REPORT OF THE 2014 ICCAT EAST AND WEST ATLANTIC SKIPJACK STOCK ASSESSMENT MEETING

(Dakar, Senegal - June 23 to July 1, 2014)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held in Dakar, Senegal from June 23 to July 1, 2014. The General Secretary of the Department of Fisheries and Maritime Affairs of Senegal, Mr. Oumar Ndiaye, opened the meeting and welcome participants. Dr. Pilar Pallarés, on behalf of the ICCAT Executive Secretary, thanked the Government of Senegal for hosting the meeting and providing all logistical arrangements.

Dr. Daniel Gaertner (EU-France), the Skipjack (SKJ) Species Group Rapporteur, chaired the meeting. Dr. Gaertner welcomed meeting participants ("the Group") and proceeded to review the Agenda which was adopted with some changes (**Appendix 1**).

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

P. Pallarés	Items 1 and 9
H. Murua, A. Delgado de Molina	Item 2
G. Scott, C. Palma	Item 3
A. Fonteneau, J. Pereira	Item 4
C. Brown, D. Die, H. Andrade	Item 5
J. Walter, M. Lauretta, G. Merino	Item 6
D. Gaertner	Item 7
J. Million, D. Gaertner	Item 8

2. Review of biological historical and new data for SKJ

Skipjack tuna is a gregarious species that is found in schools in the tropical and subtropical waters of the three oceans. Skipjack is the predominant species under fish aggregation devices (FADs) where it is caught in association with juvenile yellowfin tuna, bigeye tuna and with other species of epipelagic fauna. Skipjack is a species showing an early maturity (around first year of life), high fecundity and spawns opportunistically throughout the year in warm waters above 25º C (Cayré and Farrugio, 1986). Skipjack is also thought to be a faster-maturing and shorter lived species than yellowfin tuna (Maunder, 2001).

The increasing use of FADs since the early 1990s, have changed the species composition of free swimming schools. It is noted that, in effect, the free schools of mixed species were considerably more common prior to the introduction of FADs. Furthermore, the association with FADs may also affect the biology (food intake, growth rate, plumpness of the fish) and the ecology (displacement rate, movement orientation) of skipjack and yellowfin.

The table below summarized the biological parameters adopted by the SCRS and used in the 2014 Atlantic skipjack (East & West) assessments based on the information presented in the meeting about growth, mortality, and other biological parameters.

Skipjack (East & West)

Parameter	***2008 Assessment***	***2014 Assessment***
Natural mortality	Assumed to be 0.8 for all ages	L < 15 cm: 12.01*Exp ((-0.08*L)+(0.0005*L^2))+1.77 L > 15 cm: 12.01*Exp ((-0.08*L)+(0.0005*L^2)) From Table 6, Gaertner 2014 (East and West)
Assumed "birth date" of age 0 fish	February 14 (approximate mid-point of the peak spawning season)	February 14 (approximate mid-point of the peak spawning season)
Plus group	Age 5+	Age 5+
Growth rates	L (cm) = 94.9 * [1 – exp(-0.340 * t)] (West) - Pagavino and Gaertner (1995) L (cm) = 97.258 * [1 – exp(-0.251 * t)] (East) - Hallier and Gaertner (2006)	For Bayesian Production Model bootstrap from: Chu Vien Tinh, 2000; Tanabe *et al*., 2003; Chur and Zharov, 1983; Yao 1981 in Wild and Hampton, 1994; Uchiyama and Strushaker, 1981; Chi and Yang 1973 IN Wild and Hampton, 1994; Joseph and Calkins, 1969 from Table 3 in Gaertner 2014
Weights -at-age	W(kg) = 7.480 x 10^{-6} * FL $(cm)^{3.253}$ (Entire Atlantic)	W(kg) = 7.480 x 10^{-6} * FL $(cm)^{3.253}$ (Entire Atlantic)
Maturity schedule	Assumed to be knife-edge at the beginning of age 2	A 3-line model, fixed at zero for ages 0 to 6 months, linear increasing at a rate of 0.125 (1/8) from 7 to 14 months, and fixed at one for 14+ months (West & East)

2.1 Growth

Document SCRS/2014/075 reviews the skipjack growth in the East Atlantic including current knowledge, uncertainties concerning skipjack growth, and growth information gathered by tagging programs in the Atlantic and other oceans. The skipjack recoveries available in the Atlantic seems the more valuable set of data to evaluate growth, however, tagging data is limited in relation to geographical coverage, number of tags, their limited durations at liberty, and size range of tagged fish. The much faster growth of skipjack that has been observed in the temperate areas of the Atlantic (Gaertner *et al*. 2008) is tentatively explained. The paper also concludes that the von Bertalanffy model may not be convenient to describe the growth of skipjack, due to the fast growth during the pre-recruitment phase (between birth and 40 cm) and because fish over that size may show different growth rates of skipjack depending on the area (e.g. seasonally migrating to temperate and equatorial waters). The 2-stanza growth is also observed for skipjack in other oceans. The Group discussed if the changes in growth rates by area was due to different population or different growth rates (trade-off between growth and reproduction) between areas, the Group agrees that different growth rates could be the most plausible explanation. The Group noted that only 1 growth model is needed if only 1 stock is considered for the East and, for this case, the Group agrees that the growth curve should be the one presented in this paper assuming a fast growth of skipjack <40cm and an average growth for larger individuals between equatorial and temperate growth rates. If more than one area is used for the East skipjack stock, then separate growth curves for temperate and equatorial areas should be used.

A presentation on growth estimation of skipjack from ICCAT tag return information shows that, although there is valuable information for small length ranges, relatively little tag recovery information is available for larger skipjack to inform L_∞ estimates which resulted in high standard error on L_∞ and unstable solutions for L_∞ across bootstraps with some biologically implausible estimates in some iterations (**Figure 1**). The authors suggested potential solutions and future directions to improve the skipjack growth curve such as the application of alternative bootstraps with resampling of residuals (to maintain sample sizes of larger fish and longer times at liberty), use of Bayesian models with prior distributions on L_∞ and k, and to include stock and seasonal-variability estimation (Gaertner *et al*. 2008).

The Group noted that for the Bayesian surplus production models, formulation of a prior on the intrinsic rate of population growth "r" was needed, and the Group agreed that this can be obtained through life-history analysis of k and L_∞ distribution, including the uncertainty in their estimation（estimations are presented in **Appendix 4**).

2.2 Natural mortality

Document SCRS/2014/073 presents indirect estimates of Atlantic skipjack natural mortality rates based on life history parameters. In the paper, *M* is estimated for the entire population and by length size classes using 7 and 4 different estimators, respectively, and using Monte Carlo resampling to account for uncertainty in life-history parameters. After omitting the estimates of one of the entire population *M* estimator judged too low with regard to the *Z* value derived from a mean length method and according to the state of the skipjack stocks currently admitted, the 6 *M* estimators were averaged and a global *M* was estimated at 1.27 (95% C. I., 1.04 -1.52). The 4 M-at-length estimators were then combined with the global *M* to estimate a rescaled M-at-length as follows: Assuming that the global *M* describes the natural mortality for the most representative size class of skipjack in the catch, (e.g. the 40-45 cm FL class), relative M-at-length were calculated by dividing each M-at-length by the value of *M* at 40-45 cm FL. These relatives M-at-length were rescaled at the *M* entire estimate level and averaged between the 4 equations in order to provide one unique vector of natural mortality at-length (**Figure 2**). Combining *M* fixed estimator for the entire population and M-at-length allows integration of several methods and provides a vector of natural mortality at-length which depicts more accurately the decrease in mortality with body size than the simple constant value of 0.8 commonly used by ICCAT in skipjack stock assessments.

The Group noted that the value of mortality at length estimated in this paper is higher than the *M* currently assumed for ICCAT and at the same level of other tuna RFMOs. Thus, the Group agrees to use the recently estimated (SCRS/2014/073) values for the current stock assessment.

A presentation on length-based estimators of mortality rates gives an overview of recent advances in estimating mortality rates from mean length data, including the use of auxiliary information on fishing effort, catch rates, and catch. From Beverton and Holt's basic, one-sample, equilibrium estimator of total mortality rate, Gedamke and Hoenig (2006) were able to develop an estimator of period-specific total mortality rates (*Z*) that uses a time series of observations on mean length. This model does not require equilibrium conditions (constant mortality rate with time). Of particular interest is the incorporation of fishing effort data in the Gedamke-Hoenig model. For each year, total mortality rate can be parameterized as $q f + M$ where *q* is the catchability coefficient, *f* is fishing effort and *M* is the natural mortality rate. Thus, the problem of estimating year-specific mortality rates becomes one of estimating just two parameters, *q* and *M*. Interestingly, the estimates of *Z* are far more reliable than the estimates of *q* and *M*. When effort is not known, it is possible to replace it in the model with effective effort = total catch / catch per unit effort. A new model is under development in which the model based on mean length and effort is combined with a surplus production model.

The Group acknowledges the presentation and information provided but raised questions about the feasibility to apply such methodology to skipjack because direct research surveys are not available, the difficulty to split the purse seiner effort on FADs/free, and changes in mean length for short-term species as skipjack where most of the catch is based on recruitment can reflect changes in recruitment rather than changes in Z. For those methods to be applied for short term life species there should be a relationship between mean length and Z as if mean length just explained changes in recruitment (or availability) the method does not work. The Group agreed to carry out an exercise to estimate mean length for the East and West skipjack stocks using a GLM standardized mean length across the fleets. The Group noted that there are no significant changes in mean length over the time period investigated both for the East and West stock which would be considered a good stock indicator. However, it should be taken into account that small changes in mean length for skipjack can affect greatly the total mortality of the species (Gaertner 2010).

A presentation was made on recent research on empirical estimators of natural mortality rate (*M*) based on life history characters. In this presentation, estimators of natural mortality rate were compared by seeing how well they predicted independent estimates of natural mortality rate from the literature. A dataset for 215 species of fish was compiled consisting of the following for each species: an independent, direct estimate of *M*, an estimate of maximum age (t_{max}), the von Bertalanffy growth parameters (K *and* L_∞) and mean water temperature. Ten-fold cross-validation was performed to predict *M* values. Empirical methods based on t_{max} performed considerably better than the Alverson-Carney approach based on t_{max} and *K* which, in turn, performed considerably better than estimators based on *K*, or *K* and L_∞, or *K* and L_∞ and mean water temperature. The best estimator within a class (e.g. estimators based solely on t_{max}) was difficult to determine. It is recommended by Then *et al*. (in review) that an estimator based on t_{max} should be used in preference to one based on growth parameters or growth parameters and water temperature. The best estimators appear to be: $M = 4.899\ t_{max}^{-0.916}$, prediction error = 0.32 and $M = 4.118\ K^{0.73}\ L_\infty^{-0.33}$, prediction error = 0.6. Combining estimators based on t_{max} and growth parameters as a weighted mean does not appear to offer any advantage over using an estimator based on just t_{max}.

The Group posed a question of whether, when an empirical estimation of M is available, it would be better to use an empirical estimate or the regression line based on t_{max} to avoid the process/estimation error. The author of the presentation commented that the empirical value, if available, would be preferred provided that the data/methodology applied for the estimation is good. Assuming that the t_{max} of skipjack is 6 years the t_{max} estimator gives an *M* of around 0.8 which is the *M* used in previous assessment.

2.3 Ecology (i.e. FAD effect on the SKJ ecology, environment)

The Group discussed some aspects of the ecology of SKJ. A recent document (Wang *et al*., 2014) with data from the Pacific, on the influence of FAD in SKJ, was presented. This document shows that longitudinal gravitational center for skipjack catch on FADs is less affected by large ENSO events than longitudinal gravitational for free school catch; however, the authors used catch information only without fishing effort and/or fishing behavior which may be a large assumption affecting the interpretation of the results of the study.

The Group noted that many available papers investigating the same issue from a different perspective were discussed in the Ecological Trap workshop held in January 2014 in Sète (France). Therefore, the Group recommended an exhaustive literature review to be carried out for the next meeting, so that the likely effects of FADs on skipjack and yellowfin biology, ecology and movement, can be discussed.

2.4 Revision of the SKJ stocks structure (2 vs. 5 components)

Document SCRS/2014/073 presents information on the movement patterns and stock structure of skipjack in the Atlantic in order to assess how many skipjack stocks are in the Atlantic Ocean. The paper discusses skipjack movements observed in the Atlantic Ocean based on an analysis of fishery data (catches at size by time and area strata), environmental data (mainly SST) and tag recapture skipjack data since 1970. Its goal was to evaluate the validity and limits of the 2 stocks hypothesis presently used by ICCAT. When seasonal North-South movements are clear for skipjack, the range of these skipjack movements is quite limited in scale: showing an average distance of less than 500 miles between tagging and recovery positions, skipjack recoveries being very seldom observed at distances over 1500 miles (1% of recoveries). Because of these limited movements, the authors concluded that the skipjack population is quite viscous in the Atlantic and that there is a very low probability of mixing between skipjack distributed in the North and South Atlantic. The authors recommended that skipjack tagging should be done in order to improve the presently limited scientific knowledge on skipjack movements. Although the authors concluded that the current 2 independent hypothesis (East and West) is realistic for management purposes, they recommended that the stock fishery indicators, and probably future stock assessment methods, should be structures based on smaller and more homogeneous areas. As an example, 7 areas stratification is recommended for current analysis of stock indicators (**Figure 3**).

The paper also presented the geographical average distribution of skipjack catch in relation to water temperature, specifically catch distribution in warm waters over 25°C and in temperate waters at SST lower than 25°C (**Figure 41**). Time and area strata where skipjack are caught in cold waters may be predominantly skipjack feeding zones where areas of warm waters catches may correspond to the predominant spawning area of skipjack. It can be also noted that skipjack catches in cold waters <25° in the Cape Lopez area during the main fishing season (3rd quarter) are quite artificial: these catches are caught in frontal areas that cannot be identified in the 5°-quarter analysis used to build this figure. Cape Lopez skipjack fishing area could easily be classified as an area of warm waters.

The Group noted that one of the reasons for the limited movement observed in the Atlantic compared to other oceans could be (i) the few tagging experiments conducted in the West and (ii) the lower rate of long-term tag recoveries (very few in comparison to other oceans) which can affect the conclusion about the distance travelled by skipjack in the Atlantic. Based on the low exchange rates across latitude 10ºN showed by tagging data, the Group also questioned the possibility of two different management units limited at 10ºN. The reason for this is that the stock in the north would not be self-sustained as spawning is occurring in equatorial waters (south of 10ºN population). The Group acknowledge the review done and agreed to base the management advice on current adopted stock structure of 2 stocks (East and West) but also to develop fishery indicators for a smaller areas (**Figure 3**) as well as to carry out, as an exercise, stock assessment with different stock structure (Southwest Atlantic vs. equatorial East).

3. Review of direct fishery information

This section describes the current status of Task I nominal catch (T1NC) statistics, Task II catch and effort (T2CE) and Task II size information (T2SZ) available to the assessment. It also describes the revisions, corrections and preliminary 2013 estimations made to both Task I and Task II data, and ultimately adopted by the Working Group (SG) for the assessment.

The consequent adjustments to the Secretariat preliminary estimations of CATDIS (from 1950 to 2012) and CAS (from 1969 to 2013) are also documented in this section, as is a general description of the SKJ tagging information available to the assessment.

Several documents were presented to the Working Group updating information on fisheries which result in Atlantic skipjack catches. These are briefly discussed below.

SCRS/2014/034 provided data on by-catch of skipjack (*Katsuwonus pelamis*) caught by the Spanish surface fleets, troll and baitboats, targeting albacore (*Thunnus alalunga*) in the Bay of Biscay and Northeastern Atlantic fishing grounds. Monthly catch statistics and samples of fork length were collected at the main landing fishing ports along the north Spanish coast during the summer fishery seasons from 2005 to 2012. Overall less than 100 t per year were caught in this fishery between 2005 and 2010, but increased in 2011 and 2012 to 240 t and 336 t, respectively. The Working Group noted the contribution and agreed that the catch and size frequency data be incorporated into the ICCAT data base.

SCRS/2014/076 presented the available statistics for the years 2010 to 2013 for tuna vessels flying the flag of Guinea in offshore waters. Only 2012 and 2013 data are complete regarding logbooks, which include information on effort, catch and landings at canneries and at the local market in Abidjan. The statistics were based on data from logbooks, on size-sampling carried out on board after catch, using the European data validation process (AVDTH) as well as monitoring of fish landings sold on the local market (e.g. by-catch) in Abidjan. The Guinean fleet consists of 3 vessels in 2013. The fleet mostly fishes on floating objects (86% of sets on FADs on the period 2010-2013) mainly centered in the region of 2° North latitude and 2° East longitude. Tuna catches reached 11,423 and 8,515 t in 2012 and 2013 of which it was estimated that 86% was skipjack, 10% yellowfin and 4% mixtures of bigeye, albacore and other species. Relatively large amounts of this production were sold on the Ivorian market: 1,320 t, 4,015 t, 6,514 t and 4,600 t in 2010, 2011, 2012 and 2013, respectively or nearly 50% of total production. This first data processing begs a number of questions should be addressed in the future including categorization of declared free schools sets, species composition and size structures by species. The Working Group welcomed the data provided by the authors and recommended that further monitoring and analysis of the Guinean data take place and reported upon at future meetings.

SCRS/2014/078, 079, and 080 provided summaries of recent Spanish tropical purse seine, Canary Islands baitboat, and European and associated flags purse seine and baitboat catch and effort. These documents, in combination present a summarized statistical balance of the European and assimilated purse seine and baitboat fleet from 1991 to 2013 (**Figure 4**). The document presents indications on fleet characteristics (type of fishery by number category), fishing effort by type and vessel size category, number of 1º square visited by the fleet by year during the period, catches, effort and CPUE by species for purse seine and baitboat, as well as the average individual weight by species and by gear. Fishing maps are also presented indicating fleet deployment in the Atlantic, as well as the time-area distribution of European and assimilated purse seine catches in 2013 compared to the average 2008-2012 scenario. The Working Group well appreciated the work involved in compiling the documents and noted that the information contained provides a strong basis for conduct of the work of the Group.

SCRS/2014/088 provided a review of Ghanaian catch and effort and size data for the period of 2006-2012. Similar estimates for the 1973-2005 period were made in 2013. This revision has shown that skipjack tuna catches by the Ghanaian fleets were likely significantly higher, 28% higher, on average (around 12,000 t/year) for the 2006-2012 period, compared to what was previously estimated (**Figure 5**). The Working Group agreed the data in SCRS/2014/088 represented the best available information which should be incorporated into the ICCAT database. It was noted, however, that the large amount of size frequency information collected on the Ghanaian fleet for this period was not used in estimating overall size composition of the catches, a feature which the Working Group recommended be remedied in the future.

Document SCRS/2014/063 provided a summary of data collected (quantities by type of vessels and flags, species composition, size structure) since 1982 on catches landed by tuna fisheries in Abidjan and sold on the local market. Landings of *faux poisson* between 1982 and 2013 at the fishing port of Abidjan were estimated.

Accumulating more than 30,000 t, total landings dropped to 22,306 t in 2013. At 18,134 t in 2013, *faux poisson* landed by purse seiners represent 81.2% of the 2013 total amount (**Figure 6**). In recent years, skipjack tuna accounts for over 30% of landings of this "by-catch", followed by small tunas (skipjack and frigate, **Figure 7**). The Working Group noted, as previously, that the estimates of *faux poisson* attributed to the Ghanaian fleet could represent a double count of skipjack since at least some of these fish are measured when sampled in Tema. Nonetheless, the exact proportion of the catch measured in Tema is not known and the Working Group recommended incorporating the total estimates of *faux poisson* into the catch at size and catch tables used for further analysis, but without attribution to flag.

3.1 Task I (catches)

The Secretariat presented to the WG the most up-to-date T1NC data for both skipjack (SKJ) stocks, informing that, the largest portion of the 2013 data did not arrive to the Secretariat until the deadline. However, due the prompt reaction of the WG Chair/Secretariat, an urgent request for missing data was made to the ICCAT CPCs. This action allowed (with some exceptions) to incorporate all the information arriving until last week into the ICCAT-DB system and be part of the data presented. Some other T1NC series were presented on the first day of the meeting (Ghana BB and PS from 2006 to 2012; Guinea (Rep.) PS from 2010 to 2013). After some deliberation the WG decided to accept and incorporate and use all the information available until the end of the first day of the meeting. After that period virtually all (except Brazil and Venezuela on SKJ-W) of the most important fisheries were completed for 2013.

The WG revised all the T1NC catch series and did some corrections and preliminary estimations. The most important ones were:

- Morocco 2012: LL catch summed to HAND with no changes in totals
- Côte d'Ivoire GILL 2011catch: corrected with the average of 2010 and 2012
- Ghana BB and PS fully revised from 2006 to 2012 (SCRS/2014/088). 2013 catches preliminary estimated as a 3 year (2010-2012) average
- Guinea (Rep.) PS catches from 2010 to 2013 revised based on doc. SCRS/2104/076
- Belize PS catches for 2012 and 2013 corrected by the WG (based on logbook information)
- Equatorial Guinea 2010 HAND catches reclassified as PS
- Highly improbable LL reported catches of Panama (2013 with 499 t) and Suriname (2012 with 374 t) removed from Task I (0 t) until further explanation is obtained
- Carry overs for 2013 missing catches as preliminary estimations: Brazil BB/UNCL (average of 6 previous years); Venezuela BB/PS/GILL (average of 3 previous years); USA RR (average of previous 3 years)

The final T1NC are presented in **Table 1** and **Figure 8**. Preliminary 2013 estimations of the eastern stock indicate overall catches (22,739 t) similar to the ones of 2011 and 2012. The western stock catch figure of 27,100 t for 2013 is highly uncertain, mainly due to the unavailability of official data from the two most important flags (Brazil and Venezuela).

3.2 Task II (catch-effort and size samples)

Task II information is made of two distinct dataset types. One contains catch and effort information (T2CE). The other one contains size frequencies information (T2SZ). Both types can contain observed data (a large portion nowadays properly identified) and inference data (partial or total extrapolations to T1NC catch).

With the new SCRS standard catalogues recently adopted, the availability of both Task II dataset types can be compared with the respective T1NC series on a "fishery" (flag/gear/region combinations) basis, ranked by its decreasing order of importance (overall catches of the period analysed). For that purpose, the Secretariat presented an updated version of the SKJ catalogues for both stocks for the period 1980 to 2012. The SKJ-E and SKJ-W stocks are presented in **Tables 2** and **3**, respectively. The WG acknowledged the effort of the Secretariat to implement this tool. In addition, it proposed various improvements (i.e. flexibility in the ranking criteria, and studying the possibility of inclusion of data quality indicators like weighted quantitative scores, etc.) that could be included in the future.

In relation to the data itself, the known short ICCAT-DB version (in MS-ACCESS) of the databases T2CE (t2ce.mdb) and T2SZ (t2sz.mdb) were made available to the WG. In addition, some specific extractions of 2CE, mainly the 1991-2013 FAD/FSC catch and effort series of the EU tropical fleets (having 5 distinct effort types) were extracted from the databases for CPUE standardisation with GLM models.

3.3 CADIS updates

The CATDIS dataset is an estimation reflecting the T1NC catches of the nine major ICCAT species (comprises SKJ) stratified by quarter and a 5 by 5 degree square grid (hereafter 5x5 grid), covering the period 1950-2012. It uses the best Task II (mostly T2CE) information available and it is updated once every year (around March/April) for the ICCAT Statistical Bulletin (www.iccat.int/en/pubs_sbull.htm) and the use of the SCRS.

At the beginning of the meeting, the Secretariat has shown the most up-to-date (as of April 2014) CATDIS estimations available, noting that CATDIS is the best option available to try out the SKJ 5 stock hypothesis. The only drawbacks identified were:

a) The time lag of 2 month of updates when compared with the current T1NC approved by the WG (which includes the fully revised series of Ghana from 2006 to 2012)
b) It does not contain 2013

Aiming to solve item (a), the WG proposed that a straightforward adjustment be made to CATDIS applying simple year/stock ratios (T1NC/CATDIS) to the entire CATDIS series in order to synchronise both series, and this way incorporate into CATDIS the newly T1NC series adopted.

The differences by stock / year between CATDIS and T1NC, and the respective ratios used are shown in **Table 4** for SKJ-E since 1980 (the unique part with discrepancies).

The visual map shown in **Figure 9** is the result of assigning the square of the 5x5 grid system in CATDIS to stocks. And the 5 resulting catch series associated with the 5 five stocks is presented in **Table 5** and **Figures 10** to **12**.

3.4 CAS estimations

The Secretariat presented at the beginning of the meeting a preliminary version of the SKJ catch-at-size estimations (1969 to 2013, both stocks). This version, was then fully revised by the WG in order to incorporate all the changes adopted on T1NC, and also, to include new Task-II data (T2CE and T2SZ). The WG Chair urgent request for missing data made to the ICCAT CPCs, allowed to incorporate the most important size/CAS data available until 2012 (both stocks). For 2013, the Eastern stock misses the Ghanaian CAS estimations, and the Western stock misses the most important fisheries (Brazil and Venezuela).

The SKJ standard substitution rules used in CAS estimations, for both stocks, were fully revised by the WG (with some new rules added and others replaced) and are presented in **Table 6** and **Table 7**.

As a common procedure, the Secretariat divides the overall CAS estimation in two distinct processes:

a) *Update of the current CAS (1969-2006)*: created for the last SKJ assessment (Anon. 2009) these estimations are fully revised aiming to take care of large changes in T1NC (like the Ghanaian 1996-2012 tropical species correction made during the last SCRS) drop/reclassification of some T1NC series, inclusion of new T2SZ/CAS data recovered or re-estimated, etc. The last year is completely dropped by default (usually data for that year are preliminary).
b) *New CAS (2006-2013) estimations*: this process builds for the first time the entire CAS of those newly years, taking into account all the new information available on both, Task I and Task II data. It is here where, in the absence of size data of a given fishery over the time-space (combinations of fleet/gear/year/stock) dimensions, the substitution rules are applied.

The current CAS-SKJ update process (a) had some minor but important changes, like the incorporation of all the Ghanaian CAS estimations approved during the 2013 tropical meeting held in Tenerife (Anon. 2014). These changes include:

- Ghana BB (1973 to 1996 and 2005) and Ghana PS (1980-87 and 2004-05) series
- New size samples for 2004 (Cape Verde) and 2005 (Cape Verde and Senegal)
- Pertinent adjustments (re-raise) of CAS to the changes made to the T1NC series of Ghana BB and PS (tropical species tuna correction to series 1996 to 2005, made in 2013 by the SCRS)
- Revised T1NC estimations of *faux poisson* (MIX.FR+ES PS 1982-2004) now, without the Ghana *faux poisson* catch component (officially included in the Task I statistics)

The new CAS-SKJ estimation process (b), took into account all the new data arriving until the end of the second day of the meeting, in particular:

- Ghana BB and PS CAS from 2006 to 2012 (SCRS/2014/088)
- Guinea (Rep.) PS CAS for 2012 and 2013 (SCRS/2014/076)
- *Faux poisson* combined (all flags) size frequencies from 2007 to 2013 (SCRS/2014/063)
- Other size samples from missing datasets recovered during the meeting (NEI-ETRO related fleets data for 2006, Cape Verde PS 2011 and 2012

Finally, a new version of the CAS was obtained taking into account, all the changes adopted in T1NC, all the new Task II information, and, the fully revised SKJ substitution rules. The SOP (sum of products) comparison shows no differences (less than 1%) in weight between T1NC and CAS per stock. The overall CAS matrices per stock are presented in **Tables 8** (SKJ-E) and **Figure 13** for SKJ-E, and **Table 9** and **Figure 14** for SKJ-W. The mean weights (obtained from the CAS) per stock and major gear are shown in **Figure 15**.

3.5 Other information (tagging)

In relation to the SKJ conventional tagging information, the Secretariat informed that no major change exists to the dataset presented to the last SCRS. A total of about 40,500 releases made between 1960 and 2011 (95% of which between 1980 and 2002), and 6,700 recoveries (~15% ratio of recovery) obtained on its majority between 1981 and 2002. The time at liberty has almost 83% of the recoveries obtained on the first 90 days, 8% with 180 days, 3% with 270 days (98% on the first year) and only 2% on the second year. **Table 10** summarises the SKJ conventional tagging available in the ICCAT database.

The largest majority of the SKJ were tagged on the Eastern stock nearby the tropical region. The recoveries were obtained mostly on the same zone. The strait displacement between release and recovery locations is shown in **Figure 16**.

A participant presented information on a skipjack tagged in the Bay of Biscay on 15th July 2012 measuring 50 cm which was recovered in the tropical purse seiner fishery grounds on 13th October 2013 at 74 cm travelling around 1,600 nautical miles. The Group noted that, although the distance travelled was in the range of distance travelled by skipjack, this recapture is unique because it is the most northerly tagged skipjack, just in the northern limit of SKJ distribution, recaptured in the tropical waters of the Atlantic. The Group was informed that this information has already been sent to the ICCAT Secretariat.

3.6 Summary of progress in Task I and II information available for the SKJ stock assessment

The total catches obtained in 2012 in the entire Atlantic Ocean (including estimates of skipjack in the *faux poisson* landed in Côte d'Ivoire) reached an historic record of 267,000 t. Estimated catch in 2013, while still provisional, is in excess of 250,000 t and may increase as more complete reports become available, especially from the Western Atlantic (**Table 1**, **Figure 8**). Recent catches represent a considerable increase compared to the average catches of the five years prior to 2010 (163,000 t). In these catch estimates, however, it is possible that the catches of a segment of the Ghanaian fleet, sampled in Tema, are double counted in the estimates of *faux poisson* used by the Working Group.

The numerous changes that have occurred in the skipjack fishery since the early 1990s (such as the progressive use of FADs and the increase of the fishing area towards the West and North) have brought about an increase in skipjack catchability and in the biomass proportion that is exploited. At present, the major fisheries are the purse seine fisheries, particularly those of EU-Spain, Ghana, Belize, Panama, EU-France, Guinea (Rep.)., Cape Verde, Côte d'Ivoire, Guatemala and Curaçao among others, followed by the baitboat fisheries of Ghana, EU-Spain, EU-Portugal, EU-France, Senegal and others. The preliminary estimates of 2013 catches made in the East Atlantic amounted to 229.200 t, about the same level as in 2012, but which represents, a sharp increase of about 42% as compared to the average of 2007-2011 (**Figure 17**). A strong increase in the skipjack catches by European purse seiners is noted, probably due to the high selling price of this species and increases in FAD effort over recent years (**Figure 4**, **Table 1**). The proportion of the catches on floating objects continued to increase up to 2007, reaching around 90% of the catches**.** The high catches, unusual for this type of fishing off Mauritania beyond 15^{o}N latitude in 2012 and 2013 between August and November, reinforce this trend. It should be noted that the catches are made on practically single species schools (**Figure 9**).

The unreported catches of some purse seine fleets were estimated by comparing monitored landings in West African ports and cannery data to catches reported to ICCAT. The Species Group has had cooperation from many CPCs of this region and from the professional sector in estimating these catches and significant revisions have been made in recent years for the purse seiners as well as for the other fleets since 2005. Notably, species composition and catch at size of the Ghanaian baitboat and purse seine fleet, has been thoroughly reviewed. This review has resulted in new estimates of Task I and Task II catch and effort and size for these fleets for the 1973-2012 period. Similar estimates for the 2006-2012 period are expected to be available soon. This revision has shown that skipjack tuna catches by Ghanaian fleet were significantly higher, on average around 9,000 t/year for the 1996-2005 period, compared to what was previously estimated (**Figure 5**).

New estimates of *faux poisson* indicate amounts of around 10,500 t of skipjack/year between 2005 and 2013 for the overall purse seiners operating in the East Atlantic, although some of this may be included in estimates of catch reported by certain fleets (**Table 1**). The estimates are incorporated into the overall catch used for analysis, including the catch-at-size matrix.

In the West Atlantic, the major fishery is the Brazilian baitboat fishery, followed by the Venezuelan purse seine fleet. Catches in 2013 in the West Atlantic have been estimated at 27,000 t, although no fleet catches for the West were reported in time to be considered by the Working Group. A very strong increase in 2012 (29% compared to the average catches observed in the previous 5 years), largely due to the good catches reported by Brazilian baitboats (**Figure 18**) was previously noted. It remains uncertain if these good catches continued into 2013.

It is difficult to estimate effective fishing effort for skipjack tuna in the East Atlantic because this species is not always targeted and besides it is difficult to estimate fishing effort related to fishing under FADs and to quantify the assistance provided by the supply vessels. Nominal purse seine effort, expressed in terms of carrying capacity (corrected by days-at-sea), has decreased regularly since the mid-1990s up to 2006. However, due to acts of piracy in the Indian Ocean, many European Union purse seiners have transferred their effort to the East Atlantic. This situation, which added to the presence of a relatively new purse seine fleet operating from Tema (Ghana) since 2003, has considerably increased the carrying capacity of purse seine fishing in the Eastern Atlantic since that time. The number of EU purse seiners in the East Atlantic following this trend has stabilized since 2010. Baitboat nominal effort has remained stable for more than 20 years.

It is considered that the increase in fishing power linked to the introduction of innovation technologies on board the vessels as well as to the development of fishing under floating objects has resulted in an increase in the efficiency of the various fleets, since the early 1990s.

With respect to the West Atlantic, the fishing effort of the Brazilian baitboats (i.e. the major skipjack fishery in this region) seems to have been stable over the last 20 years.

4. Fishery indicators

Skipjack tuna has been considered by most tuna RFMOs as a notoriously difficult species to assess. These difficulties are mainly due to the fact that the annual recruitment is a large proportion of total biomass and that it is difficult to characterize the effect of fishing on the population with standard fisheries data and stock assessment methods. The uncertainties in the stock structure and the difficulties to estimate PS CPUE that could be considered as being proportional to SKJ biomass, are worsening these basic uncertainties.

This structural problem is mainly due to the development of fish aggregating devices (FADs) that are playing a major role in the current SKJ fisheries, when the multiple changes in these FAD fisheries remain poorly understood by scientists.

Furthermore, SKJ catches by LL fisheries are so low that they are not likely to exert much fishing mortality on SKJ nor are catch rates thought to be particularly reflective of SKJ abundance (whereas longlines are of major interest for all other tuna stocks).

Indicators based on fishery data cannot estimate well the absolute SKJ biomass or the fishing mortality suffered by the SKJ stocks. However, these fishery indicators could help:

- to understand better changes in SKJ stocks and fisheries and
- to infer the status of SKJ stocks (i.e. if they are overfished or not)

Examples of these main basic indicators that have been selected, estimated and discussed by the WG are given thereafter.

4.1 Skipjack fishery indicators

4.1.1 Yearly catches

4.1.1.1 Yearly catches by stock

Figure 8 shows yearly total catches by stock (Eastern and Western Atlantic). This indicator is a fundamental one, as its trend may be indicative of the stock status, for instance when the trend in fishing effort and when the main biological characteristics (mainly its longevity) of the studied stock are known.

It was noted that SKJ catches have been quite stable in the Western Atlantic. This lack of contrast in the yearly Western Atlantic catches constitutes a major structural difficulty in the stock assessment analysis. On the contrary, SKJ catches have steadily increased in the Eastern Atlantic since the early sixties, and especially during recent years (2010-2013).

Another indicator of the trend in SKJ total catches in the Eastern Atlantic is also shown by the Relative Rate of Catch Increase (RRCI or Grainger and Garcia index), comparing the yearly catch to the trend in catch, depicted by the average of catches observed during the previous years (**Figure 19**). This method proposed by Gaertner *et al*. 2001, allows comparison of each yearly catch to the smoothed level of 3 previous years, (a 3 years smooth is used due to short duration of SKJ exploited life).

Sustained increases of SKJ catches have been observed in the Eastern Atlantic during the last 5 years. In a period of increasing fishing pressure due to FADs and to the increasing SKJ prices, these increased catches might be indicative that the recent high SKJ catches would be sustainable, for a SKJ stock exploited during few years and then showing very little inertia in its answer to an increased effort.

In should also be noted that the total SKJ catches observed in the Western Atlantic (**Figure 8**) are due to the combination of catches taken in the South West Atlantic by the Brazilian fishery and in the Caribbean and North West Atlantic by a combination of various fisheries. These yearly catches in the Northern and Southern Western Atlantic are shown by **Figure 20**.

From this figure it can be seen that the levels and trends of SKJ catches are widely distinct in these 2 areas: Southern catches were quite stable at an average level of 22,000 t (1982-2012 period) and show peak levels during recent years, when the Caribbean-North Western SKJ fisheries, dominated by Venezuela (72 % of SKJ catches in the 1982-2012 period), showed lower average catches (7,000 t during the 1950-2012 period) and marked peaks in its catches during 2 periods (1982-1985 and 1991-1993).

4.1.1.2 Yearly SKJ catches by fishing mode (FAD and free schools)

This basic information is relevant as the FAD fisheries are catching the majority of total catches in the Eastern Atlantic (56% of total SKJ catches during the period 2009-2013).

Figure 21 shows that SKJ catches have been always dominated by FAD catches during the 1991-2013 period; this dominance of FAD catches have increased during recent years. This figure also shows that SKJ catches associated to FADs were quite stable during the 1991-2009 period (a period of declining fishing effort) but steadily increasing since 2009.

The percentages of the yearly catches caught by each PS fleet on FAD and on free schools, expressed as the % of FAD associated catches is a good indicator of the fishing pressure targeting FAD and SKJ. This indicator is shown for the French and Spanish PS active in the Eastern Atlantic by **Figure 22**.

This figure shows that while the percentages of FAD associated catches were very similar for French and Spanish PS during the 1992-2004 period (France 40%, Spain 45%), since 2005 the percentage for Spanish PS drastically increased (average 2005-2013 at 67% with a maximum of 83% in 2013). For France, the percentages of FAD associated catches decreased during the first part of the period to increase since 2008, but at a much lower level (average 2005-2013 at 32 % of FAD associated catches and around 45% in 2013).

4.1.2 Mean yearly length and/or weight

Figure 23 shows that the average weight of SKJ caught by PS declined steadily during the 1991-2010 period, although a marked increase of average weight has occurred in 2012 and 2013. It was noted that this increase in the Eastern Atlantic since 2011 was mainly due to the large catches of very large SKJ off Mauritania. It can also be noted that the SKJ caught by baitboats in the same northern area are often much bigger than SKJ caught by PS. It should also be noted (as shown by **Figure 32**) that an increased numbers of very small and very large SKJ have been caught recently.

The mean lengths of skipjack for the Eastern and Western Atlantic stocks are shown in **Figure 24**. After a short period of similar values and trends, the mean length of the Western stock increased more than 10%, establishing a difference between stocks of around 16%. This difference has been maintained over the whole period. Regarding trends, the mean length of the Eastern stock shows a slightly decreasing trend while the average length of the Western stock has remained stable over the period.

The Group also calculated the average length by area. For this purpose, based on the characteristic of the fisheries, four large areas were considered:

- Area 1: bounded by 10º N on the North and 30º W on the West and including skipjack sampling areas SJ72, SL73, SJ74, SJ77, SJ78 and SJ79
- Area 2: bounded by 10º N on the South and 30º W on the West and including skipjack sampling areas SJ71, SL75 and SJ76
- Area 3: bounded by 5º S on the South and 30º W on the East and including skipjack sampling areas SJ80, SL81, SJ82 and SJ83
- Area 4: bounded by 5º S on the North and 30º W on the East and including skipjack sampling area SJ84

Figure 25 shows average length of skipjack by area. The higher mean length corresponds to the Southwestern area (Area 4) while the smaller values correspond to the equatorial and Southeastern area (Area 1). In the last 20 years the average length has been kept stable in all the areas although very recently, Areas 1 to 3 have shown some increasing trend.

For the Eastern Atlantic large skipjack is found in areas closed to Senegal-Mauritania and Cape Lopez (**Figure 26**).

4.1.3 Yearly average SKJ catches by PS vessels (EU fleet)

A marked increase in the average yearly SKJ catches by EU purse seiner vessel over the 1980-2013 period is shown in **Figure 27**. The figure shows low yearly catches of about 750 t during the early eighties, while average yearly catches over 3,000 t have been obtained since 2011. This major increase observed in the yearly catches of purse seiners depicts the increase in targeting SKJ by the EU PS fleet (and of its concomitant increased use of FADs) but also the increased efficiency of this fleet. It should also be kept in mind that during the early 1980-1990 period, the EU PS did not use FADs and mainly targeted free schools (or setting on natural floating logs).

4.1.4 Carrying capacity of the Eastern Atlantic fleets

Nominal carrying capacity of PS and BB in the Eastern Atlantic and total number of PS active yearly in the area is shown in **Figure 28**. This figure shows the stability of the BB fleet in the Eastern Atlantic, while the carrying capacity of PS fleet and the number of purse seiners have shown a marked decline during the period1982-2006, followed by a moderate increase since 2006 (mainly due to purse seiners coming back from the Indian Ocean due to Somalian piracy).

4.1.5 Yearly catch per set (free schools and FAD sets) and yearly numbers of FAD sets in the Eastern Atlantic (EU PS fleet only)

SKJ catch per set tend to be quite stable during the studied period (**Figure 29**). SKJ catch per set are much higher in the FAD sets (most often dominated by SKJ) than in the free schools sets that are most often dominated by YFT. The average catch per set has been always larger for the Spanish fleet than for the French fleet (22.6 t/FAD set and 16.7 t/FAD set respectively).

Figure 30 shows that the yearly numbers of free schools and FAD sets were equivalent until 1996, and FAD sets have been increasingly and widely dominant during recent years.

4.1.6 Species composition of FAD sets in various areas (EU PS multispecies samples)

The species composition of FAD samples of the EU landings obtained following a multispecies sampling scheme for the 2000-2010 period shows significant differences, with SKJ widely dominating the FAD sets in the northern area (N of 10°N), while most FAD sets are multispecies in the Equatorial areas (with about 70% of SKJ, and most often a mixture of YFT and BET; **Figure 31**).

4.1.7 Yearly catch at size matrix

Figures 32 and **33** show the yearly catch at size for the Eastern and Western skipjack stocks, respectively. For the Eastern stock, the figure shows the yearly changes in SKJ CAS and the yearly relative importance of the 3 age classes (0, 1 and +2 years) and the size at first maturity as a function of the observed yearly CAS. As it was noted before, the CAS of small SKJ is probably underestimated before 2007 due to its lack of *faux poisson* CAS.

4.1.8 Yearly total catch at size taken on each stock: trend in the yearly catches by size categories, tentatively by 3 age categories (Ages 0, 1 and 2+)

The yearly catches of 3 categories of SKJ in the Eastern Atlantic, small (0-46 cm), medium (46-60 cm) and big (over 60 cm), corresponding approximately to catches of ages 0, 1 and 2+ (based on the 2014 CAS figure), are represented in **Figure 34**.

The main results are:

- Steadily increasing trend of ages 0 and 1 catches
- Nearly identical levels and trend of age 0 and 1 CAS, but dominant age 0 catches since 2007 due to the incorporation of *faux poisson* CAS since 2007 (as *faux poisson* SKJ CAS is lacking before 2007, catches of age 0 were underestimated before this date)
- Stable catches of age 2+ SKJ during the 1975-2011 period, but with a large increase in 2012 and 2013

4.1.9 Yearly size of the area fished yearly with significant catches of SKJ

The change over time of the number of 5°x5º squares fished yearly in the entire Atlantic by all fleets (CATDIS file) with a yearly SKJ catch >10t is shown in **Figure 35**. Three periods of changes in the sizes of the areas fished with SKJ catches can be identified: an early 1969-1977 period of steadily increased surface, followed by the 1978-1995 period of stable surface, which is followed by the 1995-2013 period showing a marked increase in the area fished (reaching a maximum surface in 2013).

4.1.10 Yearly SKJ catches in selected areas of higher SKJ catches

Figure 36 shows the 3 yearly "best productive" 5°x5º squares in terms of higher catches of SKJ. Quite stable levels of best yearly catches of SKJ/5° square are noted with a historical "golden" catch in 2013 (CWP 415015). This 415,015 square has been the most productive SKJ CWP during 13 of the 23 years. "Golden" 5°squares catches (average 20,000 t) are much productive than all the other squares ("silver" average=12,000 t and "bronze" squares=10,000 t).

Figure 37 also shows the 5° squares where these highest SKJ catches have been observed (1991-2013).

4.1.11 SKJ yearly landing prices

The change over the years of the average yearly price of SKJ and YFT (corrected for inflation in the US and converted to 2013 $) in the Bangkok market (**Figure 38**), shows that SKJ prices have been quite constant during the 1984-1998 period, followed by a period of very low prices in the 1999-2006 (down to a minimum close to $500/t in 2000). This period of low prices has been followed by an increase in prices, reaching a maximum over $2000/t in 2013. The consequence of the recent increase in the SKJ prices has been the increasing fishing pressure on the SKJ stock in the Atlantic. It should also be noted that SKJ and YFT prices were very similar during recent years.

4.1.12 SKJ geographical indicators

The average location of the Atlantic SKJ catches for the period 1970-2012 (CATDIS file) is presented in **Figure 39**. For the EU PS fisheries there were changes in the locations of the SKJ catches during recent years (2007-2013). A new major fishing zone off Mauritania and increased catches were observed south of 7°S (**Figure 40**).

Another geographical indicator of the SKJ fisheries is the average distribution of SKJ caught in warm waters and in temperate waters (i.e. at SST over 25°C and lower than 25°C, respectively; **Figure 41**. See document SCRS/2014/74, where this approximation has been based on quarterly and 5° average catches and SST).

Time and area strata where SKJ is caught in cold waters may be characterized as feeding zones when areas of warm water catches may correspond to the predominant spawning strata for this species. It can be noted that the SKJ catches in cold waters <25° during the main fishing season (3rd quarter) in the Cape Lopez area are quite artificial; these catches are caught in frontal areas that cannot be precisely identified in the 5° quarter analysis used to build this figure. This Cape Lopez SKJ area could easily be classified as being from warm waters.

4.1.13 Indicators of changes in fishing power of PS

It is commonly admitted that the fishing power of the PS fleet has been permanently increasing since the beginning of this fishery in 1962. Most of these changes in the fishery have been described, but their effect on the fishing efficiency remains poorly estimated by scientists. However the study by Torres-Ireneo *et al.* 2014 gives an interesting overview of the technical changes observed on French purse seiners during the 1981-2010 period. These cascading changes are one of the main causes explaining the increasing trend of the nominal SKJ CPUEs and of the steadily increasing catchability estimated by the models for most PS fleets. **Table 11** summarises these changes.

4.1.14 Yearly by catches of BET and YFT in the FAD fishery targeting SKJ

As most FAD fishing catch a mixture of SKJ and juvenile YFT and BET, it is also interesting to follow the trend in the yearly catches of YFT and BET in the FAD fishery (**Figure 42**). The yearly catches of these 2 species have been very similar during the studied period, and depict the same declining trend during recent years while an increasing trend SKJ in catches is observed. This marked divergence between recent catches of SKJ and the combined catches of young YFT and BET associated to FADs could be due to various factors: the increased SKJ catches in the northern area where BET and YFT have very seldom been caught (see **Figure 31**), as well as other causes not identified yet.

4.2 YFT and BET stocks indicators

There was no discussion during the WG on the fishery indicators concerning these 2 species. Two SCRS documents (SCRS/2014/081 and 82) were made available. They develop an analysis and a discussion of the results of GLM CPUEs of the Japanese LL fisheries. These standardized CPUEs are very important components in most stock assessments on these 2 species as these standardized CPUEs are one of the most relevant data sets to tune the stock assessment analysis. Unfortunately, these standardized CPUE cannot be calculated for SKJ because of the very low and poor catches in the Japanese LL fishery.

Considering the multispecies characteristic of the tropical PS fishery, **Figure 43** shows the overall selectivity (FAD or free school) of the three main tropical species relative to the length of first maturity. It is evidenced that skipjack is on the right of the maturity ogive, which typically implies that the stocks can be fished at higher levels without large impacts on future spawning potential. This is not the case for bigeye or yellowfin since the selectivity of FAD fishing is to the left of the maturity ogive, which implies a relatively lower level of fishing pressure can result in important impacts on future spawning potential.

5. Review of SKJ catch per unit effort series

5.1 SKJ Relative abundance indices (see Appendices 5-7 for the Construction and Evaluation of CPUE Series)

At the start of the meeting two relative abundance indices were presented for two of the major fisheries harvesting skipjack, the Brazilian baitboat and the US longline (SCRS 2014/086, SCRS 2014/091). In addition, a third fishery independent index was presented for the Gulf of Mexico part of the stock based on larval data (SCRS 2014/093). Unfortunately only the Azorean baitboat CPUE was updated before the meeting and presented for the East, forcing the Group to carry out analysis to update the major relative abundance indices at the meeting and reducing the time devoted to assessment runs.

Based on the ICCAT catch/effort Task II, SCRS 2014/086 presents an update for 1981-2011 of the Brazilian baitboat index presented in 2008. Three areas were considered with the southern and northern areas being fished only during part of the year and the central part receiving effort year round. Because data were aggregated by month and 1 degree grid and SKJ is the target of the fishery there were <1% of the data that had zero catch so such data was ignored in the analysis. Several GLM models with different structures were implemented but ultimately log CPUE model was selected as the most appropriate response variable to be used in the analysis. The only factors incorporated in the model are yearly, quarter and area because the data comes from ICCAT Task II catch and effort. Given the presence of significant interactions yearly factors were calculated by averaging the predictions over the factors area and quarter. Although there is no data available for the year 2000, this index is considered to be continuous. The Group requested some additional analysis for this data set: using generalized linear mixed models instead of exclusively fixed factors (assuming interactions as random effects); and using different weights when averaging over grid to calculate the standardized indices when using a fixed effects approach. New estimates were not that different to the ones originally provided in the paper so the Group decided to retain the original results contained in SCRS 2014/086.

SCRS 2014/091 presents a relative abundance index for 1992-2013 for the US longline fishery based on observer data. Skipjacks are only one of the many species caught in this fishery and are considered a bycatch. Longline data corresponding to sets where sharks were targeted or demersal longlines used were excluded from the analyses. Most observations are from the Gulf of Mexico and the East USA, especially in recent years. A delta model was used to account for the large presence of zero catch per set observations. Nominal positive catch rates and nominal proportion of positive sets show increasing trends. Explanatory factors considered were year, quarter, area, target species, and the number of light sticks. Models selected for proportion positive sets and catch of positives sets contained the same structure. The resulting standardized index fluctuates without a trend until the end of 1990s and then increases in the 2000s. This index is less precise than the larval index described later and that also covers the Gulf of Mexico. Regulatory changes in the US associated with circle hooks were not accounted but happened prior to the observed increase in the index by about four years. Given the change in regulations associated with the imposition of circle hooks in the longline fishery and the unknown impacts associated with skipjack catch rates, the Group decided to treat the index as two separate series, 1992-2003 and 2004-2013.

SCRS 2014/93 provides an index of spawning for the GOM for 1982-2012 on the basis of larval data and an analysis method similar to the one presented previously for bluefin tuna (Ingram *et al.* 2010). The occurrence of SKJ in larval tows of the survey was more consistent than that of Bluefin tuna larvae which tends to be caught only in a few stations but in large numbers. Relative larval abundance is estimated by correcting observed number of larvae by a mortality term so as to correct for the effect of age at larval age. This correction should not create biases but depends on the assumption that mortality does not change between years. This study could be a model for fishery independent indices for tropical tunas in areas where the stock is more abundant. It does come in at a high cost but at least for the Gulf of Mexico provides an index with interannual variability of the same magnitude than the other available fishery dependent indices for the Western skipjack stock. It was noted that a current EU funded regional project (PREFACE) plans to carry out at sea surveys that could be used as a platform to test the use of this method in the West African coast.

Standardization of Azores baitboat data for 1963-2013 was initiated prior to the meeting but the paper was not completed, the analysis and results will be presented to the species Group as an SCRS document. Skipjack catches are very variable in this fishery were bigeye tuna are also caught. The fleet has many different vessel types but the largest vessel lands the majority of the catch. The fishery is highly seasonal, mostly in the first quarter. Two different data sets were prepared one with all the data, the other for only a subset of the fleet that has fished more consistently through time. Given the numerous records with zero catch the delta method was used. Some diagnostic plots show patterns that are not desirable, unfortunately these patterns are not informative about whether the index represents only local abundance or overall stock abundance. It was discussed that this index showed high variability and the Group proposed to attempt to use SST to eliminate part of this variability. Attempts were made at the meeting to explain part of the CPUE variability by using monthly average SST from NOAA satellite data. SST was able to explain the seasonal signal in proportion positives, but not the interannual variability in CPUE, therefore the index was retained in its original form, and for the version that used the subset fleet.

The WG conducted the standardization of the catch rates of the BB fleet of the Canary Islands for the period 1980-2013 (**Appendix 5**). Details of the fishery and the origin of the information are provided in document SCRS/2014/079. The standardization method used a delta lognormal model distribution. The most significant explanatory factors for the binomial model on the proportion of positives were Year, Quarter and the interaction Year*Quarter (considered as a random interaction). As for the lognormal model, the most significant explanatory factors were Year, Quarter and Fleet, as well as the interactions Year*Quarter and Year*Fleet. The WG discussed about the potential problems regarding this CPUE index including the need of incorporating the target effect in the standardization process and the incidence of periods of cessation of SKJ fishing activity due to fall in prices. As for the implications of the effect of not incorporating target as an explanatory factor, the WG noted that this was somehow incorporated in the model through the binomial component; the distribution of the proportion of SKJ in the total catches by trip mirrored the distribution of the proportion of positives, becoming redundant.

The WG also attempted to standardize the Dakar BB fishery CPUE using basically the information available in Task II ICCAT database. Variables considered were total catch of SKJ, YFT and BET, effort, average price by Year, Quarter and Flag. A “target” variable was defined with 3 categories, depending on the weight proportion of SKJ in the catches. Because of the lack of records with zero catch of skipjack, the standardization method used a lognormal model distribution. Details of the analysis are shown in **Appendix 6**.

Standardization of the EU PS fleet (Spain and France) data for 1990-2012 fishing in the Equatorial area (between 10 N and 10 S) was accomplished at the meeting. Standardized catch rates of skipjack caught by French and Spanish purse-seines were calculated using a delta-lognormal generalized linear model. Description of the data set and the process used to split fishing effort between free and fad school is included in **Appendix 7**. The explanatory variables year, month, area, fleet (French or Spain) and especially the type of fishery (on free school or on FAD) proved to be important to explain the variability of the catch per unit effort. Sensitivity analysis showed that the closures did not strongly affect the estimations of standardized CPUEs. Price of skipjack (inflation adjusted) was tested as a factor but was not selected as significant in the final model. More details are in SCRS/2014/094. Overall variability of the standardized indice was relatively low. There was a slight decreasing trend until 1997, followed by an increase until 2005, and then a slight decrease until 2012. Three additional relative abundance indices based on CPUE were available from the last assessment but for which there has not been an update: the US rod and reel (1982-2005), the Venezuelan purse seine (1985-2005) and the EU purse seine fleet fishing on free schools off Senegal and Mauritania (1980-2006).

The Group used the CPUE evaluation guidelines provided by the Methods Working Group (Anon. 2013) to summarize the relevance and quality of the information provided by each relative abundance index available at the meeting. The Group modified the description of each specific rating so as to be most useful to relative abundance indices for tropical tunas. The methodology proposed by Walter and Cass-Calay (2012) was used to determine the bounds of plausible biological variability for each index. Relative Biomass at the beginning of each time series and r were obtained from the last skipjack assessment (ICCAT 2009). The summary ratings of the different criteria (**Table 12**) were used to inform the Group during the discussions on whether indices were sufficiently well estimated or contained informative data to be used in the assessment.

For the Western stock all indices were accepted for the assessment with the exception of the US rod and reel which was not accepted it indexes the same part of the population than the US longline index presented at the meeting. Additionally the rod and reel data is thought to be less reliable for skipjack than the longline observer data because of the difference in the quality of the observations from the observers and recreational fishers. The final indices used for the assessment of the Western stock were therefore, the Brazilian baitboat, the Venezuelan purse seine, the US longline and the Gulf of Mexico larval index (**Figure 44, Table 13**). Western indices tend to show large inter-annual variability and a slight tendency of increase since 2000.

For the Eastern stock all indices were accepted including two indices for the purse seine fishery because they cover distinct geographical areas of the fishery (**Figure 45** and **Table 14**). Three of the indices, the Canarian baitboat, Azores baitboat and EU purse seiners fishing off Senegal and Mauritania on free schools show very high variability. The Dakar baitboat and the purse seine EU fishing in the equatorial area index are considerably less variable. There is no clear tendency that can be seen from these indices except for a slight overall increase.

The Group developed options for statistical weights that could be associated with the relative abundance indices for the purposes of controlling their contribution to the model fitting. As in previous times it was decided that weighting should represent either the area covered by a fishery relative to the total area occupied by the stock and the proportion of the total catch captured by a given fishery (**Table 15**). For the Western stock indices, weights by area for the US LL, BRA BB and VEN PS were obtained from the 2011 yellowfin tuna stock assessment. For the Gulf of Mexico larval index we use the weights associated with the US longline fleet operating in the Gulf of Mexico. Weights by catch for the Gulf of Mexico larval index were based upon the catch of the Gulf of Mexico longline fleet. Weights by catch for the US longline indices were based upon the US pelagic longline catches.

For the Eastern stock indices, weights by area for the BB Canary, BB, BB Azores and BB Dakar and were obtained from the 2011 yellowfin tuna stock assessment. Weights by catch were estimated from Task I catch data as the proportion of the total catch in each area (East and West). EU Spanish ETRO baitboat catches were used for the Dakar baitboat indices and EU Spanish Canary Island baitboat catches were used for the Canary Islands baitboat indices. Azores baitboat indices were weighted using EU Portugal baitboat catches. EU purse seine indices were weighted as the sum of the EU France and EU Spain purse seine catches.

5.2 Estimates of change in catchability in the EU purse seine fishery

Difficulties in the estimation of catchability changes in tuna purse seine indices specially those associated with FAD fishing (Scott and Lopez 2014) have been subject to much recent review (Anon. 2012), however, these difficulties are yet to be surmounted. A current EU research project (CECOFAD) is endeavoring to collect new data that in the future could help the Group, but such project is still to produce estimates that are usable in the assessment process.

During the last SKJ assessment it was assumed that EU PS increased its catchability by 3% a year even though estimates of increases for more recent years suggested increases up to 5%. In order to update these estimates the Group conducted a new analysis by using CPUE observations from the EU purse seine fishery. The assumption of this analysis is that relative changes in juvenile BET could be a proxy for those experienced by SKJ catchability, because both are mainly captured together on FAD associated mixed schools. These BET are primarily zero and one year olds (**Figure 46**) and thus purse seine CPUE indices have been assigned to index these two year classes in the age-structured models used in BET assessments. During the 2010 assessments a VPA run was produced that did not make use of the PS indices (run 6). In theory this run provides estimates of numbers of age zero and one year olds that are not influenced by PS CPUE. The run however does use catch at age information from the purse seine. Estimates of numbers of zero and one year old BET from run 6 were transformed into biomass by multiplying them by the average weight at age of BET caught by the EU PS which is 2.3 kg for age zero fish and 5 kg for one year fish (BET Assessment 2010). According to these calculations the biomass of BET of age 0 and 1 decreased by about half from 1975 to 2008 (**Figure 47**). On the other hand, the CPUE of the EU PS Spain for BET (FAD and free school combined) about tripled from 1979 to 2008. Estimates of CPUE for the combined France and Spain EU PS fleet, whether combining FAD and free school catches or separating them, also show large increases in CPUE from 1991 to 2013 (**Figure 48**).

In theory the PS CPUE should be an index of the biomass of age 0 and 1 BET, but clearly the two have opposing tendencies. If we assume that the differences in these tendencies are solely the result of changes in catchability, it is possible to estimate q_{year} and therefore the average change in q for any year.

$$q_{year} = \frac{Cpue_{year}}{Biomass_{year}}$$

Estimates of catchability by year for BET were obtained for PS Spain, PS EU (FAD+Free), PS EU (FAD), PS EU (Free) (**Figure 49**) and show in all cases varying degree of increases in time. As expected, estimates of catchability of free school PS are always lower than those of FADs. For the EU PS fleet the ratio of catchability between FAD and Free schools for the period 1991-2008 does not show a significant change, although it varies substantially between years, and averages a value of 4.4 (**Figure 50**).

Given the estimates of catchability obtained for the different BET CPUE series for PS, it is possible to calculate an average annual increase in q. This was accomplished by fitting a linear regression of q as a function of year, calculating the estimate of q from the regression for the last and first year, and dividing by the number of years of the series. This was done for all the available purse seine CPUE series and for two periods for the Spanish CPUE series: prior and after 1991 (**Table 16**).

The estimates of the percent increase in q are sensitive to the inclusion of the last three years of biomass estimates (2006-2008) which should be also the years where the estimated numbers of age zero and one are most uncertain. Eliminating these estimates of q leaves a more consistent interpretation of the changes in q. Increases in q for the PS may have been about 2.5% per year in the 1980s and 1990s. From 1991 to 2005 this increase has been about 6%. Increases in free schools associated q (about 7.5%) would have been slightly higher than that of FAD (6%). The fact that the overall PS q increases corresponds to the value for FADs is the consequence that the majority of the catch of BET caught by PS is caught on FAD associated schools.

It is important to note that these increases could be considered as upper bounds of the possible increases in catchability that have occurred because they are conditioned on the assumption that the difference between estimates of biomass from the assessment models and that provided by the purse seine index are solely the result of an increase in catchability.

The Group discussed the applicability of these apparent increases in BET catchability for skipjack. For the period prior to 1991 the estimated increase in q of 2.5% estimated above is similar to the value of 3% used in previous skipjack assessments, therefore it was agreed to continue to use a 3% increase for purse seine indices of Free+FAD prior to 1991. Estimates of increases in catchability for BET for the period after 1990 are at least twice as big, 6-8% depending on the data and range of year used.

In the current assessment of skipjack two indices of purse seine CPUE are used. The equatorial purse seine index uses more detailed, set data and corrects for the effect of a mixture of free and FAD school sets. In doing so it probably accounts for part of the increase in catchability previously not accounted for by other standardizations of purse seine CPUE data. The correction is likely to be more important for the period after 1990 when the shift from free schools to FAD schools was more pronounced. The Group agreed that the new equatorial purse seine index does not require any correction. The second purse seine index, for EU PS fishing off Senegal and Mauritania on free schools, was corrected by 3% for both the period before and after 1990.

6. Stocks assessment

6.1 Stock assessment models

6.1.1 Stock assessment model overview

The start date for the models was 1950 for Eastern skipjack and 1952 for Western skipjack. It was assumed that the biomass in each of these years was very close to virgin conditions, since fishing prior to this period occurred on a relatively small scale, and development of the large-scale baitboat and purse seine fisheries occurred after 1952 and 1950. The spatial structure of the models was initially two areas, East and West for continuity with the 2008 stock assessment (**Figure 51**). Multiple alternative stock structures were evaluated by the Group but only the Southwest (primarily the Brazilian fishery) and the southeast areas were recommended for construction of indicators and assessment models.

Two alternative models were analyzed for Eastern skipjack, including a catch-only model (Martell and Froese 2012), and a Bayesian Surplus Production (BSP) model (McAllister *et al.* 2001). Four alternative stock assessment models were analyzed for Western skipjack, and included a mean length-based mortality estimator (Gedamke and Hoenig 2006), a catch-only model (Martell and Froese 2012), a BSP model, and a Stock Production Model Incorporating Covariates (ASPIC) model (http://nft.nefsc.noaa.gov/ASPIC.html). Model assumptions and parameterizations are described in detail in the following sections.

6.1.2 Alternative weighting for indices of abundance

Three weighting parameterizations for indices of abundance were considered for each of the modeling platforms described in the following section. As mentioned in chapter 5.1, weighting methods included:

1. equal index weighting
2. index weighting by area fished and
3. index weighting by catch
4. time limitations precluded any of the area or catch weighting scenarios from being evaluated

6.1.3 Modelling approaches

6.1.3.1 Catch only model (Martell and Froese 2012)

A relatively simple method was used to obtain plausible MSY estimates and other biological parameters from catch only data, based on assumptions on resilience (corresponding to the intrinsic growth rate r in the stock production model) and the plausible range of relative stock sizes at the beginning of the time series (Martell and Froese 2012). We used a medium resilience range and high resilience ranges as defined by Martell and Froese (2012), i.e. medium resilience of $0.2<r<1$, high resilience of 0.6<r<1.5 (fishbase estimate for skipjack), and an initial (in 1950) relative stock size range of 50 to 90% of carrying capacity K or pristine biomass. The identification of pairs of r-K values compatible with the catch time series and the above assumptions was performed using the R-code for batch processing made publicly available in http://www.fishbase.de/rfroese/CatchMSY_2.r. For each plausible r-K pair, an estimate is obtained as MSY=1/4 r K. This MSY estimation algorithm has been validated against analytical fish stock assessment estimates of MSY (Martell & Froese, 2010). We ran the model for four geographical areas based on the geographical coordinates agreed by the Group: East, West, Southwest and Southeast (see maps).

6.1.3.2 Mean length based total mortality estimation (Gedamke and Hoenig 2006)

The method of Gedamke and Hoenig (2006) for estimating time period-specific total mortality rates from a time series of mean length data was modified by Then (2014) to incorporate information on fishing effort. Everywhere that Z(t), the total mortality rate in year t, appears in the Gedamke-Hoenig model, it is replaced by Z(t) = q f(t) + M where q is the catchability coefficient, f(t) is the total fishing effort in year t, and M is the natural mortality rate. This reduces the problem to one of estimating just two parameters, q and M. Then (2014) assumed annual reproduction but, for the purpose of applying the model to skipjack, it was necessary to assume continuous reproduction throughout the year. This entails using a monthly, rather than an annual, time step in the calculations, and this was done for the current assessment.

For Western skipjack, we used the length frequency data available for the Brazilian baitboat fishery. This fleet accounts for the majority of the total catch from the Western Atlantic and it was assumed that the length frequencies are representative of the entire Western Atlantic fishery. We set Lc to be either 50 or 55 cm, corresponding to ages of 1.83 and 2.49 years according to the growth model of Vilela and Castello (1991). We assumed ages spanned the range from 1.83 to 6.83 for Lc = 50 and from 2.43 to 7.43 for Lc = 55. It was assumed that the age distribution arose from continuous spawning rather than annual spawning. To deal with the continuous distribution of reproduction, we performed calculations 12 times per year, assuming constant natural mortality and fishing effort over the course of a year.

The mean lengths observed in the first few years of fishing were explained by the fishing efforts in the years immediately before the recording of data began. Thus, it was necessary to make an assumption about the level of effort prior to commencement of data collection. We tried two models, assuming that the effort before data collection was zero (fishery began on a virgin stock) and that the effort prior to data collection was equal to the first observed fishing effort (fishery was at equilibrium when observations began). The results shown in the following section are based on the assumption of equilibrium fishing effort prior to the time series; however, the near virgin assumption is recommended as a sensitivity in future assessments.

Effort was expressed as number of trips (in thousands). It was obtained by taking the total catch from the Western Atlantic and dividing by the CPUE in the Brazilian baitboat fishery to obtain the effective effort expressed in Brazilian baitboat days.

6.1.3.3 Bayesian surplus production (BSP) models (McAllister *et al.* 2001)

The Bayesian surplus production (BSP) model (McAllister *et al.* 2001) is a non-equilibrium surplus production model that allows prior distributions on intrinsic rate of population increase (*r*), carrying capacity (*K*), biomass in the first modeled year defined as a ratio (*alpha.b0*) of *K*, average annual catch before data were recorded as well as variance, the shape parameter (*n*) for a Fletcher/Schaefer model and catchability parameters for each time series. The model uses a sampling importance resampling algorithm (SIR, McAllister and Kirkwood 1998) and can fit either a Schaefer or a Fletcher/Schaefer type production model.

In this application we use the logistic Schaefer formulation of the model and estimate *r* and *K* and *alpha.b0* using prior distributions. A lognormal (mean=1, sd=0.01) prior distribution for *alpha.b0* was assumed on the basis that biomass in the first year of the model year (1950 for Eastern skipjack and 1952 for Western skipjack) was at or close to carrying capacity. Prior distributions for *r* were determined on the basis of demographic modeling described in **Appendix 4**. Priors for *K* were initially estimated to be uniform on either *K* or *log(K)* with maximum bounds equal to 10 times the maximum observed catch and minimum bounds equal to the maximum observed catch, but the upper limit was subsequently decreased to ~ 5 times the maximum catch (**Table 17**). In this formulation of the BSP model we input prior distributions for the parameters *r* and *K* and assumed that *K* was equal to the biomass at the starting point for each of recorded catch for each model.

Initial model fitting and parameterization was necessarily to find suitable starting values for the input parameters *r* and *K* to get the model to estimate modal values which are either the maximum likelihood estimates for the non-Bayesian parameters or the mode of the posterior for the Bayesian parameters. This is performed during the ‘estimate mode’ component of the model fit procedure and often different starting values where necessary for different runs. Starting values for the various parameters are given in **Table 18**.

For each model run, the convergence diagnostics were examined during the ‘importance sample’ stage of modeling according to the methodology described in McAllister *et al*. (1998). Further, given the non-informative or contradictory nature of many of the input indices, examination of the diagnostics was particularly critical because of the potential bias that the importance function can impart on the posterior modes. It is recommended that the CV of the weights CV(wts) of the importance draws should be less than the CV of the likelihood times the priors CV(L*P) for the same draws. As a diagnostic of convergence for the sampling importance resampling (SIR) algorithm, then we used the ratio of the CV(wts)/CV(L*P) assumed that ratios greater than two were unacceptable and ratios between one and two were marginal.

A second state-space Bayesian surplus production (incorporating observational and process errors) was coded and fitted to the standardized CPUE of the Brazilian time series and to the catch of the Southwest Atlantic skipjack, using an MCMC algorithm in Program R. The priors for the model were based on the priors used in the 2008 skipjack stock assessment. Wide uniform priors were used for *K* characterized by a probability density function (pdf) bounded between the maximum observed catch and the maximum observed catch times a constant, A, that was assumed to be greater than six. Inverse gamma priors were used for the variances of the errors, and a lognormal prior was used for q. Parameterization of the above pdfs characterized a wide prior distribution conveying low information for the Western stock. Two prior distributions were used for r, namely a uniform prior bounded between zero and two (“non-informative”) and a normal pdf (mean = 1.2, sd = 0.27) truncated at a lower limit of zero and upper limit of two (“informative”). Fox and Schaefer models converged for all the parameters as indicated by Gelman-Rubin Potential Scale Reduction Factor (PSRF) (~1.01). Nevertheless, the data did not convey much information about *K* and *r*. Posterior distributions of *K* were wide and bounded at the upper limit of the priors, unless an extreme and biologically unrealistic prior was used. Posteriors of *r* were wide when a non-informative prior was applied. When the informative prior was used the posteriors of *r* were similar to the assumed prior, which indicated the data do not convey much information to estimate the parameters.

6.1.3.4 A Stock Production Model Incorporating Covariates (ASPIC)

A Stock Production Model Incorporating Covariates (ASPIC) is a non-equilibrium implementation of the well-known surplus production model of Schaefer (1957). The analytic engine for the ASPIC model incorporates several extensions to the classical stock-production models (Prager, 1992). ASPIC can fit data from up to 10 data series of fishery-dependent or fishery-independent indices, and uses bootstrapping to construct approximate nonparametric confidence intervals and to correct for bias. In addition, ASPIC can fit the model by varying the relative importance placed on yield versus measures of effort or indices of abundance. The model has been extensively reviewed and tested in the context of various applications to tuna stocks by Prager (1992). The model is more formally described in Prager (1994) and Quinn and Deriso (1999).

ASPIC version 5.3.4 was applied to CPUE and catch data for the Western stock of skipjack. Total catches used were those developed during the meeting and are based on the most updated version of Task 1 data provided to the Group and were assumed to be known since 1950. Relative abundance indices were all weighted equally in the fit. Alternative weighting based on catch proportions or area represented by the index were discussed during the meeting but not used because of time constraints. Estimates of initial parameters required by ASPIC were obtained from the estimated values obtained in the previous skipjack assessment but broad limits were provided for the algorithm to search so as not to unduly influence the fit with the initial parameter estimates. Uncertainty in estimates was derived by running the ASPIC bootstrap routine for 1000 iterations. The sensitivity of estimates to the initial estimates was tested by changing initial estimates for K and MSY over the range of search limits but always maintaining the same search limits for each parameter and only changing one initial estimate at a time (**Table 19**). Diagnostic plots investigated included residual plots for each index. The proportion of bootstrap runs that failed to converge is also reported as a diagnostic. Estimates provided correspond to bias corrected estimates from bootstrap and its corresponding percentiles 10%, 50% and 90%.

Five indices of abundance were used, four fishery dependent: Brazilian baitboats (1981-2011), Venezuelan purse seiners (1985-2005), US longline early (1992-2004), US longline late (2005-2012) and one fishery independent index the larval index for the Gulf of Mexico (1982-2012). US longline indices were split to account for the change in hook types and associated gear configuration imposed by management. B1950/K was assumed to be equal to 1.0 at the beginning of the time series on the basis that catches in the 1950s were much lower than later catches and the assumption that prior to 1950 a substantial fishery did not exist.

6.2 Stock assessment results

6.2.1 Catch only model results

The catch based model used provides a probabilistic estimation of the maximum sustainable yield and the intrinsic growth rate (*r*) and carrying capacity (*K*) parameters of the logistic surplus production model. **Figures 5.2** and **5.3** show the estimated MSY together with historical catches of each of the stocks considered and the probabilistic distribution of the estimated parameters MSY, *r* and *K.* In these figures, a recent significant increase in catch can be observed for the Eastern, Southeastern and Southwestern stocks. These catch are within the confidence intervals of the estimated MSY. However, in order to investigate if the recent catch increase could bias the MSY estimates, a retrospective analysis was run. We ran the model for the Eastern and Southern stocks for alternative data series starting in 1951 and ending in 1990, 2000, 2003, 2004-2012, and compared how much the estimated parameters would have changed without the latest catch data. We also run the model with a different prior for the resilience of skipjack, we tried the “high” resilience hypothesis which means that the prior intrinsic growth rate will range between 0.6 and 1.5, in contrast to the previous prior of 0.2-1.

Figure 5.4 shows that the estimates with data series ending at different years would produce variations on the MSY estimates for the Eastern stock (from ~ 100,000 t to 180,000 t, if estimated in 1990 or estimated now, respectively). In contrast, for the Western stock this variation is very small (29,000-31,000 t). This trend with the Eastern stock may mean that the Eastern stock is more productive than thought previously or that sustainable levels of catch have been exceeded. Any of these conclusions should be supported with additional studies. For the Southwestern stock too, the appreciated increase in catch could be caused by the expansion of the Brazilian fishery. This point is to be confirmed with further studies too.

The impact of the prior of the intrinsic growth rate for “medium” and “high” resilience of the stock could also modify our perception of the stock. For both assumptions, the estimated MSY is similar for all stocks, but the estimated *r-K* values are different. For the “medium” resilience hypotheses, we would be considering skipjack a larger but less productive stock than for the “high” resilience runs. Although the MSY may not change, the estimated fishing mortality that will lead to this MSY will be different, and so will be the time for the stock to recover from potential overexploitation.

6.2.2 Mean length mortality estimator results for the Western stock

Scenario 1: Lc equal to 50 cm. The resulting estimates of *M* and *q* for Western skipjack were 0.75 yr-1 and 0.0280, respectively. This implies fishing mortality ranged from 0.04 to 0.43 yr-1. The graph of predicted mean lengths versus year was quite flat (except in the first few years) suggesting that effort did not explain the variation in observed mean lengths very well or that length data were not tracking the changes in effort over time (**Figure 55**).

Scenario 2: Lc equal to 55 cm. The resulting estimate of *M* for Western skipjack was 0.72, very close to the value observed when Lc was set to 50 cm. The estimate of *q* was 0.0656, considerably higher than that estimated when Lc was set to 50 cm (Scenario 1). The corresponding estimates of *F* ranged from 0.10 – 1.01. The predicted mean lengths followed the observed mean lengths to a much greater degree for the model Scenario 2 with Lc = 55 (**Figure 56**).

The two model runs gave reasonable estimates of *M* for Western skipjack and suggested that the fishery has been either modestly or fully exploited, but is not currently overexploited; the results are not inconsistent with those obtained from ASPIC. The reasons for the difference in performance of the model when Lc is changed from 50 to 55 cm are not immediately apparent and deserve further investigation. It may be that the selectivity curve is dome-shaped or that larger animals emigrate out of the study area. These factors lead to a positive bias in the estimation of total mortality rate (see Then 2014). It might be expected that the magnitude of the bias would increase as Lc is increased because then the large fish (which disappear) become a larger fraction of the total fish considered. The method performed quite well given the simple data requirements and produced comparable results as the ASPIC model (**Figure 57**). Some recommendations for further work include additional model runs with alternative values of Lc, exploration of the sensitivity of the model to different von Bertalanffy growth curves, and changing the model assumption of equilibrium effort at the start of the effort series to match the assumption of near virgin condition, similar to ASPIC.

6.2.3 Bayesian surplus production model results

In the 2014 assessment, substantial work was conducted to update the prior distributions for the intrinsic rate of population increase, *r*, using recent estimates of growth and natural mortality. The newer estimates of growth and natural mortality (**Figures 58** and **59**) generally supported higher levels of *M* and faster growth and the resulting prior distribution for *r* (mean 1.5) reflects this as greater probability of higher values than the prior distribution used in 2008 (mean 1.5) (**Figure 60**). In addition the new prior for *r* shows a more skewed distribution and much greater uncertainty reflective of encompassing higher variability around growth and natural mortality (**Appendix 4**). Priors for *K* (carrying capacity) were retained from the 2008 assessment and were modeled as uniform priors on *log(K)* using bounds between the min and 5 times the maximum observed landings in the time period up to 2008. Note that the higher landings have been observed post-2008 but the initial settings remained the same. Subsequently model runs were conducted by doubling the upper bound on *K* for the East and the West.

For the 2014 assessment, 5 and 6 different BSP models were run for the Western and Eastern stocks, respectively, according to the current East and West stock definitions. Each model started from the 2008 best performing models and then the priors, CPUE indices and number of years of data were systematically varied to evaluate the influence of new data and new priors on the results (**Table 17**). The model runs conducted were: 1. Continuity using the 2008 models with the new prior to evaluate the effect of simply changing the prior; 2. New data to 2006, old prior to evaluate the influence of the new CPUE and landings data up to 2006 only; 3. New data, old prior to evaluate the effect of changing the prior and the new data; 4. New data, new prior; 5. New data, new prior but increasing the bounds on *K* to determine if *K* can actually be estimated and 6. Non-Bayesian estimation to determine if the model can converge on a frequent solution without the assistance of priors.

For the East and West models, five indices were used for each model (**Tables 13 and 14**). For the East these indices were 1. PS_EU_Dak_FS 3% increase in catchability (1980-2006), 2. PS_EU FS and FAD (1991-2012), 3. Azores BB (1963 -2012), 4. Canary BB (1980-2012) and 5. Dakar BB (1969-2012). For the West the indices used were West 1. Brazil BB, 2. US Pelagic Longline Observer Program pre 2005 and 3. post 2005; where the US pelagic longline index was split into the two time periods to account for a fleetwide switch to circle hooks and associated changes in gear configuration and catchability of skipjack 4. PS_VEN, and 5. Larval. In the 2008 models, 8 indices were used for the East and 4 for the West. Notably for the East, the PS_EU FS and FAD (1991-2012) index is an new standardization of combined FAD and FS purse seine data and for the West the Larval index is a new index. The parameter starting values (paramSKJ_INIT.out) often had to be slightly adjusted for each run (**Table 18**), generally to allow for a higher starting value for *r*. The technical inputs remained the same for each model run.

Model performance was evaluated primarily on two bases 1) model convergence as indicated by a very high CV of the weights of the importance draws relative to the CV of the likelihood times the priors cv(wts)/cv(lp) and 2) posterior distributions for *r* and *K*. High values for the cv(wts)/cv(lp) indicates poor model convergence due to contradictory or uninformative data and is indicative of a very narrow importance function (McAllister *et al.* 1998). The second measure of performance was whether the model estimated a posterior different from the prior and whether the bounds on the prior distribution determined the result.

Model results indicate that according to the first performance metric, most models except models East 4 (E4, hereafter) and the models with no priors (E6 and W6) had relatively good convergence by having cv(wts)/cv(lp) <2 (**Table 20**). But notably model E4 with new priors and new data showed extremely poor convergence according to this metric and only by increasing the bound on *K* could the same model actually show good convergence. For the East, Models 2 and 3 showed some divergence from the old prior for r (**Figure 61**) and models 1,4 and 5 all showed a tendency for *r* to be shifted higher than the new prior (**Figure 62**). However for *K* both the continuity and the new models all showed a tendency for *K* to be concentrated towards the upper bound. When this upper bound was doubled, the posterior for *K* shifted higher to the upper bound. This indicates that the absolute magnitude of *K*, and key population metrics such as MSY are almost entirely determined by the predetermined bound on *K* (**Table 20**).

For the West, both models with the old prior for *r* showed some slight divergence from the prior (**Figure 63**), indicative of some signal in the data. For the new *r* prior, there were some divergent responses. For the continuity data and the new prior there was evidence of bimodality (**Figure 64**) indicative of two potential model solutions. This bimodality is reflected in the posterior estimates for *K* which also show evidence of two potential solutions (**Figure 64**), reflective of either a high *K*, low *r* solution or vice-versa. For models 4 and 5 (new data, new prior) there was very little divergence from the new prior for *r* other than some tendency for greater density at high *r* values. However, similar to the East, the posterior distributions for *K* are generally concentrated at high values close to the bounds. Furthermore, when the bound on logK was doubled the posterior distribution values increase similarly indicating that the bounds on the prior distribution determined the result.

Model fits to indices for Eastern SKJ indicate almost no ability of the model to fit the indices (**Figure 65**). Fitted CPUE only shows a long steady decline with little evidence of any contrast in the population levels. This is reflected in less than a 10% decline in the population from virgin conditions (**Figure 67**) and very low F and F/F_{MSY} estimates over the 60 year modeled time period.

For the West there is some contrast in the estimated population trajectory and some fit to the indices (**Figures 66** and **68**). The larval index appears influential in fitting the pattern of estimated population decline between 1980 and1985. All other indices and index fits largely show an increasing pattern since the late 1980s which has continued in recent years.

Overall both East and West BSP models appear unable to estimate the carrying capacity of the population. The primary reason for this is that the landings are increasing substantially in recent years at the same time that the indices provided to the model are also increasing or stable. Hence there is no signal in the indices that the population may be declining due to the impact of increased landings and hence the model cannot estimate the ultimate carrying capacity of the population. This is evidenced by the fact that when the maximum bound on K is increased, the estimated benchmarks increase commensurately (**Table 20**). It should be noted that the new prior for *r* entertains higher values of *r* than in 2008 and greater variability in the estimate. This translates to higher CVs on estimates of MSY and other benchmarks (**Table 20**).

6.2.4 ASPIC results

ASPIC models of the Western stock had no problem converging to a solution. Residuals did not show strong autocorrelation and the proportion of bootstrap runs that failed to converge was low. Although some indices show negative correlation indicating conflicting signals these correlations were not overly high and the highest one was -0.4. Bootstrap estimates an MSY (median) of 31,370 t with 10 and 90 percentiles of 29,960 t and 32,630 t.

Corresponding estimates of F_{MSY} were 1.02 (0.78-1.25) of K 61,270 t (51,690-77,560). Biomass relative to B_{MSY} at the beginning of 2014 was estimated to be 1.28 (1.21-1.33) and the fishing mortality in 2013 relative to F_{MSY} to be 0.69 (0.64-0.76). The estimated trajectory of relative biomass shows a small decrease from 1950 until 1980, then a rapid decrease between 1980 until 1987 associated with the large catches in the early 1980s. This decrease led to a period of five years where the stock was overfished. Since the 1990s the relative biomass has been gradually increasing and the stock has not been overfished since 1996. Relative fishing mortality was low prior to the 1980s, it rapidly increased to overfished status in the early 1980s but then declined quickly at the beginning and more gradually in the last ten years. The stock only suffered overfishing in the mid 1980s.

Sensitivity runs testing the effect of initial estimates of K and MSY did not lead to substantially different outcomes (**Figure 69** and **Table 21**). K estimates were always between 58,000 and 61,000 t and MSY estimates between 31,300 and 31,600 t. Sensitivity runs testing the influence of individual indices show that the Gulf of Mexico larval index is the most influential of all 5 indices. When such index is eliminated the estimates of management quantities are more optimistic with MSY increasing to 41,290, the 2014 biomass ratio increasing to 1.55 and the fishing mortality ratio decreasing to 0.43. Eliminating any of the other indices does not substantially changes the result.

The data seems therefore somewhat informative and reasonably consistent with the dynamics of a biomass dynamic production model. The relative good performance of this model is due to a combination of facts: 1) there is some reasonable contrast in the time series catch with initial increases in catch followed by declines and further increases, 2) some CPUE indices, notably the larval index is consistent with the reported catch 3) the assumption that B1/K is known and equal to 1.0.

In summary, ASPIC results of annual biomass relative to B_{MSY} suggest that the stock declined rapidly through the 1980s but has been gradually rebuilding since the early 1990s. Fishing mortality relative to F_{MSY} increased through the 1980s, peaking in the mid 1980s and exceeding 1.0, but declined in the decade of the 1990s below F_{MSY}. Although F may have increased in recent years it remains below F_{MSY}.

6.2.5 Overview of stock status

Overall for the Western stock the suite of model results indicate that the stock is unlikely to be overexploited. This pattern was seen in the Catch-only models, the then Gedamke-Hoenig mean length model, ASPIC, and the BSP models. Estimates of MSY were between ~30,000 t (Catch-only models) and 31,000 t (ASPIC). For the BSP models, the magnitude MSY was largely determined by the bound on the prior for *K* with mean estimates almost doubling when the bound on the prior for *K* is doubled (**Table 19**). Hence they are unreliable measures of the maximum yield potential of the stock. Nonetheless, based on multi-model inference, it is not expected that the stock is overfished, and given the fact that the stock is likely to be well above B_{MSY}, annual yields above MSY should not necessarily result in an overfished condition unless yields above MSY persisted for several years. If current yields persist for several years with little discernable impact upon key indicators (mean lengths, CPUE indices, or landings) estimates of MSY might be higher than previously estimated.

Given the high potential that there could be separate Northwest and Southwest stocks and that only by considering the two areas together was there contrast in the indices, fishing effort, or in landings necessary to estimate stock productivity, there is still substantial uncertainty about the absolute level of productivity of the stock. The early Venezuelan purse-seine landings which appear to have declined due to reasons other than abundance of fish provide much of the contrast for the models. When these landings were removed and the Southwest only model run, the state-space Bayesian surplus production model and the Catch only model estimates were shifted largely to the bounds of the input priors indicating insufficient contrast to estimate the productivity of the stock. Hence there is considerable uncertainty in the absolute productivity of the stock, some of which is due to uncertainty regarding stock structure in the West.

For the East, the situation of increasing landings and increasing (Dakar BB and Canary BB) or stable (EU PS FS and FAD) CPUEs in recent years has created a dynamic situation that makes it very difficult for production models to reliably estimate MSY. This can be seen in the steadily increasing estimates of MSY from the Catch only models (**Figure 6.4**) with each additional year of data. For the BSP models, confounding between the increasing landings and increasing CPUE caused the model to only converge when the bounds on *K* (fixed at 5 times the maximum landings) were doubled, which had the effect of almost doubling the benchmark values. This coupled with the lack of fit of the BSP model to any of the indices (**Figure 65**) means that we have little confidence in production model results in this situation. What can reliably be said is that no indicator indicates that the stock is overfished. Hence, similar to the West, the high recent landings, even if above MSY, are unlikely to reduce the stock below B_{MSY} for several years, at which time the response of landings and CPUE indicators to several years of high landings could be re-evaluated.

In the East several different metapopulation structures were considered but the Catch-only model was evaluated only for the East and Southeast stock definitions (**Figure 51**). Model results only differed in the absolute magnitude of the landings and the resulting benchmarks (**Figure 52**) but not in historical pattern or current yield relative to MSY. This is not surprising as the Southeast and East stock definitions have largely the same trend in landings and the catch only model does not consider CPUE, which might differ for each stock. Hence with the same trend in landings but only a difference in magnitude, the status results are similar between the proposed Southeast and the current East stock definitions.

6.3 Indicators of performance of Atlantic skipjack tuna towards developing specifically built Harvest Control Rules

Fully quantitative stock assessments for skipjack tuna are difficult to conduct and therefore, alternative methods of investigating current stock status are required. In the meeting of the ICCAT Standing Working Group for Enhancing the Dialogue Between Fisheries Scientists and Managers, held in Barcelona in 2014, it was agreed to recommend considering the use of Harvest Control Rules for skipjack fisheries management and to develop the required methods for this task. As a first step towards designing applicable HCR, we explore the size based information available in ICCAT and the possible pathways to make them useful for the management of this fishery.

Size-related measures (e.g. mean length or weight; length compositions) have long been used as indicators of response to population decline (Beverton and Holt, 1957; Smith 1994). Given that catch length frequencies are among the easiest data to collect, it is valuable to know how to interpret such information in the context of providing directed fishery management advice. Here, we show preliminary estimates of the proportion of skipjack caught above their maturity size (P_{mat}), the proportion of skipjack fish that consist primarily of fish of the optimal size (P_{opt}), the size at which the highest yield from a cohort occurs; and P_{mega}, that demonstrate the conservation of large, mature individuals (Cope and Punt, 2009). This method was attempted in order to describe the fishery of skipjack against sustainability standards of conservation of mature and large fish.

These indicators can be used to monitor population status relative to exploitation (**Figure 70**). These metrics, added in a new term (P_{obj}), can be monitored to avoid growth and recruitment overfishing, and their quantitative linkage to stock status is investigated, although their capacity to estimate future sustainable catches at equilibrium is limited.

The parameters were estimated from the available catch at size ICCAT database prepared during this meeting as follows:

$$P_{Mat} = \sum_{L_{mat}}^{L_{max}} P_L \; ; \; P_{Opt} = \sum_{0.9L_{opt}}^{1.1L_{opt}} P_L \; ; \; P_{Mega} = \sum_{1.1L_{opt}}^{L_{max}} P_L \; ;$$
$$P_{Obj} = P_{Mat} + P_{Opt} + P_{Mega};$$

The estimated parameters for the Eastern skipjack fishery are assessed with the decision tree shown in the paper by Cope and Punt (2009, Figure 2). The sum of the values gives the P_{obj} value, which describes the selectivity of the fishery (noted in gray boxes). Following the tree down from that branch, the corresponding value of either P_{mat} or P_{opt} is interpreted to determine whether the stock biomass (SB) is at or above the target reference point (RP), in this case 0.4 of B_0.

As a very preliminary analysis, we plot the estimated indexes with the following parameters: L_{mat}=42cm and L_{opt}=47cm (**Figure 71**). According to the decision box, the estimated P_{obj} corresponds to a fishery of “fish maturity” ogive (1<Pobj<2), which follows Froese’s sustainability recommendations (Froese, 2004). Within the latter distinction, a P_{obj} value between 1 and 2 clearly distinguishes selectivity patterns containing some immature and suboptimally sized fish (e.g. the logistic selectivity pattern) from those for which P_{obj} is equal to 2. The used size at maturity is 42 cm (Gaertner, 2010; 2014), that is to say approximately 0.9 L_{opt}. In relation to the P_{mat}, it has been ranging slightly above 0.9 (red dashed line in **Figure 71**) since the beginning of its exploitation. Following the recommendations in the work by Cope and Punt (2009) the fishery will be nearby the reference point of 0.4 B_0. These size reference point estimates didn’t consider all fish caught, but the fish above the full recruitment size (40 cm).

The design of a Harvest Control Rule requires determining recommended catch and fishing mortality levels in order to lead the fishery to the desired reference point with high probability. The method preliminary presented provides benchmarks on the performance of the fishery but does not provide the specific actions to be taken for each situation. The extension of size based methods such as that presented here in order to develop applicable quantitative HCR is to be explored.

Although we have applied this method in a very preliminary manner, these and other approaches will be of great relevance to produce scientific advice on the appropriate course of action to maintain this fishery at sustainable levels. Other potential Harvest Control Rules to be contemplated for this fishery include the decision making process in a multispecies context, including the state of exploitation of yellowfin and bigeye tunas, which often accompany skipjack catch.

7. Recommendations

7.1 Research and statistics

With the aim of characterizing the fishing effort associated with the two main fishing modes (free school sets and FAD sets) used by the tropical purse seiners and baitboats, the Working Group recommended that the catch and number of sets (total and successful ones) by fishing mode (FAD and school sets) on a 1° square/month basis be submitted by each CPC to ICCAT.

According to Rec [2013-01], which stated that CPCs shall ensure that all purse-seiners, baitboats and supply vessels) flying their flag, when fishing in association with fish aggregating devices (FADs), shall collect and report all FAD activities in a FAD-logbook, the Working Group recommended that the information from supply be analyzed and incorporated into the standardization procedure.

Considering the volume of catch and size of tropical tunas not included in Task I and II by a number of fleets (e.g. due to landing this catch for the local African markets, as in Abidjan), the Working Group recommended that CPCs establish adequate logbook and sampling programs to ensure the total catch composition and disposition of the catch is fully quantified and reported as part of national statistic reporting obligations. The data collection of logbooks and samplings should be based on a full cooperation between the concerned CPCs and the Cote d'Ivoire scientists in charge of the *faux poisson* sampling program conducted in Abidjan.

It was noted by the participants of the meeting that fishing modes of major PS fisheries (e.g. Ghana) are classified with an unknown fishing mode in the CATDIS ICCAT file. Consequently, the WG is recommending that these unclassified catches should be assigned to FAD or free schools, based on the scientific knowledge on each fishery and periods.

In order to improve the standardization of the CPUEs of baitboats operating from Dakar, it has been suggested to include information on the vessel characteristics (size, structure, etc.) as well as the dates of the main changes in fishing practice over years (e.g. the beginning and the full use of the associated school fishing method, the implementation of the FADs, etc.). For the Canarian baitboat fishery it was suggested to investigate the years for which the fishery was stopped for commercial reasons to account for this in the standardization procedure.

Due to the uncertainty in the main biological parameters of skipjack (growth by area, natural mortality by length, etc.) and the limited information on movements and consequently on the structure of the stocks, the Working Group recommended that the working plan recommended by the feasibility study of the AOTTP (i.e. in terms of coverage of the spatio-temporal tagging experiments and range of size class at release) be fully adopted.

Taking into account the lack of updated biological data on skipjack reproduction, spawning areas and fecundity the Working Group recommended that reproductive studies on skipjack, and other tropical tunas, are carried out in the Atlantic as a matter of priority.

Owing to the multispecies nature of the tropical tuna fishery, the Working Group recommended that any exercise of skipjack HCR should take into account yellowfin and bigeye tunas in a multispecies context.

To support the SCRS recommendations for the tropical tuna fishery (SCRS Report 2013, chap. 15.2, p. 15), and bearing in mind the relevance of the information provided by the CAS to calculate several fishery indicators, length-based HCR, length-based stock assessment and to evaluate the benefits of spatio-temporal regulation measures, the Working Group recommended that the ICCAT Secretariat implements an automatic procedure to automatically elaborate yearly catch-at-size by stock and flexible spatio-temporal strata. Such a procedure should be specifically relevant for species as skipjack for which CPUEs are weakly correlated with abundance and consequently for which conventional stock assessment methods remain problematic.

7.2 Management advice

Considering that not all the assessment results were available by the end of the meeting, the Group was not able to produce management advice. Therefore, the recommendations on management will be postponed for discussion at the Tropical Species Group meeting.

8. Other matters

8.1 Presentation of the Atlantic Ocean Tropical Tuna Program (AOTTP) Feasibility Study

The report of the Feasibility Study of the AOTTP was presented to the Group. The Feasibility Study was conducted from March to May 2014. Its objective was to verify the technical feasibility of a scientific tagging program in the Atlantic Ocean, drawing on lessons from previous experiences; and to provide details of project implementation (timetable, resources, costs) according to different scenarios. The Feasibility Study reviewed the history and current status of the tuna fisheries in the Atlantic Ocean, including socio-economic aspects. It also studies different scenarios as well as tagging and recovery strategies and proposed activities to be implemented during the AOTTP. The main conclusion from the Feasibility Study is that a large-scale tuna tagging program in the Atlantic Ocean is feasible, and that it should be built on the experiences and lessons from the programs implemented in the Pacific and Indian oceans.

Two scenarios have been identified regarding the chartering of vessels, the first being that two vessels are chartered for the whole duration of the program, and the second being that different vessels are chartered in the mains areas of the Atlantic oceans. The latter was recommended on a technical basis, keeping in mind that the logistic associated with this scenario will be much more complicated than for the first one.

Although a wide range of tags should be used to achieve the expected results of the AOTTP, *i.e.* conventional, electronic tags (internal archival and pop-up tags), sonic and chemical tags; to meet the objectives primarily conventional tagging would be used. Recovery activities shall be well planned and dedicated teams shall be deployed in ports where landings of purse seine and pole-and-line vessels are important, *i.e.* Abidjan, Tema and Dakar. For other landing sites, the program will need to work with local institutions, the private sector and other stakeholders working with the vessels.

The AOTTP is also a unique opportunity to develop capacity building activities towards developing coastal countries in the region. Capacity building activities are foreseen at three levels during the programme:

- during the tagging activities by training national scientists and technicians to tagging techniques and tagging data collection
- training in recovery data collection and sampling for the recovery activities
- organisation of workshops on tagging data analysis and their interpretation as well as translation of the scientific advice into management measures

Capacity building should be completed by partnership for students of developing countries to conduct masters and PhDs using the data gathered during the AOTTP.

The Group acknowledged the results of the Feasibility Study and approved the report. Some comments were made that statistical analyses might not have been fully taken into account in the development of the tagging strategy, and that priorities shall be defined within the expected results to adapt the tagging strategy and the type of tags to be used during the AOTTP. The Group noted that the AOTTP was a unique operation, and that such an opportunity was probably not going to be repeated before a long period of time, and that therefore a maximum of objectives shall try to be achieved. In addition, the reality of the field and the logistic imposed by the chartering of vessels does not always allow to follow a pre-designed sampling strategy. The Group also noted that one of the objectives of the tagging program are neritic or small tunas and, thus, recommended that the feasibility study include detailed plans to tag neritic tunas which will be very valuable for coastal countries and for capacity building. The Group also suggested that the program could work with some manufacturers to develop some specific electronic tags, simpler and cheaper, than the ones existing today. Such tags could provide valuable fishery-independent data.

The Group noted that the EU has expressed interest in funding part of the AOTTP, and that a funding application was engaged with DG-DevCo. However, at least 20% of the action would need to be co-funded by other contracting parties, funding agency, the private sector or NGOs. This will be a necessary condition to be able to access the EU funding if approved. The Group therefore recommended developing a strategy to contact other potential donors.

Finally, the Group recommended that some steps would need to be taken at the level of the Commission before the program starts in order to ensure its smooth implementation. In particular, the following issues should be address as soon as possible:

- vessels chartered by the program should have access to territorial waters and EEZ in order to fish for bait and tuna in the context of this scientific program
- agreements will need to be drawn with purse seine fishing nations in order to access logbook data and retrieve information such as recovery date and location of the recovery. These agreements should include confidentiality rules for the use of this data
- strong collaboration will be needed from coastal countries to participate in tagging and recovery activities

The Group also noted that the report of the Feasibility Study was only available in French at the moment of the meeting and recommended that the Secretariat translate the report in English for it to be circulated widely.

8.1.1 Simulations studies

Estimating movements from conventional tagging data

SCRS-14-089 presented a Bayesian model that was developed based upon previous models by Hilborn (1990), Xiao (1996) and Aires-Da-Silva *et al.* (2009) to estimate movement parameters of tropical tunas from conventional tagging data. The model consisted of two parts, a population dynamics model to estimate the number of tagged fish at large in each year and area, and a tagging model to estimate the number of tags returned. The model allowed for two different regional configurations. A four region model of the entire Atlantic Ocean, separating the ocean into Northwest, Southwest, Northeast, and Southeast regions was used to estimate annual movements of bigeye tuna from historical ICCAT conventional tagging data. Movements were minimal between the Northeast and Southeast regions, but parameters were not well estimated for other regions due to the limited amount of data in the Western Atlantic. An eight region model, with statistical fishing areas based upon those from Fonteneau *et al.* (2000) representing the major fishing grounds in the Eastern Atlantic, would allow for estimating smaller scale movements observed in the tagging data. This eight region model will be appropriate for estimating skipjack movements from current tagging data, while the four region model will likely be appropriate for estimating yellowfin movements.

The Group noted that the information contained in the available tagging data was quite limited and was not providing a lot of information on movement of tropical tunas in the Atlantic Ocean, and that this was reinforcing the need to implement a tagging program to gather good data.

Simulation models to compare alternative study designs for tagging programmes

An update of the simulation model developed in 2013 to design tagging program was presented to the Group. An individual-based, age-structured, multi-state, capture-recapture model was constructed in R to simulate alternative study designs of an Atlantic Ocean tuna tagging program. Three processes were modelled to generate individual capture histories based on predicted probabilities of tag returns, including a tagging process, a population dynamic model to allow for natural mortality and migration of individuals amongst four geographic regions that included N. America, Europe and N. Africa, S. America, and W. Africa, and a tag recovery process from major fisheries operating in the Atlantic Ocean. The model was parameterized using fishery dynamics of one tropical tuna species, yellowfin tuna, to demonstrate utility, but the model is flexible for parameterization of any species. Three study designs were simulated to compare the predicted number of tag returns per region per 10,000 marks. The first simulation assumed conventional tagging and 5% on-board observer coverage of all fleets, the second simulation assumed conventional tagging and 50% observer coverage of select fleets, and the third simulation assumed genetic tagging and 100% genetic sampling of select fleets. The results indicated that the greatest number of tag returns was expected to occur within one year by the purse seine fisheries operating in W. Africa. Few tag returns per 10,000 marks were predicted for time periods greater than one year. The simulation demonstrated that ageing of recaptured fish was critical for the age-structured model, otherwise a more simplistic single age class model or size structured model will have to be developed. The model is very flexible and can be parameterized to include individual heterogeneity in natural mortality and migration probabilities, define seasonality and selectivity of fisheries to appropriately account for the time lag between release and recapture, and additional fleets can be included to weigh alternative tagging and resampling efforts. The simulation can be used to estimate cost to benefit ratios of alternative AOTTP study designs, and estimate trade-offs between sampling effort and parameter bias and uncertainty.

The Group noted that its recommendations from last year have been incorporated in the model, which had improved. It also noted that the model was using age, but that it could be useful to have it length-based, in particular for species where ageing from hard part such as otolith was not conclusive.

Insight from PREFACE & AWA on Tropical Atlantic Tuna ecology and effects on Western African fisheries economies

SCRS/2014/077 was presented to the Group. It introduced two projects, Preface (EU DG Env. FP7) and AWA (BMBF & IRD-MESR-MAEE) that will work to enhance prediction of the tropical Atlantic climate and its impact by working on the ecosystem. The Tropical Atlantic is a region of key uncertainty in the earth-climate system: state-of-the-art climate models exhibit large systematic error; large uncertainties exist in the relative roles of internal and external factors in shaping climate change; and it is largely unknown how marine ecosystems respond to climate variability and how climate change will impact them. As a consequence, model based prediction of Tropical Atlantic climate and its global socio-economic impacts are highly uncertain on all timescales. Through these projects, European and African expertise will combine regional and global scale modelling capabilities, field experiments and observation systems to: (i) reduce uncertainties in our knowledge of the functioning of Tropical Atlantic climate, climate predictions and on climate change projections; (ii) to improve the simulation and prediction of Tropical Atlantic climate on seasonal, and longer time scales, and contribute to better quantification of climate change impacts in the region; (iii) to improve understanding of the cumulative effects of the multiple stressors of climate variability, greenhouse induced climate change, and fisheries on marine ecosystems, functional diversity, and ecosystem services in the Tropical Atlantic; (iv) to assess the socio-economic vulnerabilities and evaluate the resilience of the welfare of West African fishing communities to climate-driven ecosystem shifts and global markets. In particular to reach some of its objectives, the projects will analyse habitat properties in the area, as it is a promising approach to track differential changes in horizontal and vertical habitat utilization. Pop-up tagging of bigeye and yellowfin tuna will provide detailed behavioural data and allow for controlled experimental design without depending on uncertain fisheries tag return rates having to be applied. The Preface and AWA project have built a consortium agreement and would like to develop collaboration with ICCAT and other partners in (i) tagging experiment (pop-up) on bigeye and yellowfin tuna, (ii) dynamics of tuna prey and habitat in the context of climate change, (iii) the development of bio-economics models on tropical tuna, (iv) the retrospective analysis of time series of tuna landing (mainly skipjack), (v) the capacity building in West Africa for students, technicians and scientists and obviously try to create synergy with current and future projects related to ICCAT communities.

The Group noted that these projects could bring some valuable information for stock assessment of species with a strong link to productivity but that the best group to work with would be the Sub-committee on Ecosystems. In addition, the Group noted that some similar initiatives are being developed in the Gulf of Mexico and that these projects could worked together. Regarding tagging activities, the projects are not exactly on the same timeline as the AOTTP, but the Group advised that contacts have been made with scientists having done popup tagging on tropical tuna as it is sometimes difficult to tag those species successfully and with good results.

8.2 Preparing the TOR to establish a statistical CAS building procedure for the tropical tuna species (YFT, BET, SKJ)

The Secretariat informed that, following the recommendation of the Tropical Species Group, a call for tenders was launched in May 2014 with the aim of developing both a statistical algorithm to automatically elaborate yearly catch-at-size by stock and flexible spatio-temporal strata and statistically rigorous methods for substituting missing Task II size data by accurate strata (fleet, fishing mode, time-area). In both cases documented codes in the form of an R package were requested.

The development of such procedure would provide a robust and consistent mechanism to estimate CAS and would allow the Secretariat to respond to the Tropical Species Group request of having updated the CAS of the three species (YFT, SKJ and BET) at any of the tropical stock assessment meetings.

Unfortunately no bids were received in response to this call.

The Group considered that this work is still important for the tropical species and decided to revisit the proposal during the Tropical Species Group meeting.

9. Adoption of the report and closure

The report was adopted by correspondence and the meeting adjourned.

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Table 1. Estimated T1NC catches (t) of skipjack tuna (*Katsuwonus pelamis*) by area, gear and flag used by the Working Group for the 2014 skipjack tuna assessment.

			1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	ATE		704	459	581	786	720	1192	1152	176	458	426	1171	2577	9272	16069	13749	22536	21042	21569	45730	27453	47778	76446	74393	75492	113794	52459	65571	107220	100910	83125	98806	109573	123081	103705	91568	78631	90227	93017	119527	92945	116373	183612	135401	168541	154429	146987	128484	113986	128958	149717	123750	134819	101397	129617	152281	140362	133942	130398	129601	152880	189450	214959	233935	229207
	ATW				1229	1281	1370	1396	1503	1955	1650	1830	3263	3295	2012	3963	5051	1545	1791	2790	2644	1858	2477	1990	2960	2899	3503	3562	3774	3356	7205	6570	12392	23092	32527	32015	35596	40272	32151	24164	23736	26382	26110	33404	30155	33221	29949	21860	27562	31712	29087	27356	29193	31451	21600	24749	27461	28517	26453	25443	22022	25774	23000	32383	32846	27086
	MED																				1			2				6		1		11				2		13	2	13						2		43	9	4	176	53	90	77	37	132	161	127	20	104	67	5	40	13	73	20
Landing	ATE	Bait boat	704	459	581	786	720	1192	1151	170	458	426	1148	2572	9264	15683	11864	19118	14862	13600	21532	13006	17683	27244	25289	25087	38953	16442	28710	42385	41365	44645	38159	38928	44488	34873	28085	29868	30009	38803	48015	41000	36922	41611	35660	31656	37817	33691	35872	37314	46784	44762	33909	56689	31076	34445	54602	48185	44370	35418	36339	33319	41105	39764	47122	36427
		Longline								3			23	4			19	22	32	14	35	9	12	39	52	32	108	116	23	93	25	7	7	49	16	417	22	6	19	6	4	9		5	3	2	10	3	7	47	85	42	48	53	56	66	47	71	201	405	172	58	42	30	33	13
		Other surf.							1	3				1	8	2	520	80		14	6	89	252	330	283	518	525	514	3777	7059	840	1508	3906	2528	3054	2240	1328	206	1638	1027	1506	1643	1357	2067	1602	1223	501	445	501	304	923	417	2423	764	681	551	1085	2334	5253	3389	3770	6527	5071	5816	6679	5035
		Purse seine														384	1346	3316	6148	7941	24157	14349	29831	48833	48770	49855	74208	35387	33061	57683	58680	36965	56734	66473	74824	65492	61795	48348	58353	50553	66875	47260	74802	131545	91016	125831	107244	105478	88949	71824	76680	98821	79373	72582	67408	88771	90392	88140	77379	82920	81054	102486	126938	155133	168919	179803
	ATW	Bait boat			1229	1281	1370	1396	1503	1955	1450	1830	3263	2995	1249	668	671	981	951	1155	1607	1255	1800	1600	1400	1921	2972	2836	2800	2400	2812	4365	9351	17999	22402	20057	16771	28490	25278	18675	21057	23292	22246	23972	20852	19697	22645	17744	23741	26797	24724	23881	25641	25142	18737	21990	24082	26028	23749	22865	20617	22770	19923	29468	30693	24359
		Longline																		3	2	1	6	19	24	65	80	98	25	8	31	6	5	29	30	184	25	24	8	6	9	25	23	33	29	20	16	34	19	12	21	58	22	60	349	95	206	207	286	52	49	20	30	41	96	
		Other surf.									200			300	300	300	400	500	800	1600	900	500	671	371	271	552	351	254	249	348	901	710	149	410	390	653	842	567	1657	518	355	600	600	872	764	710	1577	2023	452	556	516	481	467	951	398	367	404	316	372	1317	455	950	1104	1014	475	1122
		Purse seine													463	2995	3980	64	40	32	135	102			1265	361	100	374	700	600	3461	1489	2887	4654	9705	11121	17958	11191	5208	4964	2315	2466	3241	8527	8509	12794	5712	2059	3349	4347	3826	2936	3063	5297	2116	2296	2769	1967	2045	1209	901	2035	1943	1859	1582	1604
	MED																				1			2				6		1		11				2		13	2	13						2		43	9	4	176	53	90	77	37	132	161	127	20	104	67	5	40	13	73	20
Discards	ATE	Purse seine																																																														1		
	ATW	Longline																																																								0	0	0	0	0	0	0	
	MED																				1			2				6		1		11				2		13	2	13						2		43	9	4	176	53	90		37	132	62	28	20	104	67	5	40	10	71	17
Catch	ATE	Angola							150	18	58	89	529	1388	2055	2266	1507	1402	2764	1979	4165	1887	955	1996	1677	1443	3474	653	1514	4036	3501	3628	3482	2532	2257	318	46	131	56	80	30	85	69	66	41	13	7	3	15	52	2	32	14	14	14	14	10					50	636	44	91	
		Belize																																																												1373	2714	7429	15554	6173
		Benin																														8	30	60	68	38	10	20	11	5	3	7	2	2	2	2	2	2	2	7	3	2	2													
		Canada														14	414	14		644	923	146	585	1230		1189																																								
		Cape Verde																					1124	962	1477	1446	1332	1170	825	748	1284	998	2094	1588	1636	1400	1391	2030	877	2076	1456	971	806	1333	864	860	1007	1314	470	591	684	962	789	794	398	343	1097	7737	4999	5778	5038	5560	5155	7883	5535	8710
		Cayman Islands																															289	1800	30																															
		China PR																																																	4															
		Chinese Taipei																		7	5	3	7	7	20	32	33	10	10		7	6	4		2	2	7	4			1	3		5	3	2	10	3	5	47	73	39	41	24	23	26	16	10	9	14	19	6	11	15	13	13
		Congo																															1250	200		5	10	8	8	8	8	11	12	9	9	10	7	7	6																	
		Côte D'Ivoire																																																			1173	259	292	143	559	1259	1565	1817	2328	2840	2840	5968	10923	6748
		Cuba																						200	100		100	300	200	100	200	100	196	198	189	135	310	246	569	81	206	331	86			7																				
		Curaçao																																															7096	8444	8553	9932	10008	13370	5427	10092	8708		3042	1587	6436	9143	9179	11939	12779	17792
		EU.Bulgaria																																		7																														
		EU.España													1700	3500	3600	4052	3121	3790	9459	7018	7986	14569	23616	20398	35941	17727	16255	22347	25066	18748	26384	35458	38016	28933	46659	35100	41992	33076	47643	35300	47834	79908	53319	63660	50538	51594	38538	38513	36008	44520	37226	30954	25456	44837	38725	28168	22277	23679	35111	36722	41230	56901	66985	66830
		EU.Estonia																																										102																						
		EU.France												360	1700	2270	1900	3600	5500	5280	12420	6156	12052	18695	17295	11181	27066	12323	17039	31138	25903	18602	25767	26926	31132	29727	12994	13645	13045	17114	16504	15211	17099	33271	21890	33735	32779	25188	23107	17023	18382	20344	18183	16593	16615	19899	21879	14850	7034	4168	4439	7789	14741	13065	13139	16172
		EU.Germany																																															3																	
		EU.Ireland																																																							14	14	14			8	6			
		EU.Latvia																																										92																						
		EU.Lithuania																																										221																						
		EU.Portu	704	459	581	786	720	1192	1002	155	400	337	619	825	2275	3420	3145	2173	2348	2547	1138	1740	959	4200	3710	2206	1904	569	2068	4388	4584	3074	1954	2825	5530	1113	3974	2409	5446	8420	14257	7725	3987	8059	7477	5651	7528	4996	8297	4399	4544	1810	1302	2167	2958	4315	8504	4735	11158	8995	6057	1084	12974	4143	2794	3619
		Gabon																															25	10												1	11	51	26		59	76	21	101												
		Ghana																								288	701	1426	2199	3492	2866	4299	5812	7858	18272	24376	20697	19082	22268	24347	26597	22751	24251	25052	18967	20225	21258	18607	24205	26364	41840	52024	34980	55475	37570	32977	46030	54209	50111	46638	41791	56303	63325	61382	65776	63494
		Guatemala																																																								6389	4959	5546	6319	4036	2951	2829	3631	5186
		Guinea Ecuatorial																																																												1224	1224	1010		
		Guinée Rep.																																																													1500	1473	7942	5758
		Japan								3			23	4	1542	4599	3183	8142	5834	5913	13591	5611	11005	17954	13538	14524	19582	3808	15042	16845	14614	14686	12304	12935	9930	6002	1504	2098	2031	1982	3200	2243	2566	4792	2378									1				0	0	0	1	1	1	1	5	
		Korea Rep.																						30	29	922	2197	4574	1961	3603	8150	12018	6721	7565	2841	1908	699	153	5	6	3	6			0																		1			
		Maroc																3153	1475	933	850	145	1115	118	1	72	28	264	538	3850	1891	1852	5001	3017	3956	2531	885	1002	1220	1028	428	295	1197	254	559	310	248	4981	675	4509	2481	848	1198	268	280	523	807	1893	3779	1570	1291	2575	2317	2147	2265	2042
		Namibia																																													2	15	0	1	0	0	0	8								71	2	2	15	
		NEI (ETRO)																																	1560	3383	927	590	540	791	2994	2263	10869	11335	12409	20291	17418	16235	16211	6161	6748	8893	7127	8122	8550	9688	11137	2873	629							
		Nigeria																																																												45	12	4	
		Norway																																					581	738																										
		Panama																							676	159	979	1854	2467	3970	2980	1750	1735	144	2541	1611								8312	8719	13027	12978	14853	5855	1300	572	1308	1559	281	342		7126	11490	13468	18821	8253	8518	9590	12509	10927	14558
		Rumania																															8					3				59	142	349	73																					
		Russian Federation																																										1175	1110	540	1471	1450	381	1146	2086	1426	374						392	1130	313	260		20		
		S. Tomé e Príncipe																										30	35	118	100	34	33	90	78	103	18	20	20	20	195	196	204	201	178	212	190	180	187	178	169	181	179	179	179	179	117	166	143		229	235	241			
		Senegal																																								47	134	652	260	95	59	18	163	455	1963	1631	1506	1271	1053	733	1333	4874	3534	2278	3661	4573	2447	4823	4339	4183
		Sierra Leone																																																														6770		
		South Africa																							3	0	67	1		40	90	12	48	110	37	104	14	66	101	88	157	96	17	15	7	6	4	4	1	6	2	1	7	1	1	2	2	1	0	0	4	4	2	6	8	
		St. Vincent and Grenadines																																																					1				1	0						
		U.S.A.																		476	3179	4747	11752	16224	12152	21246	19973	7369	1766	5859	6797	2073	2608	2800	79																															
		U.S.S.R.																					138	161		286	407	359	3633	6674	2856	1161	2991	1750	3957	1223	1000	1404	1688	547	1822	1915	3635																							
		UK.Sta Helena																					100	100	100	100	9	22	19	12	21	76	70	112	271	103	85	62	139	139	158	397	171	24	16	65	55	115	86	294	298	13	64	205	63	63	63	63	88	110	45	15	25	371	29	
		Venezuela																																				358																														
	Faux Poisson																																	1595	699	683.65	338	203	208	2628	3127	3033	3292	8384	7120	9829	8857	7370	3155	4496	4486	5675	7996	4731	2176	5784	6155	1631	6741	8266	8266	10490	16296	14216	11182	7929
	ATW	Argentina																							100	16	28			33	4		17	1	137	243	505	101	138	90	7	111	106	272	123	50	1		1		2		1				30					3	12	0		
		Barbados																																78	72	39	48	36	33	21	3	9	11	14	5	6	6	6	5	5	10	3	3											1	2	
		Belize																																																														1		
		Brazil									200			300	300	300	400	500	700	1500	800	400	400	100					83	190	635	2065	6071	13913	18322	15945	13567	25101	23155	16286	17316	20750	20130	20548	18535	17771	20588	16560	22528	26564	23789	23188	25164	24146	18338	20416	23037	26388	23270	24191	20846	23307	20590	30563	30872	25062
		Canada																							7	13			181		86			180																							0					0	0	0	0	
		Chinese Taipei																		3	2	1	6	2	8	23	39	7	12		5	4	3	9	18	6	6	3	1	2	7	19		32	26	9	7	2	10	1	2	1		1	16	14	27	28	29	2	8	0	2	1	0	
		Colombia																																												2074	789	1583																		
		Cuba			1229	1281	1370	1396	1503	1955	1450	1830	3263	2995	1249	668	671	981	951	1155	1607	1255	1800	1600	1400	1500	1800	2300	2800	2400	1800	2000	2255	1086	1134	1700	1248	1632	1277	1101	1631	1449	1443	1596	1638	1017	1268	886	1000	1000	651	651	651			624	545	514	536							
		Curaçao																													40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	45	40	35	30	30	30	30	30													
		Dominica																																									60	38	41	24	43	33	33	33	33	85	86	45	55	51	30	20	28	32	45	25		13		
		Dominican Republic																	100	100	100	100	200	200	200	200	234	171	78	41	64	87	59	71	80	106	68	204	600	62	63	117	110	156	135	143	257	146	146																	
		EU.España																							120			103		266	2031	1052				209	2610	500						1592	1120	397		0		0		1	1							5	11		0	0	0	
		EU.France																							900	332	72	75				86																															17	10		
		EU.Netherlands																																																										4	9			23		
		EU.Portugal																																																			4	1	0	3	3	5	21	11		6	0	8		
		Grenada																													1	4	8	1	1	15	12	7	9	5	22	11	23	25	30	25	11	12	11	15	23	23	23	15	14	16	21	22	15	26	20					
		Jamaica																																															62																	
		Japan																								421	1126	438																															1	0	0	0	0	0	1	
		Korea Rep.																						17	16		42	91	13	6	24	1	1	20	7	175	17	20	6																											
		Mexico																															1	3		25	30	48	11	13	10	14	4	9	8	1	1		2	3	6	51	13	54	71	75	9	7	10	7	8	9	7	9	8	
		Panama																								42					720	161	1026																																	
		St. Vincent and Grenadines																																							17	28	29	27	20	66	56	53	37	42	57	37	68	97	357	92	251	251	355	90	83	54	46	50	0	
		Sta. Lucia																					71	71	71	76	76	81	88	100	100	41	40	37	38	35	64	53	76	60	53	38	37	51	39	53	86	72	38	100	263	153	216	151	106	132	137	159	120	89	168		153	143	109	171
		Trinidad and Tobago																																		1	2	1			1							3		0										0	0	0			0	
		U.S.A.													463	2995	3980	64	40	32	135	102			138			198	519	320	1695	1029	981	2753	33	697	853	1814	1115	734	57	73	304	858	560	367	99	82	85	84	106	152	44	70	88	79	103	30	61	66	67	119	54	87	112	75
		UK.Bermuda																																																			0	0	0	0	1	1	0	0	0	1	0	0	0	
		Venezuela																								276	87	98					1890	4900	12645	12778	16526	10712	5690	5750	4509	3723	3813	8146	7834	11172	6697	2387	3574	3834	4114	2981	2890	6870	2554	3247	3270	1093	2008	921	757	2250	2119	1473	1742	1778
	MED																				1			2				6		1		11				2		13	2	13						2		43	9	4	176	53	90	77	37	132	161	127	20	104	67	5	40	13	73	20

(yellow) Faux Poisson estimates from SCRS/2014/063. These may represent as much as 50% double counting in some years and should be used with caution

(tan) Estimates from the WG.

Table 2. SKJ-E catalogue (1980-2013) of Task-I vs. Task-II by stock, major fishery (flag/gear combinations ranked by order of importance) and year (1980 to 2013). [Task-II colour scheme, has a concatenation of characters ("a"= T2CE exists; "b"= T2SZ exists; "c"= CAS exists) that represents the Task-II data availability in the ICCAT-DB].

Status	FlagName	GearGrp	DS	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Rank	%	%cum
		T1 (total)		85042	99373	114109	98822	89748	77623	87853	91144	116878	90777	114833	181385	133740	167193	153711	146395	127861	113281	127364	148869	122182	134035	100875	129064	151916	139571	107390	110033	117676	123083	161823	185893	208006	213186			
CP	EU.España	PS	t1	24222	31307	34650	27623	44627	29421	39477	29707	44202	29462	43189	74001	46124	60443	45268	45834	33494	31438	27414	38912	33445	27798	21595	37658	31514	18718	14975	17658	27918	30041	34175	46823	48185	57594	1	27.5%	28%
CP	EU.España	PS	t2	ab	ac	ac	ab	ab	ab	ac	ac	ac	ac	ac	ac	ac	abc	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	1		
CP	Ghana	BB	t1	4720	4945	14250	20540	16181	16213	19180	22848	26009	22163	23663	24464	18379	19637	21258	18607	20115	20315	25895	31134	22919	44464	18516	18094	34151	26042	17339	11665	25511	18155	12534	9801	17145	13160	2	15.2%	43%
CP	Ghana	BB	t2	abc	abc	abc	abc	ac	ac	ac	ac	abc	abc	ac	abc	abc	abc	abc	abc	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	a	-1	2		
CP	EU.France	PS	t1	22588	24318	26754	27072	9189	10352	11151	15157	13704	11035	13644	31781	20383	31582	30233	22491	21409	13322	14203	18001	16686	14043	14298	18021	20127	13523	5770	3580	3945	7722	14576	13569	13395	16022	3	12.6%	55%
CP	EU.France	PS	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	3		
CP	Ghana	PS	t1	317	2682	3915	2807	3674	2869	1677	768									4090	6049	15945	20890	12061	11011	19054	14883	11879	28167	12897	22907	11876	17909	41279	40562	40555	40798	4	8.8%	64%
CP	Ghana	PS	t2	abc	abc	abc	abc	ac	ac	ac	ac									ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	-1	4		
CP	EU.España	BB	t1	2162	4151	3366	1255	2026	5668	2514	3369	3438	5838	4645	5907	7195	3217	5270	5760	5044	7075	8593	5607	3780	3156	3836	7174	7207	10119	7633	6378	8345	8647	8405	11674	19445	10186	5	4.7%	69%
CP	EU.España	BB	t2	abc	ab	ab	ab	ab	ab	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	abc	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	5		
CP	Panama	PS	t1												8247	8719	12939	12845	14853	5855	1300	572	1117	1374	281	342		7126	11490	13468	18821	8253	8518	9590	12509	10927	14558	6	4.1%	73%
CP	Panama	PS	t2												-1	-1	-1	-1	-1	-1	-1	-1	a	a	-1	-1		a	a	a	ac	ac	ac	ac	ac	ac	ac	6		
CP	EU.Portugal	BB	t1	1719	2696	4751	999	3879	2396	5422	8410	14232	7715	3954	7987	7412	5598	7510	4986	8276	4395	4519	1800	1285	2135	2940	4276	8459	4687	11001	8604	5734	904	12859	4078	2758	3610	7	4.1%	77%
CP	EU.Portugal	BB	t2	abc	abc	ab	ab	ab	ab	ab	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc	7		
NCO	NEI (ETRO)	PS	t1			1560	3383	927	590	540	791	2994	2263	10516	11335	12016	20012	17248	15964	16050	5658	5741	7675	5245	5679	6202	7654	9558	2772	629								8	3.9%	81%
NCO	NEI (ETRO)	PS	t2			-1	-1	-1	-1	-1	-1	-1	-1	a	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	c	a	a	a				8		
NCC	Curaçao	PS	t1																	7096	8444	8553	9932	10008	13370	5427	10092	8708		3042	1587	6436	9143	9179	11939	12779	17792	9	3.4%	84%
NCC	Curaçao	PS	t2																	-1	-1	-1	-1	-1	-1	-1	-1	-1		a	ac	ac	ac	ac	ac	ac	ac	9		
NCO	Mixed flags (FR+ES)	PS	t1		1595	699	684	338	203	208	2628	3127	3033	3292	8384	7120	9829	8857	7370	3155	4496	4486	5675	7996	4731	2176	5784	6155										10	2.3%	87%
NCO	Mixed flags (FR+ES)	PS	t2		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			b	b	b	b	b	b	b	10		
CP	EU.France	BB	t1	3179	2608	4378	2655	3805	3293	1894	1957	2800	4176	3455	1490	1507	2153	2546	2697	1698	3701	4179	2343	1497	2550	2305	1878	1752	2240	1610	795	778	1186	904	932	1382	613	11	1.7%	88%
CP	EU.France	BB	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	11		
CP	Cape Verde	PS	t1																	8	18	21	1		300	366	54	1040	7659	4976	5597	4876	5163	5098	7866	5450	8710	12	1.3%	90%
CP	Cape Verde	PS	t2														a			a	a	a	a		a	a	a	ab	ab	ab	abc	abc	abc	abc	ac	ac	ac	12		
CP	Senegal	BB	t1												309		42	59	18	163	455	1679	1479	1506	1271	1053	733	1323	4874	3534	2278	3661	4513	2411	4765	4277	4014	13	1.0%	91%
CP	Senegal	BB	t2												-1		-1	a	a	ac	-1	-1	-1	-1	a	-1	-1	-1	ac	ac	ac	ac	abc	ac	ac	ac	ac	13		
CP	Guatemala	PS	t1																										6389	4959	5546	6319	4036	2951	2829	3631	5186	14	0.9%	92%
CP	Guatemala	PS	t2																										a	a	ac	ac	ac	ac	ac	ac	ac	14		
CP	Maroc	PS	t1	5001	3017	3956	2348	862	1002	1220	928			1154	204	277	297	172	4878	553	4449	1861	715	180	99	125	409	440	888	288	130	107	653	890	1060	1075	1120	15	0.9%	92%
CP	Maroc	PS	t2	b	-1	-1	-1	-1	-1	-1	-1			-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	15		
CP	Japan	BB	t1	12304	12935	8520	4562	402																														16	0.9%	93%
CP	Japan	BB	t2	a	ab	a	a	a																														16		
CP	Belize	PS	t1																														1373	2714	7429	12816	7653	17	0.7%	94%
CP	Belize	PS	t2																														ac	a	a	a	-1	17		
CP	Côte D'Ivoire	GN	t1																					1173	259	292	143	559	1259	1565	1817	2328	2840	2840	3883	4926	3886	18	0.6%	95%
CP	Côte D'Ivoire	GN	t2																					-1	-1	-1	-1	-1	-1	-1	a	-1	-1	-1	a	a	-1	18		
CP	Japan	PS	t1			1410	1440	1102	2098	2031	1982	3200	2243	2566	4792	2378																						19	0.6%	95%
CP	Japan	PS	t2			a	a	a	ab	ab	ab	ab	ab	ab	ab	b																						19		
CP	Cape Verde	BB	t1	2094	1581	1584	1338	1049	1961	860	2052	1350	934	767	1309	727	625	804	1215	313	517	609	945	770	444		178	57	57		168	143	143			72		20	0.6%	96%
CP	Cape Verde	BB	t2	-1	ab	ab	ab	b	a	-1	-1	-1	-1	-1	-1	-1	a	a	a	abc	-1	ab	a	ab	b		ab	a	ab		a	a	a			a		20		
CP	Guinée Rep.	PS	t1																																5087	8001	7363	21	0.5%	96%
CP	Guinée Rep.	PS	t2																																a	-1	-1	21		
CP	Korea Rep.	BB	t1	6718	7538	2827	1553	687	153																													22	0.4%	97%
CP	Korea Rep.	BB	t2	ab	ab	ab	ab	ab	-1																													22		
NCO	NEI (ETRO)	BB	t1											353		393	278	169	271	161	503	1008	1217	1883	2443	2349	2034	1579	101									23	0.3%	97%
NCO	NEI (ETRO)	BB	t2											a	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac	ac		c							23		
CP	U.S.S.R.	PS	t1	18		1489	563	1000	1404	1679	547	1822	1915	3635																								24	0.3%	97%
CP	U.S.S.R.	PS	t2	-1		a	a	a	a	a	a	a	a	a																								24		
CP	Russian Federation	PS	t1												1175	1110	540	1471	1450	381	1146	2086	1426	374						392	1130	313	260					25	0.3%	98%
CP	Russian Federation	PS	t2												-1	b	-1	b	b	-1	b	b	-1	-1						-1	abc	-1	a					25		
CP	Maroc	HL	t1																									283	585	3313	1373	1132	1877	1420	1087	1190	922	26	0.3%	98%
CP	Maroc	HL	t2																									-1	-1	-1	-1	-1	-1	-1	-1	abc	bc	26		

Table 3. SKJ-W catalogue (1980-2013) of Task-I vs Task-II by stock, major fishery (flag/gear combinations ranked by order of importance) and year (1980 to 2013). [Task-II colour scheme, has a concatenation of characters ("a"= T2CE exists; "b"= T2SZ exists; "c"= CAS exists) that represents the Task-II data availability in the ICCAT-DB].

		T1 (total)		14340	24781	34406	33693	37465	42108	34069	26102	25674	28300	28029	35284	32060	35151	31899	23741	29453	33658	30857	29220	30918	32631	23443	26625	29316	30424	28341	27345	23911	27715	24951	33920	34505	30558				
																																							953194		
Status	FlagName	GearGrp	DS	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Rank	Σ(1995-12)	%	%cum
CP	Brazil	BB	t1	6070	13913	18156	15643	13086	25052	22542	16153	17227	20550	20026	20424	18273	17557	20372	16530	22517	25573	23567	22948	24691	24038	18185	20416	23036	25269	23012	22750	20547	22329	19747	29322	30569	26546	1	706635	74.13%	74%
CP	Brazil	BB	t2	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	-1	a	a	ab	ab	ab	ab	ab	ab	ab	a	a	a	-1	1			
CP	Venezuela	PS	t1	1890	1900	9533	10023	14089	8906	4231	4329	2310	2430	3014	6186	6893	10049	5692	2059	3348	3604	3607	2696	2590	5189	2000	2296	2769	848	1806	806	688	1808	1931	1308	1573	1604	2	134006	14.06%	88%
CP	Venezuela	PS	t2	-1	-1	a	ab	a	ab	ab	ab	ab	ab	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	-1	2			
CP	Venezuela	BB	t1		3000	3112	2714	2437	1806	1459	1421	2199	1293	777	1952	941	1123	1005	328	224	224	506	282	299	1104	552	950	501	245	201	115	69	441	177	146	124	149	3	31877	3.34%	92%
CP	Venezuela	BB	t2		-1	a	ab	a	a	ab	ab	ab	ab	a	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	-1	3			
NCO	Cuba	BB	t1	2255	1086	1134	1700	1248	1632	1277	1101	1631	1449	1443	1596	1638	1017	1268	886	1000	1000	651	651	651			624	545	514	536								4	28532	2.99%	95%
NCO	Cuba	BB	t2	b	b	bc	bc	bc	-1	bc	-1	b	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		b	-1	-1	-1	-1								4			
CP	U.S.A	PS	t1	980	2573	6	588	817	1785	977	635	5	36	227	749	496	274	20		1																		5	10169	1.07%	96%
CP	U.S.A	PS	t2	-1	ab	-1	-1	ab	ab	ab	ab	-1	-1	ab	ab	a	-1	-1		-1																		5			
CP	EU.España	PS	t1				209	2610	500						1592	1120	397																					6	6428	0.67%	96%
CP	EU.España	PS	t2				-1	-1	-1						-1	ac	-1			ac	ac	a	ac		a	ac			ac			ac	ac	ac	ac	ac	ac	6			
CP	Brazil	PS	t1			166	301	442													743	219	240	473	108	116			1119	239	403	213	223		552	9		7	5566	0.58%	97%
CP	Brazil	PS	t2			-1	ab	ab													-1	-1	a	-1	-1	-1			a	a	a	a	a	a	-1	-1		7			
CP	Brazil	UN	t1																			3								17	1033	85	748	843	311	6		8	3046	0.32%	97%
CP	Brazil	UN	t2																			-1								b	-1	-1	-1	-1	-1	-1		8			
NCO	Dominican Republic	SU	t1	59	71	80	106	68	204	600	62	63	117	110	156	135	143	257	146	146																		9	2523	0.26%	97%
NCO	Dominican Republic	SU	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1																		9			
NCO	Colombia	UN	t1															789	1583																			10	2372	0.25%	98%
NCO	Colombia	UN	t2															-1	-1																			10			
CP	Brazil	SU	t1					39	16	607	130	89	200	104	124	260	205	210			248																	11	2232	0.23%	98%
CP	Brazil	SU	t2					b	-1	b	-1	-1	-1	-1	-1	-1	-1	-1			-1																	11			
CP	U.S.A	RR	t1		180	22	108	36	28	136	94	45	19	66	86	49	81	66	21	82	64	86	99	30	49	70	61	74	15	49	52	49	102	45	77	104	75	12	2218	0.23%	98%
CP	U.S.A	RR	t2		-1	-1	a	a	ab	a	ab	a	a	ab	ab	ab	ab	ab	ab	b	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	ab	abc	ab	b	b	-1	12			
NCO	Colombia	PS	t1														2074																					13	2074	0.22%	98%
NCO	Colombia	PS	t2														-1																					13			
NCO	Argentina	UN	t1			137	243	505	101	138	90	7	111	106	272	123	50	1		1																		14	1885	0.20%	99%
NCO	Argentina	UN	t2			-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		-1																		14			
NCO	Sta. Lucia	TR	t1																								132	137	159	120	89	168		153	143	109	171	15	1380	0.14%	99%
NCO	Sta. Lucia	TR	t2																								-1	-1	-1	-1	-1	-1		-1	-1	-1	-1	15			
NCO	Sta. Lucia	UN	t1	40	37	38	35	64	53	76	60	53	38	37	51	39	53	86	72	38	100	100	153			106												16	1329	0.14%	99%
NCO	Sta. Lucia	UN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			-1												16			
CP	Panama	BB	t1	1026																																		17	1026	0.11%	99%
CP	Panama	BB	t2	-1																																		17			
NCC	Curaçao	UN	t1	40	40	40	40	40	40	40	40	40	40	40	40	40	45	40	35	30	30	30	30	30														18	790	0.08%	99%
NCC	Curaçao	UN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1														18			
CP	St. Vincent and Grenadines	TR	t1																							58	90	85	85	147	88	83	52	44	50			19	783	0.08%	99%
CP	St. Vincent and Grenadines	TR	t2																							-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			19			
CP	St. Vincent and Grenadines	LL	t1																							206	2	166	166	208	2		2	2		0		20	753	0.08%	99%
CP	St. Vincent and Grenadines	LL	t2																							a	a	a	-1	a	a		a	a		-1		20			
CP	St. Vincent and Grenadines	UN	t1									17	28	29	27	20	66	56	53	37	42	57	37	68	97	93												21	727	0.08%	99%
CP	St. Vincent and Grenadines	UN	t2									-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1												21			
NCO	Dominica	UN	t1											60	38	41	24	43	33	33	33	33	85	86	45	55	51			0	0	0	0		0			22	661	0.07%	99%
NCO	Dominica	UN	t2											-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			a	a	a	a		a			22			
NCO	Dominica	UN	t2											-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			a	a	a	a		a			22			

Table 4. Differences between CATDIS (reflecting T1NC as of April/2014) and T1NC adopted by the WG (only shows SKJ-E stock from 1980 onwards, once nothing else has changed).

	Yield(t)				**Ratios (t1/cd)**	
	CATDIS (cd)		**T1NC (t1)**			
Year	**SKJ-E**	**SKJ-W**	**SKJ-E**	**SKJ-W**	**SKJ-E**	**SKJ-W**
1980	98806	12392	98806	12392	1	1
1981	109573	23092	109573	23092	1	1
1982	124087	32527	123081	32527	0.99189	1
1983	105442	32015	103705	32015	0.98353	1
1984	91780	35596	91569	35596	0.9977	1
1985	78785	40272	78631	40272	0.99804	1
1986	90711	32151	90227	32151	0.99466	1
1987	95052	24164	93017	24164	0.97859	1
1988	121060	23736	119527	23736	0.98734	1
1989	94037	26382	92945	26382	0.98839	1
1990	118361	26110	116373	26110	0.98321	1
1991	186330	33404	183613	33404	0.98542	1
1992	140554	30155	135401	30155	0.96334	1
1993	172462	33221	168542	33221	0.97727	1
1994	155065	29949	154429	29949	0.9959	1
1995	145479	21860	146987	21860	1.01037	1
1996	131160	27563	128484	27562	0.9796	0.99996
1997	114395	31712	113986	31712	0.99643	1
1998	130093	29087	128958	29087	0.99127	1
1999	150887	27356	149717	27356	0.99225	1
2000	125215	29193	123750	29193	0.9883	1
2001	137190	31486	134819	31451	0.98272	0.99889
2002	102216	21600	101397	21600	0.99199	1
2003	128792	24749	129616	24749	1.0064	1
2004	151388	27462	152281	27461	1.0059	0.99999
2005	143367	28517	140362	28517	0.97904	1
2006	112569	26453	127986	26453	1.13695	1
2007	113332	25443	122704	25443	1.0827	1
2008	120053	22022	122777	22022	1.02269	1
2009	123715	27151	145504	25774	1.17612	0.94929
2010	164882	24422	175291	23000	1.06313	0.94178
2011	191724	33434	204066	32383	1.06437	0.96856
2012	215732	33368	225382	32846	1.04473	0.98437

Table 5. Overall SKJ catch series of the 5 stock hypothesis, and relative importance (%) within each year.

	Yield(t)						%				
Year	SKJ-NE	SKJ-CE	SKJ-SE	SKJ-SW	SKJ-NW	TOTAL	SKJ-NE	SKJ-CE	SKJ-SE	SKJ-SW	SKJ-NW
1950	704					704	100	0	0	0	0
1951	459					459	100	0	0	0	0
1952	581				1229	1810	32	0	0	0	68
1953	786				1281	2067	38	0	0	0	62
1954	720				1370	2090	34	0	0	0	66
1955	1192				1396	2588	46	0	0	0	54
1956	1002		150		1503	2655	38	0	6	0	57
1957	155	2	19		1955	2131	7	0	1	0	92
1958	400		58	200	1450	2108	19	0	3	9	69
1959	337		89		1830	2256	15	0	4	0	81
1960	619	15	537		3263	4434	14	0	12	0	74
1961	1006	177	1395	300	2995	5872	17	3	24	5	51
1962	4828	2358	2086	300	1712	11284	43	21	18	3	15
1963	7993	5756	2320	300	3663	20032	40	29	12	1	18
1964	7513	4274	1955	407	4651	18800	40	23	10	2	25
1965	10857	10193	1482	503	1045	24081	45	42	6	2	4
1966	8858	9318	2865	701	1091	22833	39	41	13	3	5
1967	9266	9588	2715	1500	1290	24359	38	39	11	6	5
1968	15729	24510	5492	800	1844	48375	33	51	11	2	4
1969	10859	14427	2168	400	1457	29311	37	49	7	1	5
1970	15060	30608	2110	403	2074	50255	30	61	4	1	4
1971	25737	38039	12671	100	1890	78438	33	48	16	0	2
1972	33145	36761	5387	107	1954	77354	43	48	7	0	3
1973	27311	24812	23701	35	2533	78391	35	32	30	0	3
1974	19317	48047	46502	59	3372	117297	16	41	40	0	3
1975	23227	26854	2459	5	3482	56027	41	48	4	0	6
1976	28045	35702	1824	92	3682	69345	40	51	3	0	5
1977	42523	60610	4088	223	3133	110577	38	55	4	0	3
1978	30838	66379	4666	650	5581	108115	29	61	4	1	5
1979	23029	56171	4317	2074	4115	89706	26	63	5	2	5
1980	24897	69877	4030	6094	6302	111198	22	63	4	5	6
1981	29922	71941	7725	13915	9162	132666	23	54	6	10	7
1982	39362	74357	9367	18477	14045	155608	25	48	6	12	9
1983	13778	88150	2111	16200	15481	135722	10	65	2	12	11
1984	21548	71618	1126	14102	18771	127165	17	56	1	11	15
1985	20679	54110	4354	25224	14549	118916	17	46	4	21	12
1986	29991	59930	310	23294	8855	122380	25	49	0	19	7
1987	30200	62458	372	16376	7787	117194	26	53	0	14	7
1988	37442	81725	360	17331	6406	143263	26	57	0	12	4
1989	24265	68106	571	20883	5502	119328	20	57	0	18	5
1990	26264	89851	258	20236	5874	142484	18	63	0	14	4
1991	44672	140428	100	20857	10960	217017	21	65	0	10	5
1992	26374	110083	64	18683	10350	165555	16	66	0	11	6
1993	42289	126568	84	17830	14994	201765	21	63	0	9	7

1994	40227	114131	72	20592	9357	184378	22	62	0	11	5
1995	41065	105825	141	16562	5298	168890	24	63	0	10	3
1996	23377	105014	101	22537	5025	156055	15	67	0	14	3
1997	40340	73280	372	25821	5889	145702	28	50	0	18	4
1998	49152	79673	308	23583	5505	158221	31	50	0	15	3
1999	46037	103367	363	22952	4407	177126	26	58	0	13	2
2000	24223	99493	123	24695	4500	153033	16	65	0	16	3
2001	34889	99741	261	24018	7439	166347	21	60	0	14	4
2002	16305	85009	123	18229	3368	123034	13	69	0	15	3
2003	29094	96694	3956	20423	4330	154497	19	63	3	13	3
2004	37107	115175	168	23071	4382	179904	21	64	0	13	2
2005	32035	108350	97	26414	2110	169006	19	64	0	16	1
2006	34551	93271	187	23328	3121	154458	22	60	0	15	2
2007	27478	94736	578	24228	1233	148251	19	64	0	16	1
2008	22782	98107	1950	20879	1148	144866	16	68	1	14	1
2009	27014	115176	4145	22131	2818	171284	16	67	2	13	2
2010	34122	137944	4220	19404	2641	198331	17	70	2	10	1
2011	28393	164536	11666	29609	2258	236461	12	70	5	13	1
2012	64194	155409	6022	30362	2314	258300	25	60	2	12	1

Table 6. SKJ-E substitution rules adopted.

		BB					HL		LL	PS							RR	SU	TP
t1GearG	**t1FlagN**	**EU.Spain**	**EU.France**	**EU.Portugal**	**Ghana**	**Senegal**	**Cape Verde**	**Morocco**	**Chinese Taipei**	**Belize**	**Cape Verde**	**EU.Spain**	**EU.France**	**Ghana**	**Mixed flags (FR+ES)**	**NEI (ETRO)**	**UK.St. Helena**	**EU.Spain**	**EU.Portugal**
BB	Cape Verde					5													
	EU.Spain	2																	
	EU.Portugal			4															
	Ghana				1														
	Namibia											1							
	South Africa											4							
GN	Angola	2																	
	Côte D'Ivoire	8																	
	EU.France																	3	
	Morocco	5																	
	Senegal					3													
HL	Angola					4													
	Cape Verde						7												
	EU.Portugal			2															
	Equatorial Guinea					2													
	Morocco	4						2											
	S. Tomé e Príncipe					3													
	Senegal					5													
	South Africa											1							
LL	EU.Spain								1										
	EU.Portugal								10										
	Japan								5										
	Namibia								3										
	St. Vincent and Grenadines								1										
PS	Angola											4							
	Belize									2		4							
	Cape Verde										8					2			
	Côte D'Ivoire												6						
	Curaçao															1			
	EU.Spain														2				
	EU.France														2				
	EU.Portugal			5															
	Ghana													2					
	Guatemala															1			
	Guinea Ecuatorial											1							
	Guinea (Rep.)												2						
	Korea (Rep.)											1							
	Morocco												7			1			
	NEI (ETRO)															2			

	Panama									1			
	Russian Federation								2	1			
	S. Tomé e Príncipe								3	1			
	Sierra Leone								1				
RR	South Africa							1					
	UK.St. Helena		3								1		
SU	EU.Spain											3	
	EU.Portugal			5									
TN	EU.France											1	
TP	Angola				4								
	EU.France											1	
	EU.Portugal			1									
	Morocco												1
TR	Senegal				4								
TW	Angola				4								
	EU.France											3	
	EU.Ireland			3									
	Russian Federation	1											
UN	EU.France											1	
	EU.Portugal			1									
	Nigeria				3								
	Nigeria				3								

Table 7. SKJ-E substitution rules adopted.

		BB		LL			PS	RR	UN
t1GearG	**t1FlagN**	**Brazil**	**Venezuela**	**Brazil**	**Chinese Taipei**	**Mexico**	**Venezuela**	**U.S.A.**	**Brazil**
BB	Brazil	16							
	Cuba		1						
	Venezuela		1						
GN	Brazil	2							
	U.S.A.							2	
	Venezuela		5						
HL	Barbados						2		
	Brazil	6							
	Dominica		5						
	U.S.A.							7	
LL	Belize			1					
	Brazil			8	2				
	Chinese Taipei				3				
	EU.Spain				1	1			
	EU.France			1	2				
	EU.Portugal			1	2	1			
	Grenada				2	1			
	Japan				2				
	Mexico				4			2	
	St. Vincent and Grenadines				3	1			
	U.S.A.							3	
PS	Argentina	2							
	Brazil						9		
	Venezuela						1		
RR	U.S.A.							1	
	UK.Bermuda							1	
TR	Dominica						5		
	St. Vincent and Grenadines						6		
	Sta. Lucia						7		
TW	EU.Netherlands						3		
	U.S.A.							1	
UN	Brazil	7							5
	U.S.A.							5	

Table 8. SKJ-E overall CAS matrix (number of fish) by year and 2 cm fork length (FL) size classes.

Li (2cm)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
-20	215	0	1379	0	0	0	0	65862	0	0	0	0	36	16	15	8	5	5	59	70	68	74	187
22	0	651	5974	0	0	0	0	1606	0	0	0	3408	795	0	0	0	0	0	0	0	0	0	0
24	430	5855	34009	3991	0	0	0	0	0	1495	0	13633	178	78	76	38	23	23	294	349	339	368	937
26	1290	13011	45498	4435	0	0	0	0	0	2990	0	6817	36510	719	703	348	378	214	2702	3215	3119	3385	8621
28	2258	20166	98349	40356	810	14260	1016	1606	306	3970	3167	10225	207294	24204	4157	2058	2889	1264	15980	19010	18791	20017	50976
30	3333	17564	24803	3991	6485	39900	10906	59301	7109	49307	29617	68528	194556	65949	47032	22565	17084	8731	77004	100110	97091	113788	268061
32	2903	16440	28020	18182	9732	62984	15470	73077	67501	57580	211299	221181	314625	131662	127336	66697	39374	25038	247690	327000	317779	364992	839477
34	30812	57296	87804	92632	131164	278762	54425	169363	199724	196749	314162	543041	663991	402353	373427	219997	180914	118521	594003	728690	749005	786897	1695612
36	73297	111350	161043	165929	357579	743387	245905	385849	492850	628915	892299	1950001	1007562	1087823	918509	599107	567771	541355	1041219	1325882	1233319	1350182	2789946
38	239863	375918	706277	899424	1012098	2076376	643076	1315450	1345590	1502437	1712343	3109894	2909790	2424711	2006049	1213977	1267552	1168950	1382285	2304549	2075927	2399274	4187870
40	465378	833124	1766624	1840463	2579907	5492365	1393103	3097610	2985524	3429702	2802686	4613752	5772309	5041985	4094311	2791157	2969841	1907577	2577894	4578270	3614222	3909038	6925722
42	868681	1681549	3253008	3108264	4819080	8533148	2173524	4022686	4288390	5058160	3788685	6139703	8519115	7529303	7650794	5254862	5126816	3658308	4989434	8012143	5753247	6138949	11784121
44	1552191	3295033	5058098	4820959	7393360	9349442	2731005	4663284	5363229	6500877	5102528	6514154	9775343	9387936	9052247	6619912	5601537	6733621	6717507	11033927	7100390	8271974	14852259
46	1294579	3179927	4111737	3909192	5938689	8191763	2756079	3984132	6291125	7102830	6025410	6165551	8182620	10956141	9664363	6095702	4704805	8621336	7495181	10465036	7528636	9640134	15669808
48	1063506	2578903	3538287	3734156	3656179	6066702	2119455	3350152	6656970	5881651	4688069	5337067	5491263	7220993	6849007	5246887	3916895	7039546	5930630	7647840	5962113	8036449	12346304
50	972682	1762195	3271293	3304463	2137251	4012251	1969402	2818785	5803462	4023878	3317219	3774454	3799113	4540572	3797155	4586622	3080816	4413716	4221957	4552048	4234700	5278927	8023604
52	1142009	1770051	3211836	3046378	1934817	2557030	1789152	1832242	3842394	2653559	2040365	2821528	2678814	3150087	2419466	3469049	2415833	2828970	3140080	2757870	2620682	3170218	4453300
54	1132356	1618988	2763909	2637444	1902518	1755519	1462370	1526187	2529906	2022837	1408769	1875486	1730636	2112903	1373386	2122117	1750929	1612880	1661204	1597327	1399053	1963619	2512298
56	791808	1116342	1673375	1665757	1328508	1082569	1161407	1070732	1698291	1601563	958126	1110270	985961	1587101	749075	1057161	1145185	900100	945889	979669	774443	1079384	1383896
58	493858	602984	922995	833377	760806	649917	574900	634038	1131228	1160228	628209	638936	585210	910298	439550	469041	741456	466417	519488	603008	409922	568807	866796
60	271529	313852	456350	345654	287261	609618	529091	384691	761016	609058	563327	532534	372605	507480	321699	232538	490276	219481	392312	403474	269698	403228	468265
62	113528	133597	197010	191319	161261	301685	230607	176758	393423	443033	490444	369739	314147	219987	178917	199350	343382	135522	246294	270428	204183	287562	307977
64	28109	62378	110863	88555	77211	103819	202812	92471	238384	201824	343118	223403	143367	116217	123538	160251	201773	72644	147850	144034	116370	223321	189082
66	7994	23706	37051	41900	50211	125935	219355	45470	122101	148077	201161	153105	110630	93175	55742	121475	102831	36144	89656	51067	41039	141421	136655
68	8284	7927	23735	18938	34679	40510	105564	21398	93549	106017	176905	120931	65681	35944	32629	74445	55621	9592	29340	15362	18458	77410	80221
70	1160	287	45	6278	7559	26977	70728	21674	36681	75053	60970	68672	35092	21275	7606	34819	21819	2354	8203	3860	32294	24702	34492
72	686	287	0	956	1424	2582	34160	6081	4964	33494	29192	33901	28329	9465	11762	7998	6571	1341	2604	3540	26860	9571	13401
74	3945	6532	10358	12455	8240	2594	22781	2999	2158	8683	12328	4269	8051	5389	927	5933	2601	243	795	5868	9550	1049	710
76	0	0	45	0	0	1729	6719	464	6474	1542	1187	2325	1634	1184	463	1309	430	0	814	6969	1228	246	183
78	0	0	0	443	0	5188	1621	928	11081	4613	0	203	936	789	849	717	435	70	647	9108	1128	121	96
80	0	0	0	0	0	0	6719	1392	4591	0	0	1143	0	1336	309	504	430	0	898	2631	97	0	0
82	0	0	0	0	0	0	0	0	9342	336	190	385	211	1670	418	101	430	0	1224	1429	0	0	0
84	0	0	0	0	0	0	0	0	2754	4485	13071	0	0	0	386	101	0	0	1879	1285	0	0	0
86	0	0	0	0	0	0	0	0	5509	8969	26141	0	0	0	154	0	0	0	1231	36	0	0	0
88	0	651	0	0	0	0	12	0	9181	8969	26141	0	0	0	0	0	0	0	931	36	0	5	0
90+	0	651	0	0	0	231732	0	0	5509	0	0	0	0	0	0	0	0	0	230	0	0	0	0

Li (2cm)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
-20	159	220	198	165	71	100	100	127	179	106	49	129	138	42	1658	15	2610	0	0	220	0	102
22	0	0	0	0	0	0	0	0	0	0	0	0	1356	36	0	0	0	0	3090	0	2	0
24	796	1107	990	824	365	727	501	634	1433	529	243	646	5516	688	5133	881	8378	11280	21180	175	154	70
26	7321	10304	9755	10945	3244	4666	4614	7745	8305	9570	2744	5947	8582	7786	7096	8523	38688	25900	58226	4698	2542	6082
28	43291	59764	54469	46846	20303	41451	43464	38574	53525	49163	28988	35165	56181	15570	38634	48301	74996	75574	121794	15396	44768	46187
30	216945	318243	270239	228050	114960	236636	218289	239329	290766	216395	156809	265243	472033	127121	171296	249101	294070	318290	347602	242570	319323	330269
32	695639	942369	909379	768043	427530	744189	638178	805354	937822	722183	423471	919909	1634554	398211	722458	896871	781293	1238445	1131077	1024986	1177774	1146340
34	1388953	1919242	1896305	1563556	1148613	1569906	1205416	1844076	1919668	1385419	894026	1876932	3169591	1420414	1335055	2316291	1879212	3432923	3373356	3429931	3947604	3008856
36	2237615	3026735	2977409	2632709	2518406	2767597	1943303	2932659	3194648	2711475	1743130	3094066	4318146	2591636	2292904	4826849	3277814	6683551	6596992	7436808	7287035	5125137
38	3029531	4291057	4177527	4275519	3357333	3640134	2640188	3868596	4146249	4238080	2826432	4357222	4845078	3828409	3757040	6756302	4644392	7824070	9494992	10930409	9807659	6780460
40	5344265	7554131	5857355	7360130	5440298	4977454	3977567	6515688	6304760	6768856	4242156	6103407	6187500	6065501	6016746	8200426	6647026	8426649	13776954	13715908	12854820	8788280
42	8920648	11472024	9683718	12352701	9473373	7678869	6517399	10355469	8001867	9289735	5899213	8760612	8026444	8786202	9015846	9106609	9933965	9731855	14730757	15633773	13591859	9702022
44	11506647	14367346	12832344	14692336	11486164	8819806	9431629	13044594	8397558	10333312	7181723	10316962	9724677	10040503	10115789	8865856	10383499	10535400	13727326	15104129	13286323	10496954
46	12174072	16126475	14092002	13354110	12126471	10123366	11314677	12635804	8090984	9092165	7623372	9256265	10443547	9635054	9892063	7996998	8063058	10196793	11701139	12448764	13827193	11406063
48	8393604	11739283	10994400	9153375	8458807	7871933	9332250	8819239	6771759	7614843	6686868	7075308	9988832	7932614	6988535	5734476	6117399	7103791	9442045	9124940	12082931	10985245
50	4812323	5764807	5605720	4306034	3810702	4202803	5715992	6282337	4953790	5559322	4497068	4969143	6987930	6012800	4742529	3533366	3687845	3880377	5917323	6209236	8135162	7900030
52	2683206	2948561	3543216	2241449	2243763	2638703	3891629	3415756	2975245	3511894	2716386	2875750	4055329	3672309	2871791	2496531	2537948	2420420	3456126	4509722	5271835	5598835
54	1504924	1812254	1643806	1046413	1364031	1128587	1828300	2019155	2246838	2055705	1577515	1681309	2213080	2194882	1941261	1654771	1636853	1768395	1721677	3080085	3419672	4795884
56	884717	1127943	1005814	674119	946840	690064	1011947	1042300	1306348	1106848	939473	1095727	1435301	1544658	1311156	1134493	1083543	1378782	919585	2018319	2466894	3699866
58	594538	698752	624865	577825	643559	488613	700080	640962	902320	797917	611387	780899	828437	950964	822353	726704	758858	1088130	635907	1471940	1742463	2750223
60	471580	500677	439992	467023	467422	345368	440923	395349	564349	553007	399150	579229	582045	647867	477583	599249	551466	830151	413765	825711	1451131	2117617
62	387746	335727	267255	353701	304933	246027	238449	216346	336085	347208	228716	366716	407036	465121	288821	368901	406867	588203	285085	581631	1007766	1724781
64	329701	156987	194193	218908	176215	128676	150032	168653	151857	216284	116470	225069	281215	295523	157141	175702	328286	332565	117362	313572	555961	1144954
66	250574	95862	128995	132198	110330	46632	74495	105488	78656	112809	54006	185414	134166	156556	109203	109204	130694	153768	59039	143872	282535	591665
68	165300	94392	97179	77181	75075	37245	23260	39334	38165	77821	31006	91260	68091	98439	91720	30452	37017	33649	45190	53696	144308	192633
70	99094	37890	38745	37299	30293	12205	19978	19073	51595	19634	15630	45821	28276	27127	43056	17448	19700	16854	8382	25860	19023	65841
72	25527	8874	25297	23452	4872	4674	8227	10624	20488	6982	11784	26753	13585	16820	13369	18529	12472	12556	10071	9783	19850	21437
74	13283	6820	7527	7162	654	289	1610	1257	3245	2315	9699	12167	7114	7624	5340	19749	17291	3073	479	3857	3915	4258
76	4378	3239	680	658	19	3027	2340	2654	2843	2130	4153	2419	3099	7610	5754	12307	8407	2013	816	3249	1337	2174
78	2581	4	0	206	10	418	196	32	715	3309	3013	4010	1067	4586	2948	3062	797	1350	706	3157	75	345
80	0	9	0	20	0	154	964	941	41	357	777	1798	111	1437	2821	2413	1934	477	1060	806	120	2
82	0	9	0	14	0	2932	664	47	165	0	534	962	18029	804	388	574	974	306	289	40	120	2
84	0	17	0	7	13	368	579	32	41	150	464	237	251	362	84	1476	238	0	259	59	47	14
86	0	0	0	0	0	2686	168	0	82	0	23	59	179	209	304	0	248	0	0	15	61	137
88	0	0	236	23	0	2717	134	16	0	0	23	89	430	365	304	0	87	0	173	101	47	72
90+	0	26	532	46	19	3515	1645	379	247	1159	91	911	1097	1586	4865	0	0	0	777	2381	1015	342

Table 9. SKJ-W overall CAS matrix (number of fish) by year and 2 cm fork length (FL) size classes.

Li (2cm)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	134	0	0	0	0	0	0	0	0
22	4	20	59	76	203	249	305	77	18	90	17	427	332	300	0	0	854	730	0	0	440	556	0
24	483	713	641	570	606	725	0	0	26	1198	91	1655	0	88	134	0	0	0	0	0	547	692	0
26	966	1425	1283	1140	1211	1450	547	637	564	1498	182	827	0	398	671	0	0	0	558	236	601	236	687
28	1448	2138	1924	1710	1817	2226	1095	1275	1080	749	182	1241	0	442	1477	0	0	0	2234	945	2406	945	2749
30	1774	2633	2411	2166	2424	2906	1673	1671	1431	3909	783	7750	1114	2187	946	655	12455	14809	2570	827	2105	827	3824
32	4667	6889	6200	5516	5856	7058	6567	7649	6910	10111	4810	14346	586	1168	1074	1597	15233	33118	4245	4073	4359	1984	13431
34	4667	6901	6212	5821	5917	7297	25794	29973	26572	16601	11228	17645	1947	830	2631	9517	14039	24018	4803	4891	5973	3228	29576
36	6598	9858	8884	8357	9224	13342	39210	44765	39656	24784	24235	23097	4465	3341	16941	29435	74431	61929	15729	14541	35220	33180	48615
38	22531	33650	30324	30542	30755	46849	66034	70284	63762	51092	54418	43597	8070	5563	27267	57144	59169	120784	75423	35993	75752	48362	129400
40	25271	37933	34243	37438	38776	81637	107273	117170	106104	113905	97105	91288	29688	33899	55503	166439	693694	305235	104571	62551	85818	66682	201535
42	33347	50165	45126	54449	60801	122935	110895	109684	103945	167491	119557	185546	118860	342011	385493	706455	1046535	382710	92871	107624	120578	101093	392942
44	49811	74812	67314	80245	91183	165884	162348	147213	139789	217238	152863	273456	211024	556393	599788	1016011	1100234	407067	310637	228622	235112	146915	517870
46	58506	87298	77641	90489	110950	178734	160843	149133	139598	275310	174964	265679	230919	252724	372662	547458	945111	551307	385229	388662	418816	357301	764298
48	54628	81661	72489	94166	111245	169504	154195	154456	147884	289632	171219	273801	300039	288780	380056	475354	1040656	710013	647630	647455	583362	755691	1070106
50	53929	78637	69155	100684	110332	131418	129231	130152	122636	262087	207463	240764	461315	435552	588385	581989	1637382	921800	728637	918838	958004	1258392	1203798
52	42913	55796	48036	95127	76940	86605	109788	120295	95062	196706	144224	191593	791849	847401	877076	985506	1447849	1110611	700643	928907	1182982	1473197	1291096
54	30338	39172	32141	80593	52448	62044	85306	86516	68894	157113	116535	197272	709685	1024875	932522	1121732	1436881	1287873	795404	777850	1128689	1437265	1214075
56	28978	36121	26582	68604	39302	41316	66266	72402	57681	126256	127240	214881	683541	932070	810707	823504	1300003	1323104	854372	742803	952198	1067439	1092767
58	30749	34421	21913	43587	29539	30070	42280	55897	48607	104651	127067	277741	466894	676323	642882	637632	1054304	1003313	792021	681610	830068	564866	855434
60	36681	41192	27279	41385	38608	33288	44513	61520	52447	79166	114447	288744	495544	550322	529001	526789	680733	690709	528055	508666	423660	287133	587671
62	20951	25311	15979	26730	27286	18921	20676	26334	25054	56136	86236	241169	400403	579967	491360	591521	389654	369122	250908	325756	265188	187178	372998
64	20650	24378	16727	25505	25362	21183	17267	23199	20283	51764	73048	186856	313405	460710	359466	421823	184073	168250	154902	189338	121263	67523	181584
66	11188	10270	5773	13009	9813	6873	12998	22146	17683	49854	46050	136135	253403	420493	354210	418866	95356	86489	103201	96953	83265	48639	119312
68	7800	10533	7397	8625	10043	9116	5407	5554	6678	38705	33913	88672	121303	279889	269078	254856	53983	42377	90439	39731	50627	19128	49356
70	16008	23493	20610	18752	23624	27093	8261	4966	4809	25990	21458	64062	82632	210578	229000	237580	32747	34016	51370	19437	55532	9030	18635
72	10140	15236	13593	12618	16593	17315	4978	2705	2590	12739	12184	24656	49859	78616	102137	78754	30380	21177	53402	15577	13613	5036	30736
74	2167	3700	3631	3439	6277	6019	4421	2353	1921	7103	6594	15935	36020	26182	47666	21523	11499	10408	29381	19331	14323	12560	15326
76	326	770	762	731	2095	1467	1039	418	467	4485	3708	11979	24272	18125	40769	11657	1934	4193	10299	6736	4724	4705	15056
78	161	331	307	284	792	770	236	116	198	5911	7112	3388	10060	5628	16100	6856	2128	2353	3274	15053	11438	11354	12563
80	0	100	100	100	621	229	293	124	185	3761	8410	334	28	633	3870	5114	1145	1352	1300	1306	337	336	4955
82	0	100	100	100	496	229	252	124	236	8700	4265	56	28	632	1658	10767	0	1149	711	497	10599	7463	16329
84	0	106	106	106	527	244	268	132	214	5749	4425	60	0	0	0	1902	506	408	126	0	0	0	1260
86	0	31	31	31	155	72	79	39	58	1200	4489	18	0	0	0	589	0	135	1179	1349	0	0	20
88	0	25	25	25	124	57	63	31	35	50	336	14	0	0	0	362	0	628	42	0	0	0	0
90+	4	20	59	76	203	249	305	77	18	90	17	13	332	300	0	227	0	0	864	438	0	0	151

Li (2cm)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
-20	0	0	0	0	0	0	0	0	346	0	0	0	0	0	0	0	715	0	0	0	566	594
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	634	0	378	396
24	0	1774	0	275	0	0	0	0	0	0	0	0	453	0	0	0	0	506	7295	0	0	0
26	0	0	1155	824	0	0	0	0	0	0	0	0	0	0	0	597	0	0	5797	0	0	0
28	0	1289	5497	707	349	0	0	0	346	0	0	0	906	2704	0	597	0	506	317	0	281	292
30	16	17414	9853	2304	835	2122	0	2193	0	3512	356	1687	10422	6084	3423	2387	715	1517	1357	703	842	877
32	581	55846	30772	4083	2088	2972	1385	2632	7805	10536	1912	3860	16312	9464	0	8951	715	9607	4748	2287	0	0
34	22136	126655	34765	11304	7504	10552	5175	11439	29247	51801	7967	9676	34005	16143	287	23244	2869	23301	12912	6399	388	396
36	77352	305485	58405	32405	27267	34462	9603	26748	32273	86042	15615	12170	24126	34110	1714	39195	12430	40302	27357	21118	11117	4312
38	68192	511811	148466	78891	65317	74830	47987	74693	91878	144326	29036	29720	46594	44766	8515	78524	12534	69169	46303	29882	11753	17933
40	120850	585948	280689	114346	152495	174051	118996	146672	143759	293890	44664	84418	67204	102154	29860	93583	24679	76308	68636	35282	24390	30986
42	221301	687480	326012	146149	173207	166691	140026	125148	149504	350015	73528	175008	128381	246827	104578	132852	189592	159879	253140	242088	306691	109213
44	357057	894314	512010	203980	208184	187345	177408	131711	201150	424878	102876	319031	381530	457876	338175	223444	361000	287723	430571	474712	592761	261905
46	530446	854665	715666	282710	320088	302026	296254	184758	187022	412820	187655	473091	901352	633999	476839	316248	442529	614689	568225	734492	737334	643520
48	707346	793075	837270	434284	510009	466211	399857	343798	312493	577273	328906	566589	1228021	909206	899011	411267	907751	847238	758888	1034903	990473	926416
50	741192	833068	981176	530893	579082	732119	521794	517416	519150	801014	526072	613550	1316435	1336928	1207369	695700	978895	963163	804968	1162238	988014	1093870
52	821480	884691	1020213	621460	689853	1000306	826161	696896	735085	935001	688940	675331	904488	1486024	1306300	774856	703572	1052802	713512	1153776	973105	1172246
54	863241	1212704	913825	606578	739246	1180427	962778	821400	894958	1013109	725172	739545	808750	1425685	1326964	587037	501498	897820	603643	1026660	911813	982295
56	851024	991056	899011	565929	775231	1205792	935285	898322	959483	952120	713743	744933	725974	1091338	954932	477783	390993	758219	500100	841072	777382	805406
58	790299	897591	797622	626496	850035	1063160	1003574	984834	1065706	817033	620136	684173	568085	543278	722913	417755	389118	611520	426923	691703	692892	651109
60	594513	553421	647356	537916	742829	781729	879816	861410	915768	551353	406792	456840	470996	334107	356017	404370	301971	493077	347861	547437	579199	510251
62	399175	361509	419515	435550	583757	508942	569000	556100	601562	448661	321183	370767	372472	174732	187717	368277	217760	321699	245239	374800	413123	325113
64	281999	271082	219096	255684	339632	291617	297054	291061	320787	327239	229787	256009	265059	106778	101836	405206	113511	146776	108464	169975	188466	160036
66	158525	96991	86267	113676	157352	192766	194228	190043	208129	267786	195645	214263	109199	38949	49210	321645	123232	113030	115102	144957	166918	108975
68	126717	40875	42848	63779	85114	99356	102864	104173	103781	196930	135962	149072	36553	19124	11474	269954	136164	78305	133518	151091	185774	81301
70	81035	65527	35469	57396	73137	41040	46780	45972	40842	56751	48216	47475	16605	21488	444	146088	117368	46839	113756	121260	156309	49473
72	84987	17582	27889	49018	53521	12795	10386	11921	10457	50353	40499	40680	13845	18825	192	75023	56444	27076	64602	60897	75868	25713
74	38854	21383	27286	25528	25560	11298	8707	8623	7372	30871	24691	25707	7474	8320	6134	49627	69733	9820	66875	65351	90866	10433
76	33567	29824	12590	11856	7746	3798	4687	2296	3085	25325	15510	16430	7526	4057	9187	31060	41483	9986	41463	37952	51756	1525
78	38048	8052	10203	16000	13269	7936	5104	5104	5218	2338	2305	2333	5782	4749	6838	4791	27205	1396	25654	23667	33962	271
80	3102	3722	1236	3476	4539	233	152	152	317	3505	2503	5920	5386	3203	6013	6363	22017	4599	21202	19205	25885	513
82	10642	1681	670	942	1702	155	1140	101	193	2248	1910	2124	0	168	0	2806	6946	585	6158	5828	9011	459
84	5603	1855	6972	175	67	0	279	10	65	210	323	325	0	3254	0	122	352	1246	110	5	272	135
86	47	404	2482	2777	3821	0	0	0	44	181	305	297	0	9	0	65	6594	519	5904	5830	8821	333
88	0	1181	2454	175	67	0	0	0	12	49	64	68	1592	267	77	67	0	112	505	2	35	0
90+	28192	628	1242	526	133	0	553	214	325	75	7945	673	2891	342	24	1116	352	398	552	0	184	189

Table 10. Skipjack tuna (*Katsuwonus pelamis*) conventional tagging summary (ICCAT-DB).

			Days at large						
Year	Releases	Recoveries	90	180	270	360	1yr+	UNK	recapture ratio (%)
1961	24								0.0
1962	26								0.0
1963	8								0.0
1964	586	1	1						0.2
1965	393								0.0
1966	781								0.0
1967	41								0.0
1968	22								0.0
1969	53								0.0
1970	111								0.0
1971	40								0.0
1972	36								0.0
1973	53								0.0
1974	17								0.0
1975	62								0.0
1976	28								0.0
1977	60								0.0
1978	119	2	1	1					1.7
1979	113	12	12						10.6
1980	6454	438	201	105	68	17	33	14	6.8
1981	7975	1121	689	175	81	51	61	64	14.1
1982	2173	1929	1853	42	4	1	4	25	88.8
1983	120	28	28						23.3
1984	242	94	73	5	4		2	10	38.8
1985	242	29	26	3					12.0
1986	225	44	39				1	4	19.6
1987	15	3	1					2	20.0
1988	43	1	1						2.3
1989	155	21	18	3					13.5
1990	2231	229	183	42	1			3	10.3
1991	821	68	67	1					8.3
1992	1352	158	130	25		1	1	1	11.7
1993	8								0.0
1994	959	140	131	9					14.6
1995	76	9	7	2					11.8
1996	546	71	63	1	1	2	1	3	13.0
1997	3094	676	582	54	23	10	6	1	21.8
1998	418	5	3	1	1				1.2
1999	3041	558	476	44	8	21	5	4	18.3
2000	1495	68	62	1	3			2	4.5
2001	3648	137	119	2	8		2	6	3.8
2002	4556	891	852	21	2	1	1	14	19.6
2003	3								0.0
2004	24								0.0
2005	4								0.0
2006	21								0.0
2007	3								0.0
2009	1								0.0
2011	2								0.0
TOTAL	42520	6733	5618	537	204	104	117	153	15.8

Table 11. Year (or time period), as indicated by rectangles, in which a new technology was introduced to the French tropical tuna purse seine fleet operating in the Eastern Atlantic Ocean (figure taken from Torres-Irineo 2014, Fisheries Research).

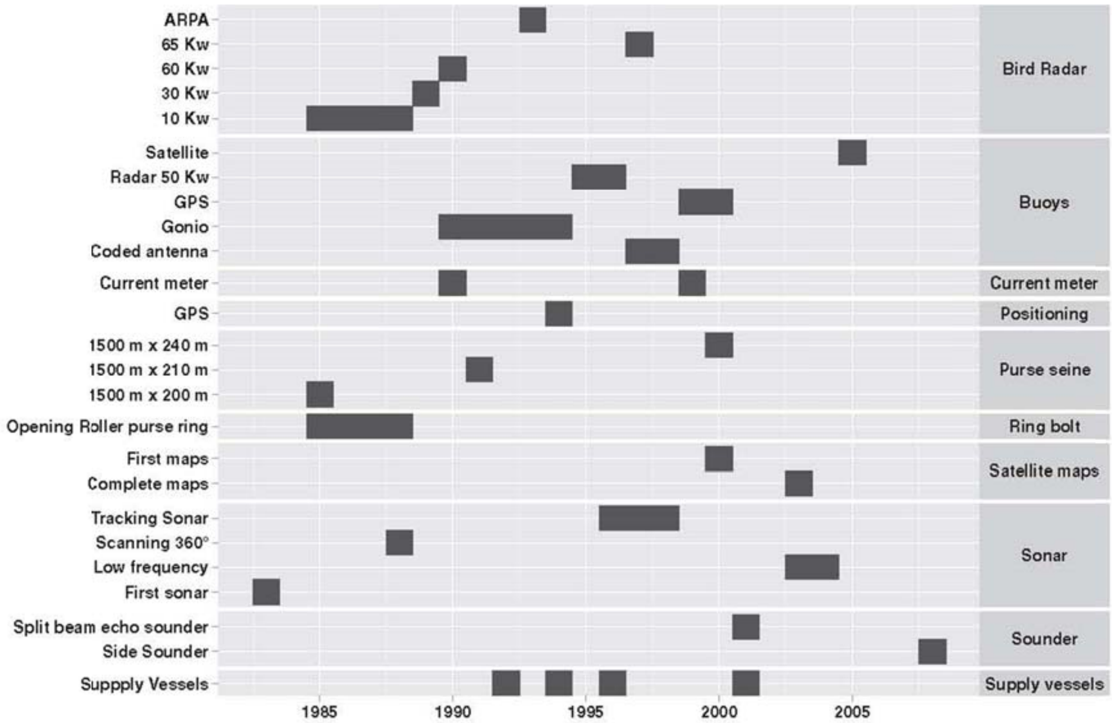

Table 12. Summary of evaluation criteria for relative abundance indices for Atlantic skipjack. Empty rows correspond to criteria that were not evaluated during the meeting.

SUFFICIENCY SCORE (1 is poor, 3 is best)			WEST					EAST				
1	2	3	Brazil BB	Larvae GOM	US LL	PS Ven	RR US	Azores BB	Canary BB	Dakar BB	PS Dakar	EU PS FAD
No Diagnostics or many assumptions clearly violated	Diagnostics presented but not all assumptions met	Full Diagnostics and assumptions probably fully met.	2	2	2	1	1	2	2	2	2	1
Not appropriate or not sufficiently described	Described but some exclusions not properly justified	Fully Appropriately described and justified	3	3	3	1	1	2	2	2	2	1
Localized fishery/scientific survey, and data represents a small area within it	Localized fishery but data represents all area or large fishery but data represents	Fishery and data represents the major geographic range of population	2	2	2	2	2	2	2	2	2	3
Index associated with less than 5% of the catch	Index associated with between 5% and 20% of the catch	Index associated with more than 20% of the catch	3	n/a	1	2	1	1	1	1	2	3
Less than 25% of the time of exploitation (<16 years)	extends between 25% and 50% of the time of exploitation (>16 years<32 years)	Extends for more than 50% of the history of exploitation (>32 years)	2	2	2	2	2	3	3	3	2	2
More than 3 other indices available for the same period of time	1 to 3 other indices available for the same period	It is the only available index for the same period of time	2	2	2	2	2	3	2	2	2	1
Only spatial and time factors included	Some gear/vessel/technology or environmental factors included	Majority of gear/vessel/technology factors included or standard scientific survey	1	3	2	2	2	1	1	1	1	2
Many conflicts for more than one period or for a period of more than 5 years	Conflict for a short period (5 years)	No conflicts										
More than 50% of annual estimates are outside plausible bounds	Between 50% and 10% of annual indices outside plausible	Less than 10% of the annual indices outside plausible bounds										
Severe trend for a period of more than 4 years	Severe trend for a short time period (4 or less years)	No severe change										
Unbalanced data respect to standarization factors: numerous data points for each factor combination	Some lack of balance in data respect to standarization factors: numerous data points for each factor combination	Well balanced data respect to standarization factors: numerous data points for each factor combination	2	3	2	1	1	3	2	2	2	2
Very Discontinuous more than two breaks in the time series	one or two breaks in the time series	Complete	2	3	3	3	3	3	3	3	3	3
Discards not considered and discarding practices probably have changed through the time period of the index	Discard not considered but discarding practices to have remained constant during the time period covered	Dead/live accounted for through observers or no discards exist during the time period of the index	2	3	3	1	1	2	2	2	2	2

Table 13. Relative abundance indices for the western stock of Atlantic skipjack. The US RR index was not used in assessment models.

	Brazil BB		Larvae GOM		US LL observer		US RR		PSVEN	
	index	stderr	index	stderr	index	cv	index	stderr	index	stderr
1981	5.86	0.22								
1982	3.83	0.3	1.8411	0.16487			4.083			
1983	3.92	0.34	1.1136	0.34764			1.581			
1984	3.6	0.33	0.57396	0.25074			1.167			
1985	4.84	0.25	0.05717	0.98558			1.409		1.516	
1986	5.58	0.25	0.77933	0.41454			0.848		0.652	
1987	4.76	0.3	0.12787	0.54462			1.046		1.018	
1988	6.51	0.26	0.21603	0.38002			0.849		0.957	
1989	4.19	0.3	1.0417	0.24823			1.142		0.947	
1990	8.19	0.26	0.79157	0.16841			1.033		1.09	
1991	4.95	0.26	0.96676	0.29713			1.237		0.434	
1992	6.55	0.21	0.8489	0.33025	1.02	0.65	0.872		1.64	
1993	8.91	0.26	1.03734	0.16309	0.26	0.7	0.952		0.795	
1994	5.48	0.22	0.75816	0.24834	0.71	0.56	0.643		0.439	
1995	6.74	0.27	0.56168	0.17172	0.17	0.64	0.501		0.528	
1996	6.66	0.19	0.67826	0.3394	0.92	0.53	1.144		0.71	
1997	7.9	0.19	0.48791	0.22748	0.34	0.63	1.999		1.38	
1998	5.42	0.23	0.76988	0.21424	1.81	0.49	1.487		2.209	
1999	5.07	0.26	0.52613	0.25849	0.51	0.49	0.514		0.525	
2000			0.81582	0.25475	0.56	0.51	0.559		1.602	
2001	6.13	0.21	1.2881	0.25561	0.7	0.51	1.298		1.289	
2002	5.19	0.24	0.96083	0.21844	0.1	1.4	0.602		1.623	
2003	8.27	0.31	2.0847	0.33259	0.61	0.67	0.492		0.827	
2004	6.26	0.23	1.27139	0.31251	1.36	0.44	0.514		0.455	
2005	9.47	0.15	0.7926	0.27111	1.27	0.45	0.046		0.366	
2006	8.25	0.18	0.99734	0.214	2.02	0.43				
2007	18.4	0.29	1.05993	0.25055	1.12	0.42				
2008	7.69	0.18	0.79805	0.19074	0.61	0.44				
2009	8.41	0.17	1.18067	0.21429	1.59	0.35				
2010	7.6	0.21	2.6972	0.29351	0.72	0.47				
2011	4.26	0.28	2.79055	0.15925	3.74	0.34				
2012			1.08547	0.21903	0.93	0.41				
2013					0.95	0.38				

Table 14. Relative abundance indices for the eastern stock of Atlantic skipjack.

	Azores BB		Canary BB		Dakar BB		PS EU Dak Free		PS Free+FAD	
.	index	stderr	index	stderr	index	stderr	index	stderr	index	stderr
1960										
1961										
1962										
1963	99.86	131.47								
1964	727.67	451.82								
1965	237.79	183.24								
1966	1062.61	408.85								
1967	159.18	135.59								
1968	409.33	363.30								
1969	37.50	44.90			0.11	0.26				
1970	5.29	6.98			0.11	0.45				
1971	866.63	581.44			0.12	0.45				
1972	344.69	306.28			0.11	0.45				
1973	67.49	68.99			0.11	0.45				
1974	26.12	29.00			0.12	0.45				
1975	7.71	10.17			0.11	0.45				
1976	217.32	217.11			0.11	0.45				
1977	1192.55	439.44			0.11	0.45				
1978	982.99	508.40			0.13	0.47				
1979	542.31	352.71			0.13	0.47				
1980	529.34	241.36	220.11	281.44	0.10	0.45	0.15			
1981	798.44	326.50	281.04	448.52	0.14	0.45	0.61			
1982	1146.41	422.22	331.19	528.98	0.14	0.45	0.61			
1983	285.61	197.25	155.43	267.45	0.13	0.45	0.10			
1984	1095.52	507.27	206.82	346.87	0.15	0.47	0.36			
1985	164.18	134.24	422.00	693.86	0.11	0.45	0.26			
1986	533.24	336.12	198.98	335.86	0.13	0.45	0.70			
1987	874.12	466.61	215.26	368.15	0.15	0.45	0.40			
1988	1984.60	623.77	263.00	444.10	0.15	0.45	0.70			
1989	1364.39	558.88	340.29	546.81	0.16	0.47	0.54			
1990	50.26	44.10	357.46	585.04	0.16	0.45	0.77			
1991	1345.59	587.19	273.56	449.05	0.14	0.42	1.06		624.67	37.37
1992	639.63	443.15	260.89	438.85	0.14	0.43	0.69		531.77	34.62
1993	562.45	338.61	162.30	285.37	0.17	0.42	0.79		581.11	37.67
1994	1018.91	500.33	268.19	439.44	0.15	0.42	0.61		591.90	37.02
1995	206.51	147.69	239.04	386.17	0.14	0.42	0.62		533.81	34.73
1996	598.01	362.92	235.43	405.88	0.15	0.42	0.29		519.91	34.28
1997	313.99	238.55	239.96	423.53	0.14	0.41	0.77		446.64	32.70
1998	433.57	246.95	514.23	860.93	0.17	0.41	0.88		457.10	33.21
1999	774.81	281.01	161.14	278.54	0.17	0.41	1.31		526.82	35.25
2000	620.47	264.09	161.68	287.97	0.14	0.41	0.86		504.07	33.81
2001	753.83	275.23	147.17	262.04	0.16	0.41	0.56		504.34	35.70

2002	963.86	445.77	51.94	93.56	0.16	0.41	0.27		556.12	36.51
2003	1531.29	496.28	170.96	306.12	0.16	0.41	0.74		676.48	40.55
2004	1102.65	372.04	172.09	306.53	0.15	0.41	0.83		661.47	40.08
2005	937.08	346.09	196.24	350.28	0.17	0.42	0.47		705.35	41.93
2006	1525.87	584.75	204.80	358.28	0.16	0.42	0.40		592.16	39.81
2007	1961.57	631.34	129.55	229.13	0.17	0.42			489.42	37.18
2008	2056.36	622.77	216.96	374.27	0.15	0.42			509.59	37.65
2009	171.75	130.87	172.36	308.28	0.17	0.42			566.50	36.73
2010	2666.70	856.30	176.86	313.22	0.17	0.41			694.02	39.20
2011	1163.47	454.52	153.57	279.44	0.19	0.42			644.34	38.82
2012	180.19	133.38	316.82	525.58	0.20	0.42			584.83	37.05
2013	398.48	307.27	183.78	323.96						

Table 15. Statistical weights for CPUE indices used in the production models of a) western skipjack and b) eastern skipjack. Weights represent the relative area covered by each fishery and the relative catch reported by each fleet.

a) Western skipjack

	By area					By catch				
	Brazil BB	**Larvae GOM**	**US LL observer**	**US RR**	**PSVEN**	**Brazil BB**	**Larvae GOM**	**US LL observer**	**US RR**	**PSVEN**
1980					0.034					0.153
1981	0.030				0.028	0.603			7.79E-03	0.082
1982	0.035				0.027	0.558		0.00015	6.76E-04	0.293
1983	0.031				0.042	0.489			3.37E-03	0.313
1984	0.059				0.076	0.368			1.01E-03	0.396
1985	0.046				0.110	0.622	4.5E-06		6.98E-04	0.221
1986	0.027			0.060	0.016	0.701	2.5E-06	3.1E-05	4.23E-03	0.132
1987	0.036		0.140	0.057	0.014	0.668	4.1E-05	1.3E-05	3.89E-03	0.179
1988	0.032		0.191	0.058	0.013	0.726		4.2E-05	1.90E-03	0.097
1989	0.039		0.191	0.058	0.012	0.779	1.9E-04	2.1E-05	7.20E-04	0.092
1990	0.031		0.168	0.054	0.015	0.767	3.8E-05	1.6E-05	2.53E-03	0.115
1991	0.024		0.101	0.042	0.008	0.611	3.3E-06	3.4E-05	2.57E-03	0.185
1992	0.037		0.116	0.044	0.014	0.606	3.3E-05	9.9E-07	1.62E-03	0.229
1993	0.027	0.024	0.104	0.039	0.013	0.528		4.1E-05	2.44E-03	0.302
1994	0.016	0.023	0.092	0.038	0.010	0.680	3.3E-05	1.9E-05	2.20E-03	0.190
1995	0.018	0.021	0.100	0.035	0.010	0.756	3.1E-05		9.61E-04	0.094
1996	0.015	0.022	0.095	0.037	0.011	0.817	7.6E-06	3.6E-06	2.98E-03	0.121
1997	0.010	0.023	0.109	0.038	0.009	0.806	3.2E-05	6.4E-05	2.02E-03	0.114
1998	0.014	0.021	0.101	0.036	0.005	0.810	3.4E-05	3.4E-05	2.96E-03	0.124
1999	0.004	0.020	0.063	0.034	0.009	0.839	1.4E-05	4.9E-05	3.62E-03	0.099
2000	0.011	0.019	0.056	0.031	0.008	0.846	7.9E-06	5.5E-05	1.02E-03	0.089
2001	0.011	0.019	0.062	0.032	0.009	0.764	4.8E-06	0.00013	1.56E-03	0.165
2002	0.015	0.020	0.056	0.033	0.006	0.842	9.3E-07	0.00014	3.23E-03	0.093
2003	0.035	0.023	0.049	0.039	0.009	0.825	2.4E-06	5.2E-05	2.46E-03	0.093
2004	0.037	0.020	0.045	0.033	0.008	0.839	1.1E-05	1.6E-05	2.70E-03	0.101
2005	0.131	0.016	0.098	0.027	0.012	0.886	1.2E-05	9.6E-06	5.30E-04	0.030
2006	0.029	0.023	0.057	0.039		0.870		9.4E-06	1.84E-03	0.068
2007	0.037	0.027	0.065	0.045		0.894		9.4E-07	2.03E-03	0.032
2008	0.028	0.026	0.059	0.043		0.933	2.0E-06	6.5E-05	2.21E-03	0.031
2009	0.028	0.026	0.059	0.043		0.866	1.9E-06	1.6E-05	3.96E-03	0.070
2010	0.028	0.026	0.059	0.043		0.859		6.2E-05	1.96E-03	0.084
2011						0.905	6.5E-06	1.3E-05	2.38E-03	0.040
2012						0.931		1.3E-05	3.15E-03	0.048
2013						0.894			2.78E-03	0.059

b) Eastern skipjack

	By area				By area			
	Azores BB	Canary BB	Dakar BB	PS EU FAD	Azores BB	Canary BB	Dakar BB	PS EU FAD
1960					0.529			
1961					0.320			
1962					0.245			
1963					0.213			0.023
1964					0.229			0.065
1965					0.096			0.067
1966					0.112			0.223
1967					0.118			0.216
1968					0.025			0.302
1969			0.009		0.063			0.320
1970			0.084		0.020			0.293
1971			0.077		0.055			0.326
1972			0.084		0.050			0.445
1973			0.100		0.029			0.341
1974			0.082		0.017			0.468
1975			0.049		0.011			0.522
1976			0.039		0.032			0.465
1977			0.042		0.041			0.467
1978			0.030		0.043			0.467
1979			0.050		0.036			0.394
1980		0.017	0.047	5	0.017	0.022		0.474
1981		0.014	0.007	4.7	0.025	0.035		0.508
1982		0.014	0.007	5.8	0.039	0.027		0.499
1983		0.015	0.038	4	0.010	0.012		0.527
1984		0.014	0.036	3.7	0.042	0.022		0.588
1985		0.012	0.017	3.2	0.030	0.072		0.506
1986		0.012	0.025	3.2	0.060	0.028		0.561
1987		0.011	0.017	3	0.090	0.036		0.482
1988		0.012	0.029	3.6	0.119	0.026	0.003	0.484
1989		0.012	0.023	3.7	0.083	0.056	0.007	0.436
1990		0.011	0.027	4.7	0.034	0.037	0.003	0.488
1991		0.008	0.013	9.7	0.043	0.031	0.001	0.576
1992		0.009	0.016	8.3	0.055	0.053	0.000	0.491
1993		0.008	0.010	13.5	0.033	0.017	0.002	0.546
1994		0.008	0.011	6.6	0.049	0.031	0.003	0.489
1995		0.007	0.013	8.8	0.034	0.035	0.004	0.465
1996		0.007	0.014	8	0.064	0.035	0.004	0.427
1997		0.008	0.012	8.5	0.039	0.052	0.010	0.393
1998		0.007	0.008	11.3	0.035	0.042	0.024	0.323
1999		0.007	0.010	9.3	0.012	0.028	0.010	0.380
2000		0.006	0.011	8.8	0.010	0.009	0.021	0.405
2001		0.006	0.010	8	0.016	0.011	0.012	0.310

2002	0.007	0.011	11		0.029	0.004	0.034	0.354
2003	0.008	0.015	8.5		0.033	0.011	0.044	0.430
2004	0.007	0.012	9.3		0.056	0.014	0.034	0.339
2005	0.005	0.010	11		0.033	0.021	0.052	0.230
2006	0.008	0.011	7		0.086	0.023	0.036	0.162
2007	0.009	0.016			0.070	0.008	0.044	0.173
2008	0.009	0.024			0.047	0.029	0.039	0.260
2009	0.009	0.024			0.006	0.011	0.048	0.260
2010	0.009	0.024			0.073	0.008	0.039	0.278
2011					0.020	0.006	0.051	0.296
2012					0.012	0.032	0.054	0.273
2013					0.016	0.014	0.031	0.331

Table 16. Estimates of percent annual increases in catchability for BET caught by purse seine fleets calculated from different CPUE data and for different periods.

CPUE Series	Years	% annual increase
EU PS Spain (Free+FAD)	1979-1990	2.4
EU PS Spain (Free+FAD)	1991-2008	8.2
EU PS Spain (Free+FAD)	1991-2005	8.3
EU PS Spain+France (Free+FAD)	1991-2008	9.0
EU PS Spain+France (FAD)	1991-2008	6.4
EU PS Spain+France (Free)	1991-2008	32.6
EU PS Spain+France (Free+FAD)	1991-2005	6.1
EU PS Spain+France (FAD)	1991-2005	5.8
EU PS Spain+France (Free)	1991-2005	7.4

Table 17. Bayesian surplus production models and inputs.

West models				
W01	Cont. data 1952-2006	N(1.17,.1)	U(log(5E4),log(2.5E5))	2008 'best' BSP model
W02	Cont. data 1952-2006	N(1.17,.25)	U(log(5E4),log(2.5E5))	2008 BSP model with wider prior
W1	Cont.data 1952-2006	New LN	U(log(5E4),log(2.5E5))	Continuity run with new prior
W2	1952-2006	N(1.17,.25)	U(log(5E4),log(2.5E5))	New data to 2006, old prior
W3	1952-2012	New LN	U(log(5E4),log(2.5E5))	New data, new prior
W5	1952-2012, inc K bound	New LN	U(log(5E4),log(5E5))	Inc bound on K
W6	test influence of priors	No priors	No priors	test influence of priors
East models				
E0	Continuity data 1950-2006	N(1.17,.25)	U(log(2E5),log(1E6))	2008 'best' BSP model
E1	Continuity data 1950-2006	New LN	U(log(2E5),log(1E6))	Continuity run with new prior
E2	New data 1950-2006	N(1.17,.25)	U(log(2E5),log(1E6))	New data to 2006, old prior
E3	New data 1950-2012	N(1.17,.25)	U(log(2E5),log(1E6))	New data, old prior
E4	New data 1950-2012	New LN	U(log(2E5),log(1E6))	New data, new prior
E5	New data 1950-2012	New LN	U(log(2E5),log(2E6))	New data, new pr, inc. K bnd
E6	1950-2012	No priors	No priors	test influence of priors

Table 18. SKJ-E BSP starting parameter and technical inputs for each run.

paramSKJ_INIT.out			
		Runs	
EAST	1	2	3, 4, 5, 6
	0	0	0
K	700000	700000	700000
n	1	1	1
r	1.3	1.3	1.4
WEST	1	2	3
	0	0	0
K	100000	100000	100000
n	1	1	1
r	1.5	1.2	1.5

techinputs.txt	
Fmin	1E-08
stepsize	0.000001
eps	1E-07
maxlikefunc	10000

Table 19. ASPIC input parameters and run descriptions for western stock of skipjack.

Initial estimates common to all runs

				q (catchability)				
	K (1000MT)	B1/K	MSY (1000MT)	GOM Larval	Ven PS	Bra BB	USLL early	USLL late
Initial estimate	100	1	35	1.0E+05	1.0E+04	1.0E+04	1.0E+04	1.0E+04
Lower limit	50		5					
Upper limit	200		75					

Sensitivity runs to test effects of initial estimates of K and MSY

	Run name								
Initial estimates	Run1	K55	K70	K150	K190	M20	M30	M40	M50
K (1000MT)	100	55	70	150	190	100	100	100	100
MSY (1000MT)	35	35	35	35	35	20	30	40	50

Sensitivity runs to test effects of removal of each index

	Run name			
	noLV	noBB	noPS	noLL
Index eliminated	GOM Larval	Bra Baitboat	Ven Purse seine	US Longline

Table 20. BSP model results for east and west stocks. Note that actual model convergence does not necessarily imply that the model should be used for advice due to the boundary conditions observed on the estimation of k. Values are posterior distribution mean and CV values.

Run	Purpose	k	k cv	r	r cv	MSY	MSY cv	B/ Bmsy	f/ fmsy	CV(wts) / CV(lp)	con verge?	hess-ian invert
West models												
W01	2008 'best' model (narrow pr)	187,430	0.23	1.18	0.12	54,917	0.25	1.67	0.33	0.88	Y	Y
W02	2008 with old prior	188,244	0.23	1.19	0.28	55,013	0.34	1.63	0.37	0.74	Y	Y
W1	Continuity, new prior	180,298	0.35	1.15	0.34	49,722	0.35	1.57	0.44	1.37	Y	Y
W2	New data to 06, old prior	187,670	0.22	1.15	0.23	53,541	0.31	1.65	0.34	1.02	Y	Y
W3	New data, old prior	179,706	0.26	1.16	0.23	51,109	0.32	1.56	0.48	0.74	Y	Y
W4	New data, new prior	168,934	0.32	1.41	0.468	55,638	0.51	1.55	0.49	0.75	Y	Y
W5	Inc K bound	283,307	0.403	1.31	0.476	89,547	0.63	1.698	0.33	0.73	Y	Y
W6	test influence of priors	146,511	0.38	1.67	0.41	58,580	0.56	1.55	0.49	6.89	no	no
East models												
E0	2008 'best' model	768,318	0.20	1.37	0.18	260,633	0.24	1.71	0.28	1.22	Y	Y
E1	Continuity, new prior	768,431	0.20	1.41	0.20	267,968	0.26	1.71	0.27	0.86	Y	Y
E2	New data to 2006, old prior	834,186	0.15	1.42	0.17	295,292	0.21	1.72	0.27	1.22	Y	Y
E3	New data, old prior	877,455	0.11	1.41	0.14	307,876	0.16	1.55	0.49	0.78	Y	Y
E4	New data, new prior	978,504	0.01	1.79	0.07	437,660	0.07	1.71	0.30	1060	no	Y
E5	New data, new pr, inc. K bnd	1,372,633	0.29	2.11	0.27	712,321	0.39	1.79	0.22	0.86	Y	Y
E6	test influence of priors	977,639	0.01	2.86	0.042	698,658	0.04	1.825	0.18	2709	no	N

Table 21. ASPIC model results for western stock, sensitivity runs compared to Run 1. Estimates are non-bootstrapped. Iterations represent the number of restarts to reach convergence.

						Catchability q					
Run	K	MSY	Fmsy	B_{2014}/ Bmsy	F_{2013}/ Fmsy	Larval GOM	BB Brazil	PS Venez	US LL early	US LL late	iter. (restarts)
Run 1	61,270	31,370	1.02	1.28	0.69	0.00002	0.00016	0.00002	0.00001	0.00003	85
K55	60,480	31,430	1.04	1.28	0.69	0.00002	0.00017	0.00002	0.00001	0.00003	64
K70	61,320	31,360	1.02	1.28	0.69	0.00002	0.00016	0.00002	0.00001	0.00003	47
K150	61,610	31,340	1.02	1.28	0.69	0.00002	0.00016	0.00001	0.00001	0.00003	146
K190	59,300	31,540	1.06	1.28	0.69	0.00002	0.00017	0.00001	0.00001	0.00003	200
M20	61,680	31,330	1.02	1.28	0.69	0.00002	0.00016	0.00001	0.00001	0.00003	97
M30	60,710	31,420	1.03	1.28	0.69	0.00002	0.00016	0.00001	0.00001	0.00003	108
M40	59,880	31,490	1.05	1.28	0.69	0.00002	0.00017	0.00001	0.00001	0.00003	22
M50	60,060	31,470	1.05	1.28	0.69	0.00002	0.00017	0.00001	0.00001	0.00003	35
No LV	92,330	41,290	0.89	1.55	0.43		0.00008	0.00001	0.00001	0.00002	28
No BB	70,500	30,200	0.86	1.22	0.75	0.00002		0.00002	0.00001	0.00003	35
No LL	52,600	32,100	1.22	1.31	0.66	0.00002	0.00019	0.00003			18
No PS	50,000	32,229	1.29	1.32	0.66	0.00003	0.00020		0.00001	0.00003	9

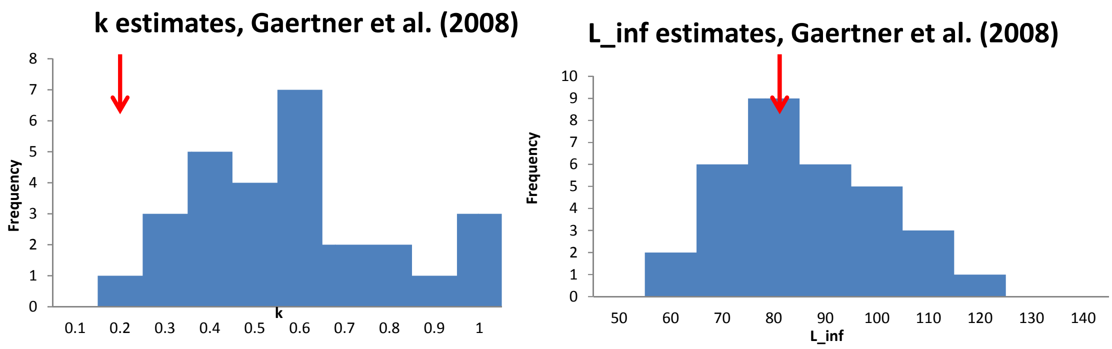

Figure 1. Estimates of k and L_∞ parameters from tagging data.

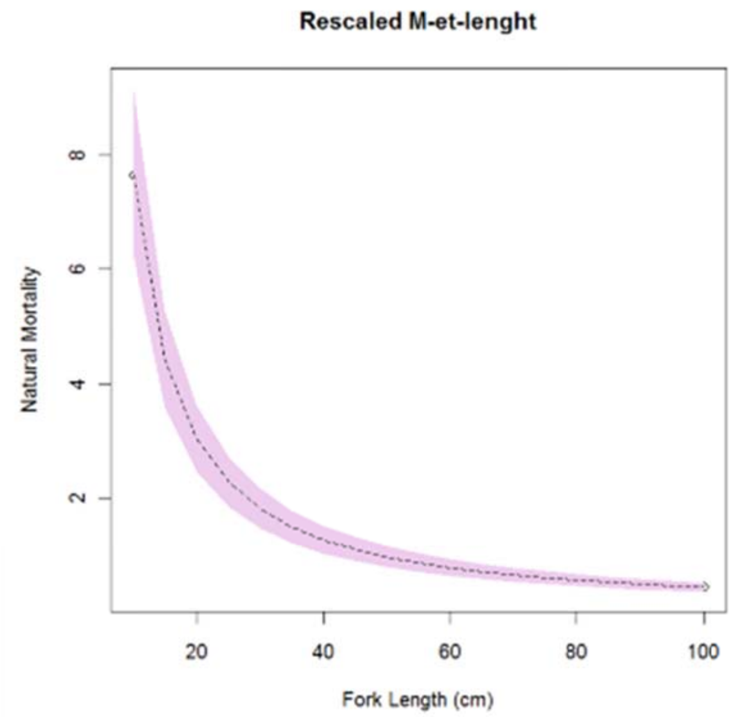

Figure2. Estimates of natural mortality by length from document SCRS/2014/073.

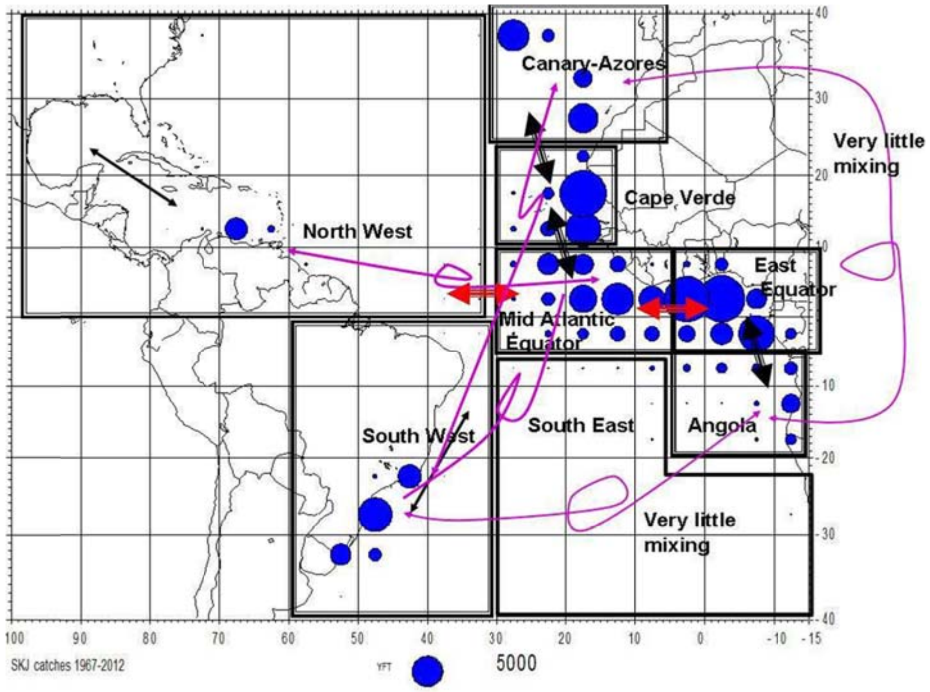

Figure 3. Proposal of seven areas stratification of the Atlantic skipjack population. These areas could be used to calculate fishery indicators.

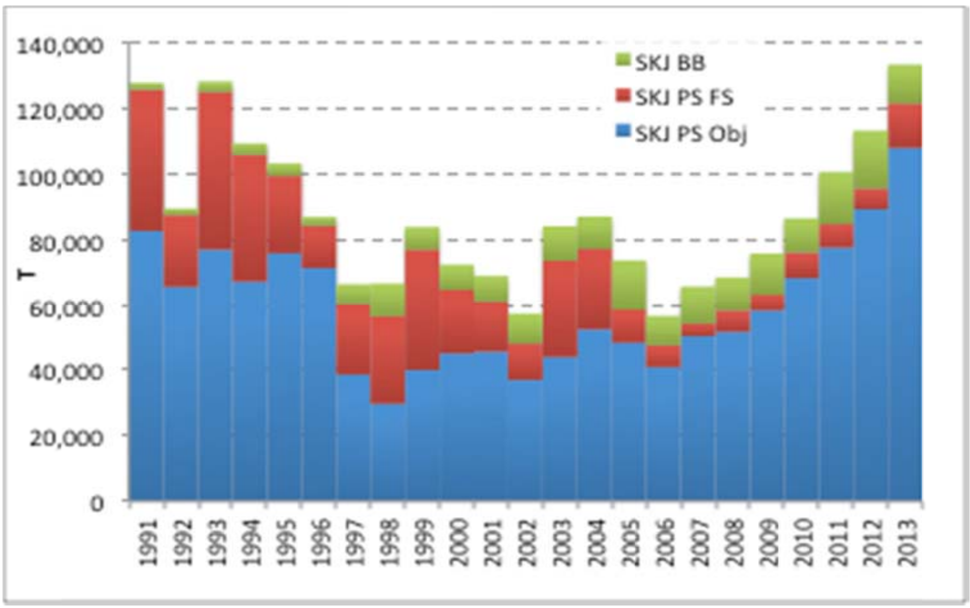

Figure 4. Skipjack catches made by European and associated tropical tuna purse seine and baitboats from 1991 through 2013.

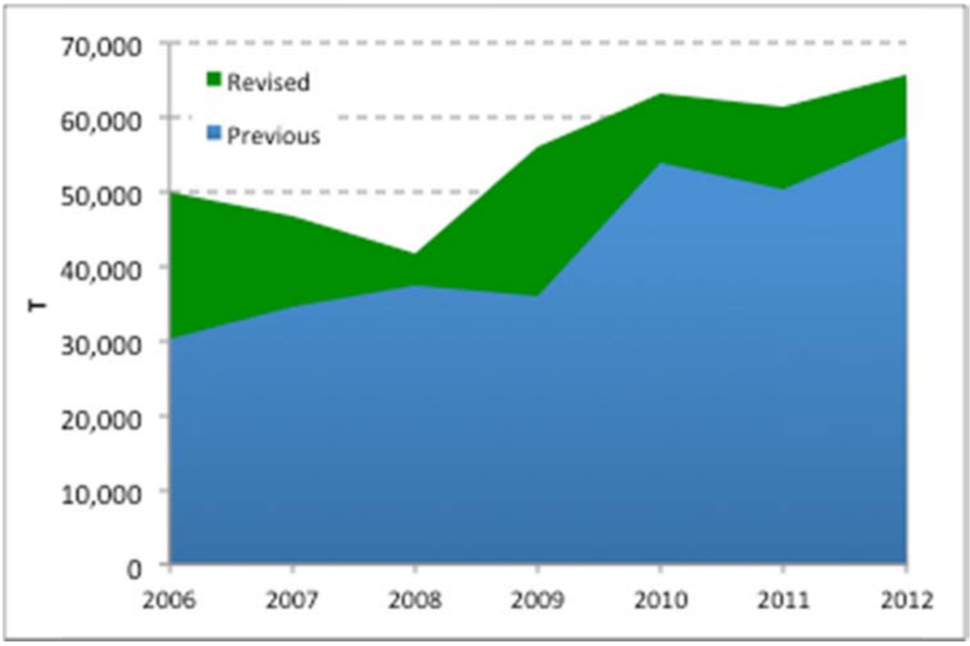

Figure 5. Comparison of the newly revised and previous estimates of skipjack landings made by Ghanaian purse seine and baitboat vessels based on the revision documented in SCRS/2014/088.

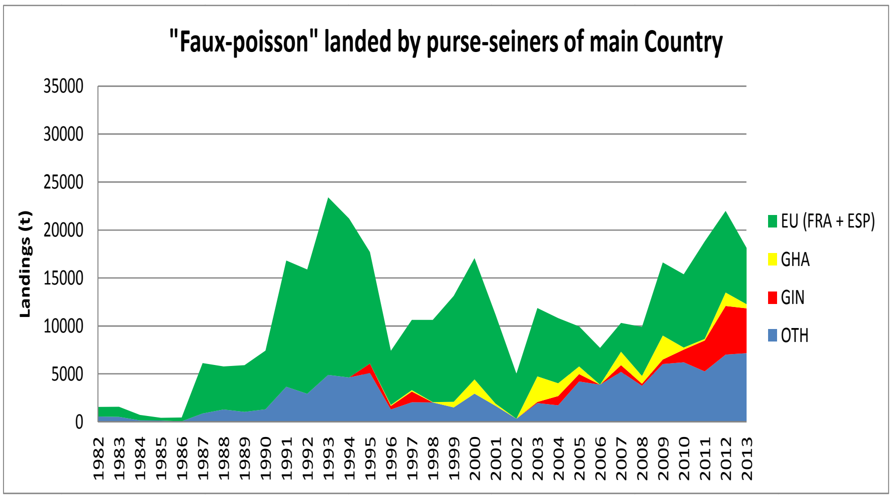

Figure 6. Cumulative estimated total landings of *faux poisson* (1982-2013) by purse seiners of the main flags.

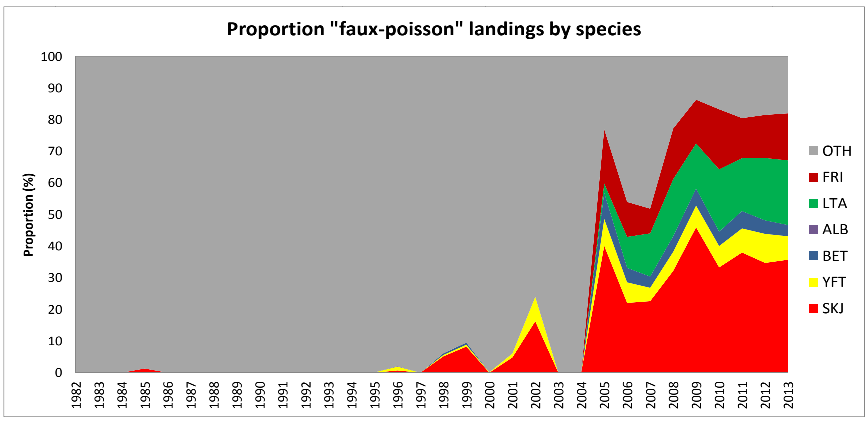

Figure 7. Proportion by species of *faux poisson* landed in Abidjan (1982-2013).

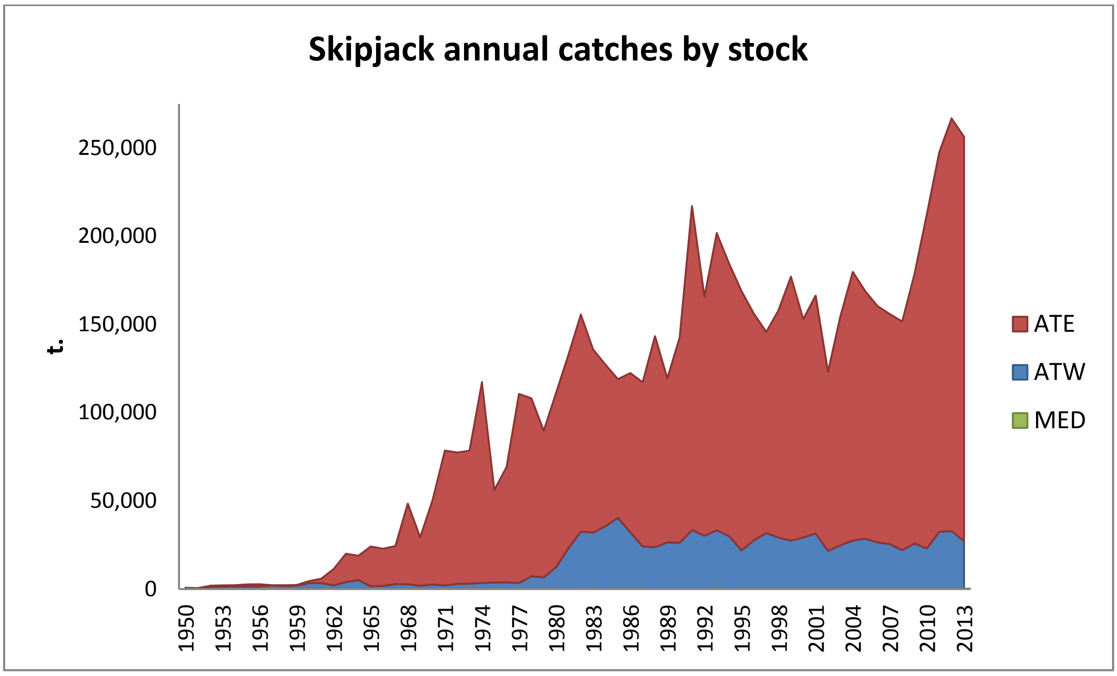

Figure 8. Cumulative Task I nominal catch (t) by stock of skipjack tuna.

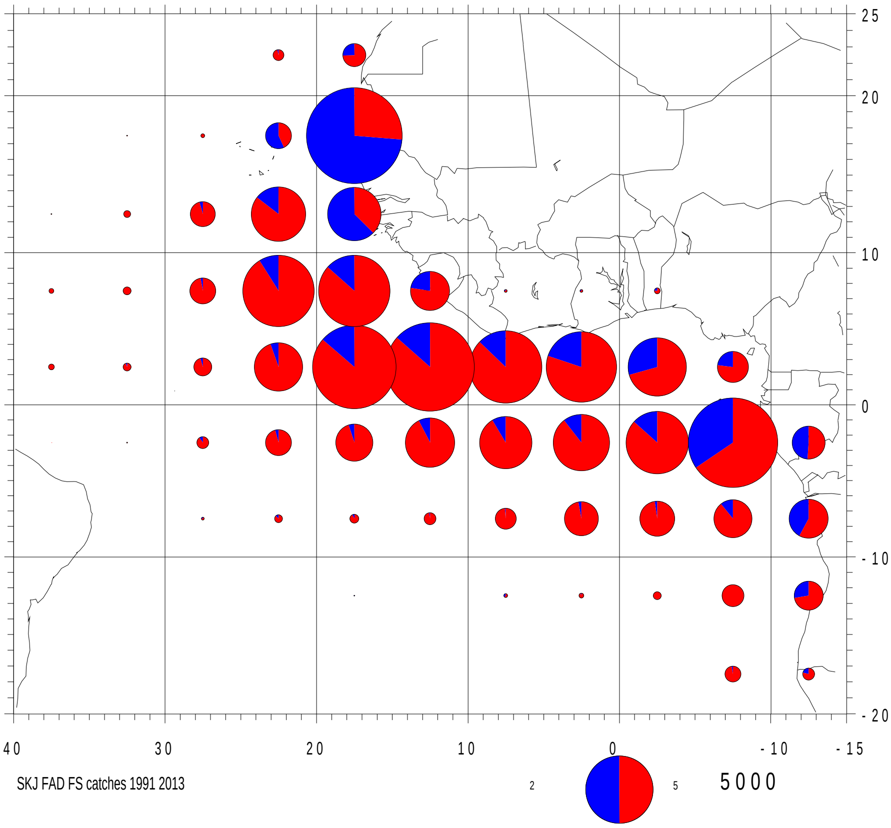

Figure 9. Geographical distribution of SKJ catches (t) (1950 to 2012) for BB [upper left] and PS [upper right], and, by PS fishing mode (FAD/Free school) in two periods (2000-2009 and 2010-2012). Upper panel maps obtaained from STAT BULL 42(I) published on May/2014. Lower panel produced by the Working Group.

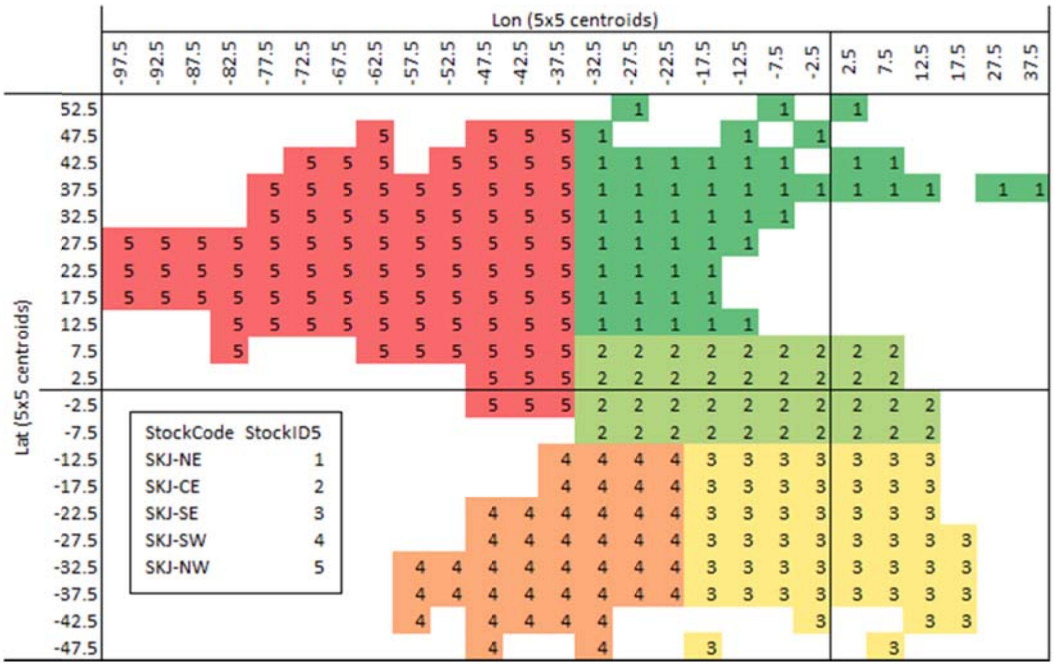

Figure 10. CATDIS 5x5 square grid set classified into the five stock hypothesis (classification algorithm result).

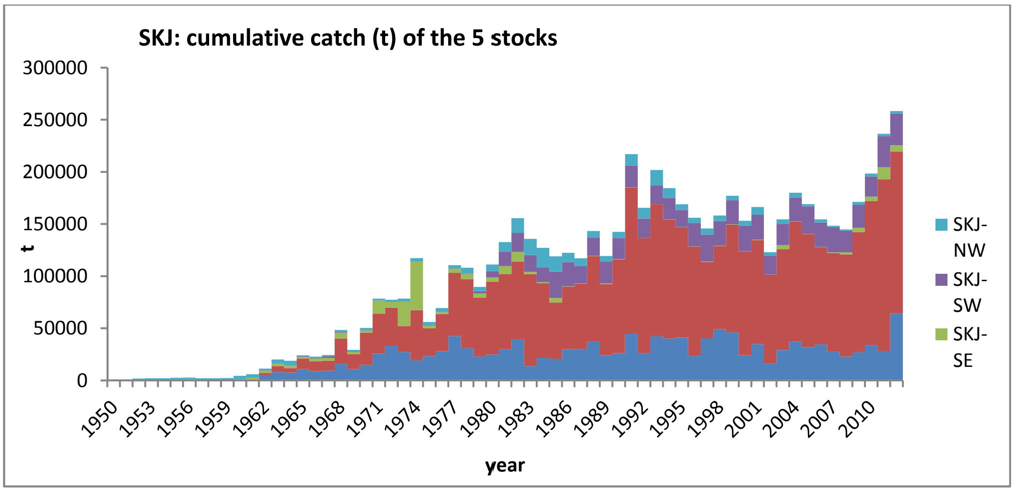

Figure 11. Cumulative catch (t) per stock (CATDIS with the 5 stock hypotheses).

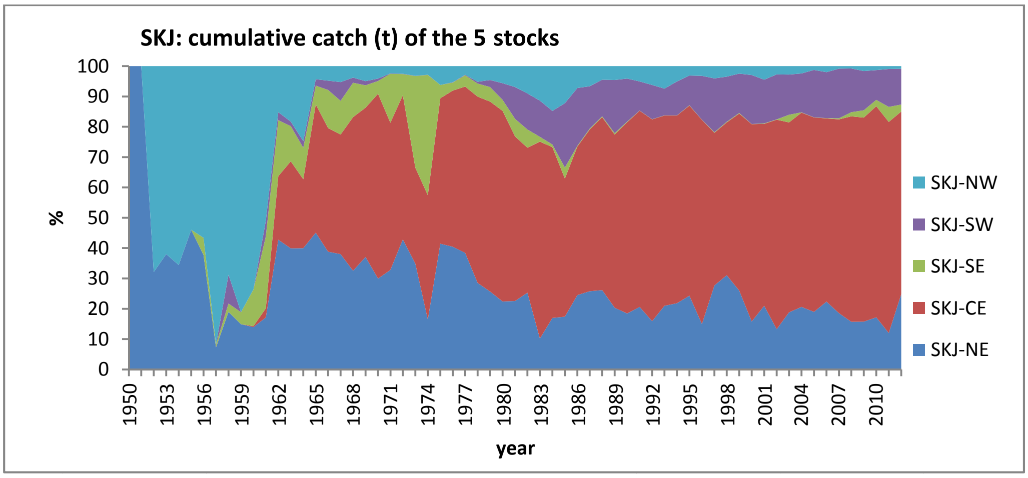

Figure 12. Relative proportion (%) of each stock per year.

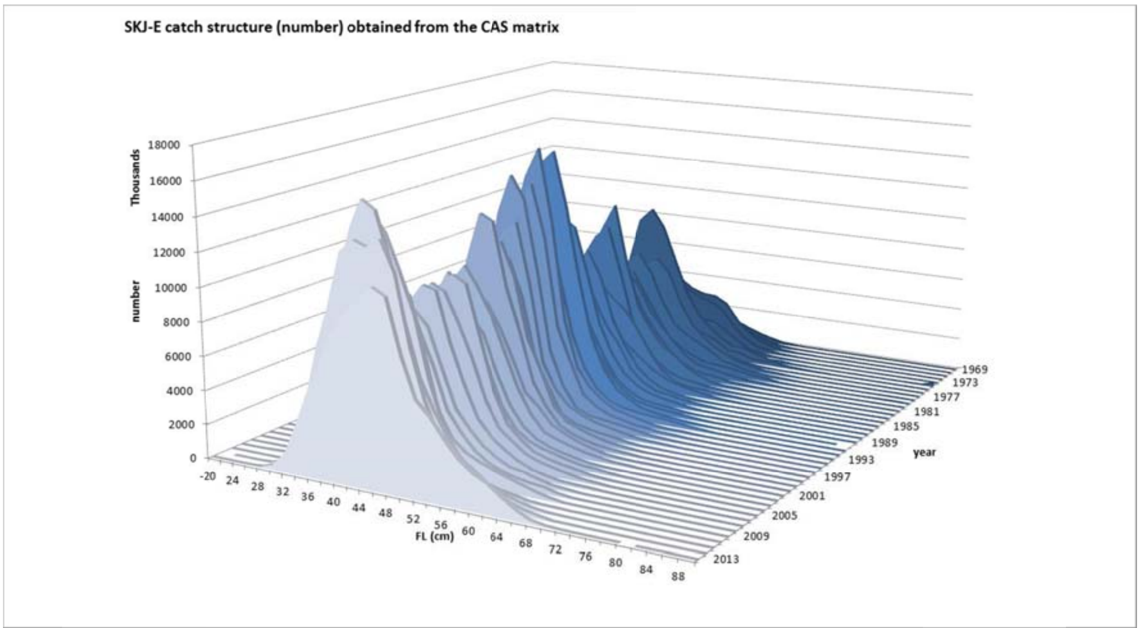

Figure 13. SKJ-E size (FL 2 cm lower limit classes) composition of the catches from 1969 to 2013.

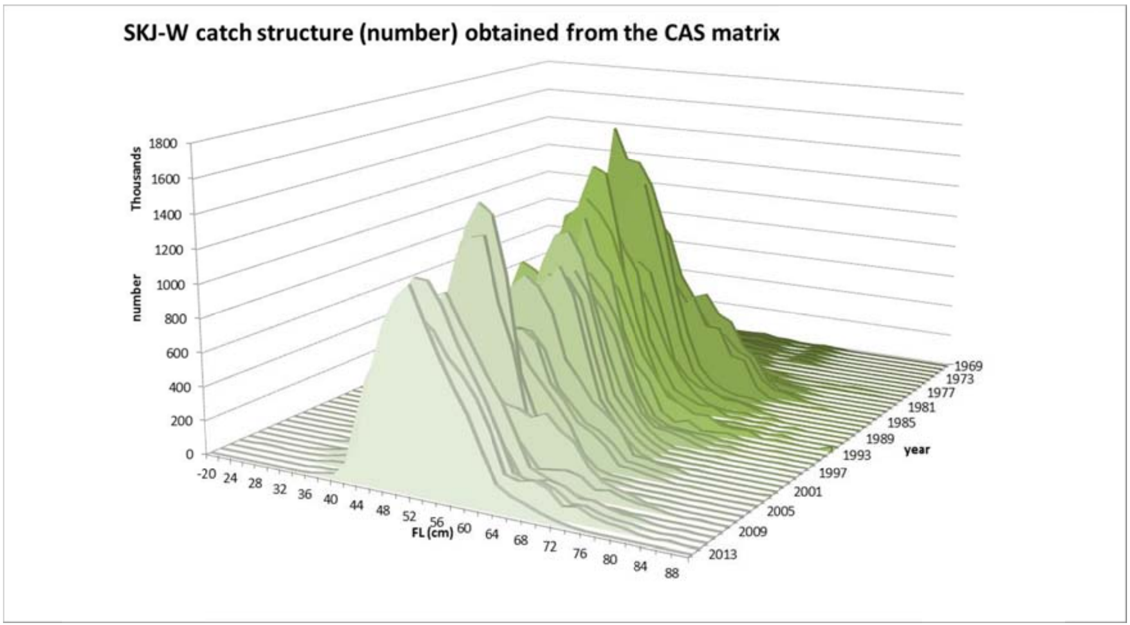

Figure 14. SKJ-W size (FL 2 cm lower limit **c**lasses) composition of the catches from 1969 to 2013.

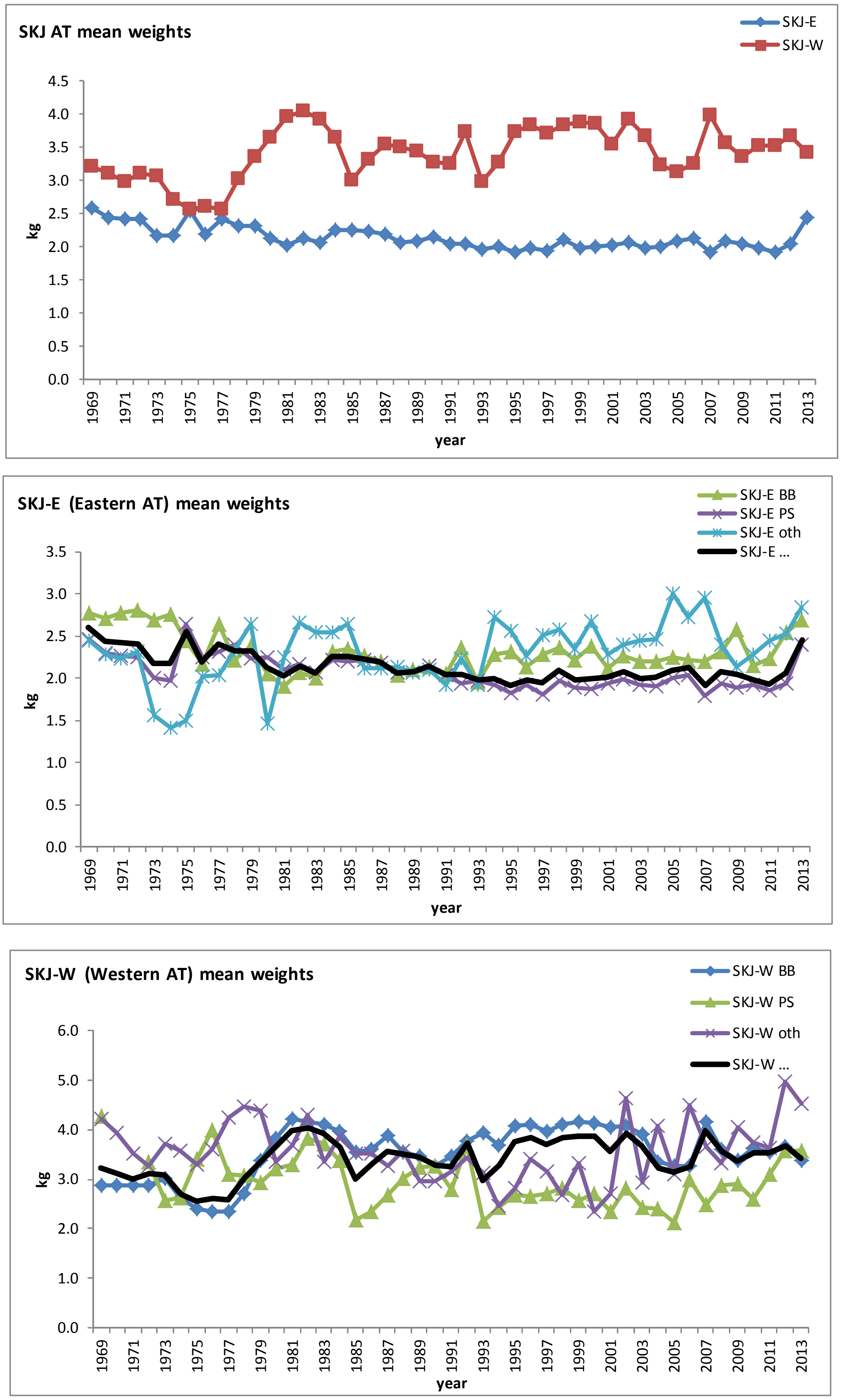

Figure 15. SKJ mean weights (weighted means estimated from the CAS dataset) by stock (upper), and within each stock, by major gear for SKJ-E (center) and SKJ-W (lower). All the series between 1969 and 2013.

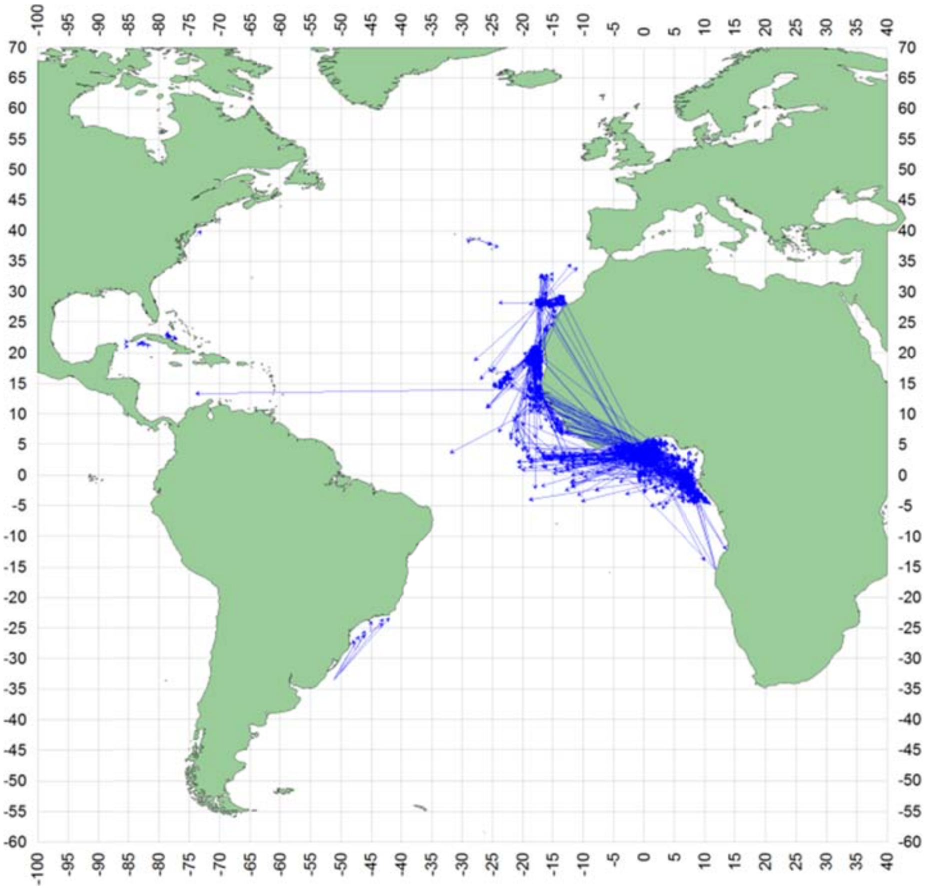

Figure 16. SKJ apparent movement (straight displacement between released and recovered geographical positions) obtained from conventional tagging.

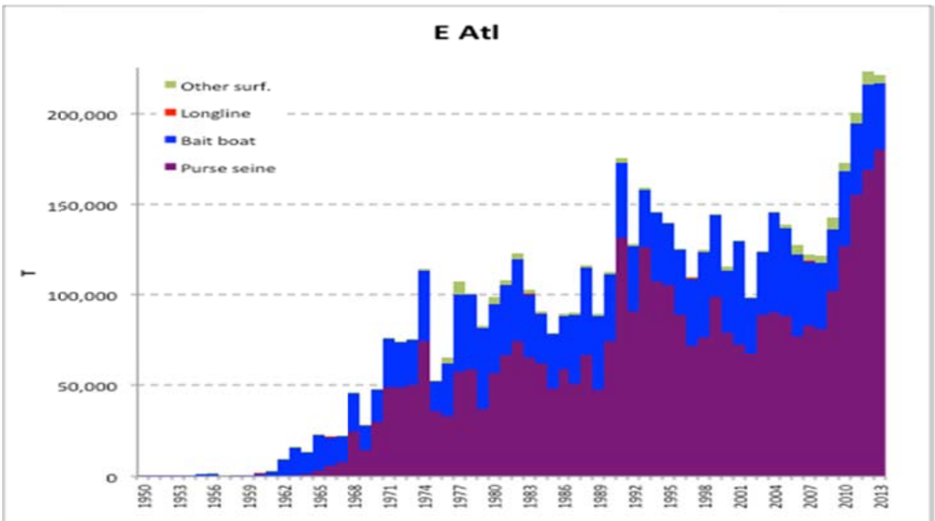

Figure 17. Eastern Atlantic catches of skipjack by gear as used by the Working Group for the 2014 stock assessment.

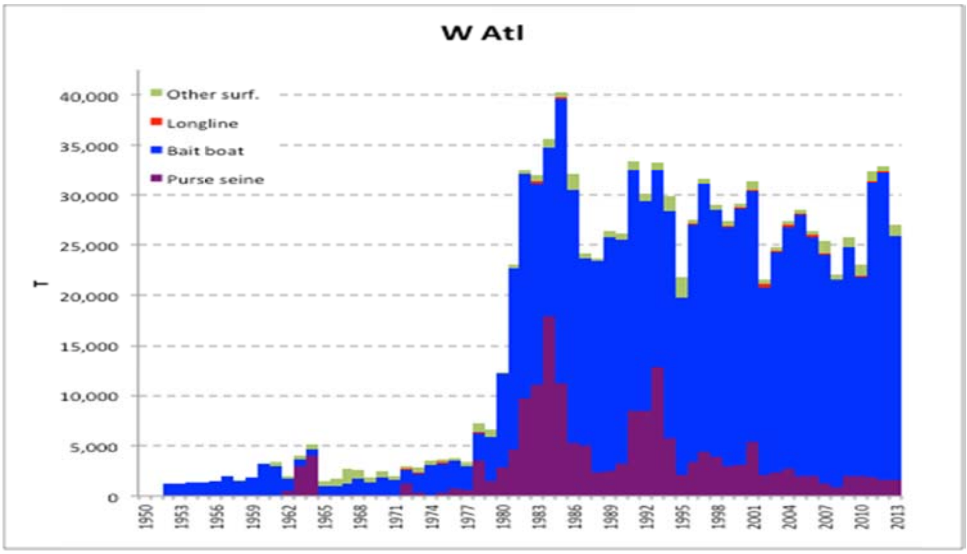

Figure 18. Catches of skipjack by gear in the Western Atlantic as used by the Working Group for the 2014 stock assessment.

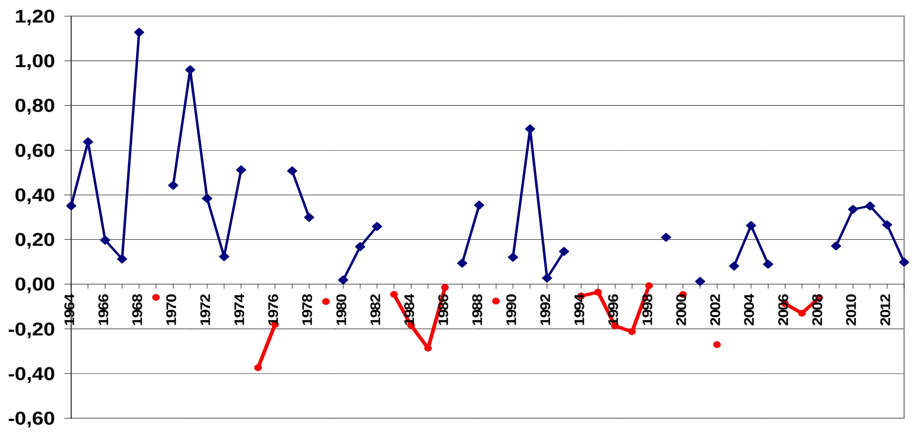

Figure 19. Rates of catch increase (in blue) and catch decrease (red) comparing yearly SKJ catches to the average of SKJ catches (Eastern Atlantic) during the 3 previous years.

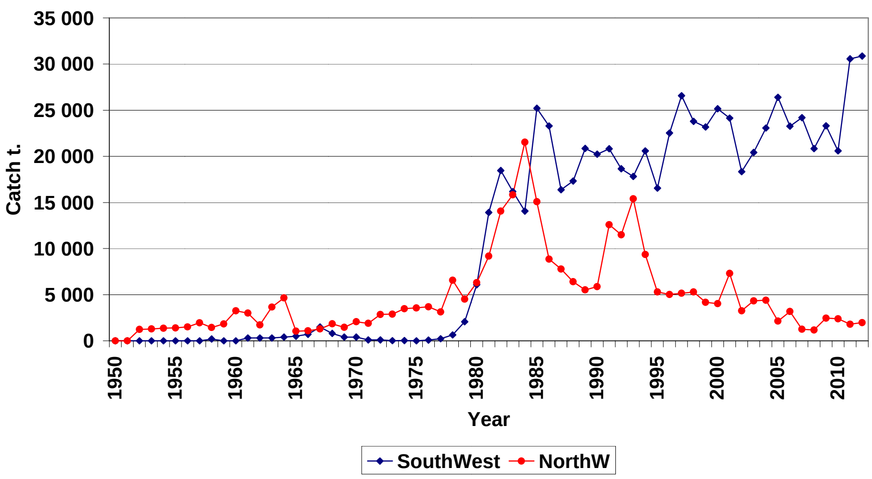

Figure 20. SKJ catches in the Northern and Southern W Atlantic.

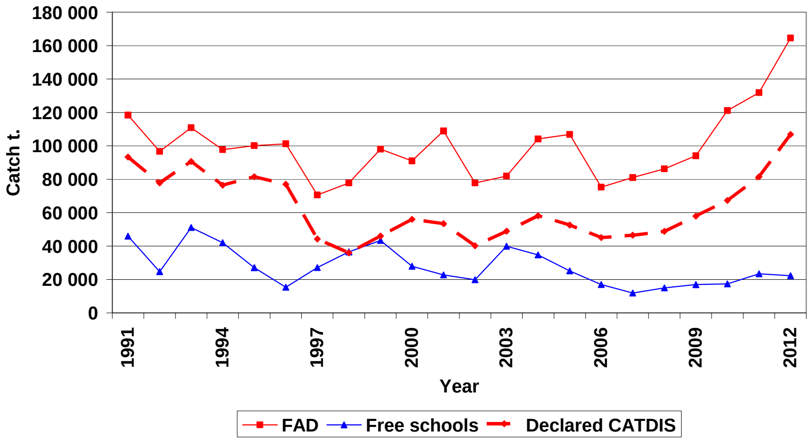

Figure 21. Estimated yearly SKJ catches on FAD and on Free schools in the Eastern Atlantic. Dotted line showing the official CATDIS data, full line ("FAD") showing total SKJ catches assuming that all Ghanaian SKJ catches were associated to FADs.

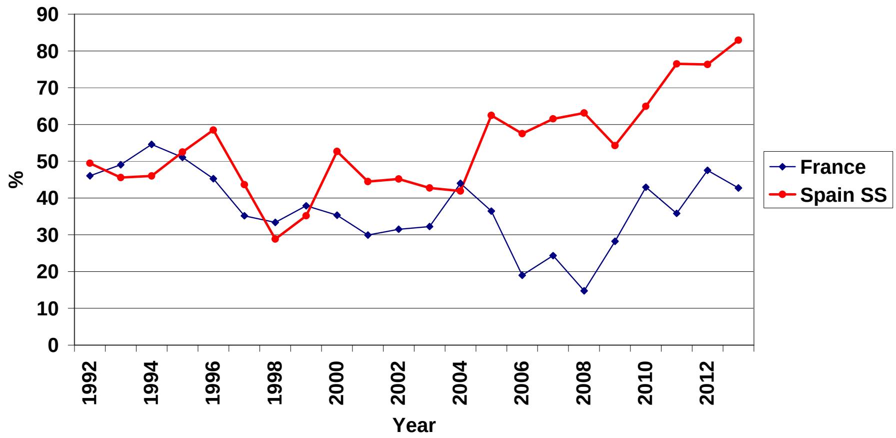

Figure 22. Yearly % of FAD associated catches in the French and Spanish PS (all species).

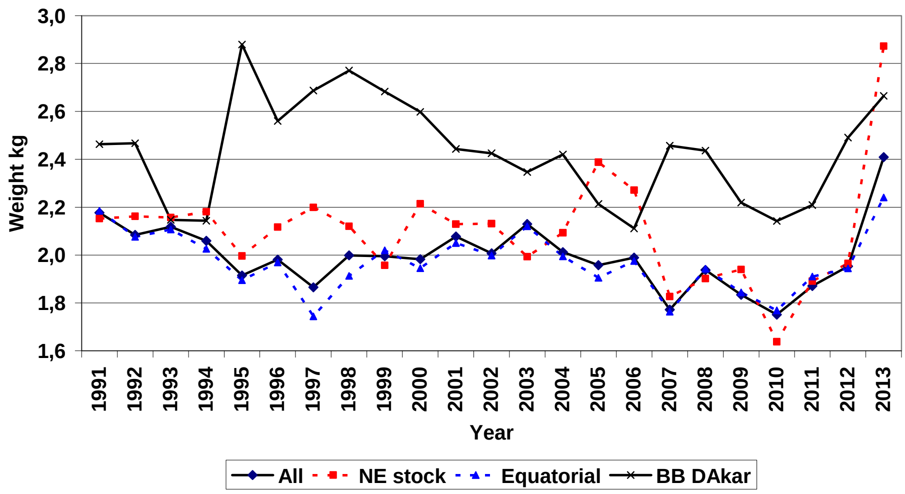

Figure 23. Average weight of SKJ caught by the EU PS and by the Dakar baitboat, total and in various areas (in the Eastern Atlantic).

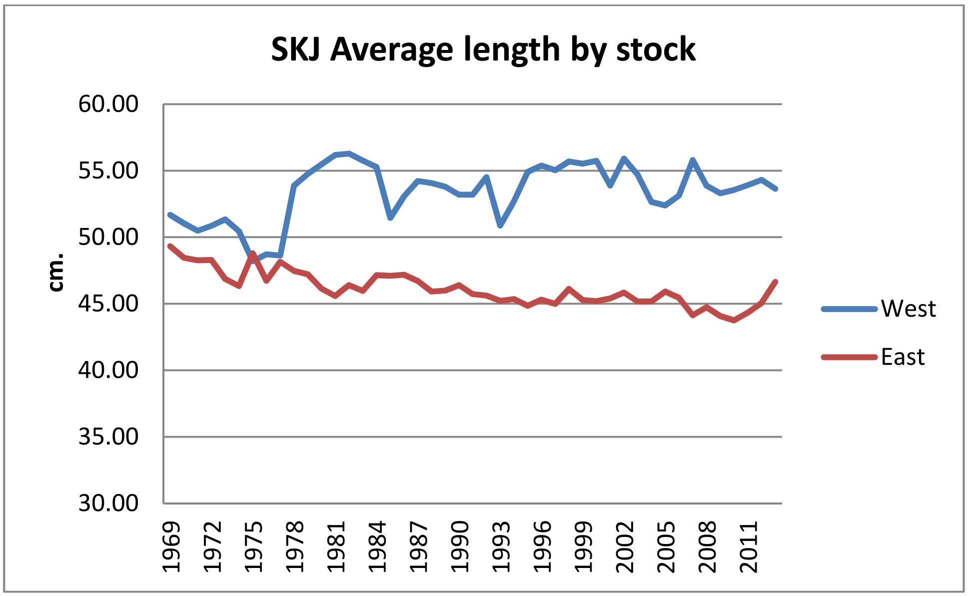

Figure 24. Skipjack average length by stock.

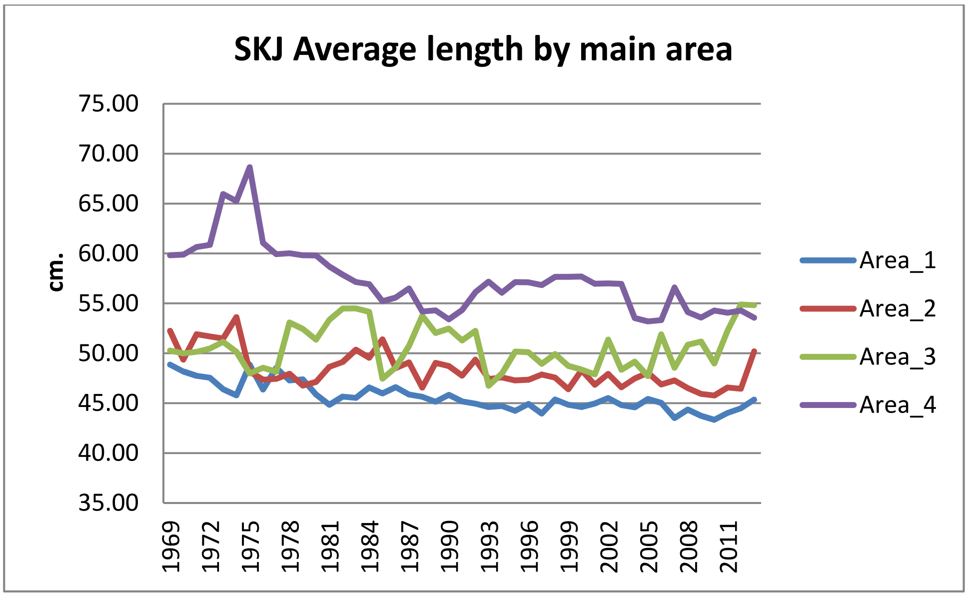

Figure 25. Skipjack average length by main area.

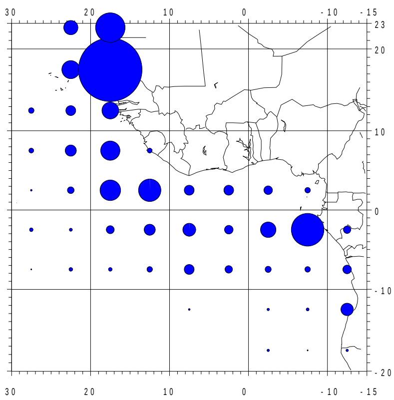

Figure 26. Average catches of large SKJ large SKJ >56 cm / EU PS during the period 2012-2013.

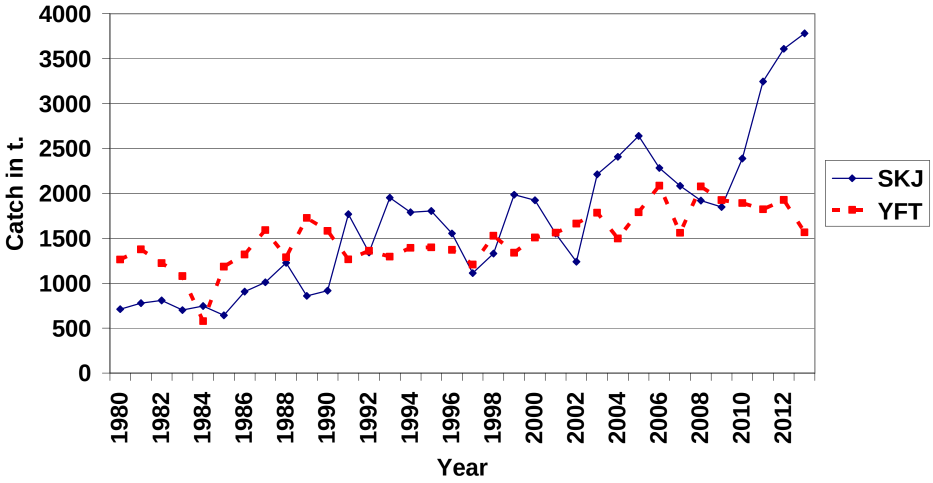

Figure 27. Average yearly SKJ catches per PS vessel (EU and associated fleet).

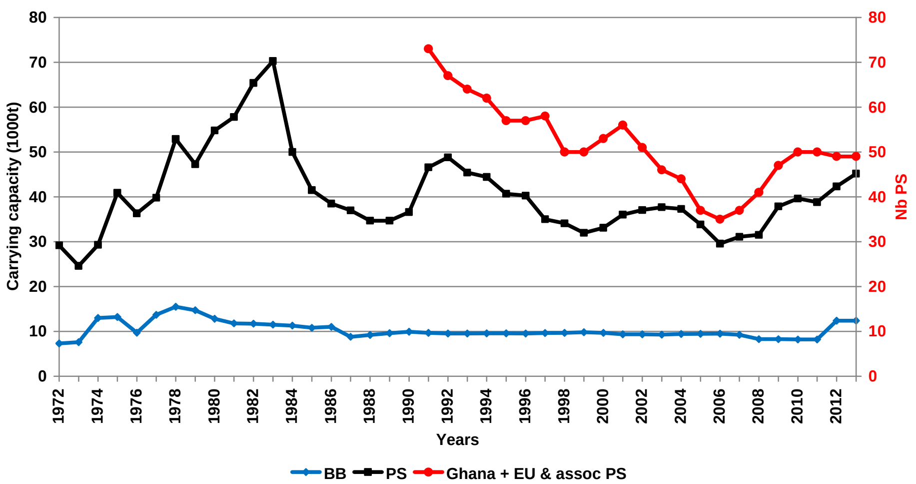

Figure 28. Nominal carrying capacity of PS and BB in the Eastern Atlantic and total number of PS.

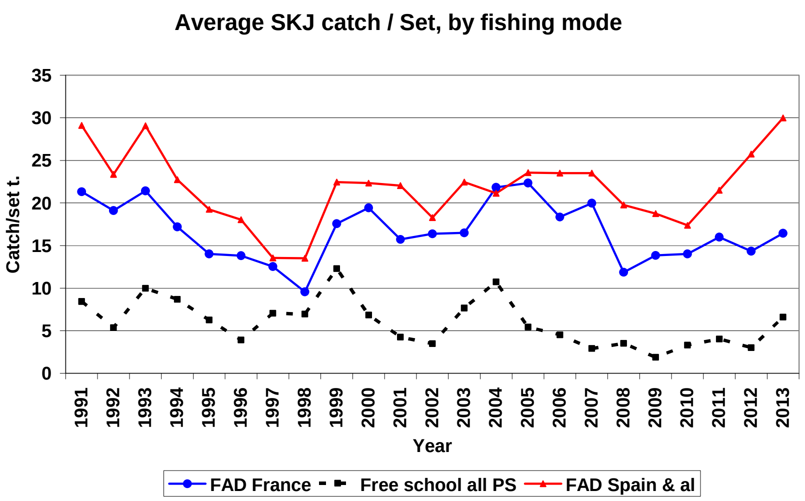

Figure 29. Average catch per set of SKJ (EU PS fleet) on FAD (French and Spanish+associated fleet) and on free schools (all PS).

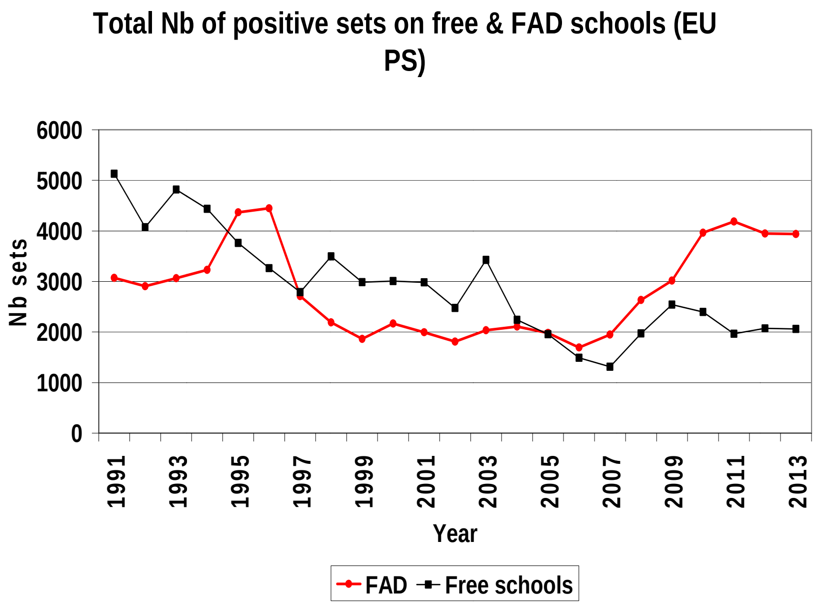

Figure 30. Total yearly number of positive sets on free schools and on FADS (EU PS fleet).

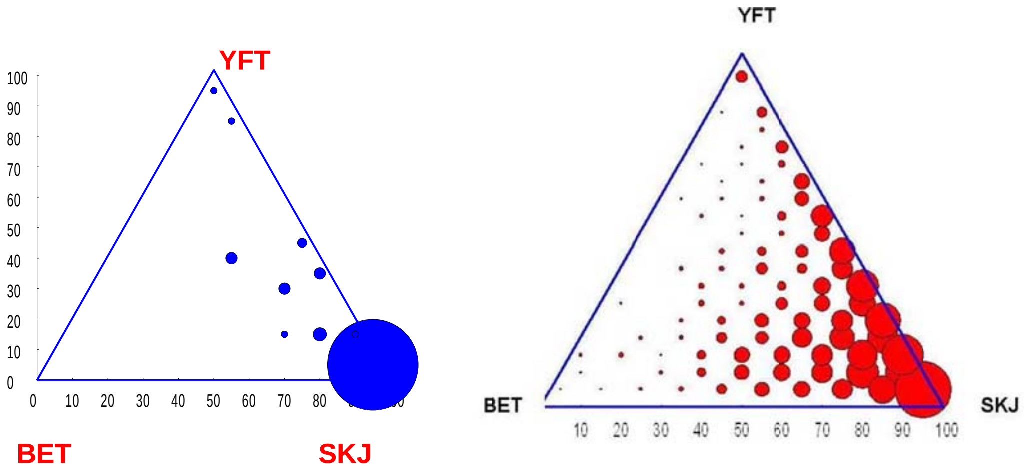

Figure 31. Species composition of FAD samples in the northern area (N of 10°N) (left) and in the equatorial area (right) (2000-2010).

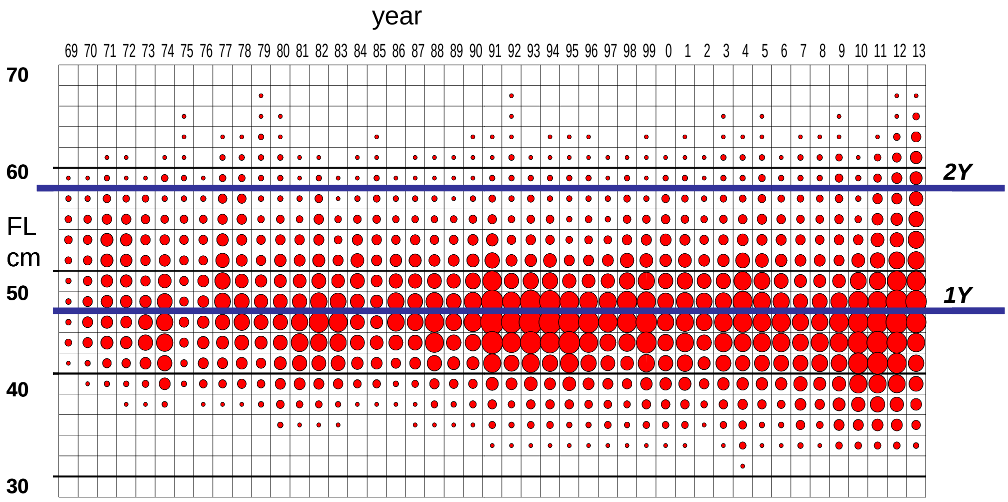

Figure 32. Yearly SKJ catch at size in weight in the eastern Atlantic, and lines potentially showing ages 1 and 2 and the size at first maturity.

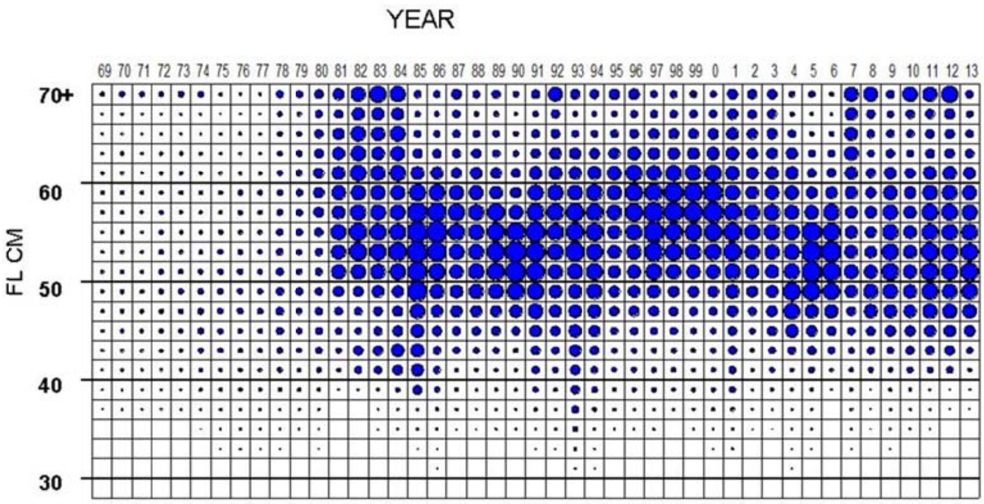

Figure 33. Yearly SKJ catch at size in weight in the western Atlantic, and lines potentially showing ages 1 and 2 and the size at first maturity.

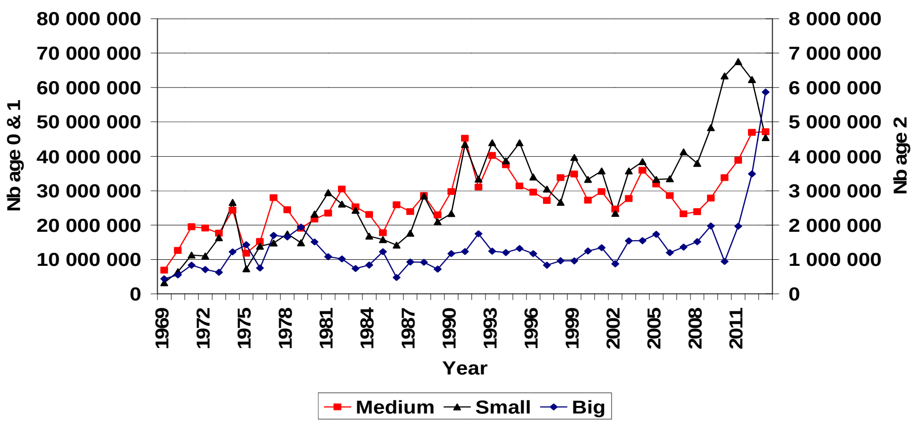

Figure 34. Yearly catches of 3 categories of SKJ in the Eastern Atlantic, small (0-46 cm), medium (46-60 cm) and big (over 60 cm), corresponding approximately to catches of ages 0, 1 and 2+ (based on the 2014 CAS figure).

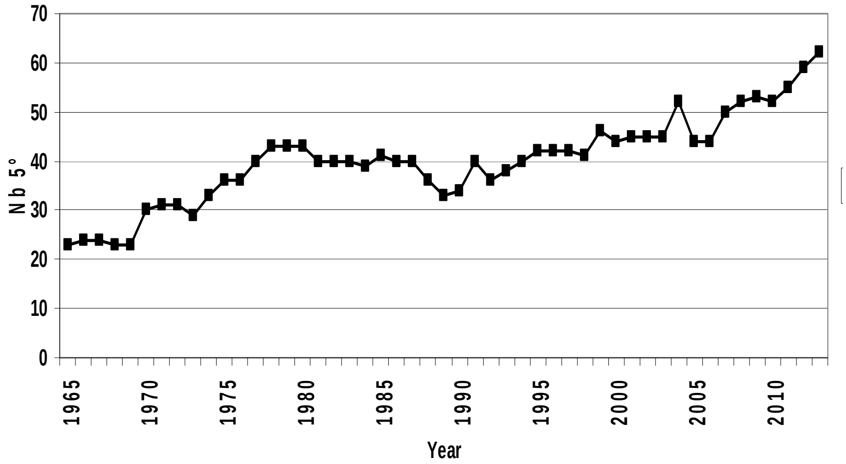

Figure 35. Number of 5° squares fished yearly in the entire Atlantic by all fleets (CATDIS file) with a yearly SKJ catch >10 t.

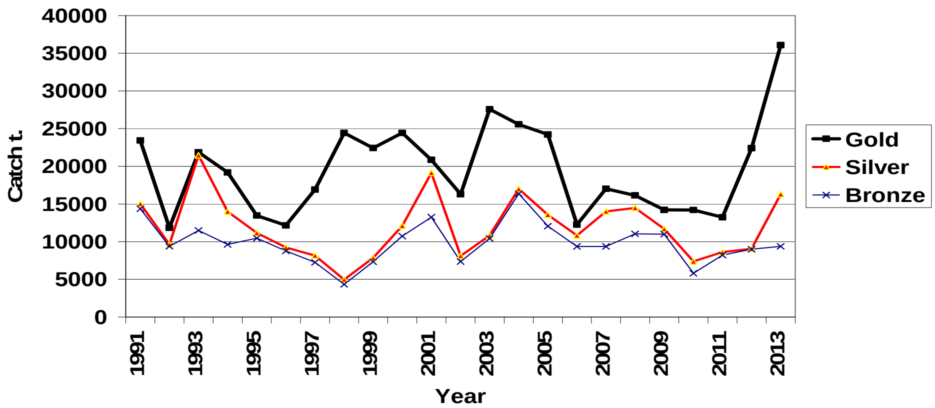

Figure 36. 3 yearly "best catches" observed in the 5° squares shower the higher catches of SKJ.

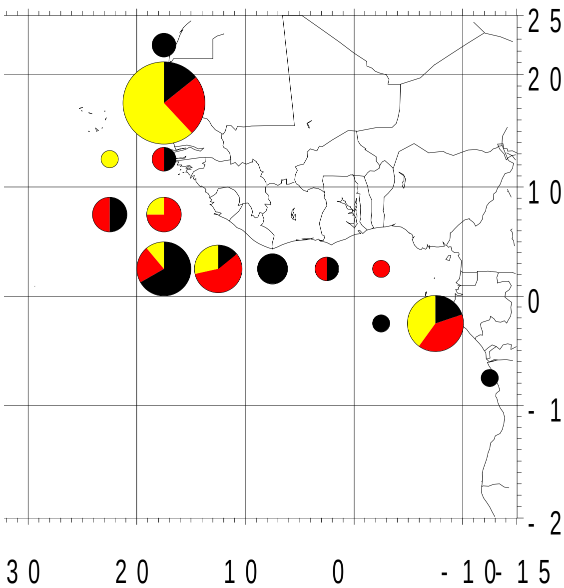

Figure 37. Geographical frequency of the 3 ranks of best SKJ yearly catches observed in the EU fleet during the 1991-2013 period (yellow: best catches, red: 2nd catches and black: 3rd catches).

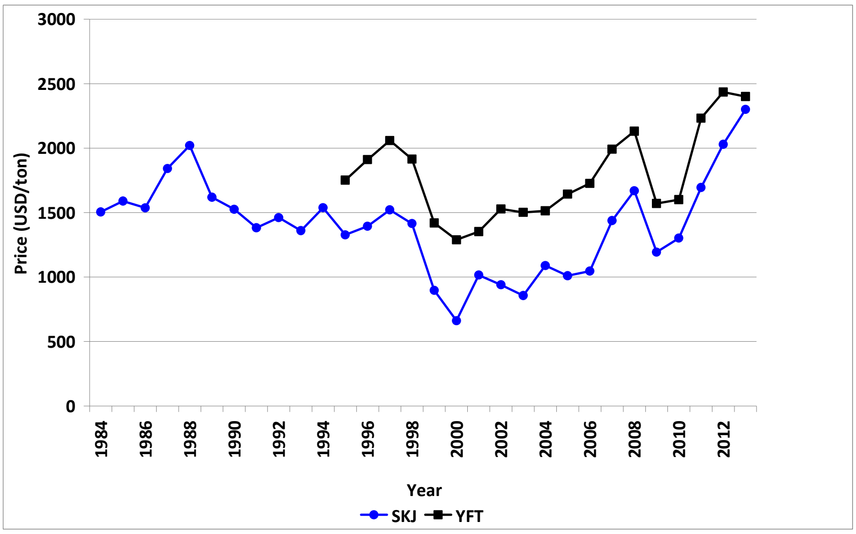

Figure 38. Average yearly price of SKJ and YFT (corrected for inflation in the US and converted to 2013 $) in the Bangkok market.

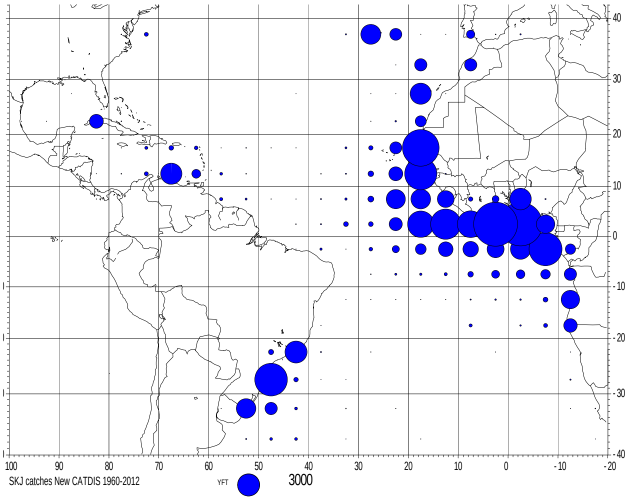

Figure 39. Average location of SKJ catches during the period 1970-2012 (CATDIS file).

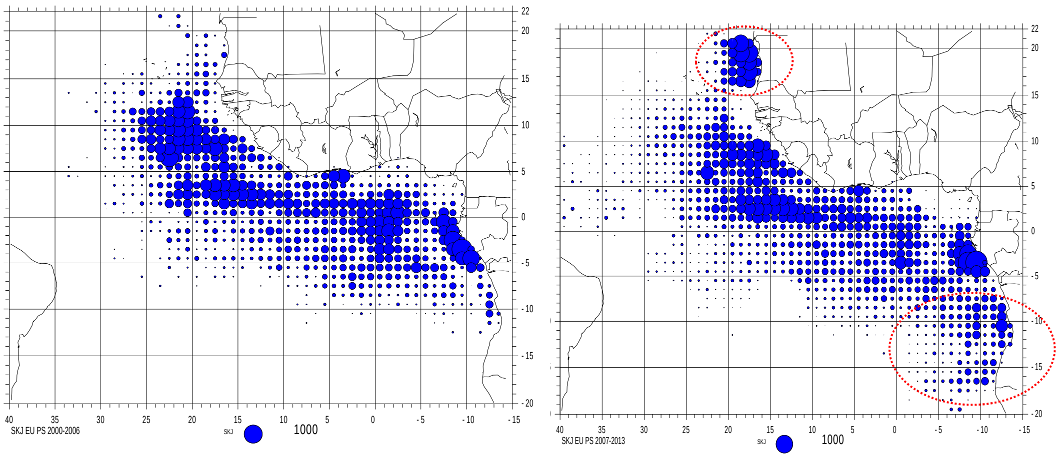

Figure 40. Average SKJ catches by 1° square of the EU PS fleet during 2 recent periods: left 2000-2006 and right 2007-2013.

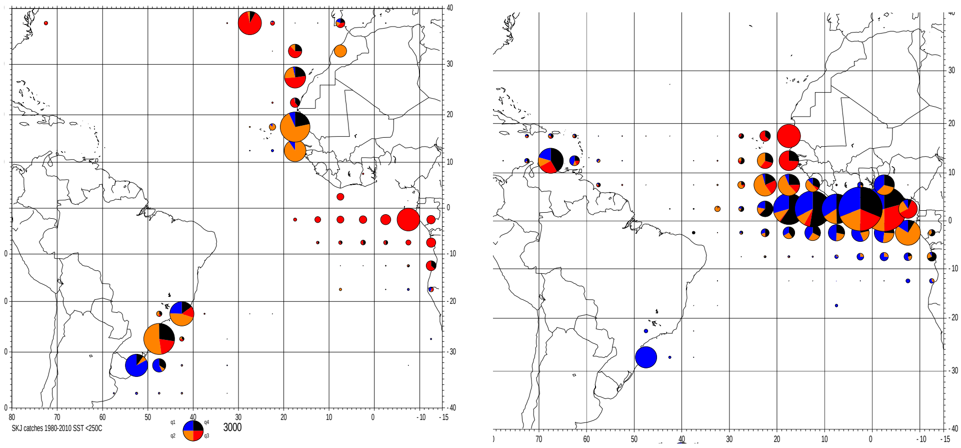

Figure 41. average SKJ catches caught quarterly at SST <25°C (left) and >25º (right) (1st q: blue, 2nd q: orange, 3rd q: red, 4th q black).

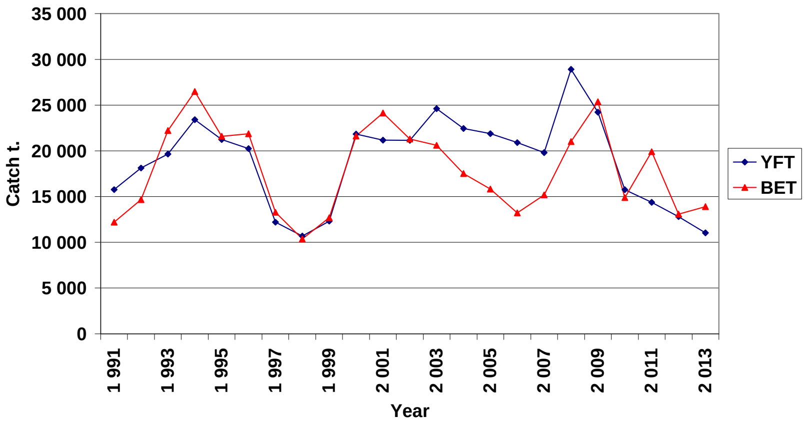

Figure 42. Yearly catches of YFT and BET in the EUPS FAD fishery.

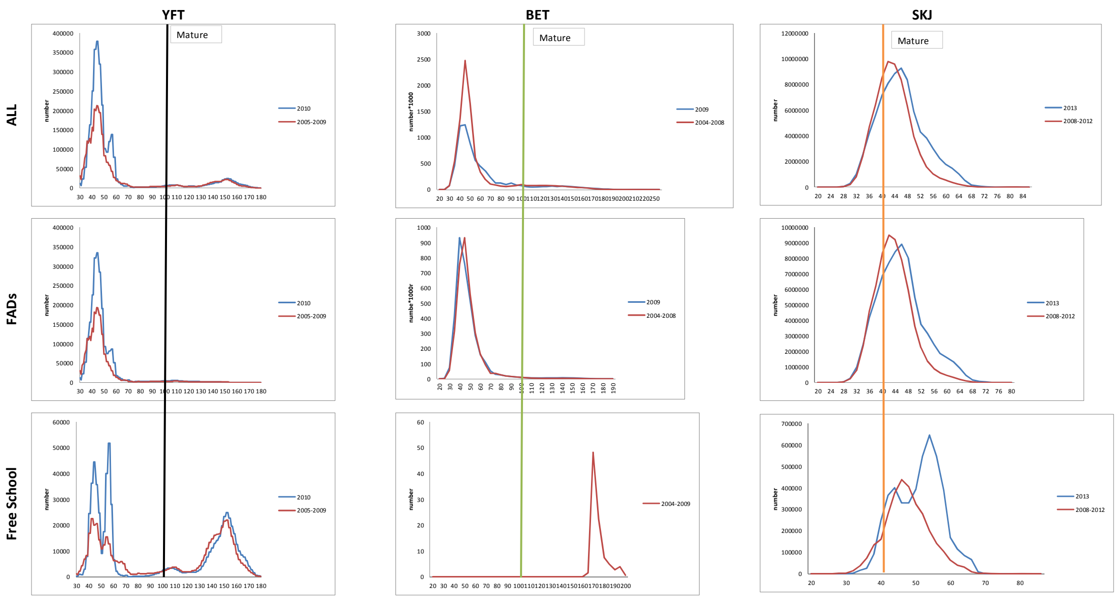

Figure 43. Size distribution of skipjack, yellowfin and bigeye purse seine catch made by Free School sets (FSC), FAD sets, and combined (ALL) relative to assumed size at maturity.

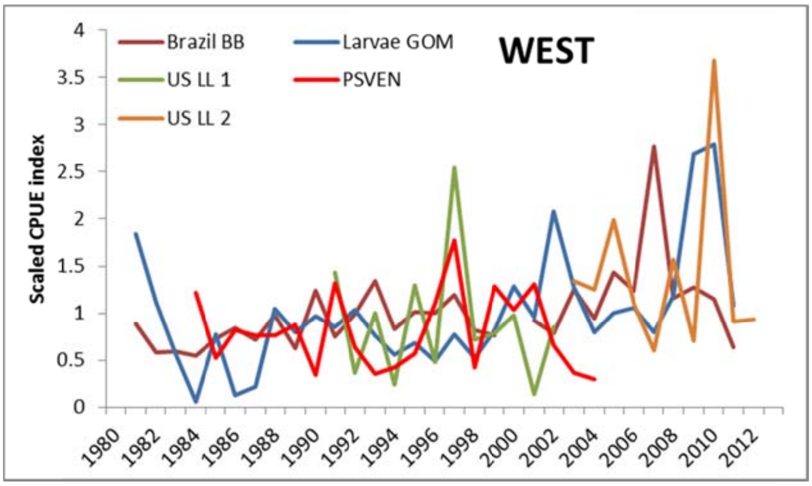

Figure 44. Relative abundance indices for the western stock of skipjack. Indices are initially scaled to their own mean. In order to facilitate viewing the LL indices and the purse seine index are then scaled to the average of the larval GOM index (the longest index of all) over the range of years that each index overlaps with the larval GOM index.

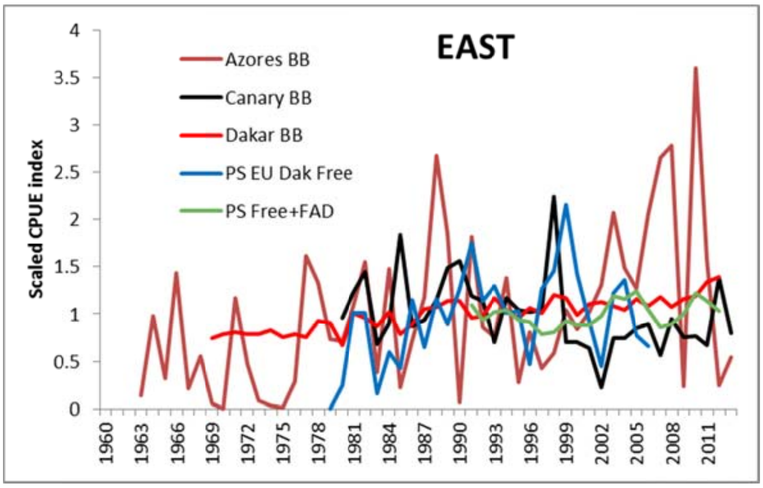

Figure 45. Relative abundance indices for the eastern stock of skipjack. Indices are initially scaled to their own mean. In order to facilitate viewing the purse seine indices are then scaled to the average of the Azores baitboat index (the longest index of all) over the range of years that each of the purse seine indices overlaps with the Azores index.

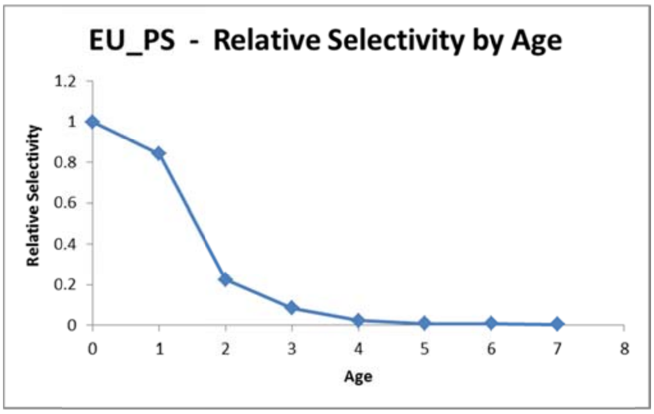

Figure 46. Selectivity of purse seine fleet towards bigeye tuna as a function of age, as estimated for the BET VPA from 2010 assessment.

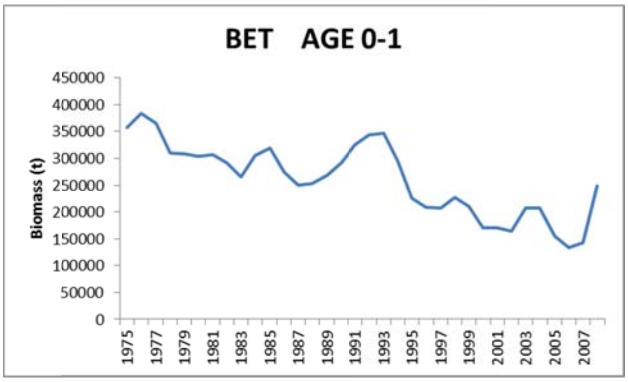

Figure 47. Estimated biomass of age zero and one bigeye tuna estimated by VPA without using the purse seine index in the estimation.

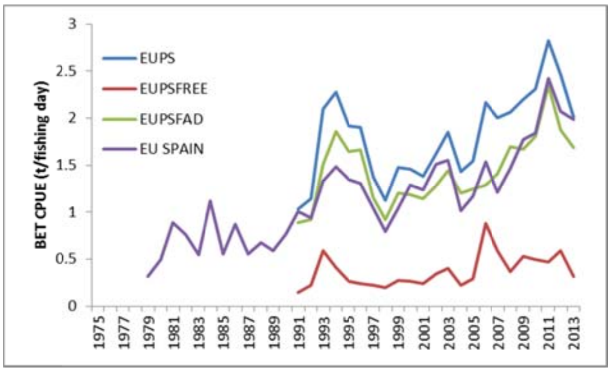

Figure 48. Estimated bigeye tuna nominal CPUE for various purse seine fleet aggregates.

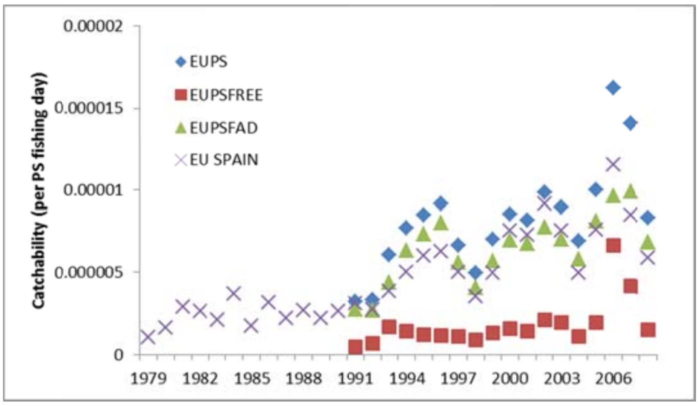

Figure 49. Estimates of bigeye tuna yearly catchability obtained by comparing estimates of biomass of young bigeye tuna to estimates of CPUE from purse seine fleets.

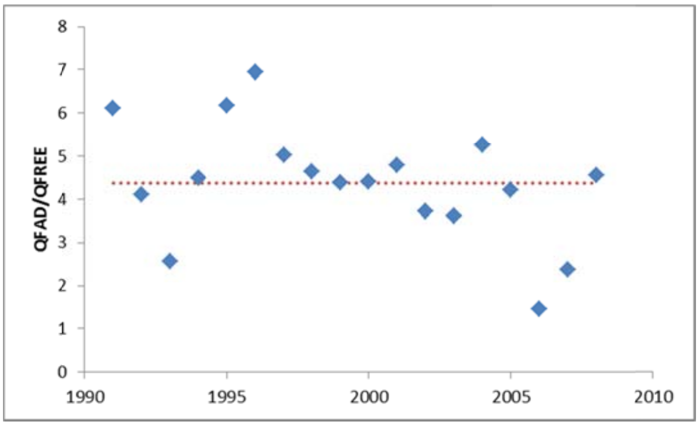

Figure 50. Estimates of the relative ratio of bigeye tuna catchability of FAD and Free school associated fishing days.

A) B)

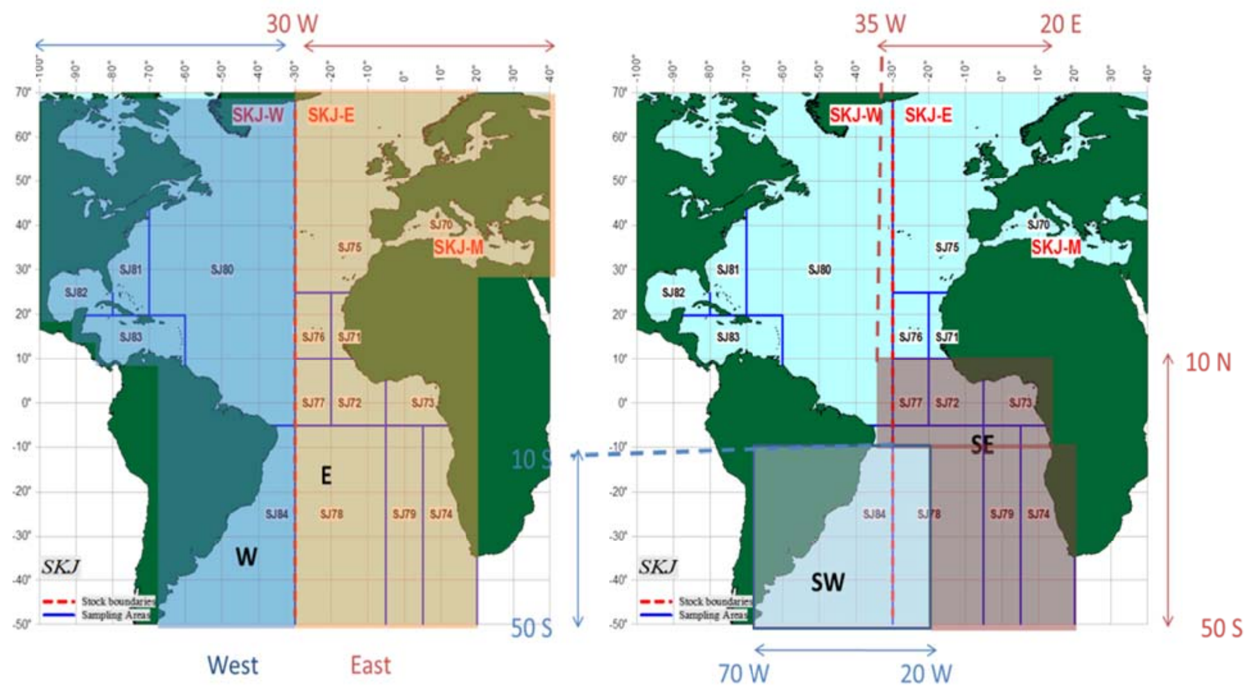

Figure 51. Geographical boundaries representations of alternative stock structure assumptions, (A) two stocks East and West separated by the 30 West Meridian, and (B) metapopulation representation of numerous stocks. Shaded areas were considered for the stock assessment models.

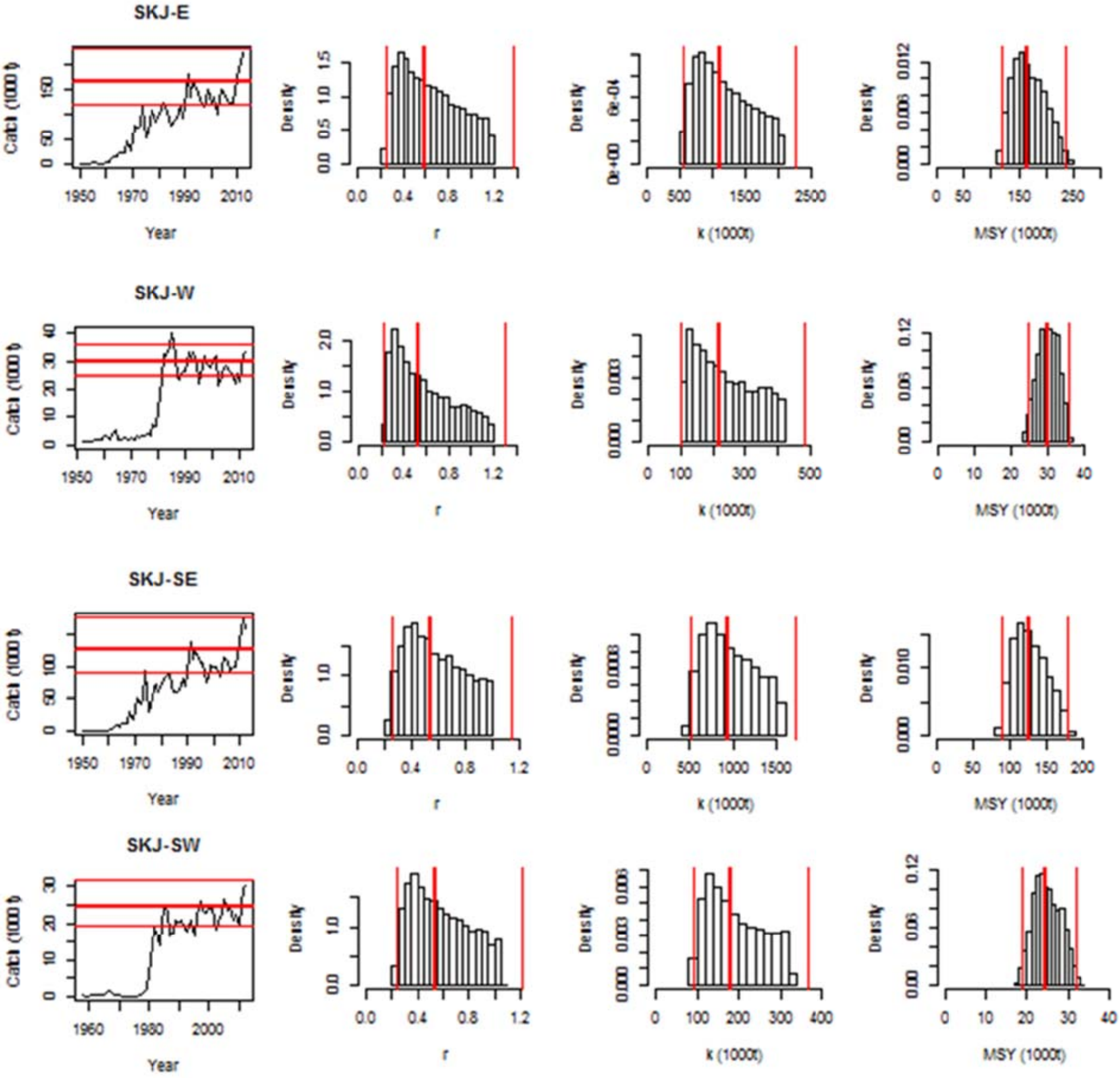

Figure 52. Medium resilience catch only model results for the East and West skipjack (upper two rows of plots), versus Southwest and Southeast stocks (lower two rows of plots) under the metapopulation structure.

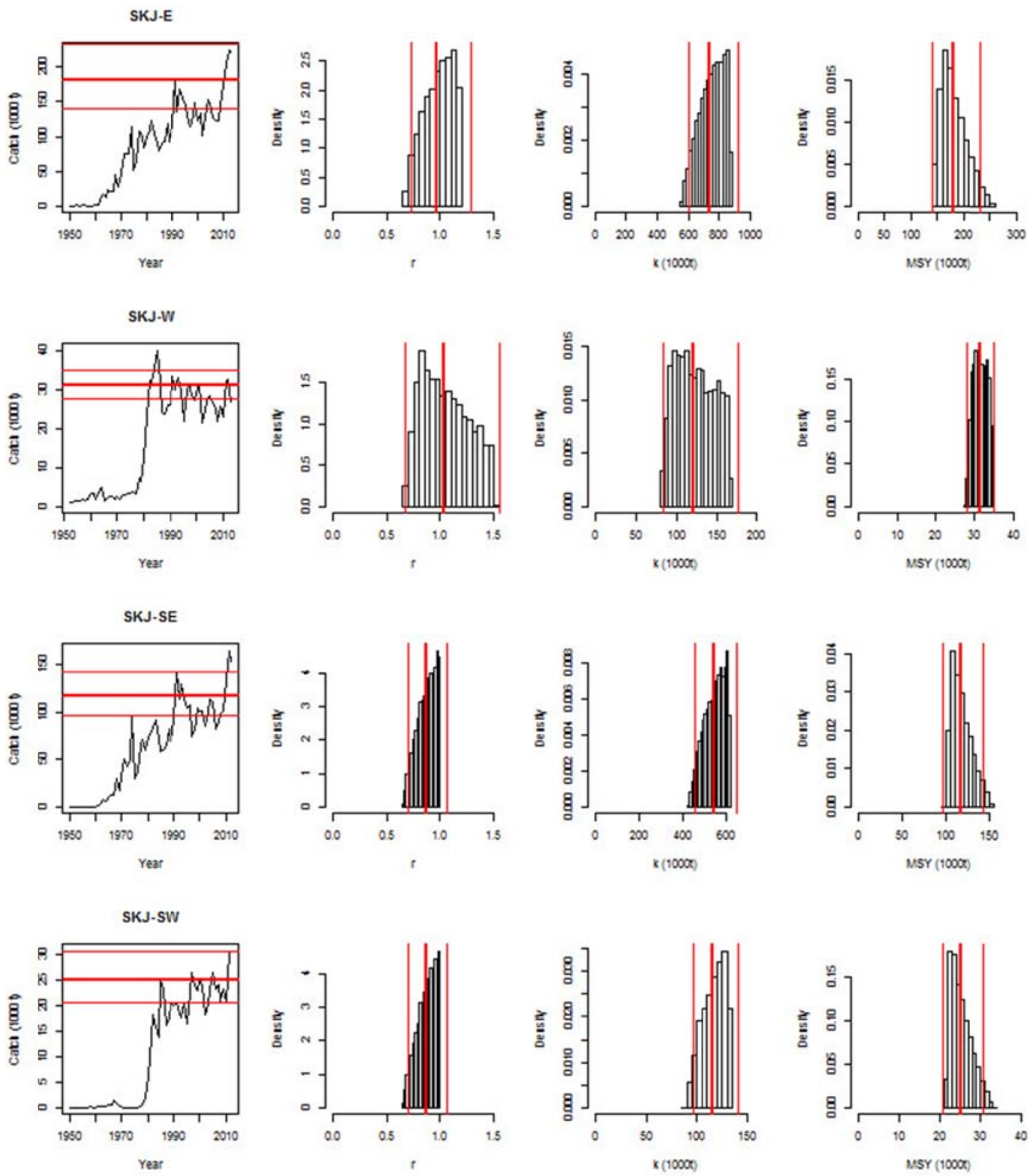

Figure 53. High resilience catch only model results for the East and West Skipjack (upper two rows of plots), versus Southwest and Southeast stocks (lower two rows of plots) under the metapopulation structure.

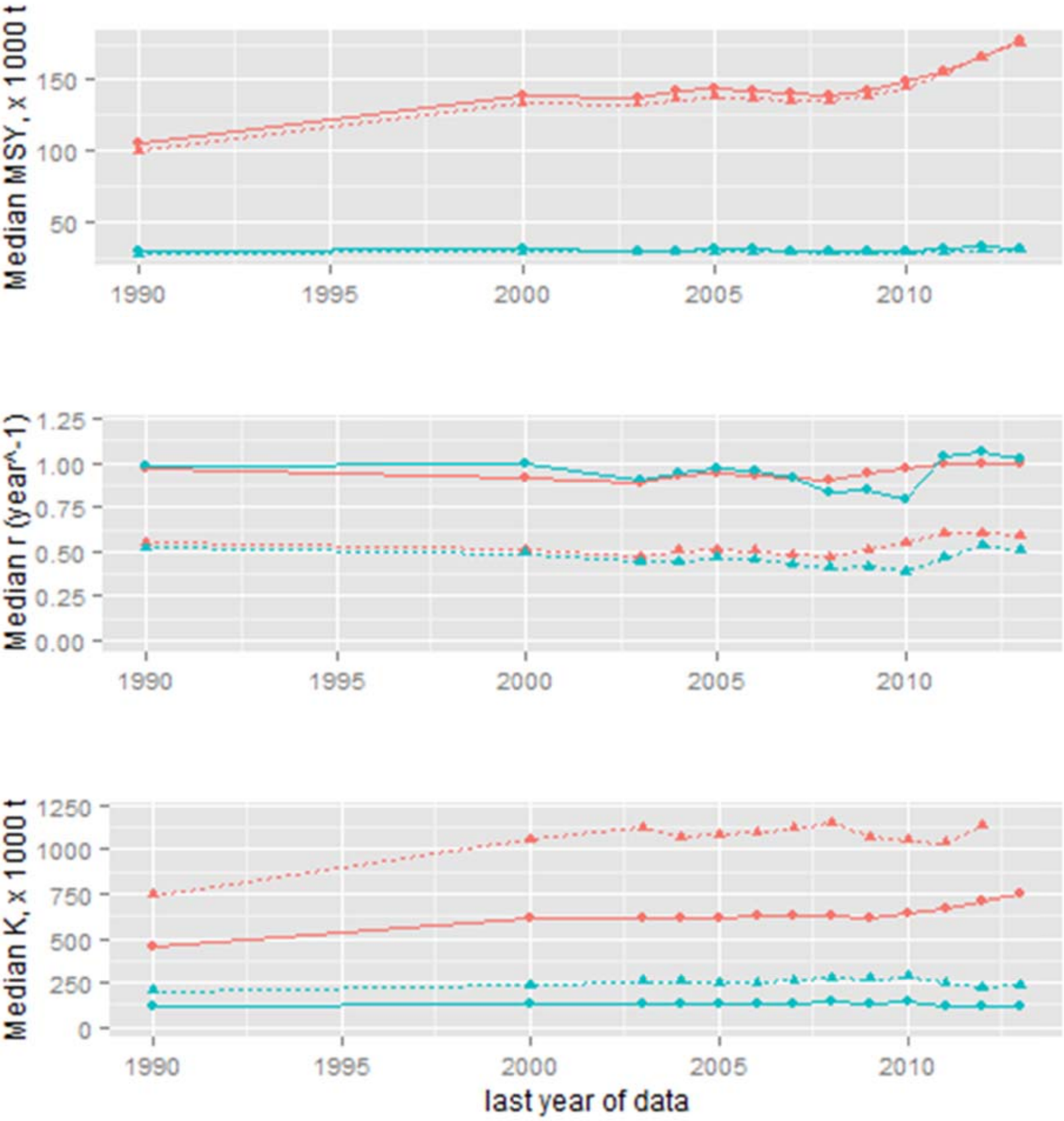

Figure 54. Estimates of intrinsic rate of population growth (r) and carrying capacity (K) for the catch only models of East and West skipjack tuna. Red: East, Blue: West. Continuous line-circles (high res), dotted line-triangles (medium res).

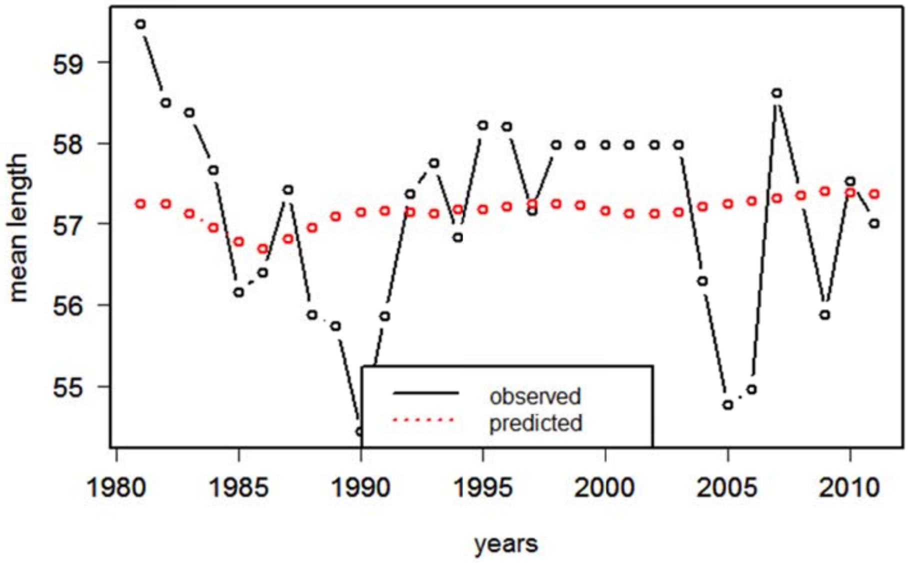

Figure 55. Observed and predicted mean lengths versus time for the mean length-based mortality model (The Hoenig-Gedamke model or THG model) fitted to length data from the Brazilian bait boat fishery and effort data from the entire western Atlantic fishery. Lc was set equal to 50 cm.

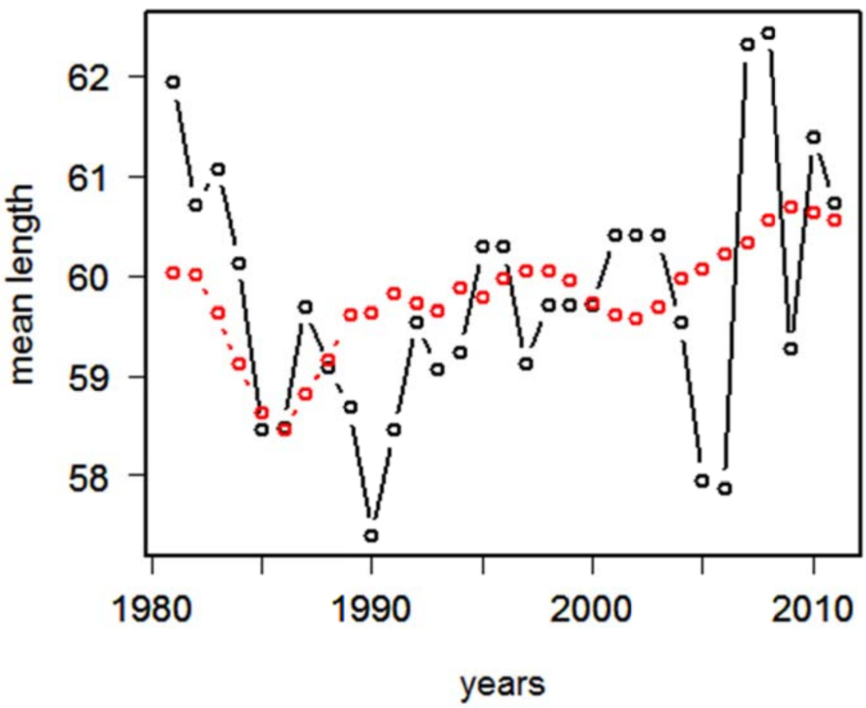

Figure 56. Observed and predicted mean lengths versus time for the THG model fitted to length data from the Brazilian baitboat fishery and effort data from the entire western Atlantic fishery. Lc was set equal to 55 cm.

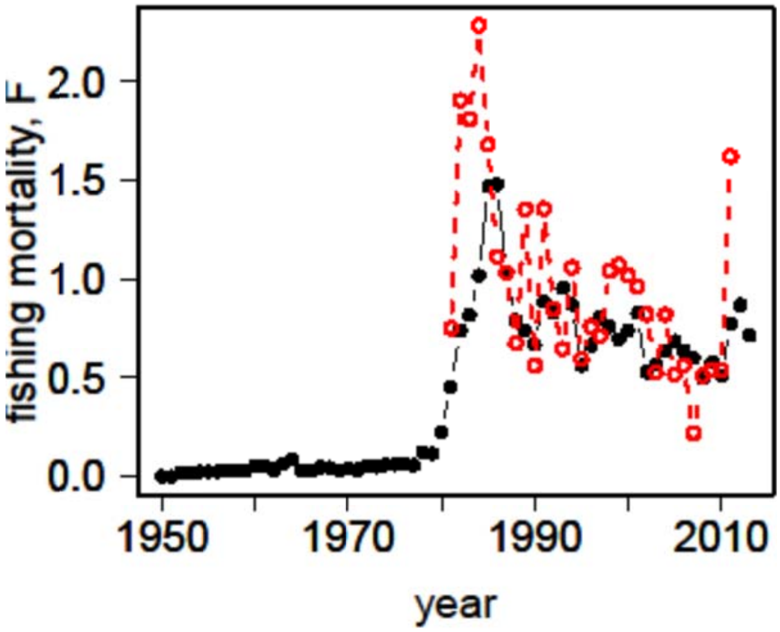

Figure 57. Comparison of fishing mortalities estimated from a production model for Western SKJ (ASPIC, black lines and solid circles) and the THG model that incorporated fishing effort (red line with open circles).

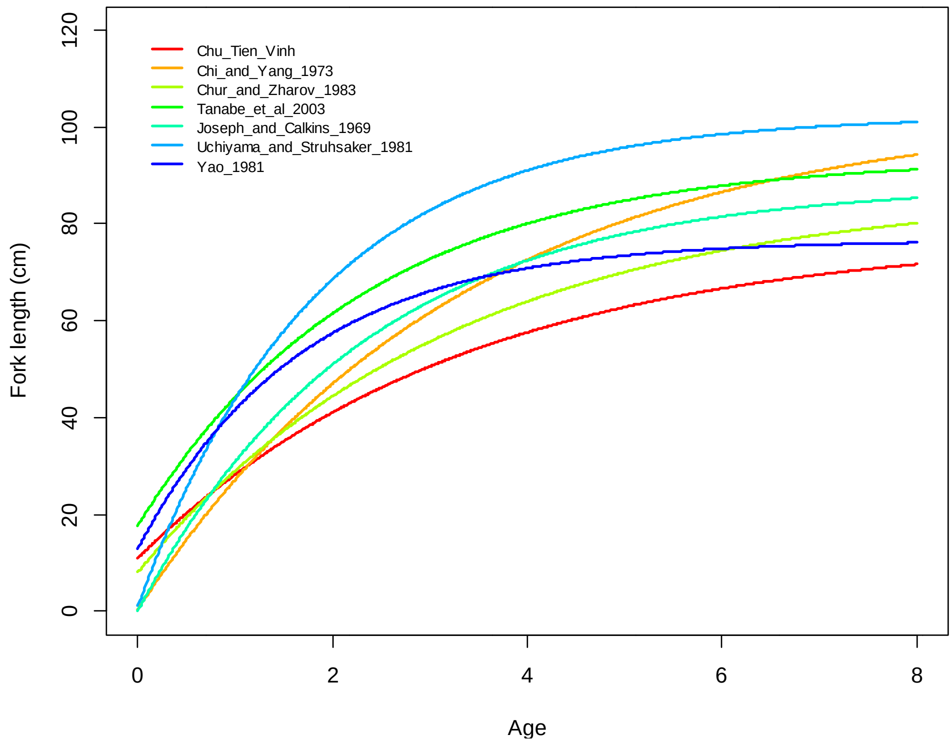

Figure 58. Published growth models of skipjack sampled (with replacement) in the Monte Carlo estimation of population growth rate (r), used as a prior distribution in the Bayesian Surplus Production model.

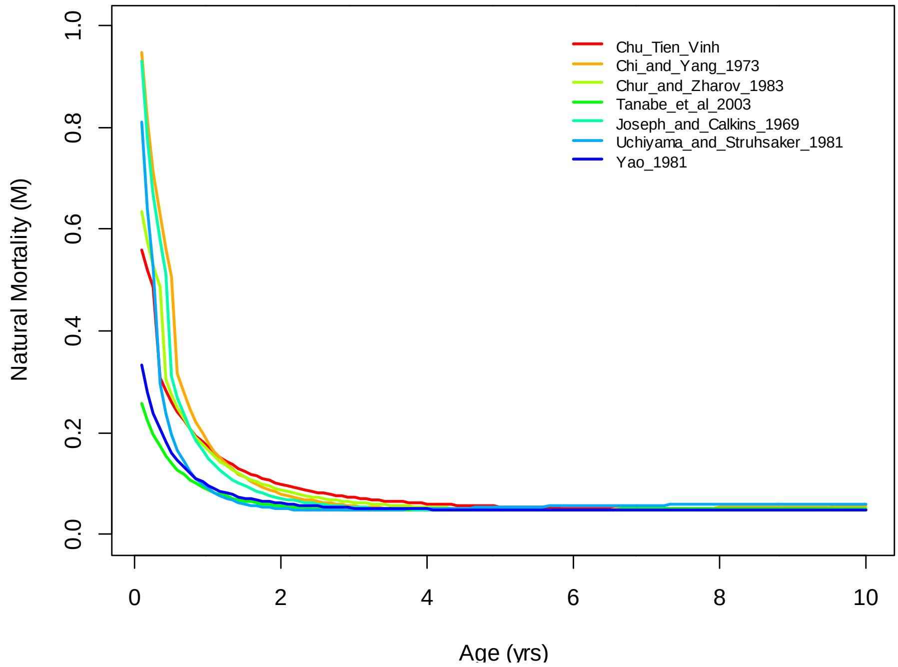

Figure 59. Estimated natural mortality schedules based on size at age estimates from the Monte Carlo sampling of the published growth curves.

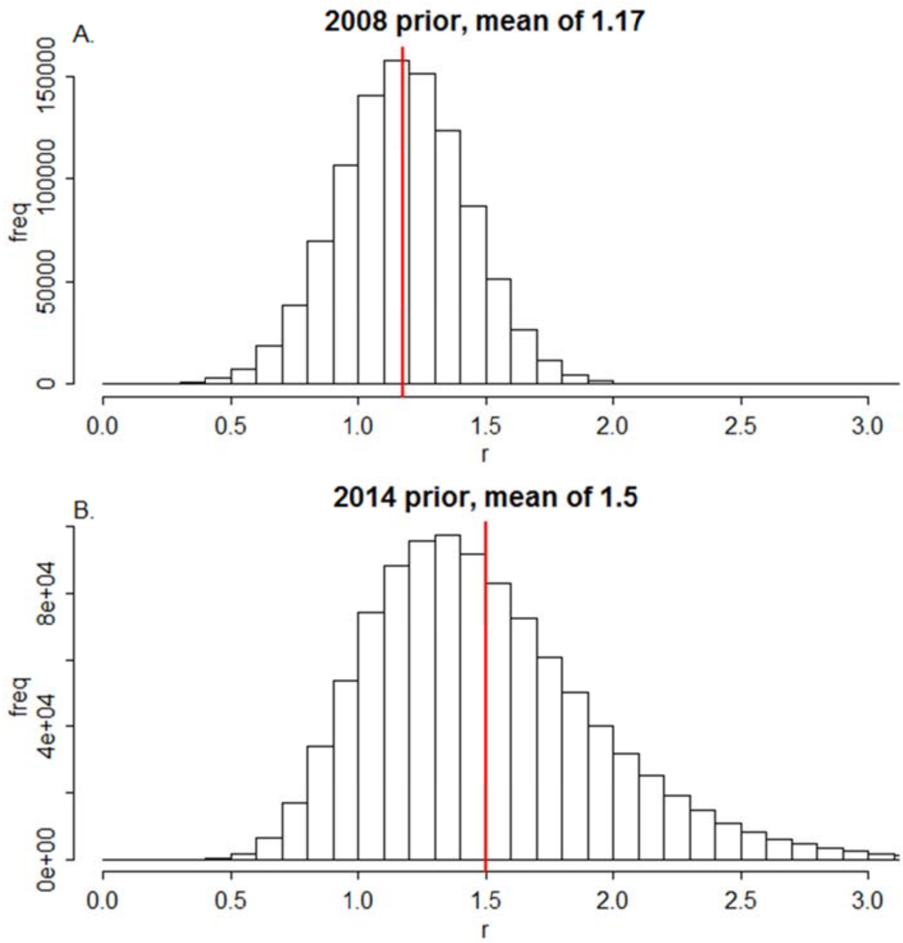

Figure 60. Prior distributions for intrinsic rate of population increase (r) from the 2008 assessment (A) and that developed for the 2014 assessment (B). The new prior was modeled with a lognormal distribution and has a higher mean as well as greater density towards higher values of r.

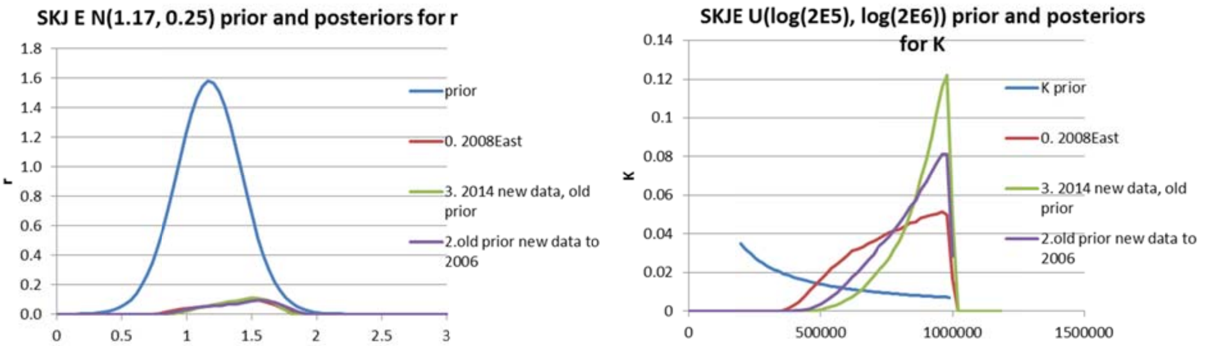

Figure 61. Priors and posteriors for SKJE using the old N(1.17, 0.25) prior for r and the Uniform(Log(2E5, log(2E6)) prior for K for SKJE models 0, 2 and 3 which all use the old prior.

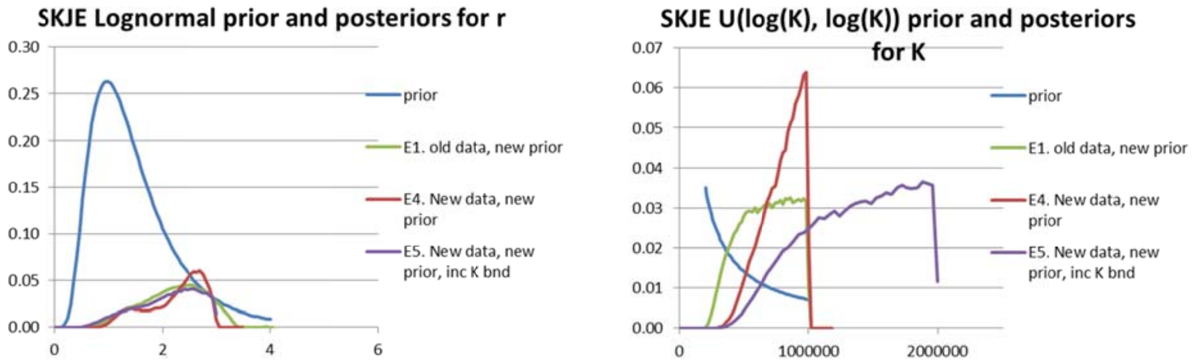

Figure 62. Priors and posteriors for r and K from the 2014 model with the new priors for r for model runs E1, E4 and E5.

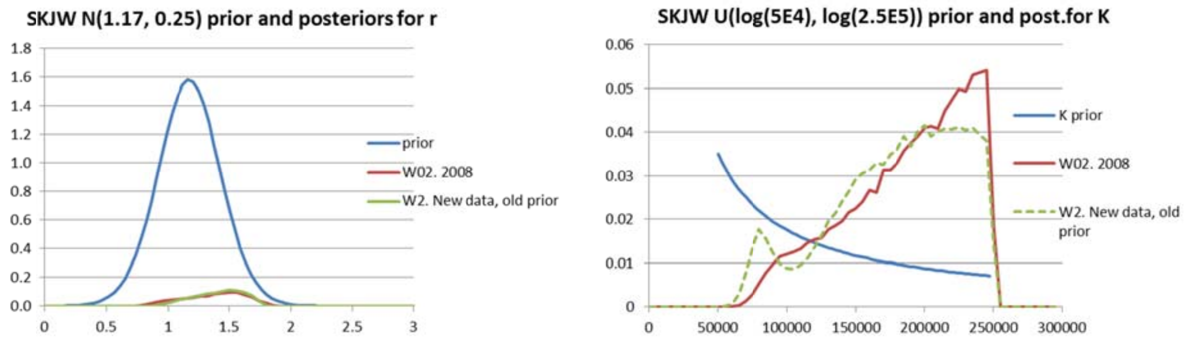

Figure 63. Priors and posteriors for r and K from the 2014 model with the old prior for r for model runs West02 and West2.

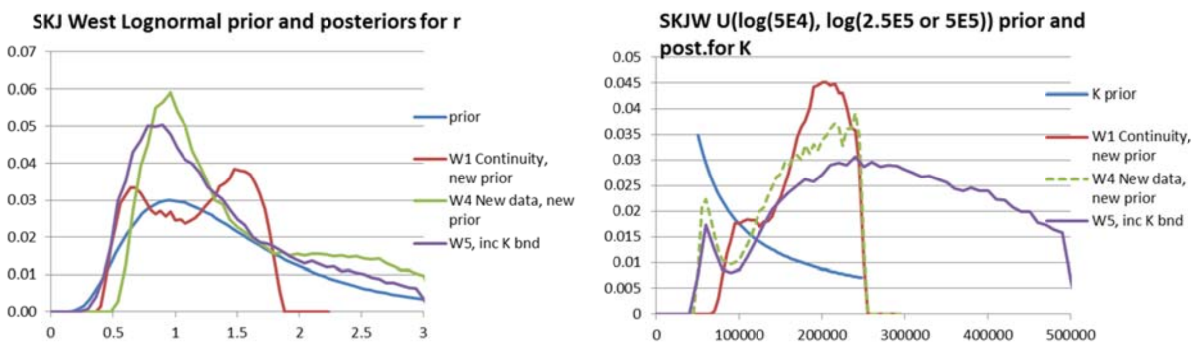

Figure 64. Priors and posteriors for r and K from the 2014 model with the new prior for r for model runs West 1, 4 and 5.

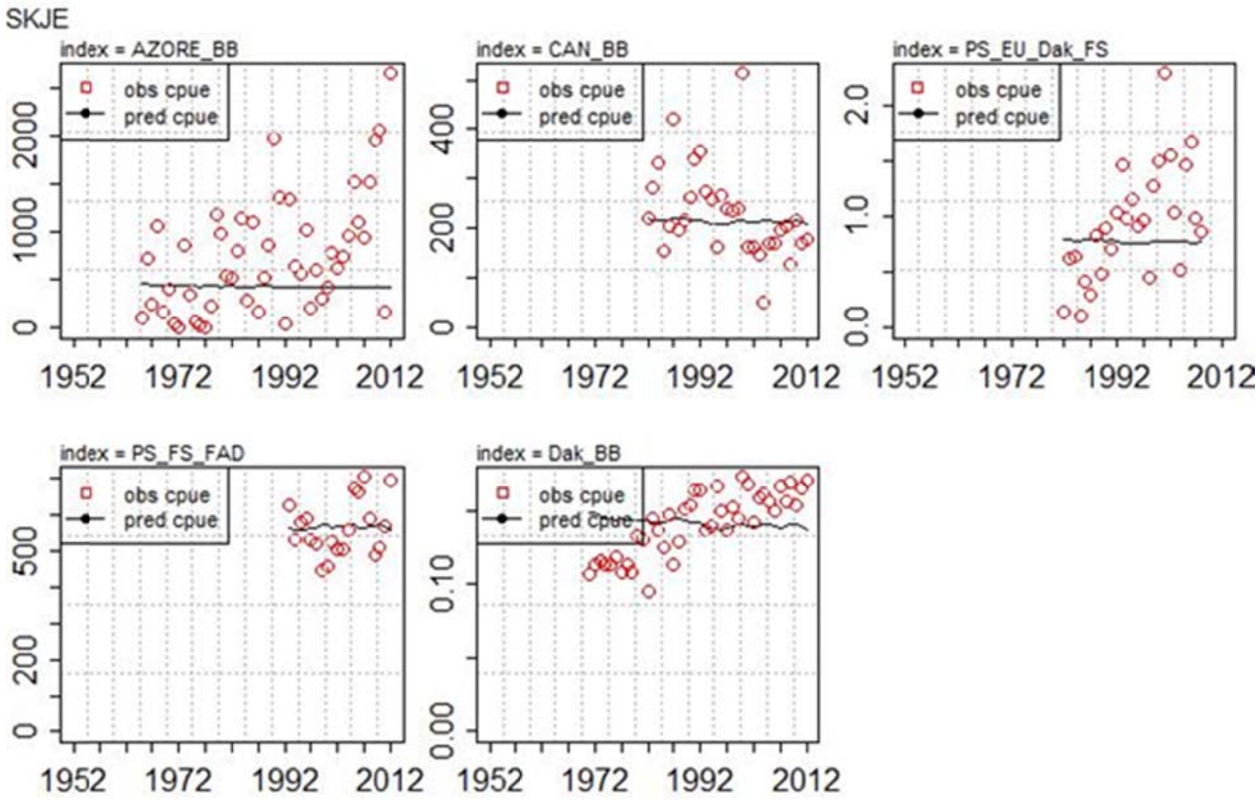

Figure 65. Fits to indices for SKJE model E4, new data, new prior.

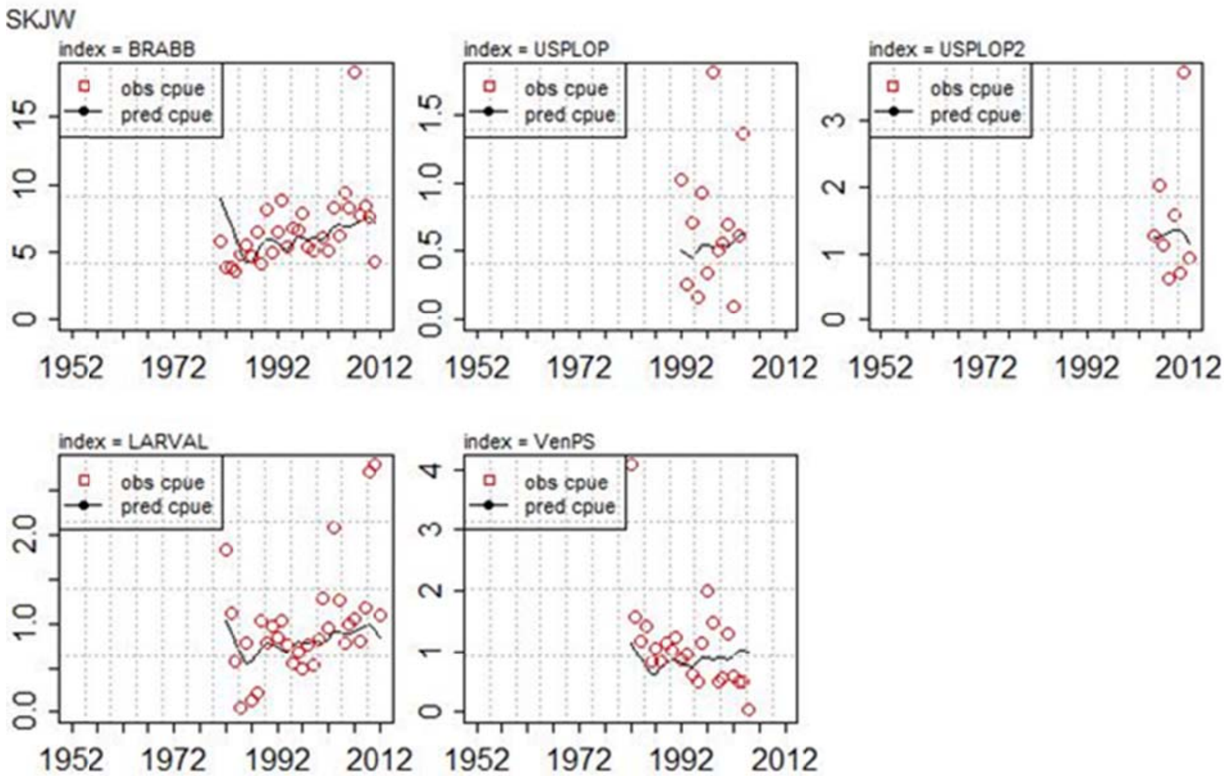

Figure 66. Fits to indices for SKJW model W4, new data, new prior.

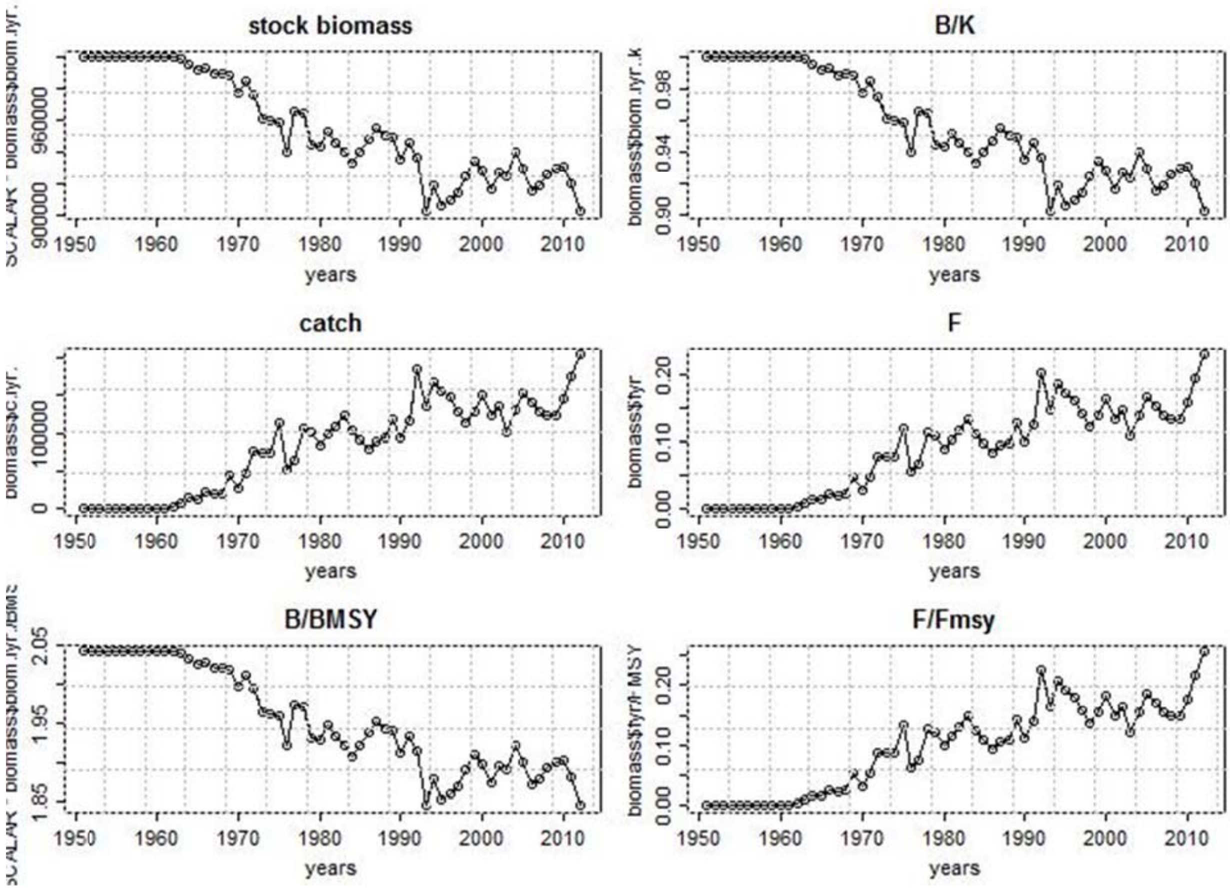

Figure 67. Stock status trajectory for SKJE, model 4, new data, new priors.

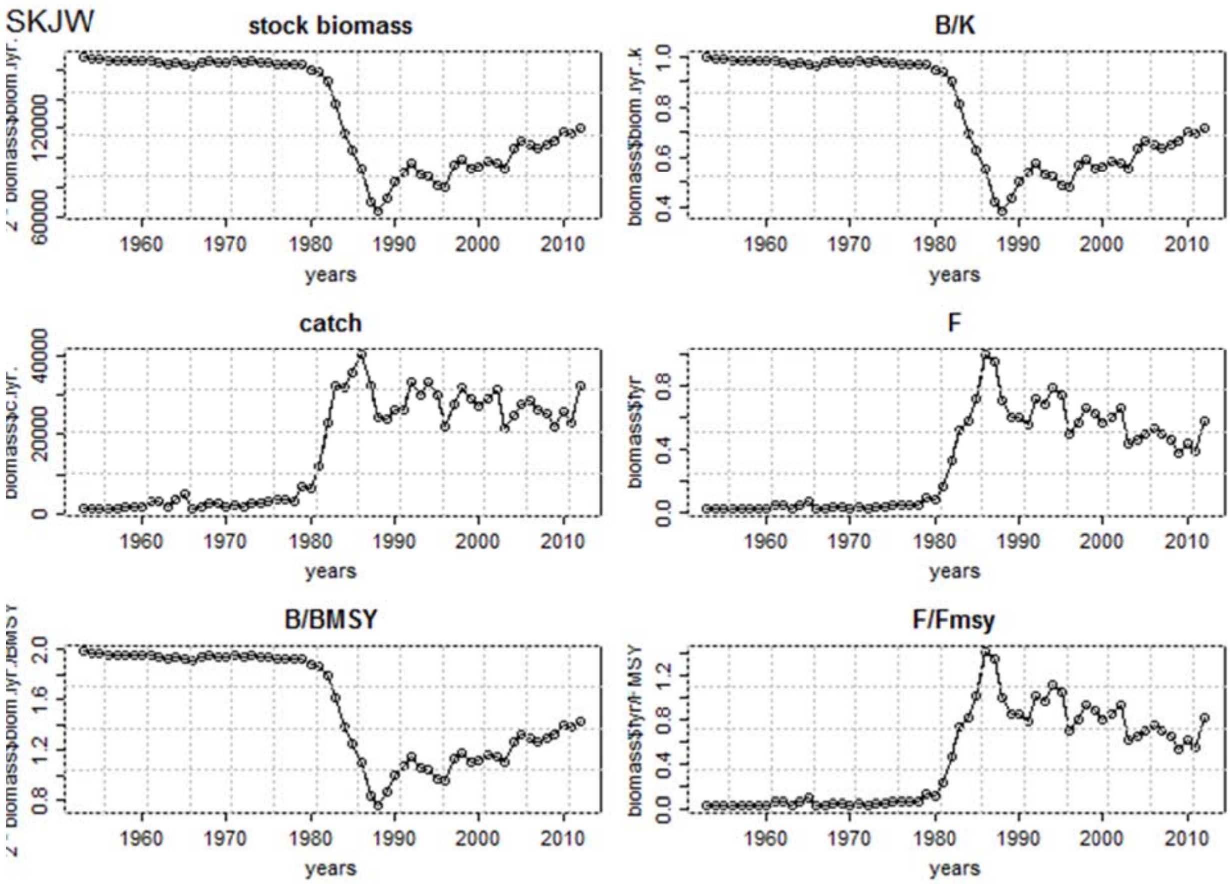

Figure 68. Stock status trajectory for SKJW, model 4, new data, new priors.

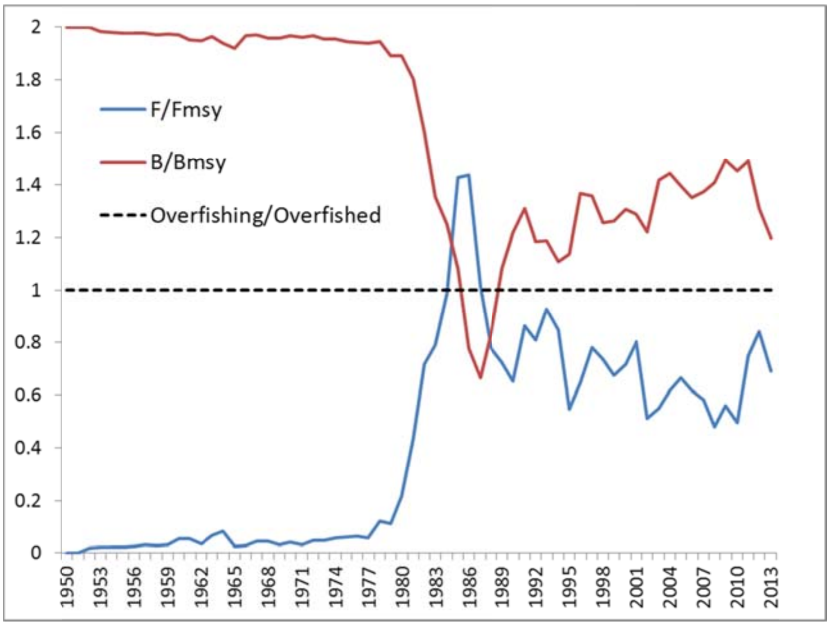

Figure 69. ASPIC estimates of relative fishing mortality and relative biomass for western skipjack run1, non bootstrapped.

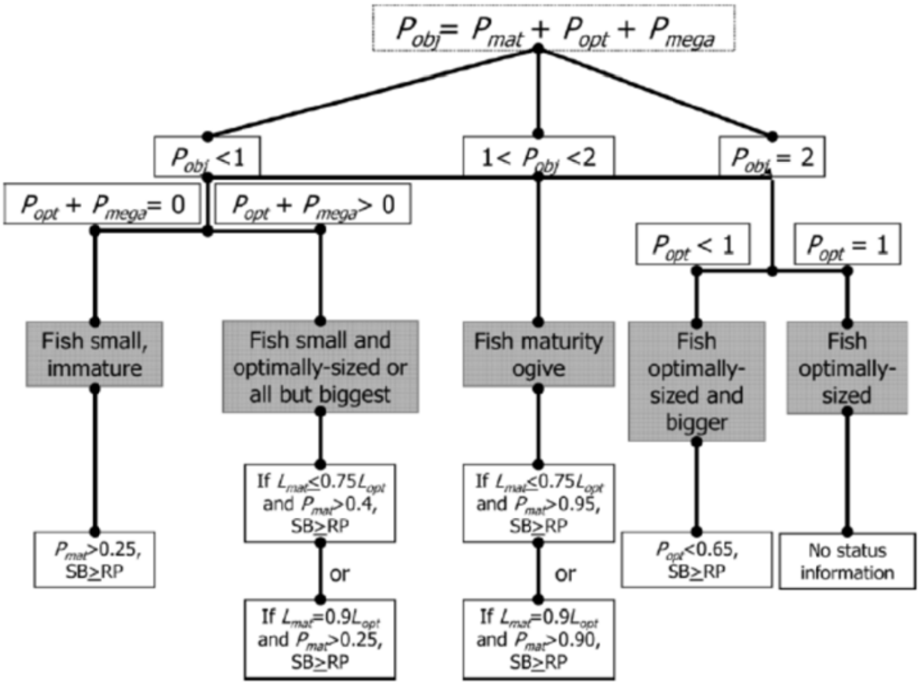

Figure 70. Decision tree explained in the paper by Cope and Punt (2009).

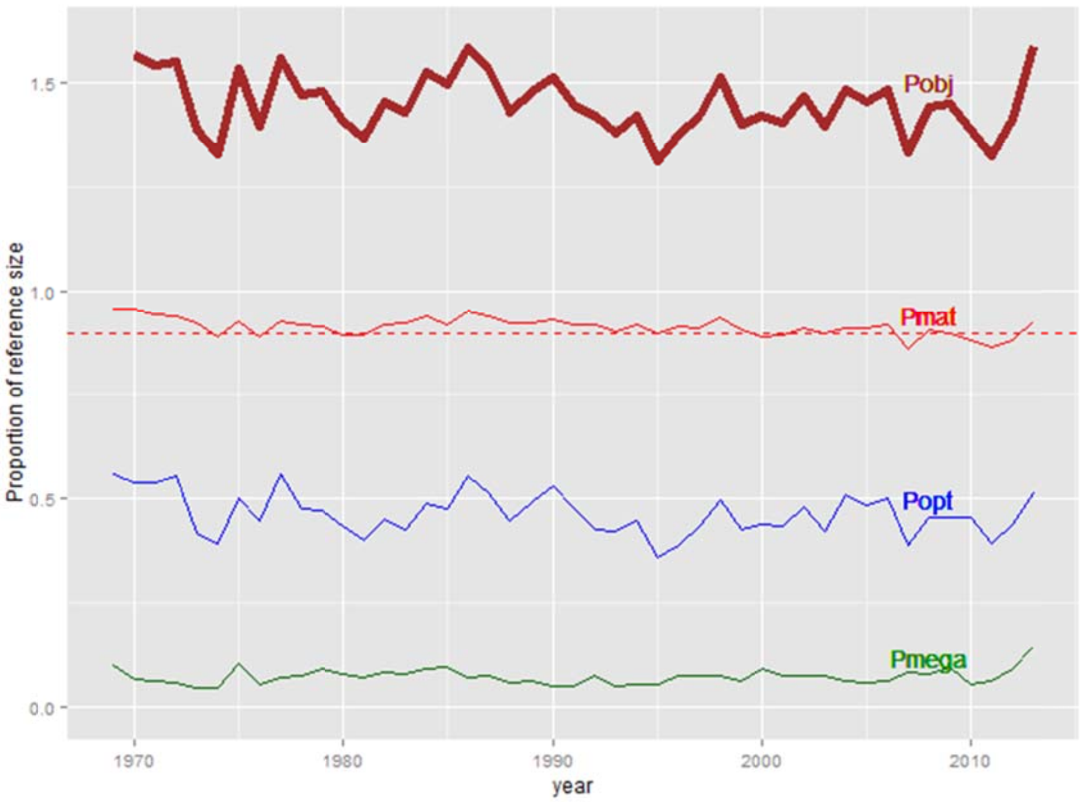

Figure 71. Proportion of reference sizes for eastern skipjack fishery.

Appendix 1

AGENDA

1. Opening, adoption of Agenda and meeting arrangements

2. Review of biological historical and new data for SKJ

   2.1 Growth
   2.2 Natural mortality
   2.3 Ecology (i.e. FAD effect on the SKJ ecology, environment)
   2.4 Revision of the SKJ stocks structure (2 vs. 5 components)

3. Review of direct fishery information

   3.1 Task I (catches)
   3.2 Task II (catch-effort and size samples)
   3.3 Other information (tagging)

4. Fishery indicators

   4.1 Historic changes in SKJ surface fishing grounds and in total area distribution (e.g. LL SKJ catches by decade)
   4.2 YFT and BET CPUEs for surface fisheries
   4.3 Others (e.g. mean weight for SKJ and YFT by fleet, apparent total mortality, etc.)

5. Review of SKJ catch per unit effort series

6. Stocks assessment

   6.1 Stock assessment models
   6.2 Stocks assessment results
   6.3 Indicators of performance of Atlantic skipjack tuna towards developing specifically built Harvest Control Rules

7. Recommendations

   7.1 Research and statistics
   7.2 Management

8. Other matters

   8.1 Presentation of the AOTTP Feasibility Study
   8.2 Preparing the TOR to establish an statistical CAS building procedure for the tropical tuna species (YFT, BET, SKJ)

9. Adoption of the report and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2014/034	Skipjack (*Katsuwonus pelamis*) bycatch estimates from the albacore Spanish surface fishery in the North East Atlantic: 2005-2012 years. Ortiz de Zárate V., Perez B. and Quelle P.
SCRS/2014/063	Faux Poisson landed in Abidjan for the period 1982-2013. Preliminary data. Chavance P., Dewals P., Amande M. J., Delgado de Molina A., Damiano A., Tamegnon A.
SCRS/2014/066	Statistiques de la pêche thonière industrielle ivoirienne en 2013. Amandè M.J., Diaha N.C., Konan K.J., Irié B.Y.D. et Dewals P.
SCRS/2014/072	Review of life history data and stock structure of Atlantic skipjack (*Katsuwonnus pelamis*). Gaertner D.
SCRS/2014/073	Indirect estimates of natural mortality rates for Atlantic skipjack (*Katsuwonnus pelamis*), using life history parameters. Gaertner D.
SCRS/2014/074	On the movement patterns and stock structure of skipjack (*Katsuwonus pelamis*) in the Atlantic: how many skipjack stocks in the Atlantic Ocean? Fonteneau A.
SCRS/2014/075	An overview of skipjack growth in the Atlantic: knowledges & uncertainties. Fonteneau A.
SCRS/2014/076	Statistiques de la pêcherie thonière guinéenne de 2010 à 2013. Camara Y., Chavance P., Amandè M.J., Dewals P., Tamégnon A., Damiano A.
SCRS/2014/077	Insight from PREFACE & AWA on tropical Atlantic tuna ecology and effects on western African fisheries economies. Brehmer P., Schmidt J., Fock H., Ferreria Santos C., Brochier T., Ngom F., Monteiro V., Augier P.A., Machu E., Capet X., Kraus G. and Keenlyside N.
SCRS/2014/078	Estadísticas españolas de la pesquería atunera tropical, en el Océano Atlántico, hasta 2013. Delgado de Molina A., J.C. Santana J.C. y Ariz J.
SCRS/2014/079	Datos estadísticos de la pesquería de túnidos de las Islas Canarias durante el periodo 1975 a 2013. Delgado de Molina A., Delgado de Molina R., Santana J.C. y Ariz J.
SCRS/2014/080	Statistics of the European and associated purse seine and baitboat fleets, in the Atlantic Ocean. Delgado de Molina A., Floch L., Rojo V., Damiano A., Ariz J., Chassot E., N'Gom F., Chavance P., and Tamegnon A.
SCRS/2014/081	Japanese longline CPUE for yellowfin tuna (*Thunnus albacares*) in the Atlantic Ocean standardized using GLM up to 2013. Matsumoto T. *et al*.
SCRS/2014/082	Standardized CPUE for bigeye tuna caught by the Japanese tuna longline fisheries operated in the Atlantic Ocean up to 2013. Matsumoto T. *et al*.
SCRS/2014/086	Updated standardized catch rates for skipjack tuna (*Katsuwonus pelamis*) caught in the southwest of South Atlantic Ocean. Carneiro V., Fialho E. and Andrade H.A.
SCRS/2014/087	Catch composition of the baitboat fishery in the Southwestern Atlantic. Andrade H.A., Guimarães-Silva A.A. and Batista C.H.O.

SCRS/2014/088 Updating of Tasks I and II for Ghanaian industrial tuna fisheries data 2006-2012. Chassot E., Ayivi S., Floch L., Damiano A and Dewals P.

SCRS/2014/089 An analysis of historical tagging data to estimate migration rates for tropical tuna in the Atlantic: an example using bigeye tuna (*Thunnus obesus*). Sculley M. and Die D.

SCRS/2014/090 Standardized catch rates for bigeye tuna (*Thunnus obesus*) from the pelagic longline fishery in the Northwest Atlantic and the Gulf of Mexico. Walter J.

SCRS/2014/091 Standardized catch indices of skipjack tuna, *Katsuwonus pelamis*, from the United States pelagic longline observer program. Lauretta M.V. and Walter J.F.

SCRS/2014/092 Feasibility study for an AOTTP. Caillart B., Million J., Fonteneau A. and Sculley M.

SCRS/2014/093 Annual indices of skipjack tuna (*Katsuwonus pelamis*) larvae in the Gulf of Mexico (1982-2012). Ingram G.W.

SCRS/2014/094 Standardization of the EU PS EU fleet (Spain and France) data for 1990-2012 fishing in the Equatorial area. Andrare H.A.

Appendix 4

ESTIMATION OF PRIOR ON INTRINSIC POPULATION GROWTH RATE (R) FOR BAYESIAN SURPLUS PRODUCTION MODELS

A prior distribution on population growth rate (r) was estimated for the East and West skipjack stocks jointly, using the Euler-Lotka formulation and methods described in McAllister *et al*. (2001). Monte Carlo resampling (with replacement) was used to incorporate uncertainty in life history parameters and corresponding estimation of the distribution of r. Using this approach, uncertainty in skipjack life-history was directly incorporated in the prior distribution. The prior distribution assumed the following life-history information and uncertainties:

1. The size-at-50% maturity was assumed to be to 42 cm (approximately 9.5 months old) and fully mature at 55 cm. A maturity schedule was developed based on these assumptions, which resulted in a maturity ogive of 0% mature between ages 0 to 6 months, a linear in increasing maturity was assumed from 0% mature at 6 months to 100% maturity (fully mature) at 14 months, and fully mature from 14 months and older.

2. Demographic priors for *r* for skipjack tuna were obtained by resampling (with replacement) from distributions of basic life history inputs. This method operates by recasting the intrinsic rate of population increase into component parts for which we either have greater knowledge of or for which we can place reasonable distributions. Prior distributions for *r* were obtained by numerically solving the Euler-Lotka population growth equation using methods outlined in McAllister (2001, 2008) and McAllister (*pers. comm.)*.

3. Inputs into the Euler-Lotka equation take the form of a standard life table representing survivorship, a fecundity and maturity schedule, lengths at age and weights at age derived from lengths and an empirical length-weight relationship. Inputs into the life tables are maturity, survival, weight and reproductive output. Weights at age were computed using the ICCAT length-weight conversions and the expected contribution of recruits per female was constructed using a Beverton-Holt stock recruitment relationship with a steepness equal to the random draw from the parameters described below. Distributions of the following parameters were repeatedly sampled to obtain *r*:

4. *Prior distribution on steepness (h)* was chosen to be distributed according to a beta( ) function with a mode of 0.9. This is based upon examination of the prior distribution for h used in the Western Pacific skipjack and yellowfin tuna assessments (beta(18, 4)) but allowing a greater density towards lower values of steepness**.**

5. *Prior distributions on growth rate parameters*. Paired values of *k,* L_{inf}, and *t0* were chosen from published von Bertalanffy growth curves containing these values, obtained from a meta-analysis (Gaertner 2008) of skipjack (**Figure 6.8**). For each iteration, a set of von Bertalanffy parameters was randomly selected and the mean size-at-age was calculated.

6. *Prior distributions of mortality at age* were assumed normal (u_i, 0.04) random variables where u_i is the mortality at age *i*. In the prior assessment (2008) the vector of mortality at age for skipjack was assumed to be constant at 0.8 for all ages. In this assessment, mortality was estimated as a function of size, based on resampling of published length-at-age relationships (**Figure 6.9**).

7. 10,000 resampled estimates of *r* were obtained from the Monte Carlo analysis.

8. A histogram of the prior distribution on population growth rate *r* of skipjack from the Monte Carlo analysis is shown in **Figure 6.10**. For the BSP model a lognormal distribution was assumed approximated by a univariate t distribution having essentially the same parameters.

Appendix 5

STANDARDIZATION OF CANARY ISLANDS BAIBOAT DATA 1980-2013

Fishery data

Details of the fishery and the origin of the information are provided in document SCRS/2014/079. The database analysis integrates 149,832 observations each of them corresponding to individual trips, with the following fields: vessel code, day, month, year, effort (number of days), SKJ catches and total tuna catch. Vessels were assigned to two fleet categories, small scale and bigger vessels, with average trip duration of 1 and 10 days respectively. Mosaic plots of the yearly evolution of the observations classified by main factors are shown in **Figure Appendix 5-1**.

Model

Because of the significant proportion of sets with zero catch of skipjack [between 27% and 82% on average per year, **Figure Appendix 5-2**], the standardization method used a delta lognormal model distribution that can take into account zero observations. The factors that were considered in the analyses were year [1980-2013], quarter [2, 3, 4] and fleet [1, 2]. Quarter 1, the period with lower presence of SKJ in the area, was excluded from the analysis in order to overcome memory requirements to run the model. The effect target was not considered because it mirrored the distribution of the proportion of positives and resulted redundant.

A step-wise regression procedure was used to determine the set of explanatory factors and interactions that significantly explained the observed variability. For this, deviance analysis tables were created for the proportion of positive observations (e.g. positive sets/total sets), and for the positive catch rates. Interactions among factors were also evaluated, if an interaction was statically significant, and included the year factor in particular, it was then considered as a random interaction(s) within the final model. The relative indices for the delta model formulation were calculated as the product of the year effect calculated using the least square means from the binomial and the lognormal model components.

According to the deviance table, the following model was selected:

Binomial	Year, Quarter, Year: Quarter
Lognormal	Year, Quarter, Fleet, Year: Quarter, Year: Fleet

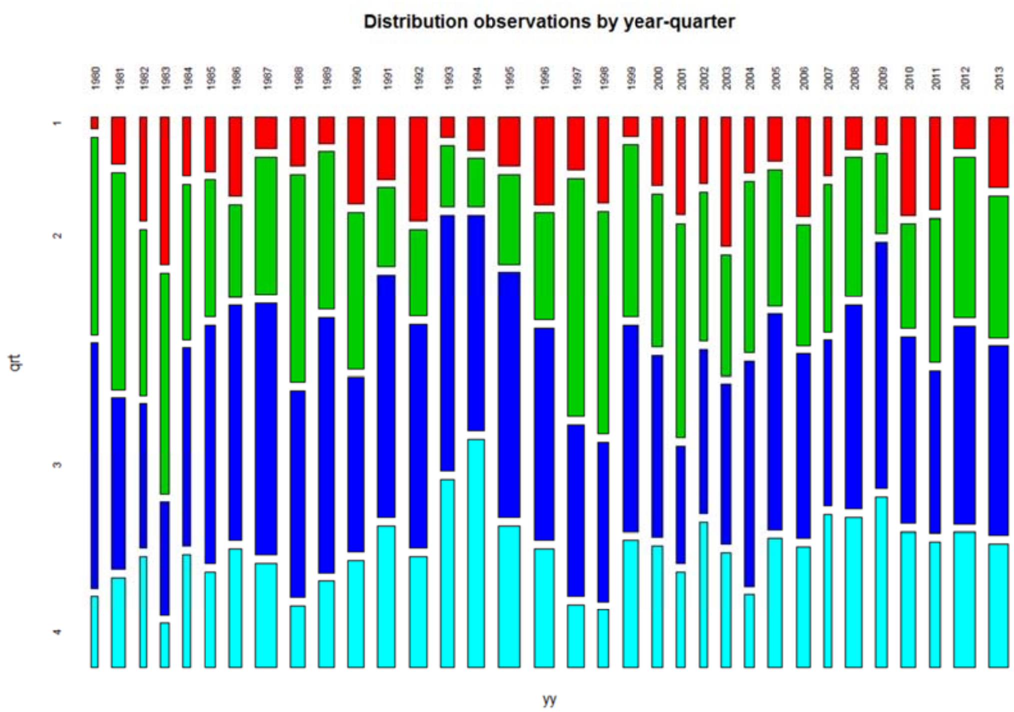
The results of the deviance analysis are shown in **Table Appendix 5-1**. The most significant explanatory factors for the binomial model on the proportion of positives included Year, Quarter and the interaction Year*Quarter (considered as a random interaction). As for the lognormal model, the most significant explanatory factors were Year, Quarter and Fleet, as well as the interactions Year*Quarter and Year*Fleet.

No significant residual patterns were observed (**Figure Appendix 5-1**). The standardized CPUE values show somewhat less pronounced trends (compared to the nominal CPUE values). The estimates of the final Delta model are provided in **Figure 45** and **Table 33** of the report.

Table Appendix 5-1. Deviance tables for the binomial (top) and the lognormal (bottom) components of the Delta-lognormal model. Significant (p<0.05) factors and interactions explaining >5% of total deviance are highlighted.

Columna1	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)	PercDevExp
NULL	.	.	149831	191576.218	.	.
yy	33	13200.8127	149798	178375.4053	0	40.34493264
qrt	2	12988.8092	149796	165386.5961	0	39.69699764
fleet	1	402.097569	149795	164984.4985	1.92E-89	1.228909131
yy:qrt	66	6128.1585	149729	158856.34	0	18.72916059

Columna1	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)	PercDevExp
NULL	.	.	99276	193531.9699	.	.
yy	33	17740.3595	99243	175791.6104	0	67.05400486
qrt	2	381.54557	99241	175410.0648	6.88E-50	1.442144307
fleet	1	1774.82485	99240	173635.24	5.04E-231	6.708382323
yy:qrt	66	3773.66747	99174	169861.5725	0	14.26349429
yy:fleet	33	2462.7711	99141	167398.8014	2.25E-286	9.30864254
qrt:fleet	2	323.654699	99139	167075.1467	1.98E-42	1.223331676



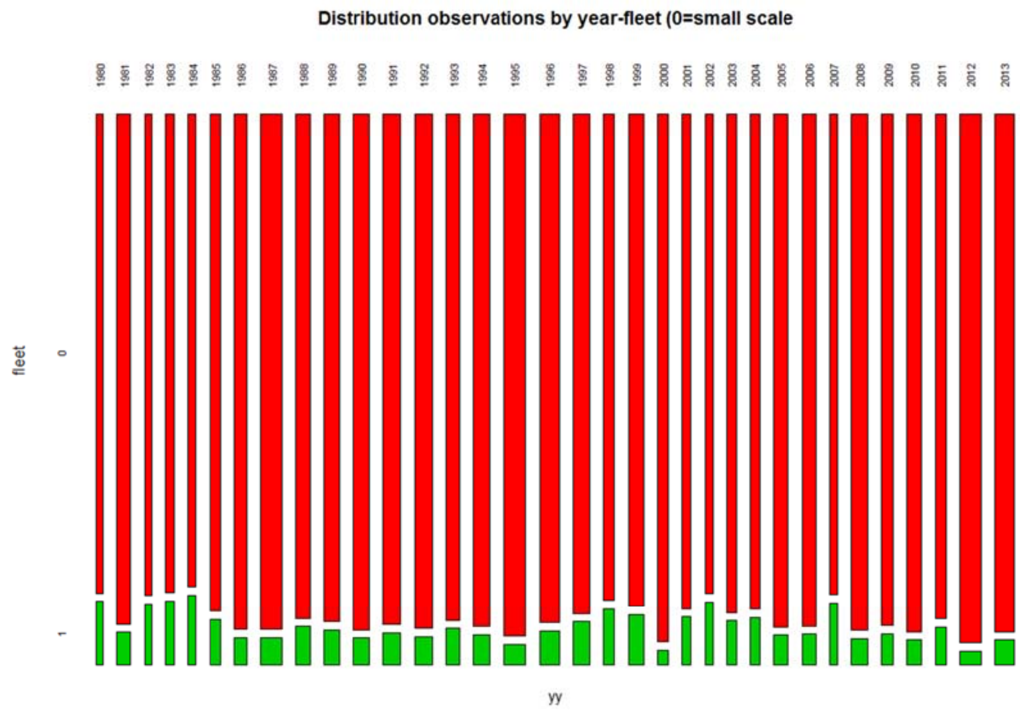


Figure Appendix 5-1. Mosaic plots of number of observations by year-quarter and year-fleet of the Canary Islands BB fleet.

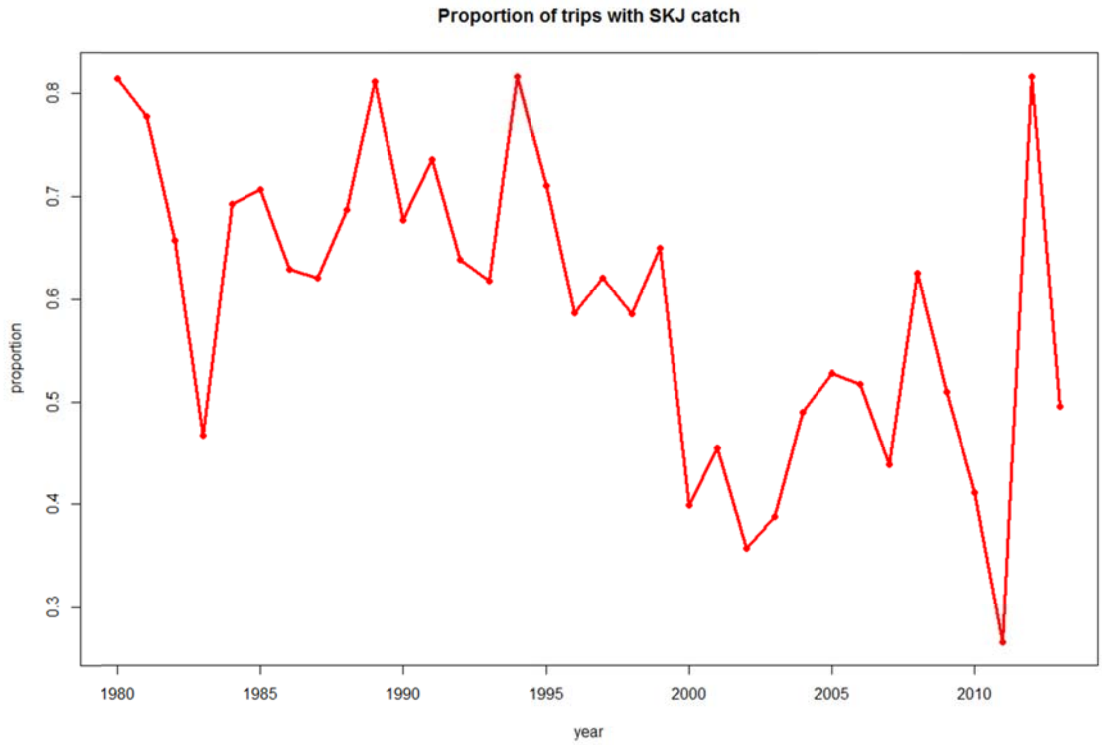


Figure Appendix 5-2. Proportion of trips of the Canary Islands BB fleet with positive SKJ catches between 1980 and 2013.

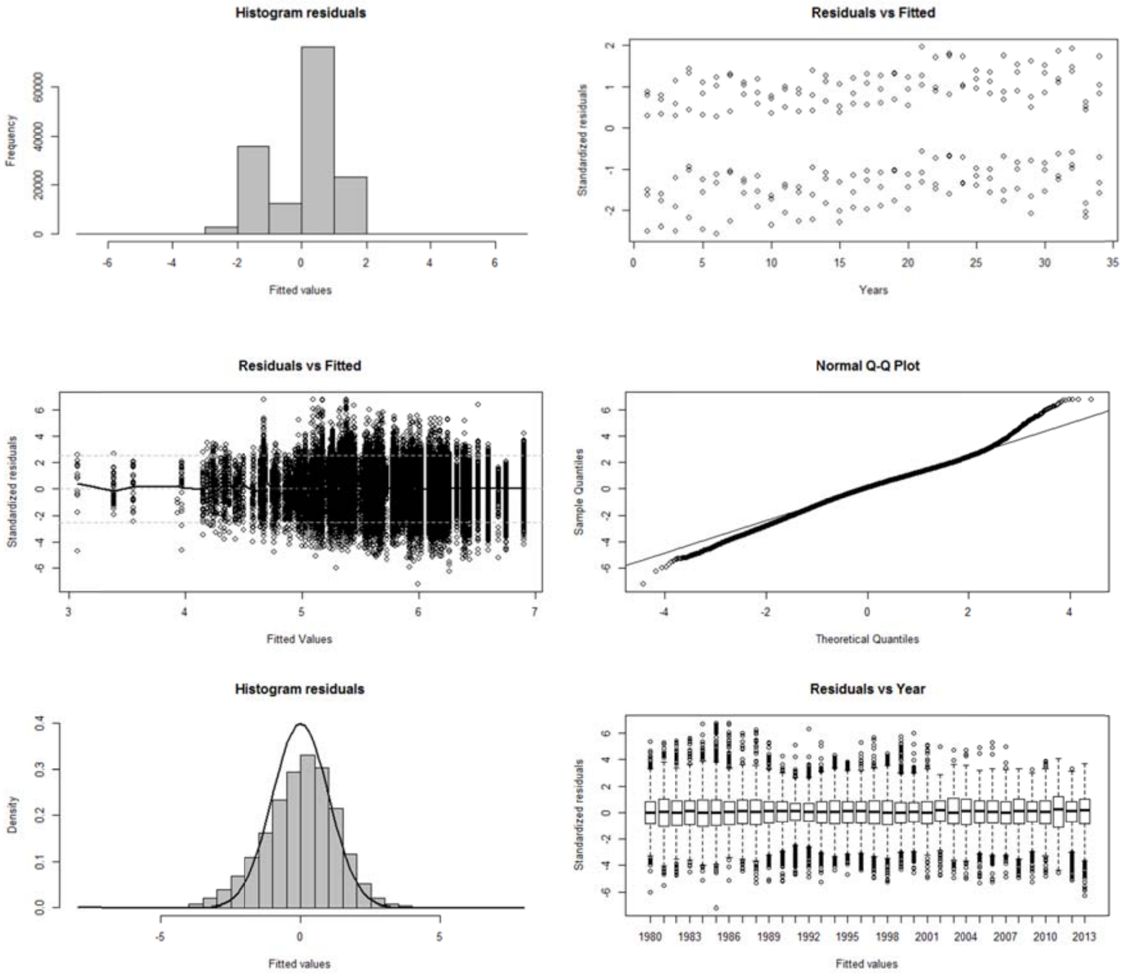


Figure Appendix 5-3. Diagnostics of the binomial (upper panel) and lognormal (lower panel) models selected.

Appendix 6

Standardization of Dakar baiboat data

Fishery data

Catch and effort information was obtained from the Task II ICCAT database. Variables considered were total catch of SKJ, YFT and BET, effort, average price by Year, Quarter and Flag. In order to consider targeting effects in the analysis, a “target” variable was defined with 3 levels, depending of the weight proportion of SKJ in the catches: “0” if the proportion of SKJ was ≤0.33, “1” if it was >0.33 and ≤0.66, and “2” if >0.66. Mosaic plots of the yearly evolution of the observations classified by main factors are shown in **Figure Appendix 6-1**.

Model

Because of the lack of records with zero catch of skipjack, the standardization method used a lognormal model distribution. The factors that were considered in the analyses were year [1969-2012], quarter [1, 2, 3, 4] and target [0, 1, 2]. The effect fleet was excluded from the standardization after a preliminary analysis of the period 1991-2012 (period with three different fleets: Spain, France, Senegal) that showed that the fleet effect was not significant.

A step-wise regression procedure was used to determine the set of explanatory factors and interactions that significantly explained the observed variability. Interactions among factors were also evaluated, if an interaction was statically significant, and included the year factor in particular, it was then considered as a random interaction(s) within the final model. The results of the deviance analysis are shown in **Table Appendix 6.1**.

The following model was selected: log(SKJ.CPUE)~yy+qrt+TARGET+(1|yy:qrt)

No significant residual patterns were observed (**Figure Appendix 6-2**). The standardized CPUE values are shown in **Figure 45** and **Table 33** of the report.

Table Appendix 6-1. Deviance tables for the lognormal components of the Delta-lognormal model. Significant (p<0.05) factors and interactions explaining >5% of total deviance are highlighted.

Columna1	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)	PercDevExp
NULL	NA	NA	242	106.095747	NA	NA
yy	21	33.3207244	221	72.775022	3.47E-88	32.93948567
qrt	3	12.8940436	218	59.880979	6.07E-40	12.74651657
Fleet	2	0.83645589	216	59.044523	2.45E-03	0.82688559
TARGET	2	22.5247818	214	36.519741	4.76E-71	22.26706473
PrixSKJc	2	0.54542651	212	35.974314	1.98E-02	0.53918601
yy:qrt	62	16.902247	150	19.072067	2.93E-23	16.70886017
yy:Fleet	41	11.8052183	109	7.266849	1.36E-17	11.67014902
yy:TARGET	23	1.6189521	86	5.647897	4.45E-01	1.60042888
yy:PrixSKJc	0	0	86	5.647897	NA	0
qrt:Fleet	6	0.53495517	80	5.112942	2.62E-01	0.52883448
qrt:TARGET	5	0.08080638	75	5.032135	9.48E-01	0.07988184
qrt:PrixSKJc	0	0	75	5.032135	NA	0
Fleet:TARGET	4	0.09378002	71	4.938355	8.53E-01	0.09270703
Fleet:PrixSKJc	0	0	71	4.938355	NA	0
TARGET:PrixSKJc	0	0	71	4.938355	NA	0

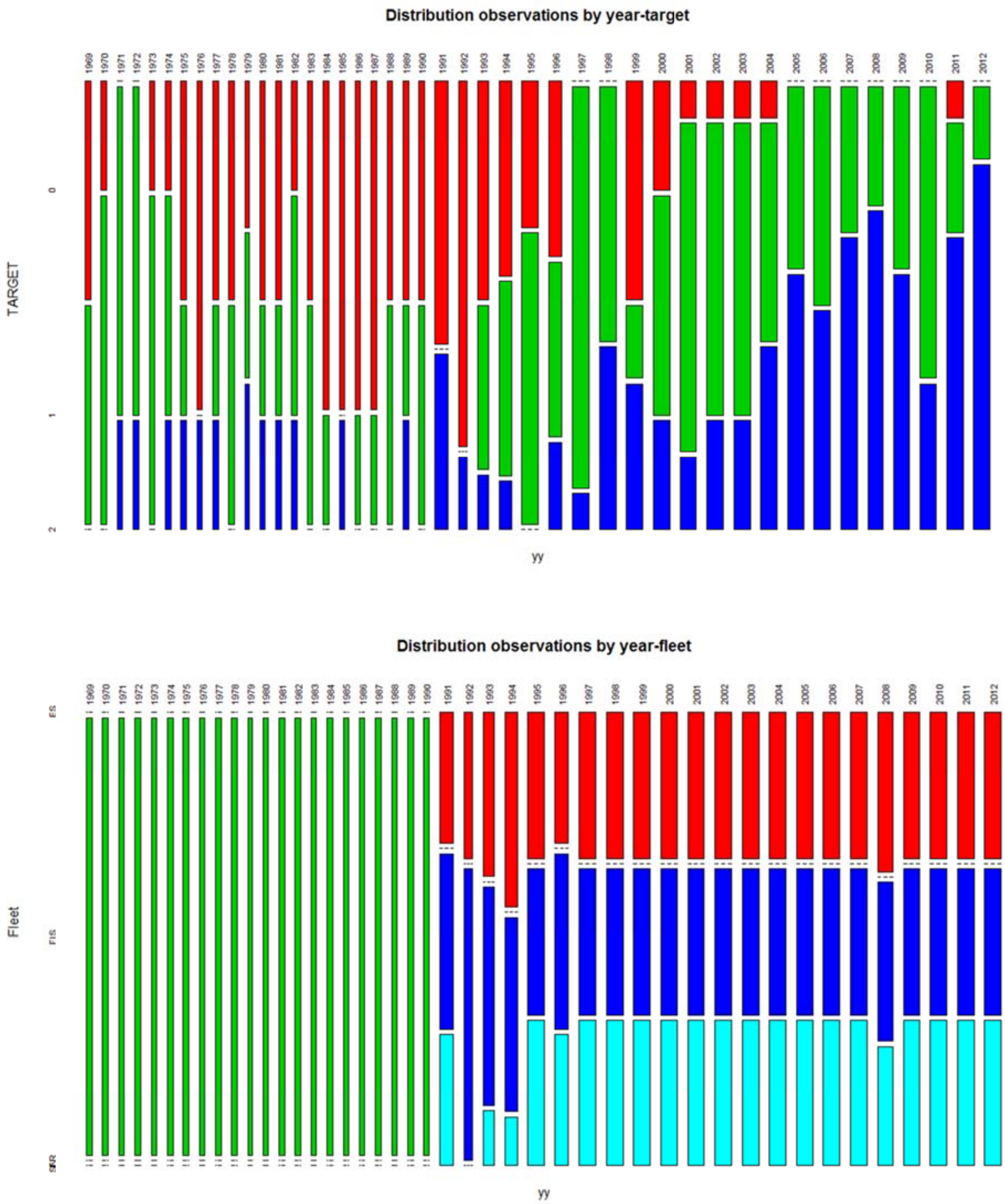


Figure Appendix 6-1. Mosaic plots of number of observations by year-target and year-fleet of the Dakar BB fleet.

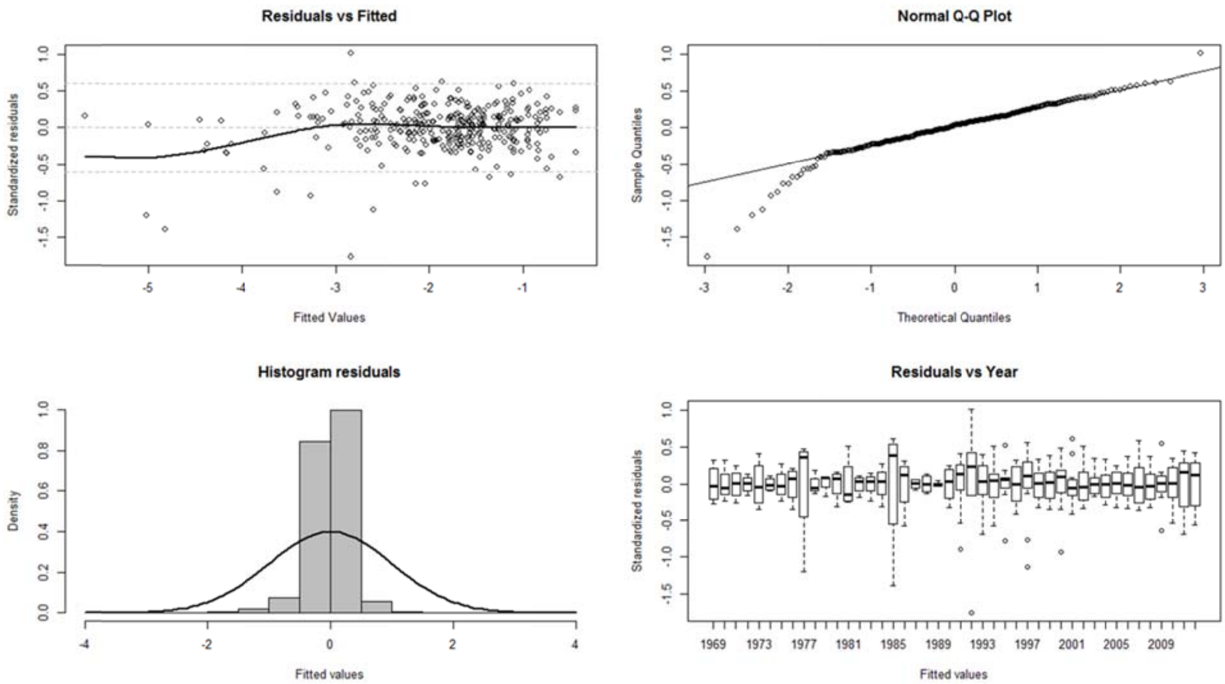


Figure Appendix 6-2. Diagnostics of the lognormal model used to standardize the BB Dakar CPUE index.

Appendix 7

Procedure used to split the purse seine nominal effort by fishing mode: FAD and free school

The effort unit considered has been the fishing day.

The criteria used to split the purse seine fishing effort by fishing mode are based on observer data. Two variables have been considered in the estimation: a) the proportion of time used in handle FADs vs time spend searching free schools, b) the proportion of time devoted on making sets including both null sets and sets with catch. Estimation have been made by fleet (France and Spain) and fishing mode (Gaertner *et al*., 2000).

Task 2 C/E data reported to ICCAT for the European and associated purse seine fleets include the information needed to carry out the procedure.

The method used to split the searching days by fishing mode has been the follow:

1. Squares without catch: When there is not catch in the square, a 3% of total effort is assigned to FAD and a 97% to free school. These percentages have been obtained from observer's data. The percentages mean that the boat is continuously searching for schools even when the boat is sailing towards a FAD and only a low percentage of the daily time is spent in FADs operations.

2. Squares with catch: The separation of effort by fishing mode is done applying the proportion of time spent in making the sets under each fishing mode:

   F.D. FADs = F.D. total* (FADs sets duration/(FADs sets duration + Free school sets duration)

The use of the duration of the sets rates instead of other alternative methods such as the catch rate have been decided in order to take into account both the total amount of catch as well as the time spend in making the null sets.

The duration of the sets is obtained from observer data. Observers take record of the duration of the set from the beginning (when the "panga", auxiliary boat to pull the net, is put in the water) to the end (when the "panga" is recovered).

For the null sets, the duration is calculated as the median value of the distribution of the duration of the null sets in the observer data. The duration of null sets is different for FADs and Free school.

For positive sets (Capture > 0.9 t), the duration is estimated by the following relationship:

Duration (mn) = $\beta_0 + \beta_1$ * Catch (t)

Adjusted by weighted Least Square (WLS= OLS with weighting factors from a robust regression type LTS). For positive sets, the factor fishing mode (FAD, Free school) had not significant effect.

For both, null and positive sets the duration differs depending of the fleet (France and Spain).

Since 1990, different relationships and null sets values have been used if the data obtained by the different observer programs detected significant changes in the values used. Currently, the values used are:

	France	Spain
Null set FAD	103 minutes	121 minutes
Null set FS	108 minutes	109 minutes
Positive set	Duration= 137.030+ 0.966*Catch (t)	Duration= 122.716+ 0.599*Catch (t)

These values are used for 2005 onwards.

References

Gaertner, D., P. Pallarés, J. Ariz, A.Delgado de Molina, V. Nordström-Fonteneau, 2000. Estimation de la durée des calées chez les senneurs français et espagnols opérant dans l'océan Atlantique, à partir des observations scientifiques du programme européen sur le patudo (1997-1999). ICCAT. Col. Doc. Cient. Vol. (LI).p : 402 – 415.