REPORT OF THE 2009 SAILFISH ASSESSMENT

(Recife, Brazil, June 1-5, 2009)

1. Opening, adoption of Agenda and meeting arrangements

Dr. Fabio Hazin, Chairman of the Commission, and Dr. Sergio Matyos, of the Brazilian Special Secretariat for Aquaculture and Fisheries, welcomed participants and offered to do anything necessary to facilitate an efficient meeting. Dr. Victor Restrepo (ICCAT Secretariat) thanked the Brazilian hosts for the excellent arrangements made for the meeting.

The meeting was chaired by Dr. David Die (USA). Dr. Die welcomed Working Group participants and reviewed the objectives of the meeting in the context of the work-plan for the billfish species group (**Appendix 4**). The Agenda (**Appendix 1**) was adopted with a minor change in the order of items. The List of Participants is attached 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, 8	V. Restrepo
2	C. Wor, F. Arocha, M. Ortiz, G. Diaz
3	D. Die, V. Restrepo
3.1	E. Prince and F. Hazin
3.2	M. Ortiz, V. Restrepo, H. Andrade, D. Die,
3.3	G. Scott, P. Goodyear, F. Arocha
4	P. Goodyear, J. Hoolihan
5-7	D. Die

2. Update of data for assessment

2.1. Catch estimates

The group spent considerable effort to split historical SAI/SPF catches into the two species for those fleets that required it because for many years they reported sailfish and spearfish together: Japan, Korea and Chinese Taipei. Analyses were conducted on the proportion of sailfish in the sailfish/spearfish aggregate reported by scientific observers for all longline fleets. Although sailfish and spearfish spatial distributions broadly overlap, there are significant differences in relative concentrations by location and fleet (**Figures 1-3**). Inspection of the proportion of sailfish indicates that sailfish represent higher proportions of the total along coastal areas and in the tropics, while spearfish proportions are higher in mid-ocean to the north and south of the tropics.

Ratios of sailfish counts versus the sum of sailfish and spearfish counts from observer data by 5 degree grid have a very uneven distribution in time, space (**Table 1**) and between fleets (**Figures 1-3**). The same can be said about the relative distribution of longline catch of the aggregate of sailfish and spearfish (**Table 2**). A review of the ratio of observer counts per reported ton caught by 5x5 degree square showed also an unbalanced distribution (**Table 3**). Most of the equatorial areas have larger number of observer counts per ton, while the temperate and higher latitudes have very few observations relative to the catch of sailfish and spearfish (**Table 3**). A binomial model (**Appendix 5**) was used to smooth these differences and obtain predictions of the proportion of sailfish for each location where some data were available for a given fleet. Such model predictions reflect the effects of the factors incorporated in the model, fleet, quarter, area (coastal/equatorial, or elsewhere) and distance from the equatorial convergence zone (3 degrees North). Predictions by quarter can only be made for those fleets where data by quarter is available, namely USA, Taipei, Spain, Venezuela and Brazil. In the case of the Japanese fleet, and because the only data available to the group for such fleet is aggregated for the entire year, predictions are made for the entire year and not by quarter. For a given fleet these predictions were only made for the grid and quarter combinations for which there were at least 20 observations for a given quarter.

In order to develop predicted ratios for quarter-grids were no observer data was available a combined ratio was calculated for each grid. This combined ratio was calculated as the average of the model predictions available for such grid from all fleets and all quarters. This ratio therefore represents an average of the predictions for a grid and does not vary with quarter. For the Korean fleet only these ratios are used. For those grids were there were

no predictions available because there was no observer data for any fleet, an average of the neighboring cell-ratios was used. Any grid at latitudes greater than those in the matrix (~50 degrees) are assumed to have 0% sailfish.

The resulting ratios were then used to separate the catches of sailfish and spearfish for the fleets that had reported them as combined (**Table 4)**.

The Secretariat updated the Task I sailfish/spearfish dataset up to 2007 based on the latest reported data and the catches of longliners calculated during the meeting. For those fleets that had recent catches but no reported catch for 2007, the group decided to use the average 2004-2006 catch. The resulting catches by flag and stock (**Table 5**) were used in the assessment.

2.2 Biology

Sex ratio

New information on the seasonality of sex ratio-at-size was presented for the western central Atlantic from the Venezuelan pelagic longline fishery and the artisanal drift gillnet fishery (SCRS/2009/025). The overall sex ratio of sailfish caught by the two Venezuelan fisheries was 0.346, indicating a strong dominance by males. Seasonal (quarterly) sex ratio by size for the combined fisheries throughout most of the season was at its lowest for sizes <165 cm LJFL. Sex ratio at size increased steadily up to 185 cm LJFL, where it levels or stops at ≥0.75, for sizes >165 cm LJFL. Seasonal (quarterly) sex ratio by size and by fishery displayed different trend patterns. In the pelagic longline fishery the trend reversed in comparison to the combined fisheries trend and that of the artisanal fishery. Males were more dominant at larger sizes (>170 cm LJFL). It can be concluded that the findings presented in relation to the proportion of female-at-size suggests that fishing mortality may differ by sex, dependent on gear and season, but its patterns are not yet fully understood.

Tagging data

SCRS/2009/47 presented an update on the US conventional tagging data for the Atlantic sailfish, spanning over 55 years, comprising 92,201 tagged sailfish and 1,896 recaptures. No trans-Atlantic or trans-equatorial movements were registered, suggesting that sailfish in the western North Atlantic have a rather coastal distribution with no evident movement to the eastern Atlantic and South Atlantic Ocean.

Depth and temperatures preferences based on data from PSAT tags were presented for both western North and South Atlantic Ocean (SCRC- 2009/048, and SCRS- 2009/063, respectively). Data from the western North Atlantic referred to 16 sailfish tagged in the southern Gulf of Mexico and the Straits of Florida. The results demonstrated a close association of sailfish with the warm shallow layers (<20 m), although presenting numerous repeated short-duration vertical movements below the local thermocline to depths of 50-150 m. The PSAT temperature data showed that sailfish spent over 90% of their time in waters ranging from 25°C to 29°C. The information obtained from two sailfish tagged in the western South Atlantic, off the Brazilian southeast coast, showed a similar pattern to those tagged in the North Atlantic; that is, both fish spent most of their time in the upper ten meters, displaying occasional deep dives.

Behavior

A reference paper (Mourato *et al.,* in review) presented a Generalized Regression Analysis and Spatial Prediction (GRASP) model, applied to catch and effort data from the Brazilian tuna longline fleet (1998-2006) and size (lower jaw-fork length) data from ICCAT. The results suggested that the spatial catch probabilities are related to distance from coast; and, that larger specimens are more frequent to the west of 40°W, as well as to the east of 25°W. The largest proportion of the sailfish caught off the Brazilian coast, from 25°W to 40°W, is comprised of individuals <155.0 cm LJFL.

2.3 Catch rates and Relative Abundance Estimates

Three documents were presented to the Group that were related to catch rate issues but did not provide estimates of indices of abundance. These are described below.

Document SCRS-09-048 presented the characterization of sailfish habitat utilization based on data collected from 16 PSATs deployed in the southern Gulf of Mexico between 2005 and 2007 aboard a commercial longline vessel. The results indicated the sailfish were primarily associated with surface waters less than 20 m depth. But, they exhibited numerous repeated vertical movements below the local thermocline to depths of 50-150m. These results indicated that sailfish vertical distribution coincides with the depths fished by shallow-set pelagic longlines and that the repeated deep dives may still allow for interactions with deep-set longlines to occur. However, the Group discussed that because the data was collected from short-term deployments (10 days), the results might not fully reflect normal sailfish behavior. It has been suggested that after a catch-release event sailfish behavior may be erratic for up to 10 days.

Document SCRS-09-049 applied a habitat-based standardization methodology (statHBS), which is based on assumptions about temperature preferences of species and the depth distribution of longline hooks, to develop relative abundance indices of sailfish based on US longline observer data. Inspection of the observer data indicated that sailfish were almost never caught by the US longline fleet east of 73°W and declined rapidly at surface temperatures less than 24°C. Most encounters by the US longline fleet were along the eastern coast of the US and in the Gulf of Mexico. The analyses of catch per unit of effort were restricted to those areas and to the months when sea surface temperature was ≥24°C. The time series of observer data available for analysis was from 1992 to 2006, with preliminary data from 2007 also available. The statHBS methodology is based on matching preferred habitat variables for the species to the depths of the longline hooks recorded in the longline observer database. Observed temperatures occupied by sailfish from PSAT data were used to form priors of their habitat preferences. The CPUE fitted with statHBS was similar to the nominal CPUE. Both series showed wide variation in relative abundance that was probably a result of low sample sizes and annual variations in the distributions of the fishery, as a result of time-area closures implemented in 2001. More detailed computations of hook depths and spatial treatment may improve the results, but the paucity of the data suggests this may not lead to useful results.

Document SCRS-09-051 analyzed billfish catches obtained during a survey conducted on the Spanish commercial surface longline in which three types of hooks and two types of baits were tested in the inter-tropical areas of the Atlantic using 263,210 hook-bait observations. The catch rates and proportion of positive sets were analysed using a GLM (Delta-lognormal) at the species level. Zone was the most important factor (alone or in interaction with others) in explaining the catch rates and/or the proportion of positive sets of most billfish species caught. The factors tested (hook and bait) were not significant for any of the billfish species. Despite the lack of significance found for both factors, the results suggest that alternative hooks could produce changes in the mean CPUE of billfish of between –13% and +9% depending on the species and hook type used. The alternative bait (squid) might also produce changes in mean CPUE from around –7% to +18%. The interaction between the alternative hooks and bait could lead to changes in mean CPUE of between –24% to +45% depending on the combination of both factor and species considered. The model assumed was appropriate for both BUM and SPF but for other billfish species alternative error distributions could be explored. The selection of the area and the experimental design could play a decisive role when predicting the advantages or disadvantages of using certain elements in a fishing gear, particularly in the case of species with low prevalence in which the proportion of zero observations tends to be high.

Relative abundance estimates

Document SCRS-09-032 presented standardized catch rate from the Côte d'Ivoire artisanal fishery. This artisanal gillnet fishery was very active between 1988 and 2008 and landings include large tuna, tuna like, billfishes and swordfish. A generalized linear model was used to provide standardized CPUE indexes for Atlantic sailfish. The model included three explanatory factors, namely "year", "month" and "quarter" with interaction between them. The standardized CPUE, for the period considered, showed a strong downward trend.

Document SCRS-09-054 presents the updated version of the analyses of the Senegalese artisanal fishery that were presented originally during the 2008 sailfish data preparatory meeting. It contains estimates of relative abundance indices for the period (1989-2006) and suggest a slight downward trend in abundance albeit in the presence of high inter-annual variability.

Document SCRS-09-033 presented standardized catch rates from the Venezuelan pelagic longline fleet (kg/1000 hooks) estimated using data collected by scientific observers. The period covered by the index was 1991-2007. The standardization procedure used a GLM model with a delta-lognormal error assumption. Variables included in the analysis were year, vessel, area, season, bait, and fishing depth. The estimated index showed a declining

and highly variable trend from 1991 through 2001, when it reached the lowest value of the time series, and a clear increasing trend from 2001 through 2007.

Document SCRS-09-045 presented standardized CPUE estimates for the US pelagic longline fleet for the period 1986 through 2008. Standardization was performed using a GLM approach assuming a delta lognormal error distribution. Separate models were fitted to the proportion of positive sets (proportion of longline fishing sets that caught at least one sailfish) and the catch rate of positive sets. Standardization procedures included the variables location, season, and year. Other variables that were included to reflect different fishing practices were hook type, number of lightsticks, target species, mainline length and a categorical classification of US vessels based on a predefined set of variables (e.g., size and type of vessel, area of operation, etc.). Indexes of abundance were estimated from mandatory logbook records (in number of fish and weight / 1000 hooks) and from data collected by scientific observers (weight / 1000 hooks). All three indexes showed similar trends with a decline from 1992 through about 2005 and an increase in the last 2 years of the time series. It was indicated that in the last 2 years the US greatly increased the observer coverage in the Gulf of Mexico to 75-80% (of the number of fishing sets). Therefore, the increasing trend observed in those 2 years could be an artifact reflecting better coverage and reporting.

Document SCRS-09-046 presented standardized indexes of abundance for the US recreational fishery estimated from 1) fishing tournaments during 1973-2008 (RBS), and 2) a data collection survey of recreational fisheries during 1981-2008 (MRFSS). Catch rates were estimated as the number of fish / 1000 fishing hours. Only data from tournaments targeting sailfish using live bait were used in the estimation of catch rates. A GLM approach was used and the variables included were year and season. Location was not included because all tournaments were located in the same US domestic management area (Florida East Coast). Because more than 95% of the records (catch and effort per day) showed catches of sailfish, only one model was fitted (catch rate) assuming a lognormal error distribution. In the case of the index estimated from the data collection survey, a GLM assuming a delta lognormal error distribution was used. Separate models were fitted to the proportion of positive trips (proportion of recreational fishing trips that caught at least one sailfish – binomial error distribution) and the catch rate of positive trips (lognormal error distribution). The variables included were area, season, type of trip, and inshore vs. offshore waters. Although both indexes were estimated using data covering different geographic ranges and data collection systems, they showed remarkably similar abundance trends. The lowest value of both indexes corresponded to year 1982 and an increasing trend was observed from 1982 through the late 1990s. A sharp drop was observed in the period 2000-2001 and an increasing trend since then.

Document SCRS-09-066 presented standardized catch rates for the Brazilian longline fishery for the period 1978-2008. A GLM approach with a delta lognormal error assumption was used to estimate two standardized indexes. Both indexes included the factors year, area, and quarter in the standardization procedure. One index also included a 'target' factor estimated through cluster analysis. Both indexes showed similar trends but the index that included the factor 'target' was much more variable. For that reason, in the assessment, the Group decided to use the index without the 'factor' target.

Document SCRS-09-067 presented standardized CPUE of sailfish caught by Japanese longliners in the Atlantic updated to 2007. The sensitivity test of Habitat model for the vertical distribution pattern of sailfish revealed that the model was very robust for the change of distribution probability in shallower layers but sensitive to the change in deeper layer. The result by GLM approach in off Africa area was similar to the one by Habitat model with swordfish vertical distribution pattern was applied as sailfish one. As this hypothesis is unrealistic, the result by GLM approach supposed to be biased.

The group thought that the lack of an uninterrupted time series of relative abundance for the Japanese longline and the Chinese Taipei longline would difficult assessments. Thus an attempt was made to calculate such indices during the meeting by analyzing 5x5 CATDIS data available at ICCAT (**Appendix 6**). The group reached the same conclusion regarding the lack of an index for the Ghanaian fishery, and similarly decided to make an attempt to use the available data at the meeting to develop an index for such fishery (**Appendix 7**).

The final list of indices of abundance (**Table 6)** that were available to the Group included those reported earlier in this section plus a few available from previous assessments: the Venezuelan recreational (SCRS/2000/075), Japanese longline (SCRS/2001/149) and Chinese Taipei (SCRS/2001/025) from the 2001 assessment, and the Venezuelan Gillnet (SCRS/2008/040) and Brazil sport (SCRS/2008/081) from the 2008 data preparatory meeting. Annual values for each index are available on **Table 7** and **Table 8** and are displayed in **Figure 4**.

Calculation of Combined Indexes of Abundance

The combined indices were estimated using a GLM approach assuming a log-error for the CPUE and the factors included in the model were 'fleet' and 'year'. Final estimates were obtained by back-transforming the least square means (LSMEANS) and correcting for bias using the standard error of the final model. Three alternative combined indexes were estimated: 1) un-weighted, 2) weighted by the annual catch of each fleet, and 3) weighted by the number of 5x5 degree grids fished by each fleet in each year. Combined indexes of abundance were estimated for the western and eastern stocks, respectively.

Western stock

The indexes used for the western stock were the JPN LL-1, JPN LL-2, TAI LL-1, TAI LL-2, TAI LL-3, US RR-RBS, US LL-PLL (kg), VEN RR, VEN GIL, VEN LL, BRZ RR, and BRZ LL.

In the case of the recreational fisheries of Brazil and the US, catches of 0.1 MT were assigned for those years when recreational catches were not included in the Task I table (Brazil 1996-2007 and US 2003-2007). The number of 5x5 degree grids fished by each commercial fishery was obtained from CATDIS, which provides the catch of each fleet by grid and by quarter. For each fleet, the quarter with the largest number of grids fished was identified for each year and that number of grids was assigned to the entire year.

In the case of the Brazil longline fishery, which had no information in CATDIS for the last six years of the time series (2003-2008), the average number of grids fished during the period 2000-2002 was assigned to the missing years. For the recreational fisheries the Group used a number of grids estimated using the knowledge and experience of national scientists. The number of grids for the Brazil, Venezuela, and US recreational fisheries were estimated to be 2, 4, and 5, respectively. The estimated combined indexes of abundance are shown in **Table 9** and **Figure 5**.

Eastern stock

The combined index for the eastern stock was estimated using the indexes CIV GIL, GHN ART, SEN ART, JPN LL-1, and JPN LL-2. Combined indexes were estimated using the same statistical models and weighting schemes used for the western stock and are shown in **Table 9** and **Figure 5**.

3. Assessment

The group agreed to use several methods, focusing primarily on production model analyses. Several variants of these were used: ASPIC (Prager, 1994, assuming a Schaefer production function), Schaefer-type and Fox-type models programmed in EXCEL, and a Bayesian Schaefer-type model (Andrade and Kinas 2007). In addition, there were other analyses with less data demands: Two analyses based on CPUE trends (without taking catch into account), and an analysis of trends in mean sizes and the spread of size distributions.

3.1 Stock structure: alternative scenarios

The initial analyses for defining Atlantic sailfish stock structure were first conducted at the Second ICCAT Billfish Workshop in Miami, FL, in 1992 (ICCAT 1994, Orbesen *et al*. 2008). At this meeting, the billfish working group examined three kinds of data for this purpose: genetic analyses (Graves and McDowell (1994), tagging data (Bayley and Prince 1994), and average size of the landings in the western and eastern Atlantic (ICCAT, 1994). There were no indications of multiple genetic stock structures, nor were there tag recapture evidence indicating trans-Atlantic or trans-equatorial movements. However, the 1992 billfish working group did find that there were highly significant differences in average size (in length, lower jaw fork length, cm) of sailfish landings between east/west and thus a east/west management unit was considered appropriate at that time (ICCAT, 1994). There was a recommendation during the current meeting that these three protocols might be a basis for choosing alternative stock structure hypotheses provided time constraints permit this option.

It was concluded that for consistency/continuity with past sailfish assessments, the working group, at a minimum, should proceed under a two stock structure hypothesis; i.e. West and East Atlantic. Discussions on possible exploratory runs with alternative stock structure hypotheses were discussed and most of the comments had a caveat that in a 5 day assessment meeting, it was unlikely that the working group would have time to make

additional runs. Opinions ranged from recommending no exploratory runs to running a possible South West or East/South West aggregate alternative (because of the geographical proximity of the eastern tip of Brazil and West /Africa).

Orbesen *et al.* (SCRS2009/047) updated conventional tagging data on sailfish and pointed out that even though conventional tag deployments for sailfish were nearly twice as high as any of the other major target species (almost 100,000), no trans-Atlantic nor trans-equatorial movements have been documented over the past 55 years. Given the total number of deployments and sailfish having the highest recovery rate among istiophorid billfish (second highest recovery rate among target species), the fact that sailfish are the only target species that has not had a documented trans-Atlantic nor trans-equatorial movements was significant. Orbesen *et al.* (SCRS/2009/047) suggested that this further demonstrates the more coastal distribution of this species compared to the marlins and spearfish. The longest confirmed sailfish displacement movement was about 2,100 nautical miles (Orbesen *et al.* SCRS/2009/047), so this species can move long horizontal distances but the exact route of this movement cannot be determined with conventional tagging. SCRS/2009/047 also offered other insights on data that might be considered in selecting alternative stock structure hypotheses. For example, it was pointed out that the eastern edge of the hypoxic plume that extends eastward off the west African coast (Prince and Goodyear, 2006) comes within 148 nm of coastal Brazil and thus this dominant oceanographic feature might be shared between the these two groups of sailfish (SW and E). The authors felt that this might support combining these groups. In addition, the geographical proximity of Brazil to the west coast of Africa (about 1,500 nautical miles) suggests it might be more likely that sailfish trans-Atlantic movements could eventually be documented with sufficient tag release efforts, rather than from the western north Atlantic to the African coast (~ 3,500 nautical miles) or to the south Atlantic (about 3,000 nautical miles). Mourato *et al.* (SCRS/2009/067) reported on 2 PSAT deployments off southern Brazil and also hypothesized that trans-Atlantic movements of sailfish might be most probable between Brazil and west Africa, although the tracks of these fish did not necessarily support such movements. Mourato *et al*., (in review) discussed their findings and found that sailfish in the east Atlantic off the west coast of Africa were larger than those in the SW Atlantic off Brazil. These findings confirm previous reports that eastern Atlantic sailfish landings are larger than in the western Atlantic (Beardsley 1980, ICCAT 1994, Prince and Goodyear 2006).

At the end of the discussion, the working group felt that an alternative to the currently accepted two-stock east/west scenario would be to consider two stock scenario but with a Northwest stock and a South & East stock. Nevertheless, due to time constraints, it was decided that alternative hypotheses should only be made after the initial model runs were done if time allowed it. At the end, there was no time available during the meeting to conduct assessments for the later scenario.

3. 2. Production model assessments

Production models were fitted with ASPIC, to Schaefer-type and Fox-type models programmed in EXCEL, and to a Bayesian Schaefer-type model (Andrade and Kinas 2007). A large number of different combinations of models and relative abundance sets were fitted by various scientists present at the meeting. After all results were made available, the group jointly developed a synthesis of production model results.

3.2.1 ASPIC model runs

Production models were fitted for the eastern and western Sailfish stock units using different combinations of the available indices of abundance and different versions of the ASPIC package. All runs were conducted with different versions of ASPIC 5. Details of the many combinations of indices attempted are presented in **Appendix 9**, but they ranged from using only combined indices developed by the group to using combinations of single indices. Cases that used combinations of indices varied from those cases that used all available indices, to some cases where only the indices of certain type of fishery were used (only longline indices, only artisanal etc…). Some cases used different versions of a given index, such as the different versions of the Japanese longline index or the US recreational indices. All together there were 9 cases considered for the east and 15 for the west. Many of the estimations used the standard FIT procedure in ASPIC but others did provide bootstrapped estimates. Iterative reweighting was only attempted in two cases. In all cases it was necessary to constraint the initial biomass to K for ASPIC to converge. Initial parameter guesses were provided for the carrying capacity K, MSY, and the catchability (q) coefficients for each index series used.

Results of the various fits were very variable, especially for the Eastern stock were the number of data series is smaller and their historical extend is shorter. Management parameters (MSY, Biomass ratios and Fishing

mortality ratios) and population productivity parameters (r and K) showed great variation among cases. For both stocks, however, there were cases that produced parameter estimates that were not likely to be plausible, indicating that certain combinations of abundance indices do not contain enough information for a reasonable fit.

If one uses the bootstrap estimates of parameter uncertainty to evaluate the quality of the fit it is clear that those cases that have less uncertainty in the estimates were obtained when all available indices were used without been combined into a single index (**Figure 6** and **Figure 7**).

The resulting biomass and fishing mortality patterns predicted by these fits vary greatly and sometimes indicate severe depletion of biomass whilst others suggest little effects of fishing. The same can be said about fishing mortality with some cases indicating large increases leading to strong overfishing whilst others do not (**Table 10**).

Estimates of current stock status are generally highly uncertain for any given case, as shown by the distribution of estimates produced by the bootstrap for the most recent values of fishing mortality rates and biomass (**Figure 8**), and the estimates of recent biomass and fishing mortality ratios are highly correlated. Also correlated are the estimates of Fmsy and Bmsy (**Figure 9**).

3.2.2 Effects of down-weighting of historical data and of the choice of surplus production function

The effect of downweighting the earlier CPUE data in the production model using the combined index was examined by implementing a production model in EXCEL. The combined index (obtained by weighting the available series in proportion to their catch) was used in the production model, with equal weights by year in one case, and with a tri-cubic downweighting of the data in the other case. The corresponding weights in a given year (y_i) were either equal to 1.0, or given by:

$$W(y_i) = \left[1 - \left\{{(2007 - y_i)}/{47}\right\}^3\right]^3$$

The effect of model choice was examined by fitting either a Schaefer or a Fox-type model:

$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - C_t$ for the Schaefer model, and
$B_{t+1} = B_t + rB_t\left(1 - \frac{\ln(B_t)}{\ln(K)}\right) - C_t$ for the Fox model.

In all cases, the initial (1956) biomass was assumed to equal *K* (**Figure 10** and **Table 11**). Not surprisingly, for a given surplus production function, results obtained with the down-weighted CPUEs were more optimistic than were those obtained with equal weighting. And, generally, for a given choice of weights, the Fox model gave more optimistic results. The only exception to this was the current ratio of F/F_{msy} estimated with the Fox model with equal weighting, which was higher than the same ratio estimated with the Schaefer model (5.40 vs 4.25).

During discussion, the Group noted that production model fits obtained with downweighting historical data and using a single CPUE index were similar to the fits obtained using multiple indices with equal weighting. This phenomenon has been observed with other assessment tools as well.

3.2. 3 Bayesian production model

A Bayesian production model, as described in **Appendix 8**, was applied to combined indices weighted by catch. After some discussion two priors (informative and non-informative) were built using multivariate student distributions. Marginal densities of the priors used in both Bayesian models for the west and east Atlantic are shown in **Figure 11**.

Preliminary results showed that the mixed importance functions obtained using adaptive importance sampling (AIS) were similar to the posteriors as indicated by entropy calculations. Empirical distributions, as obtained using SIR after the AIS approximation to the posterior, showed to be different than the priors. This was encouraging in the sense the data appears to be somewhat informative. Nevertheless, the fit of models as evaluated by comparing the observations and the predictions were very poor. The model was not able to track down the indices for the early years. Therefore the group decided to also try the following weighting function in order to assign heavier weights to indices for recent years:

$$w_i = \left[1 - \left(\frac{max(y) - y_i}{n} \right)^3 \right]^3$$

where y is the vector with the years, w_i is the weight for the ith year and n is the number of years that has information about the index of abundance. The results obtained with the weighting function were similar to those gathered by not using it, hence only the results as calculated with the original indices are shown here.

West

Fittings of the models are poor to the large indices observed in the early years and the decrease in the 1970's no matter if a penalty function was applied (**Figure 12**). Biomass decreases since the very beginning of the data series. Finally linear models fitted to the predictions for the more recent years suggest negative slopes though the slope of linear models fitted to observed indices are close to zero.

A summary of the parameters and of reference points as calculated using the posterior estimations are in **Table 12**. All estimations points to pessimistic scenarios. If we rely on the median estimations (50% quantiles) the actual biomass is close to half the B_{msy}, while the catch in the last year of the time series is 1.3 times the catch in the MSY. Nevertheless, one might keep in mind that those estimations are from a model that do not fit well the observed data.

East

Fittings of the models are poor just like in the analysis for the west Atlantic. The large indices and variability observed in the early years cannot be fitted by the model (**Figure 13** - left panels). Biomass decreases since the very beginning of the data series. Finally linear models fitted to the predictions for the more recent years tends to be negative though the slope of linear models fitted to observed indices are close to zero.

A summary of the parameters and of reference points as calculated using the posterior estimations are in **Table 13**. All estimations points that depends on biomass estimations are even more pessimistic than those gathered for the west. If we rely on the median estimations (50% quantiles) the actual biomass is close to 0.15 times Bmsy. Although the catch in the last year of the time series analyzed (2007) is bellow the Cmsy but, notice that most of the catches in the last decade were larger than Cmsy. Like in the analysis for the west, one might keep in mind that those estimations are from a model that do not fit well the observed data.

3.2.4 Summary of production model analyses

Examination of the estimates of r and K for the different cases suggested that not all cases provided satisfactory fits. Three cases in particular produced results that are clearly no plausible, cases O3, O4 and O11 with the first two estimating r values of 4.0 for the eastern stock and the last one a carrying capacity of close to 900,000 tons for the western stock. These cases are not considered in further analyses. Of the remaining cases some produced parameter estimates that also were unlikely to be plausible. To identify such cases the values of r and K for all production model fits were plotted together (**Figure 14**). Most estimates line up along a curve of the type shown in the estimates obtained through bootstrapping an individual case, but a few clearly depart from such pattern. Cases G3, G4 for the east and G1 and W3 for the west produced estimates of r less than 0.01 and case O2 and the tri cubic Fox EXCEL fit for the west produced r values greater than 0.9. These six cases were also not considered in subsequent analyses leaving a total of six useful cases for the Eastern stock and nineteen for the western stock.

It is important to note the type of parameter/model combinations that these excluded cases represent (**Table 14**). In general, ASPIC, had difficulty fitting to the combined indices for the eastern stock and tended towards a solution with very low r, often smaller than 0.01. As expected, the Bayesian production model was able to provide solutions with more reasonable values of r, in spite of the fact that it did use the combined index for the east. Although a similar thing was observed for a few of the cases that used the combined indices for the west, most often than not ASPIC was able to find reasonable solutions when combined indices were used for the western stock. In those cases where only one type of fleet index was used, (such as only recreational indices or only longline indices in the west), again ASPIC tended not to converge to reasonable solutions. In summary, simple production models, such as ASPIC or the EXCEL implementation developed by the group successfully provided estimated of population parameters for many, but not all cases where different combination of indices were attempted. On the other hand, the Bayesian production model, provided more consistent results, most likely helped by the establishment of reasonable, albeit not always informative, priors for these population parameters.

Still, it is clear that the choice of indices used often changed the estimates of production model parameters including those that have management implications such as the ratios of biomass and fishing mortality that inform us about present stock status.

Once these non-plausible solutions are excluded from the analysis a clearer picture appears on the condition of these stocks. First, the group examined the uncertainty associated with process error: here considered only as the choice of production model (ASPIC, EXCEL or Bayesian) and relative abundance index (**Figure 14**). There is large uncertainty in the values of r for both stocks, but there is a tendency for those of the eastern stock (0.1-0.6) to be greater than those for the western stock (0.02-0.3), suggesting that the stock off the coast of Africa is more productive. This is consistent with other observations related more directly to productivity (Goodyear and Prince 2006). The range of sizes of the virgin stock is also wide, from 20,000 to 60,000 tons, however, it is not clear whether the eastern stock is larger than the western stock.

The estimates of MSY and K are strongly correlated for the different cases of the eastern stock (**Figure 15**). This probably reflect the fact that there are fewer number of indices for the east and those available are often shorter in time, therefore there was less of an opportunity to establish different hypotheses (thus the reduced number of ASPIC cases) for the east. All cases attempted are therefore finding maxima of the likelihood along a ridge of the response surface that really has no clear overall maximum. The MSY estimates obtained for the eastern stock range from 1,300 to 2,500 tons. Estimates of MSY and K for the western stock are more variable. K has a similar range than that for the east, but MSY estimates are lower, varying mostly from 500 to 1,200 tons but with two low estimates of 100 and 300 tons respectively (**Figure 15**).

All except one of the estimates of the recent biomass ratio (B_{2006}/B_{msy}) and fishing mortality ratios (B_{2007}/B_{msy}) for the eastern stock indicate overfishing is taking place and the stock is overfished (**Figure 16**). For the western stock results are again more variable, with 9 cases indicating that there is overfishing and that the stock is overfished and 7 indicating that there is either no overfishing, or that the stock is not overfished or both (**Figure 16**). In general the most pessimistic cases in the west are those that used combined indices, and those that are more optimistic those that used various combinations of single indices.

To examine the uncertainty associated with "observation error" the group used the results of the bootstrapped estimations from ASPIC and the posterior estimates from the Bayesian model. Estimates of uncertainty for model parameters are also greater for the eastern stock than for the western stock, but they remain large for both (**Tables 10, 12** and **13**). For example, the ratio of B_{2006}/B_{msy} estimated from the Bayesian model with informative priors for the Eastern stock and with a combined index was 0.15, but 25% and 75% percentiles corresponded to 0.11 and 0.22 respectively. For the western stock equivalent numbers were 0.47, for the estimate and 0.36 and 0.60 respectively for the same percentiles. Estimates of the same ratio obtained from bootstraps of ASPIC fits to an eastern combined index (case F1) were 0.24, for the estimate and 0.12 and 0.39 for the 25% and 75% percentiles. Similarly ASPIC fits to a complete set of available indices for the west (case O9) provided a best estimate of 1.01, and estimates of 0.91 and 1.24 for the 25% and 75% percentiles (**Figure 17**). In general cases that used individual indices lead to smaller uncertainty than those that used combined indices. Bootstrap and Bayesian estimates of uncertainty show that there is considerable uncertainty in the recent biomass and fishing mortality ratios with some solutions differing completely on the questions of whether there is or no overfishing or the stock is or not overfished, as illustrated in **Figure 17**.

3.3 Other assessment analyses

In addition to production model fits additional analyses were conducted to provide insight on stock status. These included examination of recent trends in relative abundance on the basis of cpue indices alone, development of model free reference points and an analysis of changes in size structure of the catch.

3.3.1 Recent trends in abundance

Analyses of CPUE indices where conducted to investigate the trends in abundance that do not make any assumption of whether there is an underlying production model or any other population model. Additionally, other analyses following the procedures outline in ICCAT (2007) were conducted to determine recent changes in abundance.

In order to compare the recent abundance trends (1990-2006) that can be inferred from CPUE indices these were scaled by the mean of each index (**Table 15, Figure 18**). These scaled indices were smoothed using Generalized

Additive Models with a Loess function (GAMLoess). Most of these indices fluctuate without a trend during this period and only few show a clear declining trend such as the US Pelagic longline indices for the western stock or a clear increasing trend such as the US MRFSS index, also for the western stock (**Figures 19** and **20**).

Correlations between indices
Robust estimates of the correlation between the various available recent CPUE indices for SAI-West and SAI-East (1990-2007) were obtained using the Pearson method (**Table 16**). Generally, there is poor correlation between the twelve available indices with the exception of the Japanese Longline and the US MRFSS indices for the western stock that are strongly positively correlated. These later indices fluctuate without a trend over the period 1990-2006.

Median changes in relative abundance
Another approach applied to examine relative changes in abundance as evidenced by the available CPUE indices was a robust procedure to estimate confidence intervals for the median ratios of the indices in one year relative to the indices in another year. We estimated the 95% confidence intervals using the binomial distribution for the median of the CPUE ratios relative to the standard year 2000, following the procedures described by Conover (1980). Ten indices were used for SAI-West and four for SAI-East. For each index in a given year, the ratio of that index value relative to 2000 was computed. Then, estimates of the confidence interval for the ratio each year were obtained from the relative values (**Figure 21** and **Figure 22**).

3.3.2 Model-free reference points

Estimates of B/B_{msy} were made for each of the three combined indices for the eastern and western stock using the methods in Goodyear (2003). The method exploits the change in relative abundance (CPUE) between the beginning and ending of the available time series. It was also assumed that a Beverton-Holt stock recruitment relation was appropriate for sailfish. For the eastern stock, the average relative abundance at the beginning of the time series was estimated as the average of the first 5 years of CPUE (1967-1971) and the most recent relative abundance was estimated as the average for the last 5 years of available CPUE (2003-2007). The resulting estimates of B/B_{msy} for the eastern stock ranged from 0.08 to 0.19 with a mean of 0.13 for the unweighted, and the two weighted CPUE time series (**Table 17**). Restricting the analysis to begin with the 1980 data which omits the early years of high abundance estimates resulted in a more optimistic range for B./Bmsy of 0.43 to 0.71 with a mean of 0.54.

B/B_{msy} was similarly estimated for the western stock using the 1961-1965 mean CPUE for the beginning of the time series and the mean for the last 5 years of available data (2004-2008) as a measure of recent relative abundance. These assumptions lead to B/B_{msy} estimates for the western stock that ranged from 0.58 to 1.83 with a mean of 0.77 (**Table 17**). Restricting the analysis to begin with the 1973 data which omits the early years of high abundance estimates resulted in a more optimistic range for B./Bmsy of 0.80 to 1.99 with a mean of 1.32.

3.3.3 Size data trends

Using the length frequency information (centimeters, lower jaw-fork length) for six fleets from SAI-West and five fleets from SAI-East, we looked for signals suggesting change in year-class strength over the period 1970-2007. In addition, basic statistical information (25% quartile, median and 75% quartile) was calculated for each fleet by year to elicit any possible trend of catch-at-size. The lengths of the individual fleet time series varied greatly and were often sparse.

The size frequency quartiles are illustrated for the western stock are presented in **Figure 23** and **Table 18**. Both the Brazil and Venezuela long-term plots had slight variability, but overall were largely flat and stable. On the other hand, the Japanese data indicated high variability, a factor possibly attributable to the spatial distribution of fishing effort. The Chinese Taipei series was too short (1980-1983) to suggest a trend.

The size frequency quartiles for the eastern stock are illustrated in **Figure 24** and **Table 19**. Here, the Cote d'Ivoire gillnet data suggested a slight variability in year-class strength, but was largely stable over the period 1984-2006. The Japanese longline data were highly variable for the period spanning 1974 to 2005. Again, this may be associated with the spatial distribution of fishing effort. The data from Ghana gillnet, Brazil longline, and Chinese Taipei longline all suggested year-class variability, but the time series were too short to conclude any trends.

3.4 Summary of assessment results

It is the first time that ICCAT has been able to conduct a full assessment of both Atlantic sailfish stocks through a range of models and by using different combinations of data sources. It is clear that there remains considerable uncertainty regarding the stock status of these two stocks, however, many assessment model results present evidence of overfishing and of evidence that the stocks are overfished, more so in the east than in the west. Although some of the results suggest a healthy stock in the west, few suggest the same for the east. The eastern stock is also assessed to be more productive than the western stock, probably providing a greater MSY. The eastern stock is likely to be suffering stronger overfishing and most probably has been reduced further below the level that would produce the MSY than the western stock. Reference points obtained with model free methods reach similar conclusions.

Examination of recent trends in abundance suggest that both the eastern and western stocks suffered their greatest declines in abundance prior to 1990 and since then there is no strong evidence of abundance being declining or increasing for either of them. In general there is low correlation between individual indices for this period although some individual indices clearly decline or increase.

Examination of available length frequencies provide similar results to those obtained before for marlins, namely, that average length or length distribution have not changed much during the period where there are observations, thus reducing the value of using length as an indicator of fishing pressure.

4. Management implications

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, particularly for the west as various production model fits indicated the biomass ratio B/B_{msy} both above and below 1.0. The results for the eastern stock were more pessimistic 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. The biomass of the stock shows little, if any, signs of recovery. Inspection of smoothed trends of the individual relative abundances for the most recent years does not reveal a consistent shift in the recent population trajectory. Based on the available information, the Group recommends that catches should be reduced from current levels. It should be noted, however, that artisanal fishermen harvest a large part of the sailfish catch along the African coast. The Commission should consider practical and alternative methods to reduce fishing mortality and to assure data collection systems and timely reporting of catch and effort.

4.2 Western stock

The current western Atlantic assessment suggests that the stock declined over the available time series but has remained relatively stable since the 1980s. Inspection of the smoothed trends in the individual relative abundance time series for the last 18 years indicates differences amongst the time series which foster uncertainty with respect to the current trajectory of this stock. These observations lead the Group to recommend that the West Atlantic sailfish catches should not exceed current levels. It should be noted however, that the recreational fisheries in this area are almost entirely a catch and release fishery. Also this component of the fishery for sailfish has been adopting technologies in recent years to minimize the mortality of released sailfish even without management intervention. Commercial landings are prohibited in the U.S. Also, artisanal fishermen harvest a large part of the western sailfish catch.

4.3 Other issues

The distribution of sailfish indicates a relatively high concentration extending across the tropical Atlantic from Brazil to the western coast of Africa. This relatively continuous band strongly suggests genetic exchange between the eastern and western stocks, and may also imply that at least some of the sailfish biomass of the Eastern stock is supported by production from the southern component of the Western stock off Brazil. Whether this connection is sufficiently important that mixing between the eastern and western stock should be explicitly considered for assessment and management purposes is uncertain. However, the current relative biomass of the

Eastern stock appears to be lower than that in the west. This observation supports the notion that the eastern and western stocks should be considered separate management units.

5. Executive Summary for SAI

This items was postponed to be addressed during the 2009 Species Group meetings

6. Other matters SAI

The group agreed that the SAI stock assessment work carried out during the meeting was to be used as the basis for 2009 SCRS advice and, as such, no more model runs would be conducted during the Species Group or SCRS meetings.

7. Other matters, all billfish

The group reviewed progress of the billfish work plan as well as the Enhanced research program for billfish. Suggestions were made to modify both. It was agreed to circulate these after the meeting to interested scientists, with a view to having further discussion during SCRS 2009.

8. Report adoption and closure

The report was adopted by correspondence. The Chairman thanked participants for their hard work. He also thanked the meeting hosts for the excellent logistical support provided, and then he declared the meeting closed.

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Table 1. Nominal proportion of sailfish in the sailfish-spearfish aggregate by 5 degrees of latitude and longitude for all longline fleets and years combined where the species were identified separately: a), percentage sailfish, b), total number of observations, all fleets all years..

a)

Average of Lon5																							
Lat5	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
45											0%	0%						0%					
40							0%		0%	0%	0%	0%					0%						
35					100%	58%	27%	0%			0%	0%	0%	0%		0%	0%	0%					
30					94%	11%	42%	0%	0%	2%	2%			0%	17%	2%		0%					
25	100%	95%	92%	100%	93%	7%	56%	3%	2%	4%	2%	0%	4%	0%	4%	60%	0%						
20		78%	50%	100%		83%	34%	19%	2%	34%	28%	0%	7%	12%	11%	19%	19%						
15						100%	19%	21%	27%	30%	4%	2%	2%	29%	40%	62%	58%						
10				98%	93%	34%	69%	69%	69%	58%	51%	6%	21%	41%	91%	94%	97%						
5				99%	95%				85%	82%	65%	78%	57%	68%	87%	96%	99%	100%					
0										100%	100%	90%	88%	63%	66%	81%	66%	71%	96%	86%	100%	100%	
-5													100%	70%	70%	65%	57%	72%	82%	81%	99%	100%	
-10													26%	50%	47%	46%	41%	21%	25%	34%	89%	100%	
-15													0%	58%	44%	58%	33%	44%	100%	11%	35%	50%	
-20												0%	0%	49%	31%	21%	0%	0%		31%	11%		
-25											33%	2%	50%	4%	2%	0%	25%	0%	0%	11%	20%	97%	
-30											11%	0%	33%	0%				0%		50%	0%		0%
-35										0%	0%		100%							100%			0%
-40										100%													
-50														100%									

b)

ım of Nfish Lon5

Lat5	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
55																							
50																							
45											12	28						1					
40							1		1	3	4	4					1						
35					2	50	244	59			5	6	1	4		10	3	4					
30					358	613	12	6	833	391	221			11	4	59		1					
25	114	755	198	18	345	2938	1581	2065	246	161	185	76	82	7	23	20	13						
20		9	4	29		22	129	358	25	37	18	119	103	50	58	357	95						
15						23	408	518	86	189	268	196	182	941	909	208	423						
10				83	1367	235	1468	435	559	182	78	473	483	1010	915	930	338						
5				89	213				440	538	530	523	502	678	1416	2879	1664	22					
0									0	1	219	856	14262	9193	2287	1134	2872	2237	3265	8290	393	1	
-5													4	2850	1038	3011	2671	1481	2653	2378	728	181	
-10												0	34	469	367	245	483	596	882	795	1075	434	
-15													10	370	1236	161	28	128	17	582	357	23	
-20												1	4	46	475	71	35	18		55	44		
-25											10	33	22	42	51	2	40	17	2	249	50	65	
-30											33	34	4	6	0	0	0	4		8	4		12
-35										4	22		9	0	0		0			8			20
-40										20													
-45																							
-50														1									

Table 2 Total catch (t) of SAI+SPR by 5x5 degree, all longline fleets combined, estimated from the CATDIS ICCAT database.

of Catch_t lon

Lat	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
55									13														
50																	0	0					
45												1	0	0	0	0	7	7					
40						1	2	7	3	8	2	6	6	4	1	4	10	10	1				
35					211	71	43	22	3	1	1	3	37	5	1	14	10	5	8				
30		143	1258	26	128	27	14	12	15	10	7	11	29	10	2	6	2	3	1				
25	1628	177	356	4303	575	8	8	10	7	11	8	13	10	30	2	3	4	1					
20	109	186	114	2672	5	29	133	28	17	45	9	15	14	6	11	15	26						
15	12	18	48	36	27	17	760	77	15	14	34	35	77	38	40	69	9661						
10				107	180	890	921	5533	230	81	49	45	263	284	221	176	1863	516	0				
5				32	123			3	209	317	352	257	152	254	269	374	785	878	1	44			
0										0	225	660	943	745	458	388	1954	1859	1353	37852	3365	197	1
-5											0	1	4	856	691	324	472	262	274	677	405	283	1
-10													148	692	760	833	1216	292	79	291	74	76	
-15													244	297	719	728	732	436	21	335	28	96	
-20											199	2840	460	214	201	329	157	117	26	152	82	142	
-25											659	519	272	84	35	6	19	9	11	17	74	125	1
-30										82	60	19	27	12	42	32	6	7	26	399	82	60	21
-35									1	3	5	71	11	13	5	12	2	1	0	10	66	56	149
-40										0	0	0											0
-45																							

Table 3. Sampling ratio (number of observations per ton of catch SAI+SPR from longline fleets) proportion to estimate the SAI/SPF ratios by 5x5 degree squares. Note, in this estimate of sampling ratio the catch of the square lat lon 0,0 was excluded, as likely it refers to unknown location for the reported catch.

Lat5	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
55																							
50																							
45												0.000%						0.000%					
40							0.000%		0.000%	0.000%	0.000%	0.000%					0.000%						
35					0.003%	0.026%	0.077%	0.010%			0.000%	0.000%	0.000%	0.000%		0.001%	0.000%	0.000%					
30					0.340%	0.122%	0.001%	0.001%	0.095%	0.030%	0.012%			0.001%	0.000%	0.003%		0.000%					
25	1.381%	0.993%	0.525%	0.576%	1.475%	0.181%	0.091%	0.151%	0.014%	0.014%	0.011%	0.007%	0.006%	0.002%	0.000%	0.001%	0.000%						
20		0.012%	0.003%	0.577%		0.005%	0.128%	0.076%	0.003%	0.012%	0.001%	0.013%	0.011%	0.002%	0.005%	0.040%	0.018%						
15						0.003%	2.307%	0.296%	0.009%	0.020%	0.067%	0.051%	0.104%	0.264%	0.268%	0.106%	30.401%						
10				0.066%	1.828%	1.556%	10.055%	17.906%	0.955%	0.110%	0.028%	0.159%	0.945%	2.131%	1.506%	1.218%	4.684%						
5				0.021%	0.194%				0.684%	1.267%	1.388%	1.001%	0.569%	1.283%	2.836%	8.009%	9.720%	0.144%					
0										0.000%	0.366%	4.201%	100.000%	50.981%	7.788%	3.270%	41.753%	30.935%	32.871%	23.343%	9.839%	0.001%	
-5													0.000%	18.138%	5.339%	7.252%	9.370%	2.891%	5.410%	11.973%	2.192%	0.381%	
-10													0.037%	2.414%	2.076%	1.518%	4.368%	1.296%	0.518%	1.720%	0.592%	0.245%	
-15													0.018%	0.818%	6.609%	0.872%	0.152%	0.415%	0.003%	1.452%	0.075%	0.016%	
-20												0.021%	0.014%	0.073%	0.711%	0.174%	0.041%	0.016%		0.062%	0.027%		
-25											0.049%	0.128%	0.044%	0.026%	0.013%	0.000%	0.006%	0.001%	0.000%	0.032%	0.027%	0.060%	
-30											0.015%	0.005%	0.001%	0.001%	0.000%	0.000%	0.000%	0.000%		0.024%	0.002%		0.002%
-35										0.000%	0.001%		0.001%	0.000%	0.000%		0.000%			0.001%			0.022%
-40										0.000%													
-45																							
-50																							

Table 4: Catches (tons) of a) sailfish and b) spearfish calculated for the longline fleets of Chinese Taipe, Japan and Korea from the reported aggregate of sailfish/spearfish and by using the ratios estimated from the fit of observer count data to the binomial model presented in appendix 5

	Chinese Taipei				Japan				Korea Rep.			
	SAI		SPF		SAI		SPF		SAI		SPF	
YearC	ATE	ATW	ATE	ATW	ATE	ATW	ATE	ATW	ATE	ATW	ATE	ATW
1956						1		0				
1957					71	24	19	4				
1958					32	66	7	13				
1959					4	5	8	11				
1960					50	65	41	59				
1961					173	21	131	36				
1962	2		0		216	63	241	80				
1963	3		1		215	105	280	135				
1964	2		0		238	244	277	411	0	1	1	1
1965	1	1	0	0	745	586	586	554	2	3	3	3
1966	11	14	4	6	458	234	779	374	23	45	39	42
1967	54	74	17	32	229	58	175	216	86	64	145	59
1968	421	60	136	26	293	117	255	305	26	83	23	77
1969	333	80	90	99	124	125	106	103	311	176	84	140
1970	122	34	174	77	42	205	53	294	257	253	69	200
1971	370	94	156	76	54	234	71	87	253	249	68	197
1972	252	7	533	10	40	93	49	39	246	241	66	192
1973	226	37	265	70	20	60	46	18	43	54	26	42
1974	36	36	63	44	5	78	14	40	36	45	22	36
1975	11	9	14	19	11	90	27	22	29	44	17	19
1976	29	29	188	97	1	103	3	30	108	45	57	19
1977	8	1	51	4	5	14	19	9	29	45	17	20
1978	2	3	5	7	3	4	8	5	13	10	5	4
1979	5	6	14	12	8	4	11	16	4	12	1	7
1980	1	11	4	25	13	3	20	19	27	30	7	21
1981	3	25	9	56	17	26	33	18	17	28	7	13
1982	19	7	48	15	16	85	22	50	23	8	10	11
1983	6	9	14	22	23	15	24	7	2	18	1	18
1984	2	14	6	31	32	23	31	11	24	24	10	28
1985	3	12	6	27	41	16	43	22	20	33	9	39
1986	0	20	1	44	32	8	39	20	2	10	0	4
1987	1	9	4	22	16	2	21	4	8	1	12	0
1988	2	92	4	208	26	5	31	17	11	1	4	2
1989	3	86	4	85	26	12	31	10	12	12	5	5
1990	5	42	8	41	31	12	32	13	12	16	4	9
1991	4	37	6	36	6	27	10	46	22	1	8	0

1992	80	17	135	16	15	0	27	1	2	2	1	1
1993	157	112	263	111	27	1	31	1	2	3	1	2
1994	38	117	63	116	45	8	36	2	5	4	1	4
1995	58	19	97	19	52	2	26	3	5	4	1	4
1996	24	19	41	18	47	4	25	4	11	12	3	10
1997	56	2	94	2	19	17	30	1	4	4	1	4
1998	44	65	73	64	58	3	22	8				
1999	66	17	112	16	16	10	33	11				
2000	45	11	75	11	26	12	29	11	0			
2001	50	33	52	24	6	3	20	3				
2002	62	31	62	39	20	3	0					
2003	49	13	25	12	21	8	0					
2004	15	8	15	11	70	5	0					
2005	25	21	25	20	50	22	0					
2006	36	5	37	17	62	4	0					
2007	109	14	22	20	149	1	0					

Table 5 Estimated Catches (t) of Atlantic sailfish (Istiophorus albicans) by stock (East and West) and Flag

	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
ATE	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Benin	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	36
Cape Verde	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
China P.R.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chinese Taipei	...	...	...	...	...	...	2	3	2	1	11	54	421	333	122	370	252	226	36	11	29	8	2	5	1	3
Côte D'Ivoire	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cuba	...	...	...	...	...	...	...	10	20	43	31	371	56	52	42	21	13	42	96	110	185	65	69	40	79	79
EC.España	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
EC.Portugal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
EC.United Kingdom	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gabon	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ghana	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	3040	4726	4517	764	1885	2691	1191	891
Japan	...	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
Korea Rep.	...	...	...	...	...	...	...	...	0	2	23	86	26	311	257	253	246	43	36	29	108	29	13	4	27	17
Liberia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Maroc	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mixed flags (FR+ES)	...	...	...	...	...	...	...	2	4	4	11	18	36	46	67	93	143	148	235	256	327	400	405	375	432	504
NEI (ETRO)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Panama	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	31	9	7	41	13	4	...	...	...
Russian Federation	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
S. Tomé e Príncipe	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Senegal	...	...	...	...	...	...	...	...	...	...	...	76	76	81	87	112	122	144	107	122	189	160	143	107	325	498
St. Vincent and Grenadines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Togo	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U.S.A.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U.S.S.R.	...	...	...	...	...	...	...	...	...	3	5	14	13	14	11	14	39	14	9	7	1	13	5	...	...	37
Total ATE		**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**
	...	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**
ATW	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Aruba	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	10	20	20	30	30	30	30
Barbados	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Belize	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Brasil	...	...	...	...	...	159	91	46	46	46	46	23	57	27	21	43	64	37	78	76	186	287	246	201	231	64
China P.R.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chinese Taipei	...	...	...	...	...	...	...	...	...	1	14	74	60	80	34	94	7	37	36	9	29	1	3	6	11	25
Cuba	...	...	...	...	...	...	...	13	29	59	44	151	258	19	58	30	17	58	133	152	122	91	51	151	119	134
Dominica	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dominican Republic	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
EC.España	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
EC.Portugal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Grenada	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	31	37	40	31	36
Japan	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
Korea Rep.	...	...	...	...	...	...	...	...	1	3	45	64	83	176	253	249	241	54	45	44	45	45	10	12	30	28
Mexico	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
NEI (ETRO)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Netherlands Antilles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28	28	28	28	28	28	28	28	21	21	21	21
Panama	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	44	13	9	...	18	3	2	...	...
Seychelles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
St. Vincent and Grenadines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sta. Lucia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trinidad and Tobago	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U.S.A.	...	...	...	...	111	126	142	157	173	188	194	201	207	214	220	227	233	240	248	254	261	308	308	308	308	533
UK.British Virgin Islands	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Venezuela	...	...	...	...	...	44	68	33	40	96	72	123	90	111	440	338	101	91	84	60	59	56	66	93	58	72
Total ATW	**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**
Total Atlantic	**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**

	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
ATE	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Benin	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
Cape Verde	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
China P.R.	...	...	...	...	...	...	...	...	...	...	...	...	3	3	3	3	5	9	4	5	11	4	4	8	...	8
Chinese Taipei	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
Côte D'Ivoire	...	...	40	40	40	40	66	55	58	38	69	40	54	66	91	65	35	80	45	47	65	121	73	93	78	52
Cuba	158	200	115	19	55	50	22	53	61	184	200	77	83	72	533	...	...	...	...	...	...	...	...	...	...	...
EC.España	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	257
EC.Portugal	...	...	...	...	...	...	...	...	...	...	1	2	1	2	1	2	27	53	11	3	8	13	19	11	136	43
EC.United Kingdom	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	0	...	...
Gabon	...	...	...	...	...	...	...	...	...	...	...	3	3	110	218	2	...	...	...	0	...	4	...	...	...	...
Ghana	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
Japan	16	23	32	41	32	16	26	26	31	6	15	27	45	52	47	19	58	16	26	6	20	21	70	50	62	149
Korea Rep.	23	2	24	20	2	8	11	12	12	22	2	2	5	5	11	4	...	...	0	...	...	...	...	...	...	...
Liberia	...	...	...	...	...	...	...	...	...	...	...	...	...	33	85	43	136	122	154	56	133	127	106	122	118	115
Maroc	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	...	...
Mixed flags (FR+ES)	521	499	354	364	403	394	408	432	595	174	150	182	160	128	97	110	138	131	98	44	39	44	41	35	32	36
NEI (ETRO)	...	...	...	...	...	...	...	...	...	...	...	27	51	57	69	86	127	120	77	43	3	2	16	7	8	10
Panama	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Russian Federation	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
S. Tomé e Príncipe	...	...	...	...	...	...	78	86	97	84	78	81	88	92	96	139	141	141	136	136	136	136	515	346	292	384
Senegal	572	510	163	241	572	596	587	552	1092	546	917	936	260	678	610	556	270	412	412	266	138	361	263	254	292	737
St. Vincent and Grenadines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	1	5
Togo	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	22	36	23	62	55	95	135	47	31	71
U.S.A.	...	...	...	...	...	...	...	...	...	2	4	1	1	3	1	...	...	...	...	...	...	...	...	...	...	...
U.S.S.R.	...	...	...	...	2	5	4	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total ATE	**2796**	**3706**	**2445**	**2269**	**2065**	**2553**	**2109**	**1710**	**2367**	**1556**	**1837**	**2290**	**1270**	**1745**	**2252**	**1334**	**1373**	**1516**	**1320**	**1449**	**1477**	**1731**	**1932**	**1735**	**1575**	**2399**
	...	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**
ATW	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Aruba	30	30	30	30	30	23	20	16	13	9	5	10	10	10	10	10	10	10	10	...	...	...	...	...	...	...
Barbados	...	...	...	...	...	...	...	69	45	29	42	50	46	74	25	71	58	44	44	42	26	27	26	42	58	42
Belize	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	12
Brasil	153	60	121	187	292	174	152	147	301	90	351	243	129	245	310	137	184	356	598	412	547	585	534	416	140	123
China P.R.	...	...	...	...	...	...	...	...	...	...	...	...	3	3	3	3	3	9	4	3	1	0	1	0	...	0
Chinese Taipei	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
Cuba	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
Dominica	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	3	...	1	...	3	3
Dominican Republic	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
EC.España	...	...	...	...	...	...	...	0	0	8	13	13	19	36	5	30	42	7	14	354	449	196	181	113	148	184
EC.Portugal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	0	2	12	12	110	19	53
Grenada	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
Japan	85	15	23	16	8	2	5	12	12	27	0	1	8	2	4	17	3	10	12	3	3	8	5	22	4	1
Korea Rep.	8	18	24	33	10	1	1	12	16	1	2	3	4	4	12	4	...	...	...	...	...	...	...	...	...	...
Mexico	...	...	...	...	...	...	...	...	...	...	...	2	19	19	10	9	65	40	118	36	34	45	51	55	42	47
NEI (ETRO)	...	...	...	...	...	...	...	...	...	...	...	15	27	30	36	46	67	64	41	23	1	1	9	4	4	6
Netherlands Antilles	21	21	21	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15	15	...	...	...	...	...	...	...
Panama	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Seychelles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...
St. Vincent and Grenadines	...	...	...	...	...	...	...	...	2	1	4	4	4	2	1	3	...	1	...	2	164	3	86	73	59	18
Sta. Lucia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...	...	...	...
Trinidad and Tobago	...	64	58	14	25	35	24	11	9	4	4	56	101	101	104	10	7	4	3	7	6	8	10	9	17	13
U.S.A.	452	734	495	282	462	496	508	381	304	407	330	265	207	374	300	406	294	235	121	69	110	5	7	4	5	7
UK.British Virgin Islands	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...
Venezuela	57	119	81	81	77	80	22	24	24	65	71	206	162	93	155	175	248	169	83	126	159	133	158	178	184	248
Total ATW	**1042**	**1185**	**1151**	**1004**	**1212**	**1146**	**1071**	**964**	**1162**	**1116**	**1327**	**1332**	**1158**	**1224**	**1141**	**1163**	**1328**	**1349**	**1523**	**1451**	**1981**	**1316**	**1396**	**1435**	**1028**	**1149**
Total Atlantic	**3838**	**4891**	**3596**	**3273**	**3277**	**3699**	**3180**	**2674**	**3530**	**2672**	**3163**	**3622**	**2429**	**2969**	**3393**	**2496**	**2701**	**2865**	**2843**	**2900**	**3458**	**3047**	**3328**	**3169**	**2602**	**3548**

Table 6. Available CPUE indices for the sailfish assessment

WESTERN STOCK				
#	Index	Data source	Period	ID
1	US-LL index (kg/1000 hooks)	data collected by scientific observers SCRS/2009/046	1992-2008	(US LL_POP).
2	US-LL index ((kg/1000 hooks)	data collected by mandatory logbooks SCRS/2009/045	1986-2008	(US LL_PLL).
3	US-LL index (fish/1000 hooks)		1986-2008	(US LL_PLL).
4	US-RR recreational index (fish/1000 hooks)	data collected by the Recreational Billfish Survey (SCRS/2009/046)	1973-2008	(US RR-RBS).
5	US-RR recreational index (fish/1000 hooks)	data collected by the Recreational Marine Recreational Fishery Statistical Survey (SCRS/2009/046)	1973-2008	(US RR-MRFSS).
6	Venezuela-RR recreational index (fish/1000 hooks)	From port landing reports (SCRS/2000/075)	1961-1995	(VEN RR).
7	Venezuela GIL index (kg)	Data from scientific sampling of landings (SCRS/2008/040)	1991-2007	(VEN GIL).
8	Venezuela LL index (kg)	Data from scientific observers (SCRS/2009/033)	1991-2007	(VEN LL).
9	Brazil RR recreational index (fish/1000 hooks)	Data from tournament reports (SCRS/2008/081)	1996-2007	(BRZ RR).
10	Brazil LL (fish/1000 hooks)	Data from logbooks (SCRS/2009/066)	1978-2008.	
11	Japan LL index (fish/1000 hooks)	Estimated with a GLM for the 2001 assessment (SCRS/01/149)	1967-1993	(JPN LL1).
12	Japan LL index (fish/1000 hooks)	Estimated with a GLM for the 2009 assessment (SCRS/2009/067)	1994-2007	(JPN LL2).
13	Japan LL index (kg)	Estimated during the meeting from the T2CE (see **Appendix 6)**	1960-2007	(JPN LL-3;)
14	Korea LL index (kg)	estimated during the meeting from the T2CE (see **Appendix 6)**	1967-1969, 1975, 1978-1994, 1996,1997,1999	(KOR LL).
9	Chinese Taipei LL index	prepared at the 2001 assessment (SCRS/2001/025) Table 4	1967-1975, 1979- and 1993-1999. The indexes for each time period were treated as separate fleets	(TAI_LL_1)/ (TAI_LL_2)/ (TAI_LL_3)
EASTERN STOCK				
1	Cote d'Ivoire artisanal index (number of fish)	Data correspond to number of fish landed by gillnet vessels (SCRS/2009/032)	1988-2007	(CIV ART).
2	Senegal artisanal index (kg)	The gears included in this index were gillnet, troll and handline, the data represents weight of landings (SCRS/2009/054)	1989-2006.	(SEN ART)
3	Japan LL index (fish/1000 hooks)	Estimated with a GLM. This index was prepared for the 2001 assessment (SCRS/01/149)	1967-1999.	(JPN LL-1).
4	Japanese LL index	Estimated with a GLM prepared for the 2009 stock assessment (SCRS/2009/067)	1994-2007	(JPN LL-2).
5	Japan LL index (kg)	Estimated during the meeting from the T2CE (see **Appendix 6)**	1960-2007	(JPN LL-3).
6	Korea LL index (kg)	Estimated during the meeting from the T2CE (see **Appendix 6)**	1967-1969, 1975, 1978-1994, 1996,1997,1999	(KOR LL).
7	Ghanaian gillnet	Calculated during the meeting (see **Appendix 7)**.	1993-2007	(GHN GIL)

Table 7: Standardized indexes of abundance for the SAI western stock. Indices are denoted as: USLL1 = US Longline observers, USLL2 = US Longline logbooks kg, USLL3 = US Longline logbooks numbers of fish, USRR1 = US recreational tournaments (RBS), USRR2 = US recreational surveys (MRFSS), VENRR = Venezuela recreational, VENGL = Venezuela Gillnet, BRZLL = Brazil longline, BRZ = Brazil recreational, JPNLL1 = Japan longline early period, JPNLL2 = Japan longline recent period, JPNLL3 = Japan longline from task 2.

	US LL1	US LL2	US LL3	US RR1	US RR2	VEN RR	VEN GL	VEN LL	BRZ LL	BRZ RR	JPN LL-1	JPN LL-2	JPN LL-3
1960													0.804
1961						0.475							1.103
1962						0.462							1.397
1963						0.162							1.355
1964						0.369							1.525
1965						0.259							1.867
1966						0.803							1.973
1967						0.583					11.340		2.215
1968						0.56					10.643		3.308
1969						1.183					12.989		2.272
1970						0.609							2.159
1971						0.518					10.921		1.435
1972						0.39							1.182
1973				1.009		0.284							1.397
1974				0.774		0.419							1.377
1975				1.031		0.243							0.750
1976				0.792		0.27							0.754
1977				1.211		0.13							1.665
1978				1.12		0.082			0.432				1.252
1979				1.061		0.128			0.378				1.145
1980				1.223		0.147			0.373				0.925
1981				1.181	0.486	0.096			0.330		0.714		1.291
1982				0.26	0.252	0.055			0.163		0.661		1.305
1983				0.253	0.905	0.151			0.126		0.989		1.350
1984				0.561	0.591	0.259			0.174		0.249		1.001
1985				0.428	0.502	0.214			0.069		0.244		0.752
1986		1.083	1.172	0.561	0.687	0.127			0.164		1.167		0.844
1987		0.685	0.684	0.536	0.416	0.206			0.263				0.926
1988		1.28	1.253	0.793	0.66	0.101			0.253		0.193		0.690
1989		1.328	1.353	0.55	0.578	0.193			0.493		0.411		0.506
1990		1.454	1.546	0.865	0.648	0.028			0.107		0.335		0.376
1991		1.759	1.813	1.038	1.037	0.04	12.74	15.36	0.312				0.611
1992	2.028	2.402	2.578	1.373	1.364	0.006	16.44	11.68	0.339				0.519
1993	1.675	1.908	1.883	0.9	1.045	0	27.53	8.61	0.774				0.467
1994	0.942	1.385	1.23	1.423	0.975	0.039	31.28	11.82	0.081			0.0067	0.414
1995	0.644	0.874	0.82	1.265	1.246	0.011	34.45	11.75	0.252			0.0044	0.482
1996	1.190	0.874	0.856	1.366	0.966		31.47	5.72	0.381	0.858		0.0034	0.333
1997	0.808	1.396	1.17	1.499	0.706		37.53	8.57	0.331	0.772		0.0047	0.383
1998	0.569	0.994	0.98	1.727	1.351		41.32	5.05	0.295	0.887		0.0040	0.399
1999	1.497	1.297	1.244	0.999	1.636		48.72	24.49	0.185	0.475		0.0073	0.431
2000	2.124	0.922	0.939	0.753	1.228		31.27	6.39	0.246	0.724		0.0063	0.444
2001	0.490	0.313	0.335	0.824	0.749		25.44	4.17	0.430	0.701		0.0036	0.250
2002	0.363	0.384	0.463	1.035	1.361		20.32	6.40	0.307	0.590		0.0036	0.358
2003	0.511	0.385	0.43	1.267	1.381		31.12	5.30	0.233	0.435		0.0088	0.406
2004	0.699	0.541	0.578	0.919	1.128		44.24	7.44	0.359	0.508		0.0043	0.386
2005	0.916	0.223	0.284	0.996	2.017		41.82	5.58	0.522	0.527		0.0124	0.509
2006	0.371	0.241	0.248	1.113	1.095		30.43	7.83	0.343	0.716		0.0066	0.345
2007	0.688	0.426	0.389	1.028	1.179		40.82	16.83	0.439	0.472		0.0041	0.369
2008	1.501	0.846	0.752	2.205	1.813				0.657				

Table 8 Standardized indexes of abundance for the SAI eastern stock. Refer to the text for description of each index. Indices are denoted as: CIVAR = Cote d'Ivoire artisanal, SENAR, Senegal artisanal, JPNLL1 = Japan longline early period, JPNLL2 = Japan longline recent period, JPNLL3 = Japan longline from task 2, KORLL = Korea longline.

	CIV AR	SEN AR	GHN AR	JPN LL1	JPN LL2	JPN LL3	KOR LL
1960						0.736	
1961						5.036	
1962						1.080	
1963						0.778	
1964						2.405	
1965						2.028	
1966						1.951	
1967				5.645		0.660	
1968				2.482		1.799	
1969				2.682		2.846	0.902
1970				3.306		4.269	
1971				0.365		1.086	
1972				0.963		1.007	
1973				1.707		0.579	
1974				0.156		0.470	
1975				0.155		0.449	
1976						0.612	
1977				2.959		0.375	
1978						0.686	
1979				0.526		0.262	0.628
1980				0.534		0.527	1.677
1981				1.051		0.325	1.240
1982				0.953		1.078	2.040
1983				0.617		0.421	
1984				0.769		1.147	
1985				0.379		0.635	0.360
1986				0.956		0.670	0.153
1987				0.633		0.485	
1988	0.61			0.267		0.483	
1989	0.30	1.60		0.148		0.398	
1990	0.35	2.10		0.191		0.250	
1991	0.40	0.30		0.155		0.198	
1992	0.18	0.55		0.171		0.212	
1993	0.18	0.40	0.015	0.440		0.379	
1994	0.24	0.40	0.014		0.182	0.476	
1995	0.12	0.25	0.006		0.162	0.176	
1996	0.11	0.55	0.018		0.177	0.332	
1997	0.19	1.20	0.007		0.135	0.736	
1998	0.16	1.70	0.007		0.226	0.988	
1999	0.25	0.65	0.004		0.185	0.511	
2000	0.11	1.40	0.003		0.083	0.693	
2001	0.18	1.20	0.008		0.049	0.788	
2002	0.20	0.50	0.014		0.243	0.775	
2003	0.10	3.20	0.016		0.169	1.663	
2004	0.20	0.65	0.006		0.097	0.313	
2005	0.20	0.60	0.010		0.083	0.944	
2006	0.20	0.45	0.005		0.117	1.398	
2007	0.25		0.006		0.248	1.887	
2008							

Table 9 Estimated combined Indexes of abundance for the western and eastern stocks. Indices differ because of the different weighting used in the process of combination: "weighted-catch" correspond to weighting proportional to the reported catch associated with the fleet corresponding to the index, "weighted area" to weighting proportional to area of the fishery (measured by the number of 5 degree grids) where catch was reported for the fleet associated with the index.

	Western Stock			Eastern Stock		
	Un-weighted	Weighted by catch	Weighted by area	Un-weighted	Weighted by catch	Weighted by area
1961	0.347	0.187	0.321			
1962	0.337	0.182	0.313			
1963	0.118	0.064	0.110			
1964	0.269	0.145	0.250			
1965	0.189	0.102	0.175			
1966	0.586	0.316	0.543			
1967	0.350	0.205	0.590	2.805	5.644	4.075
1968	0.604	0.316	0.780	1.233	2.481	1.792
1969	0.879	0.386	0.935	1.332	2.681	1.936
1970	0.436	0.225	0.400	1.642	3.305	2.386
1971	0.661	0.356	0.847	0.181	0.365	0.263
1972	0.250	0.128	0.211	0.479	0.963	0.695
1973	0.148	0.073	0.156	0.848	1.707	1.232
1974	0.154	0.058	0.171	0.078	0.156	0.113
1975	0.142	0.064	0.154	0.077	0.155	0.112
1976	0.102	0.046	0.082			
1977	0.087	0.070	0.090	1.470	2.958	2.136
1978	0.072	0.069	0.077			
1979	0.056	0.058	0.045	0.261	0.525	0.379
1980	0.078	0.066	0.073	0.265	0.534	0.386
1981	0.079	0.064	0.077	0.522	1.051	0.759
1982	0.035	0.017	0.039	0.473	0.953	0.688
1983	0.045	0.016	0.045	0.307	0.617	0.446
1984	0.047	0.030	0.034	0.382	0.769	0.555
1985	0.030	0.018	0.023	0.188	0.379	0.274
1986	0.058	0.031	0.066	0.475	0.955	0.690
1987	0.056	0.034	0.049	0.315	0.633	0.457
1988	0.059	0.056	0.049	0.236	0.303	0.198
1989	0.073	0.046	0.060	0.163	0.215	0.111
1990	0.037	0.039	0.042	0.205	0.288	0.144
1991	0.055	0.060	0.081	0.104	0.050	0.111
1992	0.045	0.070	0.079	0.101	0.083	0.120
1993	0.044	0.084	0.094	0.149	0.104	0.292
1994	0.055	0.067	0.074	0.161	0.128	0.125
1995	0.063	0.066	0.064	0.095	0.048	0.064
1996	0.055	0.062	0.054	0.149	0.108	0.115
1997	0.063	0.079	0.061	0.157	0.144	0.134
1998	0.070	0.078	0.079	0.185	0.135	0.139
1999	0.057	0.053	0.047	0.113	0.080	0.100
2000	0.051	0.048	0.052	0.100	0.102	0.088
2001	0.043	0.065	0.037	0.149	0.115	0.132
2002	0.044	0.054	0.046	0.140	0.143	0.124
2003	0.043	0.047	0.039	0.219	0.234	0.194
2004	0.053	0.072	0.051	0.117	0.084	0.103
2005	0.047	0.088	0.042	0.135	0.113	0.120
2006	0.048	0.061	0.043	0.098	0.069	0.087
2007	0.060	0.088	0.060	0.128	0.078	0.112
2008	0.101	0.063	0.095			

Table 10: Management parameters obtained from different cases fitted to ASPIC for the eastern and western stocks of Atlantic sailfish. Values shown correspond to the non- bootstrapped estimates of MSY, the ratio of the latest fishing mortality (2007) to the fishing mortality at MSY and the ratio of the most recent estimate of biomass (2006) to the biomass at MSY. For boostrapped fits the 50th, 25Th and 75th percentile are shown. Description of cases is provided in Appendix 9.

		MSY			Fratio			Bratio		
Stock	**Case**	**Estimate**	**25%**	**75%**	**Estimate**	**25%**	**75%**	**Estimate**	**25%**	**75%**
East										
	g3	2340			3.77			0.14		
	g4	76.25			185.9			0.09		
	g6	2105			2.51			0.28		
	o3	5072			0.27			1.73		
	o4	4949			0.174			1.83		
	o7	2247	2131	2359	0.62	0.57	0.76	1.15	0.997	1.246
	o8	1868	455	1897	1.58	1.17	27.81	0.53	0	0.62
	f1	2106	1713	2341	3.89	2.64	5.65	0.241	0.12	0.391
	f2	2460	2179	2481	2.26	1.71	2.76	0.261	0.172	0.341
West										
	g1	99.6			3.07			0.35		
	g2	873			1.4			0.94		
	g5	284			8.63			0.45		
	o1	1220			0.673			1.25		
	o2	1455	1198	1550	0.593	0.47	0.9	1.247	0.93	1.41
	o5	1062	291	1154	0.814	0.51	1.43	1.189	0.918	1.49
	o6	1163			0.74			1.189		
	o9	1027	563	1198	1.015	0.74	1.62	1.099	0.91	1.24
	o10	844			1.48			0.913		
	o11	18690			0.028			1.967		
	o12	1220			0.75			1.13		
	o13	663			1.67			1.029		
	w1	117.8			1.28			0.3914		
	w2	858.1			0.0736			0.9506		
	w3	140.2			1.02			0.4136		

Table 11. Results of EXCEL production models. Current status estimates for the western stock assuming different surplus production functions (Schaefer or Fox) and using different weighting options for the combined CPUE index.

	Schaefer		**Fox**	
	Equal wt	**DownWt**	**EqualWt**	**DownWt**
F_{2007}/Fmsy	4.25	1.64	5.40	0.94
B_{2008}/Bmsy	0.44	0.90	0.49	1.16

Table 12 – Bayesian production model for Western stock. Summary of the posterior estimations as calculated using informative and non-informative priors.

Infomative Prior			Quantiles		
Estimations	5%	25%	50%	75%	95%
R	0.07	0.12	0.16	0.21	0.31
K	14300.37	18867.77	22556.09	27135.48	34597.32
Q	4.40E-06	5.66E-06	6.71E-06	8.04E-06	1.05E-05
C_msy	622.82	789.87	888.14	981.60	1110.36
B_msy	7150.19	9433.89	11278.05	13567.74	17298.66
B_last	2496.54	4023.73	5313.12	6995.76	10152.69
ER_msy	0.04	0.06	0.08	0.10	0.15
B_last/B_msy	0.24	0.36	0.47	0.60	0.84
C_last/C_msy	1.03	1.17	1.29	1.45	1.84
ER_last	0.11	0.16	0.22	0.29	0.46
ER_last/ER_msy	1.29	2.02	2.82	4.07	6.61
Non-Informative Prior					
r	0.04	0.07	0.10	0.14	0.25
k	16921.34	24561.25	29971.76	35845.21	45878.09
q	3.13E-06	4.22E-06	5.15E-06	6.39E-06	8.87E-06
C_msy	421.16	594.53	736.39	858.30	1061.26
B_msy	8460.67	12280.63	14985.88	17922.60	22939.04
B_last	3000.63	4817.13	6716.01	9270.89	14729.77
ER_msy	0.02	0.03	0.05	0.07	0.12
B_last/B_msy	0.24	0.35	0.47	0.59	0.84
C_last/C_msy	1.08	1.34	1.56	1.93	2.73
ER_last	0.08	0.12	0.17	0.24	0.38
ER_last/ER_msy	1.40	2.52	3.54	5.34	8.72

Table 13 – Bayesian production model for the Eastern stock. Summary of the posterior estimations as calculated using informative and non-informative priors.

Infomative Prior			Quantiles		
Estimations	5%	25%	50%	75%	95%
r	0.09	0.10	0.12	0.16	0.23
k	33932.98	41923.28	48266.65	53163.40	57335.94
q	1.28E-05	1.54E-05	1.75E-05	1.99E-05	2.53E-05
C_msy	1254.78	1369.19	1509.60	1711.73	1949.20
B_msy	16966.49	20961.64	24133.33	26581.70	28667.97
B_last	1316.22	2520.94	3621.83	5150.18	8302.47
ER_msy	0.04	0.05	0.06	0.08	0.11
B_last/B_msy	0.06	0.11	0.15	0.22	0.36
C_last/C_msy	0.54	0.61	0.69	0.76	0.83
ER_last	0.13	0.20	0.29	0.42	0.80
ER_last/ER_msy	1.78	3.02	4.46	6.47	12.02
Non-Informative Prior					
r	0.07	0.08	0.10	0.13	0.16
k	41811.99	48105.48	53632.09	58523.89	63889.35
q	1.20E-005	1.45E-005	1.64E-005	1.87E-005	2.25E-005
C_msy	1062.84	1194.15	1348.75	1511.57	1709.30
B_msy	20905.99	24052.74	26816.04	29261.95	31944.68
B_last	1398.16	2529.31	3705.68	5129.38	7921.48
ER_msy	0.03	0.04	0.05	0.06	0.08
B_last/B_msy	0.05	0.10	0.14	0.19	0.28
C_last/C_msy	0.61	0.69	0.78	0.88	0.98
ER_last	0.13	0.20	0.28	0.41	0.75
ER_last/ER_msy	2.56	4.01	5.61	8.06	14.61

Table 14. Description of production model runs excluded from analyses on the basis of the extreme values estimated for r or K. Indices represented are: CAW=Combined area weighted, CCW= Combined catch weighted, CUW= Combined unweighted, JAPLL1 = Japanese longline early period, JAPLL2 = Japanese longline recent period, JAPLL3 = Japanese longline – task II, CIVAR = Cote d'Ivoire artisanal, SENAR = Senegal Artisanal, GHNGL = Ghana gillnet, USLL2 = US Longline logbooks kg, USRR1 = US recreational tournaments (RBS), USRR2 = US recreational surveys (MRFSS), VENRR = Venezuela recreational, VENGL = Venezuela Gillnet, BRZLL = Brazil longline, BRZ = Brazil recreational, KORLL= Korea longline, TAILL = China Taipei longline. (*) JAPLL1 & JLL2 combined as a single index.

Model	Case	Version	Stock	Indices used	Excluded because
ASPIC	G3	5.16	E	CAW	r < 0.01
ASPIC	G4	5.16	E	CCW	r < 0.01
ASPIC	O3	5.33	E	JAPLL1, JAPLL2, CIVAR, SENAR, GHNGL	r=4.0
ASPIC	O4	5.33	E	JAPLL1, JAPLL2	r=4.0
ASPIC	O11	5.33	W	USRR1, USRR2, BRZRR, VENRR	K ≈ 900,000
ASPIC	O2	5.33	W	JAPLL3, USLL2, BRZLL, VENLL, KORLL	r>0.9
ASPIC	W3	5.33	W	CUW	r < 0.01
EXCEL	Fox	Tricubic	W	CCW	r>0.9
ASPIC	G1	5.16	W	CAW	r < 0.01

Table 15. Scaled CPUE indices available for SAI-West and SAI-East (shaded) for 1990-2007.

Year	VEN Gill	VEN LL	BRA LL	BRA RR	US RBS	US MRFSS	US PLL	JPN LL	CIV Gill	SEN Art	JPN LL	GHN Gill
1990	–	–	0.337	–	0.865	0.648	1.454	–	1.545	2.136	–	–
1991	0.40	1.60	0.986	–	1.038	1.037	1.759	–	1.766	0.305	–	–
1992	0.51	1.22	1.071	–	1.373	1.364	2.402	–	0.795	0.559	–	–
1993	0.86	0.90	2.446	–	0.9	1.045	1.908	–	0.795	0.407	–	1.634
1994	0.97	1.23	0.255	–	1.423	0.975	1.385	1.170	1.060	0.407	1.182	1.555
1995	1.07	1.23	0.798	–	1.265	1.246	0.874	0.768	0.530	0.254	1.052	0.656
1996	0.98	0.60	1.205	1.231	1.366	0.966	0.874	0.594	0.486	0.559	1.149	1.900
1997	1.17	0.89	1.046	0.829	1.499	0.706	1.396	0.820	0.839	1.220	0.877	0.801
1998	1.28	0.53	0.933	1.056	1.727	1.351	0.994	0.698	0.706	1.729	1.468	0.748
1999	1.51	2.55	0.584	0.486	0.999	1.636	1.297	1.274	1.104	0.661	1.201	0.467
2000	0.97	0.67	0.777	1.354	0.753	1.228	0.922	1.100	0.486	1.424	0.539	0.342
2001	0.79	0.43	1.358	1.030	0.824	0.749	0.313	0.628	0.795	1.220	0.318	0.810
2002	0.63	0.67	0.969	1.089	1.035	1.361	0.384	0.628	0.883	0.508	1.578	1.456
2003	0.97	0.55	0.735	0.940	1.267	1.381	0.385	1.536	0.442	3.254	1.097	1.734
2004	1.38	0.78	1.134	1.179	0.919	1.128	0.541	0.751	0.883	0.661	0.630	0.643
2005	1.30	0.58	1.650	0.914	0.996	2.017	0.223	2.165	0.883	0.610	0.539	1.087
2006	0.95	0.82	1.085	0.551	1.113	1.095	0.241	1.152	0.883	0.458	0.760	0.552
2007	1.27	1.76	1.387	1.341	1.028	1.179	0.426	0.716	1.104	–	1.610	0.614

Table 16. Pearson estimates of the correlation coefficient r (above diagonal) and probability values (below diagonal) between available indices of SAI-West and SAI-East (shaded) for 1990-2007. The p values represent the probability that r=0.

	VEN Gill	VEN LL	BRA LL	BRA RR	US RBS	US MRFSS	US PLL	JPN LL	CIV Gill	SEN Art	JPN LL	GHN Gill
VEN Gill		0.177	-0.070	-0.216	0.069	0.316	-0.379	0.273	-0.221	0.162	0.040	-0.491
VEN LL	0.497		-0.257	-0.370	-0.086	0.162	0.389	0.038	0.582	-0.380	0.384	-0.340
BRA LL	0.790	0.318		0.278	-0.234	0.127	-0.034	0.037	-0.190	-0.305	-0.295	0.184
BRA RR	0.498	0.235	0.379		-0.138	-0.207	-0.147	-0.397	-0.366	0.140	0.097	0.166
US RBS	0.792	0.742	0.350	0.668		0.014	0.207	-0.158	-0.259	0.069	0.498	0.253
US MRFSS	0.215	0.533	0.615	0.516	0.957		-0.231	0.703	-0.222	-0.103	0.119	-0.082
US PLL	0.132	0.122	0.893	0.647	0.408	0.356		-0.178	0.323	-0.201	0.223	0.160
JPN LL	0.344	0.898	0.900	0.198	0.588	0.005	0.541		0.067	0.181	-0.307	0.081
CIV Gill	0.393	0.014	0.450	0.2339	0.298	0.374	0.190	0.819		-0.186	0.212	-0.243
SEN Gill	0.549	0.145	0.234	0.681	0.791	0.694	0.439	0.552	0.474		0.015	0.104
JPN LL	0.892	0.174	0.305	0.763	0.068	0.685	0.443	0.284	0.466	0.960		0.283
GHN	0.062	0.214	0.510	0.605	0.361	0.771	0.569	0.783	0.381	0.772	0.326	

Table 17. Estimates of B./Bmsy for various treatments of the combined CPUE time series for east and west Atlantic sailfish using the method presented in SCRS/02/75.

	Period	CPUE Time Series			
		Unweighted	Weighted by Catch	Weighted by Area	Mean
East	(2003-07/(1967-71)	0.192	0.079	0.117	0.129
	(2003-07/(1980-84)	0.708	0.487	0.430	0.542
West	(2004-08/(1961-65)	0.651	1.083	0.577	0.770
	(2004-08/(1973-77)	1.157	1.988	0.799	1.315

Table 18. SAI-West: length frequency statistics (75% quartile, median, and 25% quartile) by year (1971-2007) taken by the Brazilian longline fleet, Japanese longline fleet, Chinese Taipei longline fleet, Japanese Far Seas longline fleet, Venezuelan artisanal fleet, and Venezuelan gillnet fleet. Lengths are lower jaw-fork length (cm).

		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
BRA-LL																																						
	75%	178	167	167	167	172	172	172	172	172	161	167	167	167	167	–	161	167	167	161	–	–	162	–	–	–	–	–	–	181	171	174	–	–	–	176	172	177
	median	167	161	161	156	161	167	161	161	167	156	156	156	156	161	–	151	156	156	151	–	–	162	–	–	–	–	–	–	174	166	167	–	–	–	162	164	170
	25%	156	156	156	151	156	156	156	156	160	145	145	151	151	156	–	140	151	151	151	–	–	162	–	–	–	–	–	–	167	160	160	–	–	–	146	152	160
TAI-LL																																						
	75%	–	–	–	–	–	–	–	–	–	145	143	–	258	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	median	–	–	–	–	–	–	–	–	–	118	140	–	258	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	25%	–	–	–	–	–	–	–	–	–	118	140	–	221	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
JPN-LL																																						
	75%	161	161	156	163	167	167	199	188	–	172	–	140	163	188	194	–	–	–	172	163	–	124	–	–	–	–	–	173	173	138	–	153	–	146	–	–	–
	median	156	156	145	154	161	156	188	188	–	172	–	134	154	183	191	–	–	–	167	153	–	124	–	–	–	–	–	163	163	136	–	152	–	144	–	–	–
	25%	148	145	140	145	156	151	188	188	–	172	–	129	145	178	183	–	–	–	161	144	–	124	–	–	–	–	–	149	149	133	–	151	–	143	–	–	–
JPNF-LL																																						
	75%	–	–	–	–	–	–	–	–	–	–	–	190	95	140	128	195	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	median	–	–	–	–	–	–	–	–	–	–	–	157	90	125	125	145	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	25%	–	–	–	–	–	–	–	–	–	–	–	110	85	114	123	131	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
VEN-Art																																						
	75%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	173	167	176	176	172	175	176	174	176	177	175	174	172	174	174	174	174	176	175	173	173
	median	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	166	160	165	173	168	170	170	167	170	171	172	171	170	172	170	172	173	174	170	170	172
	25%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	158	156	159	166	162	163	165	160	163	162	170	167	160	168	163	170	170	172	163	166	169
VEN-GN																																						
	75%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	170	175	173	173	173	175	174	174	173	173	173	173	173	173	172	170	173
	median	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	165	168	168	169	168	169	168	168	167	168	168	167	168	167	166	165	168
	25%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	159	165	164	165	164	164	163	163	162	163	162	162	162	161	160	160	162

Table 19. SAI-East: length frequency statistics (75% quartile, median, and 25% quartile) by year (1971-2007) taken by the Brazilian longline fleet, Cote d'Ivoire gillnet fleet, Chinese Taipei longline fleet, Ghanaian gillnet fleet, and Japanese longline fleet. Lengths are lower jaw-fork length (cm).

	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
BRA-LL																																					
75%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	164	179	191
median	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	150	170	182
25%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	137	164	173
CIV-LL																																					
75%	–	–	–	–	–	–	–	–	–	–	–	–	–	175	180	170	180	185	185	185	185	180	180	185	180	180	180	185	185	180	180	185	185	185	–	187	–
median	–	–	–	–	–	–	–	–	–	–	–	–	–	165	175	165	175	175	175	175	175	175	175	175	175	170	175	180	180	175	175	175	175	175	–	178	–
25%	–	–	–	–	–	–	–	–	–	–	–	–	–	150	165	154	170	170	170	170	170	170	170	170	170	155	170	175	175	165	170	170	170	170	–	171	–
TAI-LL																																					
75%	–	–	–	–	–	–	–	–	–	–	181	226	178	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
median	–	–	–	–	–	–	–	–	–	–	167	226	167	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25%	–	–	–	–	–	–	–	–	–	–	154	226	161	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
GHN-GN																																					
75%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	220	190	190	–	–	–	186	185	190	190	190
median	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	185	180	185	–	–	–	175	175	178	180	180
25%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	175	175	180	–	–	–	170	170	170	171	175
JPN-LL																																					
75%	–	–	–	194	199	160	209	210	221	172	189	194	145	199	215	–	199	188	191	151	183	–	–	–	180	–	–	171	180	152	178	185	178	162	161	–	–
median	–	–	–	194	188	151	194	210	199	172	183	188	145	188	188	–	199	188	172	151	183	–	–	–	178	–	–	160	162	139	178	136	172	158	156	–	–
25%	–	–	–	194	172	134	179	199	194	166	178	170	140	178	178	–	199	178	161	151	170	–	–	–	175	–	–	150	142	135	178	126	160	153	146	–	–

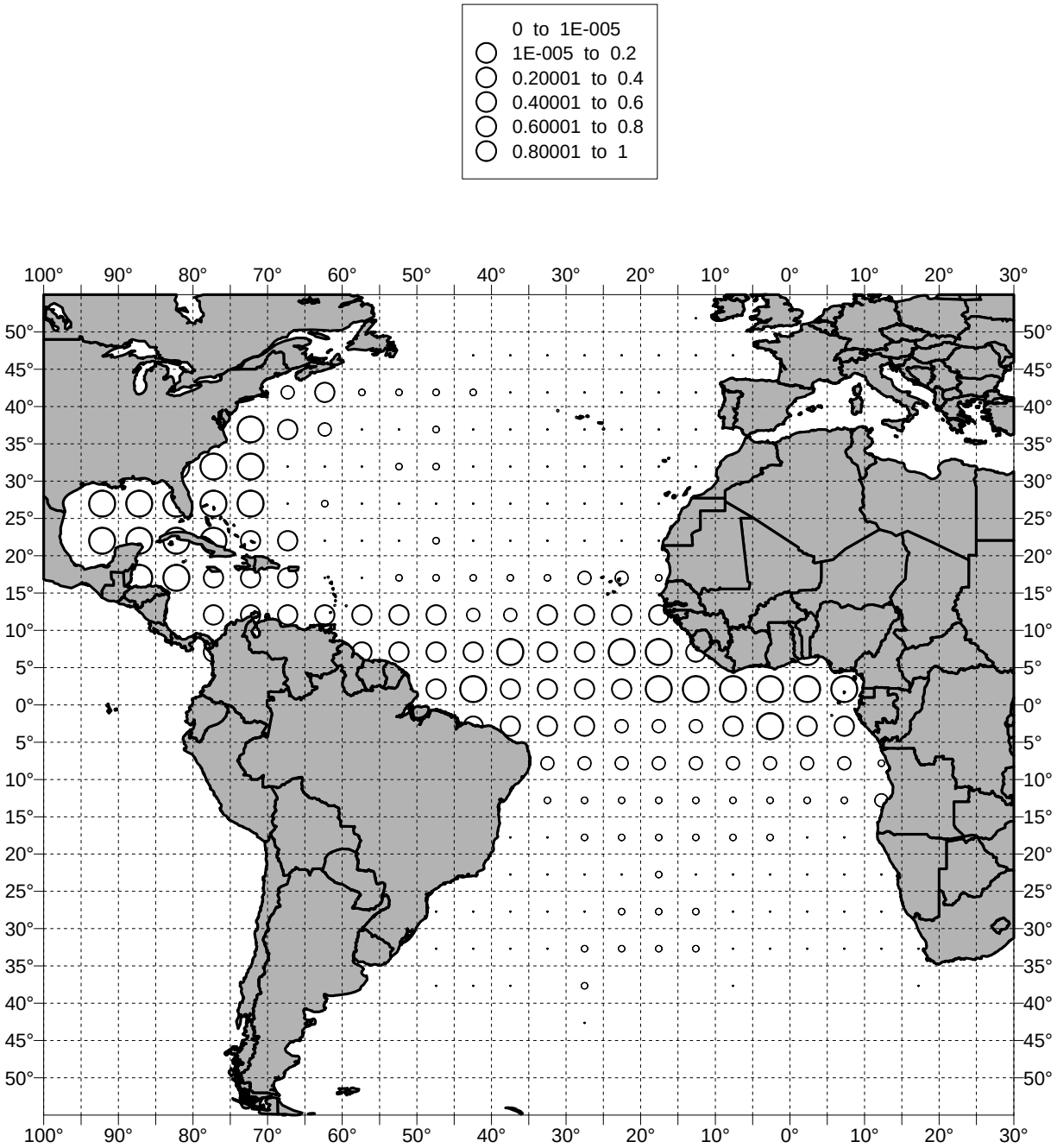


Figure 1. Sailfish/(Sailfish+Spearfish) ratios for Korea obtained from observer data. Ratios are aggregated over the period of available data.

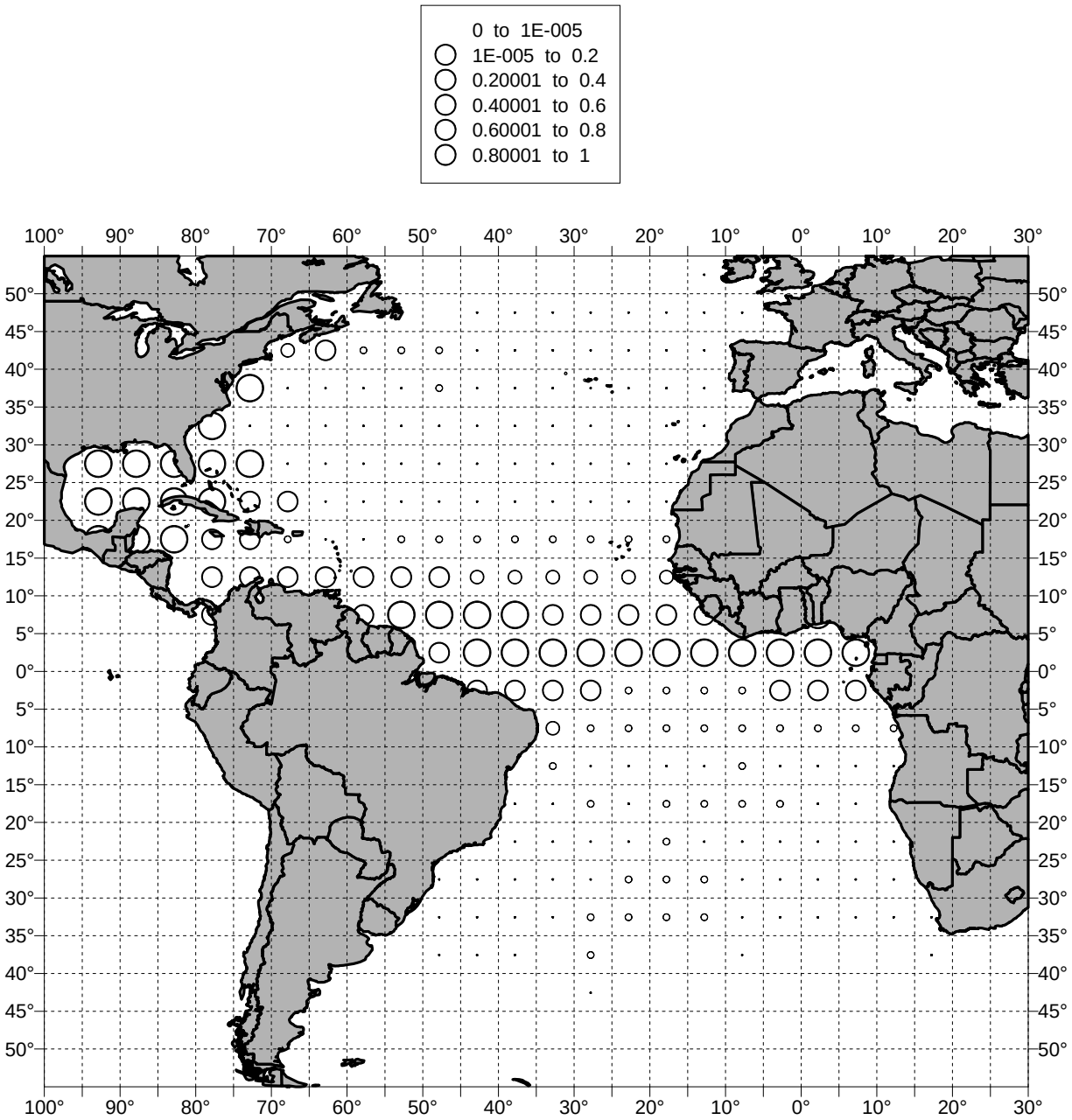


Figure 2 Sailfish/(Sailfish+Spearfish) ratios for Japan obtained from observer data. Ratios are aggregated over the period of available data.

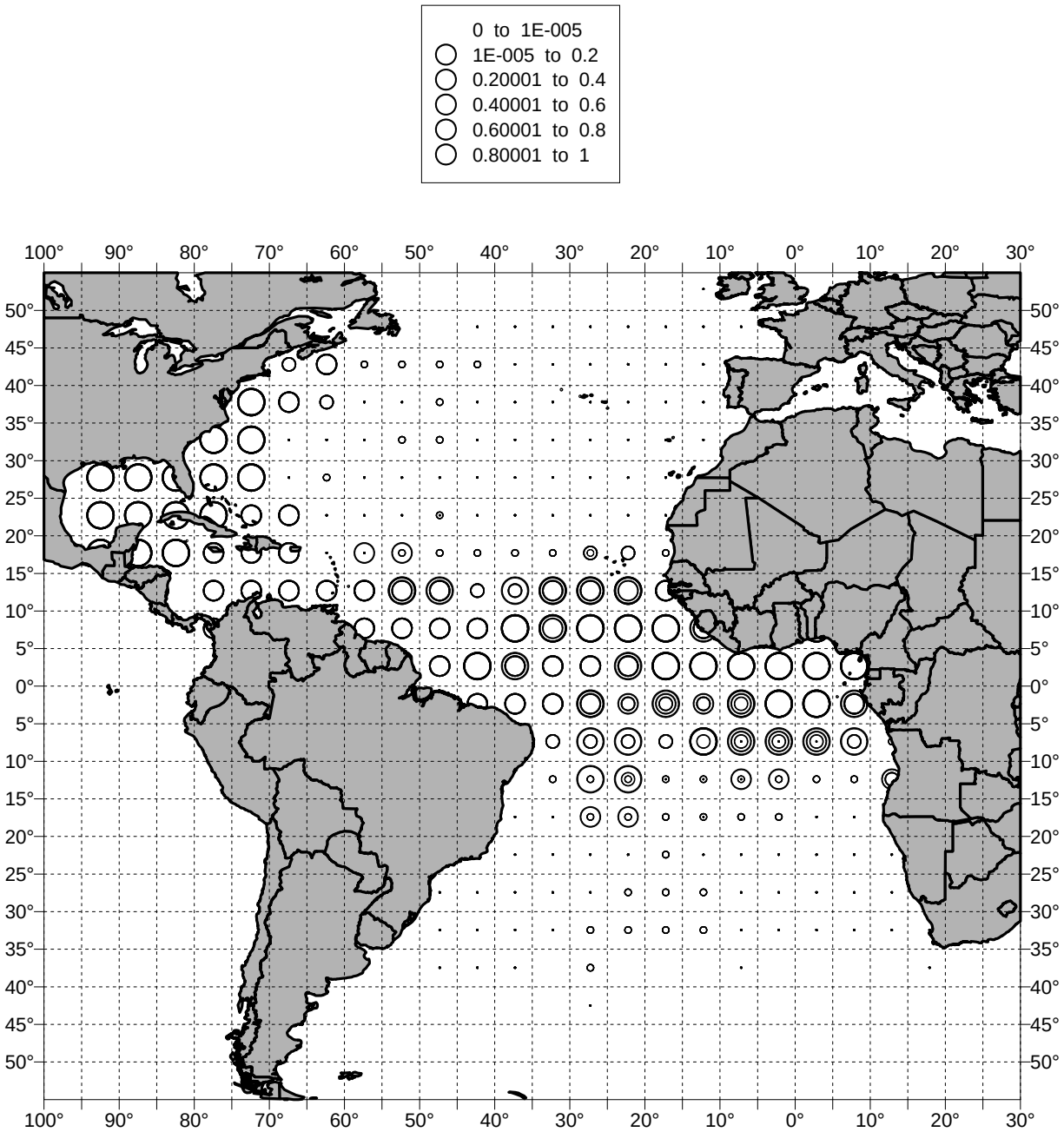


Figure 3 Sailfish/(Sailfish+Spearfish) ratios for Chinese Taipei obtained from observer data. Ratios are calculated quarterly if enough data is available by aggregating observations over the period of available data. Each circle within a grid represents estimates for each quarter.

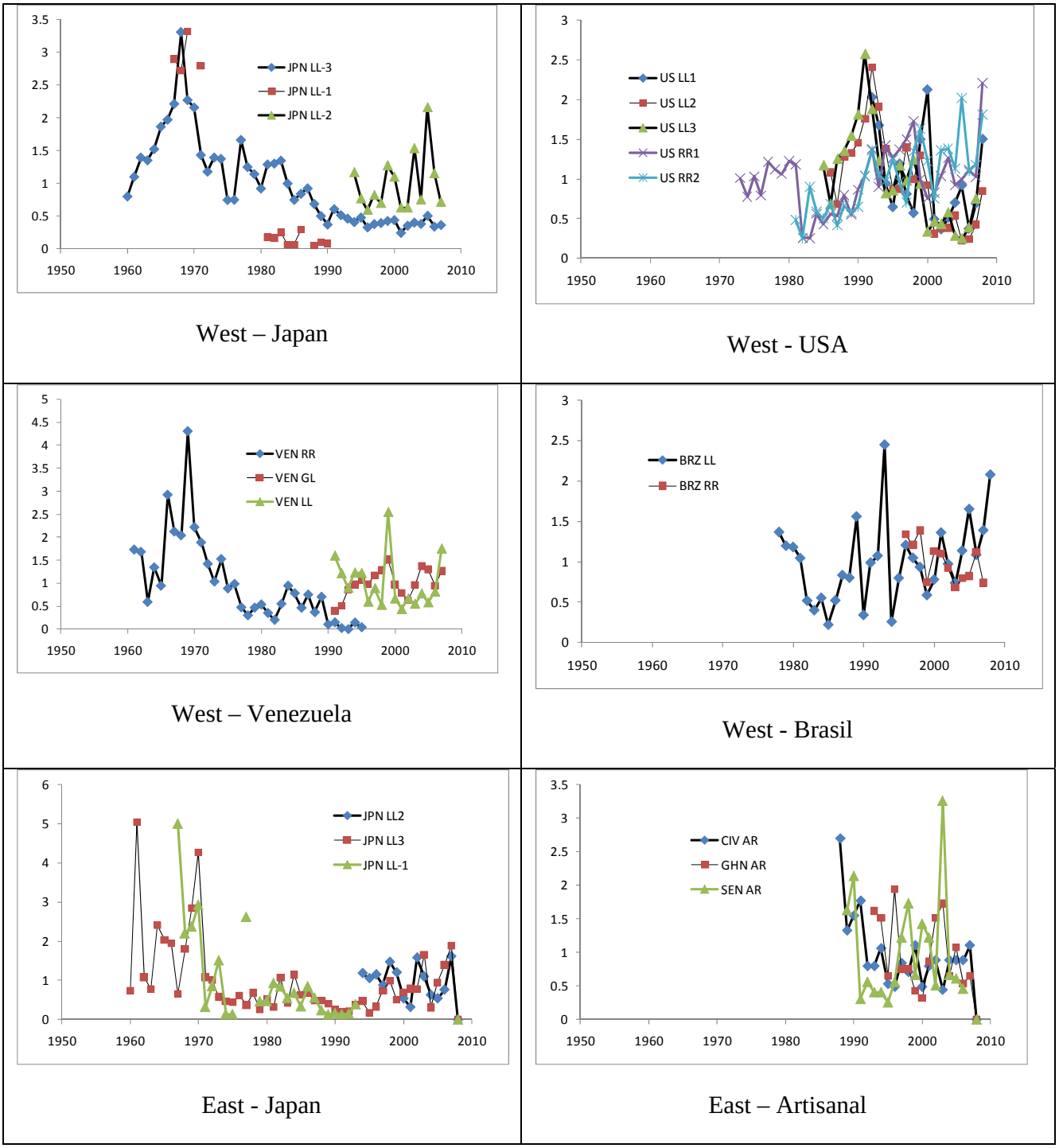
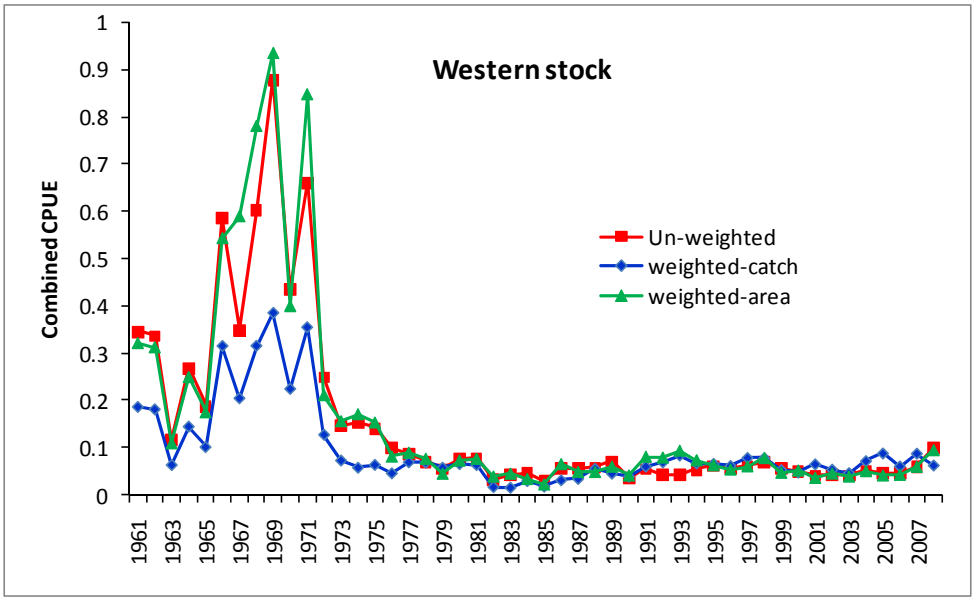


Figure 4. Relative abundance indices obtained by standardizing cpue data for various fleets. All indices were scaled to the mean of each series prior to graphing.

)



b)

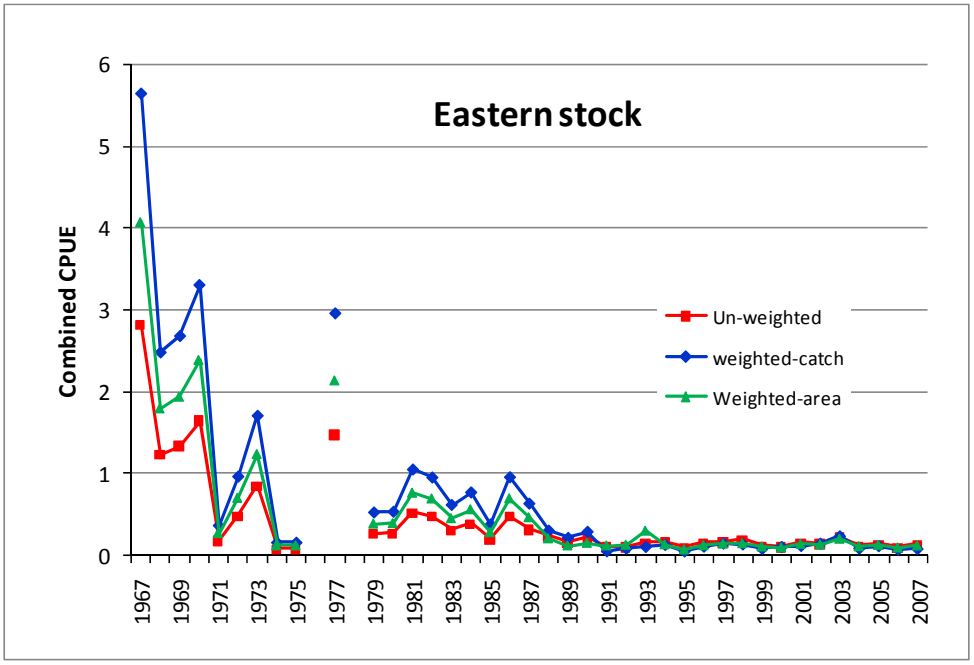


Figure 5. Estimated combined indexes of abundance for the a) western and b) eastern stocks. Indices differ because of the different weighting used in the process of combination: "weighted-catch" correspond to weighting proportional to the reported catch associated with the fleet corresponding to the index, "weighted area" to weighting proportional to area of the fishery (measured by the number of 5 degree grids) where catch was reported for the fleet associated with the index.

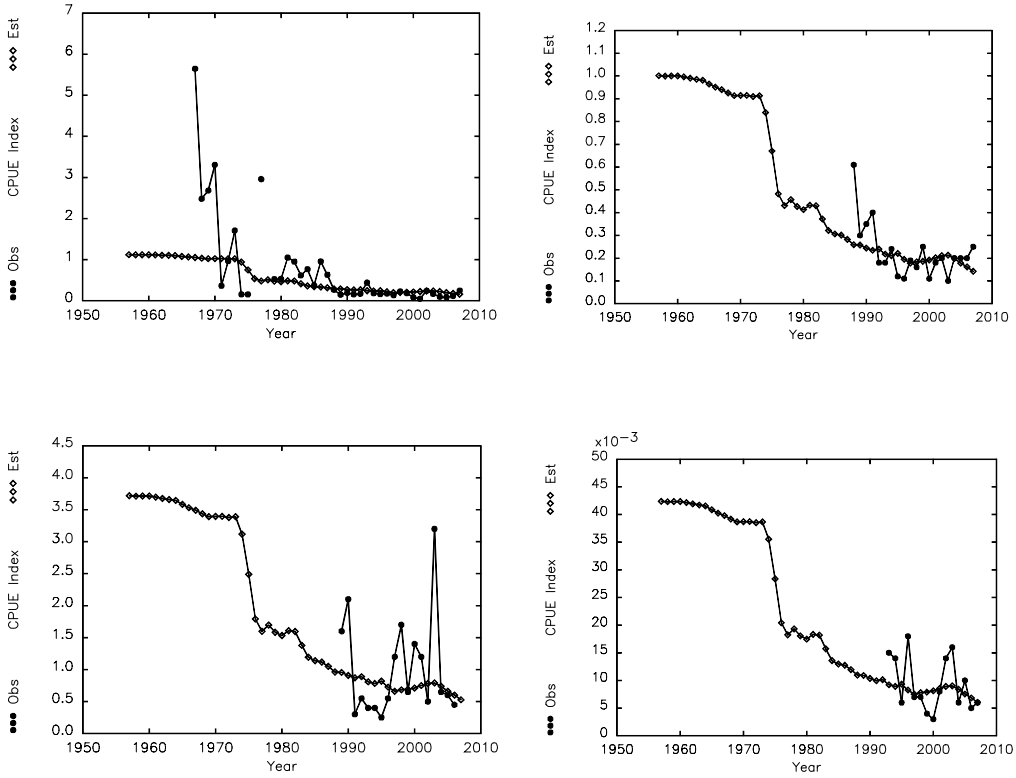


Figure 6 - ASPIC fit model results of case F2 fpr the eastern stock. Each panel correspond to the fit of the model to each of the cpue indices, from top left, Japan LL1 and Jap LL2, top right, CIV ART, bottom left SEN ART and bottom right GHA GIL.

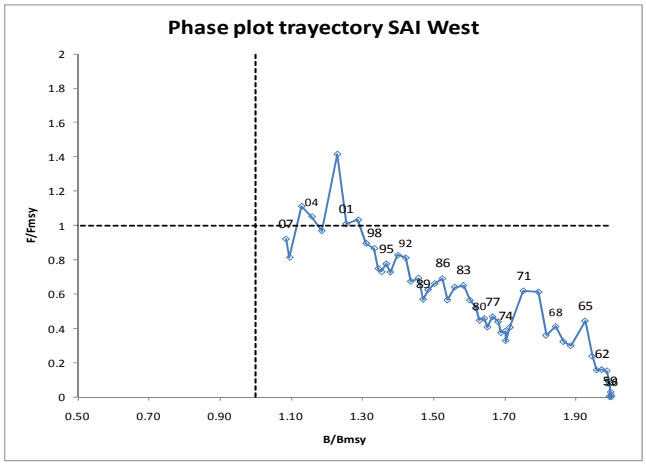


Figure 7. Results of ASPIC fit of case O9 for the western stock fit to all available indices. Trends in time of fishing and biomass ratios plotted in a phase plot that indicates when overfishing and overfished reference points are reached. Numbers next to diamonds denote the year of the estimate.

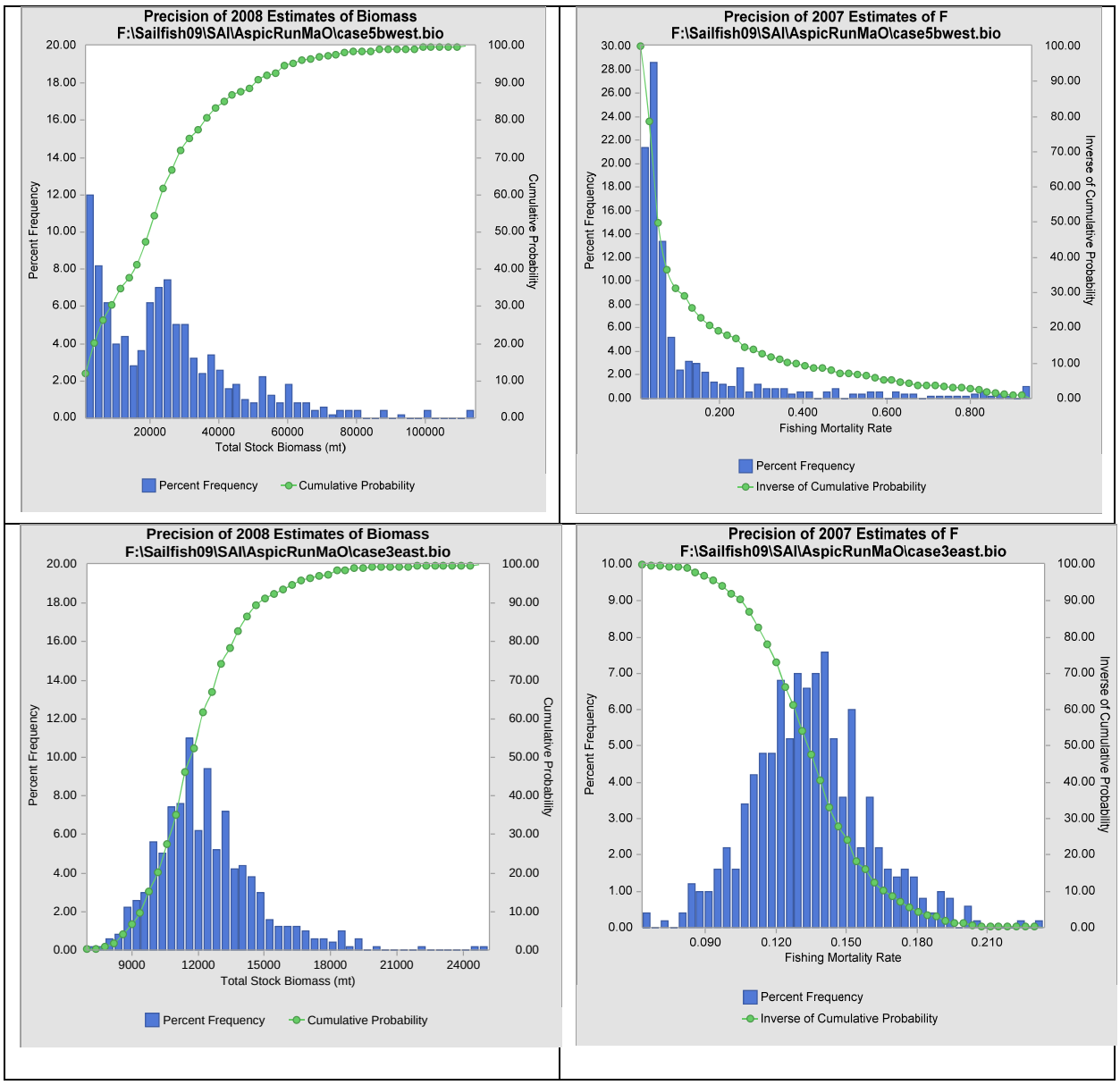


Figure 8 Results of fits for ASPIC case O9 for the western stock (top row) and O7 for the eastern stock (lower row). Probability distribution and cumulative distribution (circles) for the last year (2008) of total stock biomass (left panel) and fishing mortality rates (right panel). Description of cases provided in Appendix 9.

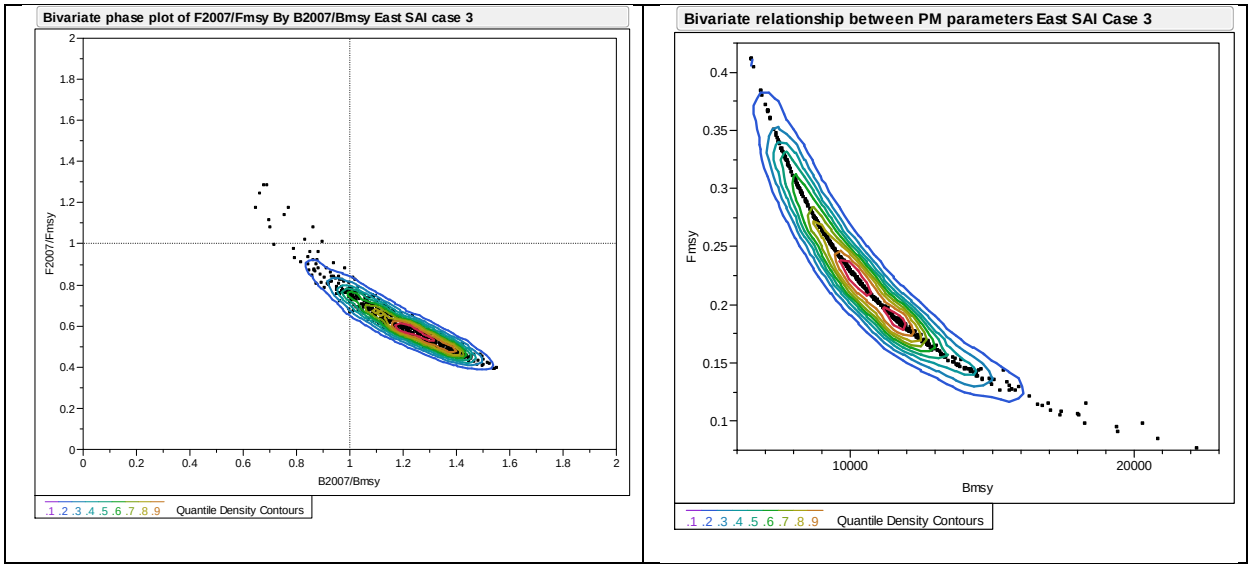


Figure 9. Results of ASPIC fit of case O7 for the eastern stock. Countours represent non-parametric density quantiles of the 500 bootstrap runs and points each of the runs. Left panel Fishing mortality and biomass ratios, right panel Fishing mortality and biomass at msy. Description of cases provided in Appendix 9.

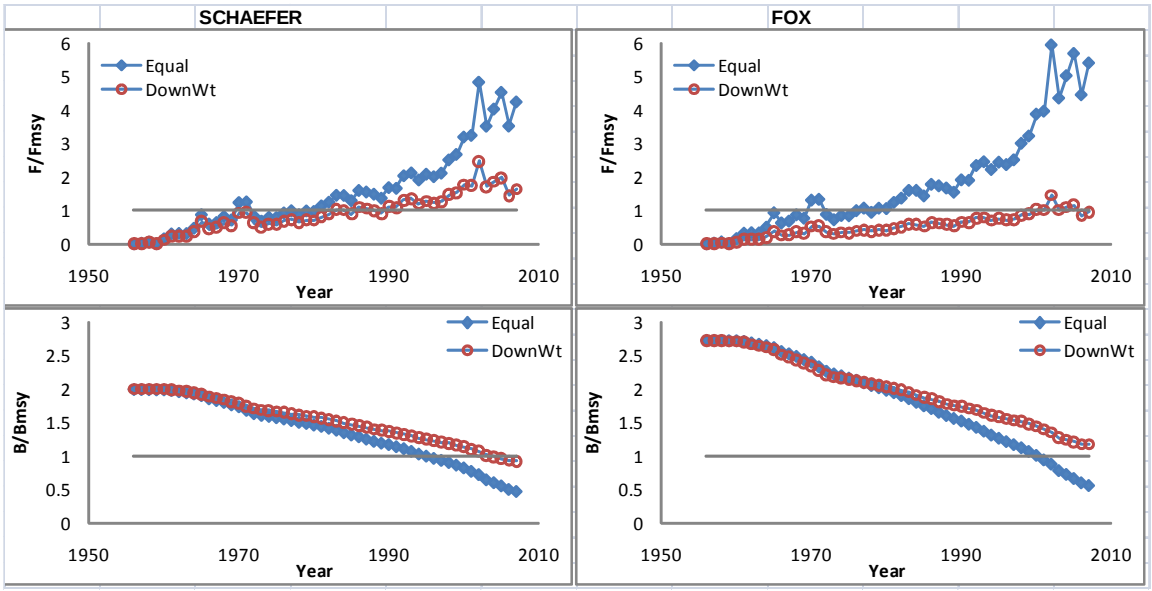


Figure 10. Production model results for the western Atlantic data (combined index, catch-weighted) fitted with EXCEL. The results show either the trajectories of F/Fmsy (top row) or B/Bmsy (bottom row). On the left are the results for a Schaefer model, and on the right, the results for a Fox model. Each panel shows the fits obtained either with equal weighting of the CPUE observations, or down-weighting the historical data.

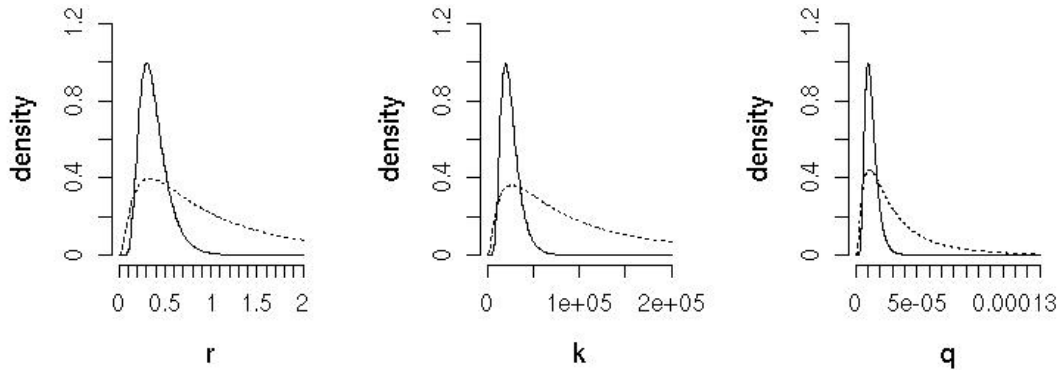


Figure 11 – Bayesian production model, marginal priors for r, k and q. Dashed lines stand for the non-informative, while continuous lines stand for the informative prior.

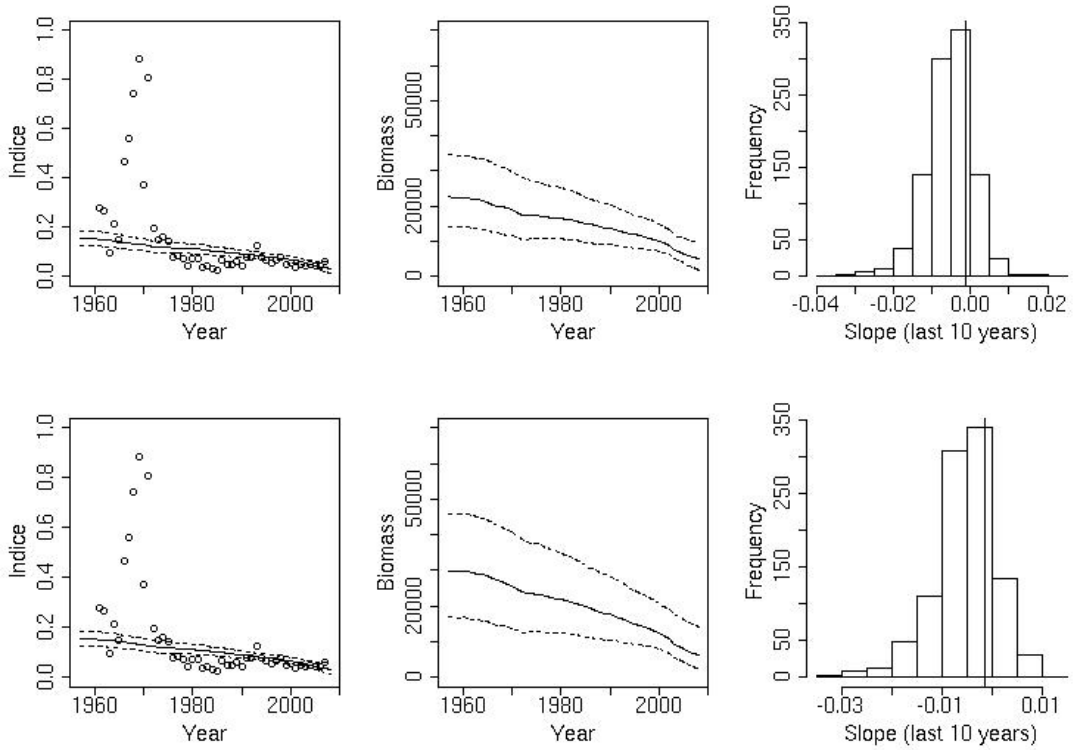


Figure 12 – Bayesian production model, indices and biomass profiles as calculaled using informative (upper row) and non-informative priors (lower row) for the western stock.

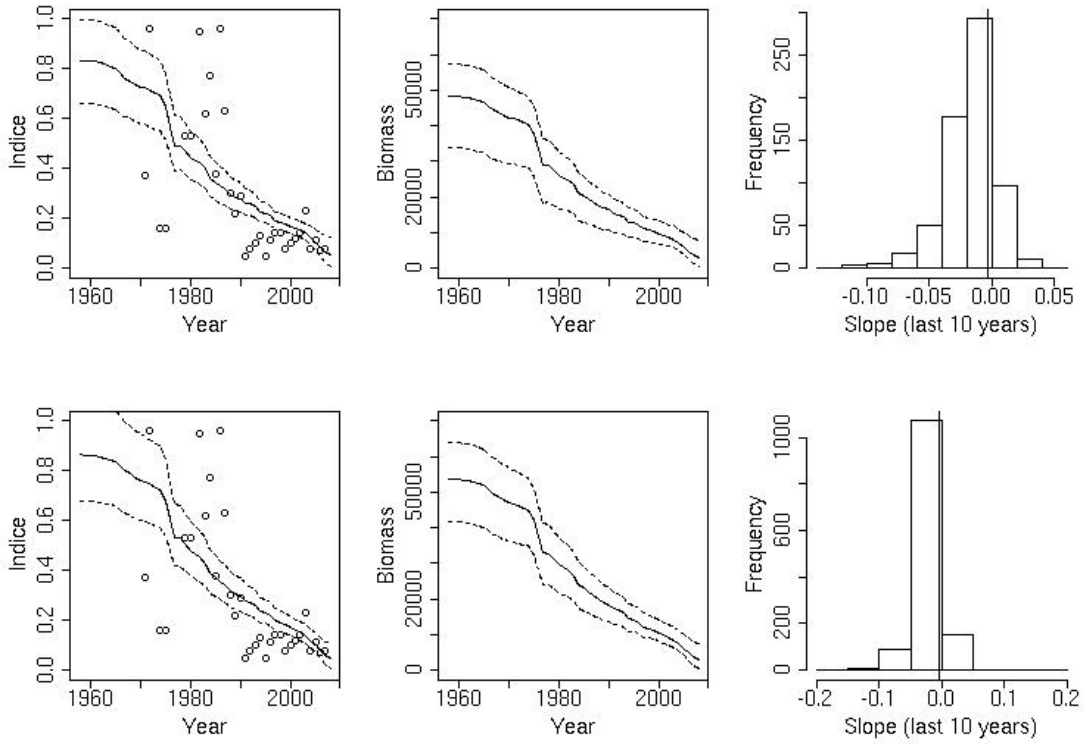


Figure 13 – Bayesian production model, indices and biomass profiles as calculaled using informative (upper row) and non-informative priors (lower row) for the eastern stock.

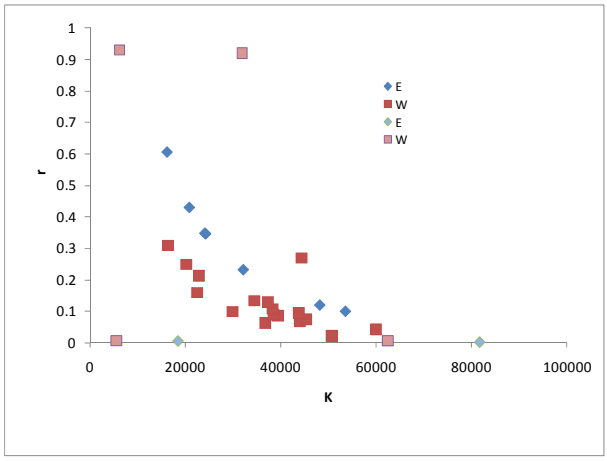


Figure 14 Uncertainty in estimates of r and K for different cases of production models that differ according to the model/data combination used. Three cases that produced r estimates of 4 or a K estimate of almost 900,000 tons are excluded from this graph. Furthermore, cases denoted by light colors represent additional cases not considered in further analyses because values of r were either smaller than 0.01 or larger than 0.9

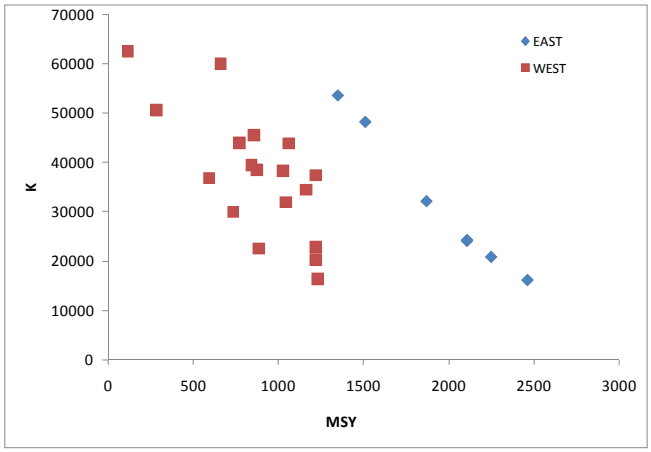


Figure 15: Uncertainty in estimates of K and MSY for different cases of production models that differ according to the model/data combination used.

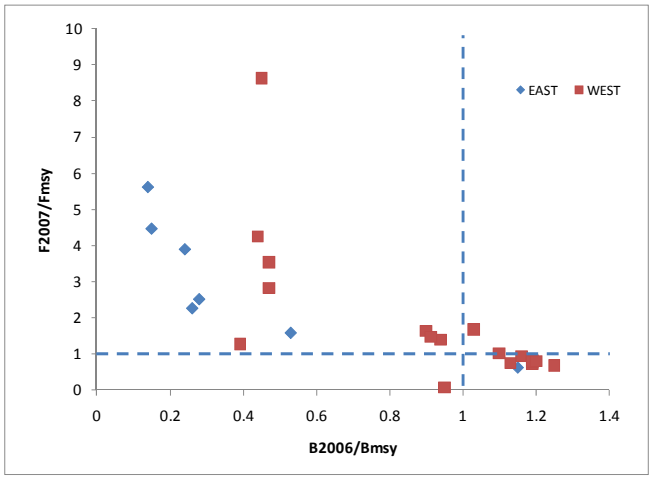


Figure 16 Uncertainty in estimates of recent biomass ratio and fishing mortality ratio for different cases of production models that differ according to the model/data combination used.

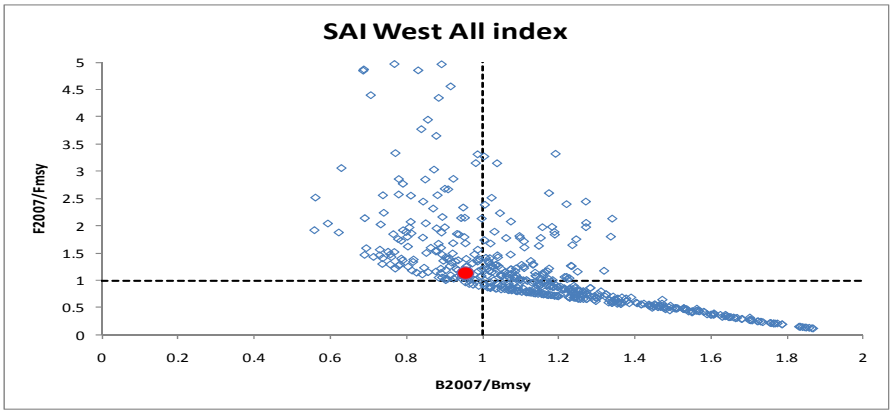
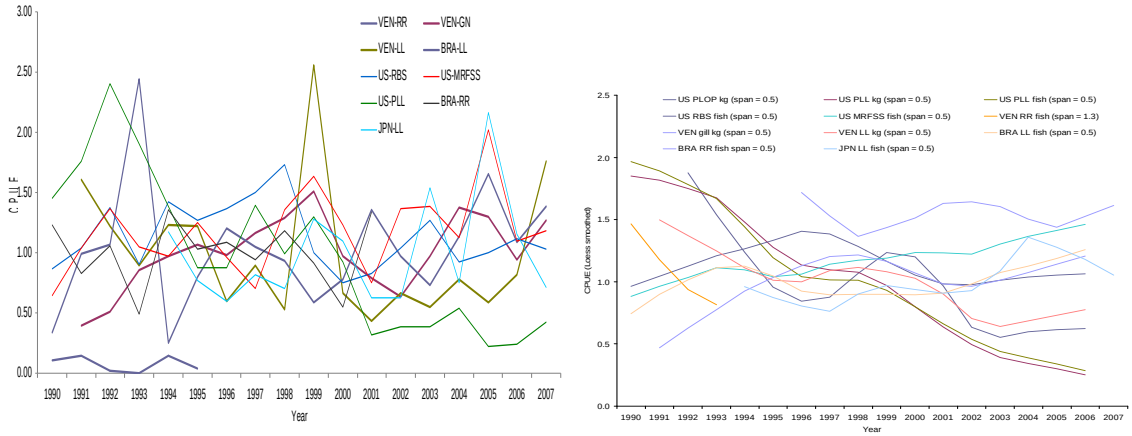


Figure 17. Results of ASPIC fit of case O9. Boostratpped estimates of Biomass and fishing mortality ratios of terminal year with the median value (red-circle).

a) Western Stock



b) Eastern Stock

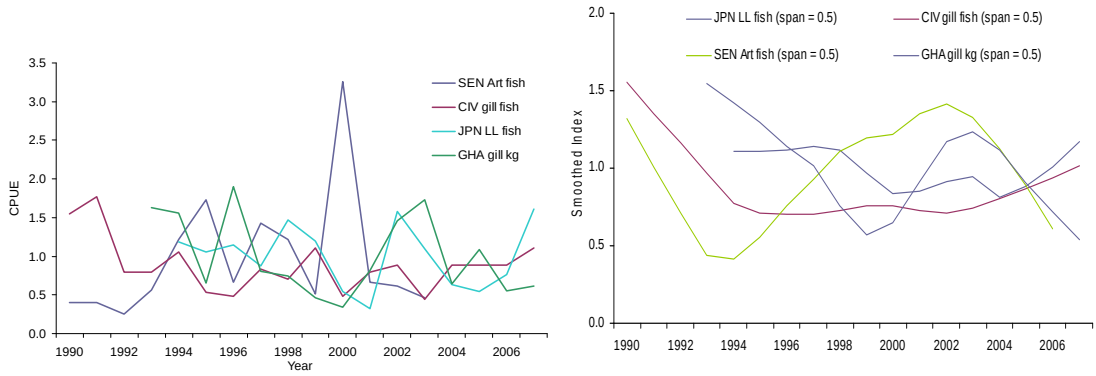


Figure 18. Trends in recent (1990-2007) abundance according to CPUE indices available. a) Western stock b) Eastern stock. Left hand column represent scaled indices, right hand column the same indices but smoothed through LOESS.

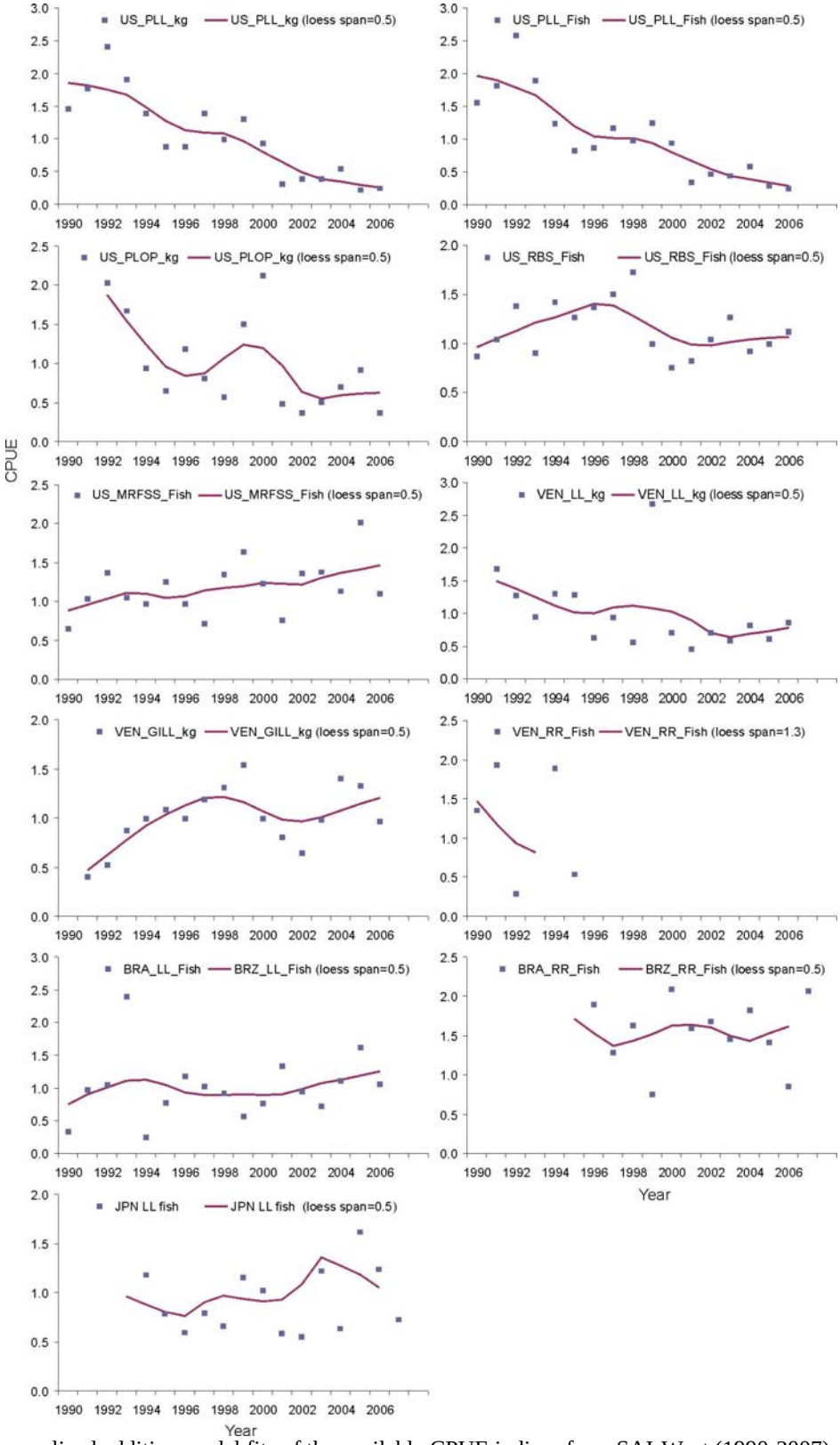


Figure 19. Generalized additive model fits of the available CPUE indices from SAI-West (1990-2007).

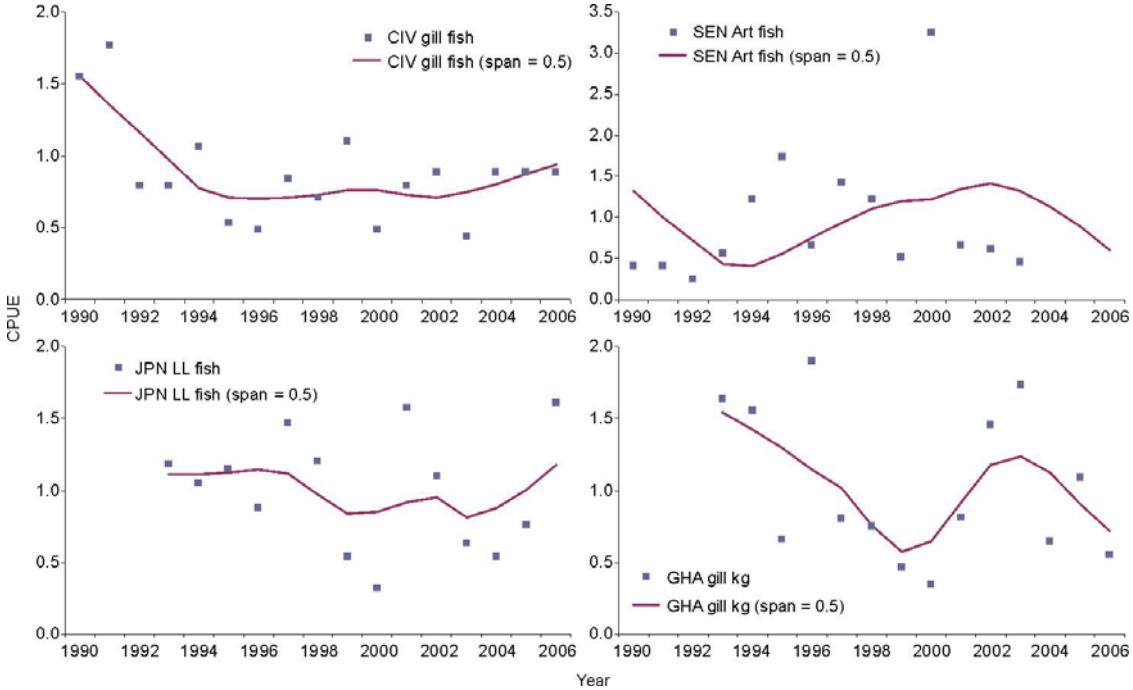


Figure 20 Generalized additive model fits of the available CPUE indices from SAI-East (1990-2007).

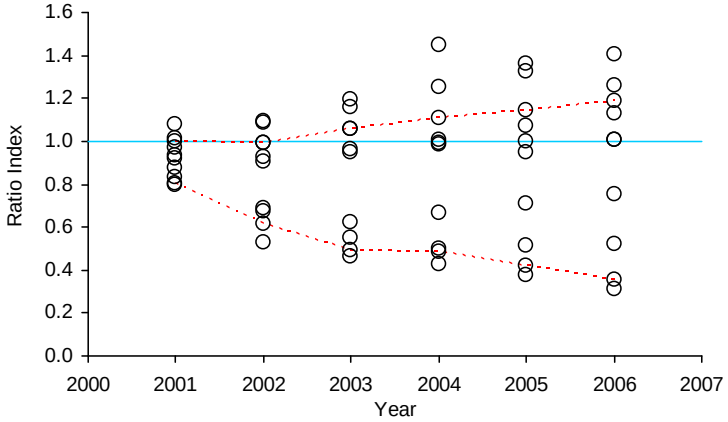


Figure 21. Estimated confidence intervals for median of the CPUE ratios, relative to the standard year 2000 for SAI-West.

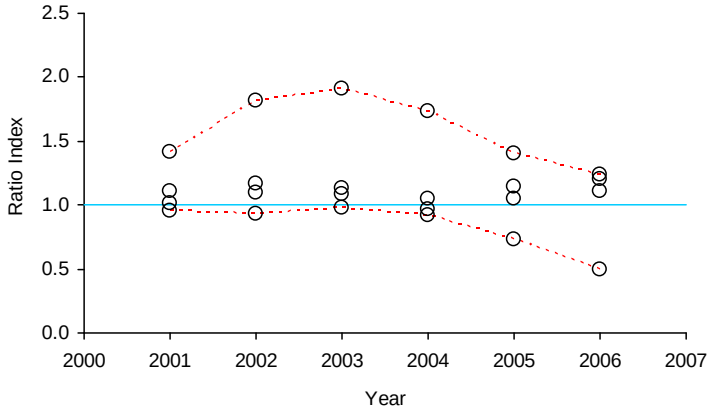


Figure 22 Estimated confidence intervals for median of the CPUE ratios, relative to the standard year 2000 for SAI-East.

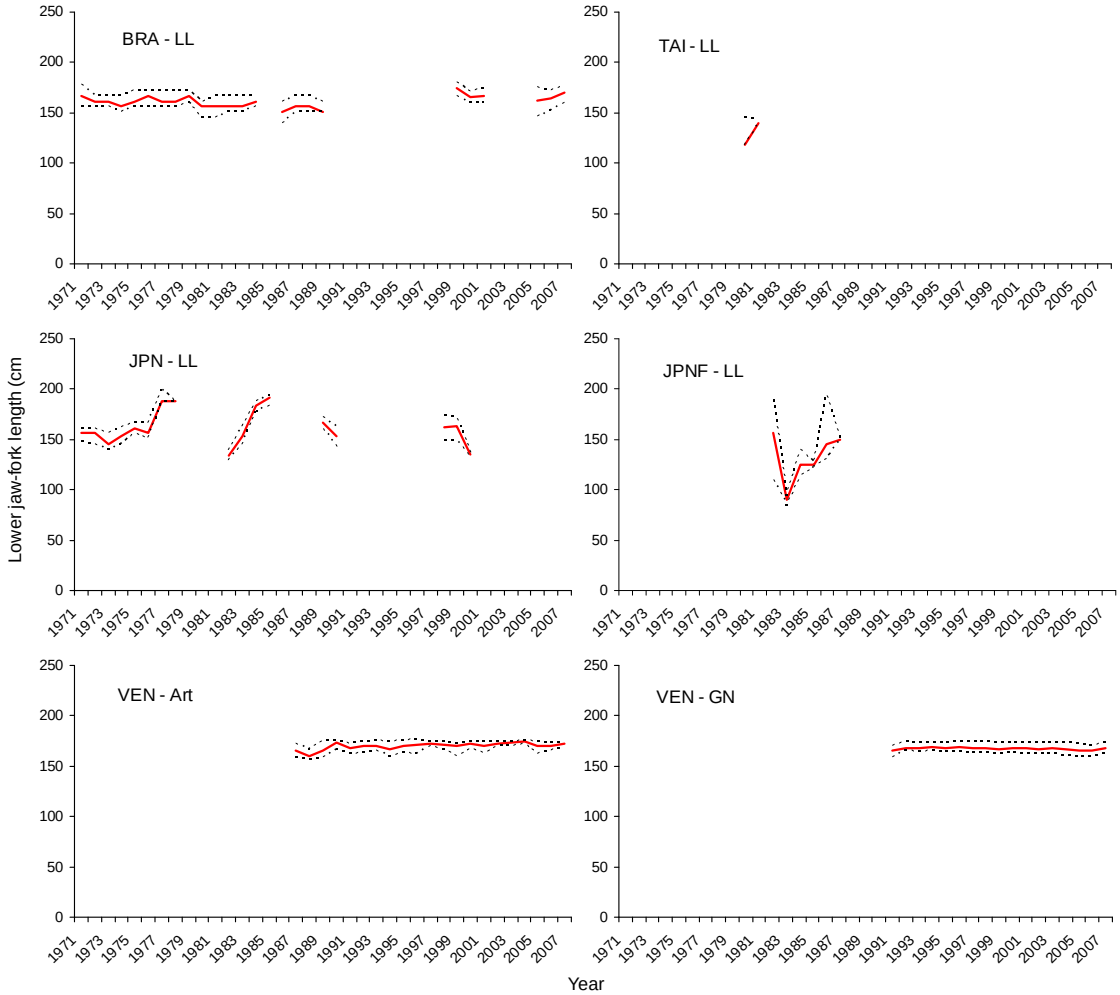


Figure 23. SAI-West: length frequency statistics- 75% quartile, median, 25% quartile taken in the Atlantic Ocean (1971-2007) by the Brazilian, Japanese, Chinese Taipei, Japanese Far Seas longline fleets, and Venezuelan artisanal and Venezuelan gillnet fleets. Lengths are lower jaw-fork length (cm).

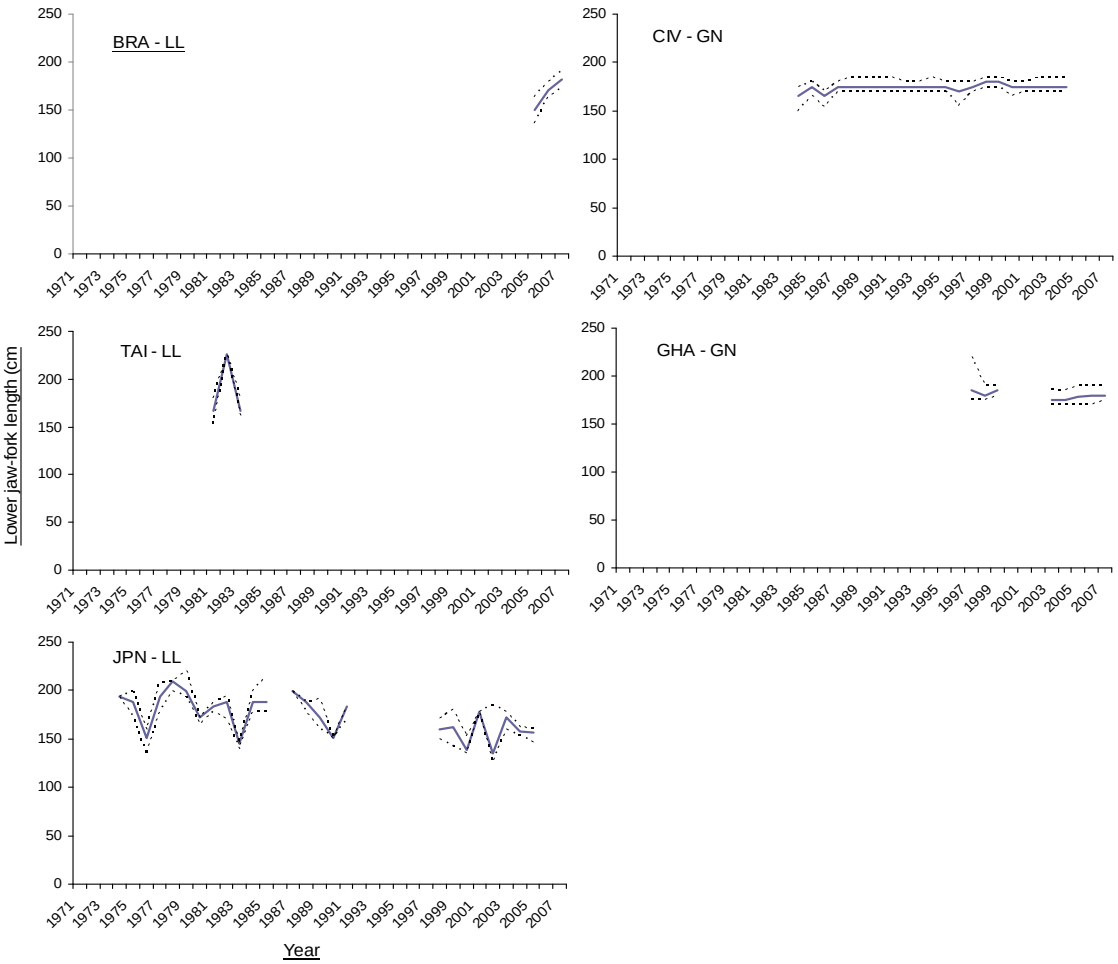


Figure 24. SAI-East: length frequency statistics- 75% quartile, median, 25% quartile taken in the Atlantic Ocean (1971-2007) by the Brazilian, Japanese, Chinese Taipei, longline fleets, and Ghanaian and Cote d'Ivoire gillnet fleets. Lengths are lower jaw-fork length (cm).

Appendix 1

AGENDA

Tentative Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Update of data for assessment
   2.2. Biology
   2.1 Catch estimates
   2.2. Biology
   2.3 Relative Abundance estimates
3. Assessment
   3.1 Stock structure: alternative scenarios
   3.2 Production model assessments
   3.3 Other assessment analyses
   3.4 Summary of assessment results
4. Management implications
   4.1 Eastern stock
   4.2 Western stock
   4.3 Other issues
5. Executive summary for sailfish
6. Other matters, sailfish
7. Other matters, all billfish
8. Report adoption and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2009/032 Exploitation des poissons porte-épées par la pêcherie artisanale maritime en Côte d'Ivoire. I: CPUE standardisée des voiliers de l'Atlantique Istiophorus albicans N'Da K., G.R. Dedo.

SCRS/2009/033 Standardized catch rates for sailfish (Istiophorus albicans) from the Venezuelan pelagic longline fishery off the Caribbean Sea and adjacent areas: An update for 1991-2007. Arocha, F. and M. Ortiz.

SCRS/2009/045 Updated sailfish (Istiophorus platypterus) catch rates from the U.S.pelagic longline fishery in the Northwest Atlantic and Gulf of Mexico 1986-2008. Ortiz, M., Diaz, G.A., and Hoolihan, J. P.

SCRS/2009/046 Updated estimates of sailfish catch-per-unit-effort for the U.S. Recreational Billfish Tournaments and U.S. recreational fishery (1973-2008). Hoolihan, J.P., Ortiz, M., Diaz, G.A. and Prince, E.D.

SCRS/2009/047 US conventional tagging results for Atlantic Sailfish (1954-2008), with comments on possible stock structures. Orbesen, E., Snodgrass, D., Hoolihan, J. and Prince, E.

SCRS/2009/048 Sailfish (Istiophorus platypterus) habitat utilization in the southern Gulf of Mexico and Florida Straits, with implications on vulnerability to shallow-set pelagic longline gear. Kerstetter, D.W., Bayse, S.M. and Graves, J.E.

SCRS/2009/049 CPUE Standardization of the US Longline Observer Data Using StatHBS C. Goodyear, P.

SCRS/2009/051 Changes in billfish catch rates due to the use of different hooks and baits in the configuration of the surface longline gear targeting swordfish (Xiphias gladius) in the Atlantic ocean. Mejuto, J., Ortiz de Urbina, J., Ramos-Cartelle, A. and García-Cortés, B.

SCRS/2009/052 Prevalence of istiophorids (fam. istiophoridae) on the basis of observations of the Spanish surface longline fleet targeting swordfish (Xiphias gladius) in the Atlantic ocean. García-Cortés, B. Fernández, J., Ramos-Cartelle, A. and Mejuto, J.

SCRS/2009/054 Relative abundance indices for sailfish from the artisanal fleet from Senegal. Diatta , Y., Die D.J. and Fitchett, M.D.

SCRS/2009/063 First observations of migratory movements and habitat preference of Atlantic sailfish, Istiophorus platypterus, in the southwestern Atlantic ocean. Mourato, B.L., Carvalho, F.C., Hazin, F.H.V., Pacheco, J.C., Hazin, H.G., Travassos, T. and Amorim, A.F.

SCRS/2009/064 Estimating the sailfish and spearfish catch ratios based on Brazilian longline observer data in the equatorial and south Atlantic ocean. Wor, C., Mourato, B.L., Hazin, F.H.V., Hazin, H.G. and Travassos, P.

SCRS/2009/065 Ratios of Sailfish and Spearfish in longline observer data. Die, D.

SCRS/2009/066 Standardized catch rate of sailfish (Istiophorus platypterus) caught by Brazilian longliners in the Atlantic ocean (1978-2008). Wor, C., Mourato, B.L., Hazin, H.G., Hazin, F.H.V., Travassos, P. and Andrade, H.

SCRS/2009/067 Update of Standardized CPUE for Sailfish Caught by Japanese Longline in the Atlantic Ocean. Yokawa, K.

Appendix 4

Billfish Work Plan

Summary

The Working Group proposed to conduct the next assessment of sailfish in 2009.

The Working Group is planning new assessments for blue marlin and white marlin in 2011, with a preceding data preparatory meeting to be held in 2010. To achieve this, the Working Group needs to continue with developing methods to better interpret the historical changes in billfish CPUE from longline data; and, the continued improvement of biological parameters, catch and relative abundance of marlins.

Background

The last stock assessments for blue marlin and white marlin were conducted in 2006 (Anon. 2007b). No assessments have ever been conducted on spearfish. The last attempted assessment for sailfish (Anon. 2002) was unable to estimate biological reference points such as maximum sustainable yield or the current state of the stock, mainly because of the uncertainty in the basic data required in the assessment. ICCAT has invested in billfish research for the purpose of improving the quality of data needed for stock assessments. However, additional information is still required to elucidate biological characteristics (e.g. defining essential habitat, survival, and growth), catch statistics (particularly for artisanal fisheries), and relative abundance indices.

Work completed in 2008

- A data preparatory meeting for the sailfish assessment was held in May 2008.
- The estimation of age and growth parameters has been completed for white marlin. Work is in progress on an equivalent study of blue marlin, while new studies are just getting underway for sailfish and longbill spearfish.
- A study on blue marlin reproduction off West Africa was completed, but similar work on sailfish in the same area requires an additional year for completion.
- A research project is underway to identify genetic biomarkers for Atlantic billfishes, with emphasis on delineating the genetic stock structure of white marlin and roundscale spearfish. The project is supported through international collaboration and facilitated by members of the ICCAT Billfish Species Group.
- Research on vertical habitat of sailfish and white marlin expanded in 2008, whereas equivalent research on blue marlin was conducted in earlier years.
- The review of billfish catches from artisanal fleets continued, especially in West Africa; however, a more recent smaller initiative has started in the Caribbean with a study in the Dominican Republic.
- New relative abundance indices for sailfish were obtained from several recreational, artisanal and longline fleets. Several previously available sailfish indices were updated. A new index was obtained for West African blue marlin.
- A review of Atlantic-wide sailfish catches was conducted, however, there is still a need to separate spearfish from some of the historical longline catches. To that extent, preliminary ratios of sailfish/spearfish have been developed by 5 degree grid.

Proposed work for 2009

Work can be separated into two major programs, one aimed at preparing the next sailfish assessment, and the other at preparing for future blue marlin and white marlin assessments.

In preparation for the 2009 sailfish assessment the following analyses are required:

- Continue the collection and analysis of biological samples to study the age, growth and reproduction of sailfish in Côte d'Ivoire.
- Continue the efforts of reviewing catch estimates, especially for those countries that are known to land sailfish but do not report it to ICCAT.

- The relative abundance indices of the following fleets need to be updated to provide estimates that include the year 2007:
  - Japanese longline
  - Chinese Taipei longline

- Analyses of data from the following artisanal fleets need to be initiated, or completed, to obtain new relative abundance indices for all important artisanal fleets:
  - Côte d'Ivoire
  - Ghana
  - Sao Tomé and Principe
- If possible, updates should be conducted for those indices presented before the 2009 sailfish assessment so that they include data through year 2007. Additionally, a summary of all available size frequency data should be provided for all fleets.
- In order to prepare for an assessment of blue marlin and white marlin in 2011 the Working Group should prepare and plan for a marlin data preparatory meeting in 2010 that focuses on:
  - developing methods and data analyses that can facilitate the interpretation of historical longline CPUE indices;
- accounting for under-reporting in the fleets that have been required to release marlins;
  - recovering and compiling statistics on marlin catches made by FAD fisheries from the Caribbean;
  - Use genetic analyses to review the reliability of species identification for marlins and spearfish, as reported by the various fleets and observer programs;
  - Post-release survival of marlins.

Appendix 5

A Generalised Linear Model for the ratio of Sailfish to spearfish in Atlantic longline catches

By Humber Andrade

The selection of the generalized linear model used to predict the ratio sailfish/(sailfish + spearfish) was based on Akaike Information Criteria and chi-square tests on the deviance table (**Table 1**). In spite of the model appearing overparameterized, it was accepted because the intention was to derive a prediction that closely resembled the observed data. The main factors explaining the variance are "areaf" (fishing area), "lav" (distance from equatorial area) and "Fleet".

The summary of the coefficients estimated using the model are shown in **Table 2**. Fleets that really differ from the intercept (Brazilian fleet) are Chinese Taipei (TAI) and Venezuela (VEN). Coastal area (areaf1) has a strong positive effect if compared with the intercept (oceanic areas). The distance from the equatorial area, as measured by covariate "lav" also showed a positive effect. Hence, the models predictions suggest that the ratio sailfish/(sailfish+spearfish) are greater in coastal and equatorial areas than in other scenarios.

Comparisons between predicted and observed data are in **Figure 1**. Overall, the predictions seem biased, although the prediction errors were deemed acceptable given the available data for the analysis. Nevertheless, future efforts to use these predictions models are encouraged by the group.

Table 1. Deviance table for the generalized model used to predict the ratio sailfish/(sailfish + spearfish) for the Atlantic Ocean. Besides "Fleet", "qf" and "areaf" are also factors standing for quarter and area (oceanic or coastal) effects. "lav" is a continuous variable representing the distance of fishing set with respect to the equatorial area. Akaike's Information Criterion was 28161.64 and the proportion of variance explained by the model is 0.61. Column entitled "Dev.Exp1" stands for the proportion of total explained variance (0.61) that are due to the inclusion of each term in the model. Column "Dev.Exp2" stands for the proportion of data variance explained by each factor or covariate.

	Df	Deviance	Resid. Df	Resid. Dev	P(>|Chi|)	Dev.Exp1	Dev.Exp2
NULL			1206	67636.65			
Fleet	5	8422.32	1201	59214.33	0	20.36	12.45
qf	3	528.87	1198	58685.46	2.64E-114	1.28	0.78
areaf	1	16641.87	1197	42043.59	0	40.24	24.6
lav	1	12884.71	1196	29158.88	0	31.15	19.05
Fleet:qf	12	1141.26	1184	28017.61	7.66E-237	2.76	1.69
Fleet:areaf	5	878.96	1179	27138.66	9.54E-188	2.13	1.3
Fleet:lav	5	634.51	1174	26504.14	7.04E-135	1.53	0.94
qf:areaf	3	8.04	1171	26496.1	0.05	0.02	0.01
qf:lav	3	65.14	1168	26430.96	4.68E-014	0.16	0.1
areaf:lav	1	153.75	1167	26277.2	2.62E-035	0.37	0.23

Table 2. Summary of the coefficients estimated using the model.

Estimate	Std.	Error	z	value
(Intercept)	0.75	0.17	4.36	1.31E-005
FleetJapan	-0.09	0.13	-0.67	0.5
FleetSpain	0.21	0.29	0.72	0.47
FleetTAIP	5.09	0.23	22.36	<2E-016
FleetUSA	-0.15	0.37	-0.39	0.69
FleetVzla	-3.73	0.27	-14.04	<2E-016
qf2	0.07	0.18	0.39	0.7
qf3	0.2	0.18	1.14	0.25
qf4	0.06	0.17	0.37	0.71
areaf1	1.04	0.17	6.3	2.95E-010
lav	-0.05	0.01	-7.61	2.80E-014
FleetJapan:qf2	NA	NA	NA	NA
FleetSpain:qf2	0.37	0.29	1.3	0.19
FleetTAIP:qf2	-1.76	0.19	-9.16	<2E-016
FleetUSA:qf2	2.14	0.28	7.72	1.17E-014
FleetVzla:qf2	0.54	0.13	4.08	4.59E-005
FleetJapan:qf3	NA	NA	NA	NA
FleetSpain:qf3	2.3	0.32	7.09	1.33E-012
FleetTAIP:qf3	-3.15	0.19	-16.28	<2E-016
FleetUSA:qf3	4.69	0.32	14.49	<2E-016
FleetVzla:qf3	2.06	0.12	17.56	<2E-016
FleetJapan:qf4	NA	NA	NA	NA
FleetSpain:qf4	0.02	0.3	0.06	0.95
FleetTAIP:qf4	-2.49	0.19	-13.26	<2E-016
FleetUSA:qf4	1.81	0.32	5.58	2.36E-008
FleetVzla:qf4	1.05	0.11	9.67	<2E-016
FleetJapan:areaf1	0.59	0.12	4.91	9.15E-007
FleetSpain:areaf1	-0.12	0.16	-0.73	0.46
FleetTAIP:areaf1	1.95	0.1	19.48	<2E-016
FleetUSA:areaf1	2.65	0.25	10.68	<2E-016
FleetVzla:areaf1	2.64	0.17	15.18	<2E-016
FleetJapan:lav	-0.09	0.01	-13.83	<2E-016
FleetSpain:lav	-0.08	0.01	-7.95	1.80E-015
FleetTAIP:lav	-0.22	0.01	-24.15	<2E-016
FleetUSA:lav	-0.04	0.02	-2.31	0.02
FleetVzla:lav	0.04	0.02	2	0.05
qf2:areaf1	-0.04	0.17	-0.23	0.82
qf3:areaf1	-0.79	0.16	-4.84	1.32E-006
qf4:areaf1	-0.22	0.16	-1.39	0.17
qf2:lav	-0.01	0.01	-1.8	0.07
qf3:lav	-0.06	0.01	-7	2.53E-012
qf4:lav	0	0.01	0.43	0.67
areaf1:lav	-0.06	0	-12.41	<2E-016

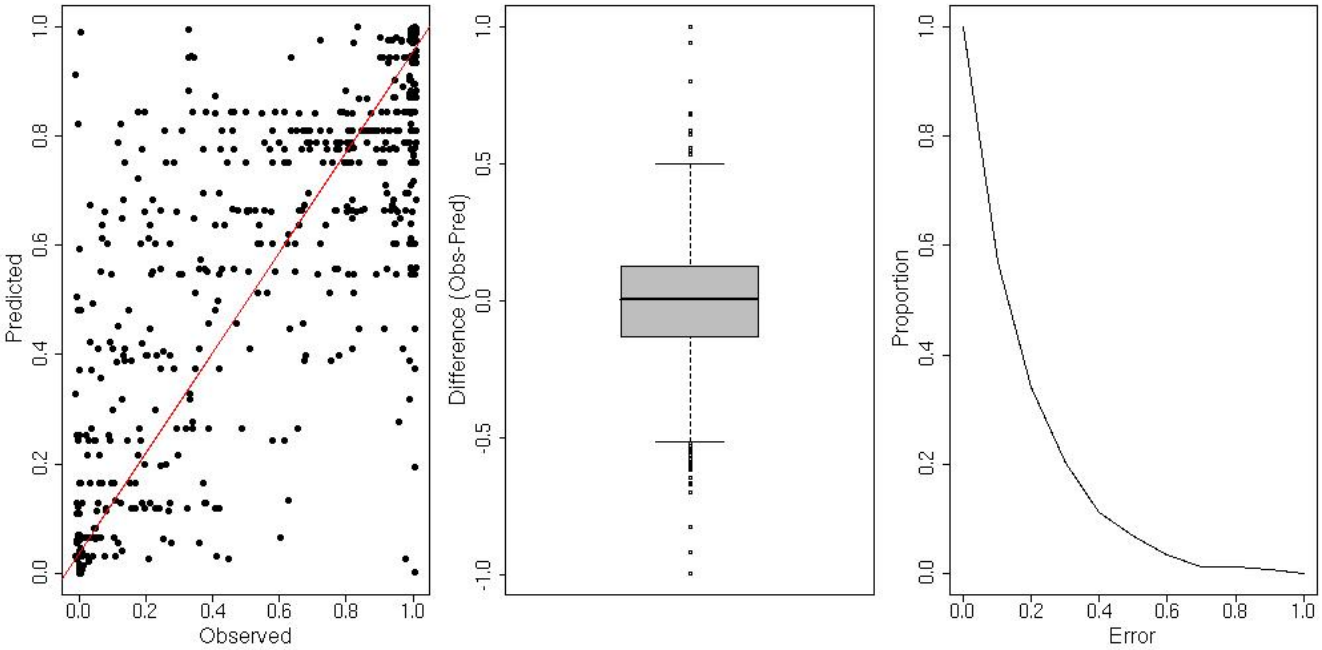

Figure 1. Scatterplot for predicted and observed sailfish/(sailfish+spearfish) ratio (left panel), boxplot for the difference between observed and predicted ratio (mid panel), and estimated proportion of predictions that result in error larger than those showed in the x-axis (right panel). Calculations were for cells in which the number of fish observed was greater than 10.

Appendix 6

Analyses of CPUE data for several longline fisheries

By Gerry Scott and Mauricio Ortiz

Through more than half of the time allocated for the sailfish assessment Working Group meeting, no updated, standardized catch rates time series were available from two of the fleets upon which previous sailfish stock assessments were based. This lack of information severely hampered the progress the Working Group could make in assessing the stock status and advising the Commission, since much effort was directed toward attempting to recover and analyze this information through the ICCAT data bases. While partial information from the Japanese fleet was sent to the WG late in the meeting, no new analysis was forthcoming from scientists having access to a full time series of catch-effort data from the Chinese Taipei fleet. Recognizing the lack of information, the Working Group decided to analyze the available catch-effort information available at the Secretariat from the Japanese, Chinese Taipei, and Korean fleets using aggregated catch-effort data. Two approaches were used.

The first approach relied on the CATDIS and longline effort estimates data files, which provide information on longline catch and effort at a 5x5xcalendar quarter spatial-temporal scale. The CATDIS catch estimates used were those resulting from the Working Group separation of sailfish from spearfish for Japanese, Chinese-Taipei, and Korean longline fleets, as described in Section 2.a of this report. For these analyses, simple GLMs of the natural log-transformed catch kg / 1000 hooks by 5x5 cell were modeled across the entire area of fishing, controlling for each 5x5 lat-lon, calendar quarter, and year in the analysis. To some degree this approach accounts for targeting effects to a level whereby the fine spatial scale of the analysis is a proxy for targeting. Below the model formulation and summary outputs. **Figure GPS** draws comparison between the standardized catch rate patterns resulting from this analysis and those used in the 2001 assessment and an update which became available to the Working Group late in the meeting. The spatial extent of the data used in the analysis conducted by the Working Group was broader than used in the 2001 analysis, as only 5x5 degree aggregated data were available to the Working Group. SAS Code used to generate catch rate patterns from CATDIS and Hook estimates.is available at the ICCAT Secretariat.

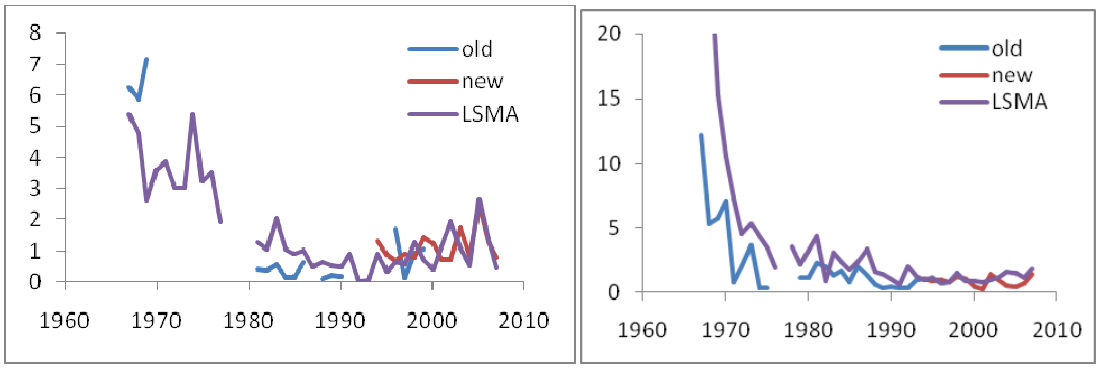

Figure GPS. Comparison of sailfish catch rates resulting from analysis of CATDIS and Hooks data sets for Japanese (left) and Chinese-Taipei (right) longline with those available in 2001 or updated by national scientists.

Appendix 7

Calculation of a standardized CPUE for the fishery of Ghana

By Mark Fitchett

Artisanal fisheries from Ghana have had documented catch and effort on a monthly time scale since 1974 to 2007. Data is collected in metric tons (mt) and effort in trips taken. Gear and methodology is gillnet using small-scale canoes. CPUE was analyzed by implementing a GLM approach using Statistical Analystical Software (SAS). Data was from years 1983, 1988, 1990, and 1991 were omitted due to perceived sampling errors during a time period of economic hardship in Ghana. A preliminary GLM using data from 1974 to 2007 was run using log-transformed and box-cox powers data (powers = 0.227) assuming a Gaussian error distribution (passing tests for normality).

The preliminary GLM used year, fishing season (high and low), and a year*season interaction. High season included months October to May while a low season included months June to September.

An apparent discontinuity in CPUE is observed and the model fit was poor. Upon review of effort reported, it is noted that from 1974 to 1990, data was report in area units of 1x1 degree grid squares and in 5x5 grid squares from 1991 to 2007. In addition, further review of effort patterns of the number of canoes in the fishery versus total trips reported suggests that effort was reported on a different scale or possibly different units prior to 1990 when trips were the unit of effort, such as hours fished.

For the development of an index of abundance, years 1992 to 2007 were used. Effort used in trips per month and catch in metric tons (mt) per month. Zero catch made up less than 3.5%, but were not discarded. A small constant of 1x10-8 was added to CPUE. Data was transformed in the R program to normality using Box-Cox Powers (power=0.2292) and passed a test of normality using a CVM test.

CPUE was analyzed by implementing a GLM approach using Statistical Analystical Software (SAS). The GLM used effects of year, cuatrimestre, and a year*cuatrimestre interaction. Cuatrimestres (four month periods) were defined as January-April, May-August, and September-December.

The Ghana CPUE series shows a slightly declining trend from 1993 to 2007, with a peak in 1996 and 2003 and a minimum in 2000 and 2006. In addition, further analyses of the Ghana gillnet fishery suggests a need to explore environmental impacts.

Table 1. ANOVA Table for GLM using CPUE = Year + Cuatrimestre + Year*Cuatrimestre

Source	**df**	**Sum Squares**	**Mean Square**	**F Value**	**Pr > F**
Year	15	0.29460662	0.01964044	3.72	<.0001
Cuatrim	2	0.50612532	0.25306266	47.94	<.0001
Year*Cuatrim	28	0.27287553	0.00974555	1.85	0.0111

R-Square	Coeff Var	Root MSE	Response Mean
0.597521	21.62864	0.07265	0.335914

Table 2. Relative Abundance of Sailfish from the Ghana Gillnet fishery.

Year	Mean	Lower	Upper
1993	0.015182	0.009207	0.023777
1994	0.01445	0.008711	0.022741
1995	0.006098	0.003264	0.010534
1996	0.017662	0.010906	0.027261
1997	0.007446	0.004106	0.012569
1998	0.006951	0.003795	0.011825
1999	0.004339	0.002198	0.007813
2000	0.003182	0.001527	0.005966
2001	0.007527	0.004158	0.01269
2002	0.013536	0.008094	0.021441
2003	0.016116	0.009845	0.025094
2004	0.005979	0.003191	0.010353
2005	0.010101	0.005814	0.01649
2006	0.005128	0.002671	0.009045
2007	0.00571	0.003025	0.009941

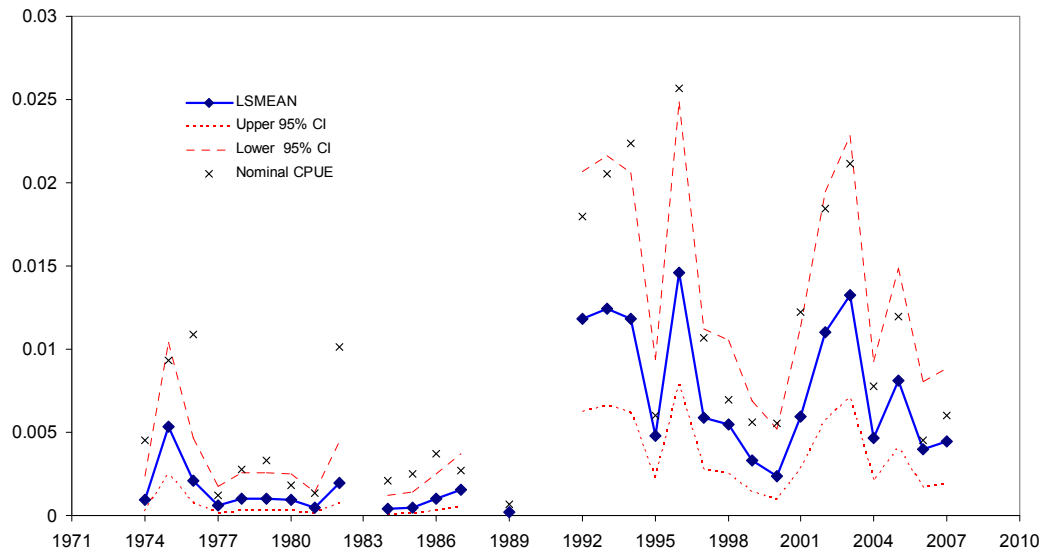

Figure 1. Preliminary CPUE index of sailfish for Ghana gillnet fishery.

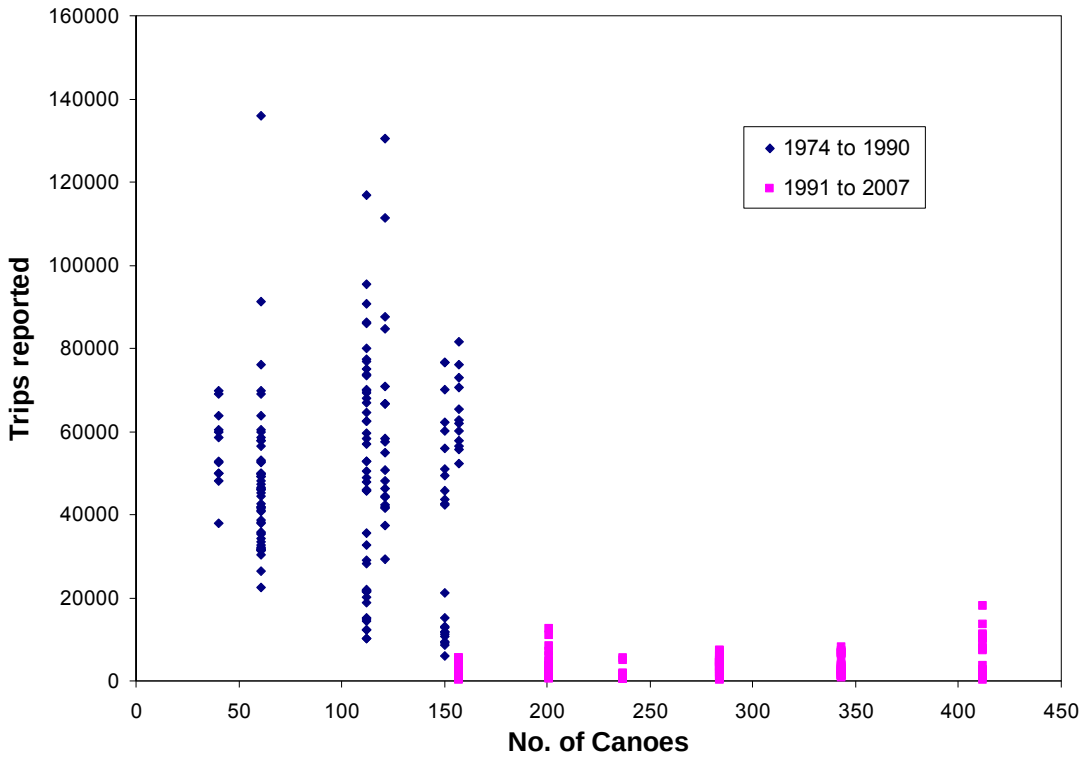

Figure 2. Relationship of canoes in the Ghana gillnet fishery versus trip reported (by month) from 1974-1990 and 1991-2007.

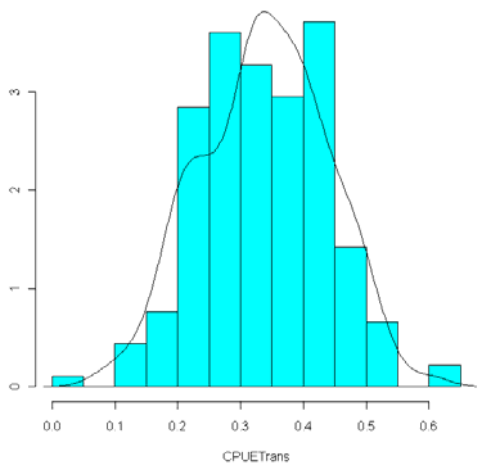

Figure 3. Histogram of data from 1993-2007 Transformed CPUE data using Box-Cox Powers method and a simulated normal curve.

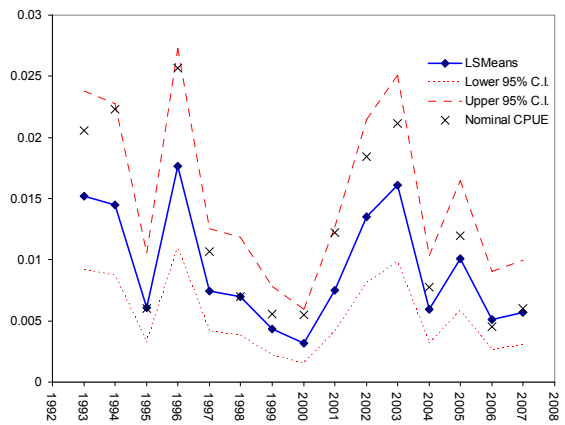

Figure 4. Standardized Ghana CPUE Index from years 1993 to 2007.

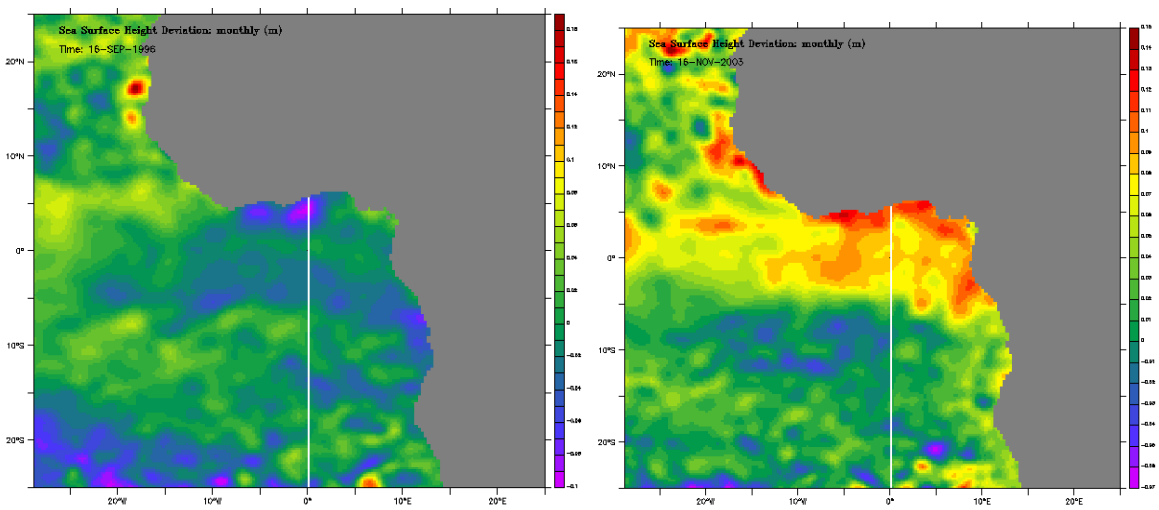

Figure 5. Map of montly altimetry sea surface height anomaly (SSHA) of the West African coast during an exceptionally poor fishing month. (left) and an exceptionally successful fishing month (right).

Appendix 8

A Bayesian production model for Atlantic sailfish

By Humber Andrade

A biomass dynamic model was used because only catch and catch rate times series were available. Despite simple models lack realism the result gathered with them are in many situations as useful as those obtained with complex, more data demanding models (Ludwig & Walters 1985).

We used the following version of the Schaefer model.

(1) $$B_t = \left[B_{t-1} - C_{t-1} + r \cdot B_{t-1}\left(1 - B_{t-1}/k\right)\right] \cdot e^u$$

where C and B are the catch and the biomass, and time is indexed by t . The parameter r is the population growth rate, k is the carrying capacity biomass, and u is normally distributed random process noise with variance W . The observation error in C_t is assumed to be negligible. The relationship between the biomass B_t and an observable index I_t of abundance is

(2) $$I_t = q \cdot B_t \cdot e^v$$

where v is a normally distributed random variable with variance V accounting for observational noise, and q is the catchability coefficient.

We assumed q approximately constant relying on the "standardization" of the catch rates as calculated using generalized linear models (GLM).

In the state-space model as described in equations 2 and 1, besides the nuisance parameters W and V , there are three parameters of interest, r, k and q. Because it is mathematically more convenient to deal with parameters defined over the real line, we define $\theta = \{\log\ r, \log\ k, \log\ q\}$ as the three dimensional parameter vector of interest in the Bayesian approach.

Bayesian approach to the assessment model

Bayesian inference of θ is obtained using prior probability density distribution $\pi(\theta)$ and likelihood $L(\theta) = p(\text{data} \mid \theta)$ after the data have been sampled. The posterior density distribution for θ is

(3) $$p(\theta \mid \text{data}) = \frac{\pi(\theta) \cdot L(\theta)}{\int \pi(\theta) \cdot L(\theta)}$$

We first describe the likelihood function, then we explain how we built the prior and posterior probability distributions.

Likelihood

In order to estimate θ only the observational error was considered. The solution is summarized bellow. After taking the logarithm of equation 2 and for notational convenience, we define $Y_t = \log\ I_t$ and $\mu_t(\theta) = \log(q \cdot B_t)$. The probability model for data point Y_t is

(4) $$p(Y_t \mid \theta, V) \sim N(\mu_t(\theta), V)$$

where $N(\mu_t(\theta), V)$ is an one-dimensional normal distribution with mean $\mu_t(\theta)$ and variance V. Let the complete data set be $Y(\tau) = \{Y_1, .., Y_\tau\}$, hence the joint likelihood is $L(\theta, V) = p(Y(\tau) \mid \theta, V)$. If independent prior distributions are assumed for θ and for V, say $\pi(\theta, V) = \pi(\theta) \cdot \pi(V)$, then the likelihood $L(\theta)$ is obtained by marginalization with respect to V

(5) $$L(\theta) = \int p(Y(\tau) \mid \theta, V)\pi(V)dV$$

If the prior for V is an inverse-gamma density distribution, say $\pi(V) \sim IG(\alpha, \beta)$, the solution is

(6) $$L(\theta) \propto \left\{ 2\beta / \left[2\beta + \sum_{t=1}^{\tau} (Y_t - \mu_t(\theta))^2 \right] \right\}^{\alpha+\tau/2}$$

That choice is convenient because the inverse-gamma is conjugated with the normal probability in equation (5). The resulting likelihood equation is simple in the sense that it only depends on the residuals with respect to $\mu(\theta)$ and on the prior parameters for V. The first and the second central moments for the posterior inverse-gamma distribution of V are

(7) $$E[V \mid Y(\tau)] = \frac{1}{\alpha+\tau/2-1} E^{p(\theta \mid Y(\tau))} \left\{ \left[2\beta + \sum_{t=1}^{\tau} (Y_t - \mu_t(\theta))^2 \right] / 2\beta \right\}$$ and

(8) $$E[V^2 \mid Y(\tau)] = \frac{1}{(\alpha+\tau/2-1)(\alpha+\tau/2-2)} E^{p(\theta \mid Y(\tau))} \left\{ \left[\frac{2\beta + \sum_{t=1}^{\tau} (Y_t - \mu_t(\theta))^2}{2\beta} \right]^2 \right\}$$ where $E[\cdot]$

and $E^{p(\theta \mid Y(\tau))}[\cdot]$ represent the expectation and the expectation over the posterior.

In order to calculate the likelihood (eq. 6), biomasses are estimated recursively using equation 1. Hence an initial value, the biomass for the first year, needs to be defined in advance.

Prior

The prior may strongly affect the posterior distribution when database is non-informative. Therefore, it is very important to show how the priors have been built. We shall use a three dimensional non-central student distribution for $\theta = \{\log r, \log k, \log q\}$, so that $\pi(\theta) \sim T_3(df, m, c)$, where df is the degree of freedom, m is the mean vector and c is the main diagonal of the (3x3) covariance matrix of the three dimensional student density function $T_3(\cdot)$. We assumed independence among the parameters so that all off-diagonal terms of the covariance matrix are zero. The impact on the posterior was evaluated by using two different prior distributions. In the "informative" prior we summarized all available knowledge on the parameters to the best of our knowledge. In the "diffusive" prior we exaggerated our ignorance by inflating variances. In order to define these prior distributions we first build suitable independent normal distributions for each component of the vector , then we used the means and the variances of these three distributions to build vector m and the main diagonal of the covariance matrix c in the three dimensional student prior.

Posterior

In order to draw a sample from the posterior distributions using the Monte Carlo methods the initial step is the choice of a suitable importance function. A good importance function must be easy to sample from and should be similar to the true posterior density distribution function. The standard importance function is a multivariate normal or student distribution centered at the maximum likelihood estimates and with covariance matrix proportional to the Hessian matrix (Gelman et al. 1995). Some improvement in the method of choosing importance function when using the sampling importance resampling (SIR) algorithm has been developed by McAllister & Ianelli(1997). The mixture of student distributions is another alternative to improve the first importance function (West 1992, 1993). This procedure called adaptive importance sampling (AIS) can be followed by a SIR when drawing the final sample, and was the method we chose. Relative entropy (RE) as suggested by West (1993) was the diagnostic measurement we used in the AIS/SIR procedure to assess the convergence. RE approximates 1 as $g(\theta)$ approaches $p(\theta \mid data)$. The adaptive updating procedure of $g(\theta)$ is performed recursively until a target minimum relative entropy has been reached. Further details on AIS algorithm and it's technical issues are in Kinas (1993).

Application of the model to sailfish data

Only combined indices weighted by catch were used to fit the bayesian production model. After some discussion two priors (informative and non-informative) were built using multivariate student distributions. Marginal densities of the priors used in both bayesian models for the west and east Atlantic are in figure 1.

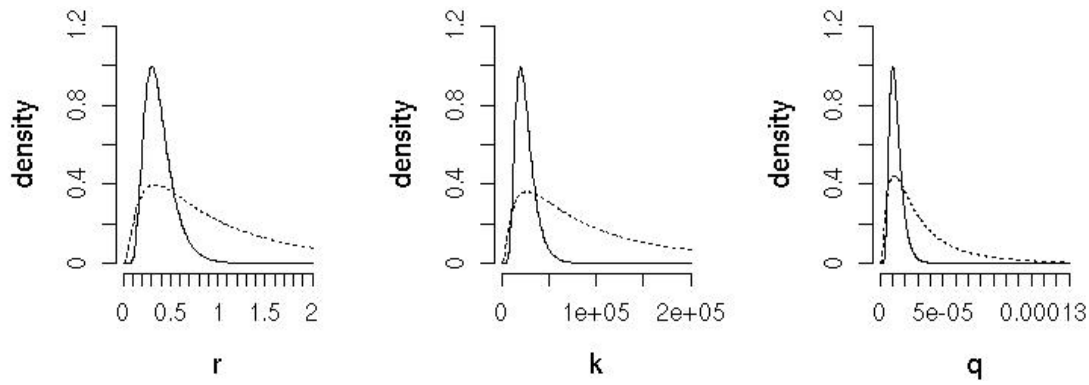

Figure 1. Marginal priors for r, k and q. Dashed lines stand for the non-informative, while continuous lines stand for the informative prior.

Preliminary results showed that the mixed importance functions obtained using adaptive importance sampling (AIS) were similar to the posteriors as indicated by entropy calculations. Empirical distributions as obtained using SIR after the AIS approximation to the posterior showed to be different than the priors. This was encouraging in the sense the data appears to be somewhat informative. Nevertheless, the fit of models as evaluated by comparing the observations and the predictions were very poor. The model was not able to track down the indices for the early years. Therefore the group decided to also try a "penalty" function in the model in order to assign heavier weights to recent years indices. The results were similar to those gathered by not using the penalty function, hence only the results as calculated with the original indices are shown.

West

Marginal posteriors distributions are in **Figure 2**. The posteriors as calculated using informative and non-informative priors showed some small differences. Posteriors for r and q calculated with informative prior are shifted to the right if compared to those gathered with non-informative prior. In opposition the posterior for k as calculated using the informative prior is shifted to the left.

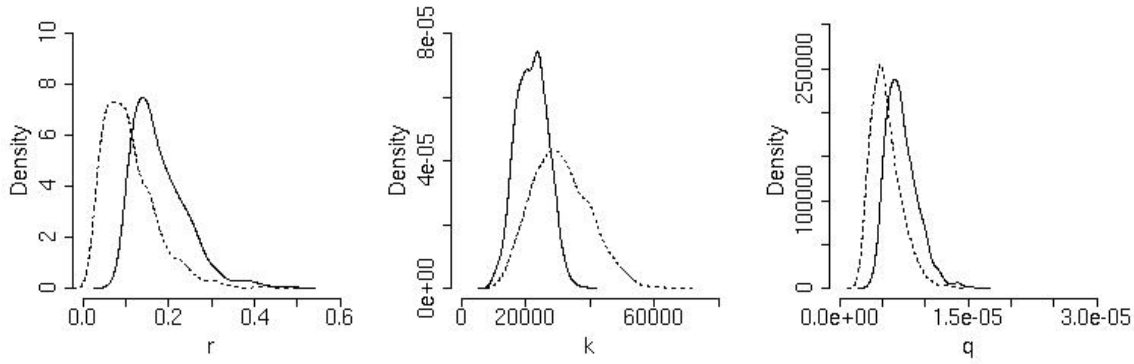

Figure 2. Posteriors as calculated using informative (continuous line) and non-informative priors for r, k and q. Upper row stand for the results gathered with the original indices, while the results obtained assigning heavy weights for indices of the more recent years are in the bottom row.

Fittings of the models are poor in the sense the large indices observed in the early years and the decrease in the 1970's no matter if penalty function was applied (**Figure 3** - left panels). Biomass profiles decreases all across the year since the very beginning of the data series. Finally linear models fitted to the predictions for the more recent years suggest negative slopes though the slope of linear models fitted to observed indices are close to zero.

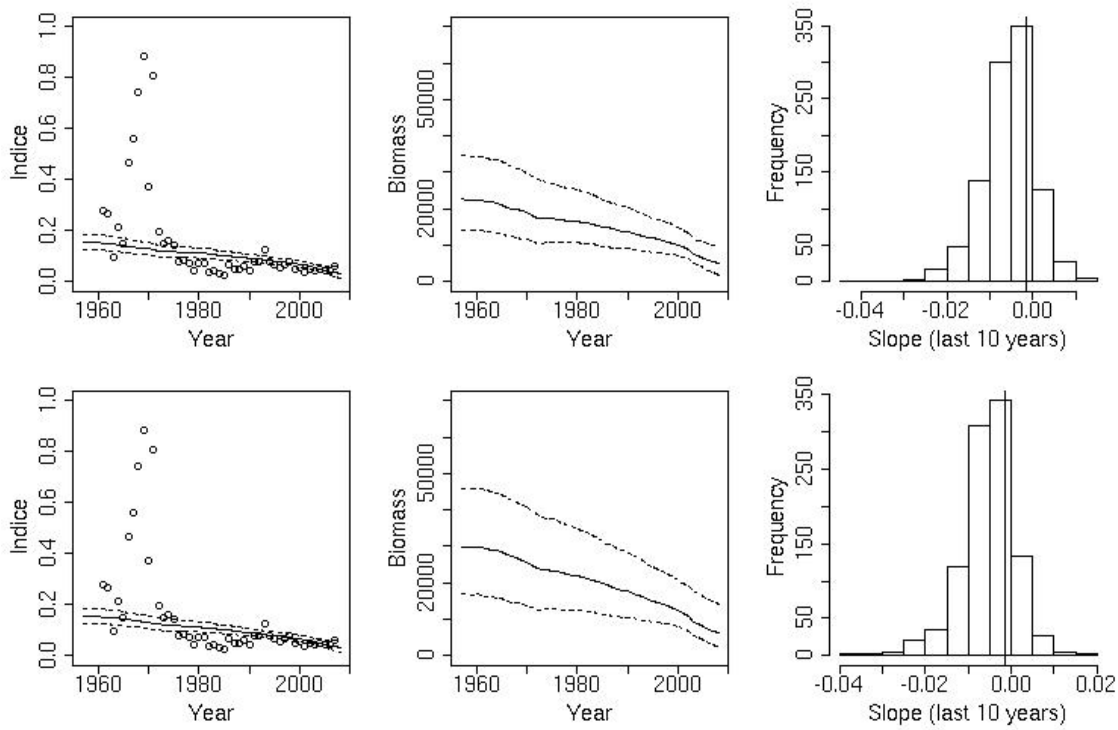

Figure 3. Indices and biomass profiles as calculaled using informative (upper row) and non-informative priors (bottom row). The slope of linear models fitted to the observed and predicted indices of the most recent years are in the left panels. Histograms stands for the predictions while the vertical continuous line stand for the slope calculated for the observed data.

A summary of the parameters and of reference points as calculated using the posterior estimations are in **Table 1**. All estimations points to pessimistic scenarios. If we rely on the median estimations (50% quantiles) the actual biomass is close to half the Bmsy, while the catch in the last year of the time series is 1.3 times the catch in the MSY. Nevertheless, one might keep in mind that those estimations are from a model that do not fit well the observed data.

East

Marginal posteriors distributions are in **Figure 4**. The posteriors as calculated using informative and non-informative priors showed some small differences just like the analysis for the west Atlantic. Actually the results for the east are similar to those of the west in several ways. Posteriors for r and q calculated with informative prior are shifted to the right if compared to those gathered with non-informative prior. In opposition the posterior for k as calculated using the informative prior is shifted to the left.

Fittings of the models are poor just like in the analysis for the west Atlantic. The large indices and variability observed in the early years can not be fitted by the model (**Figure 5** - left panels). Biomass profiles decreases all across the year since the very beginning of the data series. Finally linear models fitted to the predictions for the more recent years tends to be negative though the slope of linear models fitted to observed indices are close to zero.

A summary of the parameters and of reference points as calculated using the posterior estimations are in table 2. All estimations points that depends on biomass estimations are even more pessimistic than those gathered for the west. If we rely on the median estimations (50% quantiles) the actual biomass is close to 0.15 times Bmsy. Although the catch in the last year of the time series analyzed (2007) is bellow the Cmsy but, notice that most of the catchs in the last decade were larger than Cmsy. Like in the analysis for the west, one might keep in mind that those estimations are from a model that do not fit well the observed data.

Table 1. Summary of the posterior estimations as calculated using informative and non-informative priors.

Infomative Prior			Quantiles		
Estimations	5%	25%	50%	75%	95%
r	0.07	0.12	0.16	0.21	0.31
k	14300.37	18867.77	22556.09	27135.48	34597.32
q	4.40E-06	5.66E-06	6.71E-06	8.04E-06	1.05E-05
C_msy	622.82	789.87	888.14	981.60	1110.36
B_msy	7150.19	9433.89	11278.05	13567.74	17298.66
B_last	2496.54	4023.73	5313.12	6995.76	10152.69
ER_msy	0.04	0.06	0.08	0.10	0.15
B_last/B_msy	0.24	0.36	0.47	0.60	0.84
C_last/C_msy	1.03	1.17	1.29	1.45	1.84
ER_last	0.11	0.16	0.22	0.29	0.46
ER_last/ER_msy	1.29	2.02	2.82	4.07	6.61
Non-Informative Prior					
r	0.04	0.07	0.10	0.14	0.25
k	16921.34	24561.25	29971.76	35845.21	45878.09
q	3.13E-06	4.22E-06	5.15E-06	6.39E-06	8.87E-06
C_msy	421.16	594.53	736.39	858.30	1061.26
B_msy	8460.67	12280.63	14985.88	17922.60	22939.04
B_last	3000.63	4817.13	6716.01	9270.89	14729.77
ER_msy	0.02	0.03	0.05	0.07	0.12
B_last/B_msy	0.24	0.35	0.47	0.59	0.84
C_last/C_msy	1.08	1.34	1.56	1.93	2.73
ER_last	0.08	0.12	0.17	0.24	0.38
ER_last/ER_msy	1.40	2.52	3.54	5.34	8.72

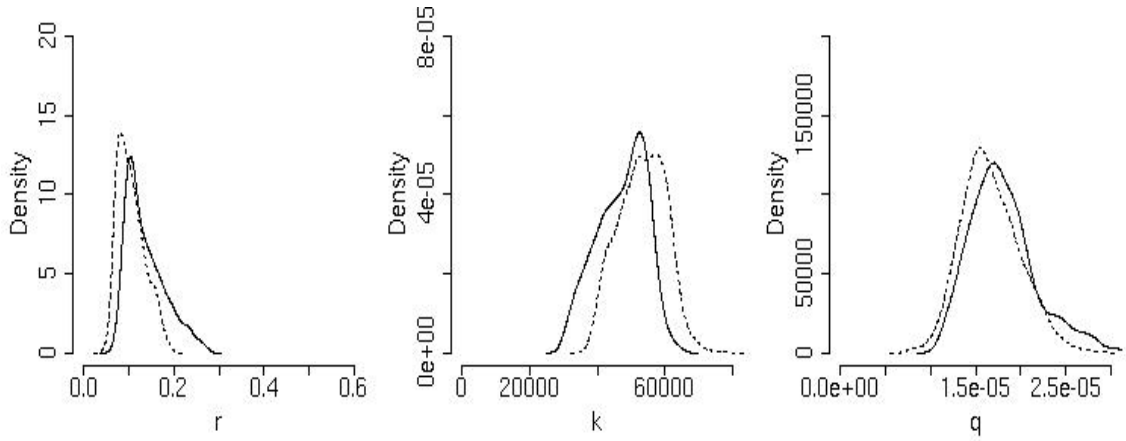

Figure 4. Posteriors as calculated using informative (continuous line) and non-informative priors for r, k and q. Upper row stand for the results gathered with the original indices, while the results obtained assigning heavy weights for indices of the more recent years are in the bottom row.

Table 2 – Summary of the posterior estimations as calculated using informative and non-informative priors.

Infomative Prior			Quantiles		
Estimations	5%	25%	50%	75%	95%
r	0.09	0.10	0.12	0.16	0.23
k	33932.98	41923.28	48266.65	53163.40	57335.94
q	1.28E-05	1.54E-05	1.75E-05	1.99E-05	2.53E-05
C_msy	1254.78	1369.19	1509.60	1711.73	1949.20
B_msy	16966.49	20961.64	24133.33	26581.70	28667.97
B_last	1316.22	2520.94	3621.83	5150.18	8302.47
ER_msy	0.04	0.05	0.06	0.08	0.11
B_last/B_msy	0.06	0.11	0.15	0.22	0.36
C_last/C_msy	0.54	0.61	0.69	0.76	0.83
ER_last	0.13	0.20	0.29	0.42	0.80
ER_last/ER_msy	1.78	3.02	4.46	6.47	12.02
Non-Informative Prior					
r	0.07	0.08	0.10	0.13	0.16
k	41811.99	48105.48	53632.09	58523.89	63889.35
q	1.20E-005	1.45E-005	1.64E-005	1.87E-005	2.25E-005
C_msy	1062.84	1194.15	1348.75	1511.57	1709.30
B_msy	20905.99	24052.74	26816.04	29261.95	31944.68
B_last	1398.16	2529.31	3705.68	5129.38	7921.48
ER_msy	0.03	0.04	0.05	0.06	0.08
B_last/B_msy	0.05	0.10	0.14	0.19	0.28
C_last/C_msy	0.61	0.69	0.78	0.88	0.98
ER_last	0.13	0.20	0.28	0.41	0.75
ER_last/ER_msy	2.56	4.01	5.61	8.06	14.61

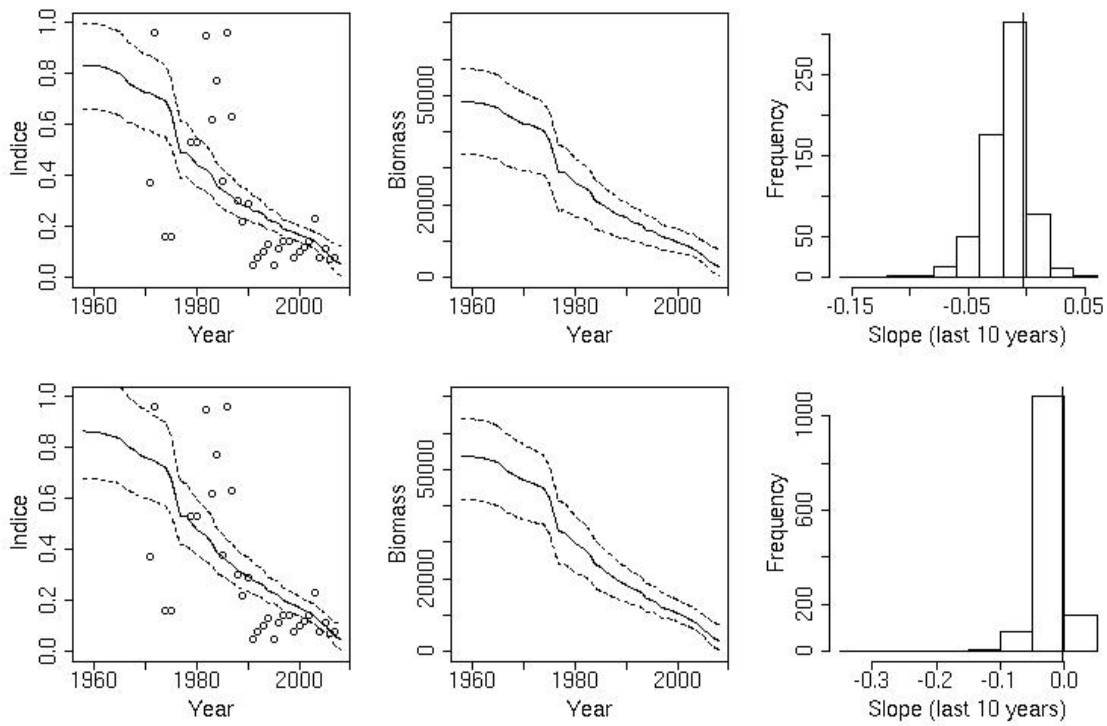

Figure 5. Indices and biomass profiles as calculaled using informative (upper row) and non-informative priors (bottom row). The slope of linear models fitted to the observed and predicted indices of the most recent years are in the left panels. Histograms stands for the predictions while the vertical continuous line stand for the slope calculated for the observed data.

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Appendix 9

Production models for the eastern and western Atlantic stocks with ASPIC models

Mauricio Ortiz, Phil Goodyear, Katerina Wor, Mark Fitchett and David Die

Production model evaluations were evaluated for east and west SAI stock units using different combinations of the available indices of abundance and different versions of the ASPIC package (Table D1). Some of the estimates obtained were nom-boostrapped and others were boostrapped. In all cases it was necessary to constraint the initial biomass to K for the ASPIC to be able to converge. The ASPIC version 5.33 used is part of the NFT toolbox http://nft.nefsc.noaa.gov). Initial parameter guess were provided for the carrying capacity K, MSY, and the catchability (q) coefficients for each index series used.

Table 1. Description of ASPIC runs for the Eastern and Western stock. ASPIC options correspond to: FIT = normal fit, BOT =Bootstrapped fit, IRF = Iterative reweighting. Indices used were: CAW=Combined area weighted, CCW= Combined catch weighted, CUW= Combined unweighted, JAPLL1 = Japanese longline early period, JAPLL2 = Japanese llongline recent period, JAPLL3 = Japanese longline – task II, CIVAR = Cote d'Ivoire artisanal, SENAR = Senegal Artisanal, GHNGL = Ghana gillnet, USLL2 = US Longline logbooks kg, USRR1 = US recreational tournaments (RBS), USRR2 = US recreational surveys (MRFSS), VENRR = Venezuela recreational, VENGL = Venezuela Gillnet, BRZLL = Brazil longline, BRZ = Brazil recreational, KORLL= Korea longline, TAILL = China Taipei longline. (*) JAPLL1 & JLL2 combined as a single index.

Author	Case	Version	Option	Stock	Indices used
Goodyear	G1	5.16	FIT	W	CAW
Goodyear	G2	5.16	FIT	W	CCW
Goodyear	G3	5.16	FIT	E	CAW
Goodyear	G4	5.16	FIT	E	CCW
Goodyear	G5	5.16	FIT	W	CUW
Goodyear	G6	5.16	FIT	E	CUW
Ortiz	O1	5.33	FIT	W	JAPLL3
Ortiz	O2	5.33	BOT	W	JAPLL3, USLL2, BRZLL, VENLL, KORLL
Ortiz	O3	5.33	BOT	E	JAPLL1, JAPLL2, CIVAR, SENAR, GHNGL
Ortiz	O4	5.33	FIT	E	JAPLL1, JAPLL2
Ortiz	O5	5.33	BOT	W	USRR1, USRR2, BRZRR, VENRR
Ortiz	O6	5.33	FIT	W	JAPLL3, USLL2, BRZLL, VENLL, KORLL, USRR1, USRR2, BRZRR, VENRR
Ortiz	O7	5.33	BOT	E	JAPLL3, CIVAR, SENAR, GHNGL
Ortiz	O8	5.33	BOT	E	CIVAR, SENAR, GHNGL
Ortiz	O9	5.33	BOT	W	JAPLL2, USLL2, BRZLL, VENLL, USRR1, BRZRR, VENRR, VENGN, TAILL
Ortiz	O10	5.33	FIT	W	JAPLL1, USLL2, BRZLL, VENLL, USRR1, BRZRR, VENRR, VENGN, TAILL
Ortiz	O11	5.33	IRF	W	USRR1, USRR2, BRZRR, VENRR
Ortiz	O12	5.33	IRF	W	JAPLL3, USLL2, BRZLL, VENLL, KORLL
Ortiz	O13	5.33	FIT	W	JAPLL1, JAPLL2, USLL2, BRZLL, VENLL, USRR1, BRZRR, VENRR, VENGN, TAILL
Wor	W1	5.33	FIT	W	CAW
Wor	W2	5.33	FIT	W	CCW
Wor	W3	5.33	FIT	W	CUW
Fitchett	F1	5.24	BOT	E	CUW
Fitchett	F2	5.24	BOT	E	JAPLL1/JAPLL2, CIVAR, SENAR, GHNGL (*)

The working group decided to leave the choice of aspic version and initial estimates up to the individual scientists running ASPIC. This lead to the different choices of ASPIC version seen in table 1, however, because they all used only different subversions of ASPIC 5 it is believed that the mathematical algorithm used in the fit is the same, so results should not be affected by such choices. The choice of initial parameter estimates clearly does affect the final parameter estimates, especially when the data used in the fit is not informative enough to produce precise solutions, as it was the case in many of the cases fitted. In order to quantify such differences a sensitivity analysis was run on the effects of different initial parameter estimates on one of the most uncertain cases that uses a combined index, case F1. The results of such sensitivity analysis suggest that most of the differences in estimates were driven by the combination of relative abundance indices used, not by the choice of initial estimates **(Table 2)**.

Table 2. Sensitivity of ASPIC results to initial parameters estimates for case F1 that used an Area-Weighted combined CPUE Index for the East Atlantic stock. Values in the table correspond to final estimates of model parameters and goodness of fit measures.

Intitial	**Final estimates**						
MSY, K	**MSY**	**K**	**B_{2006}/BMSY**	**F_{2007}/FMSY**	**F_{2007}**	**r^2**	**MSE**
1000, 7500	2388	20240	0.193	2.171	0.512	0.227	0.619
2000, 15000	2373	20580	0.193	2.187	0.504	0.227	0.619
3000, 25000	2373	20580	0.193	2.171	0.512	0.227	0.619
4000, 45000	2388	20240	0.193	2.172	0.513	0.228	0.636

Results were more variable for fits of the data from the Eastern stock were the number of data series is smaller and their historical extend is shorter, however, there were cases that produced parameter estimates that were not likely to be plausible for both stocks, indicating that certain combinations of abundance indices do not contain enough information for a reasonable fit to a production model. For the eastern stock estimated values of K ranged from 4,929 tons to 81,720 tons and for r ranged from 0.00374 to 4.0. For the western stock estimated values of K ranged from 5,519 tons to 891,000 tons and for r ranged from 0.0072 to 0.93. Some of these values, especially the very high and low values of r and k, probably indicate some of these fits represent solutions where the chosen indices are not sufficient to produce a biologically plausible set of estimates **(Table 3)**.

Management parameters showed similar variation **(Table 4)**. For the eastern stock estimated values of MSY ranged from 76 tons to 5,072 tons, for the biomass ratio B_{2006}/B_{msy} ranged from 0.09 to 1.83 and for the fishing mortality ratio F_{2006}/B_{msy} ranged from 0.27 to 186. For the western stock estimated values of MSY ranged from 100 tons to 18,690 tons, for the biomass ratio B_{2006}/B_{msy} ranged from 0.35 to 1.97 and for the fishing mortality ratio F_{2006}/B_{msy} ranged from 0.03 to 8.63. As mentioned before it is likely that several of these estimates represent unlikely estimates because of the limited information provided by the chosen combination of indices.

If one uses the bootstrap estimates of parameter uncertainty to evaluate the quality of the fit it is clear that those cases that have less uncertainty in the estimates were obtained when all available indices were used without been combined, cases F2 and O7 for the east and case 09 for the west.

Table 3. Productivity parameters obtained from different cases fitted to ASPIC for the eastern and western stock of Atlantic sailfish. Values shown correspond to the non- bootstrapped estimates of K and r. For boostrapped fits the 50th, 25Th and 75th percentile are shown.

		K			r		
Stock	**Case**	**Estimate**	**25%**	**75%**	**Estimate**	**25%**	**75%**
East							
	g3	18520			0.0072	0	0
	g4	81720			0.00374	0	0
	g6	24140			0.348	0	0
	o3	5072			4	0	0
	o4	4949			4	0	0
	o7	20900	18290	24470	0.43	0.346	0.516
	o8	32200	27600	109200	0.232	0.03	0.278
	f1	24320	18560	37260	0.346	0.182	0.504
	f2	16210	15830	22370	0.606	0.39	0.626
West							
	g1	5519			0.0072	0	0
	g2	38444			0.09	0	0
	g5	50630			0.0224	0	0
	o1	37400			0.1304	0	0
	o2	6252	2291	18380	0.93	0.326	2.7
	o5	43850	31350	109300	0.096	0.014	0.116
	o6	34510			0.134		
	o9	38290	9194	49220	0.108	0.058	0.212
	o10	39430			0.086		
	o11	891000			0.084		
	o12	22910			0.214		
	o13	60030			0.044		
	w1	62520			0.007536		
	w2	45460			0.0755		
	w3	62400			0.0074		

The resulting biomass and fishing mortality patterns predicted by these fits vary greatly and sometimes indicate severe depletion of biomass whilst others suggest little effects of fishing. The same can be said about fishing mortality with some cases indicating large increases leading to strong overfishing whilst others do not. **Figures 1 to 12** show these patterns as well as the quality of the fits of biomass to each index for some of the cases in table 1.

Estimates of current stock status are generally highly uncertain as shown by the distribution of estimates produced by the boostrap for the most recent values of fishing mortality rates and biomass **(Figure 13)**, and the estimates of recent biomass and fishing mortality ratios are highly correlated and so are the estimates of Fmsy and Bmsy **(Figures 14 to 16)**.

As expected, the uncertainty in biomass and fishing mmortality ratios increases for the most recent years when compared to the years at the begining of the time series **(Figure 17)**. It must be remember, however, that all these fits assume that the initial biomass ratio is equal to two, thus reducing the calculated uncertainty in this ratio for the earlier years.

Table 4. Management parameters obtained from different cases fitted to ASPIC for the eastern and western stock of Atlantic sailfish. Values shown correspond to the non- bootstrapped estimates of MSY, the ratio of the latest fishing mortality (2007) to the fishing mortality at MSY and the ratio of the most recent estimate of biomass (2006) to the biomass at MSY. For boostrapped fits the 50th, 25Th and 75th percentile are shown.

			MSY			Fratio			Bratio	
Stock	**Case**	**Estimate**	**25%**	**75%**	**Estimate**	**25%**	**75%**	**Estimate**	**25%**	**75%**
East										
	g3	2340			3.77			0.14		
	g4	76.25			185.9			0.09		
	g6	2105			2.51			0.28		
	o3	5072			0.27			1.73		
	o4	4949			0.174			1.83		
	o7	2247	2131	2359	0.62	0.57	0.76	1.15	0.997	1.246
	o8	1868	455	1897	1.58	1.17	27.81	0.53	0	0.62
	f1	2106	1713	2341	3.89	2.64	5.65	0.241	0.12	0.391
	f2	2460	2179	2481	2.26	1.71	2.76	0.261	0.172	0.341
West										
	g1	99.6			3.07			0.35		
	g2	873			1.4			0.94		
	g5	284			8.63			0.45		
	o1	1220			0.673			1.25		
	o2	1455	1198	1550	0.593	0.47	0.9	1.247	0.93	1.41
	o5	1062	291	1154	0.814	0.51	1.43	1.189	0.918	1.49
	o6	1163			0.74			1.189		
	o9	1027	563	1198	1.015	0.74	1.62	1.099	0.91	1.24
	o10	844			1.48			0.913		
	o11	18690			0.028			1.967		
	o12	1220			0.75			1.13		
	o13	663			1.67			1.029		
	w1	117.8			1.28			0.3914		
	w2	858.1			0.0736			0.9506		
	w3	140.2			1.02			0.4136		

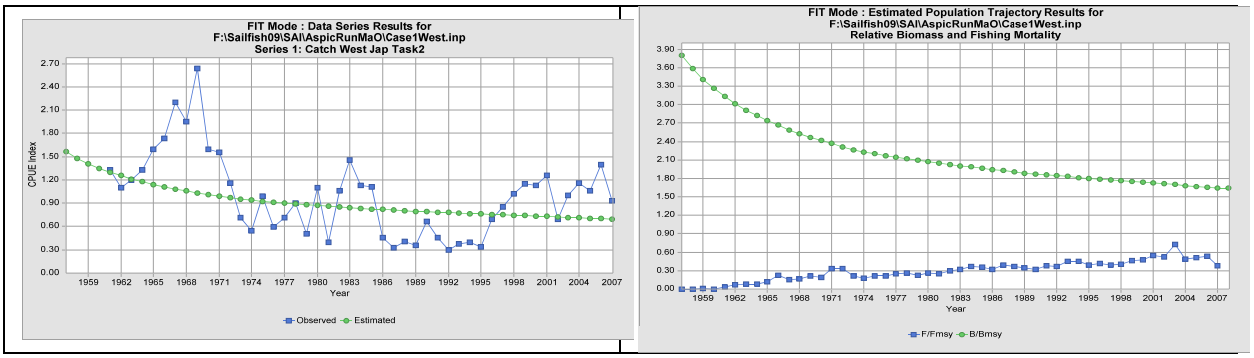

Figure 1. ASPIC fit model results of case 01 a): Standard index of abundance (squares) and model predicted CPUE trends (circles) and b) Trends of relative biomass (circles) and fishing mortality (squares).

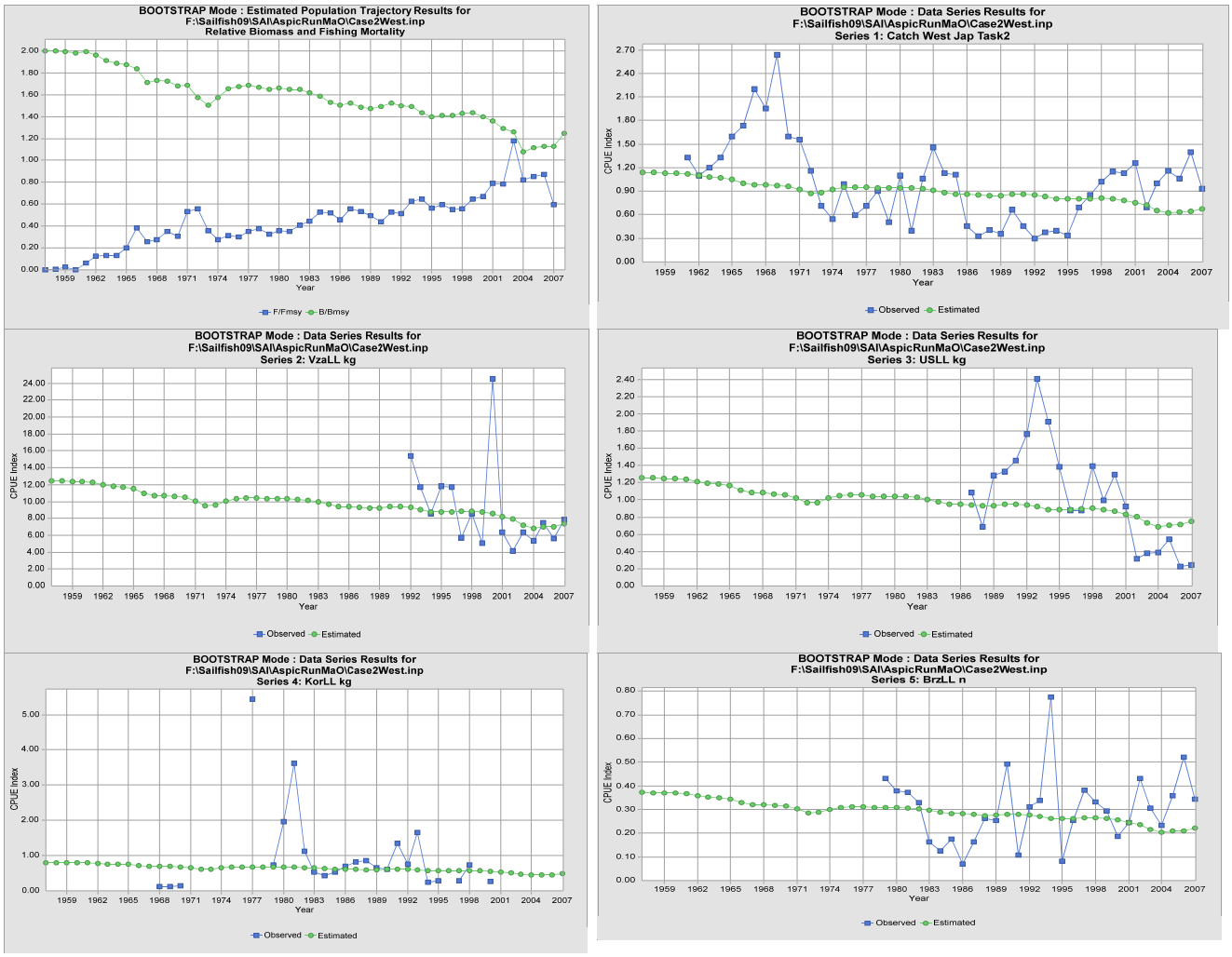

Figure 2. ASPIC fit model results of case 02. Upper Left panel presents trends of relative biomass (circles) and fishing mortality (squares).All other panels how fits of model (circles) to each standardized longline index (squares): Japan (upper right), Venezuela (middle left), US e (middle right), Korea (bottom left) and Brazil (bottom right)..

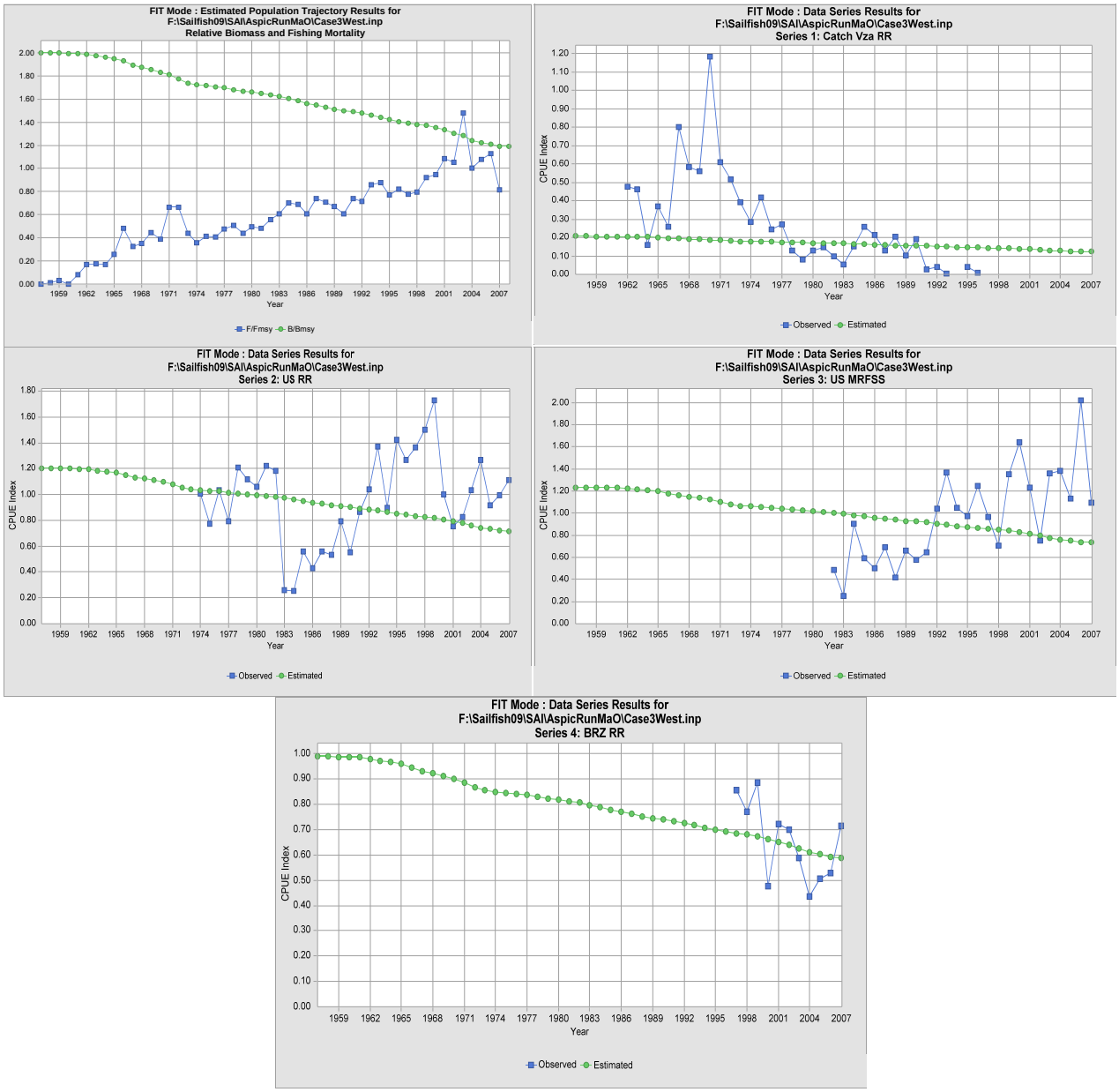

Figure 3. ASPIC fit model results of case 05. ASPIC fit model results plots. Upper Left panel presents trends of relative biomass (circles) and fishing mortality (squares). All other panels show fits of model (circles) to each standardized sport index (squares): Venezuela (upper right), US tournaments (middle left), US MRFSS (middle right) and Brazil (bottom center).

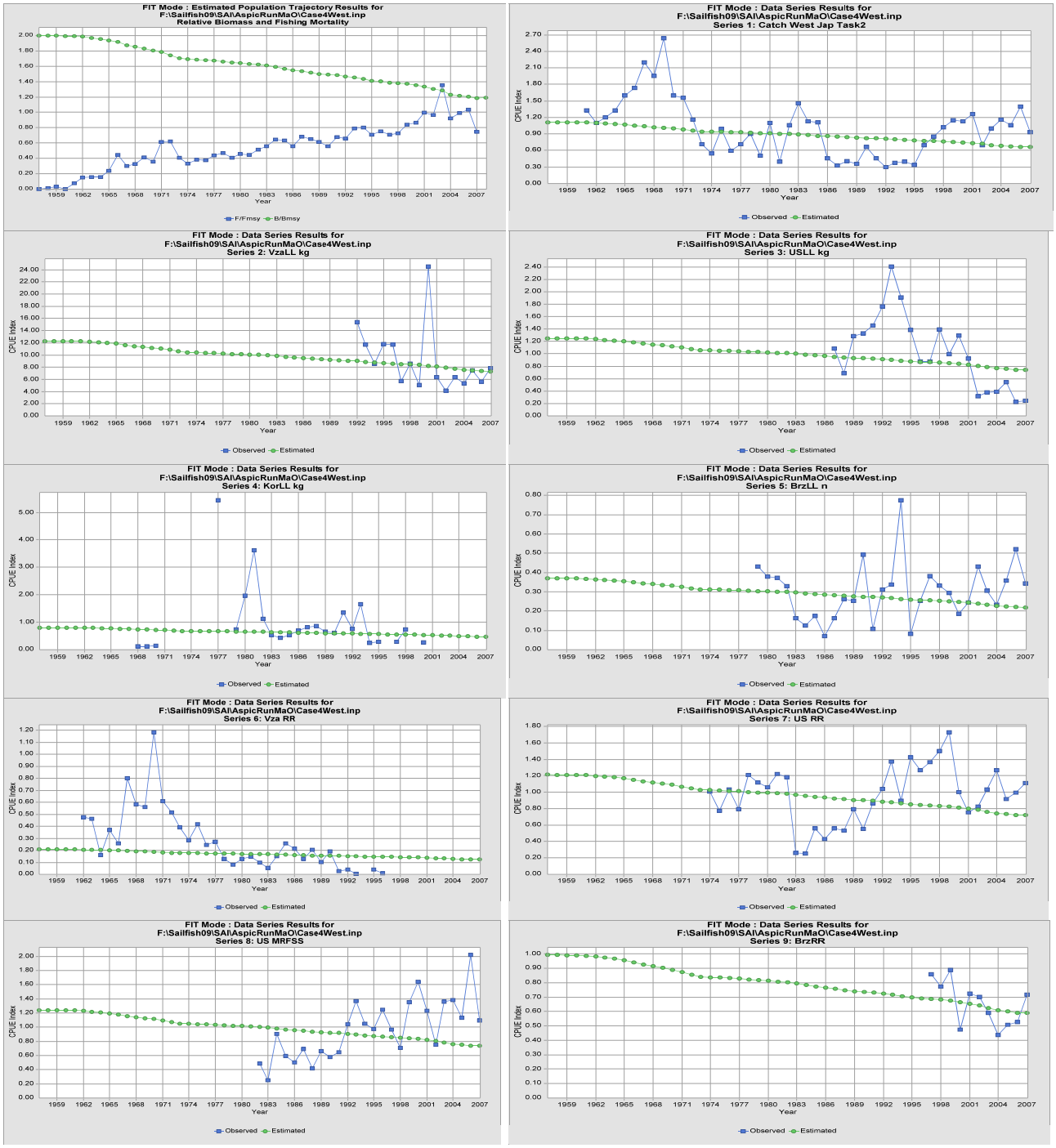

Figure 4. ASPIC fit model results of case 06. ASPIC fit model results plots. Upper Left panel presents trends of relative biomass (circles) and fishing mortality squares). All other panels show fits of model (circles) to each standardized index (squares): Japan longline (upper right), Venezuela longline (second row left), US longline (second row right), Korea longline (third tow left), Brazil longline (third row right), Venezuela sport;(fourth roow left), US sport tournaments (fourth row right), US MRFSS (bottom left) and Brazil sport (bottom right). .

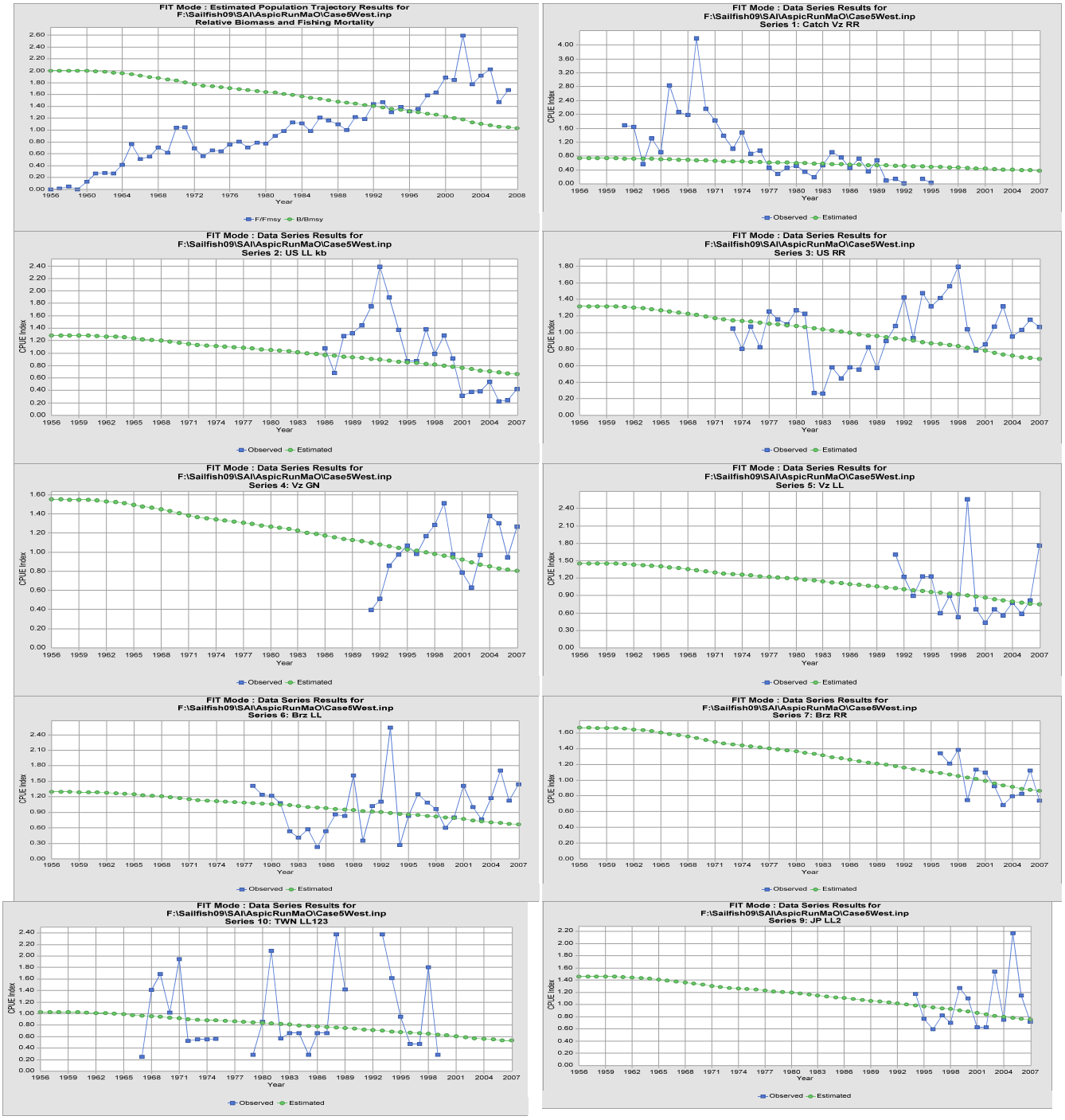

Figure 5. ASPIC fit model results of case O13. . Upper Left panel presents trends of relative biomass (circles) and fishing mortality (squares). All other panels show fits of model (circles) to each standardized index (squares): Venezuela sport (upper right), US longline (second row left), US sport (second row right), Venezuela gillnet (third tow left), Venezuela longline (third row right), Brazil longline;(fourth row left), Brazil sport (fourth row right), Korean longline ?? (fifth row left), Japan longline (bottom right) and Chinese Taipei longline (bottom right).

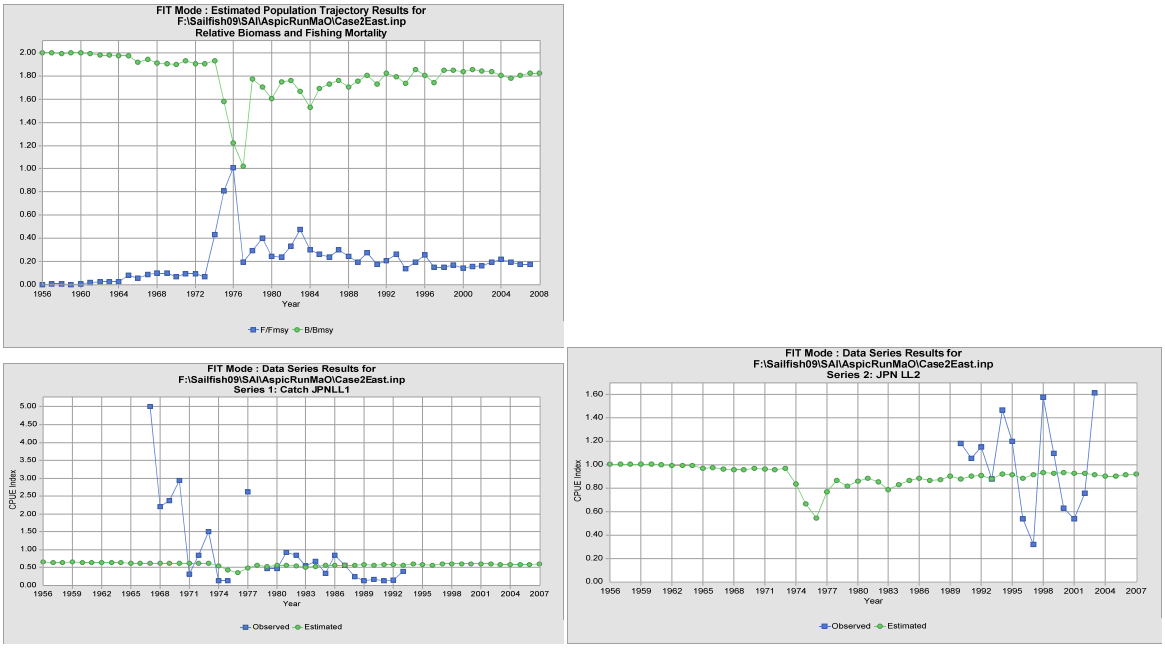

Figure 6. ASPIC fit model results of case 03. ASPIC fit model results plots. Upper panel presents trends of relative biomass (circles) and fishing mortality (squares). Other panels show fits of model (circles) to japanese longline standardized indices(squares) for the early period (bottom left and recent period (bottom right)).

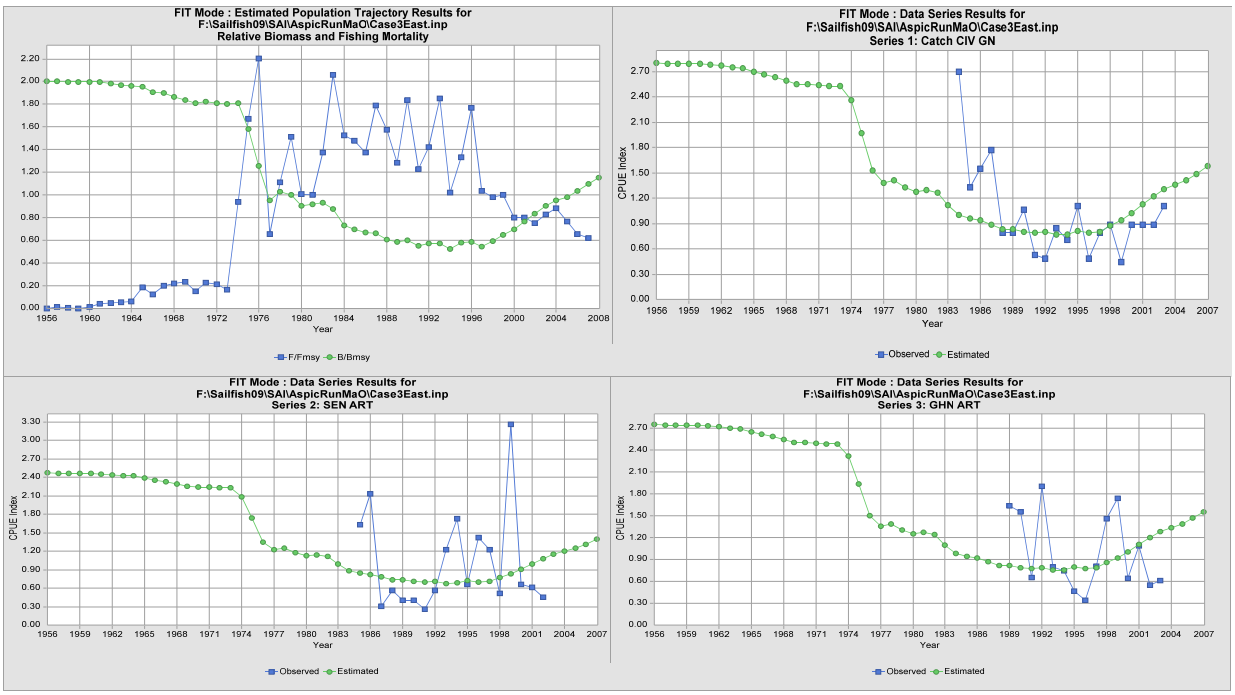

Figure 7. ASPIC fit model results of case 04. ASPIC fit model results plots. Upper left panel presents trends of relative biomass (circles) and fishing mortality (squares). Other panels show fits of model (circles) to artisanal standardized indices(squares): Cote d'Ivoire (upper right), Senegal (bottom left) and Ghana (bottom right).

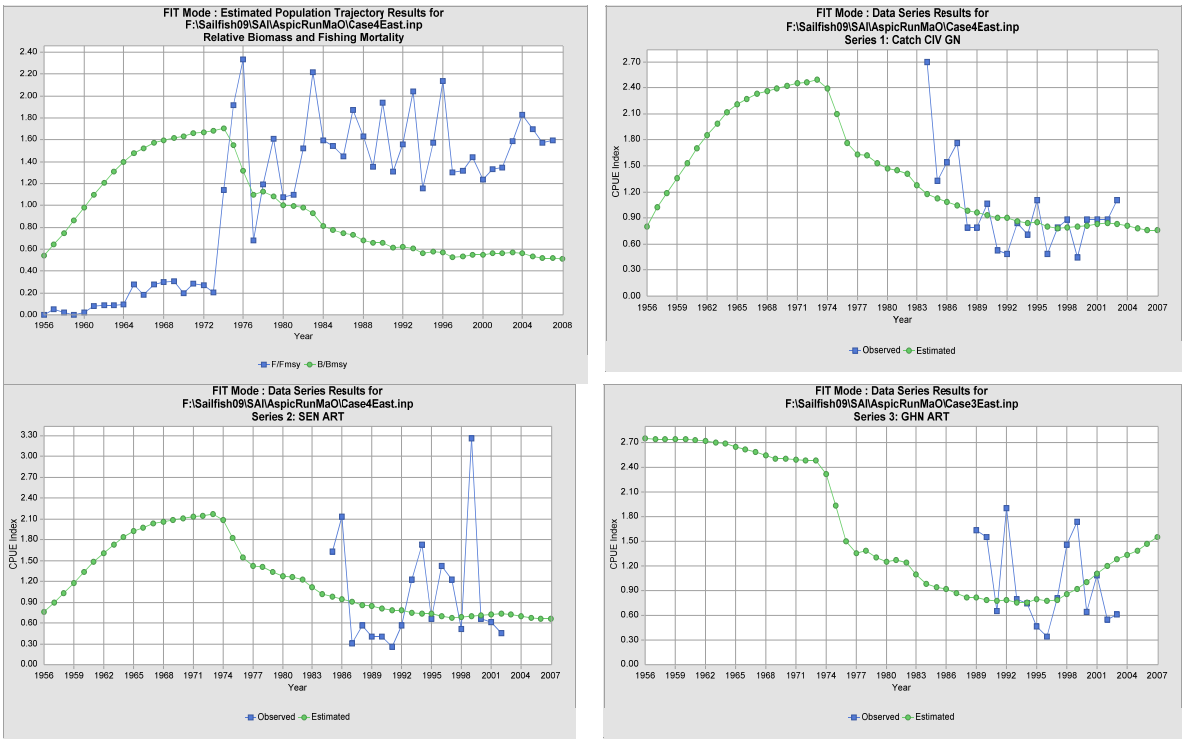

Figure 8. ASPIC fit model results of case 07. ASPIC fit model results plots. Upper left panel presents trends of relative biomass (circles) and fishing mortality (squares). Other panels show fits of model (circles) to artisanal standardized indices(squares): Cote d'Ivoire (upper right), Senegal (bottom left) and Ghana (bottom right).

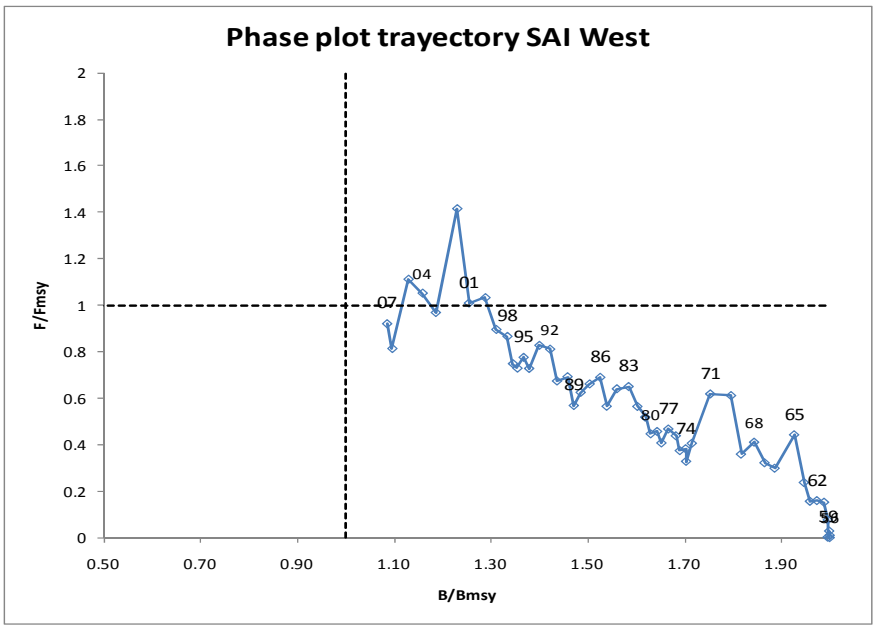

Figure 9. Results of ASPIC fit of case O9. Trends in time of fishing and biomass ratios plotted in a phase plot that indicates when overfishing and overfished reference points are reached. Numbers next to diamonds denote the year of the estimate.

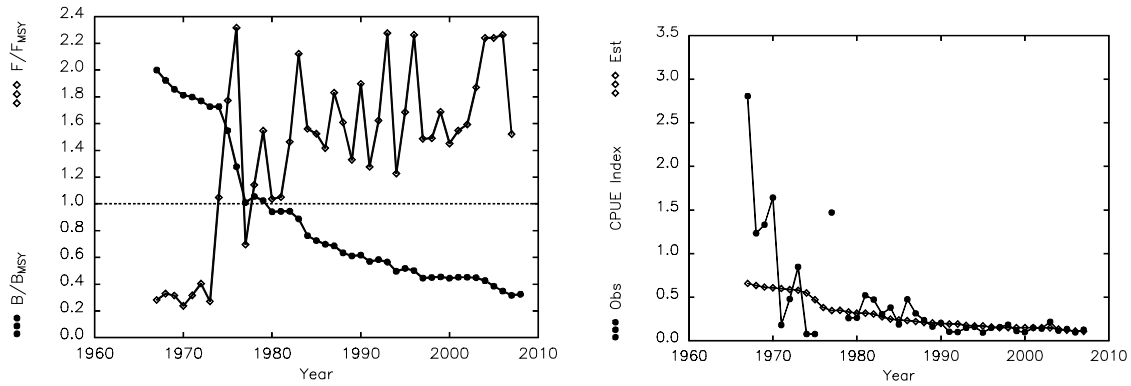

Figure 10. ASPIC fit model results of case F1. Left panel Fishing and biomass ratios, right panel estimated biomass and observed cpue.

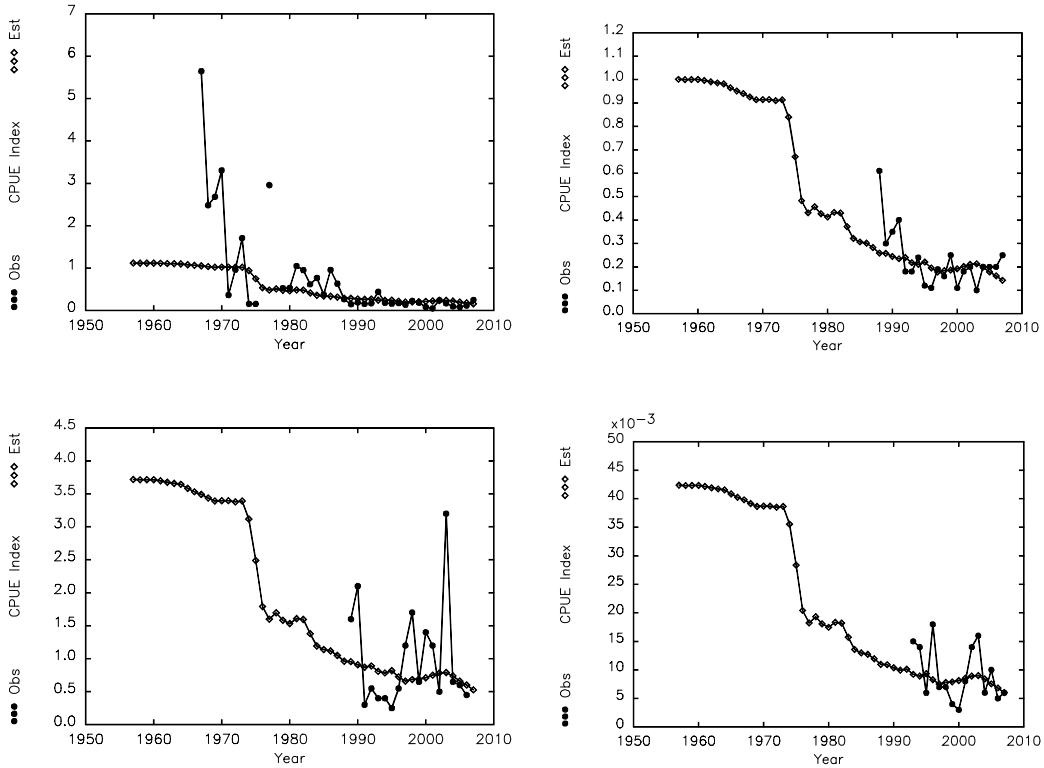

Figure 11. ASPIC fit model results of case F2. Each panel correspond to the fit of the model to each of the cpue indices, from top left, Japan LL1 and Jap LL2, top right, CIV ART, bottom left SEN ART and bottom right GHA GIL.

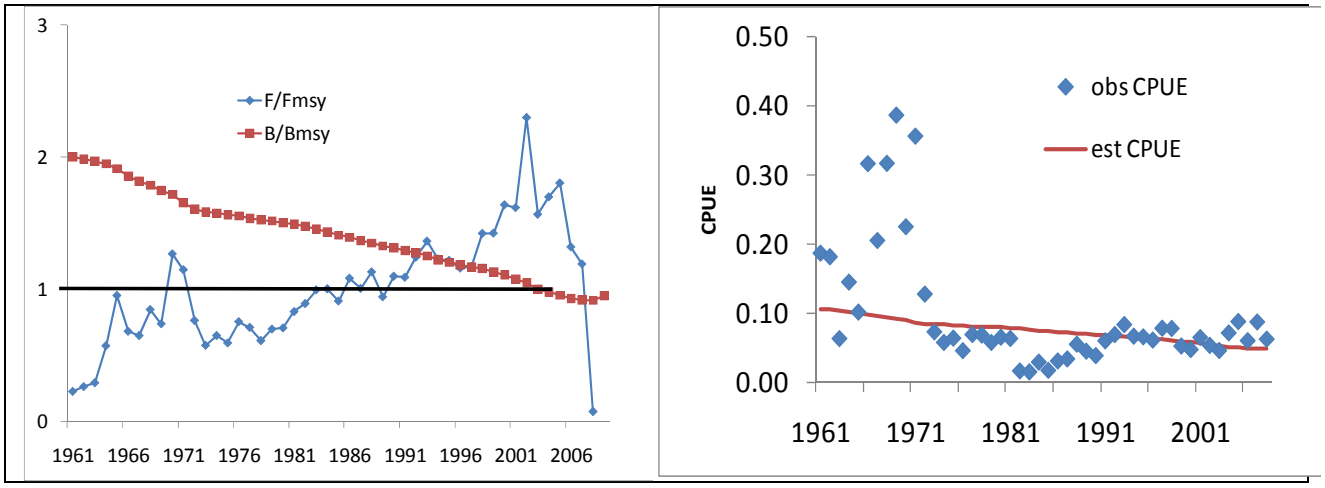

Figure 12. ASPIC fit model results of case W2. Left panel presents the estimated biomass ratio and fishing mortality ratios and the right panel the fit of the estimated cpue to the observed cpue.

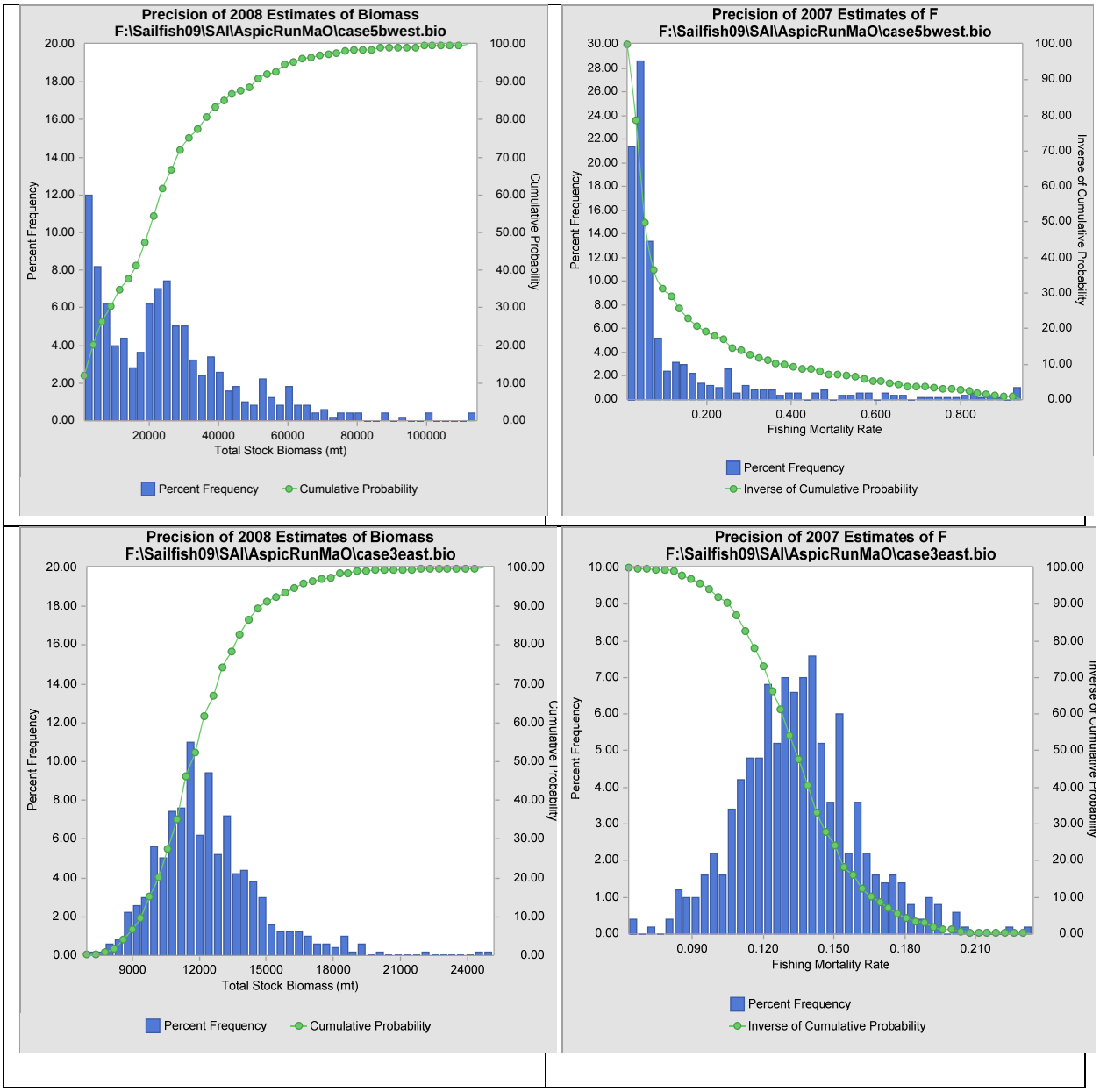

Figure 13. Results of fits for ASPIC cases O9 (top row) and O7 (lower row). Probability distribution and cumulative distribution (circles) for the last year (2008) of total stock biomass (left panel) and fishing mortality rates (right panel).

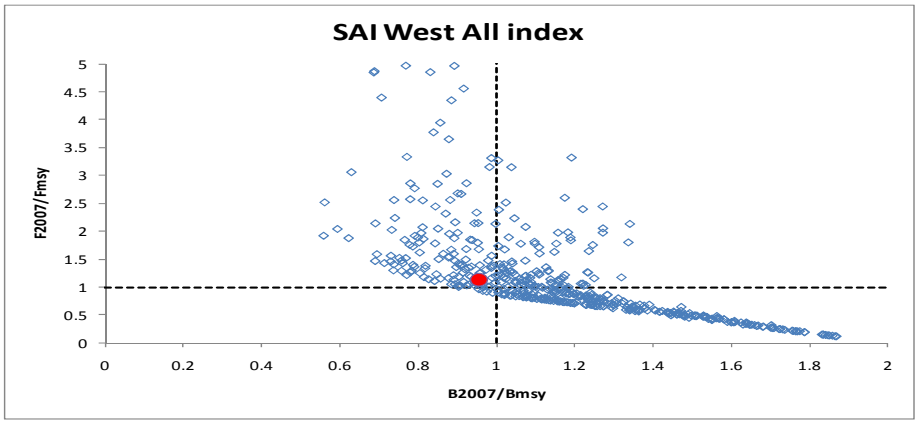

Figure 14. Results of ASPIC fit of case O9. Boostratpped estimates of Biomass and fishing mortality ratios of terminal year with the median value (red-circle).

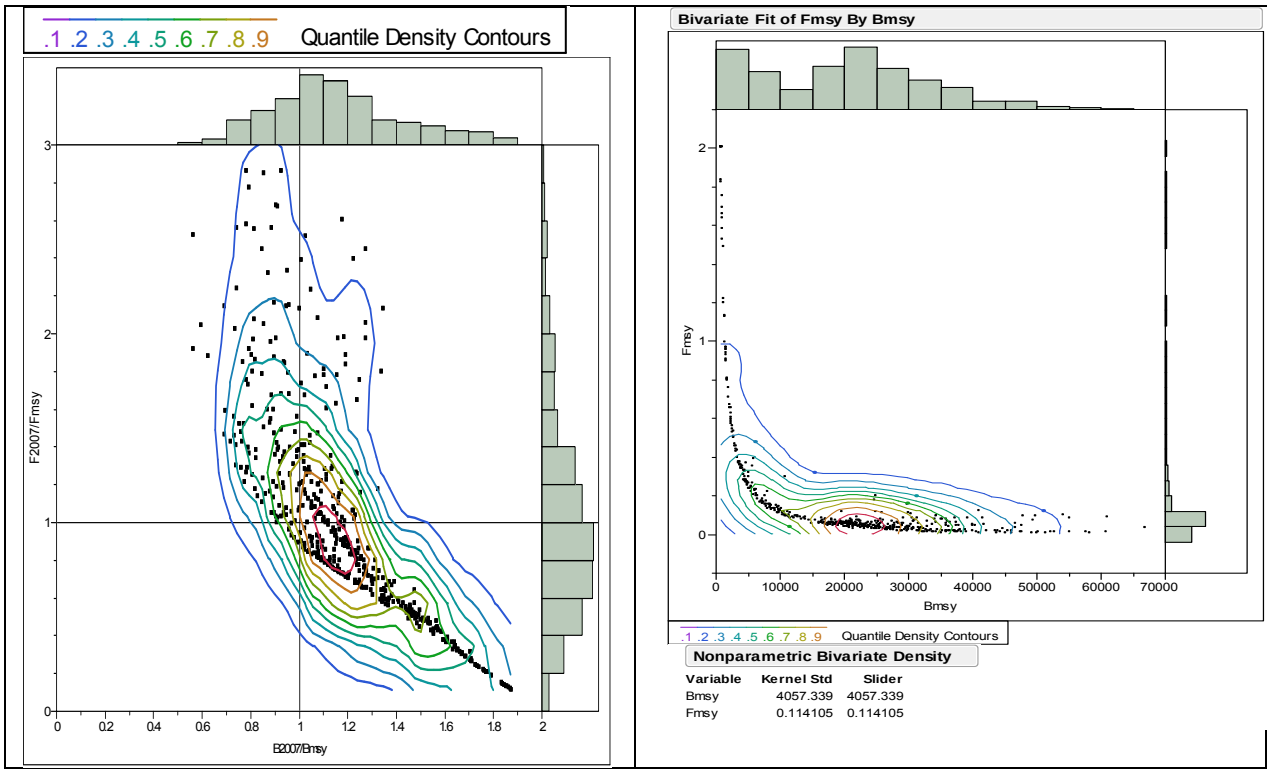

Figure 15. Results of ASPIC fit of case O9. Countours represent non-parametric density quantiles of the 500 bootstrap runs and points each of the runs. Frequency distribution histograms are also shown at the side of each variable correspondly. Left panel Fishing mortality and biomass ratios, right panel Fishing mortality and biomass at msy.

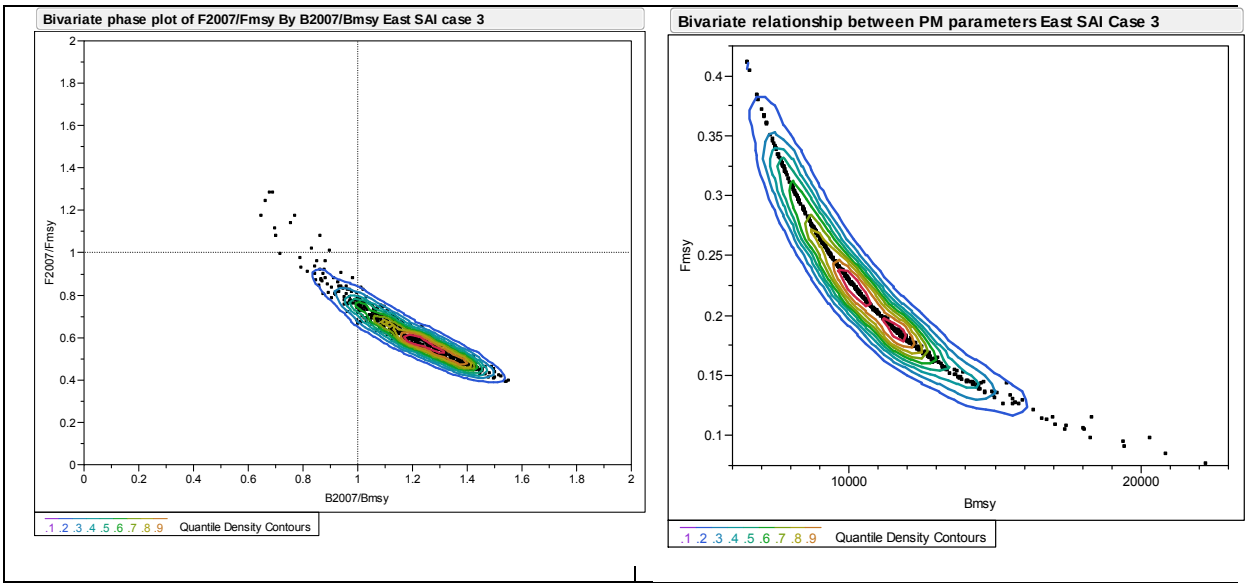

Figure 16. Results of ASPIC fit of case O7. Countours represent non-parametric density quantiles of the 500 bootstrap runs and points each of the runs. Left panel Fishing mortality and biomass ratios, right panel Fishing mortality and biomass at msy.

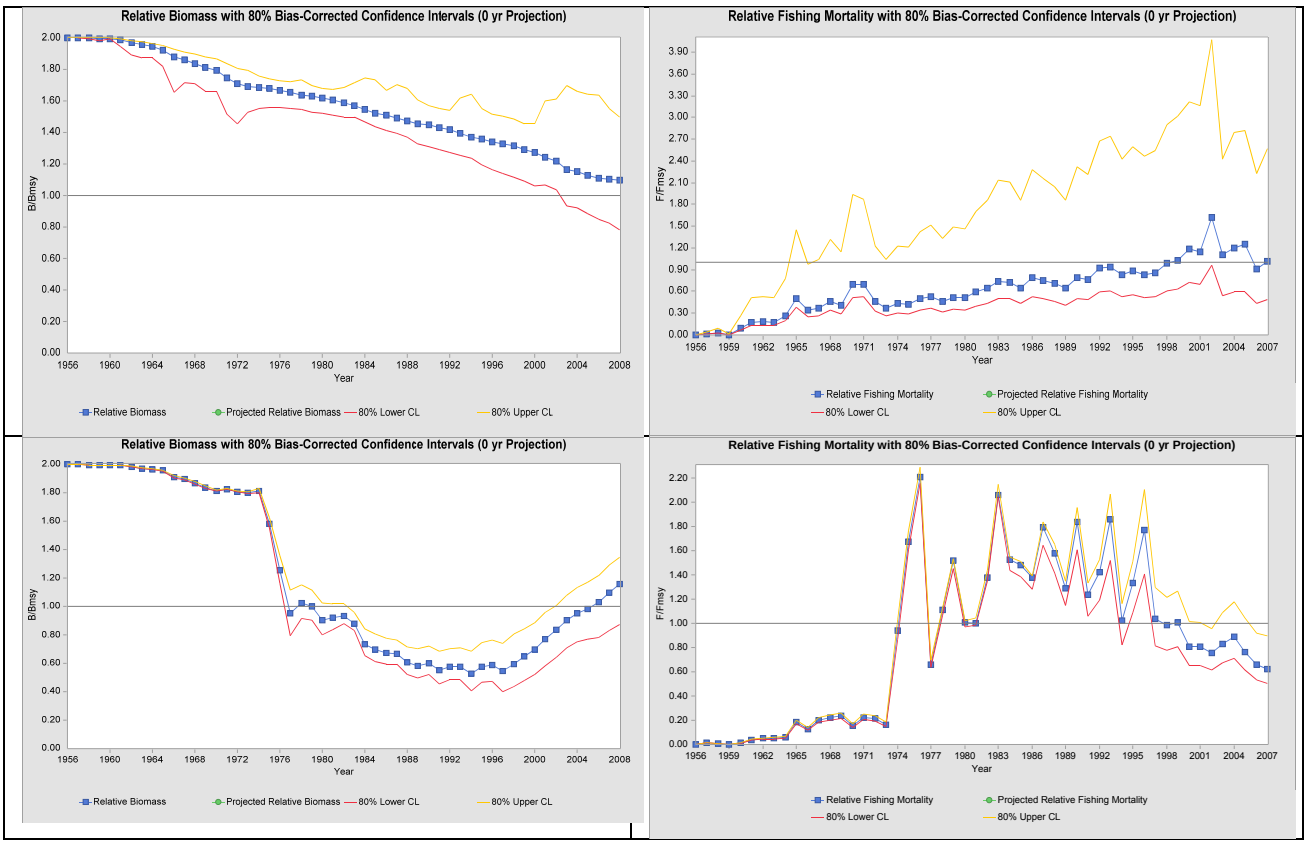

Figure 17. Results of ASPIC fits of cases O9 (upper panels) and O7 (lower panels). Trends of biomass ratios (left panels) and fishing mortality ratios (right panel) from 500 non-parametric bootstraps. Line with marker reflect the median results and single lines the estimated 80% confidence bounds.