likelihood, and posterior distributions from MCMC analysis of Model_2.1. Red triangle represents the starting value and the dotted line the posterior median value.

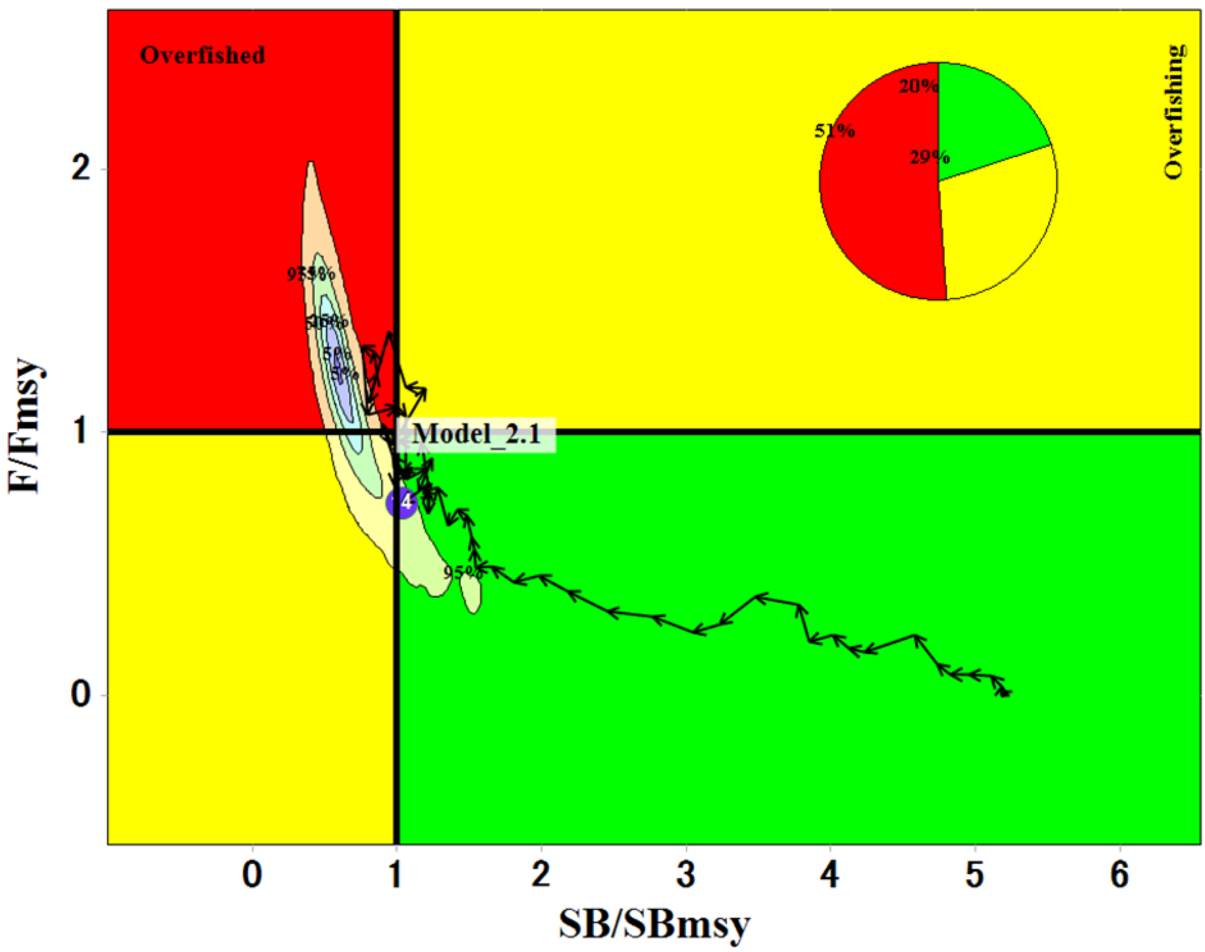


Figure 25. Kobe status plot for Model_2.1

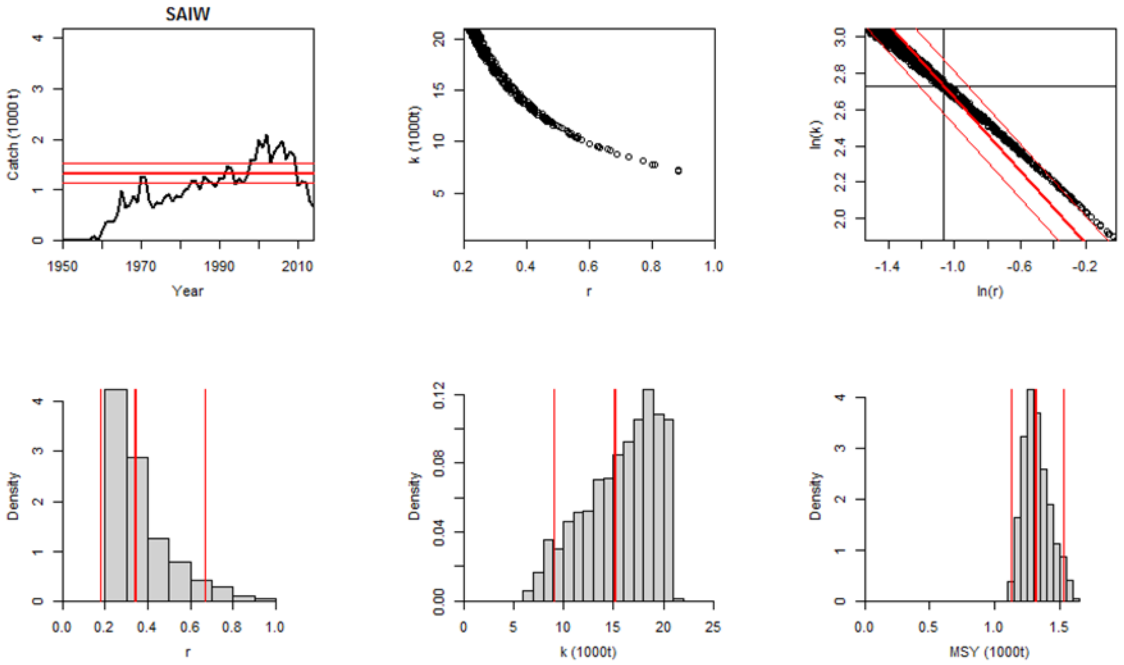


Figure 26. Posterior distributions of r, K, and MSY for SRA SAI_west.

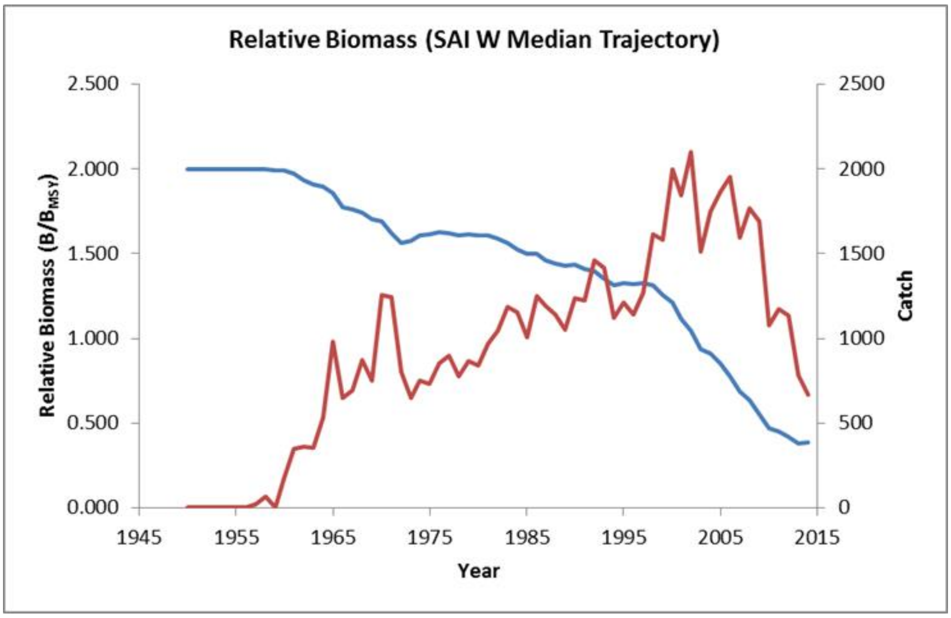


Figure 27. Median Biomass trajectory for SAI_west.

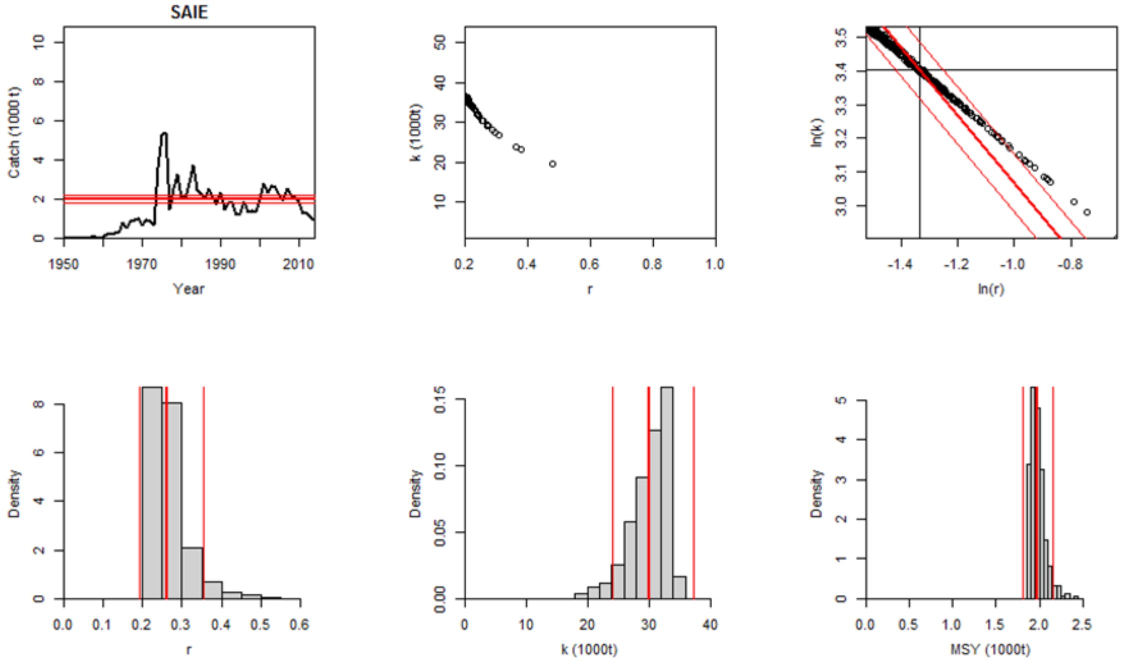


Figure 28. Posterior distributions of r, K, and MSY for SRA SAI_east.

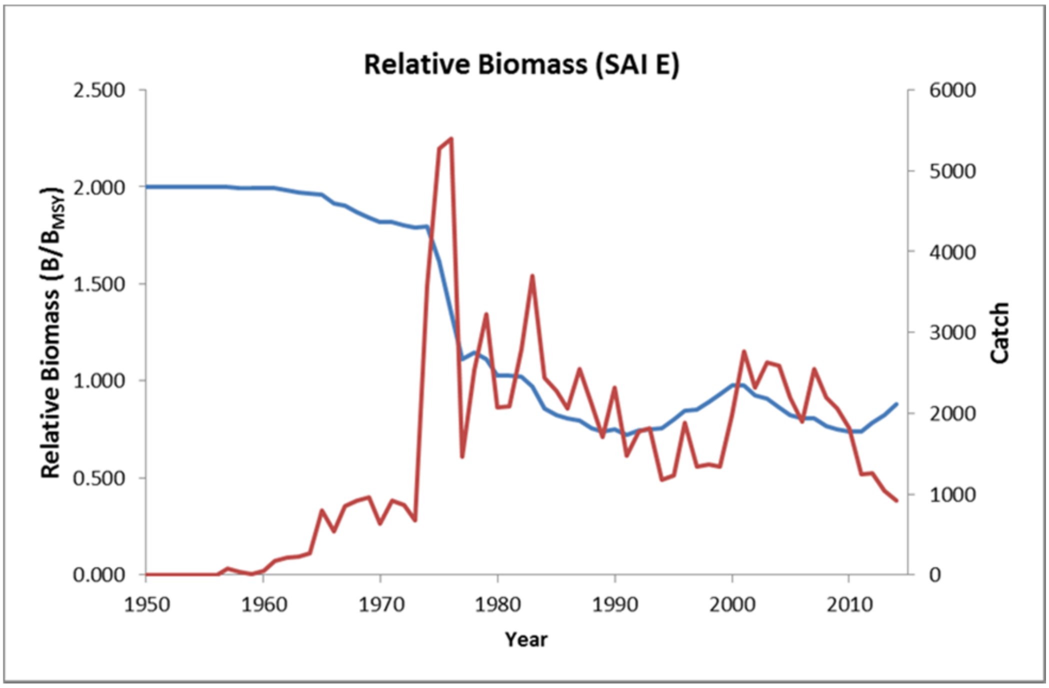


Figure 29. Median Biomass trajectory for SAI_east.

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, and size
    2.3. Relative abundance estimates (CPUEs)
3. Stock Assessment
    3.1. SAI east
    3.2. SAI west
4. Management recommendations
    4.1. SAI east
    4.2. SAI west
5. Recommendations on research and statistics
6. Other matters
7. Adoption of the report and closure

Appendix 2

List of Participants

BRAZIL

Leite Mourato, Bruno
Profesor Adjunto, Departamento de Ciências do Mar, Universidade Federal de São Paulo Avenida Almirante Saldanha da Gama, 89. Ponta da Praia, 11030-400 Santos, SP, Brazil
Tel: +55 61 2023 3540, Fax: +55 61 2023 3909, E-Mail: bruno.pesca@gmail.com;mouratobr@gmail.com

CÔTE D'IVOIRE

Konan, Kouadio Justin
Chercheur Hidrobiologiste, Centre de Recherches Océanologiques (CRO), 29 Rue des Pêcheurs, BP V 18, Abidjan 01, Côte d'Ivoire
Tel: +225 07 625 271, Fax: +225 21 351155, E-Mail: konankouadjustin@yahoo.fr

EUROPEAN UNION

Fernández Costa, Jose Ramón
Ministerio de Economía y Competitividad, Instituto Español de Oceanografía - C. Costero de A Coruña, Paseo Marítimo Alcalde Francisco Vázquez, 10 - P.O. Box 130, 15001 A Coruña, Spain
Tel: +34 981 218 151, Fax: +34 981 229 077, E-Mail: jose.costa@co.ieo.es

GHANA

Ayivi, Sylvia Sefakor Awo
Fisheries Directorate of the Ministry of Food and Agriculture, Marine Fisheries Research Division P.O. Box BT 62, Tema, Ghana
Tel: + 233 2441 76300, Fax: +233 3032 008048, E-Mail: asmasus@yahoo.com

S. TOMÉ E PRÍNCIPE

Da Conceiçao, Ilair
Chef du Département de Recherche, Statistiques et de l'aquaculture, Direcçao das Pescas, Responsavel pelo serviço de Estatística Pesqueira Bairro 3 de Fevereiro - PB 59, Sao Tomé, São Tomé and Príncipe
Tel: +239 990 9315, Fax: +239 12 22 414, E-Mail: ilair1984@gmail.com

SENEGAL

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

UNITED STATES

Babcock, Elizabeth
Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33133, United States
Tel: +1 305 421 4852, Fax: +1 305 421 4600, E-Mail: ebabcock@rsmas.miami.edu

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

Díaz, Guillermo
NOAA-Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33139, United States
Tel: +1 305 361 4277, E-Mail: guillermo.diaz@noaa.gov

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

Fitchett, Mark
University of RSMAS, 4600 Rickenbacker Causeway, Miami Florida 33149, United States
Tel: +1 305 989 8308, Fax: +1 305 421 4600, E-Mail: mfitchett@rsmas.miami.edu

Forrestal, Francesca
Cooperative Institute of Marine and Atmospheric Studies, University of Miami, RSMAS/CIMAS4600 Rickenbacker Causeway, Miami Florida 33149, United States
Tel: +1 305 421 4831, E-Mail: fforrestal@rsmas.miami.edu

Hoolihan, John
NOAA Fisheries, Southeast Fisheries Science Center75 Virginia Beach Drive, Miami Florida 33149, United States
Tel: +1 305 282 8376, Fax: +1 305 361 4562, E-Mail: john.hoolihan@noaa.gov

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

Perryman, Holly
CSWY, 4600 Rickenbacker CSWY, Miami, FL 33165, United States
Tel: +1 305 421 4924, E-Mail: hperryman@rsmas.miami.edu

Prince, Eric
33 Senner Court, Shalimar Florida 32579, United States
Tel: +1 305 298 5849, E-Mail: drmarlin1947@gmail.com

Schirripa, Michael
NOAA Fisheries, Southeast Fisheries Science Center75 Virginia Beach Drive, Miami Florida 33149, United States
Tel: +1 305 361 4568, Fax: +1 305 361 4562, E-Mail: michael.schirripa@noaa.gov

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

Walter, John
NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division75 Virginia Beach Drive, Miami, Florida 33149, United States
Tel: +305 365 4114, Fax: +1 305 361 4562, E-Mail: john.f.walter@noaa.gov

VENEZUELA

Arocha, Freddy
Instituto Oceanográfico de Venezuela Universidad de Oriente, A.P. 204, 6101 Cumaná Estado Sucre, Venezuela
Tel: +58-293-400-2111 ; mobile +58 416 693 0389, E-Mail: farocha@udo.edu.ve; farochap@gmail.com

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

CHINESE TAIPEI

Su, Nan-Jay
Assistant Professor, Department of Environmental Biology and Fisheries Science, No. 2 Pei-Ning Rd. Keelung, Taiwan, Chinese Taipei
Tel: +886 2 2462-2192 #5046, E-Mail: nanjay@ntou.edu.tw

OBSERVERS FROM INTERGOVERNMENTAL ORGANIZATIONS

FOOD AND AGRICULTURE ORGANIZATION - FAO

Pérez Moreno, Manuel
United Nations House, Christ Church, BB11000 Bridgetown, Barbados
Tel: +1 246 426 7110, E-Mail: manuel.perezmoreno@fao.org

ICCAT

De Bruyn, Paul
ICCAT Secretariat,
Mail: paul.debruyn@iccat.int

Appendix 3

List of documents

SCRS/2016/071	Standardized catch rates of sailfish (*Istiophorus albicans*) caught as bycatch of the Spanish surface longline fishery targeting swordfish (*Xiphias gladius*) in the Atlantic Ocean	García-Cortés B., Ramos-Cartelle A., Fernández-Costa J., and Mejuto J.
SCRS/2016/075	Standardized CPUE from the Rod and Reel and artisanal drift-gillnet fisheries off La Guaira, Venezuela, updated through 2014.	Babcock E.A., and Arocha F.
SCRS/2016/092	Standardized catch rates of sailfish caught by the Brazilian fleet (1978-2012) using a Generalized Linear Mixed Model (GLMM), with a delta log approach	Mourato B.L., Hazin H., Carvalho F., and Hazin F.
SCRS/2016/093	Estimated sailfish catch-per-unit-effort for the U.S. recreational billfish tournaments and U.S. recreational fishery (1972-2014)	Hoolihan J.P., and Lauretta M.
SCRS/2016/094	Standardized CPUE for sailfish caught by the Japanese tuna longline fishery in the Atlantic Ocean from 1994 to 2014	Kai M., and Okamoto H.
SCRS/2016/095	Regional Caribbean Billfish Management and Conservation Plan	Perez-Moreno M.
SCRS/2016/098	Characterization and standardization of the Atlantic sailfish (*Istiophorus albicans*) catch rates in the East Atlantic from the Portuguese pelagic longline fishery	Coelho R., Lino P.G., and Santos M.N.
SCRS/2016/099	Generalized additive models for predicting the spatial distribution of billfishes and tunas across the Gulf of Mexico	Perryman H.A., and Babcock E.A.
SCRS/2016/100	An assessment of Western Atlantic sailfish for 2016	Schirripa M.J.
SCRS/2016/101	Maximum sizes in the Atlantic sailfish catch	Goodyear C.P., and Schirripa M.J.
SCRS/2016/102	CPUE standardization of sailfish (*Istiophorus platypterus*) for the Taiwanese distant-water longline fishery in the Atlantic Ocean	Su, N-J and Sun, C-L
SCRS/2016/103	Stock Assessment of Western Atlantic Sailfish (*Istiophorus platypterus*) Using a Bayesian State-Space Surplus Production Model	Mourato, B. L. and Carvalho, F.

Presentations

SCRS/P/2016/025	Genetic stock delimitation of sailfish (*Istiophorus platypterus*) in the Atlantic Ocean	Ferrette B.P.L.S., Mourato B., Coelho R., Santos M.N., Oliveira C., Foresti F., Amorim A.F., Arocha F., Hoolihan J., Constance D., Ngom-Sow F., Mendonça F.
SCRS/P/2016/026	Relative Abundance Indices for Atlantic Sailfish (*Istiophorus albicans*) from the Artisanal Fleet from Senegal	Ngom-Sow, F. N.
SCRS/P/2016/027	Standardization of CPUE Series for the Ghanaian Artisanal Sailfish Fishery	Ayivi, S.

Appendix 4

Ghana data estimations

During the 2009 assessment it was reported that the catch and effort data from Ghana used in the standardization of CPUE for the gillnet fishery had very different patterns in the relationships between CPUE, trips and number of canoes when you compared data prior or after 1992. Such differences led the group in 2009 to disregard the Ghana CPUE data prior to 1992. Such pattern was also seen again when the data were standardized in preparation for the current assessment (SCRS/P/2016/027).

At the current assessment it was pointed out that the reported catch of Ghana changed greatly prior an after 1992. Catches from the 1970s contain values five to ten times greater than those after 1992. During the mid 1970s the Ghana catch represent more than 80% of all Atlantic catch. Such high catches prior to 1992 occurred at a time when the number of canoes was not very different to levels post 1992, so they cannot be explained by simply the presence of a larger fleet in the historical period (**Figure 1**). Furthermore, prior to 1992 the species composition of billfish landings reported by Ghana is very different to that post 1989 (**Figure 2**). The post 1989 species composition is, however, similar to the species composition of the gillnet fishery of neighboring Cote d'Ivoire (**Figure 3**), except that Ghanaian catches have relatively more sailfish than Côte d'Ivoire.

All these observations suggest that the Task I reported catch of billfish for Ghana may not be accurate. The Group recommends that Ghanaian landings prior to 1972 should be reviewed thoroughly, however, the group agreed the reported catches from task 1 were to be used for the assessment.

The Group, however, estimated an alternative series of Ghanaian landings of billfish for the period 1956-1989 to be used as a sensitivity analysis. Alternative catches were obtained by estimating an average species composition of billfish for the period 1990-1999 and calculating the average catch of each billfish per canoe from the data for that same period. The billfish catch for each year was then calculated as the product of the number of canoes that year and the average annual catch per canoe for each species.

The alternative catch estimated for Ghana from 1973-1989 (**Table 1, Figure 4**) is much lower than that reported to ICCAT in Task I but similar to catches in the 1990s, however, the catch estimated prior to 1973 is significant, even though no catch was reported to ICCAT. It is important to note that these calculations assume that the catch composition does not change through time, that annual catch per canoe was constant and that the number of canoes is a good index of gillnet effort. Nunoo *et al.* 2015 point out that the Ghanaian fishing fleet existed long before it started being mechanized in the 1940s, so it is possible that the catches of sailfish extend back to the 1950s and possibly earlier.

References

Nunoo F.K.E., Asiedu B., Amador K., Blhabib D. and D. Pauly. 2015. Reconstruction of marine fisheries catches for Ghana, 1950-2010. Fisheries Center, the University of British Columbia. Working paper Series 2015-10. 26 p.

Table 1. Alternative time series of billfish catch for Ghana gillnet. Catch is calculated as the product of the average catch per canoe (1991-1999) and the number of canoes. Bold number of canoes are those reported (Nunoo *et al.* 2015). Other number of canoes were calculated with linear interpolation for years were there was no canoe census.

	SAI	*BUM*	*SWO*	*WHM*	*Canoes*
1955					**4800**
1956	216	211	55	6	4940
1957	223	222	57	6	5080
1958	229	217	59	6	5220
1959	237	229	60	6	5360
1960	241	235	62	7	**5500**
1961	257	250	66	7	5859
1962	272	265	70	7	6217
1963	288	281	74	8	6576
1964	304	296	78	8	6935
1965	319	311	82	9	7293
1966	335	326	86	9	7652
1967	351	342	90	10	8011
1968	367	357	94	10	8369
1969	382	372	98	10	**8728**
1970	377	367	97	10	8606
1971	372	362	95	10	8483
1972	366	357	94	10	8361
1973	361	351	92	10	**8238**
1974	363	354	93	10	8297
1975	366	356	94	10	8355
1976	369	359	94	10	8414
1977	371	361	95	10	**8472**
1978	354	345	91	10	8089
1979	337	329	86	9	7705
1980	321	312	82	9	7322
1981	304	296	78	8	**6938**
1982	315	307	81	9	7193
1983	326	318	84	9	7448
1984	337	329	86	9	7704
1985	349	339	89	10	7959
1986	360	350	92	10	**8214**
1987	357	348	92	10	8160
1988	355	346	91	10	8106
1989	353	343	90	10	**8052**

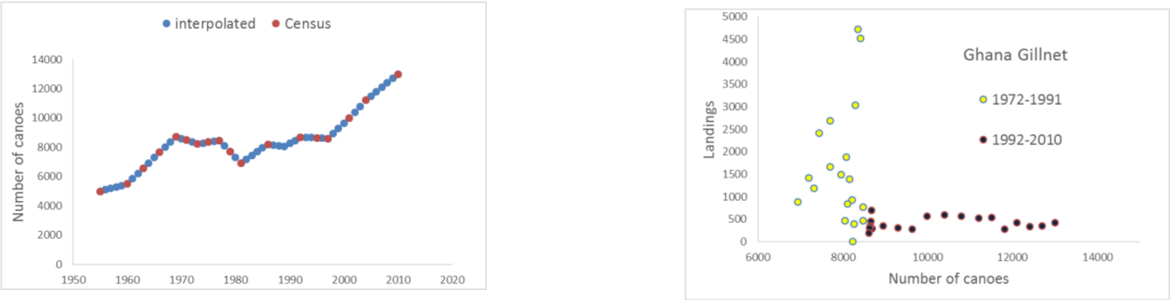

(a) (b)

Figure 1. Canoes and landings. Ghanaian artisanal ocean-going fleet (a) Number of canoes reported by Nunoo *et al*. 2015 (red dots) and lineary interpolated values (blue dots). (b) Relationship between number of canoes and sailfish landings from task I for two periods prior to 1992 (yellow dots) and after 1991 (blackdots).

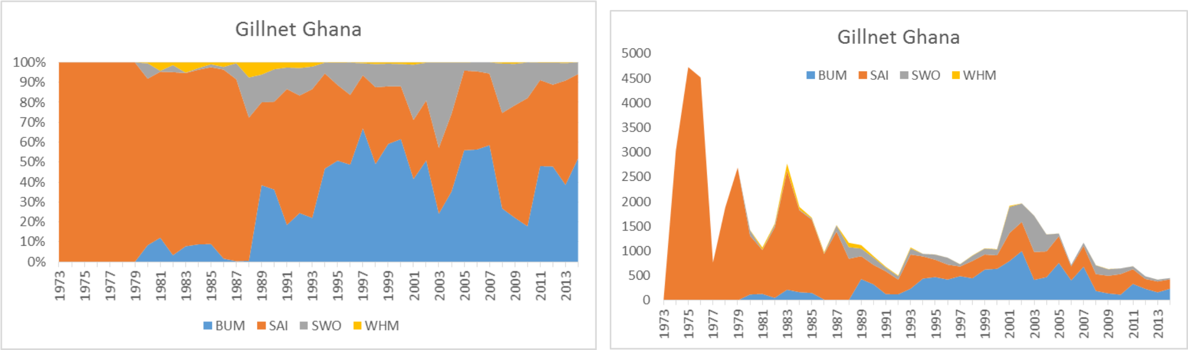

(a) (b)

Figure 2. Species composition (a) and total billfish landings (b) of task I artisanal gillnets of Ghana.

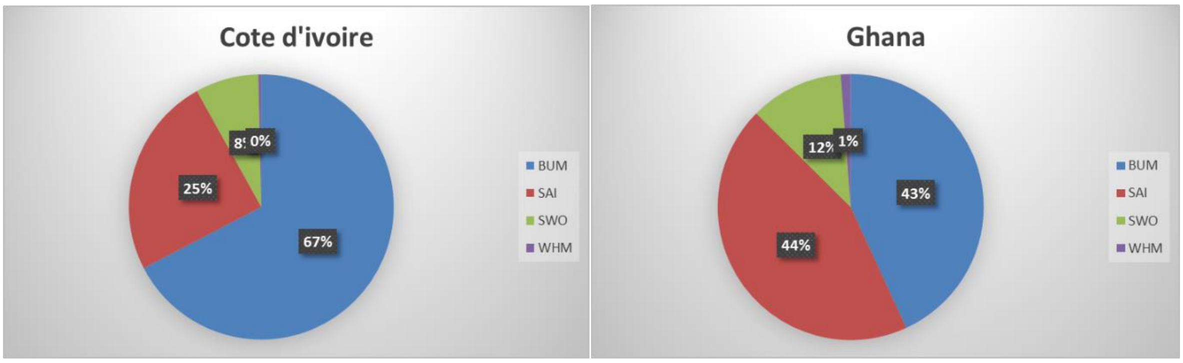


Figure 3. Comparison of species of composition of gillnet landings for billfish for 1990-1999 from Ghana and Cote d’Ivoire.

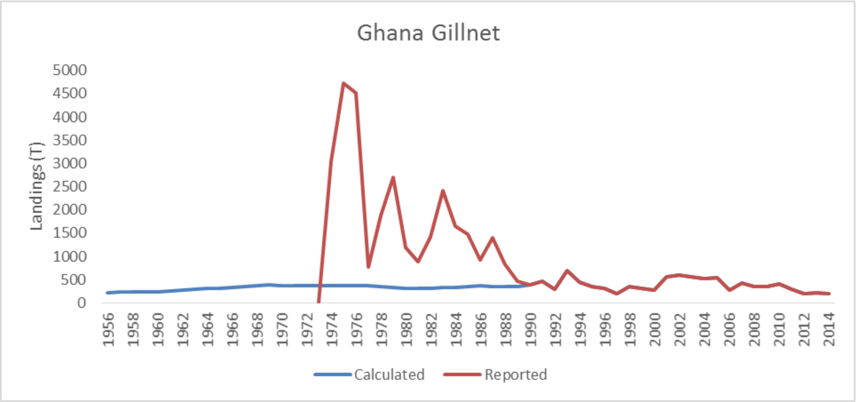


Figure 4. Reported Task I catches of Ghana gillnet (red) and alternative catch for 1956-1989. Alternative catch developed as the product of the number of canoes and the average catch per canoe for 1990-1999.

Appendix 5

Bayesian surplus production models in the East

For the eastern Atlantic population, Bayesian production models were run using both the BSP model that is cataloged in the ICCAT catalog of methods (BSP-VB, Babcock 2007, McAllister and Babcock 2003) and a JAGS version of the same model based on Millar and Meyer (BSP-JAGS, Meyer and Millar 1999). The JAGS version differed from the Millar and Meyer formulation in that it included a boundary condition by which combinations of parameter values that caused the biomass to be lower than the catch in any year were down-weighted in the likelihood. This was implemented using the ones trick (Lunn *et al.* 2013). The BSP-VB model similarly throws out parameter draws that crash the population.

The BSP-VB did not converge at all for the series weighted models, since the percent of the importance weight on a single draw was larger than 0.5%. For the other models, the convergence diagnostics were adequate, but the Hessian estimates of variance and covariance were not believable (**Table 1**). The catch weighting series put very high weights on the Japanese longline series, and then on the Ghana series (**Figure 1**). The models appeared to fit the CPUE series fairly well (**Figure 2**). However, the posterior distributions of both r and K were nearly identical to the prior (**Figure 3**) implying that the data did not provide any information on the values of the parameters. Because of the very wide posterior distribution of K, the population was estimated to be very large and not heavily fished (**Figure 4**).

The JAGS models applied to the same datasets had much better convergence diagnostics (**Table 2**). Except for the runs with catch weighting, all the runs estimated posterior distributions of r that were higher than the prior (**Figure 5**). The posteriors of K were fairly well estimated.

References

Babcock, EA 2007. Application of a Bayesian surplus production model to Atlantic white marlin. Col. Vol. Sci. Pap. ICCAT, 60(5): 1643-1651

Lunn, D., Jackson, C., Best, N., Thomas, A. and Spiegelhalter, D. 2013. The BUGS Book: A Practical Introduction to Bayesian Analysis. CRC Press. 381 pp.

McAllister, MK and Babcock, EA. 2003. Bayesian surplus production model with the Sampling Importance Resampling algorithm (BSP): a user’s guide. Available from www.iccat.int/en/AssessCatalog.htm

McAllister, MK, Pikitch, EK and Babcock, EA. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. Can. J. Fish. Aquat. Sci. 58: 1871–1890.

Meyer, R. and Millar, R. B. 1999. BUGS in Bayesian stock assessments. Canadian Journal of Fisheries and Aquatic Sciences 56(6): 1078-1087.

Table 1. Convergence diagnostics for BSP-VP models. The percent maximum weight diagnostic should be less than 0.5. The Hessian variance of K should be large (i.e. 1000s).

Diagnostic	*E-up-equal*	*E-up-catch*	*E-up-series*	*E-down-equal*	*E-down-catch*	*E-down-series*
% max wt	0.49	0.02	49.82	0.29	0.09	45.00
var(K)	3.98E-03	9.97E-07	8.80E-17	9.55E-17	5.08E-02	9.52E-17

Table 2. Convergence diagnostics for the BSP-JAGS runs in the Eastern Atlantic.

Number	*Description*	*Rhat*	*n.eff*	*converged*
1a	E-up-equal wt	1.01	1800	yes
1b	E-up-catch wt.	1.00	920	yes
1c	E-up-series wt.	1.02	200	yes
2a	E-down-equal wt.	1.12	180	yes
2b	E-down-catch wt.	1.00	1300	yes
2c	E-down-series wt.	1.00	990	yes
3a	E-down-equal-2 GHN	1.01	1500	yes
3b	E-down-equal-GHN2	302.75	2	no
1d	E-up-prior.3	1.61	6	no
2d	E-down-prior.3	1.15	35	yes
1e	E-up-Bo=K	1.01	230	yes
2e	E-down-B0=K	1.00	900	yes
1f	E-up-low process	1.04	99	yes
1g	E-up-no process	8.08	2	no

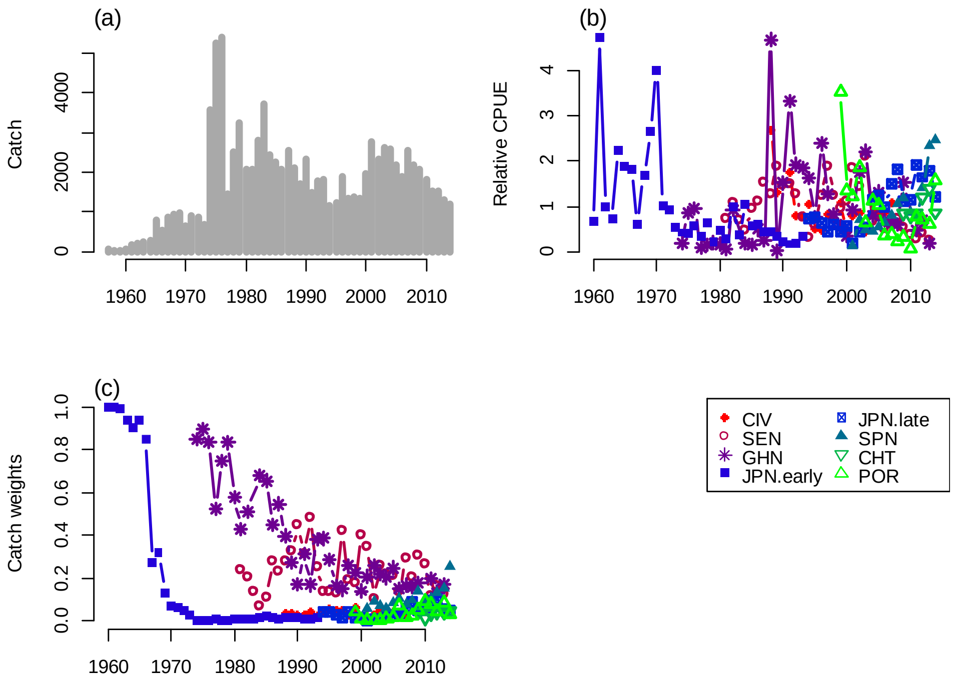


Figure 1. Catches (a), indices (b), and catch weighing (c).

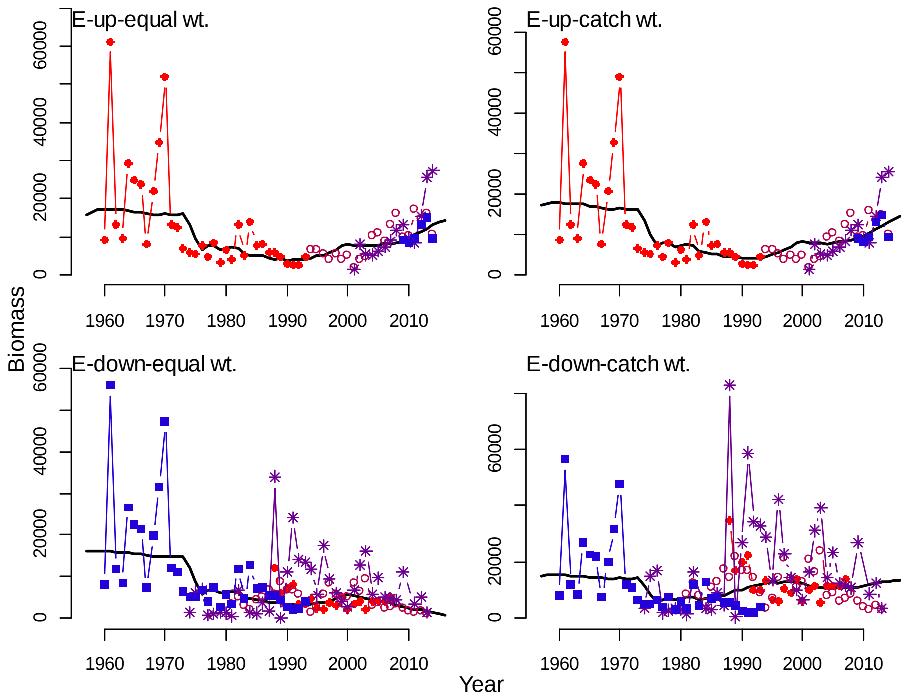


Figure 2. Fit at mode of posterior distribution for the BSP-VP model for the east.

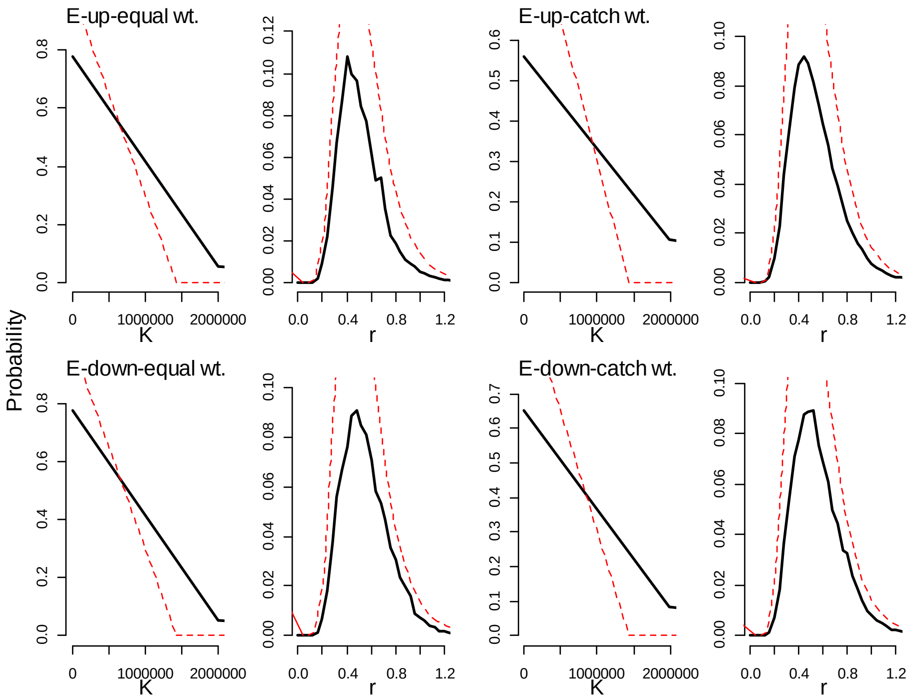


Figure 3. Priors (red dashed) and posteriors (solid black) or K and r from the BSP-VP model for the East.

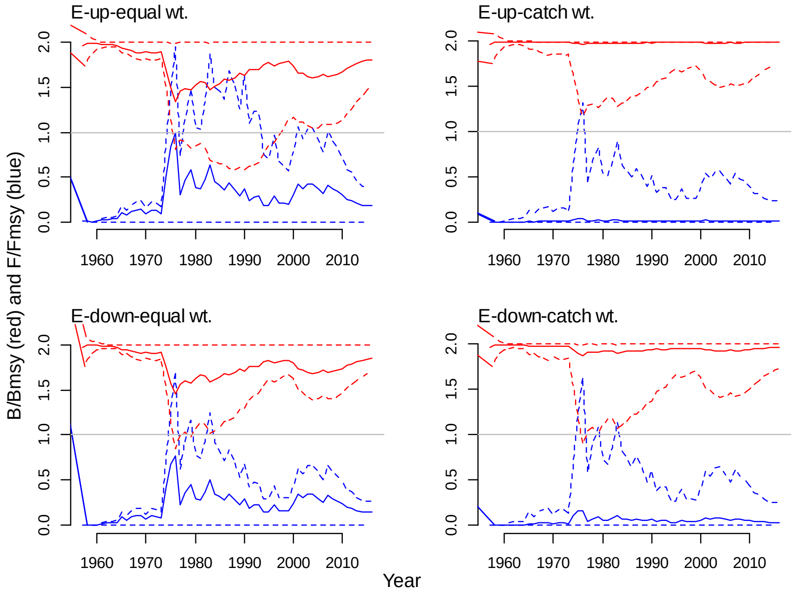


Figure 4. Fishing mortality (red) and biomass (blue) with 80% credible intervals.

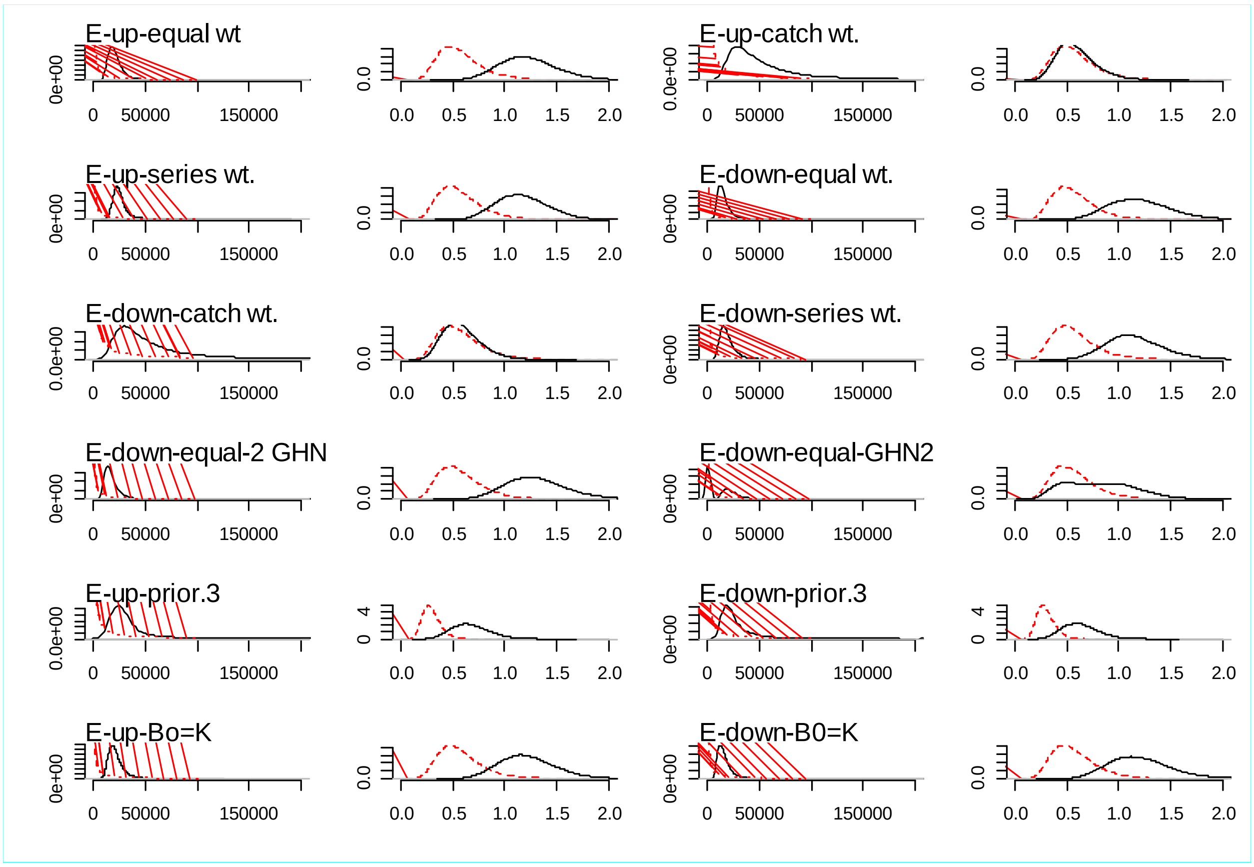


Figure 5. Priors (dashed red) and posteriors (solid black) for K and r from the BSP-JAGS models in the East.

Appendix 6

Demographic estimate of r

For the Bayesian production models used in the 2009 assessment, the prior for the intrinsic rate of population growth (r) had a mean of 0.3, implying a moderately productive stock. Carruthers and McAllister (2010) used a demographic method to estimate a prior distribution of r, and found a mean value of 0.08, implying the population was less production. There have been some updates to the demographic information for sailfish since the last assessment. Therefore, the working group used the Carruthers and McAllister method with the updated values of the biological parameters (**Table 1**) to produce a new demographic prior for r.

The demographic method uses estimates of the survival to each age (l_a), and the fecundity at each age (m_a) to calculate the population growth rate at low population sizes (r), using the Euler-Lotka equation. Assuming the natural mortality (M) is constant, the survival to each age is calculated as exp(-Ma). Fecundity at age is calculated from the fraction mature at age times the weight at age (calculated from length at age) times the expected number of age 1 recruits per kg of SSB at low population size, which is calculated from steepness. The life history parameters at age calculated from the mean values of the parameters shown in **Table 1** are shown in **Figure 1.**

A Monte Carlo method was used to develop a prior distribution for r. Each input parameter was given a distribution (**Table 1**), with the mean agreed to be the working group, and a distribution and variance that gave a reasonable range of values. Values of each input parameter were drawn from the specified distributions (**Figure 2**), and each set of parameters was used to calculate r. The resulting distribution of r values (**Figure 3**) is well described by a lognormal distribution with a mean of 0.45 and CV of 0.30. This implies a much more productive stock than was assumed in the 2009 assessment.

The Euler-Lotka method gives a value of r as an instantaneous rate. For models that use an annual time step, the mean value of r would be exp(0.45)-1=0.57.

References

Carruthers, T. and M. McAllister. 2011. Computing prior probability distributions for the intrinsic rate of increase for Atlantic tuna and billfish using demographic methods. Collect. Vol. Sci. Pap. ICCAT, 66(5): 2202-2205 (2011).

Table 1. Parameters used in the demographic analysis of r.

Parameter	*mean*	*cv*	*distribution*	*Source*	*Description*
M	0.35	0.2	norm	working group	Natural mortality (1/year)
Linf	206.8	0.05	norm	working group	Von Bertalanffy Asymptotic length
K	0.36	0.05	norm	working group	Von Bertalanffy growth parameter
t0	-0.24	0.05	norm	working group	Von Bertalanffy age at zero length
a	1.00E-06	0	fixed	manual	Weight at length parameter
b	3.2683	0	fixed	manual	Weight at length parameter
h	0.7	0.2	beta	SS model	Steepness h=0.2 + 0.8 Beta()
a50	3	0.1	norm	SCRS/2015/SAI	Age at 50% maturity
d95	3.4	0.1	norm	SCRS/2015/SAI	Age at 95% maturity
amax	12	0	na	manual	Maximum age

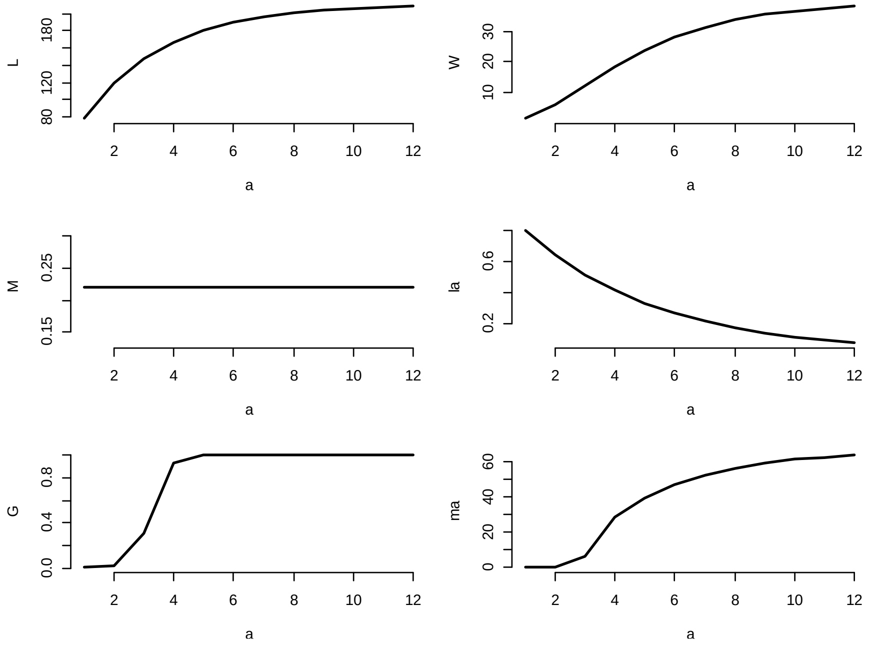


Figure 1. Length (L), weight (W), natural mortality (M), survival to age (l_a), maturity (G), and fecundity at age(m_a), at mean values of the input parameters.

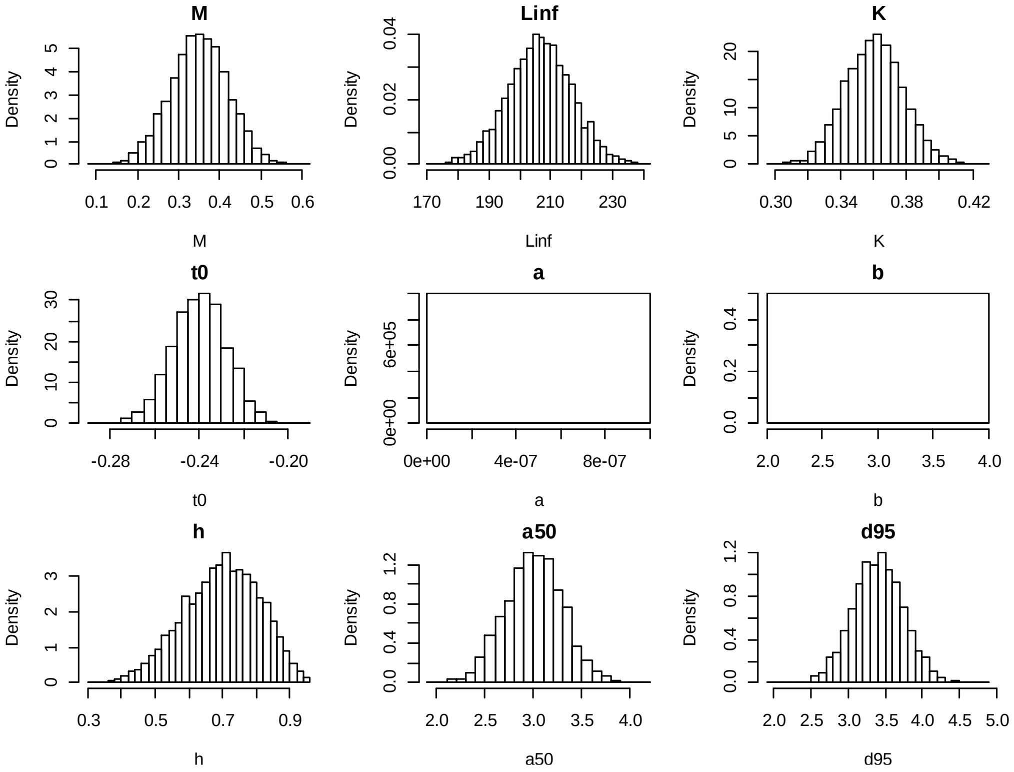


Figure 2. Distributions of parameters used in the demographic analysis.

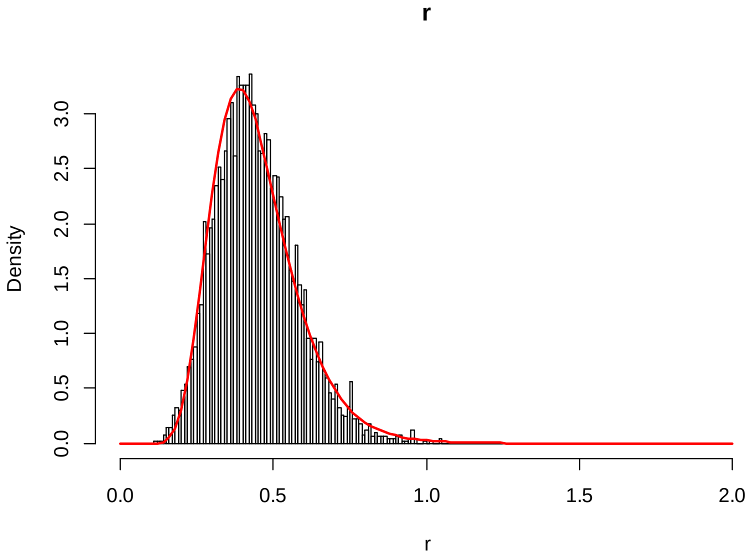


Figure 3. Histogram of r from Monte Carlo simulations. Red solid line is a lognormal distribution with the same mean and variance, used as a prior for r.