REPORT OF THE 2014 ICCAT
MEDITERRANEAN SWORDFISH STOCK ASSESSMENT MEETING

(Heraklion, Greece – July 21 to 25, 2014)

1. Opening, adoption of agenda and meeting arrangements

The Meeting was held at the Hotel Astoria in Heraklion, Greece from July 21 to 25, 2014. Dr. Josu Santiago, on behalf the ICCAT, opened the meeting and welcomed participants ("the Working Group").

Dr. George Tserpes (EU-Greece), meeting Chairperson, welcomed meeting participants and proceeded to review the Agenda which was adopted with some adjustments (**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:

Items 1, 6 and 7: Secretariat
Item 2: J. Neilson
Item 3: D. Die, J. Neilson
Item 4: L. Kell, E Babcock
Item 5: J. Santiago, M. Santos

2. Description and evolution of the Mediterranean swordfish fisheries

Mediterranean swordfish fisheries are characterized by high catch levels. It should be noted that average annual reported catches (on average about 13,408 t from 1988 to 2013) are similar to those of the North Atlantic, though the Mediterranean is a much smaller body of water compared to the North Atlantic. However, the potential reproductive area in the Mediterranean is probably relatively larger than that in the Atlantic. Further, the swordfish productivity of the Mediterranean Sea is thought to be very high.

Swordfish fishing has been carried out in the Mediterranean using harpoons and driftnets (drifting gillnets) at least since Roman times. Currently, with a high demand for swordfish for fresh consumption, swordfish fishing is carried out all over the Mediterranean Sea. The biggest producers of swordfish in the Mediterranean Sea in recent years (2003-2013) are Italy (41%), Morocco (14%), Greece (9%), Tunisia (8%) and Spain (10%). Also, Algeria, Cyprus, Malta, Tunisia and Turkey have fisheries targeting swordfish in the Mediterranean. Incidental catches of swordfish have also been reported by Albania, Croatia, France, Japan, Libya, Syria and Portugal. The Group recognized that there might be additional fleets taking swordfish in the Mediterranean, for example, Israel, Lebanon, Egypt and Monaco, but no data are reported to ICCAT or FAO.

Mediterranean total swordfish landings showed an upward trend from 1965-1972, stabilized between 1973-1977, and then resumed an upward trend reaching a peak in 1988 (20,365 t). The sharp increase between 1983 and 1988 may be partially attributed to improvement in the national systems for collecting catch statistics. Since 1988, the reported landings of swordfish in the Mediterranean Sea have declined, and since 1990, they have fluctuated between about 10,000 to 16,000 t. In 2013, catches were 11,254 t (Task 1,**Table 1**).

In recent years (2003-2013), the main fishing gears used are surface longlines (on average, representing 84% of the annual catch) and gillnets. Since 2012, gillnets have been eliminated. **Figure 1** presents the evolution of the catches according to the fishing gear. Swordfish are also caught with harpoons and traps, and also as by-catch in other fisheries (longlines and driftnets targeting albacore, purse seines etc).

There have been several important management initiatives by ICCAT in recent years, and a summary of the measures is provided here.ICCAT first signaled its intention to protect juvenile Mediterranean swordfish in 2003, when it stated that "In order to protect small swordfish, Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities shall take the necessary measures to reduce the mortality of juvenile swordfish in the entire Mediterranean" [Rec. 03-04].The Recommendation was made more explicit in Rec. 07-01, where a one month closure was established: "Fishing for Mediterranean swordfish shall be prohibited in the Mediterranean Sea during the period from October 15 to November 15, 2008."Rec. 08-03 extended the closure period from 1 October to 30 November.The period of closure was extended in Rec. 11-03 which stated "Mediterranean swordfish shall not be caught (either as a targeted fishery or as by-catch), retained onboard, trans-shipped or landed during the period from 1 October to 30 November and during an additional period of one month between 15 February and 31 March." Most recently, Rec. 13-04 reaffirmed this closure period.

Concerning minimum sizes, Rec. 11-03 established a minimum size that prohibited the retaining on board, transshipping, landing, transporting, storing, selling, displaying or offering for sale Mediterranean swordfish measuring less than 90 cm LJFL or, in alternative, weighing less than 10 kg of round weight or 9 kg of gutted weight, or 7.5 kg of gilled and gutted weight. However, the CPCs may grant tolerances to vessels that have incidentally captured small fish below the minimum size, with the condition that this incidental catch shall not exceed:

> a) 10% by weight or/and number of pieces per landing of the total swordfish catch of said vessels (in 2012),
> b) 5% by weight or/and number of pieces per landing of the total swordfish catch of said vessels as from 2013.

The minimum size regulation was reaffirmed and extended for the 2013 fishing season in Rec. 13-04.

A ban on the use of driftnets within the Mediterranean was established in 2003 (Rec. 03-04), but full compliance with the regulation occurred several years later.Rec. 09-04 established a list of fishing vessels allowed to fish for Mediterranean swordfish.Most recently, there have also been restrictions on the number of hooks carried by individual longliners (2800 maximum), hook size (no smaller than 7 cm in height) and longline length (55 km).These restrictions were established for 2012 (Rec. 11-03) and remained in force for 2013 (Rec. 13-04).

Fishery Descriptions from Working Group Participants

Scientists participating in the WG provided a summary of recent fishery developments, including domestic management measures (which are in addition to the ICCAT measures described above), below. **Figure 2** shows the Mediterranean areas considered in the fisheries descriptions given below.

The Working Group was pleased to note the good participation of the CPCs listed below, which represented a considerable improvement compared with the last stock assessment meeting. Together, the catches associated with these countries represent about 95% of the 2013 total catch of Mediterranean swordfish.

Algeria

Swordfish fishing in Algeria is a well-established activity and around 303 small fishing boats with length≥9 m participate in the fishery.The most common gear used in the targeted fishery is surface longline, with some incidental catches of swordfish made by trawlers and purse-seiners. The longline length varies between 3000 to 6000 m, and the number of hooks depends on the length of the main line.In general, fishermen arrive on the fishing grounds around sunset after 3 to 4 h of transit. The surface longline drifts with the current almost 4 h, with the fishing depth being around 200 m.

The fishery is seasonal in nature, and because of ICCAT closures and weather, the fleet is operational for only 4-5 months of the year.The average annual LL catch over the past five years is about 420 tonnes, but there is significant variation from year to year. The best season for targeting swordfish is the period from June to September.

Algeria has implemented the ICCAT management measures described earlier.

The WG reviewed SCRS/2014/095, which provided further details of the Algerian fishery from 2003 to 2013.The Group noted that there were some significant discrepancies between the Task 1 catch data from Algeria and the information presented in the working paper.The authors were requested to reconcile the differences and prepare a report for the upcoming meeting of the Subcommittee on Statistics of the SCRS.The official landings information could then be amended if necessary.

EU- Greece

The Greek swordfish fleets operate throughout the eastern Mediterranean basin using exclusively drifting longlines. In 2013, about 160 vessels were actively involved in the swordfish fishery. Most of them entered the fishery occasionally, mainly during the summer months. The swordfish fishing season follows the established temporal closures by ICCAT and a special license is required for a commercial fishing boat to be allowed to fish for swordfish.

Swordfish comprises the bulk of large pelagic catches of the Greek fishing fleets and according to ICCAT records, Greece is among the most important producers in the Mediterranean. Swordfish production during the 2013 fishing season was estimated to be up to 1730 t, which is among the highest production rates of the last decade. The estimated CPUE rates were also reflecting this relatively higher production.

Greece has implemented the ICCAT management measures described earlier.

EU- Italy

Italy has a long historical tradition in the swordfish fishery, reflected by the development of several fisheries in more recent times. As a matter of fact, Italy has an important fleet of longliners which provides the bulk of the catches, while minor catches are obtained by the few harpoon vessels still active in the Strait of Messina, the tuna traps, the sport fishery and some other surface gears. The structure of the Italian fleet has undergone major changes after the driftnet ban, because Italy had the most numerous driftnet fleet in the Mediterranean and it was not easy to apply and enforce the new regulation, due to a strong tradition.

The longline fleet is widespread all over the various seas around Italy, with a higher concentration in the southern Italian regions. The fishing grounds show moderate yearly variability, depending mostly on oceanographic factors. Most of the vessels are small-medium longliners, distributed in a great number of harbours, usually exploiting local fishing grounds. They have licenses for different gears (longline, trammel net, bottom gillnet, etc) and show a strictly seasonal activity, switching from one gear to the other according to the seasons and fishing opportunities. Other vessels, medium-large in size, usually carry out a more focused activity, alternatively targeting swordfish and albacore or bluefin tuna and covering various areas in the Mediterranean Sea. Some fleets are active all the year round, while the majority of the vessels are active from spring until early autumn.

The fishery has been strongly affected by the increase in the price of fuel, bait and technical equipment and the simultaneous decrease in the price of the product.

The longline fishery has changed considerably in the last five years. From 2009-2010, the mesopelagic longline has been gradually introduced in almost all Italian swordfish fleets, which has led to an increase in catches of individuals of larger size and decreases in the catches of juveniles. The mesopelagic longline gear is set deeper and for longer periods of time compared to the traditional approach for the Italian fisheries. The new approach is now dominant in the Italian longline fisheries. This is particularly noteworthy, as these fisheries are among the largest within the stock area, and the changes have implications for the use of catch rates as indices of abundance in the stock assessment.The Group received details on the new developments in several working papers, summarized below.

SCRS/2014/100 presented the effects of the introduction of the new mesopelagic long line in the Ligurian Sea fishery since 2010, substituting the traditional surface long line. The results showed a significant increase of swordfish mean size and nominal CPUE, with a decrease of the by-catch for the first two years (2010 and 2011). A substantial decline, both of mean size and CPUE values, was recorded in the 2012, followed by a small recovery in 2013. The introduction of this new gear revealed the unexpected presence of a fraction of the swordfish population, made up of large spawners, so far only partially exploited by commercial fishing.

SCRS/2014/106 documented the results of a study of the catch composition of the Italian fishing fleet from 2007 to 2013. Data were collected in several landing ports around the Italian coast and at sea following ICCAT methodologies. For every sample, the lower jaw-fork length (LJFL) and the round weight (RWT) were measured. For the gutted fish, the RWT was estimated using the ICCAT conversion factors for Mediterranean swordfish. Whenever it was impossible to measure the weight, an estimate was made using the length-weight relationship for Mediterranean swordfish. In order to estimate the age of every sample the second radius of the anal fin was collected. Sex determination of the fish , where possible, was carried out by visual inspection of the gonads during the gutting operation 27,530 fish were sampled during the period 2007-13: the highest number of samples comes from the Tyrrhenian Sea area, and two other important areas were the Adriatic Sea and the Straits of Sicily. Considering the period 2007-2013, the general trend in total catch is negative. Since 2004 the percentage of “unclassified” catches begins to decrease, and practically disappeared in the last two years.

27,530 fish were measured for length (maximum number 6,382 in 2008, minimum 1,353 in 2011). The samples were grouped by class size (5 cm). 98% of swordfish caught are between 80 and 190 cm with a mean length of 140 cm. The percentage of undersized individuals is very low for each year (max. 8% in 2007) and it generally decreased from 2007 to 2013.The samples observed by sex during the period 2010-2013 were 1,865 (810 female and 1,055 male). The length classes most represented were between 120 and 175 cm: these classes gather 78% of the total male catches and 57% of the females. Females were relatively more numerous in the classes over 175 cm (22% of the total of the females compared with 12% of the total of male catches). The general mean is 160 cm for females and 140 cm for males. The samples collected for age were 752: about 90% of the samples belong to the classes 2 to 6. Considering sex there are some differences between males and females: for males the most represented age classes are between 2 and 5. The greater number of females are between ages 2 to 7. For the period 2007-09 data are not available.

SCRS/2014/111 focussed on a description of the new form of longlinine, referred to by the authors as midwater or mesopelagic. Since the banning of the gillnet fishery ("spadara") occurred in 2002, the Italian swordfish fishery is practiced only by pelagic longlines. Some fishermen have gradually modified the traditional surface pelagic longline in a midwater fishing gear, which has proven very efficient and it was gradually adopted by most of the Italian longline fleet. A project to examine the phenomenon was undertaken during 2012, comparing also size distribution of the catch and fishing practices of the two different fishing gears, the traditional surface longline and the midwater longline.

About 800 "drifting longliners" were estimated to have swordfish as the main target. A sample of 352 vessels was selected to collect information about the use of the gear, and a sub-sample of 26 vessels was selected to collect catch data. The main biometric parameters of the catches were collected during sampling, as well as technical data concerning fishing gears and other relevant information. In Italy, at least 800 "pelagic longliners" are estimated to have swordfish as the main target. The vessels are mainly distributed in Tyrrhenian sea, with the bulk of the fleet around the Sicilian coasts (both Tyrrhenian and Ionian Sea), Straits of Messina, Sicilian channel and South Adriatic Sea.

Even if the midwater fishing technique is by far the most used,the majority of vessels use both gears depending on the sea condition, season and fishing opportunity. Surface longline is easier to manage and faster in the fishing activity (smaller size and shorter soaking time); it can be used by smaller boats and much closer to the coast (fishing in the surface layers) and produces its main effort only during night hours.

Midwater longline is often much longer set durations, needs greater depths and distance from the coast. It fishes all day long, utilizing a considerable volume of the water column. Usually more than one gear is set during the same fishing trip, therefore a greater fishing effort can be deployed.

A total of 2070 individuals (LJFL between 81.8 and 235.0 cm, average length 121.73 cm) were sampled in three ports. The midwater gear catches on average bigger swordfish but also a wider size range, while surface longline catches are more limited to medium and small sizes. CPUE values, in terms of Kg/1000 hooks are 141.8 Kg in the overall sampling, with partial values of 174.8 for midwater and 78.5 for the surface longline.

Italy has implemented the ICCAT management measures described earlier.

EU-Spain

The Spanish fishery in the Mediterranean targeting swordfish is carried out by surface longlines and by "piedra-bola" longlines. Swordfish are also caught seasonally, in small quantities, as by-catch species on longlines targeting both bluefin tuna and albacore. The total catch of swordfish in 2013 was up to 1 607 tons, comparable with that in the most recent years of the fishery. The surface longline fishery has remained quite stable regarding fishing effort, number of vessels involved in the fishery as well as their technical characteristics (on average, length 11 m; HP 145 and GRT 25).

The Spanish swordfish longline fishery in the Mediterranean is regulated following ICCAT recommendations described earlier.

Morocco

The Moroccan swordfish fishery in the Mediterranean Sea has been in operation since 1983. With the introduction of the driftnet in the area in the early 90, the fishery has had an important expansion during the

1990s. Since 2008, the Mediterranean catches have been significantly reduced due to the implementation of the national plan for banning the driftnet, following the ICCAT recommendation (Rec.03-04).

After the total ban of driftnet use in Moroccan waters since 2012, swordfish is mainly targeted by longliners in the Mediterranean, particularly in the strait of Gibraltar (Figure 2). The fishing season occurs during August-September and from December to January, with a peak in December.Minor catches of this species are also taken occasionally by traps and purse seines.

After the peak landings of 4,900 tons recorded in 1997, the swordfish catches have shown a steady decline since 2005 and were 770 tons in 2013. The average catch during the period 2012-2013, was about 786 tons, which represented a decrease of about 44% with respect to the period 2009-2011. This important reduction in the total catches is due to the complete ban of driftnet since 2012.

Over the last decade, the average size of the landed fish in the strait of Gibraltar did not show any clear trend, it remained relatively stable around 145cm (45kg).

In addition to the ICCAT management measures already described, Morocco has established a freeze on fishing effort through the suspension of the investments for vessel construction since 1992 (Circular note No. 3887 of 18 August 1992). Morocco also implemented a minimum size of 125 cm up to and including 2011, but the new ICCAT minimum size (Rec. 11-03) has been implemented for 2012 and later.

Tunisia

Swordfish is an important economic species for Tunisia. National production is around 1000 t since 2003. The main fishing season is the summer. Surface longline is the most commonly used gear type.There are 466 vessels allowed to catch swordfish (year 2013). This fleet is attached to 20 landing ports. The main port is in the north. However, the eastern region has the main part of the fleet (62%). Vessels range in length between 5 to 20 m,(GRT) tonnage range 1.7 and 49 t and engine power (HP) from 30 to 500 cv.

Fishing regulations follow the ICCAT recommendations described earlier. Further details on the Tunisian swordfish fishery may be found in SCRS/2014/109.In its review, the WG noted some differences between Task 1 and the landings information in SCRS/2014/109, but the discrepancies were slight (about 2%)

Turkey

The Turkish swordfish fishery in the Mediterranean dates back to the early 17th century. The fishery in Turkey has been carried out in Aegean Sea and eastern Mediterranean Sea. While harpoon gear has been used in the northern Aegean Sea, longlines have been used in the Aegean Sea and the eastern Mediterranean Sea.However, some swordfish are also caught incidentally by purse seines as by-catch.About 150 vessels were involved in the swordfish fishery and most of them are smaller than 20 m LOA. This fishery is carried out 6-7 months per year due to the closed seasons and meteorological conditions.

The annual catch is variable, ranging between 7 tons in 1976 and 589 tons in 1988. Total catch amount of swordfish was 79.7 t in 2012, and it slightly increased to 96.8 t in 2013 but still there has been a considerable decrease in the total catch of swordfish that can be attributed to the end of the gillnet fishery.

Turkey has implemented the ICCAT management measures described earlier. In addition, Turkey uses a minimum landing size of 125 cm LJFL

Summary of National Fisheries

It is clear from the fishery descriptions presented here that the Mediterranean swordfish fishery supports a number of important national fisheries with significant numbers of active vessels.However, the Group noted that the number of vessels on the ICCAT list (ICCAT Record of SWO-MED Vessels, established under Rec. 11-03, which contains a list of fishing vessels authorized to catch swordfish in the Mediterranean Sea often much larger than the number of active vessels authorized by CPCs to fish Mediterranean swordfish in 2013.

ICCAT CPC	Authorized vessels active in 2013
Algeria	303
EU.Cyprus	na
EU.Spain	70
EU.France	na
EU.Greece	160
EU.Croatia	na
EU.Italy	1944*
EU.Malta	na
EU.Portugal	na
Morocco	na
Tunisia	Around 460
Turkey	100
Total	2990

(*) in accordance with the current EU and international provisions, fishing log-book data available for 1944 vessels of L.O.A. > 10 MT., 264 vessels with catches reported on the log-book for 2013.

The above list reflects information available to the WG at the time of the assessment, and as indicated, is an underestimate of the number of active vessels involved in the Mediterranean fishery.

3. Update of basic information: swordfish

3.1 New Biological Information

The Group reviewed SCRS/2014/110, which presented results of a growth study of swordfish in the Strait of Gibraltar based on monthly size frequencies data collected from the Moroccan driftnet fishery during the period 2006-2011. The growth parameters were estimated by the modal progression analysis (MPA), using both the Bhattacharya and NORMSEP methods.

The growth pattern of swordfish in the Strait of Gibraltar was found to be very similar to that obtained from past studies in various Mediterranean areas (Tserpes and Tsimenides 1995). Given the existing growth differences among Atlantic and Mediterranean swordfish, this suggests that the majority of fish caught in this area are most likely belonging to the Mediterranean stock. However, further studies are needed to identify the degree of mixing among stocks.

The Group recalled that in another recent paper (Akyol and Ceyhan 2013) obtained comparable results from direct age determination using anal fin spine sections.

Given the general agreement of the available age and growth studies, the growth equations adopted by the WG continue to be those developed by Tserpes and Tsimenides (1995).In addition, given the consistency of the results of the various age and growth studies, the Group concluded that modelling work should reflect a high degree of certainty in the estimated growth parameters.

As no new information was presented for other biological parameters, the WG used the same inputs as were used in the 2010 stock assessment.A summary of the biological parameters used by Group is provided below:

Parameter	Mean	CV	Distribution	Description	Source
M	0.206	0.25	lognormal	Natural mortality (1/year)	McAllister (2014)
Linf	238.58	0.1	lognormal	Von Bertalanffy Asymptotic length	Mean: ICCAT Manual. CV: Working group
K	0.185	0.1	normal	Von Bertalanffy growth parameter	Mean: ICCAT Manual. CV: Working group

t0	-1.404	0.2	normal	Von Bertalanffy age at zero length	Mean: ICCAT Manual. CV: Working group
a	8.90E-07	0.1	lognormal	Weight at length parameter	Mean:ICCAT Manual. CV: McAllister (2014)
b	3.554738	0.1	normal	Weight at length parameter	Mean:ICCAT Manual. CV: McAllister (2014)
L50	142	0.2	lognormal	Length at 50% maturity	Mean:ICCAT Manual. CV: McAllister (2014)
d	0.2	0.2	lognormal	Parameter of the logistic maturity ogive	Working group
h	0.83	0.14	beta	Steepness h=0.2 + 0.8 Beta(5.86. 1.59)	McAllister (2014)

3.2 Catch, Effort Size at Age, Catch at Age

At the beginning of the meeting, the Secretariat presented the most up-to-date information available for the Mediterranean swordfish stock. This covers the Task I nominal catch (T1NC), Task II catch and effort (T2CE), and Task II size frequencies (T2SZ).No new conventional tagging data were available since the 2010 assessment.

Task I catches

The complete SWO-MED summary table is presented in **Table 1**. The values for 2013 are preliminary. The Working Group noted that the available catch data appeared to be generally complete.The Group considered that the value for Tunisia may reflect an estimate, given the consistency of catches in recent years, and the WG requested that the values be checked. Subsequently, the Group learned from the Tunisia representative that the data reported were in fact estimates. The Algerian scientist noted discrepancies between the Task I Algeria catches and the values reported in their National Reports. It was recommended that Algeria statistical correspondent revised, update and present to the SubCom Stats the Task I NC submitted by year and gear type for the 2008 to 2010. The Group also noted that the 2012 catches for Italy (other surface gear) were not reported.For the purposes of the assessment, it was assumed that the 2012 catch for Italy (other surface gear) was the average of 2010, 2011 and 2013 (718 t).

In 2013, the total yield for the stock increased to 12164 t, an increase of about 23% compared to 2012, which was the lowest annual catch since 1983.

Figure 1 shows the T1NC yearly catch trends by year and major gear. In the previous stock assessment, it was noted that the SWO-MED stock is among the stock with largest T1NC catches with gear “unclassified”. While such catches are not a major component of the contemporary years, there remain ranges of years where significant catches are designated as gear “unclassified”.Efforts should be made by the national scientists of the relevant CPCs to discriminate T1NC catches by gear for the time periods in question. **Figure 1** also illustrates the increase in the importance of the longline gear component.

Task II (catch-effort and size samples)

The detailed catalogue of T2CE is presented in **Table 2**.Although there are some significant absences of size information (for example, EU-Italy in 2013), the Group noted a general improvement in data availability in the most recent years.

The Secretariat presented a summary of the derivation of the catch at size and catch at age data in SCRS 2014/170, which is reproduced below.

Data and Methods

The ICCAT Mediterranean swordfish task II data comprise size information since 1975 to 2013, with some few size observations from 1961.However, number of size samples increased only after 1994, with the highest peak in the 2010.CAS has been submitted by CPCs since 1991 representing over 90% of the information available (**Figure 3**). Size and CAS data has been submitted by Mediterranean CPCs and at least 17 different type of fishing gears (**Figure 3**).Eleven CPCs have submitted size samples and only 5 CAS (EU.Cyprus, EU.Italy, EU.Spain, EU.Malta and Maroc). Lower Jaw Fork length (LJFL) is the main size measurement reported (99%), but there are also few weight frequency samples (WGT, 1213 observations).Overall, a total of 754,534 fish size measurements and 2,916,005 Catch-at-size are available for the Mediterranean swordfish. Size ranges from 11 to 295 LJFL cm; sizes above 450 cm were considered outliers and excluded from any further analysis (2 observations).

Figure 4 shows the size distributions of the size samples and the CAS data.Overall both type of data show similar information, central tendency and variance are similar, distributions show a left skew distribution with a peak at 105-110 LJFL size, extending from 60 to 220 LJFL cm. Six main fishing gears were reported with catches of swordfish, longline (LL), bait-boats (BB), trap (TRP), gillnets (GN), harpoon (HRP), handlines (HND) and unknown gear category (UNK). Task II data include other variables such Flag, Fleet, Port zone, and time period.Most of the data is reported with month of catch, however some observations are reported in quarterly or semester strata.For the later, data were assigned to the mid-month of the corresponding quarter or semester.

Figure 5 shows the size distribution of the SWO-M by year from 1975 forward.For early years 1975 to 1984, the average size of fish were above the overall mean, albeit the limited number of observations.Since 1987, the size distribution of SWO-M fish has remain rather stable, with a mean about 110 LJFL cm, however yearly histograms show differences in the spread and shape of the distributions.

A mosaic plot of year versus month indicated that size samples are available for all months, except in the early years and in more recent years. From 2010 forward, the size samples are primarily from the months of August and September (**Figure 6**).The boxplots of size by month indicate some seasonal pattern, with larger size fish caught in May and June, compared to the rest of months (**Figure 6**). There are also differences in the size distribution by gear type (**Figure 7**). Harpoon catch larger size fish, albeit few samples are available; on the other hand, longlines and gillnets catch smaller size fish.

Catch at Size and Age Estimation

The main purpose of size frequency input data is to provide information to assessment models of the size and or age distribution of the catch. This assumes that size frequency data is representative of the fleet(s) catch.In models where age composition is the input, normally the input CAA matrix is estimated from the combined CAS of all fleets. For Mediterranean swordfish, CAA has been generated from the overall CAS, if a CPC reported CAS for their fleets, this information is the main input to overall CAS, if only size frequency samples were provided, these were raised to estimate total CAS for a given particular fleet, or when neither CAS or size data is available, a substitution size frequency data is used following the prior recommendations from the Swordfish Working Group.In general, the substitutions are from comparable gear-area fleets.Tables of substitution applied to the CAS information are available from the ICCAT Secretariat; **Figure 8** summarizes the level of substitutions for the 2006-2013 period. Finally, the CAS was compared with the Task I reported Catch by flag/fleet, the conversion of fish numbers to yield used the current length weight relationship (Mejuto and De la Serna, 1993) for Mediterranean swordfish, and good agreement was noted.

Using the current adopted size at age relationship for Mediterranean swordfish (Tserpes and Tsimenides, 1995) a CAA matrix was constructed using a simple slicing algorithm applied to the monthly reported CAS matrix. The ageing was done on the size range from 30 to 290 cm in 1 cm interval, where the 290 cm bin is a plus group, estimating age distribution from ages 0 to 19 Plus **Table 3** shows the estimated CAA matrix and **Figure 9** the age distribution by year.

The authors of SCRS 2014/170 noted that the comparison of the size samples against the CAS provided by CPCs shows very similar distributions and central tendency values. This result indicates that CAS and or size frequency data is representative of the fisheries, noticing however that for CPCs that submitted both CAS and size frequency data they are likely using the size data to estimate their CAS.

In 2010 a comparison of CAA estimated by two procedures (Kell and Kell, 2011) was presented. The methods were an inversion of the von Bertalanffy growth model comparable to the age-slicing method used in this analysis, and a stochastic ALK procedure. They concluded based on the stochastic model that age-slicing underestimates the proportions of age of younger fish. The current CAA indicates that about 80% of the catches correspond to ages 0 to 4; being ages 1 and 2 the most predominant (**Figure 9**). Finally, estimates of mean weight at age by year shows a rather stable trend for most ages, except the plus group (**Figure 10**).

3.3. Relative abundance indices

During the meeting nine relative abundance indices were assembled to be considered for the assessment (**Table 4**). One of these indices, the index for the Sicilian gillnet fishery calculated for the period 1990-2009 by Tserpes et al (2011) was presented at the previous assessment. The index has not been updated because the drifnet ban has eliminated that fishery and no new data has been made available for it.The Group discussed the fact that this index could be biased because it includes years (2002-2009) during which the drifnet ban had been in effect. The Group suspects that during this period the distribution and quality of individual catch reports, and thus the data used for the index, may be affected by the management change to the point of making the index unreliable. The group therefore decided to only use the index for the period 1990-2001 in the assessment.

A second historical cpue index was examined corresponding to the North Ionian fishery (De Metrio et al 1999).This index presents a nominal cpue series for a single Italian fishing port, but it is very valuable in as much it presents the oldest record, going back to 1978, of swordfish longline catch rates for the Mediterranean. The group discussed the usefulness of this index but was concerned by the fact that it is not standardized, therefore decided to use it only for sensitivity analysis.It would be important to attempt to recover the original data and standardize cpue for this series.

Four of the other relative abundance indices presented were updates of previously presented indices (Greek longline 1987-2013, Sicilian longline 1991-2009, Moroccan gillnet 1999-2011 and Spanish Longline 1988-2013) and three were new indices (Turkish gillnet 2008-2010, Turkish longline 2008-2013 and Ligurian longline 1991-2009). The Sicilian longline index presented here, however, used a different subset of historical data than the one presented at the last assessment (Tserpes et al 2011).

It is important to note that although more indices were made available at this assessment in comparison to the previous assessment, the drifnet ban is greatly affecting the number of available indices for the most recent years.From 2012 onwards only the Spanish and Greek longline indices are available to inform assessment models. Fortunately these indices are associated with two of the most important Mediterranean fleets and represent data for opposite sides of the Mediterranean.Unfortunately there are no available indices for the central Mediterranean since 2010. This is partially due to changes in the way longlines have been set by Italian vessels.Since 2009 many of these vessels have partially or completely switched to using mesopelagic longlines that fish deeper than surface drifting longlines (SCRS 2014/100, SCRS2014/106, SCRS 2014/111).The Group discussed the need for collecting data on the type of longline used for each trip to be able to conduct effective standardization of cpue for the Italian longline fleets. The Group also concluded that, for the purposes of cpue standardization, mesopelagic longlines and surface drifting longlines should be considered different gear.In addition the group also discussed that there are variations in the setting of longlines, such as lightsticks, bait type, etc that ideally should be considered during cpue standardization because it is well known that they affect the catch rates of swordfish (Tserpes and Peristeraki 2004). So far only the standardization of Mediterranean swordfish for Greek longlines has considered gear type (surface drifting vs American).

The Group developed a table summarizing the characteristics of the data sets, the rigor in the implementation of the CPUE standardization and the robustness of results given our knowledge about expected stock productivity (**Table 5**). This table was derived following the recommendations of the ICCAT methods working group (ICCAT 2013) and followed similar tables derived by the Albacore and Tropical tuna working groups. The Group adapted the description of the ratings for each criterion to fit the needs of Mediterranean swordfish data. Specifically, the Group decided that ratings for the length of the time series should make reference to a fishery that started in earnest in 1980 rather than in 1950. In rating the criteria about plausibility of trends in the data the Group agreed to rate all series as a 3 because no series showed a strong trend. The Group also discussed the appropriateness of the method of Walter and Cass-Calay (2012) to rate the robustness of the data, meaning the likelihood that fluctuations in the index are plausible biologically. Doubts were raised whether such method is appropriate and whether it would be best to use the assessment model to assess this plausibility. It was pointed out that this table of criteria is meant to be used as help in the selection of indices to be used in the assessment. Therefore, obtaining a rating for the criteria cannot depend on running the assessment model. The Group agreed therefore to retain the criteria of plausibility of trends and fluctuations but did not evaluate indices according to the later criteria during the current assessment.

SCRS/2014/096 updated standardized catch rates in number of fish from the Spanish surface drifting longline fleet targeting swordfish in the western Mediterranean for the period 1988-2013. Data included 24239 trips analyzed by means of General Linear Modeling (GLM). Annual standardized CPUEs did not show a clear trend, but the index was more variable in recent years.The Group discussed whether Spanish longliners also have shown a tendency to use mesopelagic longline in recent times, like the Italian fleets.The authors of the paper pointed out that there is a small portion of the fleet which does use mesopelagic longline. This fleet, however, has not been growing and lands a small portion of the Spanish longline catch, which continues to be derived from mostly surface drifting longlines.

SCRS/2014/097 represents the indices of abundance of swordfish (Xiphias gladius) from the Turkish gillnet and longline fisheries operating in the eastern Mediterranean for the period 2008-2013. Gillnet CPUE data suggested the presence of and increasing abundance trend over the period 2008-2010, while not any particular trend was identified from the analysis of the longline data set. The Group noted the importance of this work because it was the first time indices were calculated for these two fleets.The number of observations used in the analysis is small, 133 for the gillnet and 50 for the longline leading to highly variable and uncertain indices. Given this and the small number of years that these indices represent the Group decided not to use these indices in the assessment. It is important to highlight the information these indices provide for the purposes of describing the fisheries in the eastern side of the Mediterranean and encourage the authors to update the longline index as new data become available and possibly as more historical data are recovered.

SCRS/2014/104 presented annual standardized catch rates from the Greek surface drifting longline fisheries operating in the Aegean and Levantine seas from 1987-2013.Modeling of CPUE data was made by GLM techniques included temporal variables in the model.There have been considerable catchability changes over time due to gear modifications, and some of these changes were taken into account in the paper by adjusting cpue accordingly. The Group noted that although CPUE levels do not show any particular trend over time, it is clear that from 2000 onwards the estimated indexes are generally lower (with the exception of 2013) than those of the earlier years.

SCRS/2014/105 presented annual standardized catch rates from the Sicilian traditional surface drifting longline fisheries operating in the Tyrrhenian Sea and the Straits of Sicily. Data covered the period 1991-2009 and standardized indices were estimated by means of GLM that took into account the effects of year, month and area. Results did not demonstrate the presence of any particular trend over time and again where rather variable from one year to the next. Although this is an update of the index presented by Tserpes (2011) the estimated index is different to the one presented in 2011 because the latest dataset only includes traditional surface drifting longline operations targeting swordfish.

The document SCRS/2014/108 updated the catch rates from the Moroccan driftnet fleet targeting swordfish in the Strait of Gibraltar up to 2011. The daily catch rates were analyzed using the General Linear Modelling approach (GLM), under log-normal error assumption in order to compute standardized abundance indices. The relative abundance index showed a relatively stable trend over the considered time series. The factors year, month and vessel size explained most of the variability observed in the abundance index.This index corresponds to a fishery harvesting swordfish to the west of the current stock boundary for Mediterranean swordfish, howeverthe Group agreed to include it in the assessment, as it had been included in prior assessments.Section 3.1 provides information supporting this inclusion.

SCRS/2014/112 presented annual standardized catch rates from the traditional surface drifting longline fisheries operating in the Ligurian Sea. Data covered the period 1991-2009 and standardized indices were estimated by means of GLM that took into account the effects of year and month. Results showed that the CPUE index was gradually increasing, however, since 2000 the index is much more variable partially masking the increasing trend.

When scaled to the mean of each index and compared, the ensemble of indices did not show a clear trend of change in biomass (**Figure 11**).When individual indices are rescaled to have a mean of zero and standard deviation of one and then smoothed, it is possible to see the overall trend of all data combined (**Figure 12**).The global smoothed index shows a decline from 1987 to 1990 and then a slow increase from 1991 until present. It is important to note, however, that the smoothed index explains a small portion of the variability observed in the scaled index data. Some of the indices are negatively correlated, notably the Sicilian gillnet and the Spanish longline (**Table 6**).Two of the indices do show a slight increasing trend in the last 10 years (Spanish longline and Ligurian longline) whereas all others show high variability but no trend over such period.

For the assessment the Group agreed to give equal weighting to all indices.As an alternative to this the Group also discussed weighting the indices by the relative area covered by the fishery associated by each index and by the relative catch landed by the fisheries associated by each index.Such alternative weighting schemes have been often used by the tropical tuna and billfish working groups in production model runs.

The Group agreed that there is limited information to derive relative area weights for Mediterranean fleets because the fishing effort data available for such fleets is rather coarse, at 5 degree level, and therefore inadequate for an area of the size of the Mediterranean. The Group, however, agreed to use Task I data to derive relative catch weights. These weights were obtained directly from Task I tables available at the meeting. Catches from Moroccan Gillnets are made in both sides of the 05°W boundary.In order to associate the appropriate catches to the Moroccan index the Group assumed that 50% of those catches are made west of the 05°W boundary in the straitof Gibraltar. The Sicilian index was associated to the catch of fleets reported to ICCAT as South Ionian Sea, Tyrrhenian Sea and Sicilian Straits. Unfortunately such catch data was not available in Task I tables for all years and fleets and a few interpolations had to be made to get a complete set of relative catch weights (**Table 7**).These interpolations were required for selected years of some of the Italian indices. Whenever there was no data reported to ICCAT for that year and fleet the catch was calculated as the product of the total reported Italian catch and a constant representing the proportion that such fleet represented in the catches of 1990-1995, a period when Italy disaggregated catch reports among regional fleets.

Additionally, participants provided estimates of the Ligurian longline catch for years 1997-2000. It was not possible to reconstruct the history of catch associated to the North Ionian fishery because Task I data available for Italy for the period 1968-1975 are not reported as longline and probably included in the category unknown gear. From 1976-1984 data are reported as longline but not separated by origin of the fleet.

4. Stock Assessment

A number of assessment methods were used to provide an idea of the effect of model choice on the stock status determination and to attempt to use the widest possible range of available data.Two different production models (Bayesian and non-Bayesian), a size structured model, catch curve analysis and an age structured population model (XSA). Two of these modeling approaches were used in the previous assessment (ASPIC and XSA). Although the implementation of the Bayesian production model (BSP) is new for Mediterranean swordfish this model was used in the last assessment for the Northern stock of Atlantic swordfish (McAllister 2014).Like in the previous assessment, and due to reasons explained below, the age structured model (XSA) was chosen to develop the stock status advice and to develop projections.

4.1. Methods

4.1.1 Bayesian Surplus Production Model

A Bayesian Surplus Production model was applied to the catch and CPUE data for Mediterranean swordfish. The software used was the same as available in the ICCAT catalog of methods, except for: (1) an improvement in the handling of population crashes in the projections and (2) the output of data for Kobe analysis. This software has been used in previous ICCAT assessments including albacore, sharks, billfish and swordfish.

The Bayesian model requires priors for the model parameters, including carrying capacity (K), biomass in the first year relative to K (Bo/K) and the intrinsic rate of population increase (r). The prior for K was uniform on $\log(K)$, a vague prior that weakly favors smaller values of K. The prior for Bo/K had a mean of 1.0 and a CV of 0.2, consistent with the understanding that there was very little fishing before the starting year of 1950. The informative prior for r was derived from a method based on growth, maturity and recruitment data, developed by **McAllister (2014)** for Atlantic swordfish. See **Appendix4** for details of the derivation. The prior for r was lognormal, with mean of 0.47 and CV of 0.49 (standard deviation of $\log(r)$=0.46). The continuous time version of the BSP model was used.

Six CPUE indices were used: Moroccan gillnet, Spanish longline, Sicilian longline, Sicilian gillnet, Greek longline, and Ligurian longline. Models were run with catch versus equal weighting of the CPUE data, and with either the Schaefer or a generalized form of the production model, for four primary runs. For the equal weighting case, the observation error standard deviation was set to its maximum likelihood estimate of 0.2 for each data point. For the catch weighting case, the weights to each data point were equal to the ratio of each fleet’s catch to the total catch in each year. These ratios were re-scaled to imply an average observation error standard deviation of 0.2.For the generalized production model, the value of the shape parameter (n) in the Fletcher model was fixed to n=0.67, so that *Bmsy/K*=0.3. This value was chosen because evidence from equilibrium analysis implied that maximum surplus production is likely to occur at biomass levels less than half of *K*.

Diagnostic model runs included a post-model pre-data run for both the Schaefer model and the generalized production model. Post model, pre data runs are a method to evaluate the influence of the priors on the results. The models were also run with uniform priors to evaluate the information content of the data. Each series was also fitted independently in Schaefer model with equal weighting (σ =0.2), either with informative or uniform priors. Finally, a retrospective analysis was conducted for the Schaefer model with equal weighting (σ =0.2).

A number of sensitivity analyses were conducted. These included equal weighting with observation error variance equal to 1.0, or 0.1, and catch weighting without re-scaling the weights (average observation error variance >1 for years with multiple indices). To evaluate whether the uncertain catches in the 1950s through 1970s influenced the results, the starting year was increased to either 1965 or 1987. In the starting-year sensitivity runs, the prior CV for *Bo/K* was increased to 0.5, because there was less information on the starting biomass ratio in later years. For the run beginning in 1987, the mean *Bo/K* was set to 0.9. Finally, a sensitivity analysis was done with an alternative prior for *r* with a mean r of 0.76, and CV of 0.39.

4.1.2 ASPIC Production model

ASPIC was used to fit the available fishery-dependent relative abundance indices and total catch of Mediterranean swordfish. ASPIC 5.33 (A Stock Production Model Incorporating Covariates) is an implementation (Prager 1994) of a non-equilibrium production model derived from the surplus production model of Schaefer (1957).The software ASPIC is maintained and supported by the National Marine Fisheries Service and is part of the ICCAT software catalog. The model is more formally described in Prager (1994) and Quinn and Deriso (1999). The model incorporates several extensions to the classical stock-production models, including the ability to estimate the shape of the production function so that it departs from the Schaefer model. The ASPIC bootstrap routine was used to construct approximate nonparametric confidence intervals (80%) and to correct for bias by conducting 500 trials.Statistical weights associated to relative abundance indices were either made equal for all data points or equal to the relative contribution of the catches associated with each index.The ASPIC model was always run assuming that the catch was known without error.Initial estimates and constraints used for population parameters were kept constant for all different runs **(Table 8).** All parameters of the model, K, MSY and q were estimated during the fit.

The ASPIC model used total catch data for the 1950-2013 period and six CPUE index series that included Greek longliners, Italian longliners (two indices from Sicilia and Liguria fisheries), Spanish longliners, Moroccan gillnetters, and Italian gillnetters..It was considered that the stock was close to its carry capacity on 1950.Final estimates of model parameters (K, B_0/K, and q's) were obtained using a least absolute values criterion of fit.

A series of sensitivity analyses were run to examine the assumption made when developing the input to the ASPIC fit (**Table 9**).Among the sensitivity analysis run were one where the Ionian North index was incorporated to the data set to see how the addition of a relative abundance index with information from the mid 1970s to mid 1980s affects the fit of the production model. To see the sensitivity of the fit to the inclusion of each index, indices were removed one at a time from the input data. To see the effect of the assumption of the shape of the production function` a Fox production model and a generalized production function were fitted. To examine the effect of the length of the catch series the time series was started in 1980 rather than in 1950. Finally to see the effect of recent data on the fit a retrospective analysis was run by eliminating annual data one year at a time from the most recent year 2013 until 2008.

4.1.3 Age structured models

XSA

An age structured assessment was conducted using XSAin R using the FLXSA package (part of the FLR-project, Kell et al., 2007; http://www.flr-project.org/). The Catch-at-age (CAA) data were generated using a statistical mixture distribution analysis that was shown during the previous assessment to provide statistically more robust results than deterministic age slicing. The estimates of CVs also showed that there was little information in the length distributions to justify splitting CAS into ages greater than 5. Therefore, in line with the Atlantic swordfish assessments XSA runs were conducted with a plus group of 5, (see SCRS/2014/114 for a full documentation of the XSA runs).

Biological parameters used for maturity and natural mortality-at-age were the same as in the last assessment, i.e. fish first mature at age 3 (when 50% are mature) and are fully mature at older ages; natural mortality was assumed equal to 0.2. Weights-at-age were derived from the mixture analysis and were consistent with the CAA.

Six CPUE data sets were available for tuning the XSA: i.e. Moroccan gillneters (SCRS/2014/108), Spanish longliners (SCRS/2014/096), Sicilian longliners (SCRS/2014/105), Scilian gillneters (Tserpes et al., 2011), Greek longliners (SCRS/2014/104) and Ligurian longliners (SCRS/2014/112). The standardized CPUE indices were not differentiated by age. These indices in the XSA were considered to be representative of the 2-4 age-group abundances (the plus group is not used for calibration within XSA) as assumed in the last assessment. Fleet catchability was assumed to be independent of year-class size for all terminal years and ages.

XSA estimates the survivors (i.e. terminal Ns by age and year) for each observed value of CPUE. This is done by calibration regression to predict population numbers-at-age by year for each series and then projecting along the cohort to the oldest age or most recent year. In addition shrinkage to the mean is performed, where the terminal Ns also including a term related to recent Fs or Fs at younger ages (shrinkage to the mean F) and numbers-at-age for recruiting age classes are estimated from the geometric mean of recent recruitments (shrinkage to the mean n). Time series weights can be applied to discount past values.

Two XSA runs were conducted, i.e. that based on the 2010 settings and an alternative candidaterun based on goodness of fit diagnostics and a preliminary analysis of the size and age data using catch curves. Details of both runs including diagnostics and relative weightings are availablein SCRS/2014/114.The main changes in the alternative candidate run were to reduce the amount of F shrinkage to the mean since there have been changes in both selection pattern and mean F. The F shrinkage age range was reduced to 1 age as there were only 4 true ages and F varied by age. Based on the diagnostics, the Candidate run wasconsidered for evaluating the stock status and providing advice.The final XSA assessment covered the period up to 2013 and **Table 10** presents the control options used in the candidate run

Equilibrium yield analyses

The XSA results were used as the basis for an equilibrium analysis which combines yield and spawner per recruit analyses with a stock recruitment relationship and provide results consistent with a long-term projection.Biological parameters and selectivity-at-age were derived from the XSA results.

4.2. Stock status results

4.2.1 BSP

The CPUE series showed a slight increasing trend in recent years, and all four of the models followed this trend (**Figure 13**). The data were somewhat informative, so that the posteriors of *K* and *r* were different from the priors (**Figure 14**). In particular, the mode of*r* was higher than the mode of its prior in all four runs. The models estimated that MSY was around 30-40,000 kg. The generalized production model (*Bmsy/K*=0.3) was more optimistic than the Schaefer model. Current fishing mortality was around 0.34*Fmsy* in the Schaefer models, and 0.16*Fmsy* in the models with *Bmsy/K*=0.3 (**Table 11, Figure 15**). Mean current stock status was 1.6*Bmsy* in the Schaefer models and 2.6*Bmsy* in the generalized models. Catch and equal weighting gave similar results.

The diagnostic and sensitivity runs are described in detail in **Appendix 5**. The post-model pre-data runs return values of *r* similar to the prior, as expected. The models with uniform priors returned much higher values of *r*. The fits to the individual indices vary somewhat on how much the recent trend increases (**Figure BSP4 in Appendix 5**). A retrospective analysis of the Schaefer model run with equal weighting showed that there was no obvious retrospective pattern (**Figure BSP5 in Appendix 5**). Runs that ended around 2008 were more pessimistic than the current run, but the runs ending in 2005 were more optimistic. The sensitivity analyses found that the assumption about the average value of the observation error standard deviation has a strong effect on the results. Therefore, the models that used the maximum likelihood estimate of observation error standard deviation as the best estimate are more believable than those that used a different value. The runs with a later starting year were quite similar to the runs that started in 1950.

BSP results are particularly sensitive to the choice of observation error variance. Although MLE estimates of that variance are available from each series the Group thinks this sensitivity needs to be further investigated to reduce the uncertainty associated with the application of this model to Mediterranean swordfish.

4.2.2 ASPIC

The SP Aspic model run 1 (base case) indicated that the stock was lightly exploited from 1950 until 1965, followed by increases in catches with a decline in biomass as catches progressively increased in 1984 and thereafter (**Figure 16**).Catches peak in 1998 with over 20 thousand tons, while the stock continued declining to reach overfished status during the early 1990's. After the reduction of catches post 1995, the stock started to recover. The status of stock plot in 2013 indicates that the fishing mortality is less than the reference F_{MSY} and the biomass is above the estimated reference of B_{MSY} (**Figure 17**).

Appendix 6 includes information on various sensitivity runs that were accomplished. Several sensitivity scenarios were run with the Production Model as described in **Table 6.1.2 in Appendix 6.**The run 1 with equal weighting for all indices and estimating all parameters converged, albeit the model reported a negative correlation among some of the indices (**Table 6.1.3**).Estimated parameters and confidence bootstrapped results are shown in **Table 6.1.4 in Appendix 6**.Fits to indices of abundances and trends of relative biomass and fishing mortality are shown in **Figures 6.1.1**and **6.1.2 in Appendix 6.**No differences were observed when assuming different initial guess estimates for the B_0/K parameter.

The sensitivity run comparing shape parameter of the surplus production curve indicated that the data support a Logistic shape function rather than the asymmetric Fox model (**Table 6.1.5**, **Figure 6.1.3 in Appendix 6**).Using a Generalized model, the estimated alpha parameter was 0.503 closer to the Logistic assumption than the Fox model. However, overall the results indicate a high productivity of the stock as indicated by high estimated values of *r* above 0.7.The retrospective analysis show a pattern, with increase of relative fishing mortality and decrease of relative biomass as data from recent years are removed, these results change when data from 2008 forwards was removed (**Table 6.1.6**, **Figure 6.1.4 in Appendix 6**).A sensitivity run restricting the data to the 1980-2013 period, and adjusting the input guess of B_0/K to 0.5 indicated a similar trend of relative biomass and fishing mortality compare to the model with data from 1950 (**Figure 6.1.5 in Appendix 6**).Because relative indices of abundance are restricted to 1987 forward, the Group presented a nominal CPUE series from an Italian longline fishery presented at the SCRS (De Metrio et al 1999) (**Figure 6.1.6 in Appendix 6**).Overall results show similar trends of relative biomass and relative fishing mortality for most of the sensitivity runs.

4.2.3 Age structured models

XSA

Time series of recruitment, SSB, catch and fishing mortality are given in **Figure 18.** A retrospective analysis that was also conducted does not show any particular pattern **(Figure 19).** Recruitment shows a slightly declining trend in the last decade, while stock biomass remains stable. **Tables 12 and 13** present the estimates of population numbers and fishing mortality at-age respectively. Trends in F-at-age are shown in **Figure 20;** there appears to have been a recent decline in F, particularly for ages 1 and 2.

Equilibrium yield analyses

A Beverton and Holt stock recruitment relationship was fitted, see **Figure 21** for the fit with diagnostics. There appears to be a recent shift in recruitment in the most recent years (considering also the XSA estimates of SSB and R) and this was evaluated using the STARS algorithm (Rodionov, 2004; Szuwalski et al., 2014). The shaded area gives the mean and standard deviation of recruitment prior to the regime shift (**Figure 22**).

Following the above analysis a Beverton and Holt stock recruitment relationship was refitted to data from the period 2003 to 2012 (data from 2013 were omitted sincerecruitment in this year came solely from shrinkage) (**Figure 23).**

The resulting equilibrium estimates for several biological reference points are given in **Table 14; e**quilibrium curves are illustrated in **Figure 24.** Estimates of uncertainty derived from the Terminal N standard errors in the time series are presented in **Figure 25** and the Kobe phase plot in **Figure 26.** The current (2013) SSB and F levels suggest that the stock is overfished and subject to overfishing.

4.2.4. Synthesis of assessment results

The Group discussed the limitations and strengths of the various assessment methods used to evaluate stock status of Mediterranean swordfish and the commonalities and differences in the results obtained.There was consensus among the models that the stock had declined in the 1980s, and has been stable or slightly increasing since then. However, the XSA, ASPIC and BSP models gave different estimates of the absolute abundance, which caused them to produce very different estimates of stock status. BSP was the most optimistic, finding that the stock had never dropped below Bmsy, and current F was much lower than Fmsy. According to ASPIC, the stock had dropped below Bmsy in the early 1990s, but has now recovered above Bmsy. Current F was around half Fmsy. In contrast, the XSA found that current status was overfished and experiencing overfishing.

As in the previous assessment, the group weighed the limitations of both models, given the available data, and considered that the XSA provides a more reliable assessment of stock status than the production models. A number of reasons were cited and informed the Group in reaching this conclusion:

- catch at age data provides additional information to inform stock productivity in comparison to the production models that only use catch in biomass and relative abundance indices.
- catch at age information used is an improvement from the one used in the last assessment as a consequence of completeness in the size frequency samples characterizing the catch at size for recent years.
- The lack of contrast in the relative abundance indices make production model results to be rather uncertain because stock productivity (estimates of r and K) is poorly defined by the data. This specially affects ASPIC results which do not have the additional information on stock productivity provided by the priors supplied to the BSP. It is also the result of the lack of relative abundance indices for the period when the stock is expected to have declined in abundance (1975-1985),as catch increased.

It should be noted that the approach of using the XSA results for stock status and projections is also consistent with previous assessments. Nevertheless, the XSA results have significant uncertainty.

The historical XSA estimates suggest that, from the 90s onwards, SSB has been relatively stable with little evidence of any trend. In the last ten years there is some suggestion of a reduction in F and recruitment. Like in most XSA implementations, recent estimates from VPA are the most uncertain and any increasing trend is within the range of interannual variability seen earlier in the time series. In spite of this uncertainty, estimates of population status from XSA indicate that the stock remains in the red quadrant as current (2013) SSB is about 65% lower than B_{MSY} and F is twice the F_{MSY}. These results, however, are based on deterministic analyses and the level of uncertainty in these estimates has not been evaluated.

4.3 Evaluation of management scenarios

The XSA model outcomes were projected forward under different exploitation scenarios.Each management scenario was simulated 500 times for a period of 25 years and as in the last assessment population size and volume of landings were estimated from the commonly used exponential decay and catch equations. In addition it was assumed that: (a) annual natural mortality equals to 0.2 for all ages and (b) annual recruitment deviates were similar to the period 2003 to 2012 (re-sampling from the recruitment residuals fitted to the recent data was done). In each simulation the total catch, recruitment, harvest and spawning stock biomass (SSB) by year were estimated. All scenarios were accomplished using the Fisheries Library in R (FLR) framework (http://www.flr-project.org/, Kell et al. 2007).

Four Mediterranean-wide management scenarios were examined. The first (base case) scenario assumes a continuation of the current exploitation pattern without any change, i.e. fishing mortality (F) at age for the entire projection period will be equal to that of 2013 (last assessment year). The second scenario assumes a 20% F reduction without any change in the selection pattern. Given that certain fleets have recently adopted the mesopelagic longline which has a different selection pattern than the surface one (**Figure 27)**, the third and fourth scenarios assume a selection shift towards the mesopelagic gear for 50% of the total effort. Similarly, to scenarios 1 and 2, scenario 3 assumes no change in the overall F, while scenario 4 assumes a 20% reduction.

Results indicate that under current F, SSB will increase (**Figures 28** and **29)** under both exploitation patterns. However, even in the case of a 20% reduction of current F, SSB will still not reach the highest level in the time series, i.e. the late 80’s levels.If the selection pattern changes towards the mesopelagic gear then slightly higher yields will be provided.

Figures 30, 31 and 32 show the historical XSA estimates and projections of SSB, F and catch relative to MSY benchmarks. Although both SSB and F will remain below MSY levels, catch will be close to MSY even if F is reduced to the 80% of the current levels. This is due to the shape of the equilibrium curves (**Figure 24)**, where even increasing F by an order of magnitude greater than FMSY (0.25) results in yield decreasing only by just over 30%.

5. Recommendations

5.1 Statistics and research

- Data submission. The Group noted substantial improvement in terms of reporting data by the ICCAT deadlines, even when no analytical stock assessment is scheduled. However, late submission of data is still occurring, which preclude their use during the assessment meeting. Therefore the Group reiterated the need for data to be submitted by ICCAT deadlines.
- Participation by ICCAT Contracting Parties in the Assessment Working Group. The Group noted a substantial increase on participation, namely by scientist from several Contracting Parties having significant swordfish fisheries. This had obvious positive consequences for the Group’s ability to accurately interpret fisheries trends, and provide better advice to the Commission. The Group encouraged such level of participation in future meetings.
- Catch. All countries catching swordfish (directed or by-catch) should report catch, catch-at-size (by sex) and effort statistics by as small an area as possible (5º rectangles for longline, and 1ºrectangles for other gears), and by month. The Group noted that it is important to collect size data together with the catch and effort data to provide meaningful CPUEs.
- Discards. Recently adopted management measures may have increase discard levels, therefore the Group noted that participating countries should improve their estimates of discards of juvenile swordfish, when applicable, and submit such information to the ICCAT Secretariat.
- CPUE. The Group noted that new CPUE series have been developed and recommended the collection and recovery of historical data to increase the period covered by these time series. For example the nominal data presented in de Metrio et al. (1999) should be recovered and evaluated for possible standardization. The Group recommended EU-Italy mesopelagic longlines and traditional drifting surface longlines to be considered different gear, and separate CPUE series be developed in the future. The Group reiterated the need that CPUE to take into account the geographic stratification of the catch by gear and month using standard measures of effort for each gear (e.g., number of hooks for longline, length of nets for gillnet), on as fine a scale as possible (5ºrectangles for longline, and 1º rectangles for other gears). In addition the Group also recommended considering other gear characteristics (i.e. use of light attractors, hook style, bait type, etc.) during CPUE standardization. Although CPUE by age is the usual input for the age-structured analyses, the Group recognized that this must be based on an increased level of sampling, not merely substitution of the current data. Therefore, it is recommended that increased sampling take place so that CPUEs can be developed by age. To achieve this goal, the Group noted that it is important to collect size data together with the catch and effort data to provide meaningful CPUEs.
- Environment. The Group recommended continued work to better identify the effects of the environment on swordfish biology, ecology and fisheries. Future CPUE analyses should focus on developing additional methods to explicitly incorporate environmental variability into the model, and the influence of environment on the distribution of spawners and juveniles.
- Gear selectivity studies. Further research on gear design and use is encouraged in order to minimize catch of age-0 swordfish and increase yield and spawning biomass per recruit from this fishery. The Group recommended further studies to be conducted on the recently developed mesopelagic longlines fisheries, due to the impact these new fisheries may have in terms of catch composition, CPUE series, size distribution of the catches and consequently on the assessment of the stock status and provision of management advice.
- Stock mixing and management boundaries. Considering differences in the catch and CPUE patterns between different Mediterranean fisheries, further research, including tagging(both electronic and conventional) and genetic investigations, in defining temporal variations in the spatial distribution pattern of the stock will help to improve stock delimitation, assessment and management. The Group

also noted the need to intensify collaborative and multi-disciplinary research taking into account fine-scale (e.g. 1º squares) and quarterly sampling strata, aiming at improving the precise delimitation of the current (western) boundary between the Mediterranean and North Atlantic swordfish stocks.

- Next Mediterranean swordfish stock assessment. It is recommended that the next swordfish stock assessment be conducted no sooner than 2017, as long as there is no signal from the stock indicating decline. This allows time to increase the time series of catch and effort data, and to advance basic research and assessment methods. It should be noted that the data required for that session should be up to and including the year prior to the meeting.

5.2. Management

The available information on Mediterranean swordfish stock status indicates a relative stable pattern for biomass in the recent decades supporting catches that have ranged between 10,000 and 16,000 MT. After the adoption of several Recommendations by the Commission since 2007, including those related to the banning of driftnets and especially the management measures for the Mediterranean swordfish adopted in [Rec. 11-03], reported catches have decreased significantly from the 2000´s level, being the catches in 2012 and 2013 the minimum values of the last three decades. And reported catches of juvenile swordfish of less than 90cm has also decreased on average 54% in the last two years compared with the levels of the decade of 2000´s. Seasonal closures and the introduction of the mesopelagic LL by some fleets have contributed to the observed decrease of catches of juveniles.

Over the last 20 years biomass levels appear to be rather stable. This situation remains the same since the last assessment. However, fishing mortality levels show a declining trend since 2010 and it is likely that this is mainly due to the management measures adopted by the Commission. In any case, there is considerable uncertainty about the stock status relative to the Convention objectives, mainly due to the lack of clear signal in the data and the lack of abundance indices before 1987. The Group recommends to maintain the current management measures of Mediterranean swordfish as adopted in [Rec. 13-04] until further research increases our confidence on their effect on the stock.

However, the Group notes that the recently adopted management measures may have increased discard levels of undersized swordfish and therefore recommends a close monitoring of the fishery and that every component of Mediterranean swordfish mortality be adequately reported to ICCAT by the CPCs.

Management measures have had a positive impact, however the Group also noted that the number of vessels in the ICCAT records of vessels authorized to catch Mediterranean swordfish is higher than the vessels that are active in each CPC. The Group recommends the Commission considers the implications of this potential excess capacity.

6. Other matters

No other matters were discussed by the Group.

7. Adoption of the report and closure

A draft version of the report was adopted during the meeting and it was finalized through correspondence.

The Chairman thanked the participants for their hard work.

The meeting was adjourned.

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Table 1. Task I summary table for the Mediterranean swordfish (*Xiphias gladius*) stock: total catch (t) by major gear and flag (2013 data are preliminary).

Flag	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
TOTAL	3341	4975	5973.007	4808.936	5043.467	4313.856	4637	5284.572	5966	5547
Longline										
Algerie				100	196	500	368	370	320	521
Chinese Taipei										
EU.Croatia										
EU.Cyprus						5	59	95	82	98
EU.España	900	1100	1300	1105	700	89	89	667	720	800
EU.France										
EU.Greece										
EU.Italy							3435	3330	3750	3455
EU.Malta										
EU.Portugal										
Japan			15.007	1.936	9.467	12.856	1	4.572	2	3
Korea Rep.										
Libya										
Maroc	214	326	229	183	193	118	186	144	172	
NEI (MED)										
Syria										
Tunisie					5	3	5			
Turkey										
Sub Total	1114	1426	1544.007	1389.936	1103.467	727.856	4143	4610.572	5046	4877
Other surf.										
Albania										
Algerie										
EU.Croatia										
EU.España										
EU.France										
EU.Italy	2016	3248	4144	3136	3730	3362	312	417	764	475
EU.Malta	112	224	224	224	192	214	175	223	136	151
Maroc		1	1		3					
NEI (MED)										
Syria										
Tunisie										
Turkey	99	76	60	59	15	10	7	34	20	44
Subtotal	2227	3549	4429	3419	3940	3586	494	674	920	670

Flag	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL	6579	6814.022	6343	6896.376	13665.58	15291.96	16764.86	18319.98	20365.38	17761.89	16017.5
Longline											
Algerie	650	760	870	877	884	890	847	1820	2621	590	173
Chinese Taipei											
EU.Croatia											
EU.Cyprus	72	78	103	28	63	71	154	84	121	139	173
EU.España	750	1120	900	1321	1243	1219	1337	1133.969	1760	1250	1438
EU.France											
EU.Greece		91	773	772	1081	1036	1714	1303	1008	1120	1344
EU.Italy	3642	3362	2583	2660	2759	2493	2622	2831	2989	2989	2454
EU.Malta				59.376	93.577	171.964	143.86	163.01	233.376	121.891	134.504
EU.Portugal											
Japan	1	1.022	5	6	19	14	7	3	4	1	2
Korea Rep.											
Libya											
Maroc				43	39	38	92	40	62	97	371
NEI (MED)			517	532	552	499	524	566	598	598	918
Syria											
Tunisie		7	19	15	15	61	64	63	80	159	176
Turkey											
Sub Total	5115	5419.022	5770	6313.376	6748.577	6492.964	7504.86	8006.979	9476.376	7064.891	7183.504
Other surf.											
Albania											
Algerie											539
EU.Croatia											
EU.España				1	2	8			2	87	85
EU.France											
EU.Italy	501	461	356	366	6601	8370	8791	9494	10021	10020	6647
EU.Malta	222	192	177								
Maroc											878
NEI (MED)	728	672			219	231	243	262	277	381	442
Syria											
Tunisie											
Turkey	13	70	40	216	95	190	226	557	589	209	243
Subtotal	1464	1395	573	583	6917	8799	9260	10313	10889	10697	8834

Flag	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
TOTAL	15746.28	14709.42	13264.87	16082.21	13014.81	12052.81	14693.35	14368.87	13698.64	15568.79	15006.07
Longline											
Algerie	173	6	173	185	247	247	247				133
Chinese Taipei			1	1		1	3				
EU.Croatia								10	20		
EU.Cyprus	162	56.2	116	159	89	40	51	61	92	82.335	135.322
EU.España	1132	790	1293	1402	1351	1040	1184	1409	866.7	1395.713	1401.8
EU.France											
EU.Greece	1904	1456	1568	2520	974	1237	750	1650	1520	1960	1730
EU.Italy	2470	3518	3260	3844	3035	2617	2458	2458	2680	2639	2236
EU.Malta	129.277	85.219	90.866	47.214	71.708	71.811	100.346	152.865	186.937	175.242	101.581
EU.Portugal										13.3	115.1
Japan	1	2	4	2	4	5	5	7	4	2	1
Korea Rep.											
Libya								11		7.635	5.584
Maroc	508	807	517	527	169	273	245	323	259	205	754
NEI (MED)	733	733									
Syria											
Tunisie	181	178	354	298	378	352	346	414	468	483	567
Turkey											
Sub Total	7393.277	7631.419	7376.866	8985.214	6318.708	5883.811	5389.346	6495.865	6096.637	6963.225	7180.367
Other surf.											
Albania						13	13	13	13		
Algerie	389	389	389	415	560	560	560	825	709	816	948
EU.Croatia											
EU.España	39	32	65	101	28	146	80	34	39	40.56	81.7
EU.France					0.1						12
EU.Italy	6068	4077	3070	3921	4275	2669	3646	3646	3632	4876	4152
EU.Malta											
Maroc	1198	1885	2072	2127	1527	2461	4655	2905	2979	2503	2272
NEI (MED)	559	559									
Syria											
Tunisie											
Turkey	100	136	292	533	306	320	350	450	230	370	360
Subtotal	8353	7078	5888	7097	6696.1	6169	9304	7873	7602	8605.56	7825.7

Flag	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL	12814.04	15674.09	14404.92	14600.07	14892.95	14226.84	12163.83	11839.52	13429.68	11422.75	9888.418	11253.84
Longline												
Algerie	99		52	93	496	492	802	468	624	192.28	355.523	383.5
Chinese Taipei												
EU.Croatia							4.175	0.965	1.873	4.241	1.526	5.205
EU.Cyprus	103.584	47.404	49.112	52.782	42.684	67.412	66.621	37.771	31.057	34.61	35.254	51.485
EU.España	1420.7	1164.963	929.569	860.257	1405.368	1648.187	2062.802	1994.357	1785.408	1730.159	1580.153	1605.412
EU.France								10.19588	72.52389	39.25088	9.6075	40.461
EU.Greece	1680	1230	1129.15	1423.773	1373.87	1906.934	989.11	1131.735	1493.998	1306.314	877.31	1730.524
EU.Italy	1841	5844.23	5451.57	5559.76	5253	4563.68	4521.212	4686.6	5101.296	4579.195	3856.347	4512.279
EU.Malta	257	162.516	195.263	362.112	239.181	213.487	260.234	265.9374	422.761	532.0049	503.3602	459.9101
EU.Portugal	7.6	0.61	120.2	13.912	15.504							
Japan	0.752		2	3.745	0.386	2.582	1.495	0.525				
Korea Rep.								1				
Libya		10.064	2.439		13.5							
Maroc	1149	1670	1954	1801	1455	1107	1370	1110	1200	640	802	770
NEI (MED)												
Syria						22.185	17.066				5.4	2.5
Tunisie	1138	285.001	791	791	949	1024	1011	1012	1016	1013	1013.667	1014.222
Turkey	70						386	301	334	189.6	66.498	96.8
Sub Total	7766.636	10414.79	10676.3	10961.34	11243.49	11047.47	11491.71	11020.09	12082.92	10260.65	9106.646	10672.3
Other surf.												
Albania												
Algerie	715	665	512	542	206	109.23				23.99	31.855	19.21
EU.Croatia							0.07	2.154	3.867	1.857	2.385	4.582
EU.España	77.4	60.778	21.748	49.56	57.071	48.46915	31.888	5.267	6.677	13.515	10.48	1.547
EU.France	27		19			14.032	14.054	5.78616	5.30108	41.32429	2.35256	16.326
EU.Italy	1698	2550.9	1490.87	1900.17	2373.39	1954.64	27.76908	329.2238	920.9153	694.4133	717.8974	538.3635
EU.Malta												0.013
Maroc	2230	1630	1299	722	603	615	587	477	410	387		
NEI (MED)												
Syria						15	11.333				3.6	1.5
Tunisie		2.623										
Turkey	300	350	386	425	410	423					13.202	
Subtotal	5047.4	5259.301	3728.618	3638.73	3649.461	3179.371	672.1141	819.4309	1346.76	1162.1	781.7719	581.5415

Table 2. SWO-M catalogue (1985-2013) 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]

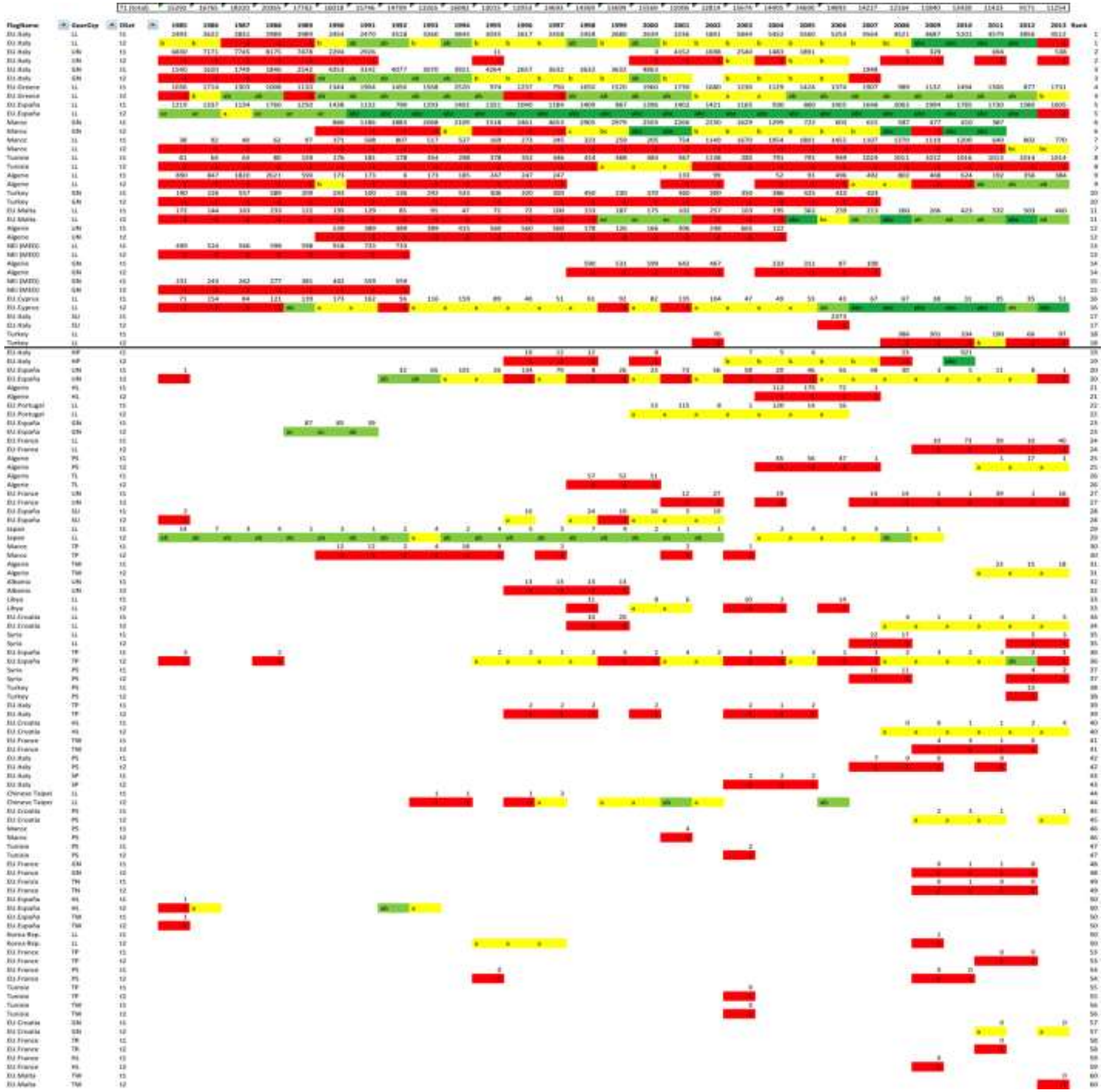


Table 3. Mediterranean swordfish catch at age 1985 – 2013 estimated using the current growth function with age slicing protocol.

YearC	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10P
1985	12,769	110,944	128,478	91,891	53,942	33,355	21,181	5,725	2,035	1,400	1,776
1986	14,447	74,202	144,172	108,854	49,854	40,587	21,068	8,545	1,314	2,648	3,185
1987	18,582	156,715	109,680	99,711	62,776	49,289	25,913	7,641	2,329	1,927	4,126
1988	26,796	249,149	175,548	98,063	76,698	45,534	21,734	6,918	3,494	1,991	4,081
1989	44,618	165,802	189,349	105,596	62,039	38,461	14,398	6,167	3,815	1,238	2,445
1990	11,074	189,157	270,543	125,424	33,500	16,531	8,869	2,893	1,689	653	1,024
1991	16,216	124,900	194,132	124,805	52,773	25,404	10,893	5,239	2,768	1,442	1,696
1992	33,637	141,664	231,548	84,954	40,036	21,645	10,826	4,594	3,708	1,866	1,034
1993	24,278	200,140	228,180	69,395	28,699	17,056	8,392	4,405	2,488	1,223	1,220
1994	35,208	144,353	270,474	106,604	37,633	20,862	12,409	6,478	3,307	1,411	2,353
1995	30,828	228,055	156,650	87,528	33,101	16,960	9,314	4,527	1,921	1,275	1,595
1996	17,552	144,767	159,069	94,334	34,691	14,542	7,155	3,641	1,794	1,085	1,121
1997	20,214	126,763	162,550	132,307	47,078	25,183	10,555	2,185	1,267	825	738
1998	32,947	224,627	158,430	77,702	37,074	25,482	13,789	6,021	3,297	1,350	1,907
1999	18,838	134,209	172,282	85,220	44,556	23,453	11,919	6,156	1,703	808	1,373
2000	8,103	160,052	171,514	113,006	48,153	28,800	12,322	6,383	2,883	1,409	1,571
2001	19,389	145,120	189,095	114,028	44,705	20,454	9,888	5,534	2,802	965	3,096
2002	10,800	218,630	229,077	86,251	24,997	14,199	5,920	3,350	1,881	749	1,602
2003	44,206	133,444	290,533	116,517	42,368	17,877	6,376	3,724	1,861	1,287	1,145
2004	42,363	224,885	166,711	94,824	39,349	21,959	9,301	4,757	2,413	1,374	1,817
2005	13,412	175,862	211,286	87,607	36,528	20,762	9,283	5,085	2,467	1,160	3,002
2006	24,143	135,409	193,417	80,144	36,290	23,396	11,652	6,930	3,574	2,229	3,021
2007	23,726	250,201	141,031	87,718	39,405	18,324	8,565	4,576	2,993	1,381	2,387
2008	6,960	211,151	211,690	80,812	30,819	13,102	4,961	1,682	893	341	716
2009	3,472	136,310	168,328	78,971	39,186	20,023	7,319	2,615	1,430	821	1,122
2010	14,460	128,375	133,141	95,737	52,083	23,684	9,013	4,296	2,598	1,406	906
2011	37,193	136,021	124,776	91,477	43,425	14,309	8,289	3,716	1,394	1,181	1,644
2012	4,549	96,698	107,180	53,870	27,136	13,482	7,556	5,061	2,224	1,406	1,260
2013	1,396	72,010	174,892	78,911	35,252	15,129	8,947	3,180	1,926	1,442	1,379

Table 4. Relative abundance indices considered in the meeting. MoGN Moroccan gillnet driftnet fishery, SpLL Spanish longline, TuGn Turkish gillnet, TuLL Turkish longline, SiLL Sicilian Longline, SiGN Sicilian gillnet, GrLL Greek longline and LiLL Ligurian longline. Indices and years in grey were not used in the assessment models because they were derived from very limited data sets (TuGN and TuLL) or observations that may have been biased by management changes (SiGN).

	MoGN	SpLL	TuGn	TuLL	SiLL	SiGN	GrLL	LiLL	IoLL
1978									66.5
1979									88.9
1980									98.3
1981									57.8
1982									77.5
1983									54.2
1984									78.18
1985									58.83
1986									41.07
1987							120.9		47.4
1988		116.7					142.6		66.6
1989		82.3							
1990		92.9				8.3	128.7		63.86
1991		75.5			100.3	9.8	170.1	88.5	54.73
1992		61.1			98.5	16.9	68.4	66.1	40.3
1993		84.1				13.0	123.1	68.8	50.91
1994		93.7			99.5	9.5	162.8	90.6	30.58
1995		88.0			124.2	14.7	99.9	94.6	33.43
1996		72.7				9.3		94.3	32.74
1997		74.2			75.9	14.0		101.1	40.11
1998		77.9			127.6	10.1	191.5	144.9	
1999	58.3	69.9			151.5	12.7	146.0	101.9	
2000	66.7	69.5			93.3	14.9	114.6	134.7	
2001	43.1	65.0			144.0	13.1	120.5	181.6	
2002	56.0	93.0			204.8		97.0	140.3	
2003	48.2	65.8			82.2		118.2	152.3	
2004	58.4	59.1			111.2	15.2	119.1	98.9	
2005	70.7	78.2			123.2	12.1	116.7	80.8	
2006	66.2	94.8			140.6	30.7	123.5	125.0	
2007	63.2	115.6			81.1		130.5	240.0	
2008	69.2	144.1	18.8	135.7	87.0	3.3	122.5	208.2	
2009	55.6	105.4	30.5	479.5	99.1	2.0	106.7	123.4	
2010	51.9	107.0	46.5	157.7			126.7		
2011	46.5	112.0		31.2			98.8		
2012		124.3		74.5			98.0		
2013		100.7		269.7			149.3		

Table 5. Criteria used to compare and document the characteristics of relative abundance indices for Mediterranean swordfish

TYPE OF CRITERIA
Information content of data
Appropriateness of method and its application
Consistency of results with biology & fishery

	criteria not necessarily equal in importance			yeaRS	1999-2011	1988-2013	2008-2010	2008-2013	1991-2009	1987-2013			1978-1997
ELEMENT	DESCRIPTION	SUFFICIENCY SCORE (1 is poor, 3 is best)			2014/108	2014/096	2014/97		2014/105	2014/104	Tserpes et al 2011		Demetrio e
		1	2	3	Gill Morocc	Spain LL	Gill Turkey	LL Turkey	Sicil LL	Greek LL	Sicil GN	Ligurian LL	N Ionian LI
1	Diagnostics	No Diagnostics or many assumptions clearly violated	Diagnostics presented but not all assumptions met	Full Diagnostics and assumptions probably fully met.	2	2	2	2	2	2	2	2	1
2	Appropriateness of data exclusions and classifications (e.g. to identify targeted trips).	Not appropriate or not sufficiently described	Described but some exclusions not properly justified	Fully Appropriately described and justified	3	3	3	3	3	3	3	2	1
3	Geographical Coverage relative to the entire distribution of the stock.	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 only part of it	Fishery and data represents the major geographic range of population	2	2	2	2	2	2	2	2	2
4	Catch Fraction relative to the total catch of the stock. Not applicable to scientific surveys	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	2	2	1	1	3	2	3	1	1
5	Length of Time Series relative to the history of systematic exploitation.	Less than 25% of the time of exploitation (<10 years)	extends between 25% and 50% of the time of exploitation (>10 years<15 years)	Extends for more than 50% of the history of exploitation (>16 years)	2	3	1	1	3	3	3	3	3
6	Are other indices available for the same time period?	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	1	2	1	1	2	2	2	2	3
7	Does the index standardization account for known factors that influence catchability/selectivity?	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	2	1	1	1	1	2	1	1	1
8	Are there conflicts between the catch history and the CPUE response?	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	3	3	3	3	3	3	3	3	2
9	Is the interannual variability outside biologically plausible bounds (e.g. SCRS/2012/039)	More than 50% of annual estimates are outside plausible bounds	Between 50% and 10% of annual indices outside plausible bounds	Less than 10% of the annual indices outside plausible bounds									
10	Are there severe biologically implausible trends in relative abundance in part of the time series (e.g. SCRS/2012/039)	Severe trend for a period of more than 4 years	Severe trend for a short time period (4 or less years)	No severe change	3	3	3	3	3	3	3	3	3
11	Assessment of data quality and adequacy of data for standardization purposes (e.g. sampling design, sample size, factors considered)	Unbalanced data respect to standarization factors: numerous data points for each factor combination (90% of the cells have less than 10 observations eg. Aggregate data such as monthly cpue used for a model with quarterly time factors)	Some lack of balance in data respect to standarization factors: numerous data points for each factor combination (More than 50% of the cells have less than 10 observations)	Well balanced data respect to standarization factors: numerous data points for each factor combination (>10 observations for more than 90% of the factorial cells)	2	2	2	2	3	3	3	3	1
12	Is this CPUE time series continuous?	Very Discontinuous more than two breaks in the time series	one or two breaks in the time series	Complete	3	3	3	3	2	2	2	3	2
13	Were discards included in the estimation of the CPUE?	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 by the index	Dead/live accounted for through observers or no discards exist during the time period of the index	2	2	2	2	2	2	2	2	2

Table 6. Correlation coefficients between relative abundance indices used in the assessment of Mediterranean swordfish. Moroccan gillnet driftnet fishery, SpLL Spanish longline, TuGn Turkish gillnet, TuLL Turkish longline, SiLL Sicilian Longline, SiGN Sicilian gillnet, GrLL Greek longline and LiLL Ligurian longline.

	MoGN	*SpLL*	*SiLL*	*SiGN*	*GrLL*	*LiLL*
MoGN	1.000					
SpLL	0.236	1.000				
SiLL	-0.208	-0.122	1.000			
SiGN	0.121	-0.394	0.401	1.000		
GrLL	0.231	-0.028	-0.073	-0.200	1.000	
LiLL	-0.105	0.557	-0.098	-0.235	0.092	1.000

Table 7. Catch associated with each index used in the stock assessment and calculated for the purposes of setting an altenative statistical weighting scheme in the production models. MoGN Moroccan gillnet driftnet fishery, SpLL Spanish longline, TuGn Turkish gillnet, TuLL Turkish longline, SiLL Sicilian Longline, SiGN Sicilian gillnet, GrLL Greek longline and LiLL Ligurian longline. Indices and years in orange (I can't see any indices or year in orange) were not used in the assessment models because they were derived from very limited data sets (TuGN and TuLL) or observations that may have been biased by management changes (SiGN). All estimates come from Task I reports with the exceptions of those figures highlighted in red of blue. Red values were estimated, not directly obtained from task I. Blue values are estimates made during the meeting from data collected in Liguria but not reported to ICCAT as disaggregated.

	MoGN	SpLL	TuGn	TuLL	SiLL	SiGN	GrLL	LiLL
1987							1303	
1988		1760					1008	
1989		1250						
1990		1438				4211	1344	
1991		1132			2120	3035	1904	166
1992		790			3302	3990	1456	101
1993		1293				3000	1568	100
1994		1402			3400	3800	2520	185
1995		1350			2660	4222	974	109
1996		1035				2590		98
1997		1179			21412	3540		196
1998		1383			21412	3540	1650	256
1999	1490	790			2335	3540	1520	151
2000	1252	1361			2300	4740	1960	129
2001	1133	1315			1948	4740	1730	84
2002	1115	1347			1604		1680	69
2003	815	1057			2041	2289	1230	177
2004	650	888			1788	1433	1129	151
2005	361	760			1797	1693	1424	202
2006	302	1060			4577	1693	1374	197
2007	308	1190			3977	1898	1907	171
2008	294	1722	n/a	386	3940	1898	989	169
2009	239	1906	n/a	301	4084		1132	176
2010	205	1727	n/a	334			1494	
2011	194	1655		189			1306	
2012		1485		66			877	
2013		1522		96			1730	

Table 8. Initial parameter estimates and constraints for parameter search for ASPIC runs.

Parameter	Initial value	Min constraint	Maximum constraint
K (MT)	150,000	10,000	1,000,000
MSY (MT)	15,000	1,000	100,000
B1/K	1	n/a	n/a
q MorGN	8.2090E-04	n/a	n/a
q SpaLL	1.2652E-03	n/a	n/a
q SciLL	1.6188E-03	n/a	n/a
q SciGN	1.7263E-04	n/a	n/a
q GrcLL	1.7673E-03	n/a	n/a
q LigLL	1.7404E-03	n/a	n/a

Table 9. Sensitivity runs developed with the SP Aspic model.

Run	Catch period		Indices	Pars Estim	Notes
R1	1950	2013	6, Avg Year	All, LAV	Est catch for 1953 = interpolate(1952,54)
R2	1950	2013	6, Avg Year	ALL, SSQ	Same as R1 but using Sum of Squares for fitting.
R3	1950	2013	5* rem -1	All, LAV	Jacknife Removal 1 index at the time
R4	1950	2013	6, Avg Year	All, LAV	Different initial values for B0/K: 0.5, 1.0, 1.5
R5	1950	2013	6, Avg Year	All, LAV	Fox model with data as R1
R6	1950	2013	6, Avg Year	All, LAV	Generalized model using R1 inputs
R7	1950	2013	6, Avg Year	All, LAV	Retrospective 1 to 6 years removed: 2013 – 2008.
R8	1980	2013	6, Avg Year	All, LAV	Change start year to 1980.
R9	1950	2013	7, Avg Year	All, LAV	Add Historic Nominal CPUE DeMetrio et al 1999 SCRS

Table 10. Control options used in the XSA run.

Plus Group	5
Last Year	2013
Time Series Weight	
Tolerance	1.00E-009
maxit	30
Minimum standard error for population estimates	0.3
SE of the mean for shrinkage	0.5
Shrink to the mean N	TRUE
Shrink to the mean F	TRUE
Shrinkage Years	5
Shrinkage Ages	1
Spline year range	20
Spline power	3

Table 11. Posterior means and CVs of parameters estimated from the four BSP runs. The beginning year was 1950, mean observation error σ=0.2, all indices were used, with the base priors.

Variable	Schaefer	*Bmsy/K*=0.3	Schaefer Catch weighting	*Bmsy/K*=0.3 Catch weighting
K (1000)	215.92 (0.89)	342.04 (0.76)	215.12 (0.90)	341.74 (0.76)
r	0.59 (0.30)	0.89 (0.32)	0.59 (0.30)	0.89 (0.32)
MSY (1000)	27.97 (0.88)	38.44 (0.66)	27.86 (0.88)	38.36 (0.66)
Bcur (1000)	188.85 (1.01)	292.85 (0.85)	188.10 (1.01)	292.52 (0.85)
Binit (1000)	212.36 (0.90)	333.48 (0.75)	211.50 (0.90)	333.40 (0.75)
Bcur/Binit	0.84 (0.15)	0.82 (0.20)	0.84 (0.15)	0.82 (0.21)
Ccur/MSY	0.54 (0.36)	0.39 (0.46)	0.54 (0.36)	0.39 (0.46)
Bcur/Bmsy	1.64 (0.09)	2.67 (0.13)	1.64 (0.09)	2.67 (0.13)
Fcur/Fmsy	0.34 (0.41)	0.16 (0.58)	0.34 (0.41)	0.16 (0.58)

Table 12. Stock number (in 000's) at age at the beginning of the year obtained from the XSA model

age \ year	1985	1986	1987	1988	1989	1990	1991
0	765.366	800.120	999.174	1133.759	970.817	827.703	843.546
1	820.176	607.241	636.480	777.997	871.280	727.747	663.828
2	567.780	550.348	415.591	383.445	398.911	536.111	385.708
3	336.816	343.860	291.294	220.539	163.026	169.315	181.574
4	181.484	204.613	213.146	165.000	102.201	56.112	72.480
5	217.175	265.738	234.518	149.455	84.603	55.283	64.088

age \ year	1992	1993	1994	1995	1996	1997	1998
0	1036.831	900.886	1032.823	903.839	809.627	916.908	894.445
1	665.887	798.116	694.922	784.477	691.663	637.932	726.694
2	386.326	390.517	438.423	397.784	420.876	407.636	381.989
3	140.475	121.260	143.192	135.565	178.138	199.140	159.672
4	66.641	57.682	54.712	55.532	60.009	84.795	85.085
5	72.487	65.806	74.599	63.145	56.100	50.052	101.659

age \ year	1999	2000	2001	2002	2003	2004	2005
0	889.401	923.087	1126.060	865.697	1032.159	1003.277	788.406
1	690.493	699.590	746.525	903.333	700.466	793.912	766.868
2	371.835	405.865	385.236	437.450	480.855	391.175	430.061
3	168.878	165.042	167.197	136.720	166.258	153.506	164.143
4	81.352	78.668	67.951	64.492	70.533	66.856	66.536
5	77.471	75.987	68.876	75.163	50.206	66.120	69.275

age \ year	2006	2007	2008	2009	2010	2011	2012
0	987.260	941.323	784.538	702.436	661.855	872.543	762.029
1	632.646	783.808	748.643	633.656	563.598	518.060	635.579
2	428.611	372.733	401.921	367.438	355.339	325.311	313.015
3	166.945	171.768	162.047	163.959	163.751	167.300	149.020
4	76.910	82.776	79.037	79.976	82.508	63.971	69.909
5	96.272	75.198	51.414	50.948	55.952	61.214	90.974

age \ year	2013
0	679.782
1	604.085
2	417.887
3	170.581
4	83.801
5	86.158

Table 13. Fishing mortality at age obtained from the XSA model.

```
   year
age 1985      1986      1987      1988      1989      1990      1991
  0 0.0314273 0.0288087 0.0502063 0.0633297 0.0881848 0.0206317 0.0364953
  1 0.1989678 0.1792240 0.3067567 0.4679847 0.2856232 0.4348728 0.3413404
  2 0.3014985 0.4362168 0.4336290 0.6552870 0.6569795 0.8826768 0.8100540
  3 0.2984136 0.2782570 0.3683882 0.5691284 0.8665624 0.6484455 0.8023506
  4 0.2984144 0.2782580 0.3683900 0.5691326 0.8665749 0.6484642 0.8023960
  5 0.2984144 0.2782580 0.3683900 0.5691326 0.8665749 0.6484642 0.8023960
   year
age 1992      1993      1994      1995      1996      1997      1998
  0 0.0616707 0.0595793 0.0750337 0.0675525 0.0383424 0.0325016 0.0587975
  1 0.3336489 0.3990706 0.3578897 0.4226792 0.3287246 0.3128393 0.4700555
  2 0.9587446 0.8032840 0.9737336 0.6033505 0.5483310 0.7372503 0.6162156
  3 0.6900867 0.5958574 0.7472263 0.6149571 0.5423184 0.6503621 0.4743366
  4 0.6901641 0.5959775 0.7450457 0.6062457 0.5491225 0.7396164 0.5411092
  5 0.6901641 0.5959775 0.7450457 0.6062457 0.5491225 0.7396164 0.5411092
   year
age 1999      2000      2001      2002      2003      2004      2005
  0 0.0400529 0.0122949 0.0203888 0.0117886 0.0624345 0.0687119 0.0201024
  1 0.3313849 0.3966375 0.3344656 0.4305262 0.3825903 0.4130462 0.3817659
  2 0.6122505 0.6868513 0.8359214 0.7674239 0.9418250 0.6684161 0.7462613
  3 0.5639441 0.6874070 0.7526321 0.4618554 0.7109958 0.6359931 0.5581027
  4 0.6414244 0.7509032 0.6419700 0.3597564 0.6345456 0.7307663 0.6359317
  5 0.6414244 0.7509032 0.6419700 0.3597564 0.6345456 0.7307663 0.6359317
   year
age 2006      2007      2008      2009      2010      2011      2012
  0 0.0307690 0.0290247 0.0135882 0.0202127 0.0449558 0.1168759 0.0322696
  1 0.3290484 0.4679090 0.5117080 0.3784347 0.3495593 0.3038385 0.2193244
  2 0.7144020 0.6329787 0.6966396 0.6082059 0.5532836 0.5807012 0.4070443
  3 0.5015237 0.5762266 0.5061593 0.4867182 0.7399226 0.6725922 0.3756363
  4 0.5893967 0.5299316 0.3573419 0.5952712 0.8183516 0.5166789 0.3815999
  5 0.5893967 0.5299316 0.3573419 0.5952712 0.8183516 0.5166789 0.3815999
   year
age 2013
  0 0.0050759
  1 0.2664159
  2 0.5421825
  3 0.4062308
  4 0.3971059
  5 0.3971059
```

Table 14. Biological reference points.

Ref.pt	**F**	**Yield (t)**	**R**	**SSB (t)**
virgin	0.00E+000	0.00E+000	8.45E+005	2.33E+005
msy	2.43E-001	1.51E+004	8.45E+005	4.76E+004
crash	3.07E+000	1.94E-003	2.44E-001	2.89E-006
f0.1	1.49E-001	1.42E+004	8.45E+005	8.12E+004
fmax	2.43E-001	1.51E+004	8.45E+005	4.75E+004
spr.30	1.74E-001	1.47E+004	8.45E+005	6.98E+004

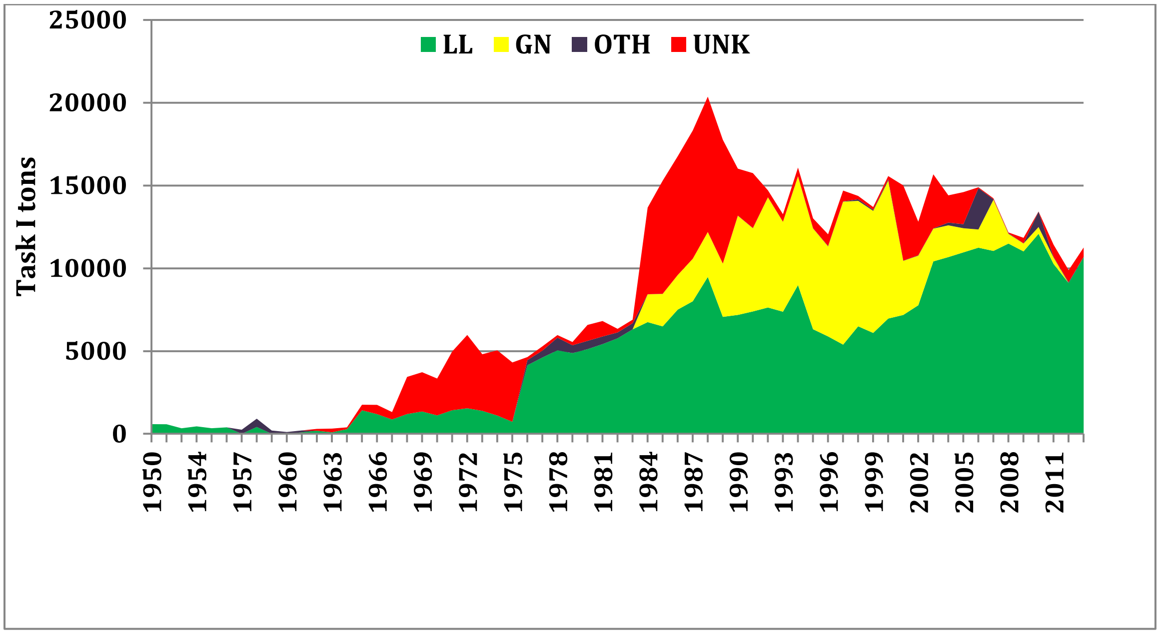


Figure 1. SWO-MED Task I annual catches (t) by gear and year.

Figure 2. Map of the Mediterranean Sea with the main locations referred to in the Report. The Mediterranean/Atlantic boundary used by ICCAT is at 5ºW longitude. The approximate provincial administrative limit for the Mediterranean used by Morocco is also shown.

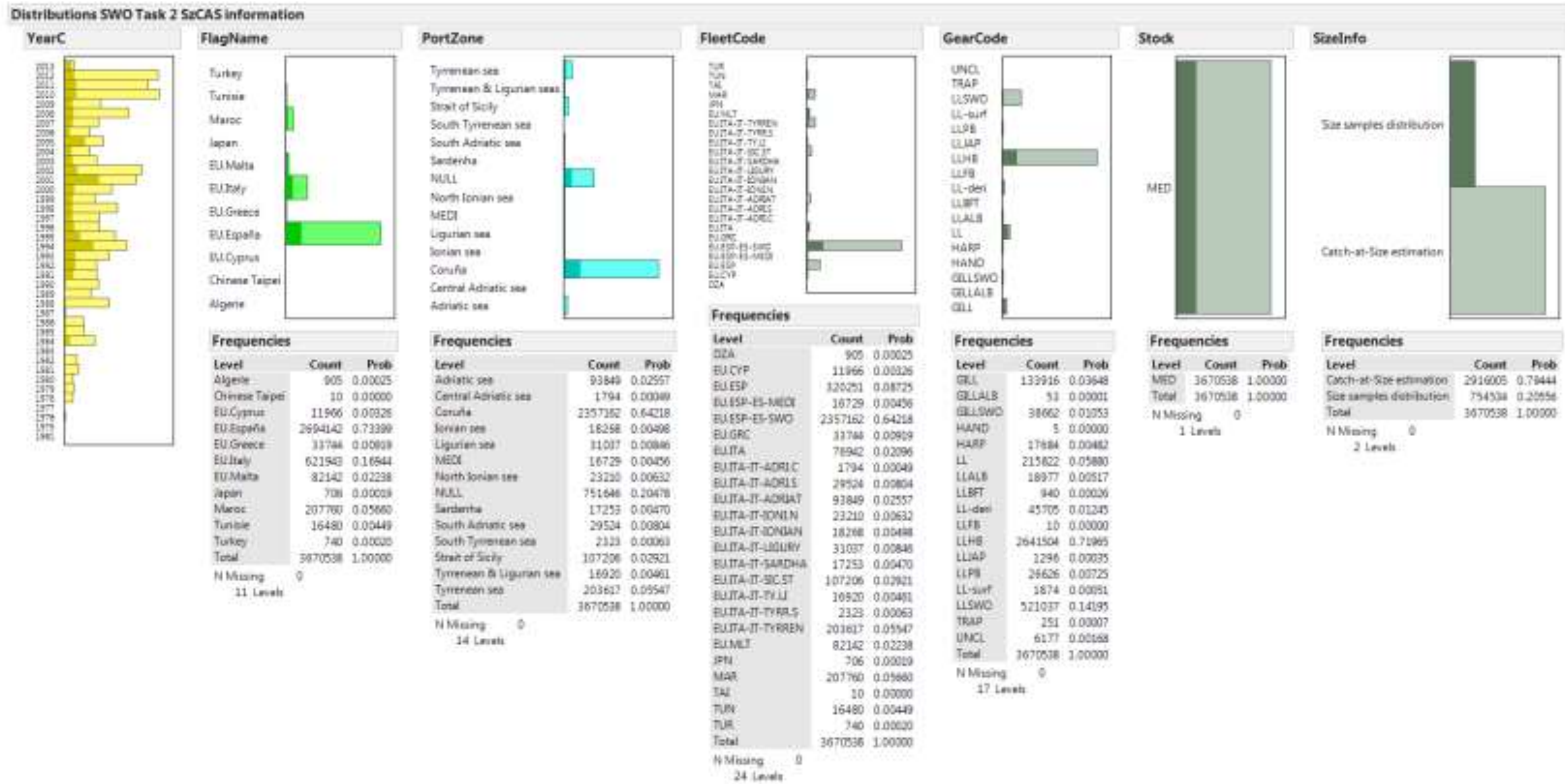
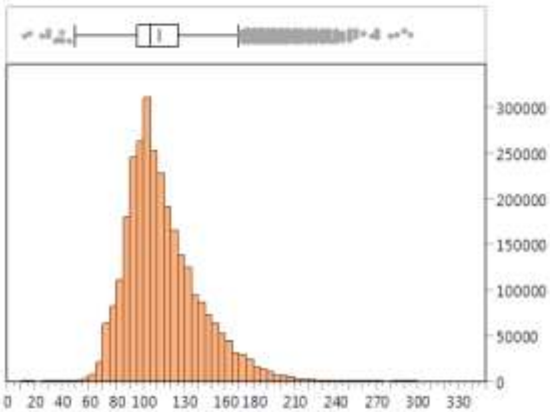


Figure 3. Mediterranean swordfish task 2 size and CAS samples distributions by year, flag, fleet, port, gear and type of information available.

SWO Med Distributions SizeInfo=Catch-at-Size estimation

SizeClass



Quantiles

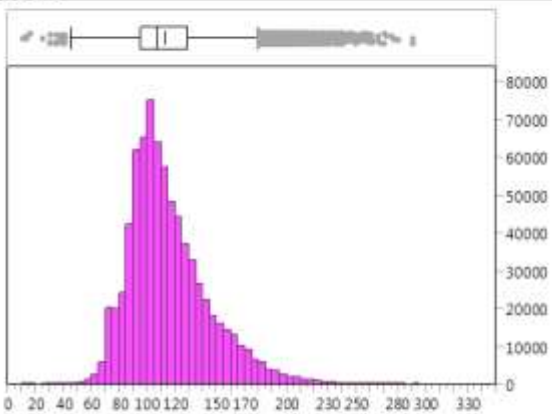
100.0%	maximum	295
99.5%		195
97.5%		175
90.0%		150
75.0%	quartile	125
50.0%	median	105
25.0%	quartile	95
10.0%		85
2.5%		70
0.5%		65
0.0%	minimum	13

Summary Statistics

Mean	111.11684
Std Dev	26.006326
Std Err Mean	0.0152295
Upper 95% Mea	111.14669
Lower 95% Mean	111.08699
N	29160046

Distributions SizeInfo=Size samples distribution

SizeClass



Quantiles

100.0%	maximum	290
99.5%		208
97.5%		180
90.0%		152
75.0%	quartile	129
50.0%	median	108
25.0%	quartile	95
10.0%		85
2.5%		70
0.5%		65
0.0%	minimum	11

Summary Statistics

Mean	113.057
Std Dev	27.900763
Std Err Mean	0.032146
Upper 95% Mea	113.12001
Lower 95% Mean	112.99399
N	753318.89

Figure 4. SWO-Med size (LJFL) distribution from the CAS submitted by CPCs (top) and size samples (bottom).

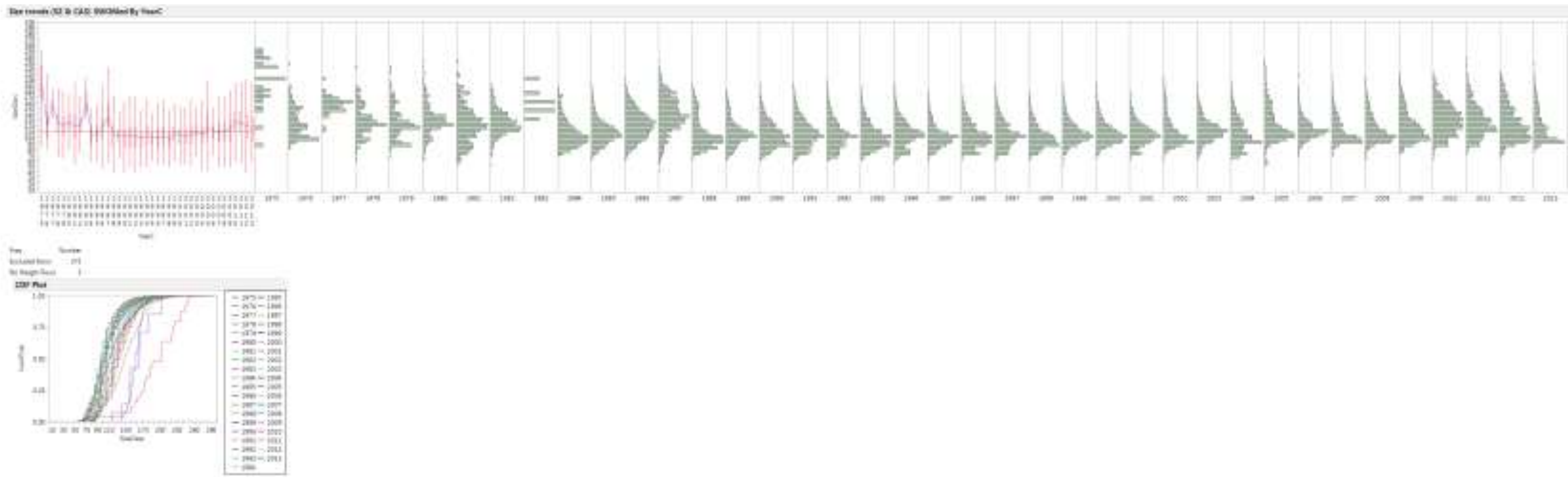


Figure 5. Sword-Med size distributions (LJFL) by year and cumulative density functions by year.

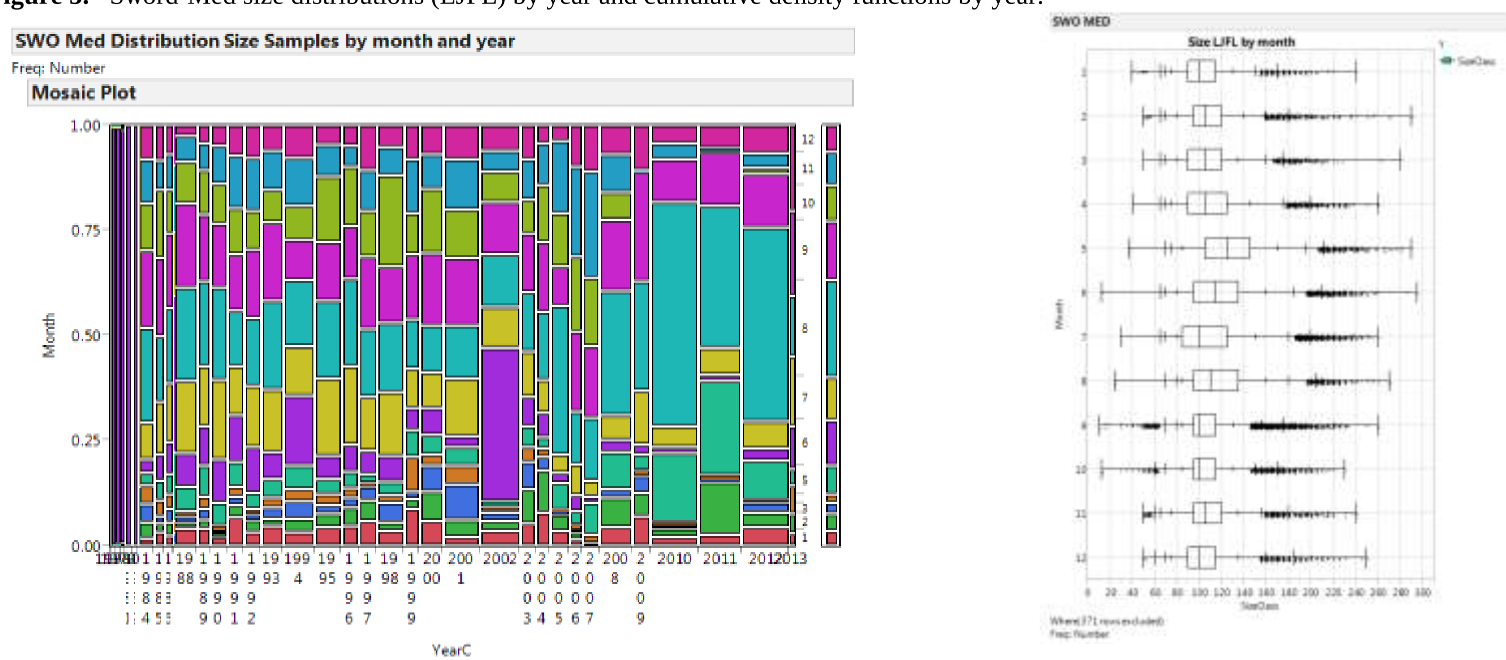


Figure 6. Mosaic plot of the size samples distribution by year - month for Mediterranean swordfish (left) and box plot of size (LJFL) distribution by month (right).

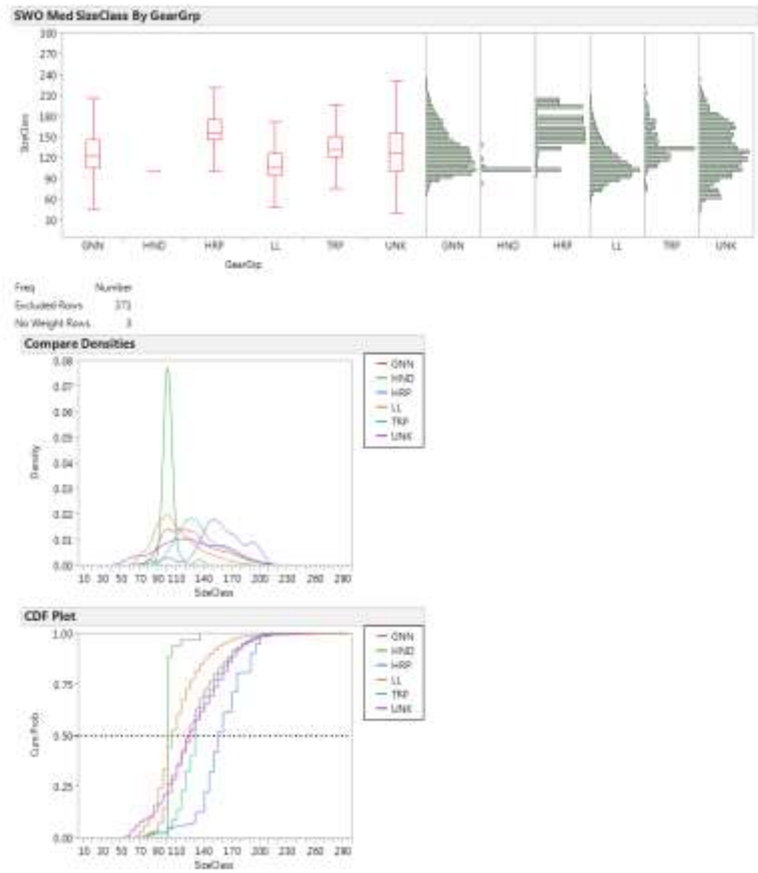


Figure 7. SWO-Med size distribution by gear type, density and cumulative density functions.

Sum of t1Yt		rfYr							
Actions	szInfo	2006	2007	2008	2009	2010	2011	2012	2013
join-raise	0	7626							
	1		67		38	31			
none	1					2883		545	
raise	0	2004	7280	962	1398	1807	2064	1263	2569
re-raise	1	1300	1190	7498	6677	5334	6490	6177	821
sub-raise		3963	5690	3704	3726	3374	2868	1184	7864

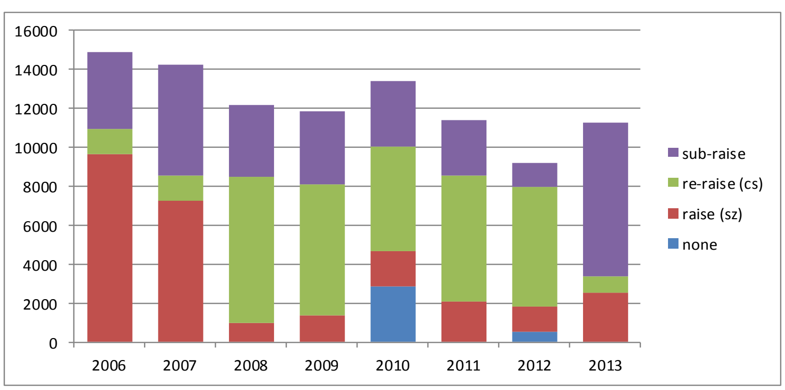


Figure 8. Summary of the substitutions and raising of Task 2 size and CAS data to estimate overall Mediterranean Swordfish CAS for the 2006 -2013 period.

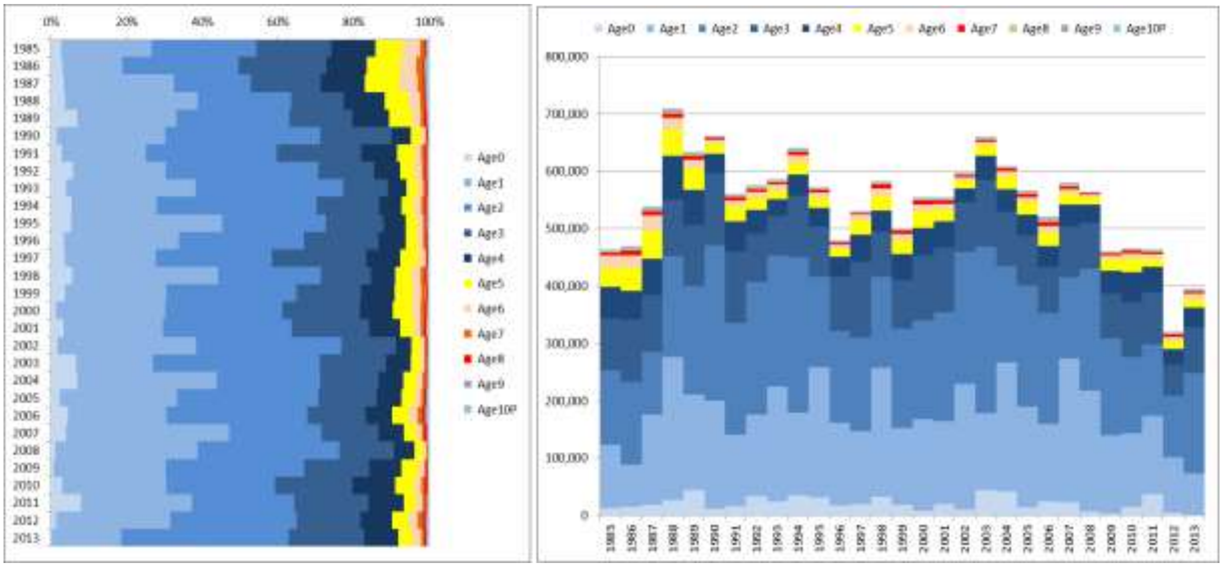


Figure 9. Catch at age Mediterranean swordfish 1985 -2013 estimated by age slicing using the current growth at age function (Tserpes and Tsimenides, 1995).

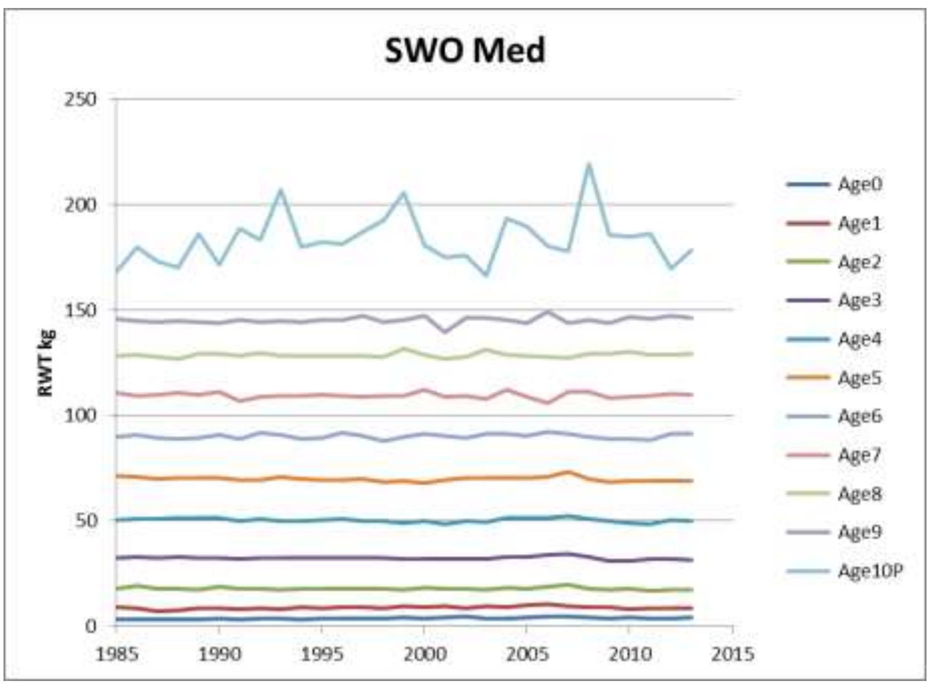


Figure 10. Estimated mean weight at age by year for Mediterranean swordfish from the CAS and CAA matrices

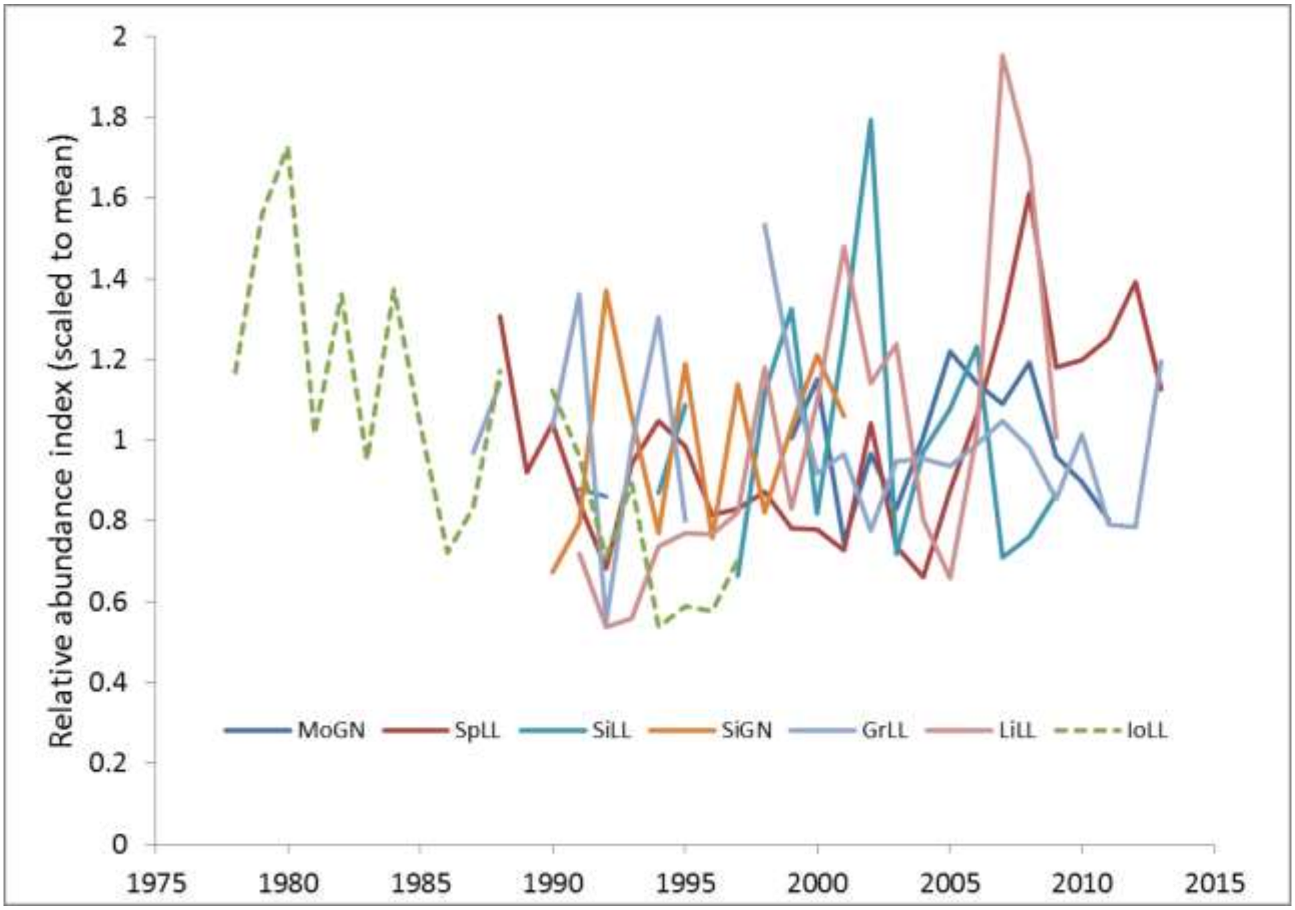


Figure 11. Relative abundance indices used in the assessment for Mediterranean swordfish. All indices are scaled to their individual means to facilitate comparison of trends and relative degree of variability. MoGN Moroccan gillnet driftnet fishery, SpLL Spanish longline, TuGn Turkish gillnet, TuLL Turkish longline, SiLL Sicilian Longline, SiGN Sicilian gillnet, GrLL Greek longline LiLL Ligurian longline, IoLL north Ionian longline. The IoLL index was only used in sensitivity analysis because it is a nominal index.

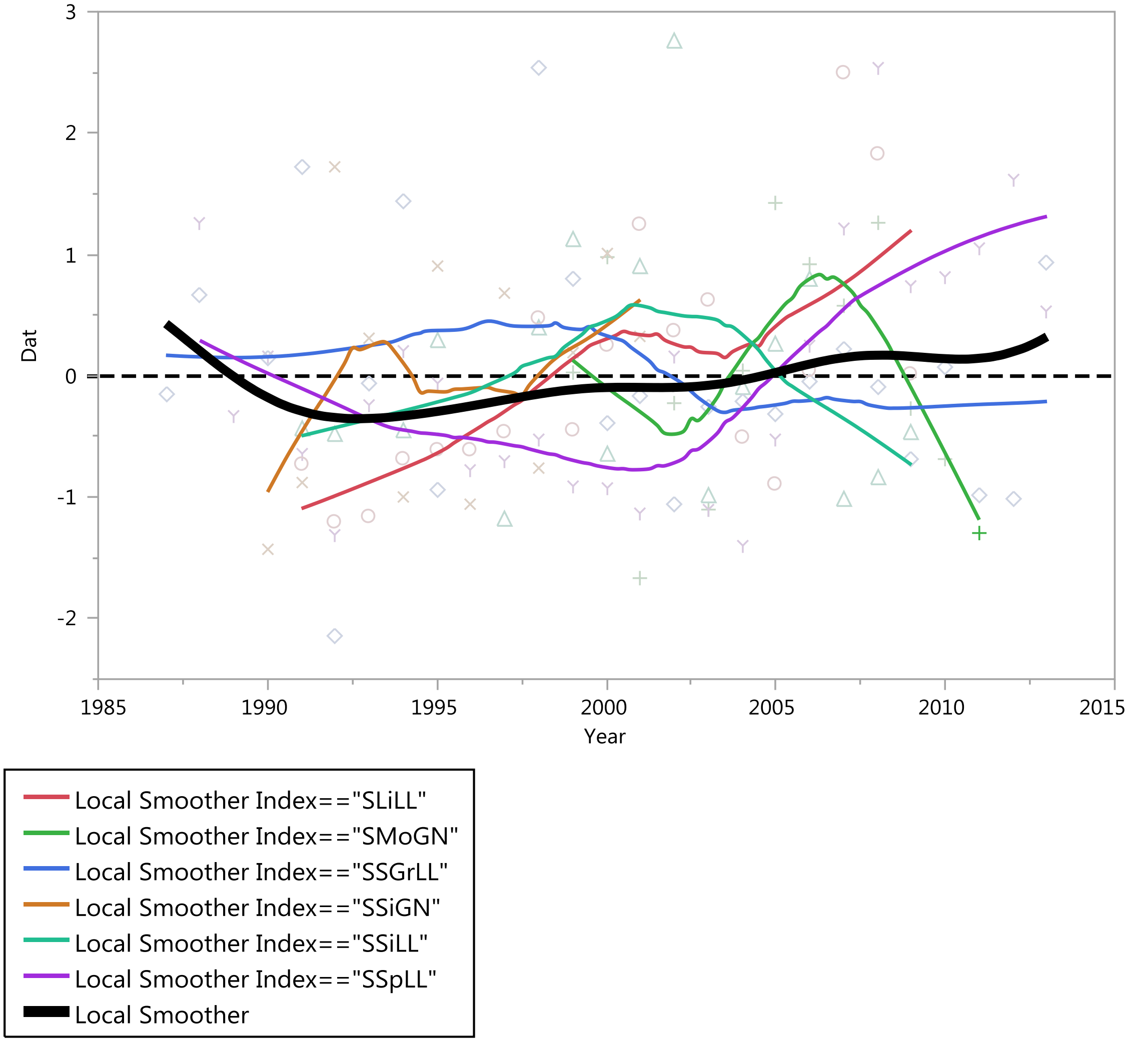


Figure 12. Relative abundance trends calculated by rescaling and smoothing indices. All indices are scaled to have a mean of zero and standard deviation of 1.0 (symbols). Scaled indices were then fitted to a smoothing function (lines). MoGN Moroccan gillnet driftnet fishery, SpLL Spanish longline, TuGn Turkish gillnet, TuLL Turkish longline, SiLL Sicilian Longline, SiGN Sicilian gillnet, GrLL Greek longline LiLL Ligurian longline and IoLL North Ionian longline. Thicker solid line represents the smoothing function fitted to all scaled indices together.

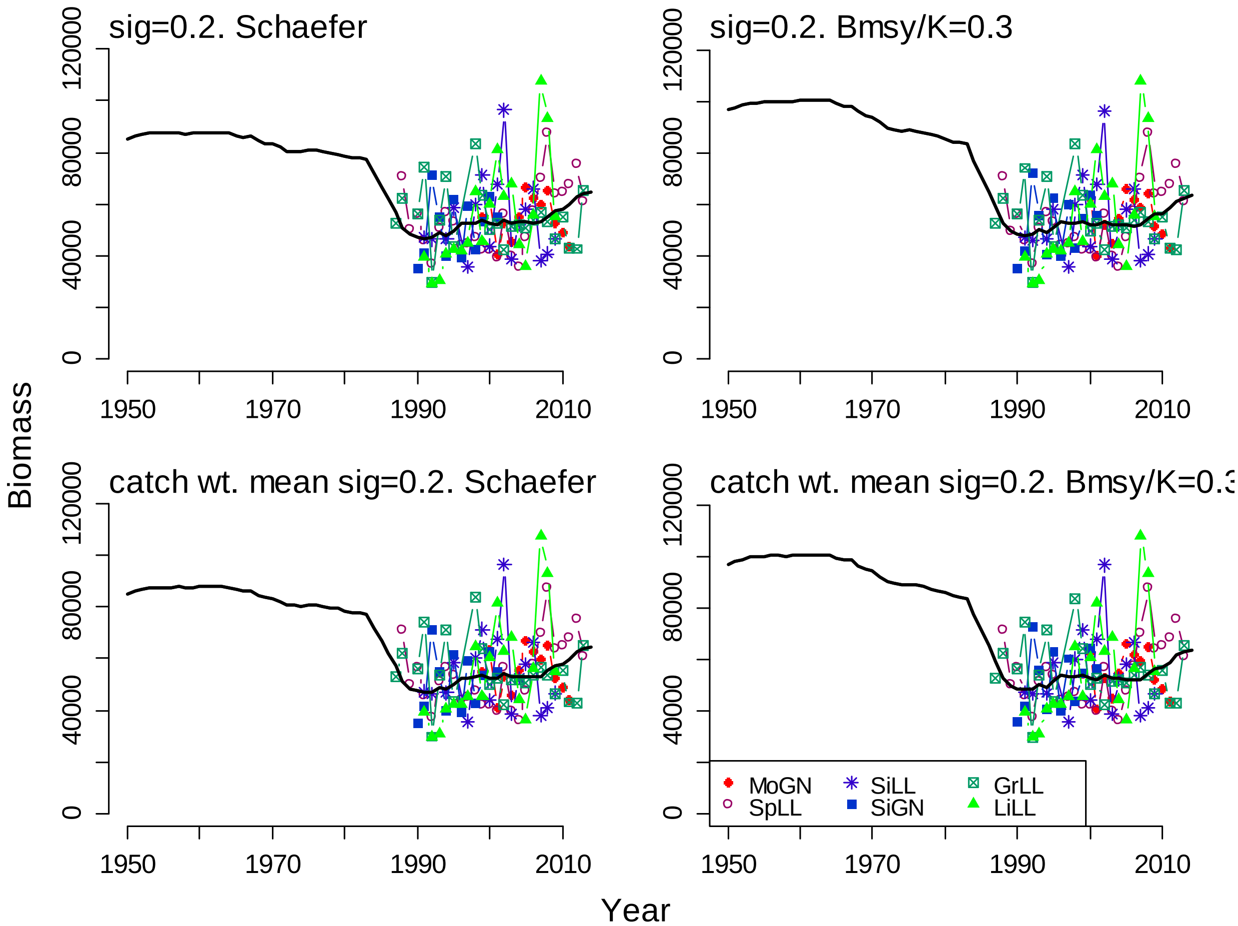


Figure 13. Fits to the indices at the mode of the posterior distribution for the four BSP runs.

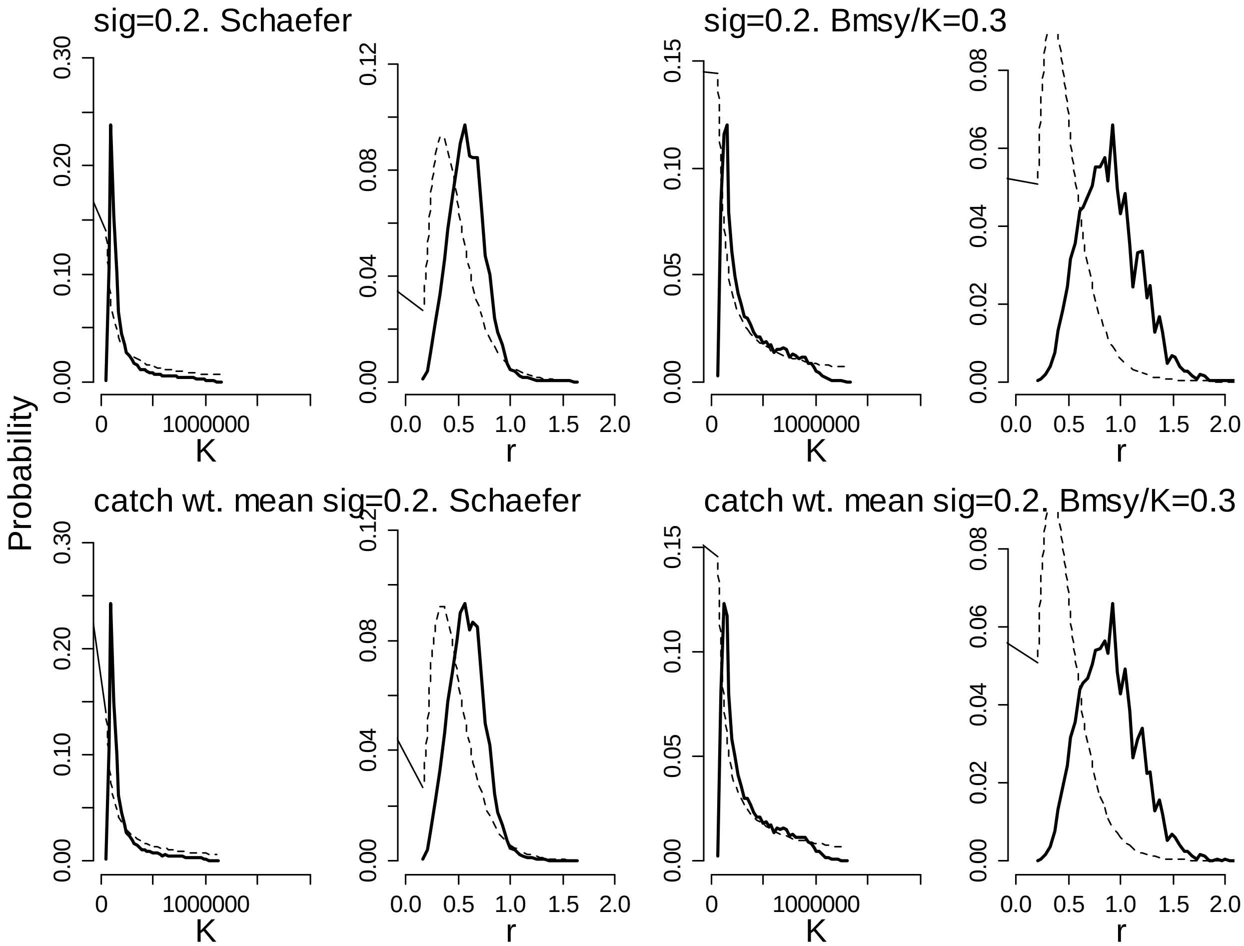


Figure 14. Prior (dashed lines) and posterior (solid lines) probability density functions for K and r for the four reference runs.

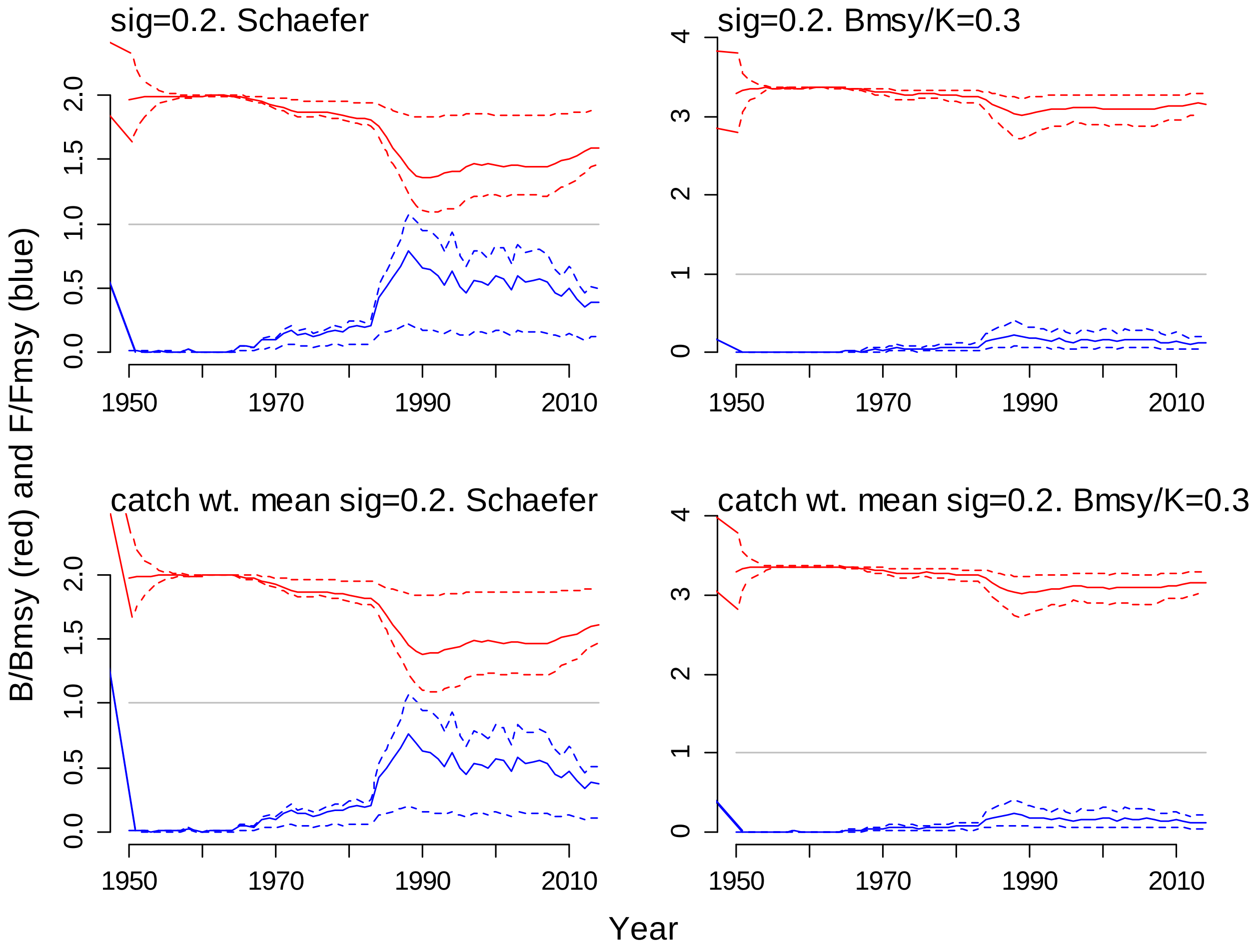


Figure 15. Median and 80% credible intervals for the four reference runs.

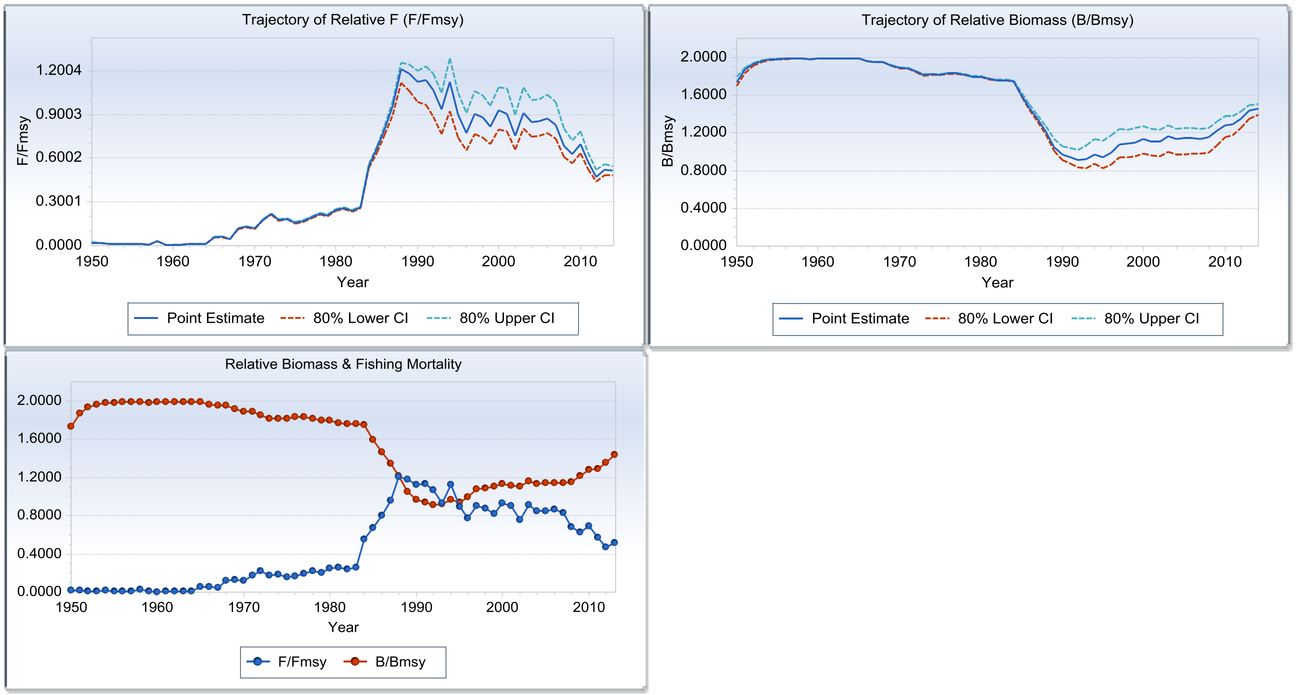


Figure 16. Relative biomass and fishing mortality trend estimates from ASPIC base case run.

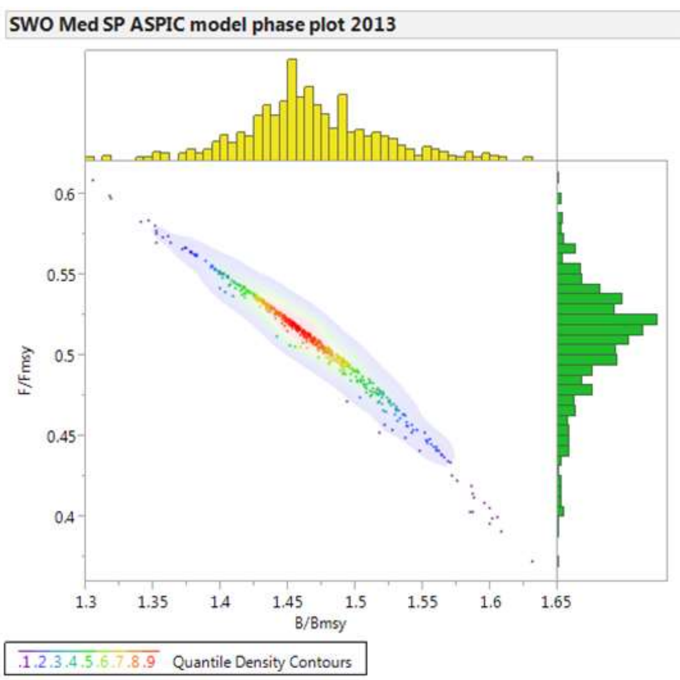


Figure 17. Relative stock status estimates in 2013 from bootstrapped runs of ASPIC base case model. The marginal histograms display distribution of 500 boots, point colors and shade indicate the quantile density of the bivariate results.

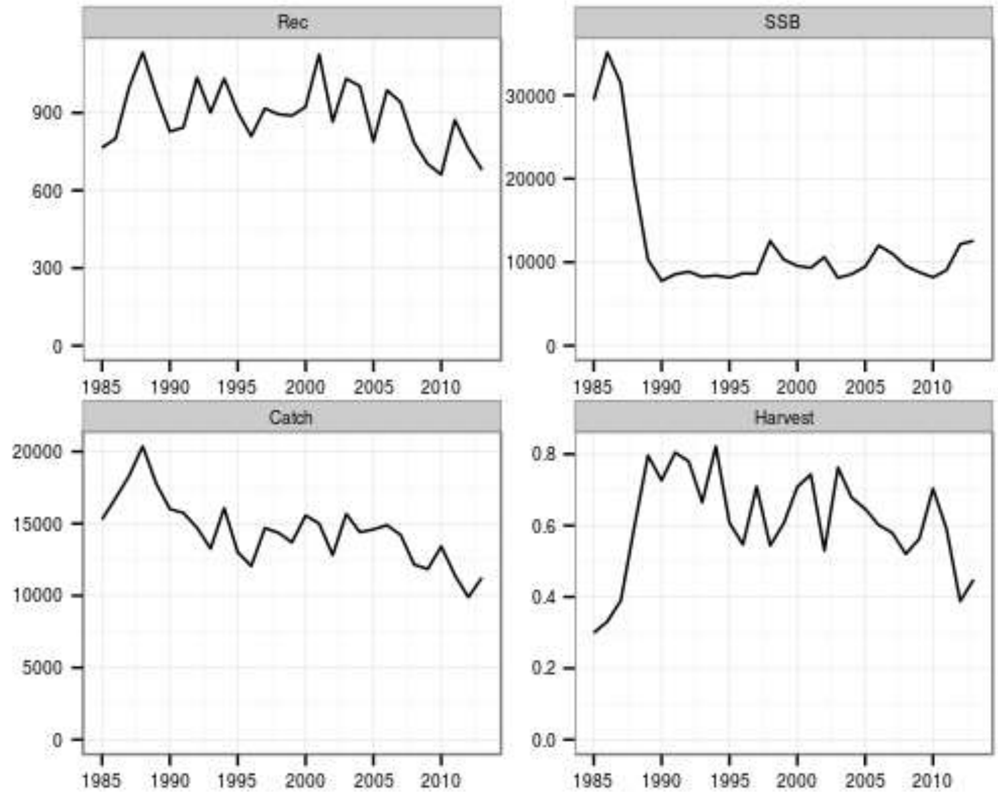


Figure 18. XSA estimates of historic time series of recruitment, SSB, catch and fishing mortality.

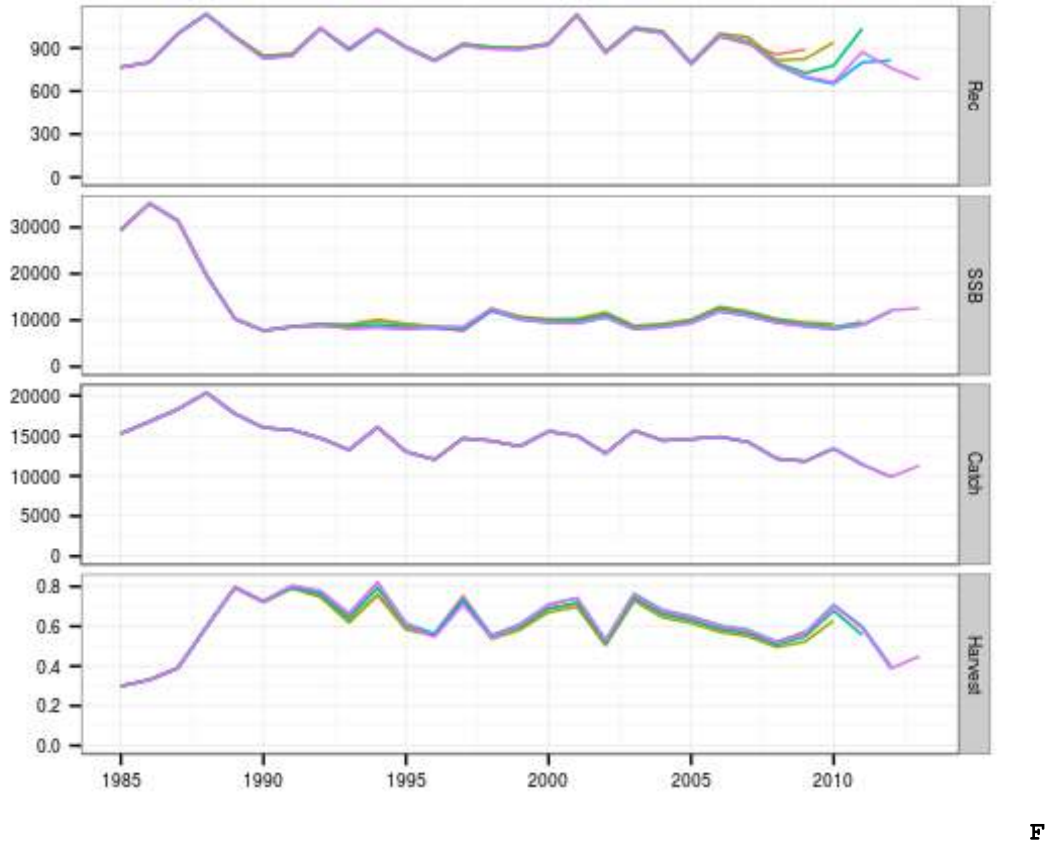


Figure 19. Retrospective XSA time series estimates.

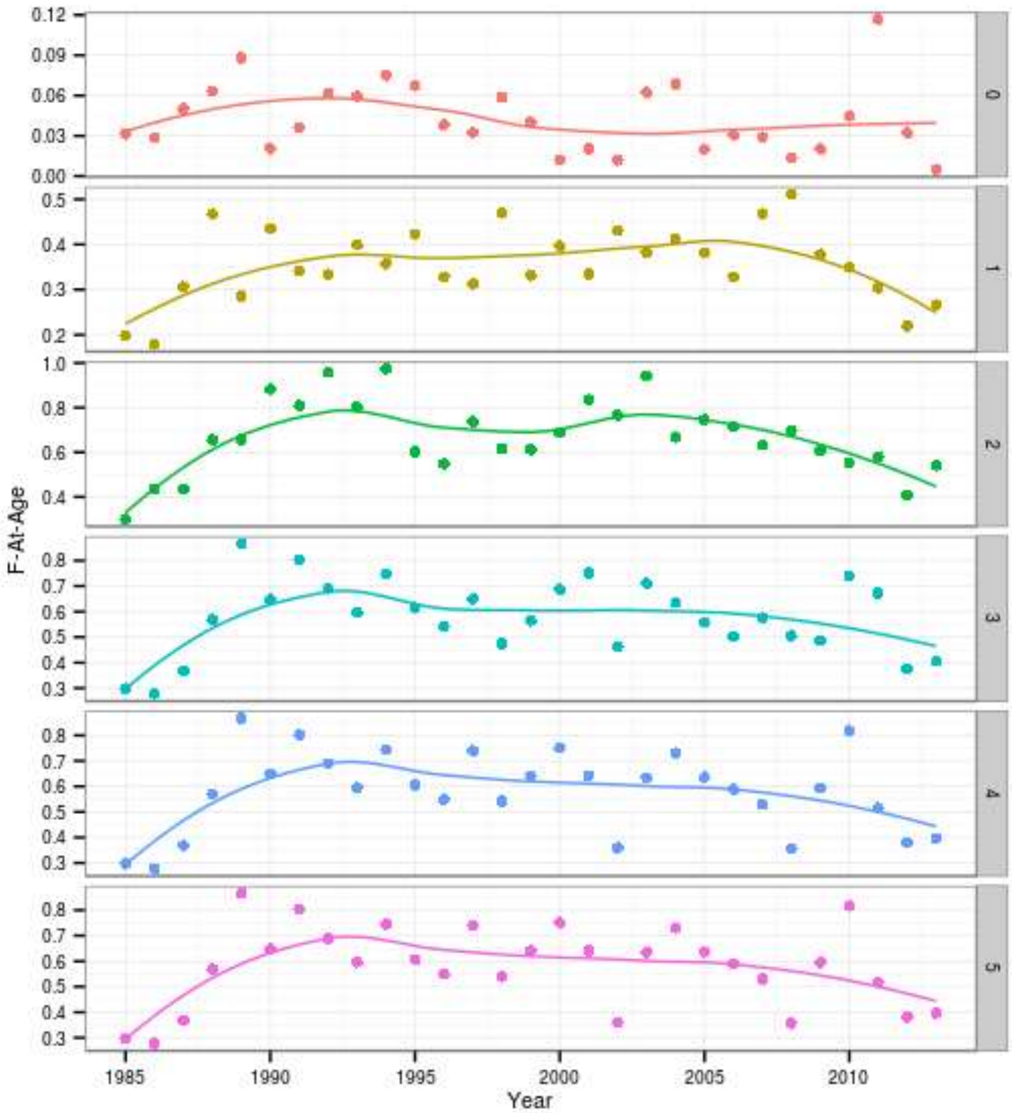


Figure 20. XSA estimates of F-at-age; lines represent lowess smoothers.

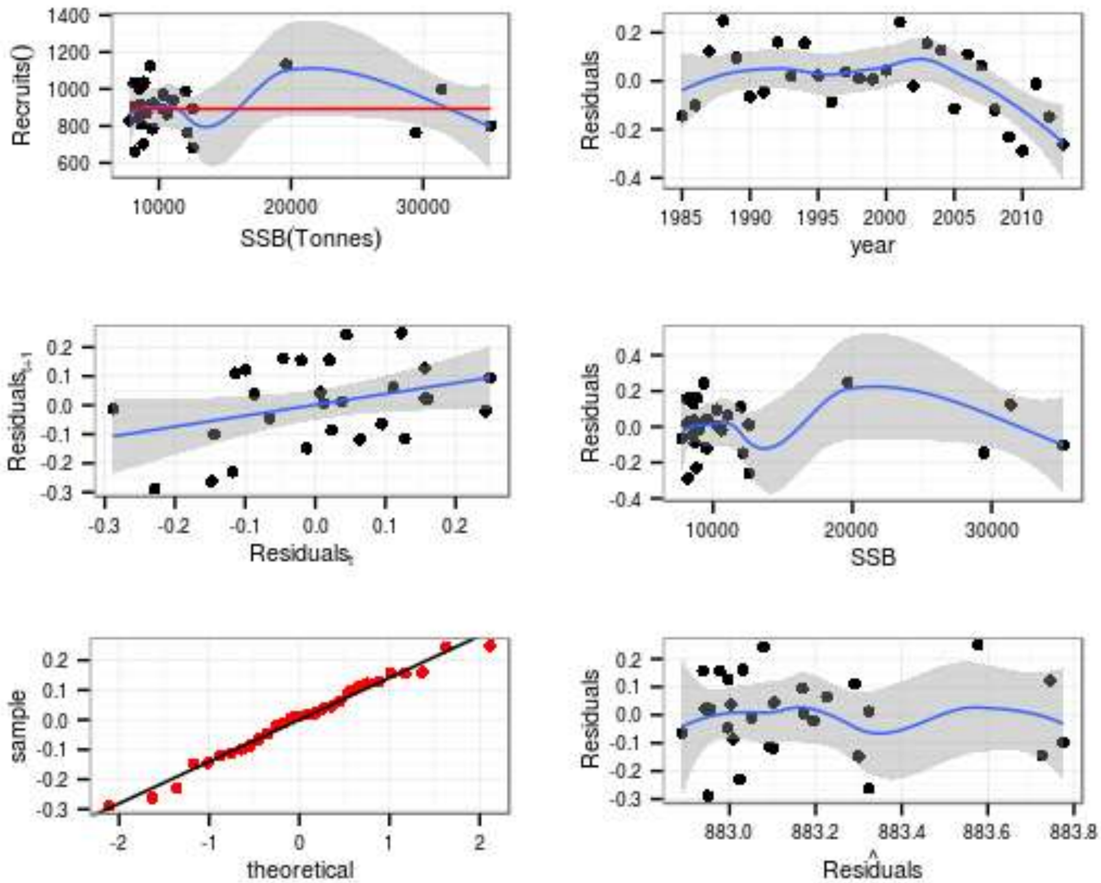


Figure 21. Beverton and Holt stock recruitment relationship (upper left) and the relevant diagnostic plots.

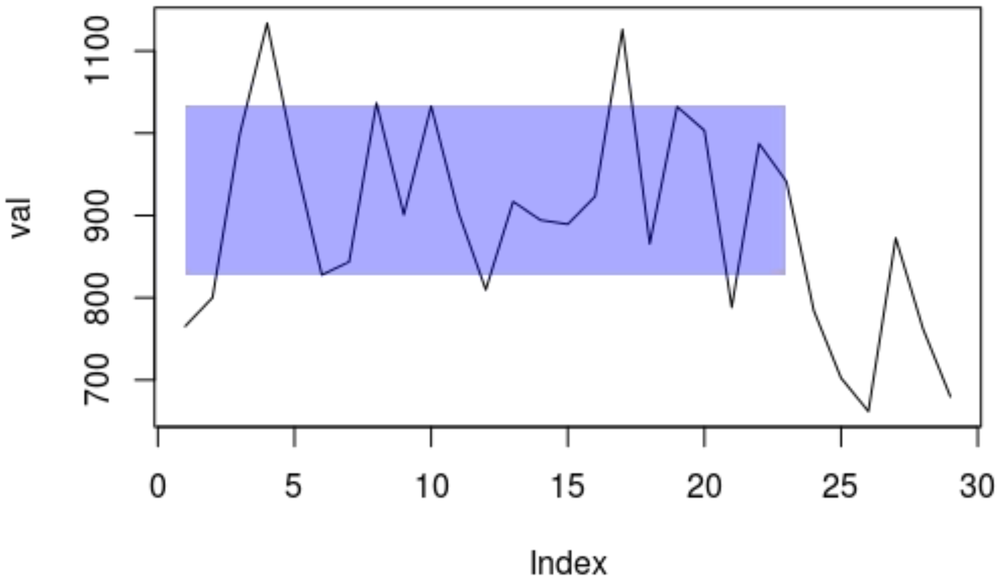


Figure 22. Evaluation of regime shift in recruitment using STARS algorithm; shaded area gives the mean and standard deviation of recruitment prior to the regime shift.

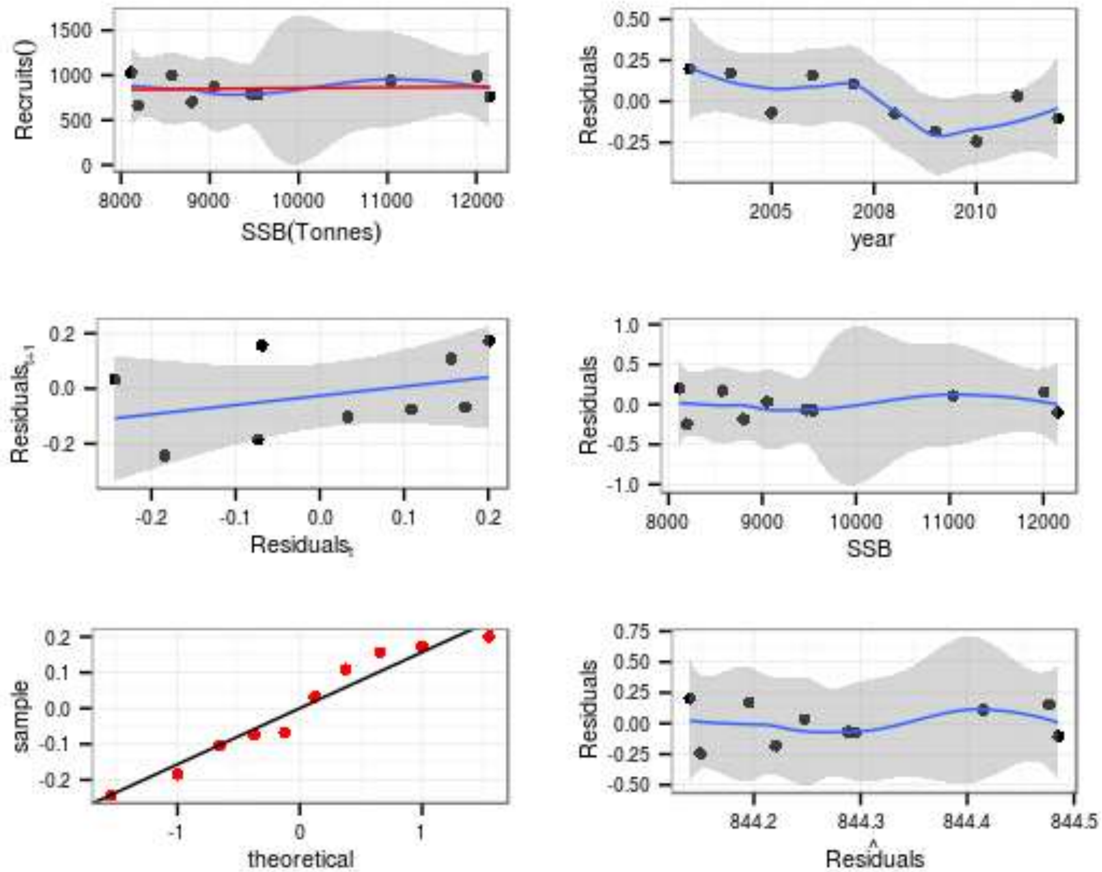


Figure 23. Beverton and Holt stock recruitment relationship (upper left) for the period 2003-2012 and the relevant diagnostic plots.

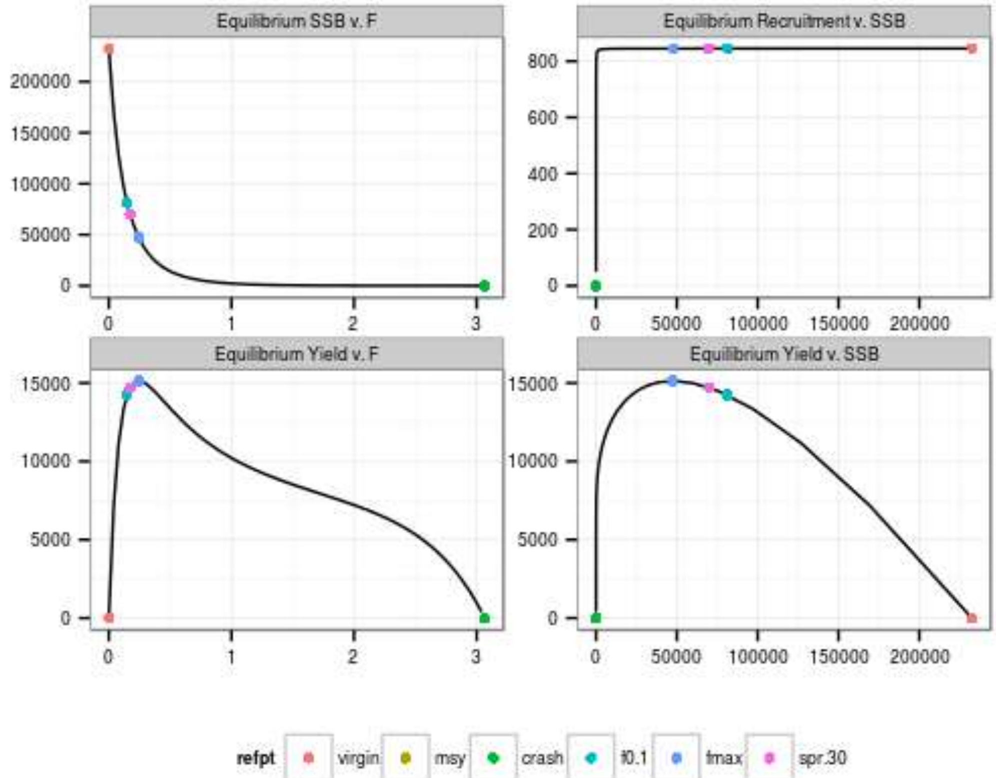


Figure 24 Equilibrium curves based on expected weight, maturity, m-at-age, selection pattern and SRR.

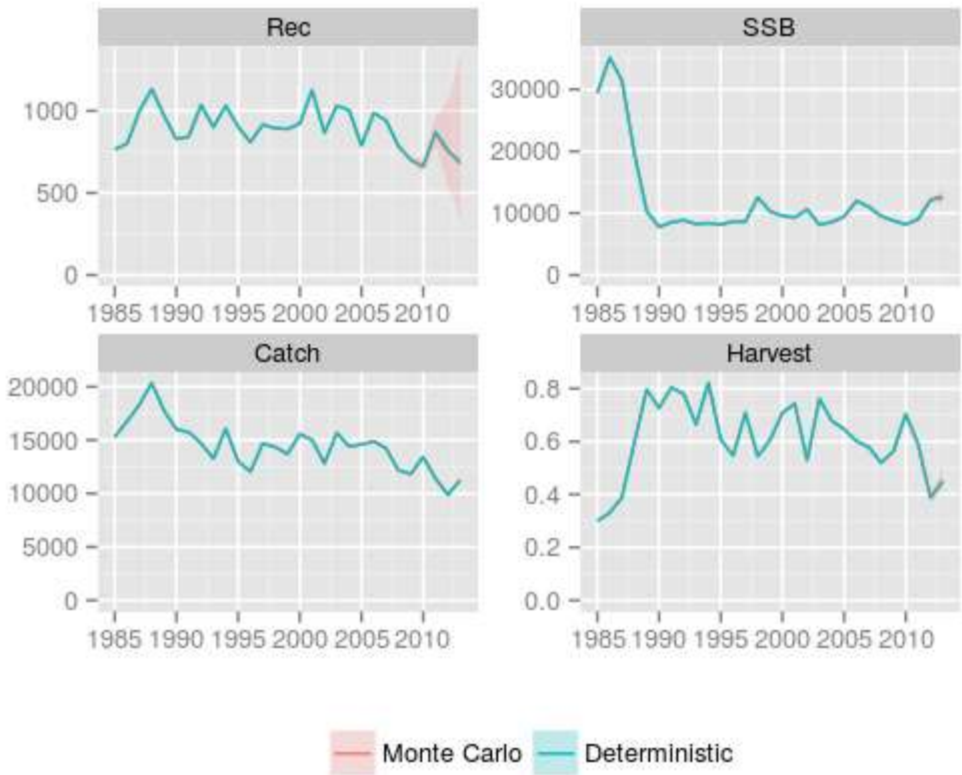


Figure 25. Uncertainty estimates of historic time series based on standard errors of terminal Ns.

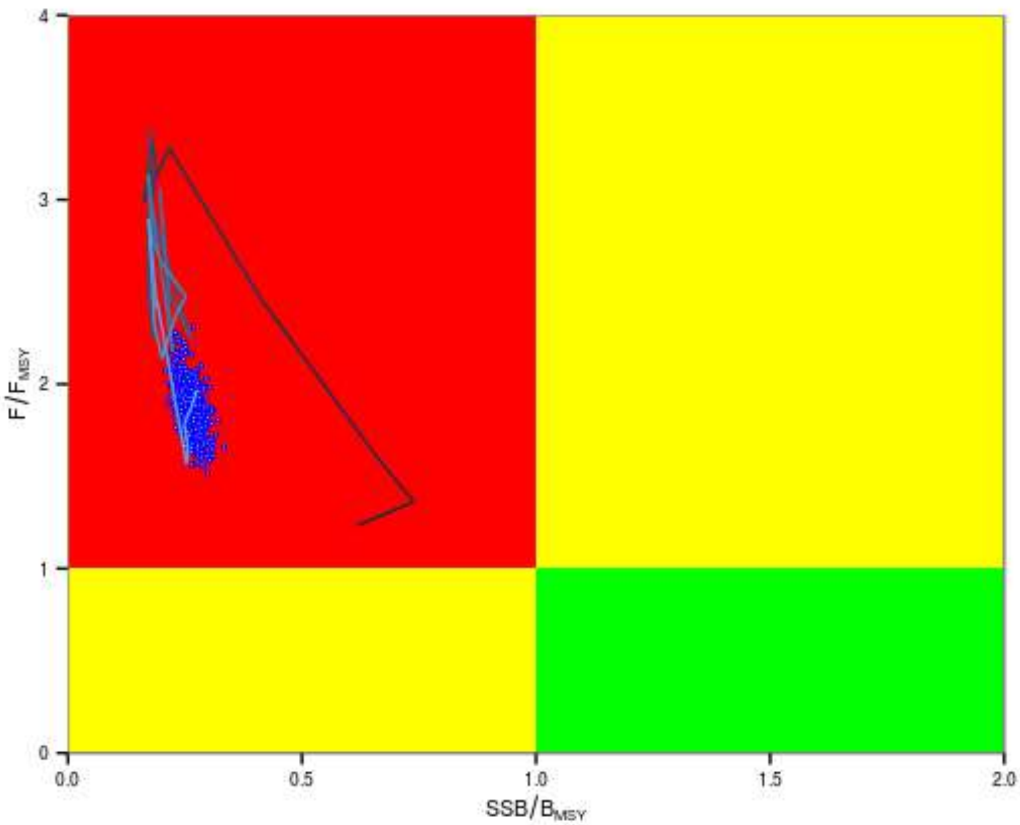


Figure 26. Kobe phase plot based on XSA results and equilibrium yield analyses reference points

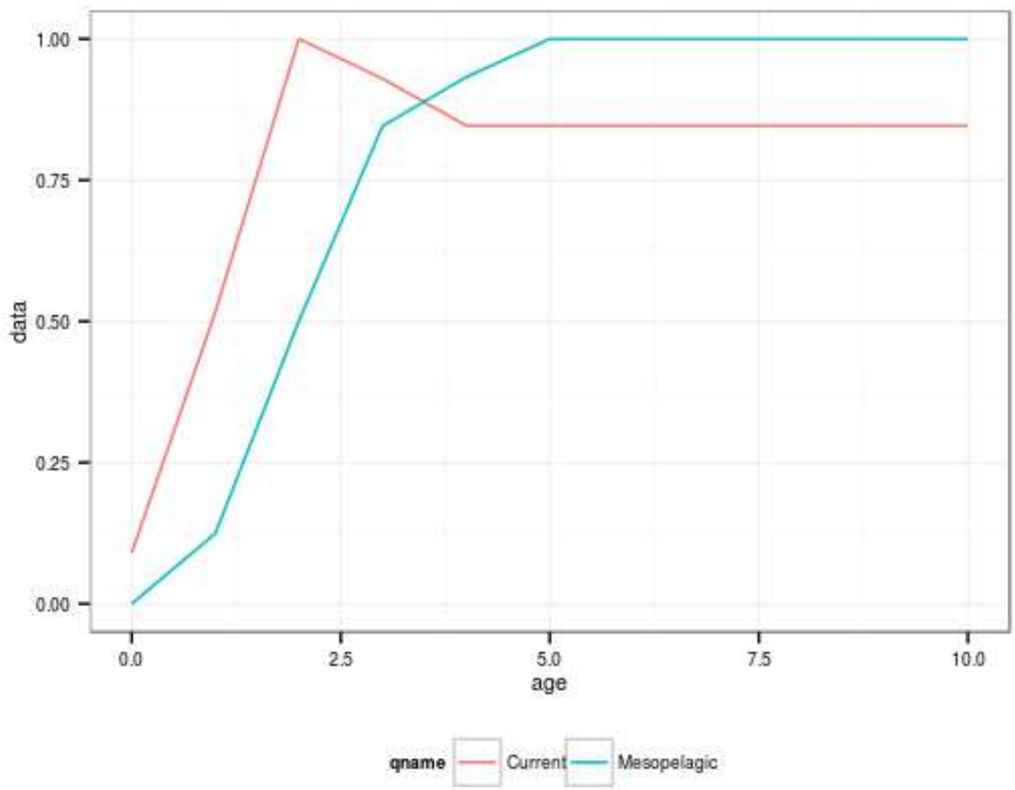


Figure 27. Relative selectivity patterns for the drifting surface (current) and mesopelagic longlines based on the last three years data

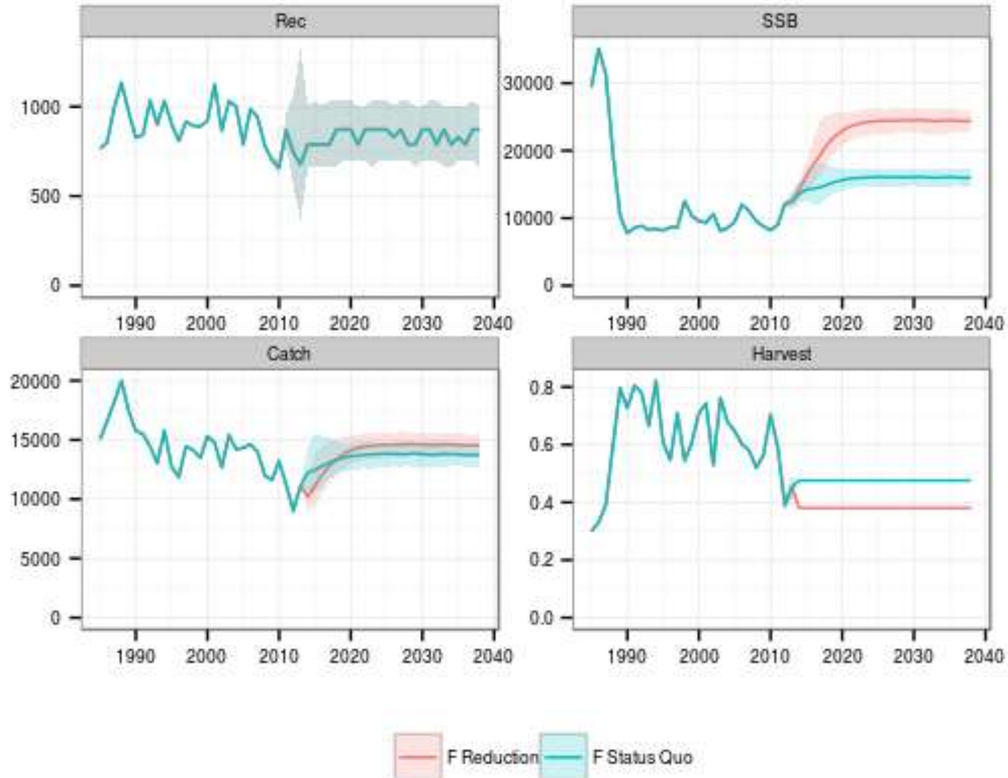


Figure 28. Projections based on the current selection pattern and two different F (harvest) levels: status quo (blue) and 80% of current (red).

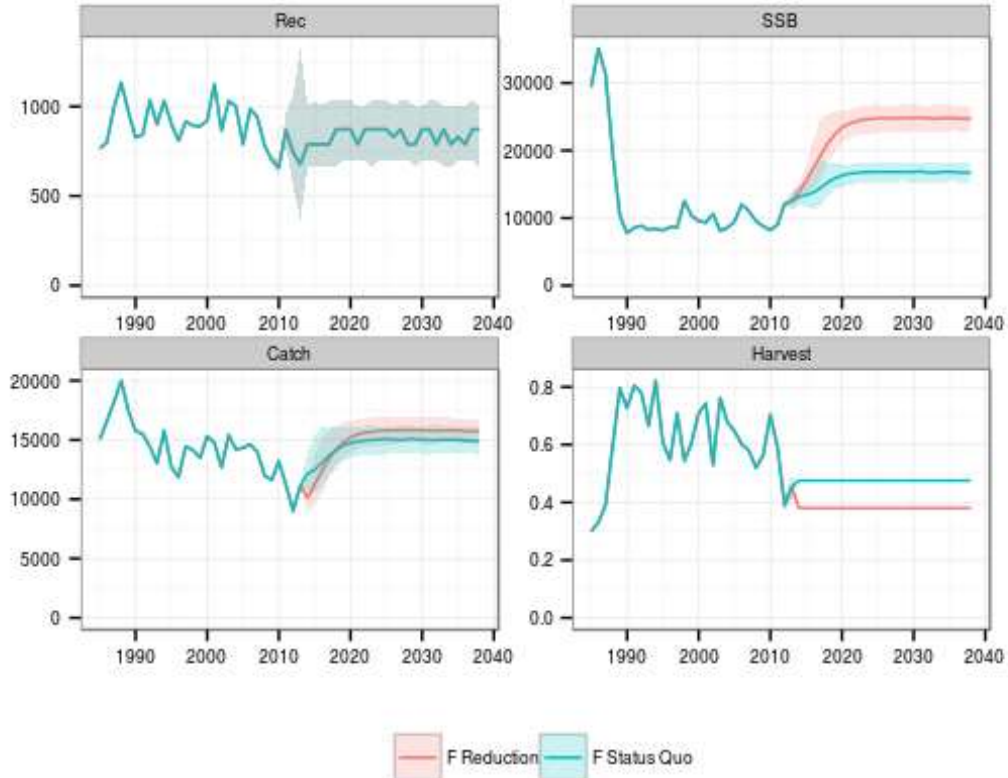


Figure 29. Projections based on a mixed selection pattern (50:50 current and mesopelagic) and two different F (harvest) levels: status quo (blue) and 80% of current (red).

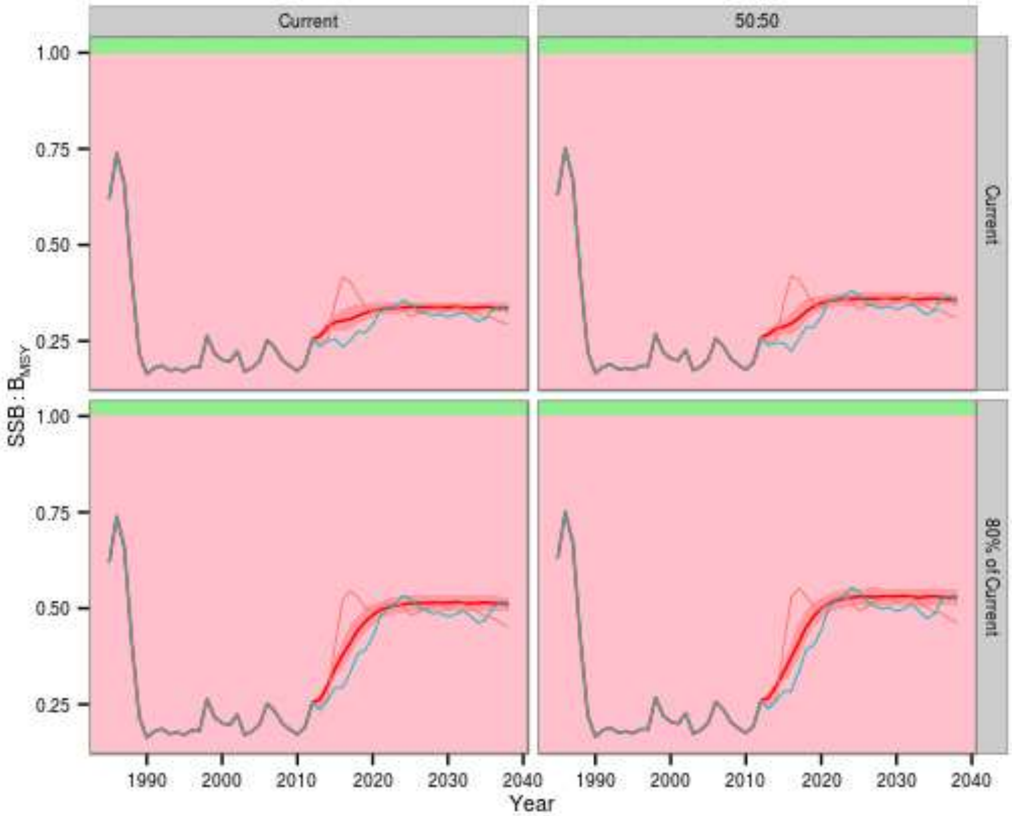


Figure 30. XSA historical estimates and projections of SSB relative to B_{MSY} assuming, either the current or the mixed selection patterns (top panel legend). For both selection patterns two different F levels were assumed: current (2013) and 80% of the current (right panel legend).

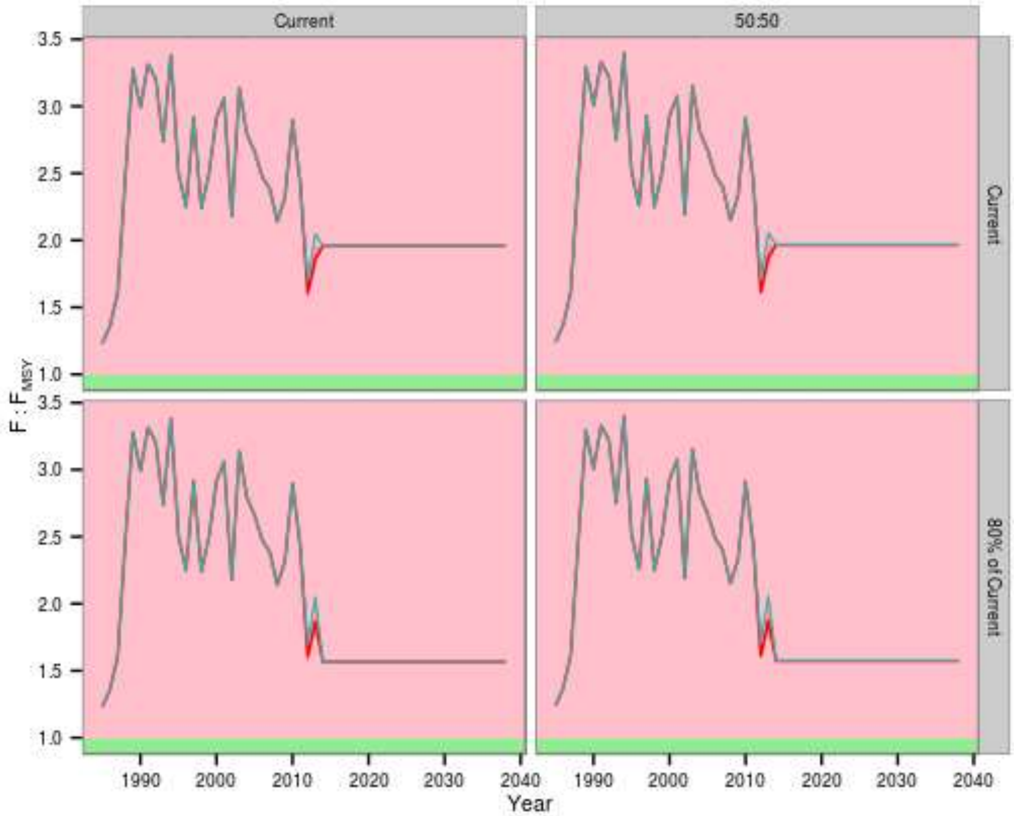


Figure 31. XSA historical estimates and projections of F relative to F_{MSY} assuming, either the current or the mixed selection patterns (top panel legend). For both selection patterns two different F levels were assumed: current (2013) and 80% of the current (right panel legend).

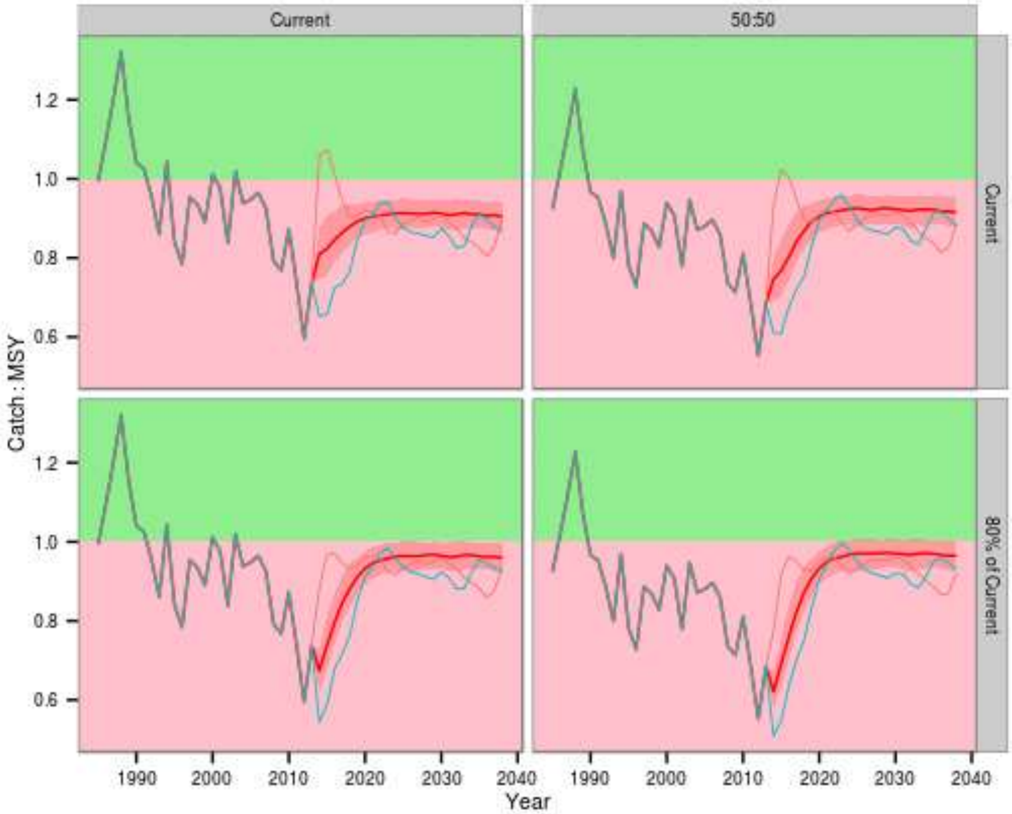


Figure 32. XSA historical estimates and projections of Catch relative to MSY assuming, either the current or the mixed selection patterns (top panel legend). For both selection patterns two different F levels were assumed: current (2013) and 80% of the current (right panel legend).

Appendix 1

AGENDA

1. Opening, adoption of the Agenda and meeting arrangements
2. Description and evolution of the Mediterranean swordfish fisheries
3. Summary of available data for assessment
   3.1 Biology
   3.2 Catch, effort, size and CAA estimates
   3.3 Relative abundance estimates
4. Stock Assessment
   4.1 Methods
   4.2 Stock status
   4.3 Projections
5. Recommendations
   5.1 Research and statistics
   5.2 Management and advice
6. Other matters
7. Adoption of the report and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2014/095 Elements d'informations sur la pecherieespadonierealgerienne. Koudri-Krim A. and Bouhadja A.

SCRS/2014/096 Updated standardized catch rates in number and weight for swordfish (Xiphiasgladius L.) caught by the Spanish longline fleet in the Mediterranean Sea, 1988- 2013. Ortiz de Urbina J., de la Serna J. M. , Mejuto J. , Saber S. and Macías D.

SCRS/2014/097 Analysis of Turkish swordfish (Xiphiasgladius) catch rates in the eastern Mediterranean. Ceyhan T., Tserpes G., Akyol O. and Ortiz de Urbina J.M

SCRS/2014/100 Effects of the introduction of the mesopelagic longline on catches and size structure of swordfish in the Ligurian sea (western Mediterranean). Garibaldi F.

SCRS/2014/104 Temporal CPUE trends of the Greek drifting longline swordfish fisheries in the E. Mediterranean. Tserpes G. and Peristeraki P

SCRS/2014/105 Standardization of catch rates from the Sicilian swordfish longline fisheries in the C. Mediterranean. Tserpes, G., Di Natale, A, Mangano, A

SCRS/2014/106 Swordfish (Xiphiasgladiusl.) catch composition of the Italian fishing fleet in the period 2007-13. Mariani A., Dell'Aquila M. and Bertolino F.

SCRS/2014/107 Review and preliminary analyses of size, CAS and CAA of Mediterranean swordfish (Xiphiasgladius). Mauricio Ortiz and Carlos Palma

SCRS/2014/108 Updated catch rates of swordfish (Xiphiasgladius) caught by Moroccan driftnet fishery in the strait of Gibraltar, 1999-2001. Noureddine A. and M. Bakkali

SCRS/2014/109 Analyses Preliminaires Des Donnees De Production Et D'Effort De Peche De L'Espadon Xiphias Gladius En Tunisie. Rafik Zarrad et Ridha M'rabet

SCRS/2014/110 Swordfish Growth Pattern In The Strait Of Gibraltar; Implications For Mixing Among Atlantic And Mediterranean Stocks. Noureddine Abid, Mohammed. Bakkali, George Tserpes and M'HamedIdrissi

SCRS/2014/111 Swordfish (Xiphiasgladius l.) fisheries using drifting midwater longline in the Mediterranean Sea by Italian fishing fleet. F. Bertolino, M. Dell'Aquila, A. Mariani, M. Valastro

SCRS/2014/112 Standardization swordfish catch rates from the Ligurian surface drifting longline fisheries for the period 1991-2009. F. Garibaldi and G. Tserpes.

Appendix 4

BSP1. DERIVATION OF INFORMATIVE PRIOR FOR r

McAllister (2014) and **Stanley et al. (2009)** proposed a method to generate an informative prior for the intrinsic rate of population increase *r* based on a stock-recruitment relationship, growth and survival. The method uses the Euler-Lotka equation to estimate *r* from the survival to age (l_x) and fecundity at age (m_x) vectors.

(1) $\sum_{a=1}^{a_{max}} e^r \, l_a m_a = 1$

This equation is solved numerically to estimate *r*. The survival to age is calculated as:

(2) $l_a = e^{-aM}$

The fecundity at age is calculated as:

(3) $m_a = \tilde{R}_S W_a G_a$

where W_a is weight at age, G_a is maturity at age, and $\tilde{R}_S$ is the number of age 1 recruits per spawner as the number of spawners *S* approaches zero. $\tilde{R}_S$ is calculated as:

(4) $\tilde{R}_S = \frac{4h}{\tilde{S}(1-h)}$

where *h* is steepness of the stock recruit curve, and S is spawners per recruit without fishing. *S* is calculated as:

(5) $\tilde{S} = \sum_{a=1}^{a_{max}-1} W_a G_a e^{-aM} + W_{a_{max}} G_{a_{max}} \frac{exp(-a_{max}M)}{1-exp(-M)}$

The information needed to use this method are the three parameters of the von Bertalanffy growth curve, the two parameters of the weight/length relationship, the two parameters for a logistic maturity ogive (in either age or length), natural mortality and steepness. Each of these parameters was given a mean and a CV taken from the literature, and a probability distribution that seemed to adequately capture the uncertainty in the parameter (**Table BSP.A1.1, Figure BSP.A1.1**). For the logistic maturity ogive with length, the value of the logistic shape parameter was chosen so that approximately 95% of the fish would be mature within one year of the age at which average length was equal to length at 50% maturity.

A value of each parameter was drawn randomly from its distribution, and the Euler Lotka equation was solved for *r*. The values of *r* were plotted in a histogram. The distribution appeared to be lognormal, and a lognormal distribution with the mean and variance calculated from the simulated values of *r* was found to adequately recreate the empirical distribution of *r* (**Figure BSP.A2.2**). This lognormal distribution was used as the informative prior for *r* in the BSP models. The mean was 0.47 and CV was 0.49 (standard deviation of log(*r*)=0.46). As a sensitivity analysis, the same method was used to calculate *r* with the assumption that mean steepness was 0.95. This gave a mean *r* of 0.76, and CV of 0.39.

Table BSP.A1.1 Values of parameters used in the Monte Carlo simulations to estimate *r*. Lengths are lower jaw fork length in cm, weights are in g.

Para-meter	Mean	CV	Dist	Description	Source
M	0.206	0.25	lnorm	Natural mortality (1/year)	McAllister (2014)

Linf	238.58	0.1	lnorm	Von Bertalanffy Asymptotic length	Mean: ICCAT Manual. CV: Working group
K	0.185	0.1	norm	Von Bertalanffy growth parameter	Mean: ICCAT Manual. CV: Working group
t0	-1.404	0.2	norm	Von Bertalanffy age at zero length	Mean: ICCAT Manual. CV: Working group
a	8.90E-07	0.1	lnorm	Weight at length parameter	Mean:ICCAT Manual. CV: McAllister (2014)
b	3.554738	0.1	norm	Weight at length parameter	Mean:ICCAT Manual. CV: McAllister (2014)
L50	142	0.2	lnorm	Length at 50% maturity	Mean:ICCAT Manual. CV: McAllister (2014)
d	0.2	0.2	lnorm	Parameter of the logistic maturity ogive	Working group
h	0.83	0.14	beta	Steepness h=0.2 + 0.8 Beta(5.86. 1.59) Alternative: h=0.2+0.8 Beta(25,1.6)	McAllister (2014)

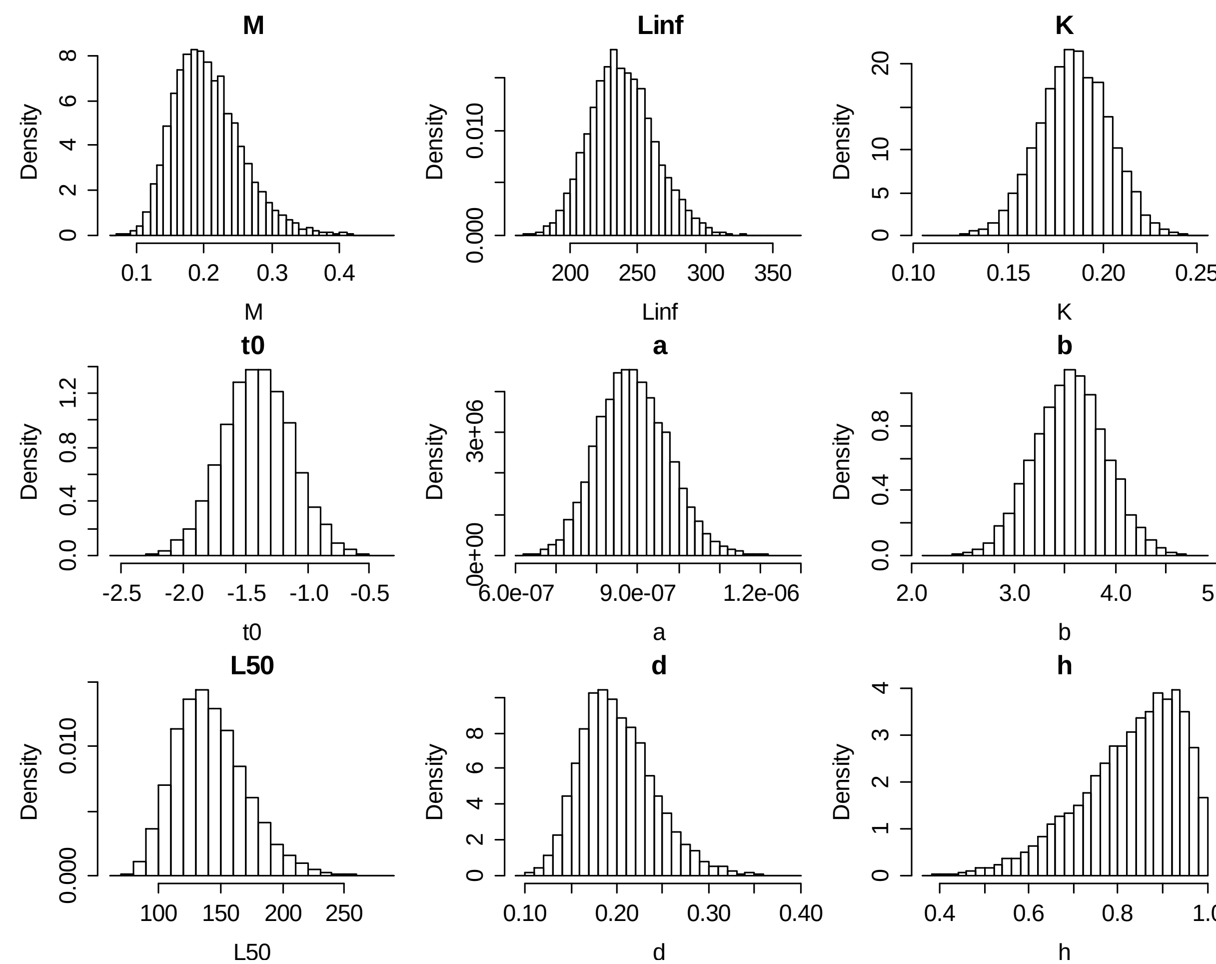
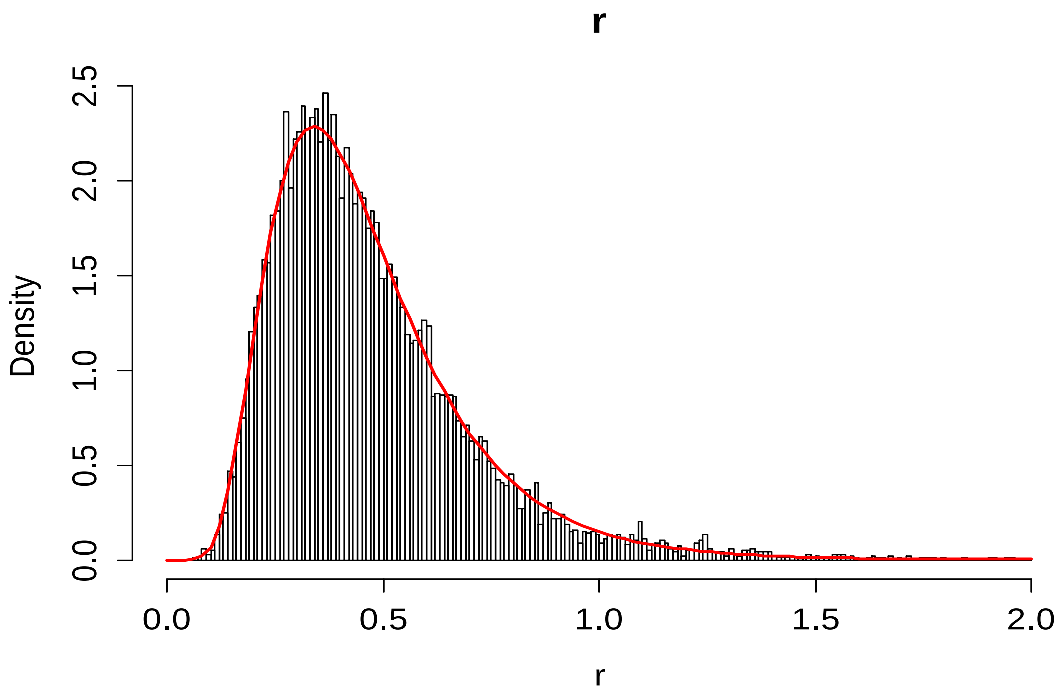


Figure BSP.A1.1. Distributions of the input parameters described in Table A1.



BSP1.A2. Empirical distribution of *r* from Monte Carlo simulations (histogram) and lognormal prior for *r* (line).

Appendix 5

BSP2. SENSITIVITY AND DIAGNOSTIC RUNS OF THE BAYESIAN SURPLUS PRODUCTION MODEL

The BSP sensitivity analyses (**Table BSP.A2.1**) giving different weights to the CPUE data points produced very different posterior distributions of the parameters. All models estimated the same general trend, but the scale varied by a factor of four (**Figure BSP.A2.1, Table BSP.A2.2**). Models with higher inputted values of the observation error variance had much wider posterior distributions, and were more similar to the priors. This seems to be caused by the fact that the priors have a higher weight relative to the data when the data are given a high observation error variance. In a case where the data are not strongly informative, this effect can influence the shape of the posterior. With higher observation error variance, the joint posterior distribution of *r* and *K* is quite broad, while using the MLE value allows the model to estimate a narrower posterior (**Figure BSP.A2.2**). Reducing the observation error variance below the MLE value (last column in **Table BSP.A2.2**), makes the priors even more narrow. Given the strong influence of observation error variance, using a value close to the maximum likelihood estimate is recommended (**McAllister 2014**).

The sensitivity analysis with a higher prior for *r* gave higher values for *r* and lower values for *K*, as expected (**Table BSP.A2.3**). Varying the starting year did not greatly change the values of *r* or *K* (**Table BSP.A2.4**). The post-model pre-data analysis, as expected, returned posteriors very similar to the priors (**Table BSP.A2.5, Figure BSP.A2.3**). The runs with uniform priors supported very high values of *r* (**Table BSP.A2.5**).

When the indices were entered into the model separately, using informative priors the results were fairly consistent, although there was some variability in the current fishing mortality rate (**Table BSP.A2.6**). Running the indices separately with uninformative priors, all supported much higher values of *r* (**Table BSP.A2.7**). The posteriors of r and K from these runs (**Figure BSP.A2.4**) show that some indices weakly support values of *r* around 0.5, but all the posteriors are rather flat.

Table BSP.A2.1. Sensitivity and diagnostic runs.

Run	Shape	Prior	Weighting	Start year
1	Schaefer	base	σ=1	1950
2	Bmsy/K=0.3	base	σ=1	1950
3	Schaefer	base	catch	1950
4	Bmsy/K=0.3	base	catch	1950
1c	Schaefer	base	σ=0.1	1950
p1	Schaefer	base	NA	1950
p2	Bmsy/K=0.3	base	NA	1950
u1	Schaefer	uninformative	σ=1	1950
u2	Bmsy/K=0.3	uninformative	σ=1	1950
u3	Schaefer	uninformative	catch	1950
u4	Bmsy/K=0.3	uninformative	catch	1950
r1	Schaefer	mean r=0.76	σ=1	1950
r2	Bmsy/K=0.3	mean r=0.76	σ=1	1950
r3	Schaefer	mean r=0.76	catch	1950
r4	Bmsy/K=0.3	mean r=0.76	catch	1950
r1b	Schaefer	mean r=0.76	σ=0.2	1950
r2b	Bmsy/K=0.3	mean r=0.76	σ=0.2	1950
r3b	Schaefer	mean r=0.76	catch, 0.2	1950
r4b	Bmsy/K=0.3	mean r=0.76	catch, 0.2	1950

1y1	Bmsy/K=0.3	B0/K CV=0.5	σ=1	1965
1y2	Bmsy/K=0.3	B0/K mean .9, CV .5	σ=1	1987
1y1b	Bmsy/K=0.3	B0/K CV=0.5	equal	1965
1y2b	Bmsy/K=0.3	B0/K mean .9, CV .5	equal	1987

Table BSP.A2.2. Sensitivity runs with different weighing of CPUE data points.

Variable	Schaefer σ=1	*Bmsy/K*=0.3 σ=1	Schaefer Catch weighting unscaled	*Bmsy/K*=0.3 Catch weighting unscaled	Schaefer σ=0.1
K (1000)	415.75 (0.62)	523.62 (0.49)	421.39 (0.61)	506.96 (0.50)	88.53 (0.11)
r	0.52 (0.46)	0.58 (0.45)	0.51 (0.47)	0.54 (0.47)	0.71 (0.09)
MSY (1000)	50.43 (0.78)	41.58 (0.61)	50.94 (0.79)	37.65 (0.65)	15.51 (0.03)
Bcur (1000)	384.07 (0.66)	440.21 (0.57)	388.06 (0.66)	413.25 (0.60)	65.82 (0.12)
Binit (1000)	407.41 (0.62)	506.01 (0.49)	412.98 (0.61)	491.34 (0.49)	87.55 (0.15)
Bcur/Binit	0.92 (0.16)	0.85 (0.22)	0.91 (0.17)	0.81 (0.25)	0.76 (0.11)
Ccur/MSY	0.34 (0.59)	0.36 (0.49)	0.35 (0.61)	0.41 (0.51)	0.73 (0.03)
Bcur/Bmsy	1.78 (0.09)	2.71 (0.13)	1.77 (0.11)	2.59 (0.18)	1.49 (0.02)
Fcur/Fmsy	0.21 (0.71)	0.14 (0.68)	0.21 (0.81)	0.18 (0.82)	0.49 (0.05)

Table BSP.A2.3. Runs with a prior for r with mean of 0.76.

Variable	Schaefer σ=1	*Bmsy/K*=0.3 σ=1	Schaefer Catch wt	*Bmsy/K*=0.3 Catch wt	Schaefer σ=0.2	*Bmsy/K*=0.3 σ=0.2	Schaefer Catch wt 0.2	*Bmsy/K*=0.3 Catch wt 0.2
K (1000)	354.38 (0.72)	430.57 (0.60)	365.42 (0.70)	430.94 (0.60)	354.40 (0.72)	430.90 (0.60)	162.73 (0.97)	237.20 (0.87)
r	0.79 (0.39)	0.84 (0.37)	0.80 (0.39)	0.84 (0.46)	0.79 (0.39)	0.84 (0.37)	0.71 (0.27)	1.08 (0.27)
MSY (1000)	67.72 (0.85)	50.91 (0.69)	70.30 (0.84)	50.28 (0.76)	67.70 (0.85)	50.91 (0.69)	28.45 (1.14)	34.32 (0.82)
Bcur (1000)	335.86 (0.76)	377.68 (0.67)	346.93 (0.74)	372.96 (0.68)	335.87 (0.76)	377.97 (0.67)	141.01 (1.13)	198.12 (1.02)
Binit (1000)	349.32 (0.73)	421.82 (0.60)	360.11 (0.71)	422.15 (0.60)	349.40 (0.73)	422.39 (0.60)	160.43 (0.98)	234.08 (0.87)
Bcur/ Binit	0.93 (0.13)	0.86 (0.21)	0.93 (0.13)	0.84 (0.23)	0.93 (0.13)	0.86 (0.21)	0.83 (0.14)	0.78 (0.21)
Ccur/ MSY	0.30 (0.69)	0.32 (0.58)	0.29 (0.71)	0.34 (0.60)	0.30 (0.69)	0.32 (0.58)	0.57 (0.35)	0.45 (0.41)
Bcur/ Bmsy	1.82 (0.08)	2.78 (0.14)	1.83 (0.08)	2.74 (0.16)	1.82 (0.08)	2.78 (0.14)	1.62 (0.09)	2.56 (0.14)
Fcur/ Fmsy	0.17 (0.80)	0.13 (0.77)	0.17 (0.85)	0.15 (0.87)	0.17 (0.80)	0.13 (0.77)	0.37 (0.39)	0.19 (0.52)

Table BSP.A2.4. Runs with Schaefer model and equal weighting, varying start year.

Variable	1950 σ=1	1965 σ=1	1987 σ=1	1950 σ=0.2	1965 σ=0.2	1987 σ=0.2
K (1000)	415.75 (0.62)	621.70 (0.77)	644.54 (0.76)	215.92 (0.89)	288.17 (1.21)	330.03 (1.01)
r	0.52 (0.46)	0.51 (0.47)	0.52 (0.48)	0.59 (0.30)	0.58 (0.32)	0.43 (0.48)
MSY (1000)	50.43 (0.78)	74.61 (0.96)	77.93 (0.94)	27.97 (0.88)	35.71 (1.24)	29.82 (1.19)
Bcur (1000)	384.07 (0.66)	589.91 (0.81)	612.31 (0.80)	188.85 (1.01)	260.46 (1.32)	281.78 (1.16)
Binit (1000)	407.41 (0.62)	550.35 (0.79)	552.44 (0.80)	212.36 (0.90)	257.69 (1.20)	245.14 (1.21)
Bcur/Binit	0.92 (0.16)	1.10 (0.37)	1.14 (0.25)	0.84 (0.15)	0.99 (0.38)	1.18 (0.10)
Ccur/MSY	0.34 (0.59)	0.29 (0.72)	0.28 (0.73)	0.54 (0.36)	0.51 (0.42)	0.55 (0.36)
Bcur/Bmsy	1.78 (0.09)	1.82 (0.09)	1.82 (0.09)	1.64 (0.09)	1.66 (0.10)	1.59 (0.12)
Fcur/Fmsy	0.21 (0.71)	0.17 (0.85)	0.17 (0.87)	0.34 (0.41)	0.33 (0.48)	0.36 (0.43)

Table BSP.A2.5. Means and CVs of parameters estimated from post model pre data (PMPD) diagnostic runs and runs with uninformative priors.

Variable	PMPD: Schaefer	PMPD: Bmsy/K=0.3	Schaefer σ=1	*Bmsy/K*=0.3 σ=1	Schaefer Catch weighting, not scaled	*Bmsy/K*=0.3 Catch weighting, not scaled
K (1000)	417.36 (0.61)	482.76 (0.52)	573.57 (0.61)	624.71 (0.60)	573.16 (0.60)	628.19 (0.60)
r	0.51 (0.48)	0.51 (0.48)	2.44 (0.59)	2.31 (0.60)	2.45 (0.59)	2.28 (0.62)
MSY (1000)	50.00 (0.79)	34.61 (0.70)	317.27 (0.84)	187.58 (0.80)	317.68 (0.84)	185.95 (0.81)
Bcur (1000)	382.13 (0.67)	380.11 (0.66)	559.00 (0.60)	588.14 (0.60)	557.50 (0.60)	587.07 (0.60)
Binit (1000)	409.38 (0.61)	468.95 (0.51)	452.66 (0.59)	453.79 (0.59)	454.38 (0.59)	455.73 (0.59)
Bcur/Binit	0.90 (0.19)	0.76 (0.31)	1.41 (0.78)	1.49 (0.73)	1.39 (0.76)	1.48 (0.72)
Ccur/MSY	0.36 (0.63)	0.47 (0.55)	0.10 (1.37)	0.14 (1.10)	0.11 (1.52)	0.15 (1.34)
Bcur/Bmsy	1.75 (0.14)	2.45 (0.25)	1.94 (0.05)	3.14 (0.09)	1.94 (0.07)	3.12 (0.11)
Fcur/Fmsy	0.26 (2.45)	0.29 (2.57)	0.06 (1.80)	0.05 (1.54)	0.06 (2.52)	0.06 (2.41)

Table BSP.A2.6. Means and CVs for Schaefer model fits by series, with informative priors.

Variable	MoGN	SpLL	SiLL	SiGN	GrLL	LiLL
K (1000)	463.29 (0.55)	315.17 (0.77)	424.82 (0.60)	414.03 (0.62)	453.80 (0.55)	362.10 (0.73)
r	0.52 (0.48)	0.54 (0.41)	0.51 (0.47)	0.53 (0.46)	0.49 (0.48)	0.58 (0.47)
MSY (1000)	56.53 (0.73)	38.26 (0.89)	51.27 (0.77)	51.01 (0.77)	53.51 (0.76)	45.22 (0.83)
Bcur (1000)	431.05 (0.59)	284.21 (0.85)	392.04 (0.65)	383.10 (0.66)	419.14 (0.60)	333.33 (0.78)
Binit (1000)	453.80 (0.55)	309.47 (0.78)	416.46 (0.60)	405.90 (0.62)	444.58 (0.56)	355.16 (0.73)
Bcur/Binit	0.93 (0.16)	0.87 (0.17)	0.92 (0.17)	0.92 (0.16)	0.92 (0.16)	0.90 (0.16)
Ccur/MSY	0.30 (0.62)	0.45 (0.50)	0.34 (0.61)	0.34 (0.59)	0.33 (0.62)	0.39 (0.56)
Bcur/Bmsy	1.81 (0.09)	1.69 (0.11)	1.78 (0.10)	1.79 (0.09)	1.79 (0.10)	1.75 (0.10)
Fcur/Fmsy	0.18 (0.78)	0.29 (0.59)	0.21 (0.82)	0.20 (1.05)	0.20 (0.76)	0.24 (0.66)

Table BSP.A2.7. Means and CVs for Schaefer model fits by series, with uninformative priors.

Variable	MoGN	SpLL	SiLL	SiGN	GrLL	LiLL
K (1000)	583.72 (0.59)	549.54 (0.66)	575.82 (0.60)	564.00 (0.62)	596.75 (0.57)	524.64 (0.73)
r	2.50 (0.58)	2.33 (0.63)	2.46 (0.59)	2.44 (0.59)	2.45 (0.60)	2.47 (0.60)
MSY (1000)	328.91 (0.81)	291.07 (0.91)	319.98 (0.84)	311.26 (0.86)	330.64 (0.81)	282.88 (0.95)
Bcur (1000)	569.35 (0.58)	531.66 (0.65)	560.82 (0.60)	549.25 (0.62)	581.18 (0.56)	507.70 (0.71)
Binit (1000)	464.61 (0.57)	424.28 (0.64)	455.59 (0.59)	445.21 (0.61)	472.71 (0.56)	405.34 (0.70)
Bcur/Binit	1.39 (0.76)	1.45 (0.80)	1.40 (0.76)	1.40 (0.78)	1.40 (0.75)	1.41 (0.87)
Ccur/MSY	0.09 (1.48)	0.13 (1.32)	0.10 (1.47)	0.11 (1.41)	0.10 (1.51)	0.16 (1.36)
Bcur/Bmsy	1.94 (0.06)	1.92 (0.07)	1.94 (0.06)	1.94 (0.06)	1.94 (0.06)	1.90 (0.09)
Fcur/Fmsy	0.05 (2.29)	0.07 (1.53)	0.06 (2.23)	0.06 (3.04)	0.06 (2.36)	0.10 (1.58)

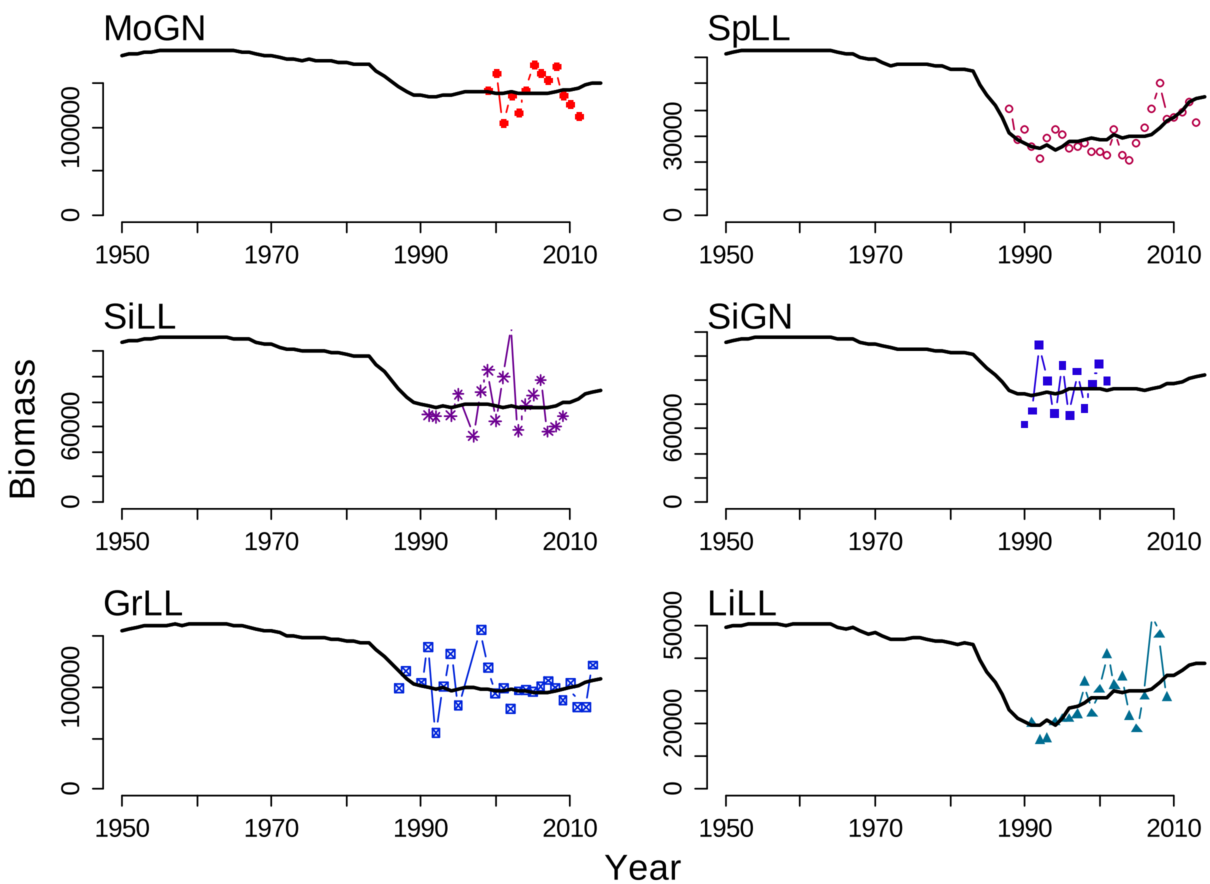


Figure BSP 4. Fits of the Schaefer model to each individual series at the mode.

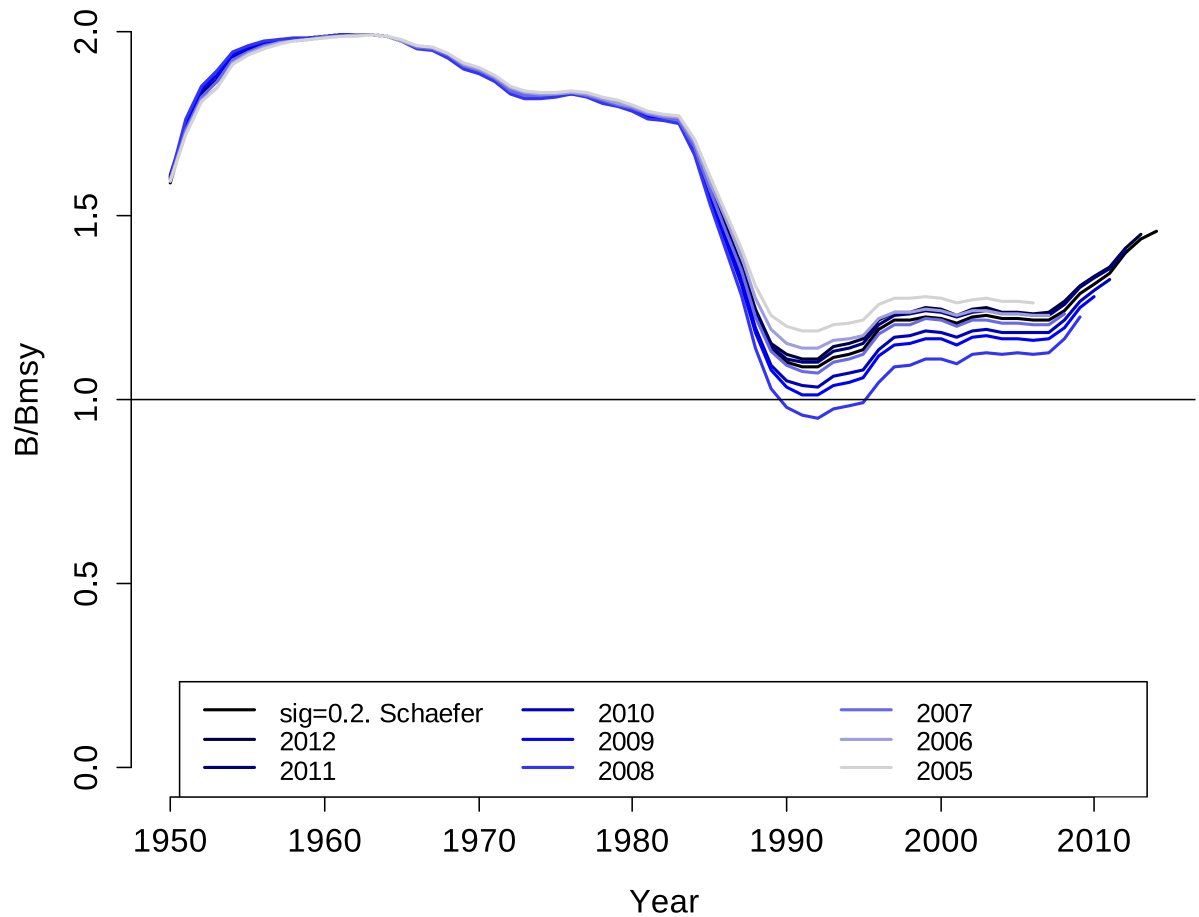


Figure BSP 5. Retrospective analysis with Schaefer model, equal σ =0.2.

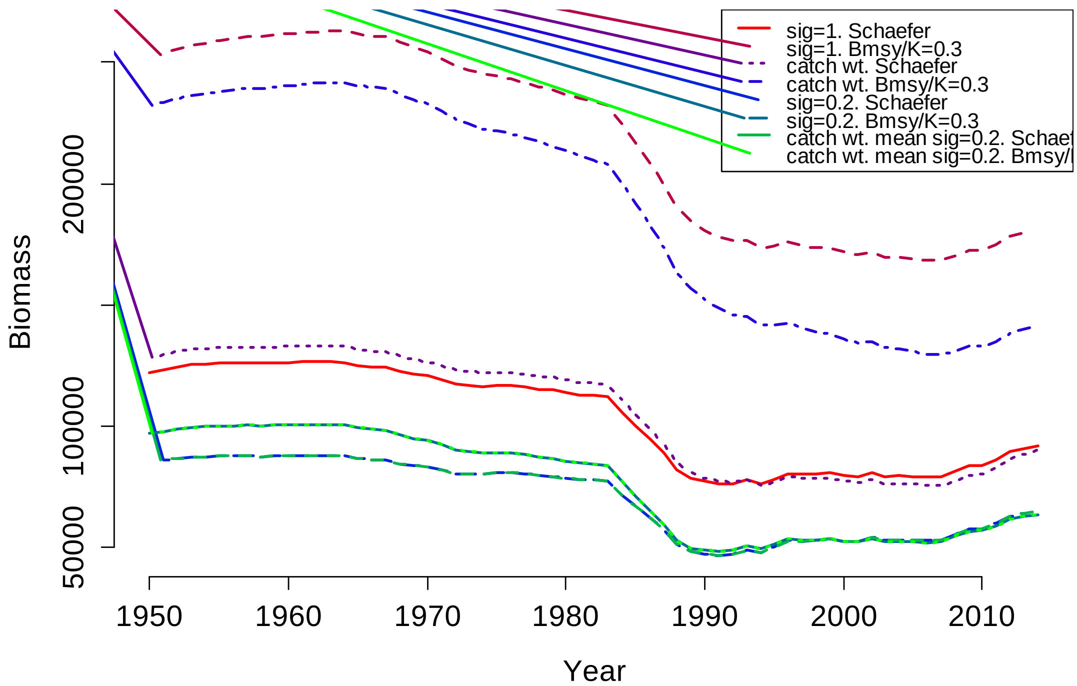


Figure BSP.A2.1. Fits at the mode of the posterior for the eight base case runs.

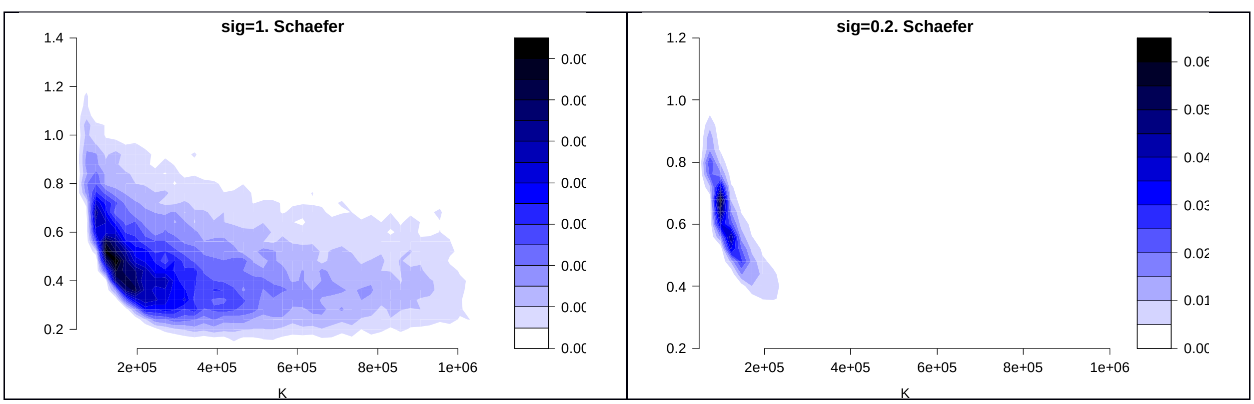


Figure BSP.A2.2. Joint posterior of r and K for run with equal weighting σ=1, and equal weighting σ=0.2.

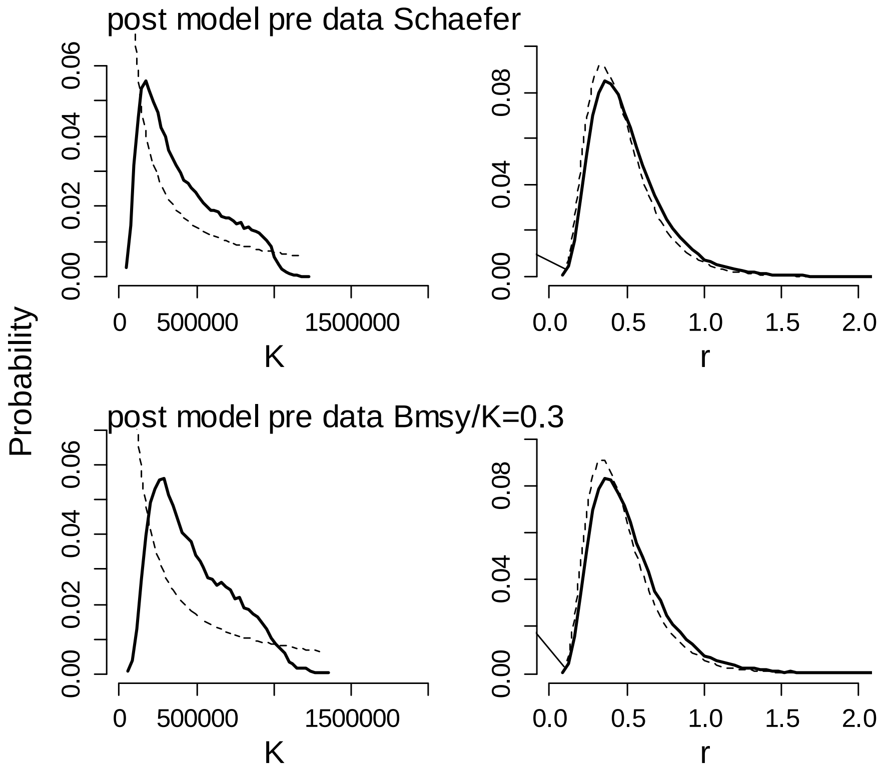


Figure BSP.A2.3. Priors (dashed) and posteriors (solid lines) for the post model pre data runs.

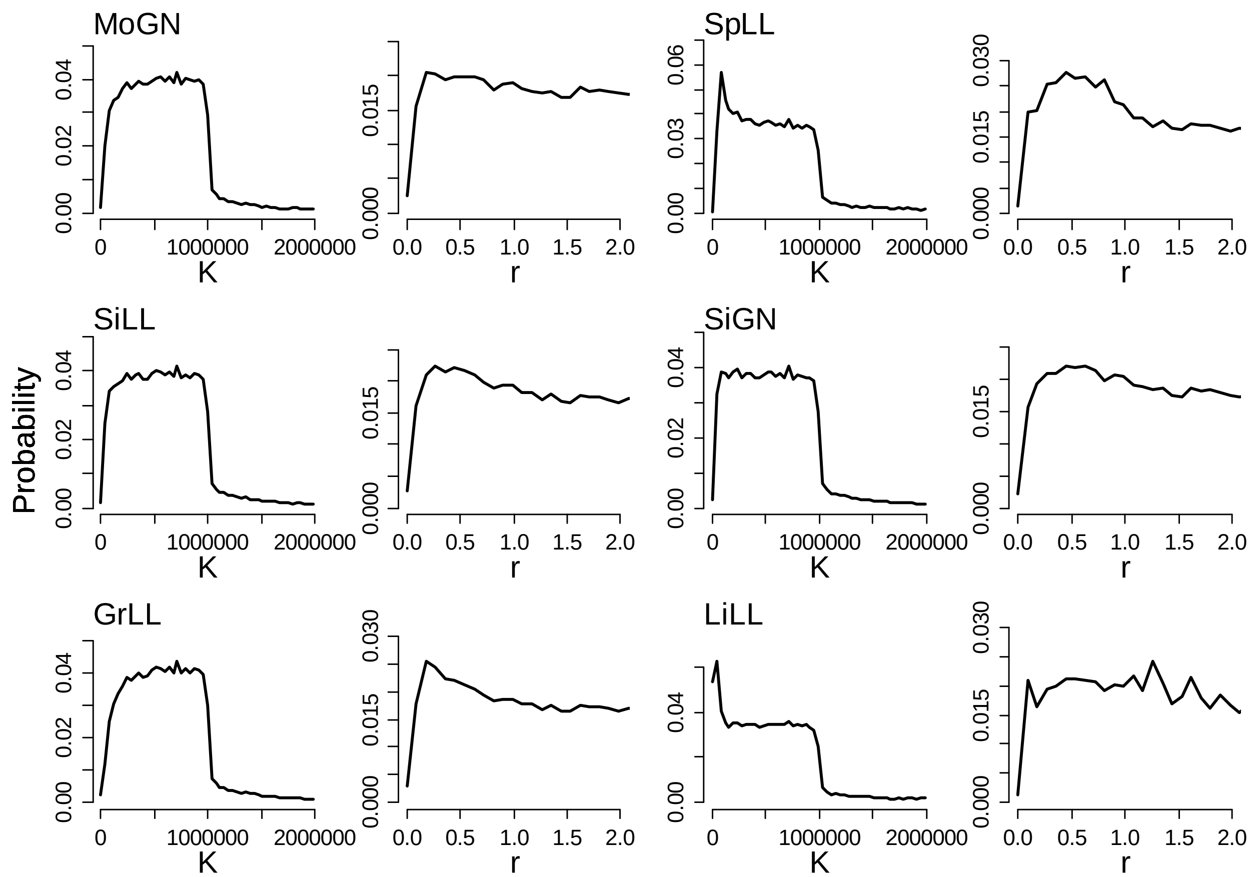


Figure BSP.A2.4. Individual series posteriors of K and r with uninformative priors

DETAILS OF ASPIC MODEL FIT

Table A6.1 Input parameters and data for the SPM Aspic vr. 5.34 NFT. (values of -9999 indicate no data).

```
BOT  ## Run type (FIT, BOT, or IRF)
"SWOMed R1"
LOGISTIC  YLD    LAV
2  ## Verbosity
500  50  ## Number of bootstrap trials, <= 1000
1  100  ## 0=no MC search, 1=search, 2=repeated srch; N trials
1.0000E-08  ## Convergence crit. for simplex
3.0000E-08  8  ## Convergence crit. for restarts, N restarts
1.0000E-04  12  ## Conv. crit. for F; N steps/yr for gen. model
8.0000  ## Maximum F when cond. on yield
5.0  ## Stat weight for B1>K as residual (usually 0 or 1)
6  ## Number of fisheries (data series)     ## IonLL index sensitivity analysis only
1.0000E+00  1.0  1.0  1.0  1.0  1.0    ## Statistical weights for data series
1.0  ## B1/K (starting guess, usually 0 to 1)
15000  ## MSY (starting guess)
150000  ## K (carrying capacity) (starting guess)
8.2090E-04  1.2652E-03  1.6188E-03  1.7263E-04  1.7673E-03  1.7404E-03    ## q (startingguesses -- 1 per data
        series)
1  1  1  1  1  1  1  1  1    ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
1000  100000  ## Min and max constraints -- MSY
10000  1e6  ## Min and max constraints -- K
64  ## Random number seed
64  ## Number of years of data in each series
```

YearC	Catch	MorGN	SpaLL	SicLL	SicGN	GrcLL	LiqLL	IonLL
1950	586	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1951	580	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1952	337	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1953	394.5	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1954	452	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1955	340	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1956	393	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1957	250.4	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1958	914	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1959	200	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1960	112	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1961	206	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1962	300	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1963	318	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1964	394	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1965	1760	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1966	1752	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1967	1317	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1968	3440	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1969	3723	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1970	3341	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1971	4975	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1972	5973.007	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1973	4808.936	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1974	5043.467	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1975	4313.856	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1976	4637	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1977	5284.572	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1978	5966	-9999	-9999	-9999	-9999	-9999	-9999	66.5
1979	5547	-9999	-9999	-9999	-9999	-9999	-9999	88.9
1980	6579	-9999	-9999	-9999	-9999	-9999	-9999	98.3
1981	6814.022	-9999	-9999	-9999	-9999	-9999	-9999	57.8
1982	6343	-9999	-9999	-9999	-9999	-9999	-9999	77.5
1983	6896.376	-9999	-9999	-9999	-9999	-9999	-9999	54.2
1984	13665.58	-9999	-9999	-9999	-9999	-9999	-9999	78.18
1985	15291.96	-9999	-9999	-9999	-9999	-9999	-9999	58.83
1986	16764.86	-9999	-9999	-9999	-9999	-9999	-9999	41.07
1987	18319.98	-9999	-9999	-9999	-9999	120.9423	-9999	47.4
1988	20365.38	-9999	116.701	-9999	-9999	142.575	-9999	66.6
1989	17761.89	-9999	82.344	-9999	-9999	-9999	-9999	-9999
1990	16017.5	-9999	92.912	-9999	8.31	128.7304	-9999	63.86
1991	15746.28	-9999	75.485	100.285	9.8	170.0798	88.46734	54.73
1992	14709.42	-9999	61.071	98.51493	16.87	68.38899	66.10005	40.3
1993	13264.87	-9999	84.072	-9999	13.04	123.1497	68.76332	50.91
1994	16082.21	-9999	93.686	99.4544	9.49	162.7566	90.59594	30.58
1995	13014.81	-9999	87.992	124.1921	14.65	99.92296	94.61741	33.43
1996	12052.81	-9999	72.728	-9999	9.33	-9999	94.34434	32.74
1997	14693.35	-9999	74.227	75.91722	14.04	-9999	101.069	40.11
1998	14368.87	-9999	77.946	127.6296	10.12	191.5122	144.937	-9999
1999	13698.64	58.256	69.918	151.4978	12.71	145.9855	101.896	-9999
2000	15568.79	66.671	69.501	93.34962	14.92	114.6219	134.6806	-9999
2001	15006.07	43.149	65.045	143.9597	13.06	120.4906	181.6245	-9999
2002	12814.04	56.034	92.961	204.8379	-9999	96.95627	140.3248	-9999
2003	15674.09	48.181	65.762	82.2238	-9999	118.1779	152.2781	-9999
2004	14404.92	58.411	59.098	111.1854	-9999	119.1237	98.85779	-9999
2005	14600.07	70.678	78.227	123.2123	-9999	116.7176	80.80129	-9999
2006	14892.95	66.164	94.817	140.6214	-9999	123.5422	125.0479	-9999
2007	14226.84	63.163	115.585	81.06036	-9999	130.5446	239.9992	-9999
2008	12163.83	69.178	144.123	86.95149	-9999	122.5142	208.1756	-9999
2009	11839.52	55.582	105.439	99.11803	-9999	106.694	123.3873	-9999
2010	13429.68	51.887	107.044	-9999	-9999	126.6964	-9999	-9999
2011	11422.75	46.505	111.983	-9999	-9999	98.78521	-9999	-9999
2012	9888.418	-9999	124.302	-9999	-9999	98.01572	-9999	-9999
2013	11253.84	-9999	100.708	-9999	-9999	149.3422	-9999	-9999

Table A6. 2. Sensitivity runs developed with the SP Aspic model.

Run	Catch period		Indices	Pars Estim	Notes
R1	1950	2013	6, Avg Year	All, LAV	Est catch for 1953 = interpolate(1952,54)
R2	1950	2013	6, Avg Year	ALL, SSQ	Same as R1 but using Sum of Squares for fitting.
R3	1950	2013	5* rem - 1	All, LAV	Jacknife Removal 1 index at the time
R4	1950	2013	6, Avg Year	All, LAV	Different initial values for B0/K: 0.5, 1.0, 1.5
R5	1950	2013	6, Avg Year	All, LAV	Fox model with data as R1
R6	1950	2013	6, Avg Year	All, LAV	Generalized model using R1 inputs
R7	1950	2013	6, Avg Year	All, LAV	Retrospective 1 to 6 years removed: 2013 - 2008.
R8	1980	2013	6, Avg Year	All, LAV	Change start year to 1980.
R9	1950	2013	7, Avg Year	All, LAV	Add Historic Nominal CPUE DeMetrio et al 1999 SCRS

Table A6. 3. Fit and diagnostic results run 1 SP Aspic model.

```
SWOMed R1                                                                                                    Page 1
                                                                                   Wednesday, 23 Jul 2014 at 10:47:23
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.34)
                                                                                                     BOT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research              LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                             YLD conditioning
            Mike.Prager@noaa.gov                                                                     LAV optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium              ASPIC User's Manual is available
surplus-production model.  Fishery Bulletin 92: 374-389.                              gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)          Input file: c:\...auricio\desktop\scrs_2014\swomed\aspic\r1\swomedr1.inp
------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization with bootstrap.
Number of years analyzed:                      64            Number of bootstrap trials:                       500
Number of data series:                          6            Bounds on MSY (min, max):       1.000E+03     1.000E+05
Objective function:            Least absolute values         Bounds on K (min, max):         1.000E+04     1.000E+06
Relative conv. criterion (simplex):       1.000E-08          Monte Carlo search mode, trials:        1             100
Relative conv. criterion (restart):       3.000E-08          Random number seed:                                64
Relative conv. criterion (effort):        1.000E-04          Identical convergences required in fitting:          8
Maximum F allowed in fitting:                 8.000


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                  error code   0
------------------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
represent the abundance of the stock. That assumption should be checked.


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------------
                                        |
1  MorGN                                |   1.000
                                        |      13
                                        |
2  SpaLL                                |   0.236   1.000
                                        |      13      26
                                        |
3  SciLL                                |  -0.208  -0.122   1.000
                                        |      11      17      17
                                        |
4  SciGN                                |   0.672  -0.550  -0.149   1.000
                                        |       3      12       9      12
                                        |
5  GrcLL                                |   0.231  -0.028  -0.073  -0.798   1.000
                                        |      13      23      16      10      24
                                        |
6  LigLL                                |  -0.105   0.557  -0.098  -0.089   0.092   1.000
                                        |      11      19      17      11      17      19
                                         ------------------------------------------------
                                               1       2       3       4       5       6


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
------------------------------------------------------------------------------------------------------------------------
Weighted           Weighted      Current    Inv. var.    R-squared
Loss component number and title                            LAV       N          MSE       weight       weight      in CPUE

Loss(-1)  LAV in yield                               0.000E+00
Loss(0)   Penalty for B1 > K                         0.000E+00     1          N/A    5.000E+00          N/A
Loss(1)   MorGN                                      1.951E+00    13          N/A    1.000E+00          N/A       -0.498
Loss(2)   SpaLL                                      4.270E+00    26          N/A    1.000E+00          N/A        0.242
Loss(3)   SciLL                                      3.668E+00    17          N/A    1.000E+00          N/A       -0.057
Loss(4)   SciGN                                      2.196E+00    12          N/A    1.000E+00          N/A       -0.070
Loss(5)   GrcLL                                      4.340E+00    24          N/A    1.000E+00          N/A       -0.547
Loss(6)   LigLL                                      4.316E+00    19          N/A    1.000E+00          N/A        0.057
..............................................................
TOTAL OBJECTIVE FUNCTION:                        2.07411705E+01
Estimated contrast index (ideal = 1.0):                  0.5396          C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):                  1.0000          N* = 1 - |min(B-Bmsy)|/K
```

Table A6. 4.Estimated bootstrapped parameters run 1 SP Aspic model.

ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Estimated Param name	Estimated Point estimate	Bias in pt estimate	relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	8.670E-01	5.531E-04	0.06%	8.510E-01	8.961E-01	8.605E-01	8.784E-01	1.798E-02	0.021
K	6.829E+04	-1.817E+03	-2.66%	6.035E+04	8.495E+04	6.628E+04	7.516E+04	8.873E+03	0.130
q(1)	1.504E-03	6.925E-05	4.60%	1.177E-03	1.763E-03	1.335E-03	1.595E-03	2.602E-04	0.173
q(2)	2.399E-03	1.218E-04	5.08%	1.885E-03	2.811E-03	2.149E-03	2.553E-03	4.038E-04	0.168
q(3)	3.147E-03	1.791E-04	5.69%	2.315E-03	3.682E-03	2.684E-03	3.296E-03	6.118E-04	0.194
q(4)	3.365E-04	1.745E-05	5.19%	2.574E-04	4.094E-04	2.912E-04	3.673E-04	7.607E-05	0.226
q(5)	3.026E-03	1.485E-04	4.91%	2.236E-03	3.470E-03	2.642E-03	3.181E-03	5.383E-04	0.178
q(6)	2.866E-03	1.496E-04	5.22%	2.147E-03	3.411E-03	2.533E-03	3.051E-03	5.174E-04	0.181
MSY	1.501E+04	2.089E+02	1.39%	1.469E+04	1.543E+04	1.481E+04	1.514E+04	3.257E+02	0.022
Ye(2014)	1.190E+04	-3.737E+01	-0.31%	1.151E+04	1.244E+04	1.174E+04	1.215E+04	4.134E+02	0.035
Y.(Fmsy)	1.139E+04	-8.180E+00	-0.07%	1.131E+04	1.150E+04	1.136E+04	1.144E+04	8.352E+01	0.007
Bmsy	3.415E+04	-9.085E+02	-2.66%	3.017E+04	4.248E+04	3.314E+04	3.758E+04	4.437E+03	0.130
Fmsy	4.395E-01	3.023E-02	6.88%	3.534E-01	5.020E-01	3.925E-01	4.519E-01	5.937E-02	0.135
fmsy(1)	2.922E+02	9.064E+00	3.10%	2.392E+02	3.405E+02	2.679E+02	3.090E+02	4.107E+01	0.141
fmsy(2)	1.832E+02	4.774E+00	2.61%	1.571E+02	2.113E+02	1.722E+02	1.945E+02	2.234E+01	0.122
fmsy(3)	1.396E+02	3.006E+00	2.15%	1.195E+02	1.682E+02	1.306E+02	1.529E+02	2.232E+01	0.160
fmsy(4)	1.306E+03	4.218E+01	3.23%	1.088E+03	1.547E+03	1.186E+03	1.395E+03	2.097E+02	0.161
fmsy(5)	1.452E+02	3.710E+00	2.55%	1.259E+02	1.647E+02	1.364E+02	1.531E+02	1.668E+01	0.115
fmsy(6)	1.534E+02	4.059E+00	2.65%	1.293E+02	1.784E+02	1.418E+02	1.642E+02	2.236E+01	0.146
B./Bmsy	1.455E+00	1.031E-02	0.71%	1.392E+00	1.506E+00	1.422E+00	1.474E+00	5.288E-02	0.036
F./Fmsy	5.189E-01	-9.230E-03	-1.78%	4.849E-01	5.595E-01	5.067E-01	5.394E-01	3.277E-02	0.063
Ye./MSY	7.926E-01	-1.187E-02	-1.50%	7.440E-01	8.455E-01	7.750E-01	8.223E-01	4.729E-02	0.060
q2/q1	1.595E+00	1.301E-02	0.82%	1.409E+00	1.763E+00	1.510E+00	1.653E+00	1.438E-01	0.090
q3/q1	2.092E+00	2.952E-02	1.41%	1.839E+00	2.357E+00	1.970E+00	2.200E+00	2.306E-01	0.110
q4/q1	2.237E-01	1.551E-03	0.69%	1.954E-01	2.608E-01	2.104E-01	2.437E-01	3.330E-02	0.149
q5/q1	2.012E+00	1.440E-02	0.72%	1.721E+00	2.195E+00	1.897E+00	2.072E+00	1.750E-01	0.087
q6/q1	1.905E+00	1.741E-02	0.91%	1.675E+00	2.148E+00	1.808E+00	1.986E+00	1.774E-01	0.093

INFORMATION FOR REPAST (Prager, Porch, Shertzer, &Caddy. 2003. NAJFM 23: 349-361)

Unitless limit reference point in F (Fmsy/F.): 1.927
CV of above (from bootstrap distribution): 0.7291E-01

Table A6. 5 Comparison of estimated shape surplus model function for SWO- Med.

COMPARISON OF LOGISTIC AND GENERALIZED MODELS

Model	Code	Exponent	Bmsy/K	B1/K	MSY	K	q1	Objective fn.	AIC_c
L	0	2.00	0.500	1.000E+00	1.501E+04	6.829E+04	1.504E-03	2.07412E+01	-1.68781E+02
G	0	2.03	0.503	1.000E+00	1.501E+04	6.891E+04	1.486E-03	2.07371E+01	-1.66432E+02

COMPARISON OF LOGISTIC AND FOX MODELS

Model	Code	Exponent	Bmsy/K	B1/K	MSY	K	q1	Objective fn.
L	0	2.00	0.500	8.529E-01	1.501E+04	6.829E+04	1.504E-03	2.07412E+01
F	0	1.00	0.368	8.608E-01	1.553E+04	7.897E+04	1.433E-03	2.09409E+01

NOTE: Following report describes Fox model w/ adjusted bounds: MSY(1.88E+03, 1.20E+05), K(1.42E+02, 3.28E+07)

Table A6. 6 SWO Medestimated parameters for retrospective analysis SP Aspic model when removing last year of data.

Run	Term Yr	MSY	Bmsy	Fmsy	*r*
M0	2013	15,010	34,150	0.440	0.879
M1	2012	15,000	33,940	0.442	0.884
M2	2011	15,000	33,940	0.442	0.884
M3	2010	14,880	34,610	0.430	0.86
M4	2009	14,750	34,740	0.425	0.849
M5	2008	15,020	28,540	0.526	1.0528
M6	2007	15,620	65,220	0.240	0.479

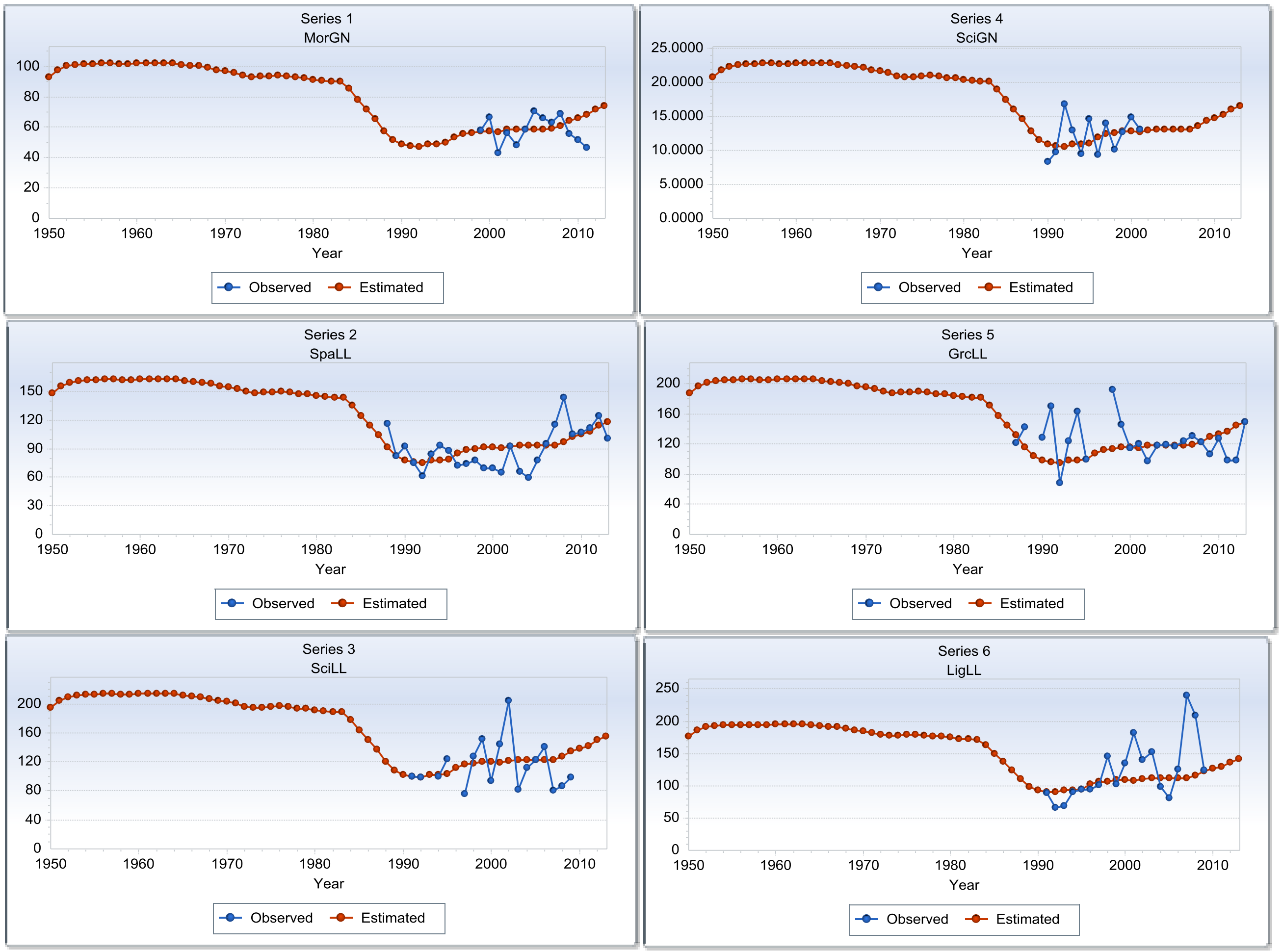


Figure A6.1 SWO-Med SPM Aspic run 1 fit to indices of abundance series.

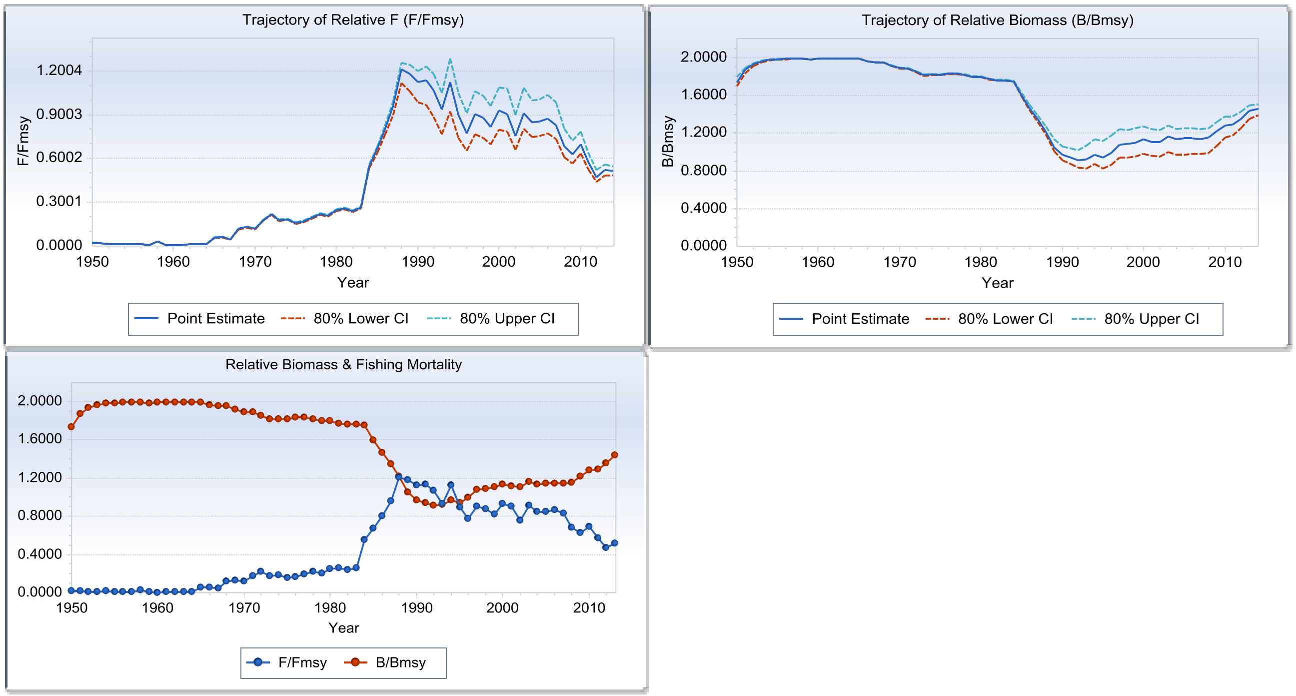


Figure A6. 2 SWO Med SPM Aspic run 1 estimated relative biomass and fishing mortality trends.

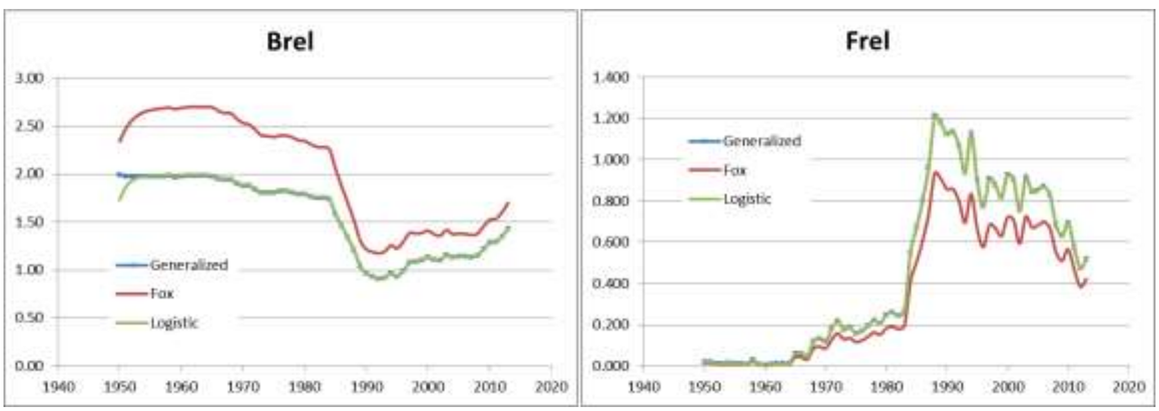


Figure A6. 3 SWO Med Relative biomass and fishing mortality trends estimated by SPM Aspic with different assumptions of the surplus shape parameter.

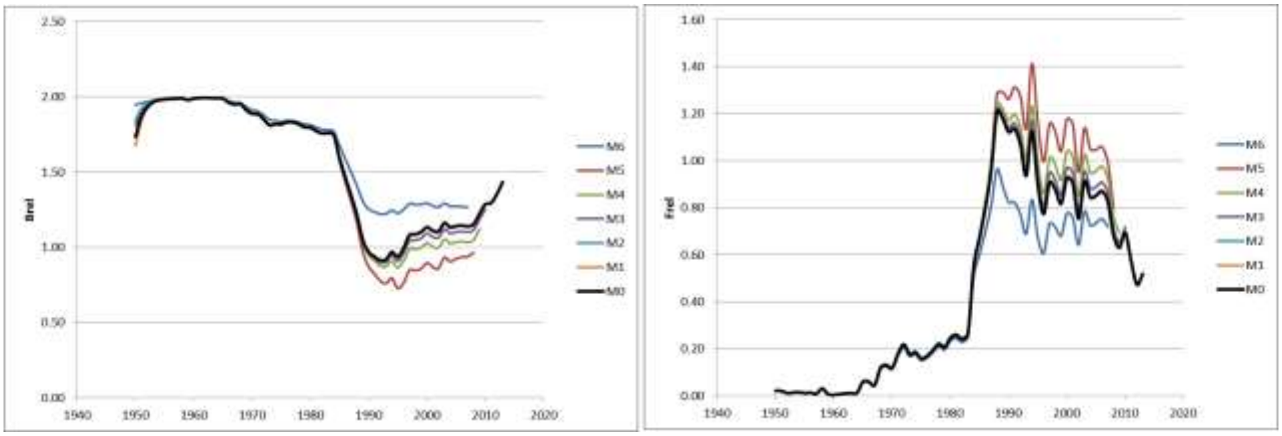


Figure A6. 4 SWO-Med estimated trends of relative biomass (left) and fishing mortality from the retrospective analysis, by removing last year data from 2007 (M6) to 2013(M0).

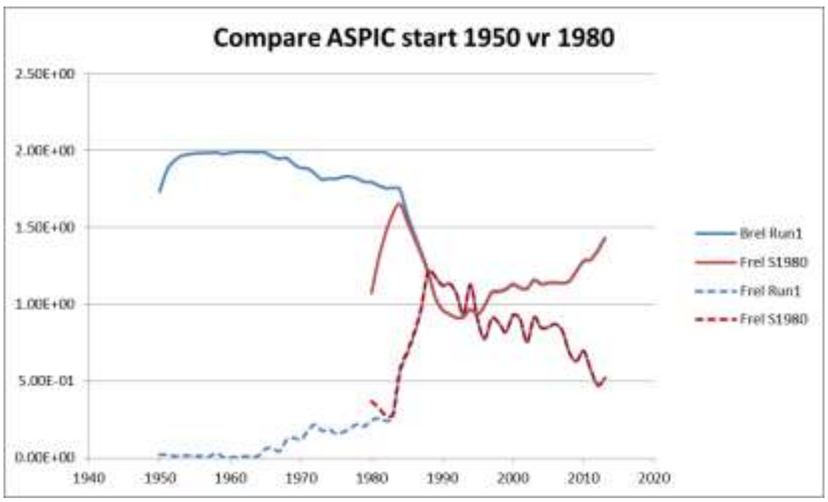


Figure A6. 5 SWO-Med comparison of the relative biomass and fishing mortality trends for SPM Aspic models starting with catch data in 1950 (Run1), or catch data in 1980(S1980).

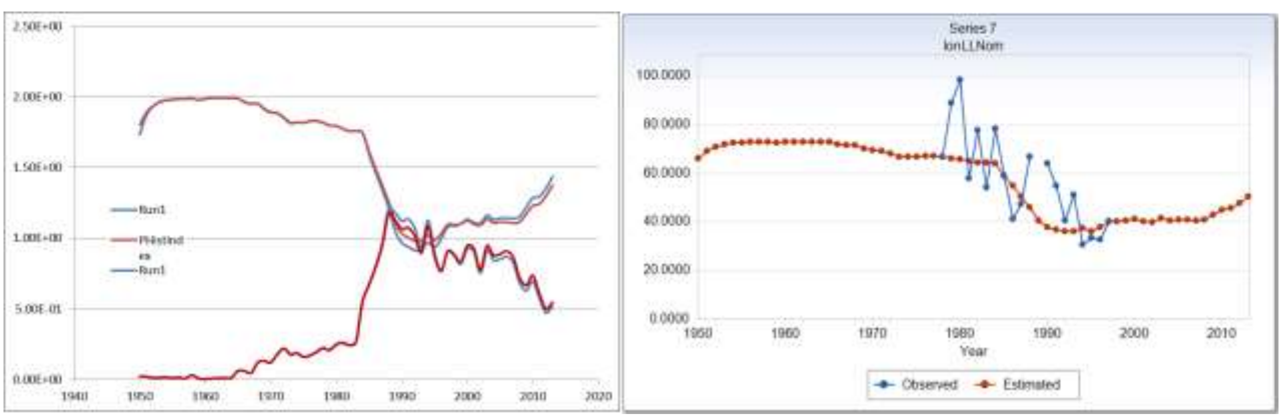


Figure A6. 5 SWO-Med comparison of relative biomass and fishing mortality trends (left) and index fit for the SPM Aspic run when introduced the nominal Ionian longline index (De Metrio et al 1999) in the run 1.

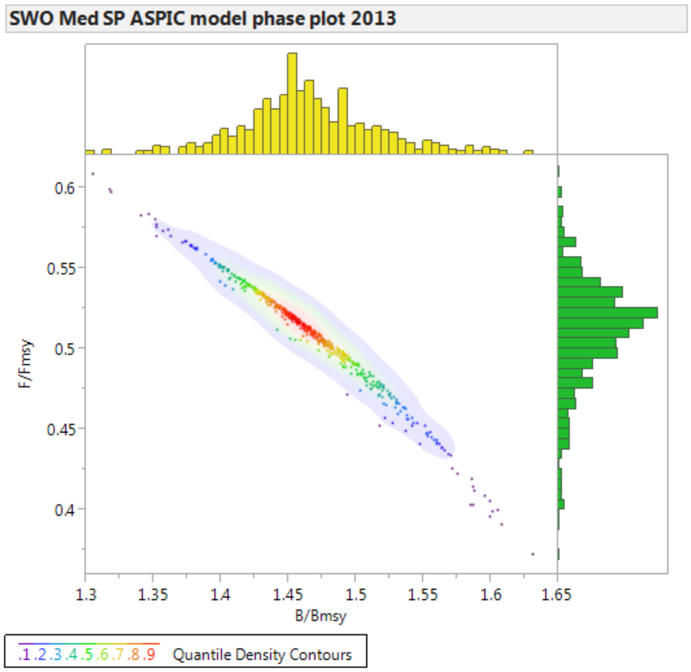


Figure A6.6 SWO-Med estimated relative stock status as of 2013 from bootstrapped SP Aspic run 1 model. The marginal histograms display distribution of 500 boots, point colors and shade indicate the quantile density of the bivariate results.