REPORT OF THE 2016 MEDITERRANEAN SWORDFISH STOCK ASSESSMENT MEETING

(Casablanca, Morocco, 11-16 July 2016)

1. Opening, adoption of agenda and meeting arrangements

The Meeting was held at the *Institut National de Recherche Halieutique* (INRH) in Casablanca from 11-16 July 2016. Mr. Jilali Bensbai (INRH) opened the meeting welcoming the participants ("the Group"). Dr. Laurence Kell, on behalf of the ICCAT Executive Secretary, thanked the INRH for hosting the meeting and highlighted the importance of the work to be developed by the Group during the meeting, aiming the provision of management advice to the Commission. Dr. Georges Tserpes, meeting Chairperson, proceeded to review the Agenda, which was adopted with a slight modification for the inclusion of the review and update of the species Executive Summary and work plan for 2017 under item 5 (Other matters) (**Appendix 1**).

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

Section	*Rapporteur*
Item 1	M. Neves dos Santos
Item 2	S. Saber, D. Macias, J. Ortiz de Urbina
Item 3	L. Kell, G. Tserpes
Item 4	R. Coelho, G. Tserpes, D. Die, M. Neves dos Santos
Item 5	G. Tserpes, R. Coelho, M. Neves dos Santos
Item 6	M. Neves dos Santos

2. Summary of available data for assessment

2.1 Biology

During the meeting three documents were presented exploring questions related to the biology of the species.

Document SCRS/2016/112 presented length-weight relationships for the Mediterranean swordfish based on a large time series of data from several fisheries operating in different areas of the Mediterranean Sea. Differences among areas were found to be statistically significant, which should be considered when adopting Mediterranean-wide equations. However, results were considered to be preliminary due to the fact that not all available data were used and the structure of certain data sets was not properly clarified. The Group suggested the accomplishment of the study, and for the purposes of the current assessment, agreed on employing the length weight relationship (Mejuto and De la Serna, 1993) used in the previous Mediterranean swordfish stock assessment session.

Document SCRS/2016/117 presented a length-weight relationship for the Mediterranean swordfish caught by the Algerian longline fishery in 2015 and 2016. The Group recognized that although it is a small sample with a narrow length distribution range, it represents a highly valuable source of information and should be included in the on-going length-weight revision mentioned in SCRS/2016/112.

Document SCRS/2016/114 presented the results of stomach contents of juvenile swordfish from the middle Aegean Sea of Turkey. Prey categories by order of importance were teleosts, cephalopods and crustaceans. Anchovy had the highest frequency of occurrence, percentage abundance and index of relative importance (IRI) whereas; sardine had the highest percentage by weight. The secondary food preference group was cephalopoda, especially *Loligo vulgaris*. This squid species was the third option in terms of IRI. Crustaceans showed low values for all the feeding indices examined in the analysis. Additionally, *Cepola macrophtalma* and *Sardinella aurita* are reported for the first time from the content of swordfish stomach in the Aegean Sea. Other studies on feeding habits of swordfish in the Mediterranean Sea reported that cephalopoda species is the main prey and teleost the second one. This difference in food preference can be due to some specimens from the present study caught by purse seine targeting anchovy and sardine.

The Group has noted that research results have demonstrated the possible occurrence of a high mixing rate between the Mediterranean and North Atlantic stocks west of the 05°W boundary separating the two stocks. It is very likely that part of the fish caught in this area belong to the Mediterranean stock but further studies are needed to identify the degree of mixing among stocks.

As no new information was presented for other biological parameters, the Group adopted the same values that were used in the 2010 and 2014 stock assessments (see list below) (Anon. 2011 and 2015).

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
t_0	-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)
L_{50}	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)

2.2 Catch, effort, and size

2.2.1 Description and evolution of the Mediterranean swordfish fisheries

Mediterranean swordfish fisheries are characterized by high catch levels. It should be noted that annual reported catches (on average about 13,802 t from 1988 to 2015) are similar to those of the North Atlantic, though the Mediterranean has a much smaller body of water. However, the potential reproductive area in the Mediterranean is probably relatively larger than that in the Atlantic. Furthermore, it has been suggested that the biological and oceanographic conditions prevailing in the Mediterranean favor the high productivity of large pelagic fish.

Swordfish fishing has been carried out in the Mediterranean since the 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 in the recent years (2003-2015) are EU-Italy (45%), EU-Spain (13%), Greece (10%), Morocco (14%), and Tunisia (7%). Also, Algeria, Cyprus, Malta, and Turkey have fisheries targeting swordfish in the Mediterranean. Incidental catches of swordfish have also been reported by Albania, EU-Croatia, EU-France, EU-Portugal, Japan, Libya and Syria.

Mediterranean total swordfish landings showed an upward trend from 1965-1972, stabilized between 1973 and 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 and up to 2011, the reported landings of swordfish in the Mediterranean Sea have declined fluctuating mostly between 12,000 to 16,000 t. In the last four years, following the implementation of the three-month fishery closure and the requirement for vessel authorization, overall fishing effort has been decreased and catches are around 10,000 t. Based on the available information during the assessment, the catches in 2015 amounted to 9,966 t catches were 9,966 t (**Table 1**).

In the period 2003-2011, the main fishing gears used were longlines and gillnets. Since 2012 the main gear employed by the swordfish targeting fisheries is longline. **Figure 1** presents the evolution of the catches according to the fishing gear. Swordfish is also caught with harpoons and traps, and also as by-catch in other fisheries (longlines targeting albacore, purse seines, etc.).

There have been several important management initiatives by ICCAT in recent years, and a summary of these 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 15 October to 15 November 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, transhipped 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. It has been reported, however, that other large pelagic fisheries, such as those of albacore, are capturing large numbers of small swordfish, particularly during the autumn and winter months (Tserpes *et al.*, 2014).

Concerning minimum sizes, Rec. [11-03] and Rec. [13-04] established a minimum size that prohibited the retaining on board, transhipping, 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 gilled-gutted weight, or 7.5 kg of dressed 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 5% by weight or/and number of pieces per landing of the total swordfish catch of said vessels.

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, hook size and longline length .These restrictions were established for 2012 [Rec. 11-03] and remain in force since 2013 [Rec. 13-04].

2.2.2 National fishery descriptions from Working Group participants

Scientists participating in the Working Group provided a summary of the recent fishery developments, including domestic management measures (which are in addition to the ICCAT measures described above). Catches associated with these countries represent about 89% of the 2015 provisional total Mediterranean swordfish catch.

EU-Greece

The Greek swordfish fleets operate throughout the eastern Mediterranean basin exclusively using drifting surface longlines. 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.

In 2015, about 200 vessels were licensed to fish swordfish, but not all of them were regularly involved in the swordfish fishery. Most of them entered the fishery occasionally. A reduction of the effort has been observed in 2015, mainly due to the low prices of the swordfish and the high costs of the longline swordfish operation (expensive bait, gear losses, light-sticks). Many of the licensed boats have changed fishing gear during the swordfish fishing season, targeting other species. A large number of these boats was involved in the albacore fishery, during the summer months of 2015. The albacore fishery during the summer, is a quite new activity for the Greek fishing fleets and has started about three-four years ago in the area of Crete by a small number of boats, which followed the Italian large pelagic fishing vessels targeting albacore in the Libyan and Cretan Seas and landing their catches in the Cretan ports. In 2015, a large part of the Greek swordfish fishing fleet has been involved in the albacore fishery during the summer months, from June to August, in various areas of the S. Aegean, depending on the availability of the resource.

Consequently, a reduction of the swordfish production has been recorded. Swordfish production during the 2015 fishing season was estimated to be up to 691 t, which is the lowest of the last twenty years. The CPUE rates were also among the lower ones observed in the last decade.

EU-Italy

Italy has a long historical tradition in the swordfish fishery which is currently reflected by the development of several fishing strategies and gears 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 purse seines and sport fishery. The structure of the Italian fleet has undergone major changes after the total UN driftnet moratoria to driftnet longer than 2,5km which entered into forced in 1992. 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 gradual process of fleet dismantling has led to a gradual reduction of fishing units in the period from 1992 to 2002, when, an EU ban to the use of driftnet to catch highly migratory species entered into force

Italy has transposed the ICCAT management measures described earlier, with the DM 03 June 2015 and DD of 29 February 2016, establishing measures for the professional longline swordfish fishery including a new list of the authorized vessels, which substantially reduced the number of the licensed boats compared to what was previously reported in the ICCAT database. Also, the recently adopted regulation is more restrictive than recommendations in place in ICCAT. Indeed, vessels are authorised to keep onboard only 2800 hooks maximum also in case of trips longer than two days.

The longline fleet is widespread all over the various seas around Italy, with a higher concentration in the southern Italian regions (over 65% of the fleet). Most of the vessels are small-medium longliners. According to the DD of 29 February 2016 the Italian fleet licensed for the professional swordfish fishery is now made up of 849 boats, mostly small-medium sized units, (45% less than 12 meters LOA and 10 GT, 78% less than 15m LOA), with an average length of 12.5m and 15.6 GT., distributed in a great number of harbours, usually exploiting local fishing grounds. Some of the smaller boats in the list 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. 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. The fishing grounds show moderate yearly variability, depending mostly on oceanographic factors. Some fleets are active all the year round, while the majority of the vessels are active from spring until early autumn.

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, at least in the first years (see SCRS/2016/120). This new approach is now incorporated in the majority of the Italian longliners that use alternatively surface and meso-pelagic according to the season. The majority of vessels use both gears depending on the sea condition, season and fishing opportunity. The mesopelagic longline gear is set deeper and for longer periods of time compared to the traditional approach for the Italian fisheries and is mainly operated during the summer months due to better weather conditions. 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. This is particularly noteworthy, as these changes in fishing patterns can have implications in the use of catch rates as indices of abundance in the stock assessment.

SCRS/2016/120 presented nominal indices of relative abundance for swordfish caught by the Ligurian longline fishery updated with 2014 and 2015 data. The trend in CPUE for the mesopelagic longline indicates that relative abundance for 2014 has strongly increased from 2013 levels, but dropped during the following season 2015. Average sizes of fish, after the drop of the previous years, remain quite constant. During the winter months fishing is active using the American Type longline: a comparison of the two gears in terms of catches, CPUEs and size frequency distributions is reported.

EU-Spain

The Spanish longline fleet targeting swordfish in the western Mediterranean operates using several gears which cover a wide range of depths. From the beginning of the fishery until year 2000, the fleet operated by using only a surface gear: the traditional or home based longline (LLHB). About 2000, part of the fleet began to use a weighed gear (*piedras*) and floats (*bolas*), having access to deeper waters, close to the sea bottom. The gear was termed *piedra-bola* or bottom longline (LLPB). After 2002, the fleet began to use the American longline (LLAM): a surface gear that introduced some new elements such as the spool, a thicker main-line, and larger distance between hooks. Finally, in 2007 a semi-pelagic longline (LLSP) began to be used.

LLSP operates in mesopelagic waters, fishing in a zone of the water column different than the previous ones. All these new elements have been implemented by the fleet probably due to improvements in profitability (increasing yield or diminishing the cost of the activity).

Some of the factors that could explain the above referred changes in fishing practices would be the reduction of the by-catch of vulnerable species, reduction of immature swordfish in the catch, as well as the increase in yield. The implementation of management measures by the Spanish legislation, such as seasonal closure in months with high yields (October-November) and the imposition of a minimum legal size (90 cm LJFL), probably has also played an important role.

The surface longline fishery has remained quite stable regarding total fishing effort. As regards effort distribution between gears, it is highly variable from year to year. Currently the main gears used by the fishery are LLSP (in summer months), and LLHB (in winter months). In addition, swordfish is also caught seasonally, in small quantities, as a by-catch species on the longline fisheries targeting bluefin tuna and albacore.

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 90s, 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. The fishing season occurs mainly in 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 only 480 tons in 2015. The average catch during the period 2012-2015, was about 705 tons, which represented a decrease of about 49% 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 has slightly increased, reaching 150 cm in 2013-2015.

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 of high economic importance for Tunisia. National production is around 1000 t (average 2003-2012). The main fishing season is the summer (July-August). Surface longline is the most commonly used gear type with sardinella as bait. Fish are landed in round weight. 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.

Turkey

The Turkish swordfish fishery in the Mediterranean dates back to the early 17th Century. The fishery in Turkey has been carried out in the 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 61 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.

Regarding potential of Mediterranean swordfish fishery in the eastern Mediterranean in the context of far-reaching driftnet banning by GFCM/ICCAT, driftnet has been recognized to be used conventionally in the past as the foremost effective fishing gear in Turkey. However, Turkey has prohibited utilization of all types of driftnet as from 2011, to comply with the relevant GFCM/ICCAT decisions.

Since then, total catch of Mediterranean swordfish in Turkish waters, as well as in the high-seas of the Mediterranean, has decreased substantially over the years since 2011 (i.e., from 330 metric tons in 2010 down to 96 metric tons in 2014) due to inefficiency and limited catch capacity of some other alternative gears that have been tried by the coastal fishers.

In this regard, the large scale driftnet banning has evidently registered quite a negative impact especially on the small-scale coastal fishermen owing to the lingering social and economic value of this type of fishery over the livelihoods of many small-scale fishers in Turkey. At present, no efficient alternative fishing gear to compensate the effectiveness of the eliminated drift-nets could be adopted by the Turkish fishermen with respect to the Mediterranean swordfish fisheries.

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.

2.2.3 Task I catches

The complete Mediterranean swordfish summary table is presented in **Table 1**. The Group noted that the available catch data appeared to be generally complete. In 2015, the provisional total yield for the stock was 9,966 t, an increase of about 2% compared to 2014 (9,794 t).

Figure 1 shows the T1NC catches by year and major gear. In the previous stock assessment, it was noted that the Mediterranean swordfish stock is among the stock with largest T1NC catches with "unclassified" gear. 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 importance of the longline gear component.

2.2.4 Task II (catch-effort and size samples)

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

2.3 Relative abundance estimates (CPUEs)

Four documents including information on the temporal evolution of the abundance indices of different Mediterranean swordfish fisheries were presented to the Working Group.

Document SCRS/2016/096 reported standardized catch rates for the Spanish longline fishery in the western Mediterranean, for the period 1988-2015. Swordfish catch rates expressed in terms of number of fish were analyzed by means of a General Linear Modelling approach assuming a negative binomial error distribution. The standardized index showed notable annual fluctuations without any definite trend for the period under study.

Document SCRS/2016/113 reported annual standardized catch rates from the Greek drifting surface longline fisheries targeting swordfish in the eastern Mediterranean for the period 1987-2015. Annual standardized indices were estimated by means of Generalized Linear Modelling techniques, and the explanatory factors included 'Year', 'Month', 'Gear type' and 'Area of fishing'. Catchability changes that took place in the fisheries were also taken into account. As regards to the trend, the standardized annual index from year 2000 onwards was generally lower than that estimated for the years preceding 2000.

Document SCRS/2016/119 showed standardized catch rates from the Moroccan fleet targeting swordfish in the Strait of Gibraltar for the period 1999-2015. Catch rates were analyzed using General Linear Modelling techniques, under lognormal error assumption. The relative abundance index showed a relative stable trend over the period 1999-2011, following an increase in year 2012, and remaining stable thereafter. The Group discussed the fact that the reported standardized index included information on two dissimilar fisheries: driftnet fishing for the period 1999-2011, and longline for the period 2012-2015. Given the disparate nature of the gears involved, it was recommended to estimate a single standardized index for each fishing gear. This document was finally revised taking into account the aforementioned comment.

Document SCRS/2016/120 presented the available longline CPUE time series for several fisheries in the Ligurian Sea for the period 1990-2015. Nominal catch rates for swordfish caught by the Ligurian longline fishery were updated for the years 2014 and 2015. The trend in nominal CPUE for the mesopelagic longline indicated a high increase in relative abundance for 2014 as compared to 2013, following a decline for year 2015.

It remains as a matter of concern the depletion of the fraction of the population made by spawners (fish larger than 140cm). The American Type longline (LLAM) which was introduced in 2011, is actively used in winter months. A comparison of the two gears in terms of catches, CPUEs and size frequency distributions is reported. Harvest rates of the young-of-the-year (YOYs) are higher in the winter months.

Given the availability of data in the last five years, three standardized CPUE indices were used in the assessment; those referring to the Greek, Spanish and Moroccan longlines. 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 2**).

3. Stock assessment

The stock was assessed using an age structured population model (XSA) as used in the previous assessment. In the previous assessment although biomass dynamic models had also been used the age structured model (XSA) was chosen to develop the stock status advice and to develop projections. This was because the lack of contrast in the relative abundance indices make production model results rather uncertain because stock productivity (estimates of r and K) is poorly defined by the data. Particularly due to the lack of relative abundance indices for the period when the stock is expected to have declined in abundance (1975-1985), as catch increased.

3.1 Methods

3.1.1 XSA

The age structured assessment was conducted using XSA in 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 6. Therefore, in line with the Atlantic swordfish assessments XSA runs were conducted with a plus group of 6, (see Kell 2015 for full documentation of methodology used).

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.

Seven CPUE data sets were available for tuning the XSA: i.e. Moroccan longlines and gillnetters (SCRS/2016/119), Spanish longliners (SCRS/2016/096), Sicilian longliners (Tserpes *et al.* 2015), Sicilian gillnetters (Tserpes *et al*., 2011), Greek longliners (SCRS/2016/113) and Ligurian longliners (SCRS/2016/120). 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. Only the Greek, Moroccan and Spanish longline series covered the recent period (i.e. allowed the terminal Ns in the recent years to be estimated), so these indices were the ones used for calibration of XSA.

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 F_s or F_s 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.

The catch-at-size (CAS) data are shown in **Figure 3**, the 2016 dataset (blue) is over laid on the 2014 data set (pink), differences are only seen for 2012 and 2013. The differences are small. The catch-at-size are summarized by *lustrum* in **Figure 4**.

The CAS are used to construct Powell Wheatherall plots (**Figure 5**) and to estimate Z (**Figure 6**), the black points are estimates for each 5 year period and blue line is a loess smoother fitted through these.

The estimation of the catch-at-age (CAA) are shown in **Figure 7**, which shows the CAS (green), the modes by age (red) and the fitted distribution (black). **Figure 8** plots the standardised residuals of the proportion of numbers-at-age from the deterministic age slicing procedure (red negative and black positive residuals), in order to look for evidence of cohort effects.

Next age based catch curves are plotted to examine differences in selection pattern. Selection pattern is determined by the vulnerability of different age classes to fishing, and is affected by availability (horizontal overlap), encounterability (vertical overlap), fishing behavior and the dynamics of the targeted stock. **Figure 9** shows estimates of selectivity by *lustrum*, **Figure 10** estimates by gear and **Figure 11** by gear and *lustrum*.

Three XSA runs were conducted, i.e. that based on the 2014 settings and two alternative scenarios: i) the continuity run; ii) Lorenzen natural mortality vector; and, iii) estimation of discards.

Lorenzen (1996) developed a set of empirical relationships for natural mortality as a function of body weight (W). The general relationship natural mortality and weight (g) is of the form

$$M(W)=M_u W^b$$

Where, M_u is the natural mortality at unit weight and b is an allometric scaling exponent. Lorenzen's estimates of b for temperate systems was b=-0.309, while M_u was derived so that M at age 3 (where fish are mature for the 1st time) was equal to 0.2 (**Figure 12**).

In the continuity run the XSA settings were the same as applied in 2014 (**Table 3**). While for the discards scenario the catch-at-age matrix was inflated by assuming that for every ton of catch, four 0-age fish were discarded (Tserpes *et al*., 2014; **Figure 13**).

3.1.2 Production model

A biomass dynamic model was used to reconstruct the biomass time series back to 1950. This was done because prior to 1985 no catch-at-size and hence catch-at-age were available to fit XSA. The estimates of *r* and *K* from XSA were used with the catch data (i.e. Task I) to estimate stock biomass.

3.2 Diagnostics

3.2.1 XSA

The CPUE series used in the calibration of XSA are shown in **Figure 14**; and the goodness fits based on the CPUE residuals are shown next. **Figure 15** plots the residuals against fitted values to check the variance, **Figure 16** plots the residuals against year to check for systematic patterns that may indicate a poor fit; **Figures 17** to **19** compares the fits to the observations for ages 2, 3 and 4, respectively; a good fit is indicated by the points falling along the y=x line (black line); the blue line is a linear regression fitted to the points. **Figure 20** checks for autocorrelation that may introduce bias and **Figure 21** are QQ plots to check for log normality. **Figure 22** show the relative weighting for each terminal year Ns by CPUE observation (columns are ages) and shrinkage.

Table 4 shows the spawning stock biomass by each of the XSA scenarios.

Figure 23 shows the fits to 1 index at a time. Retrospective analyses are performed in **Figures 24** for the 3 time series used in 2016 and in **Figure 25** for the 6 time series used in 2014. The stock numbers at age, fishing mortality and full diagnostics for the XSA are available in **Appendix 4**.

3.2.2 Production model

The fact that available data are not useful to fit a production model does not necessarily mean that the dynamics of this stock could not be explained by such model. It is possible that the relative abundance indices that are currently available do not track abundance well. Alternatively, these indices may represent a period of time when changes in stock size are relatively small and therefore there is not enough contrast in the data to estimate productivity and model parameters.

Similar conclusions, regarding production models, were reached in the past for other stocks and it has often been necessary to assume that stock productivity parameters (*r*, F_{MSY}) were known from other studies so as to fit the production model. Bayesian production models do this formally by defining a prior distribution for the value of r and other model parameters. During the 2014 Mediterranean Swordfish Stock Assessment meeting stock a prior distribution for r with mean of 0.47 and CV of 0.49 were obtained by simulation on the basis of combining estimates of von Bertalanffy growth, weight/length relationship, logistic maturity ogive, natural mortality and steepness parameters (Anon., 2015).

There have been a number of studies of swordfish stocks reporting estimates of F_{MSY} and *r* from production models (table below). All these studies report relatively high values of *r*, between 0.4 and 0.6 suggesting values of F_{MSY} range between 0.2 and 0.3 for logistic production models where *r* is twice F_{MSY}.

Stock	*Assessment*	*Model*	*Estimate*	*80% percentile/ (CV of posterior)*	*Reference*
SWO Med.	2010	ASPIC	0.52	0.36-0.68	Anon. 2011
N Atl. SWO	2013	ASPIC	0.42	0.34-0.51	Anon. 2014
S Atl. SWO	2013	ASPIC	0.49	0.21-0.77	Anon. 2014
SWO Med.	2014	Bayes Prod model	0.59	0.30	Anon. 2015

Moreover the current assessment with XSA implies a value of *r* = 0.45, similar again to the values obtained from production models.

Assuming these values of *r* truly represent the dynamics of the Mediterranean swordfish stock it is possible to use production models to reconstruct the biomass of the stock and the fishing mortality it has suffered. The only additional assumption required is that the reported catches are a precise measure of removals. For a given value of K, the virgin biomass, the logistic production model would predict yearly biomass and fishing mortality under the condition that r = 4 MSY/K. In other words for a given value of *K* and *r*,

$$MSY = r*K/4$$

We used ASPIC to implement these calculations and calculate values of B and F from 1950 to 2015 given the catch and values of *r* in the range between 0.2, 0.6 and values of *K* from 60,000 to 300,000 representing a range that largely encompasses estimates of *r* and *K* obtained in previous attempts to evaluate this stock with production models. We assume that the "best" estimate of *r* for this stock is 0.45.

Of course not all combinations of parameters can reproduce observed catches, but there are a number of them that do. Many such combinations lead to the biomass crashing and the stock not being able to sustain itself. The smallest stock with an *r* value of 0.45 that would be able to sustain itself until 2015 would have a *K* =120,000 and an MSY of 13,500. Larger stocks and less productive stocks (*r*< 0.45) would also have been sustainable but would not have led to the current state of overfishing/overfished predicted by XSA. Conversely smaller and more productive stocks (*r*>0.45) could also be sustainable but would led to a more pessimistic view of the stock status. The relative decline in biomass as a ratio of B_{MSY} can change depending on the value of r and K (**Figure 26**).

When estimates of biomass from such production models are overlayed with the nominal CPUE of Demetrio *et al.* (1999) they seem to have a similar trend suggesting that the catch rates from Demetrio *et al.* (1999) are consistent with the changes in biomass for the 1970s-1980s predicted by production models (**Figure 27**).

In conclusion, these production models may not be useful to estimate current stock status, because the most recent relative abundance indices are not consistent with the biomass trends that they predict. These models, however, seem to provide an explanation for why the biomass of the stock declined during the 1980s. These results are not inconsistent with the estimates of stock biomass obtained in the XSA model. XSA estimates that by the mid to late 1980s SSB was already well below SSB_{MSY}. Production models, on the other hand, predict that total biomass started to fall below B_{MSY} in the late 1980s or early 1990s. It is to be expected that total biomass in a production model will decline at a lower rate than SSB, and thus than the production model's calculations of when the stock become overfished would lag the estimates from XSA.

3.3 Stock Status relative to benchmarks

3.3.1 XSA

Estimates of recruitment, SSB, catch and fishing mortality for the three scenarios are shown in **Figure 28**. Stock number and F-at-age estimates by year are provided in **Appendix 4**. The main effect is to increase the estimated recruitment by a constant factor, the other time series are little changed. A bigger effect is seen in the equilibrium curves (**Figure 29**) and reference points (**Table 5**) where biomass reference points are increased and F reference points decreased for the Lorenzen M scenario. **Figure 28** presents an equilibrium analysis with reference points and **Figure 30** presents the same curves with the observations and fits. The net result is that for the Lorenzen M scenario the level of overfishing and over fished is increased as seen in the Kobe Phase Plots (**Figure 31**).

3.3.2 Synthesis of the stock status

The current assessment of Mediterranean swordfish confirms that the stock is overfished and suffering overfishing. The stock has been on this state since the late 1980s, because of the large catches in that period and the selection pattern which captures many immature fish.

Catches of immature fish remain high and the greatest mortality is suffered by fish of age 3. Recruitment has been declining for the last 15 years, and recent recruitments have been lower than the level expected to be available given recent levels of the spawning stock biomass (SSB).

There is considerable uncertainty in regards to the possible levels of future recruitment. It is unclear whether the most recent levels are associated with a change in stock productivity, if they are an artefact of the estimation process, or if they are a random occurrence that could be reverted naturally by a series of positive recruitment anomalies. The consequences of having one of these three scenarios are as follow:

1) If recruitment can naturally come back to the levels of recruitment observed in the 1980s and 1990s, then the stock is severely overfished and will require long recovery times before it reaches again B_{MSY} (this scenario is the one assumed for the projections).
2) If the tendency of recruitment is an artefact of the estimation process (such as severe underestimation of small fish killed by the fishery (as a consequence of discarding), then current recruitment may be underestimated. The stock could recover to the level of B_{MSY} faster than in case a, if undersized fish mortality is reduced.
3) If recruitment has changed because of a regime shift or changes in ecological conditions, then current stock productivity may be lower than in the 1990s and current reference points do not represent current stock conditions.

3.4 Projections

The scenario including estimates of discards was chosen to perform projections in order to provide advice on the response of the stock to management. Biological parameters (growth, fecundity, M) were the same as in historical assessment and selection patterns (landings and discards) were the average from the most recent three years. For recruitment, a Beverton and Holt stock recruitment relationship was fitted to the historical data. There was little evidence of a decline in recruitment at low population size (i.e. steepness was high). There was strong autocorrelation in the residuals (**Figure 32**), therefore when running the projections the recruitment deviates were simulated with autocorrelation (ρ=0.6, σ=0.2) (**Figure 33**). Projections were performed for F values relative to F_{MSY} in **Figure 34** and for $0.8F_{sq}$ relative to F_{MSY} in **Figure 35**. **Tables 6a** to **6c** show the Kobe II Strategy matrix of probabilities of not over fishing, not being overfished and being in the green quadrant, respectively, by year for each level of fishing mortality.

4. Recommendations

4.1 Statistics and research

4.1.1 Recommendations with financial implications

- *Stock mixing and management boundaries:* The Group noted the need to further improve the current knowledge about stock boundaries between the Mediterranean and North Atlantic swordfish stocks. For this purpose, it was recommended to conduct collaborative and multidisciplinary research, including population genetics, electronic tagging, life history, and to use fine-scale (e.g. 1º squares) and quarterly sampling strata.

- *Data recovery plan:* The Group noted that the catch and CPUEs time series currently in use in the stock assessment models start in 1985. Therefore the early period of the fisheries, which accounted to increasing catches is not being accounted in the model. As such, the Group recommended conducting a recovery of historical data, so that the entire history of the fishery is taken into account in the stock assessment models. Particular effort should be dedicated to collecting available information from the major fisheries of the early years, especially Italian fisheries.

- *Size and age at maturity:* As there may be spatial differences between the east and west Mediterranean swordfish, the Group recommended that future work is conducted to determine region specific size and age at maturity.

- *Habitat use and availability to the different gears:* The Group recommended the use of satellite tagging to provide information on habitat use for comparison of the availability of swordfish to the various fisheries, including comparisons between traditional and meso-pelagic longlines.

4.1.2 Recommendations without financial implications

- *L-W relationships:* Ongoing work and preliminary results shown to the Group indicate that the length-weight relationships currently in use in ICCAT for the entire Mediterranean might not be the most appropriate, as there may be spatial differences between the east and west Mediterranean. Therefore the Group recommended this revision to continue, and an effort to be made to incorporate all available data sets into the analysis, including data from different Mediterranean regions and fisheries.

- *Gear selectivity:* Further research on gear design and use is encouraged in order to minimize catch of juvenile swordfish and increase yield and spawning biomass per recruit from this fishery. The Group recommended further studies to be conducted on the mesopelagic longlines fisheries developed during the mid-2000's, due to the impact these 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.

- *CPUEs:* The Group recommended the collection and recovery of historical data to increase the period covered by the 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 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 for 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 (5º rectangles 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.

- *Discards.* Recently adopted management measures may have increased 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.

- *Monthly spawner - recruit proportion in the catches:* Though the monthly probability to catch undersized swordfish, or the monthly discard rate has been examined in some Mediterranean swordfish fisheries, there is no estimation of the monthly proportion of recruits and spawners in the Mediterranean swordfish catches. The Group recommended that monthly estimation of spawner and recruit proportion in the catches could facilitate management decisions for seasonal closures.

Related with statistics

- *Data recovery and reconstruction:* The Group requested that Sub-Committee on Statistics works in collaboration with the Mediterranean swordfish to evaluate the use of other methodologies in historical reconstructions for future Mediterranean swordfish stock assessments.

- *Task I and II.* The Group recommended mesopelagic longlines and traditional drifting surface longlines to be considered as different gears by the ICCAT Secretariat, and separate Task I and II series be developed in the future, and that CPCs report data using those different gear codes.

- *Next stock assessment:* The Group recommended that the next stock assessment for Mediterranean swordfish should be carried out four years from now (2020) in order to give more time for additional data to be collected and prepared. Additionally, a data preparatory meeting should be conducted the year before (2019), to analyze and prepare data for the stock assessment. If there is a change in stock status indicators during the interim period, as for example a large change in nominal catches or in average sizes, then the stock assessment should be carried out before 2020.

- *Reference points:* The Group recommended looking into alternative indicators and appropriate reference points (e.g., Lopt or measures based on reproductive potential).

- *List of recreational and commercial vessels:* The Group noted that the authorized list of vessels for Mediterranean swordfish currently groups recreational and commercial vessels. The Group requested the Secretariat to separate those two categories as per [Rec. 13-04].

4.2 Management advice

Over the last 25 years biomass levels appear to be rather stable at low levels. This situation has remained the same since the last assessment. However, fishing mortality levels have shown a declining trend since 2010. Assessment of stock status and reference points were done under the assumption that recruitment levels can come back up to the levels seen in the past (1980's and 1990's). Under such assumption the stock is currently overfished and suffering overfishing. According to the Commission objectives the stock requires rebuilding and fishing mortality has to be reduced. The level of the stock to be rebuilt to is contingent on the assumption on future recruitment which is highly uncertain. In order for rebuilding to start to take place there will be a need for substantial reductions in harvest so that responses from the population can be detected. Additionally, for the SCRS to be able to reduce uncertainty in regards to future recruitment, there will be a need to increase monitoring of landings and discards.

The Group noted that since the establishment of minimum landing sizes, the discard levels of undersized swordfish may have increased. Additionally, it has been shown that high swordfish by-catches composed mostly of undersized individuals exist in albacore fisheries operating in the autumn and winter months coinciding with the swordfish closing season. As the swordfish fishery closure aims to the protection of recruits, the impact of those fisheries needs to be taken into account, which was not possible to do in the current stock assessment. In addition, the impact of those fisheries should be considered in future management recommendations.

5. Other matters

The Group revised and updated the Executive Summary and workplan for 2017. The Group agreed that only the catch table needs to be updated during the forthcoming swordfish Species Group meeting.

6. Adoption of the report and closure

The report was adopted during the meeting. The Chairman thanked the hosts for their hospitality and participants and the Secretariat for their work during the week. The meeting was then 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 (2015 data are preliminary).

			1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL	MED		586	580	337	0	452	340	393	250	914	200	112	206	300	318	394	1760	1752	1317	3440	3723	3341	4975	5973	4809	5043	4314	4637	5285	5966	5547	6579	6814	6343	6896	13666
1-Landings	MED	Longline	586	580	337	0	452	340	393	0	414	0	0	94	188	94	282	1423	1192	869	1196	1350	1114	1426	1544	1390	1103	728	4143	4611	5046	4877	5115	5419	5770	6313	6749
		Other surf.	0	0	0	0	0	0	0	250	500	200	112	112	112	224	112	337	560	448	2244	2373	2227	3549	4429	3419	3940	3586	494	674	920	670	1464	1395	573	583	6917
3-Discards	MED	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Landings	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Algerie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	196	500	368	370	320	521	650	760	870	877	884
		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	59	95	82	98	72	78	103	28	63
		EU.España	586	580	337	0	452	340	393	0	414	0	0	0	0	0	0	1200	1000	700	1000	1100	900	1100	1300	1105	700	89	89	667	720	800	750	1120	900	1322	1245
		EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	773	772	1081
		EU.Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1568	2240	2016	3248	4144	3136	3730	3362	3747	3747	4514	3930	4143	3823	2939	3026	9360
		EU.Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	224	224	224	192	214	175	223	136	151	222	192	177	59	94
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	2	9	13	1	5	2	3	1	1	5	6	19
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	224	224	336	560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Maroc	0	0	0	0	0	0	0	0	0	0	0	94	188	94	282	224	192	170	197	250	214	327	230	183	196	118	186	144	172	0	0	0	0	43	39
		NEI (MED)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	728	672	517	532	771
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tunisie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	5	0	0	0	0	7	19	15	15
		Turkey	0	0	0	0	0	0	0	250	500	200	112	112	112	224	112	112	336	111	115	133	99	76	60	59	15	10	7	34	20	44	13	70	40	216	95
3-Discards	MED	EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EU.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL	MED		15292	16765	18320	20365	17762	16018	15746	14709	13265	16082	13015	12053	14693	14369	13699	15569	15006	12814	15674	14405	14600	14893	14227	12164	11840	13265	11450	9913	9096	9794	9966
1-Landings	MED	Longline	6493	7505	8007	9476	7065	7184	7393	7631	7377	8985	6319	5884	5389	6496	6097	6963	7180	7767	10415	10667	10848	11228	11028	11465	11020	11918	10288	9131	9047	9711	9869
		Other surf.	8799	9260	10313	10889	10697	8834	8353	7078	5888	7097	6696	6169	9304	7873	7602	8606	7826	5047	5259	3729	3639	3649	3179	672	819	1347	1162	782	49	83	91
3-Discards	MED	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	113	16	19	27	0	0	0	0	0	0	7
1-Landings	MED	Albania	0	0	0	0	0	0	0	0	0	0	0	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Algerie	890	847	1820	2621	590	712	562	395	562	600	807	807	807	825	709	816	1081	814	665	564	635	702	601	802	468	459	216	387	403	557	449
		Chinese Taipei	0	0	0	0	0	0	0	0	1	1	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EU.Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20	0	0	0	0	0	0	0	0	4	3	6	6	4	10	16	10
		EU.Cyprus	71	154	84	121	139	173	162	56	116	159	89	40	51	61	92	82	135	104	47	49	53	43	67	67	38	31	35	35	51	51	45
		EU.España	1227	1337	1134	1762	1337	1523	1171	822	1358	1503	1379	1186	1264	1443	906	1436	1484	1498	1226	951	910	1462	1697	2095	2000	1792	1744	1591	1607	2073	2283
		EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	27	0	19	0	0	14	14	16	78	81	12	66	127	127
		EU.Greece	1036	1714	1303	1008	1120	1344	1904	1456	1568	2520	974	1237	750	1650	1520	1960	1730	1680	1230	1120	1311	1358	1887	962	1132	1494	1306	877	1731	1344	691
		EU.Italy	10863	11413	12325	13010	13009	9101	8538	7595	6330	7765	7310	5286	6104	6104	6312	7515	6388	3539	8395	6942	7460	7626	6518	4549	5016	6022	5274	4574	2862	3393	4272
		EU.Malta	172	144	163	233	122	135	129	85	91	47	72	72	100	153	187	175	102	257	163	195	362	239	213	260	266	423	532	503	460	376	489
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	115	8	1	120	14	16	0	0	0	0	0	0	0	0	
		Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
		Japan	14	7	3	4	1	2	1	2	4	2	4	5	5	7	4	2	1	1	0	2	4	0	3	1	1	0	0	0	0	0	
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
		Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	8	6	0	10	2	0	14	0	0	0	0	0	0	0	0	
		Maroc	38	92	40	62	97	1249	1706	2692	2589	2654	1696	2734	4900	3228	3238	2708	3026	3379	3300	3253	2523	2058	1722	1957	1587	1610	1027	802	770	770	480
		NEI (MED)	730	767	828	875	979	1360	1292	1292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	28	0	0	0	9	4	0	
		Tunisie	61	64	63	80	159	176	181	178	354	298	378	352	346	414	468	483	567	1138	288	791	791	949	1024	1011	1012	1016	1040	1038	1036	1030	1035
		Turkey	190	226	557	589	209	243	100	136	292	533	306	320	350	450	230	370	360	370	350	386	425	410	423	386	301	334	190	80	97	56	35
3-Discards	MED	EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
		EU.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	113	16	19	27	0	0	0	0	0	0	

Note: Carry overs highlighted in yellow: average of the 3 previous years.

Table 2. SWO-M catalogue (1990-2015) of Task-I vs Task-II by stock, major fishery (flag/gear combinations ranked by order of importance) and year (1990 to 2015). [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].

Species	Stock	Status	FlagName	GearGrp	DSet	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Rank	%	%cum
SWO	MED	CP	EU.Italy	LL	t1	2454	2470	3518	3260	3844	3035	2617	2458	2458	2680	2639	2236	1841	5844	5452	5560	5253	4564	4521	4687	5101	4579	3856	2848	3384	4213	1	27.4%	27%
SWO	MED	CP	EU.Italy	LL	t2	b	ab	ab	b	ab	b	b	b	ab	b	ab	b	b	b	b	b	b	b	bc	abc	abc	abc	abc	abc	abc	abc	1		
SWO	MED	CP	EU.Italy	GN	t1	4353	3142	4077	3070	3921	4264	2657	3632	3632	3632	4863						2373	1948								0	2	13.1%	40%
SWO	MED	CP	EU.Italy	GN	t2	ab	ab	ab	ab	ab	b	b	b	b	b	ab	b		b	b	b	b	-1								-1	2		
SWO	MED	CP	EU.España	LL	t1	1438	1132	790	1293	1402	1351	1040	1184	1409	867	1396	1402	1421	1165	930	860	1405	1648	2063	1994	1785	1730	1580	1605	2019	2289	3	10.7%	51%
SWO	MED	CP	EU.España	LL	t2	ac	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	3		
SWO	MED	CP	EU.Greece	LL	t1	1344	1904	1456	1568	2520	974	1237	750	1650	1520	1960	1730	1680	1230	1129	1424	1374	1907	989	1132	1494	1306	877	1731	1344	691	4	10.6%	62%
SWO	MED	CP	EU.Greece	LL	t2	ab	ab	ab	ab	ab	ab	-1	-1	ab	ab	ab	ab	b	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	4		
SWO	MED	CP	Maroc	GN	t1	866	1186	1883	2068	2109	1518	2461	4653	2905	2979	2503	2266	2230	1629	1299	722	603	615	587	477	410	387					5	10.4%	72%
SWO	MED	CP	Maroc	GN	t2	-1	-1	-1	-1	b	-1	-1	-1	c	bc	abc	abc	b	b	b	b	b	b	abc	-1	abc	abc					5		
SWO	MED	CP	Maroc	LL	t1	371	508	807	517	527	169	273	245	323	259	205	754	1149	1670	1954	1801	1455	1107	1370	1110	1200	640	802	770	770	480	6	6.1%	78%
SWO	MED	CP	Maroc	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	bc	abc	abc	abc	6		
SWO	MED	CP	EU.Italy	UN	t1	2294	2926				11					3	4152	1698	2540	1483	1891			5	329		694	718		3	32	7	5.4%	84%
SWO	MED	CP	EU.Italy	UN	t2	-1	-1				-1					-1	-1	-1	b	-1	b	b		-1	-1		-1	-1		bc	-1	7		
SWO	MED	CP	Tunisie	LL	t1	176	181	178	354	298	378	352	346	414	468	483	567	1138	285	791	791	949	1024	1011	1012	1016	1040	1038	1036	1030	1035	8	5.0%	89%
SWO	MED	CP	Tunisie	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	8		
SWO	MED	CP	Algerie	LL	t1	173	173	6	173	185	247	247	247				133	99		52	93	496	492	802	468	459	192	356	384	549	429	9	1.9%	91%
SWO	MED	CP	Algerie	LL	t2	b	-1	-1	-1	-1	-1	-1	-1				-1	-1		-1	-1	-1	a	a	-1	-1	ab	ab	ab	ac	-1	9		
SWO	MED	CP	EU.Malta	LL	t1	135	129	85	91	47	72	72	100	153	187	175	102	257	163	195	362	239	213	260	266	423	532	503	460	376	489	10	1.7%	92%
SWO	MED	CP	EU.Malta	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	ac	ac	-1	-1	-1	abc	bc	ab	abc	ab	ab	ab	abc	ab	abc	abc	10		
SWO	MED	CP	Turkey	GN	t1	243	100	136	292	533	306	320	350	450	230	370	360	300	350	386	425	410	423									11	1.7%	94%
SWO	MED	CP	Turkey	GN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	ac	ac	ac	c				11		
SWO	MED	CP	Algerie	UN	t1	539	389	389	389	415	560	560	560	178	126	166	306	248	665	122												12	1.6%	96%
SWO	MED	CP	Algerie	UN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1												12		
SWO	MED	CP	Algerie	GN	t1									590	531	599	642	467		233	311	87	108									13	1.0%	97%
SWO	MED	CP	Algerie	GN	t2									-1	-1	-1	-1	-1		-1	-1	-1	-1									13		
SWO	MED	NCO	NEI (MED)	LL	t1	918	733	733																								14	0.7%	97%
SWO	MED	NCO	NEI (MED)	LL	t2	-1	-1	-1																								14		
SWO	MED	CP	EU.Cyprus	LL	t1	173	162	56	116	159	89	40	51	61	92	82	135	104	47	49	53	43	67	67	38	31	35	35	51	51	45	15	0.6%	98%
SWO	MED	CP	EU.Cyprus	LL	t2	a	a	-1	a	a	a	a	a	a	-1	a	-1	a	a	a	a	ab	abc	abc	abc	abc	abc	ab	abc	abc	bc	15		
SWO	MED	CP	Turkey	LL	t1													70						386	301	334	190	66	97	56	73	16	0.5%	98%
SWO	MED	CP	Turkey	LL	t2													-1						a	a	a	ab	a	ab	abc	-1	16		
SWO	MED	NCO	NEI (MED)	GN	t1	442	559	559																								17	0.4%	99%
SWO	MED	NCO	NEI (MED)	GN	t2	-1	-1	-1																								17		
SWO	MED	CP	EU.Italy	HP	t1							10	12	12		8			7	5	6			23		921						18	0.3%	99%
SWO	MED	CP	EU.Italy	HP	t2							-1	-1	-1		-1			b	b	b	b	b	-1		abc				a		18		
SWO	MED	CP	EU.España	UN	t1			32	65	101	26	134	79	8	26	23	73	56	58	20	46	56	48	30	3	5	11	8	1	53		19	0.3%	99%
SWO	MED	CP	EU.España	UN	t2			ab	ab	a	a	-1	a	-1	-1	a	-1	a	-1	-1	-1	a	a	a	a	a	a	a	a	a		19		
SWO	MED	CP	EU.France	LL	t1																				10	73	39	10	58	119	126	20	0.1%	99%
SWO	MED	CP	EU.France	LL	t2																				-1	-1	-1	-1	a	b	-1	20		
SWO	MED	CP	Algerie	HL	t1															112	175	72	1									21	0.1%	100%
SWO	MED	CP	Algerie	HL	t2															-1	-1	-1	-1									21		
SWO	MED	CP	EU.Portugal	LL	t1											13	115	8	1	120	14	16										22	0.1%	100%
SWO	MED	CP	EU.Portugal	LL	t2											a	a	a	a	a	a	a										22		
SWO	MED	CP	Algerie	PS	t1															45	56	47	1				1	17	1	0	6	23	0.1%	100%
SWO	MED	CP	Algerie	PS	t2															-1	-1	-1	-1				a	a	a	a	-1	23		
SWO	MED	CP	Algerie	TL	t1									57	52	51																24	0.0%	100%
SWO	MED	CP	Algerie	TL	t2									-1	-1	-1																24		
SWO	MED	CP	EU.France	UN	t1												12	27		19			14	14	1	1	39	1	4	0		25	0.0%	100%
SWO	MED	CP	EU.France	UN	t2												-1	-1		-1			-1	-1	-1	-1	-1	-1	-1	-1		25		
SWO	MED	CP	EU.España	GN	t1	85	39																									26	0.0%	100%
SWO	MED	CP	EU.España	GN	t2	ac	ab																									26		
SWO	MED	CP	EU.España	SU	t1							10		24	10	16	5	19													0	27	0.0%	100%
SWO	MED	CP	EU.España	SU	t2							a		a	-1	a	a	a													-1	27		
SWO	MED	CP	Algerie	TW	t1																						23	15	18	8	14	28	0.0%	100%
SWO	MED	CP	Algerie	TW	t2																						a	a	a	a	-1	28		
SWO	MED	CP	EU.Croatia	LL	t1									10	20									4	1	2	4	2	5	12	5	29	0.0%	100%
SWO	MED	CP	EU.Croatia	LL	t2									-1	-1									a	a	a	a	a	a	a	a	29		
SWO	MED	CP	Maroc	TP	t1	12	12	2	4	18	9		2				2		1													30	0.0%	100%
SWO	MED	CP	Maroc	TP	t2	-1	-1	-1	-1	-1	-1		-1				-1		-1													30		

Table 3. XSA Control options from continuity run.

Parameter	
tol	1.00E-09
maxit	30
min.nse	0.3
fse	0.5
rage	1
qage	6
shk.n	TRUE
shk.f	TRUE
shk.yrs	10
shk.ages	2
window	100
tsrange	10
tspower	1
vpa	TRUE

Table 4. Time series of Spawning Stock Biomass (SSB) as estimated by the three XSA scenarios.

Year	*Continuity*	*Discards*	*Lorenzen M*
1985	31700	31700	30168
1986	29823	29823	28641
1987	23665	23665	22883
1988	16770	16770	16246
1989	11988	11988	11566
1990	10575	10575	10182
1991	11300	11300	10876
1992	11691	11691	11229
1993	11252	11252	10817
1994	11022	11022	10609
1995	9881	9881	9499
1996	11134	11134	10715
1997	11659	11659	11227
1998	13992	13992	13527
1999	11268	11268	10929
2000	9691	9691	9388
2001	8626	8626	8332
2002	9239	9239	8913
2003	9668	9668	9336
2004	11002	11002	10634
2005	10785	10785	10451
2006	10419	10419	10108
2007	8118	8118	7845
2008	7365	7365	7116
2009	8207	8207	7967
2010	7638	7638	7401
2011	8126	8126	7845
2012	10177	10177	9819
2013	11760	11760	11357
2014	8419	8419	8104
2015	7733	7733	7442

Table 5. Stock status and reference points.

Parameter	*Continuity*	*Discards*	*M*
$SSB_{current}$	7733.238	7733.238	7442.248
Catch	9966	10129.84	9966
Fsq	0.457204	0.457204	0.470137
F_{MSY}	0.259514	0.246624	0.231917
MSY	19276.02	19683.47	20839.16
B_{MSY}	58062.84	63425.76	75524.26
$F_{0.1}$	0.18244	0.17337	0.15275
$YF_{0.1}$	18545.85	18924.29	19839.14
$BF_{0.1}$	87328.39	94761.84	119868.1
K	270952.5	286665.2	363098.3
r	0.479687	0.493279	0.479906
t2	1.438439	1.398803	1.437781
L_{opt}	190.1723	190.1723	180.7451
A_{opt}	7.216979	7.216979	6.25536

Table 6a. Kobe II Strategy matrix showing probabilities (%) of not over fishing by year for each level of fishing mortality.

F		*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
0	**F_{MSY}**	100	100	100	100	100	100	100	100	100	100
0.25	**F_{MSY}**	100	100	100	100	100	100	100	100	100	100
0.5	**F_{MSY}**	100	100	100	100	100	100	100	100	100	100
0.75	**F_{MSY}**	100	100	100	100	100	100	100	100	100	100
1	**F_{MSY}**	100	100	100	100	100	100	100	100	100	100
1.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.75	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
	F_{sq}	0	0	0	0	0	0	0	0	0	0
0.8	**F_{sq}**	0	0	0	0	0	0	0	0	0	0

Table 6b. Kobe II Strategy showing probabilities (%) of not being overfished by year for each level of fishing mortality.

F		*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
0	**F_{MSY}**	0	0	0	0	100	100	100	100	100	100
0.25	**F_{MSY}**	0	0	0	0	7	100	100	100	100	100
0.5	**F_{MSY}**	0	0	0	0	0	10	69	96	98	100
0.75	**F_{MSY}**	0	0	0	0	0	1	3	20	53	72
1	**F_{MSY}**	0	0	0	0	0	0	0	2	4	8
1.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.75	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
	F_{sq}	0	0	0	0	0	0	0	0	0	0
0.8	**F_{sq}**	0	0	0	0	0	0	0	0	0	0

Table 6c. Kobe II Strategy matrix showing probabilities (%) of being in the green quadrant by year for each level of fishing mortality.

F		*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
0	**F_{MSY}**	0	0	0	0	100	100	100	100	100	100
0.25	**F_{MSY}**	0	0	0	0	7	100	100	100	100	100
0.5	**F_{MSY}**	0	0	0	0	0	10	69	96	98	100
0.75	**F_{MSY}**	0	0	0	0	0	1	3	20	53	72
1	**F_{MSY}**	0	0	0	0	0	0	0	2	4	8
1.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
1.75	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.25	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
2.5	**F_{MSY}**	0	0	0	0	0	0	0	0	0	0
	F_{sq}	0	0	0	0	0	0	0	0	0	0
0.8	**F_{sq}**	0	0	0	0	0	0	0	0	0	0

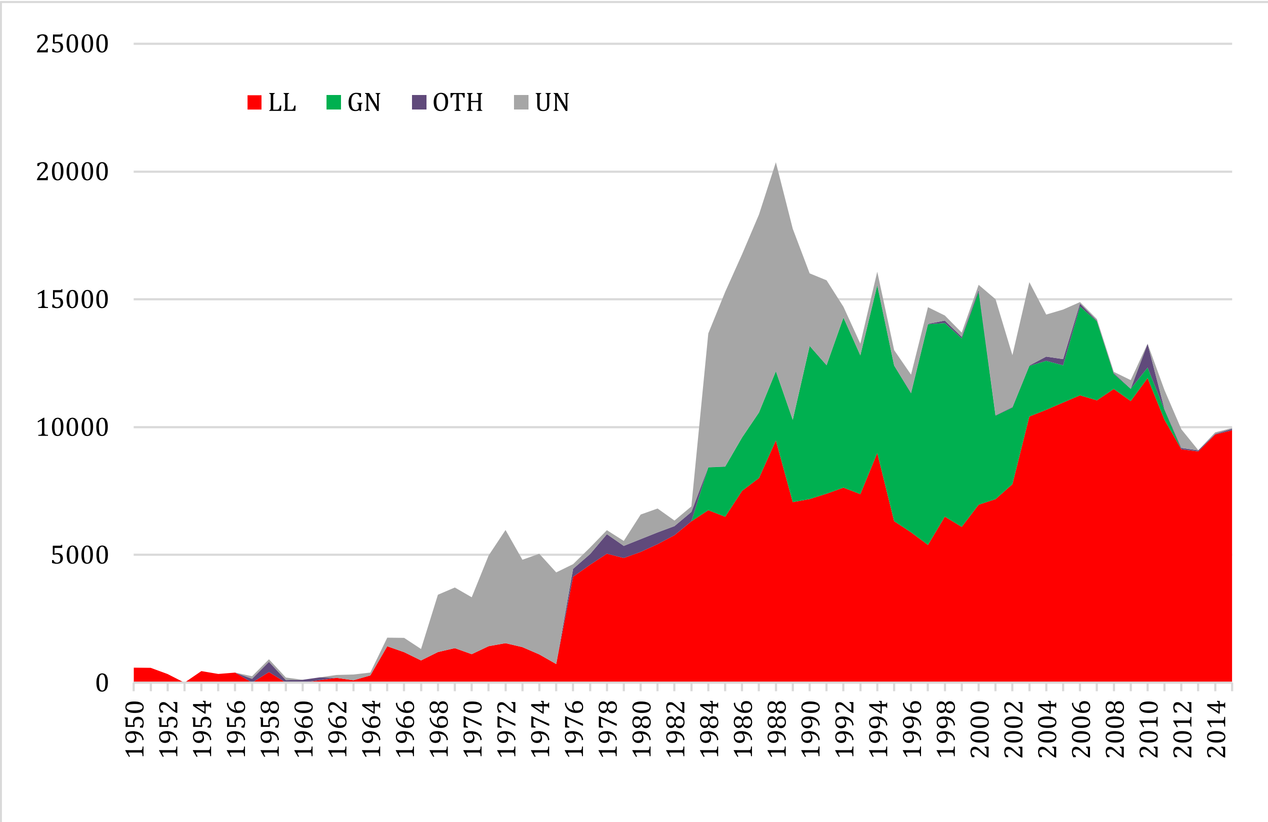

Figure 1. Task I nominal catches (t) of Mediterranean swordfish between 1950 and 2014. LL – Longlines; GN – Gillnets; OTH – Other gears; UN – Unknown gear.

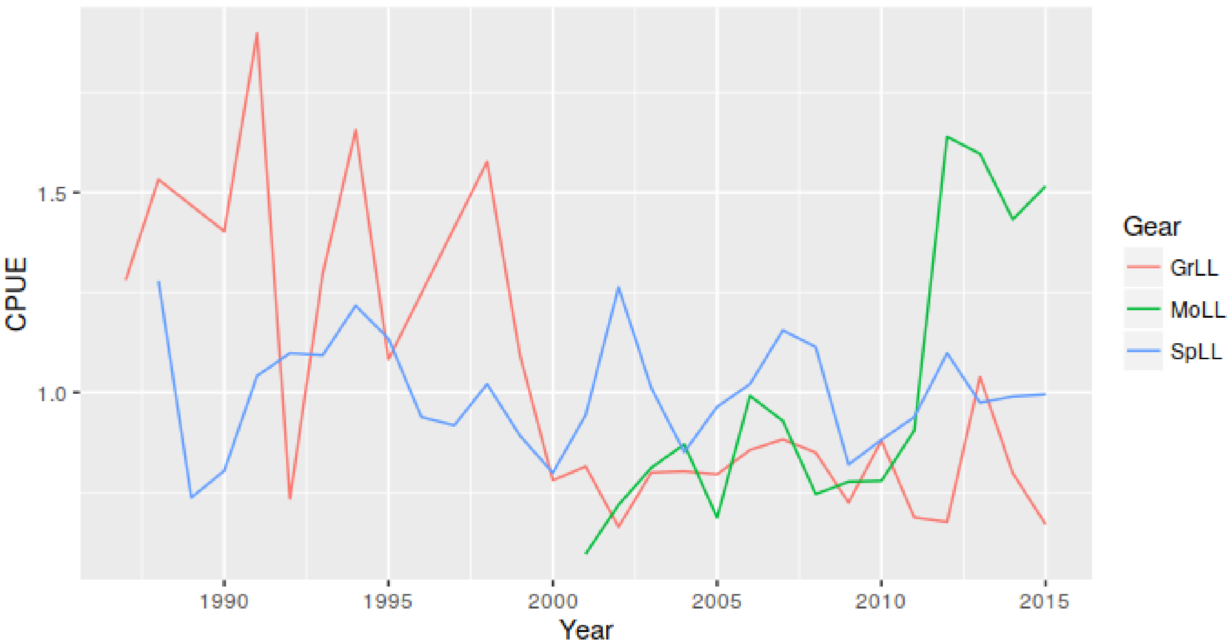

Figure 2. Relative abundance indices used in the assessment of the Mediterranean swordfish. All indices are scaled to their individual means to facilitate comparison of trends and relative degree of variability. GrLL=Greek longlines, SpLL=Spanish longlines, MoLL=Moroccan longlines.

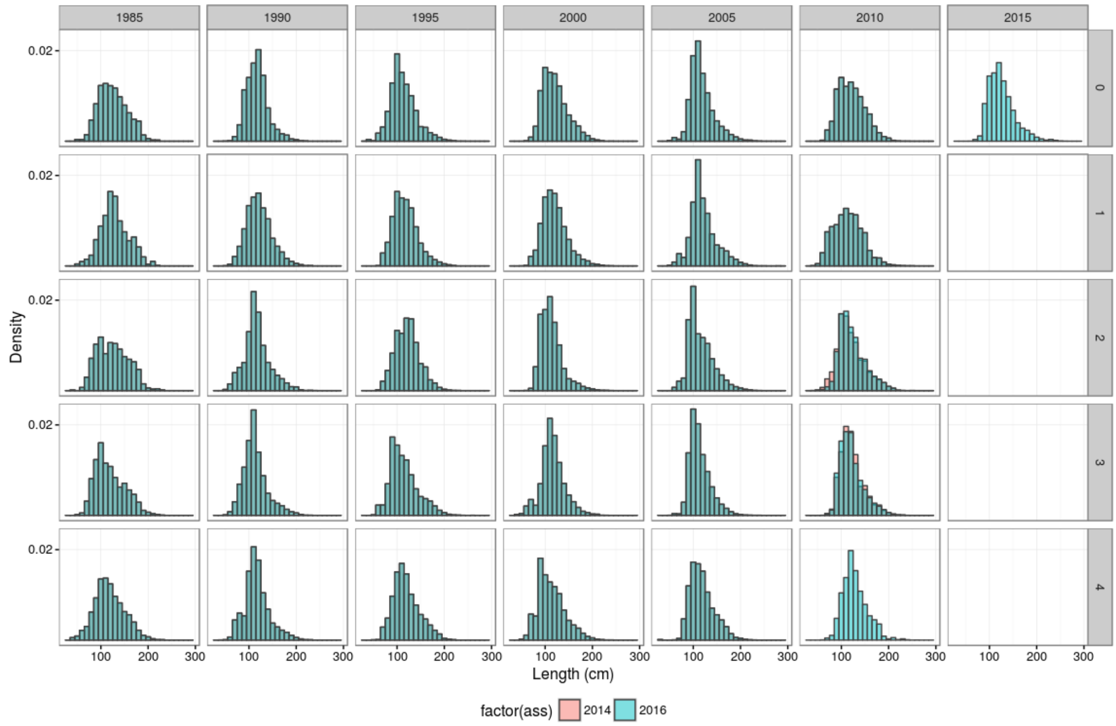

Figure 3. Catch-at-size data from 2016 (blue) compared to those used in the 2014 assessment (pink).

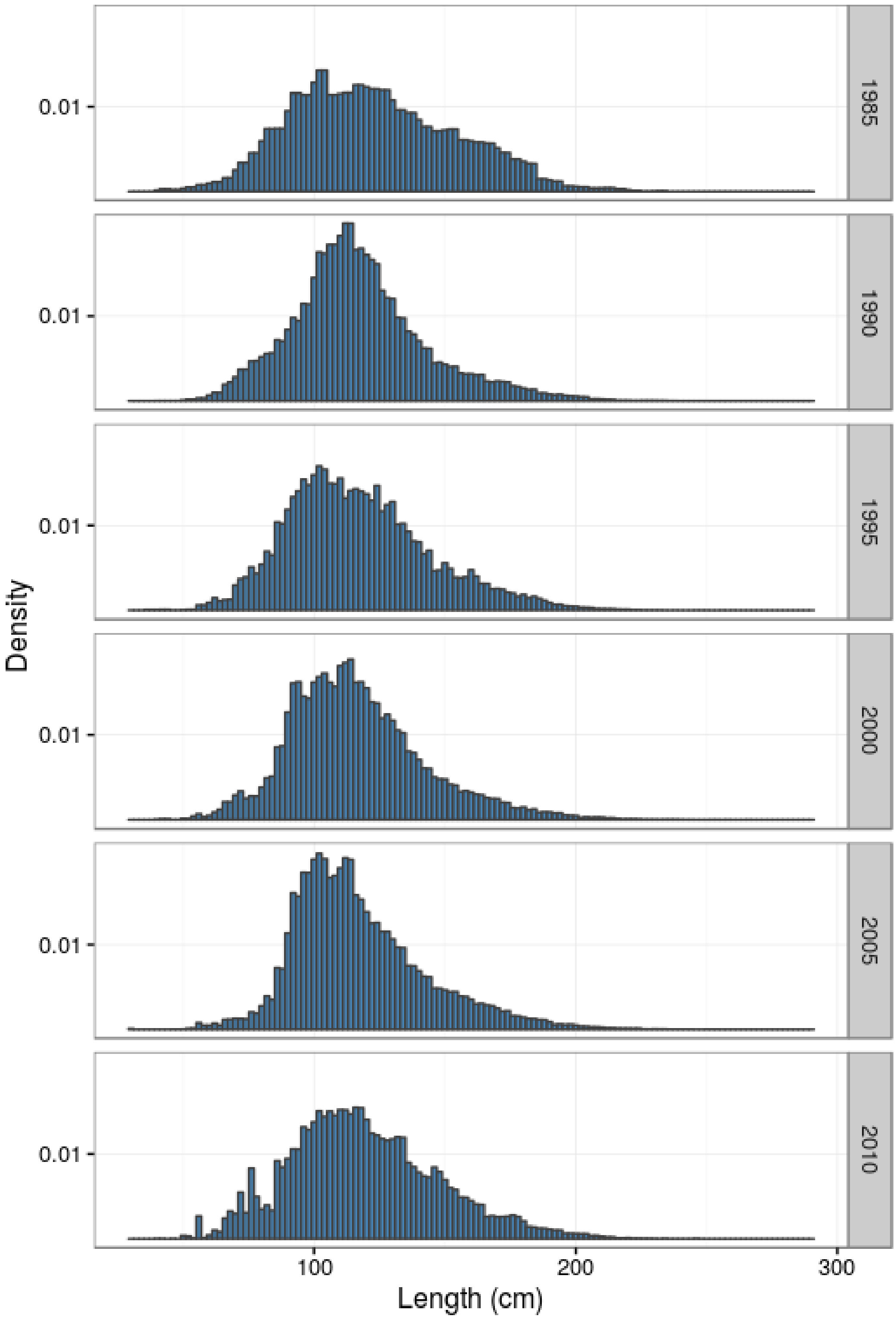

Figure 4. Catch-at-size used in 2016 summarised by *lustrum*.

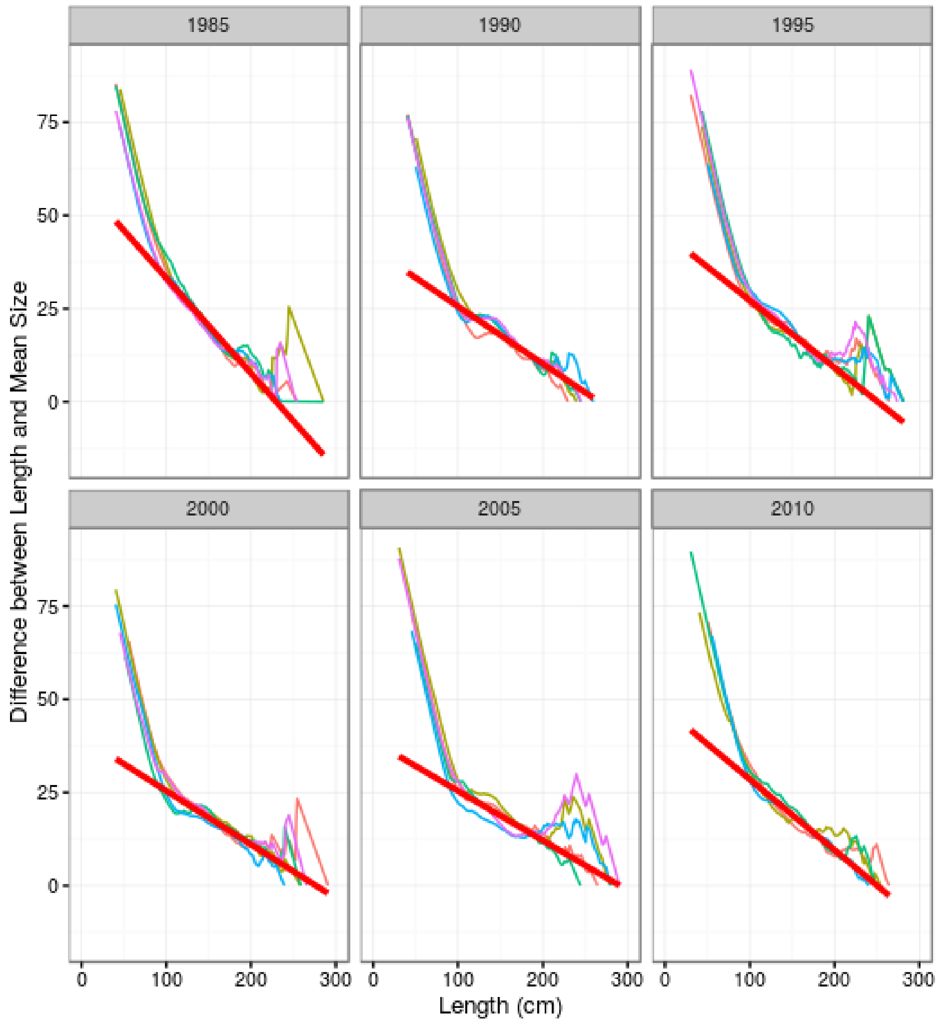

Figure 5. Powell Whetherall plots, the red lines are the linear regression fits and the thin lines are fits to each year.

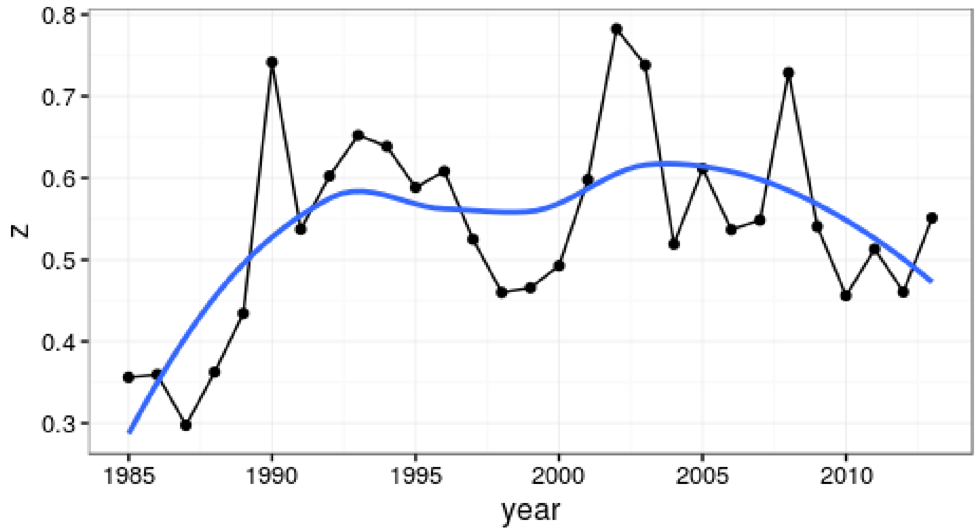

Figure 6. Estimates of Z from Powell Wetherall method, black points are estimates for each 5 year period and blue line is a loess smoother through these.

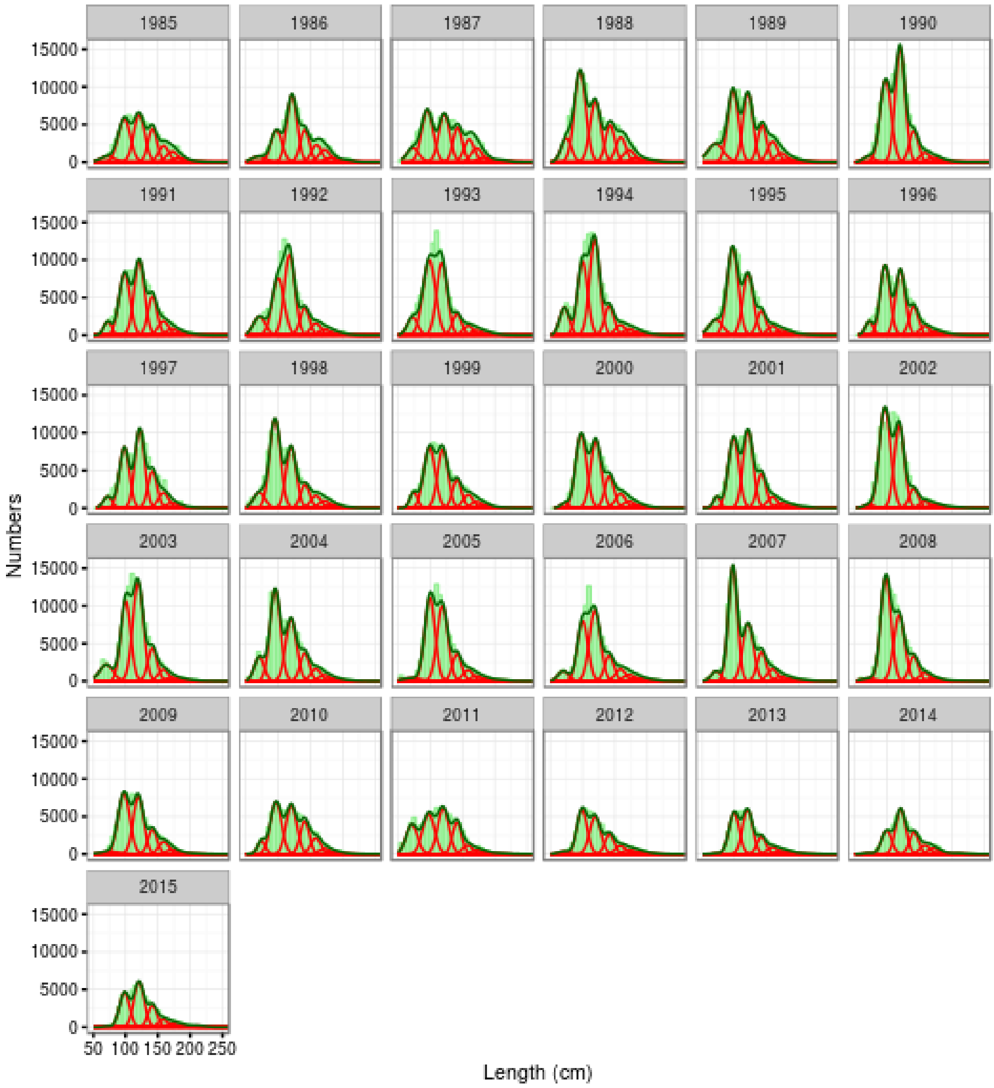

Figure 7. Length Frequencies with age modes (red) and total distributions (green) from the statistical estimation overlayed.

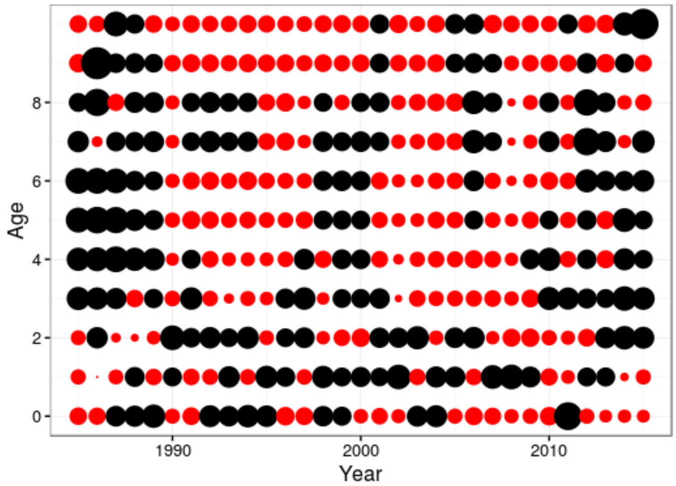

Figure 8. Estimates of Z derived from the Powell-Wetherall plots; showing the estimates from each year (black line with points) and a smoother (blue continuous line).

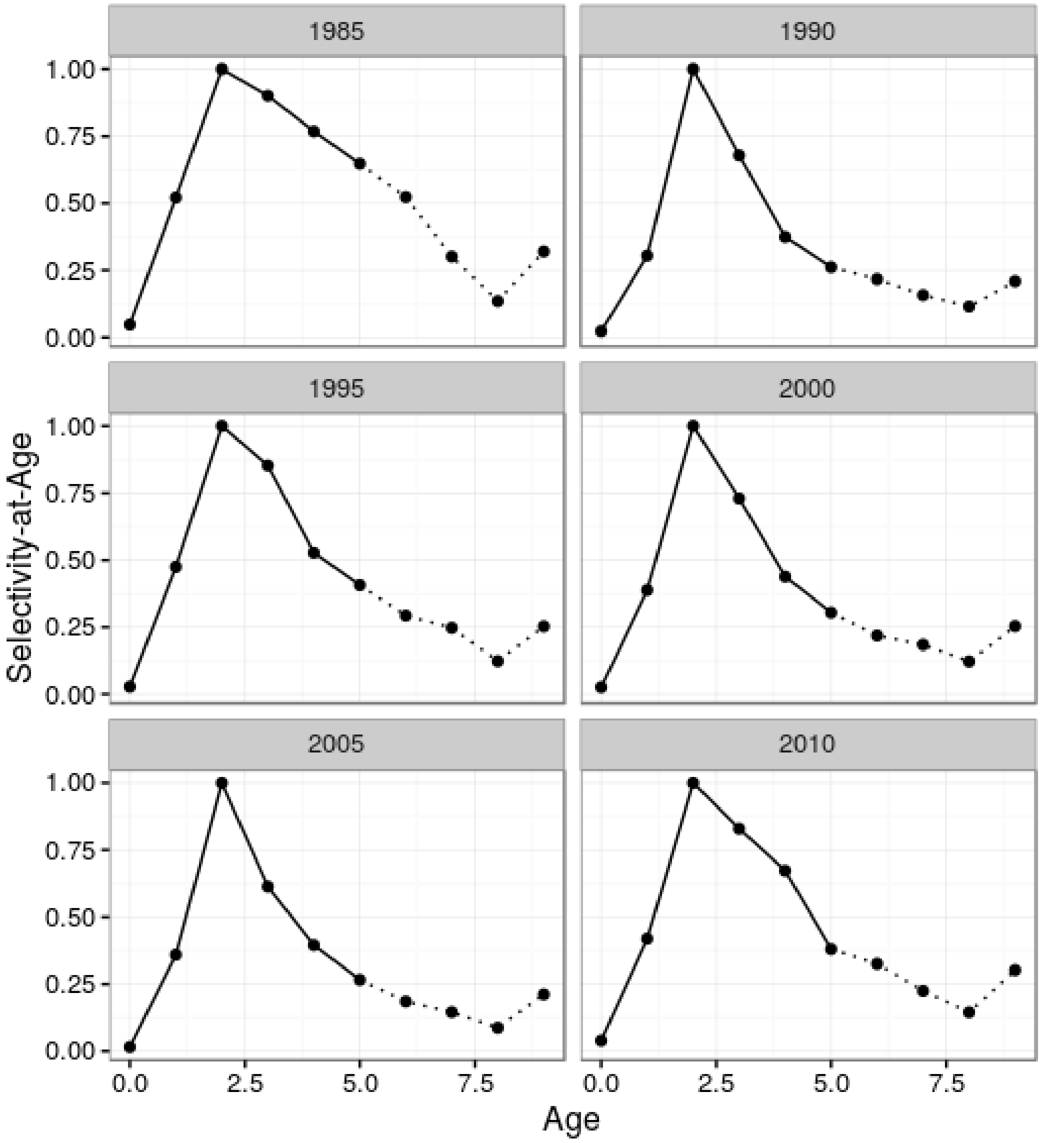

Figure 9. Estimated selectivity by *lustrum*, hatch lines are the ages in the plus group.

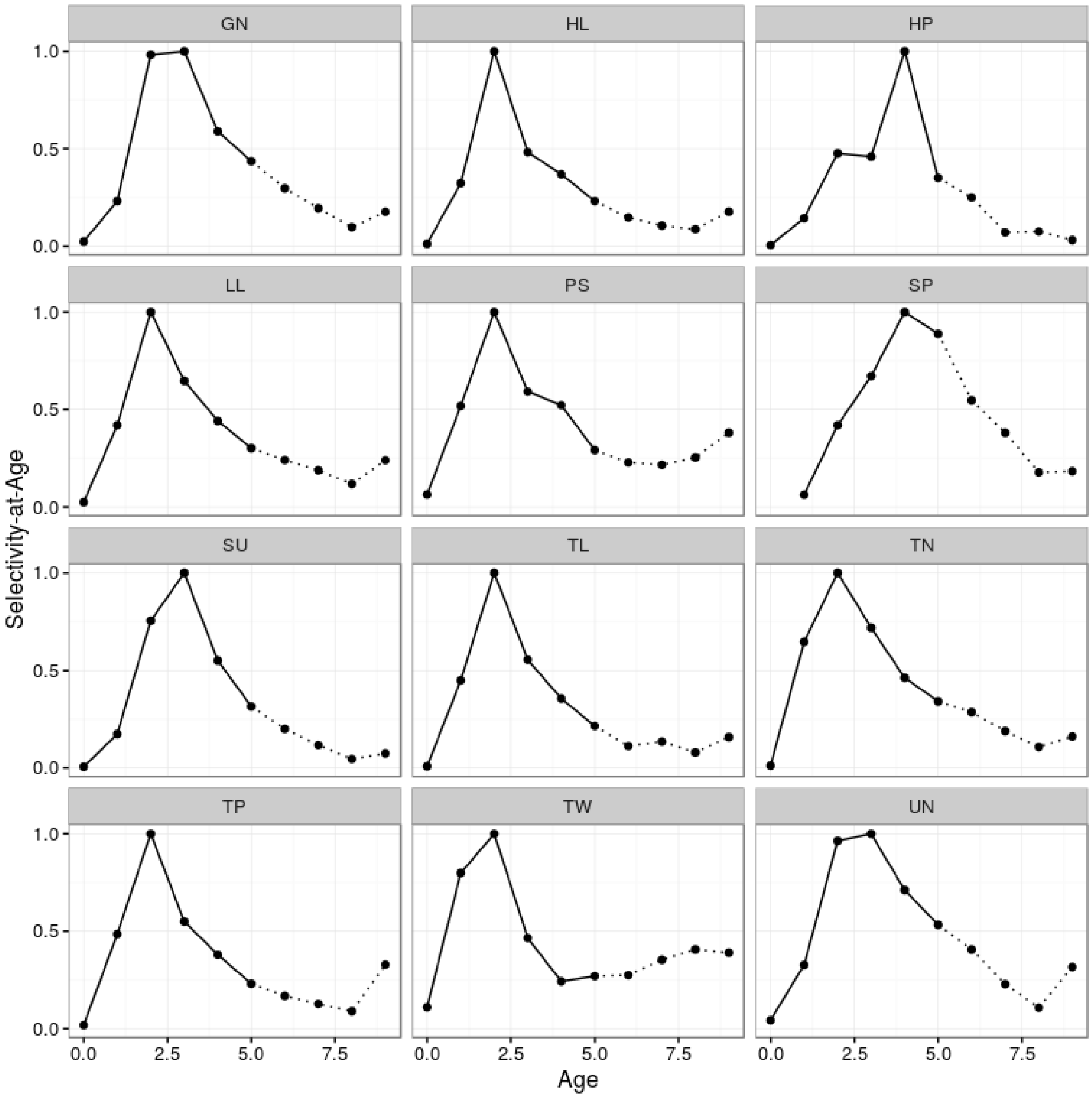

Figure 10. Catch curves by gear based on age estimates, hatch lines are the ages in the plus group.

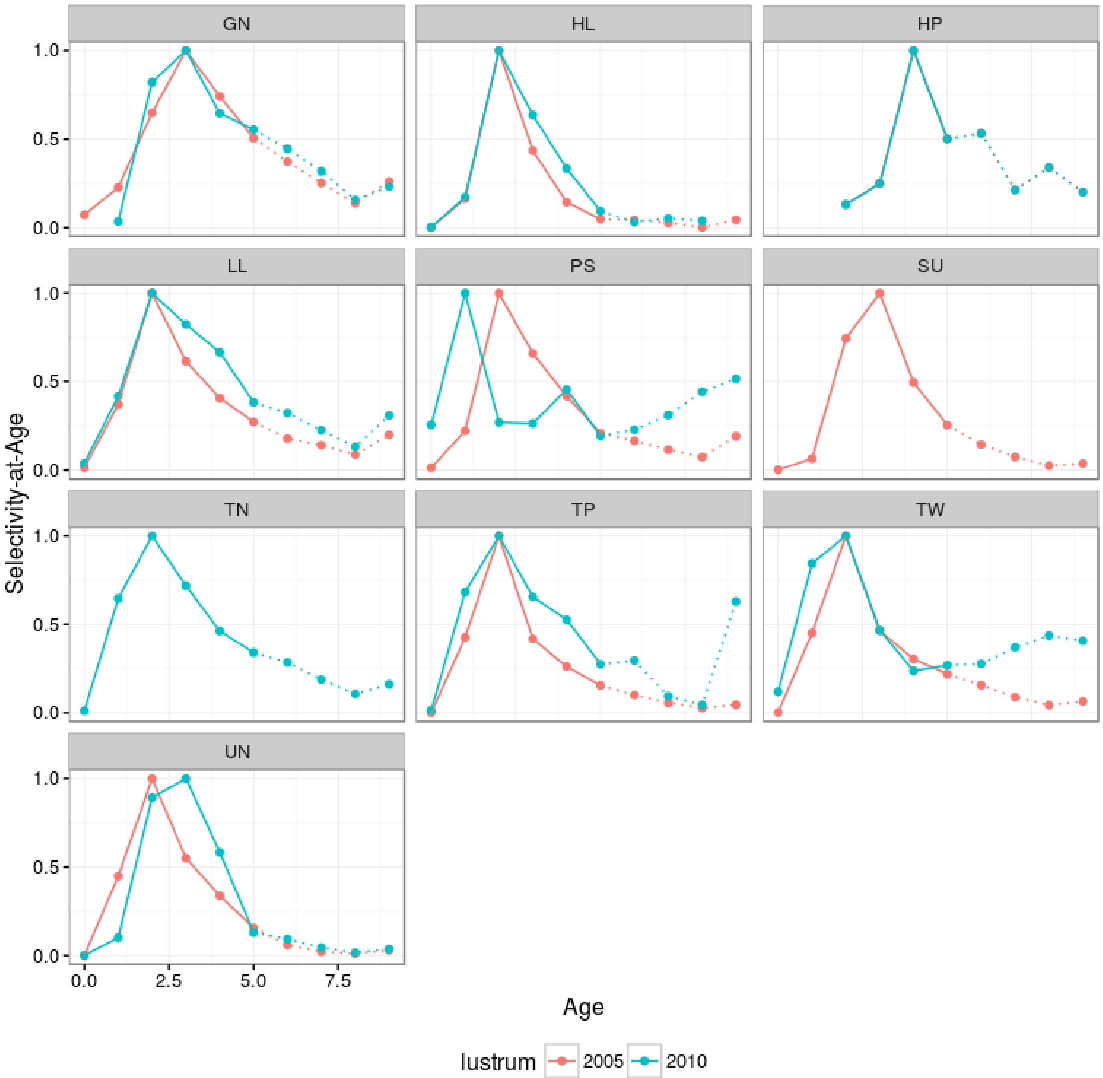

Figure 11. Catch curves by gear and lustrum based on statistical age estimates, hatch lines are the ages in the plus group.

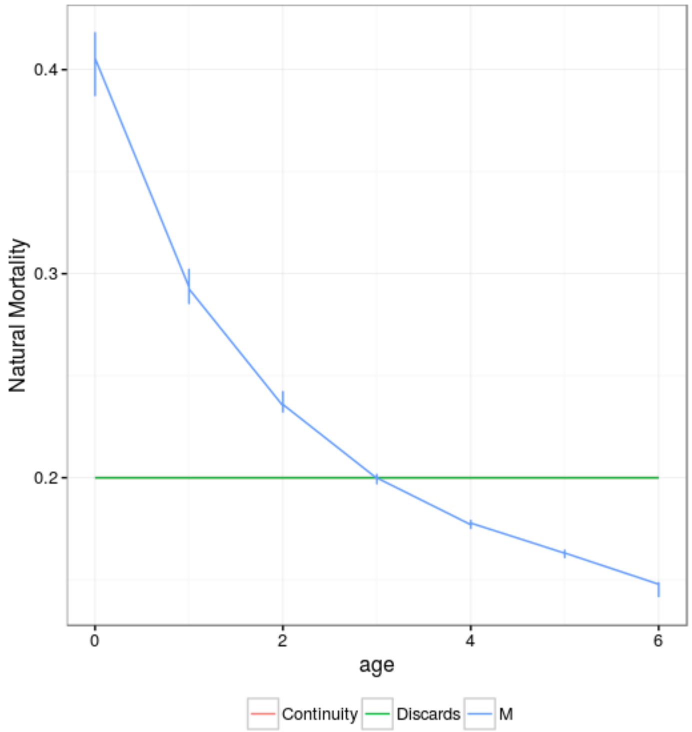

Figure 12. Mortality (M) vectors for the three XSA scenarios (note that for the continuity and discards scenarios the lines are overlapped with M=0.2).

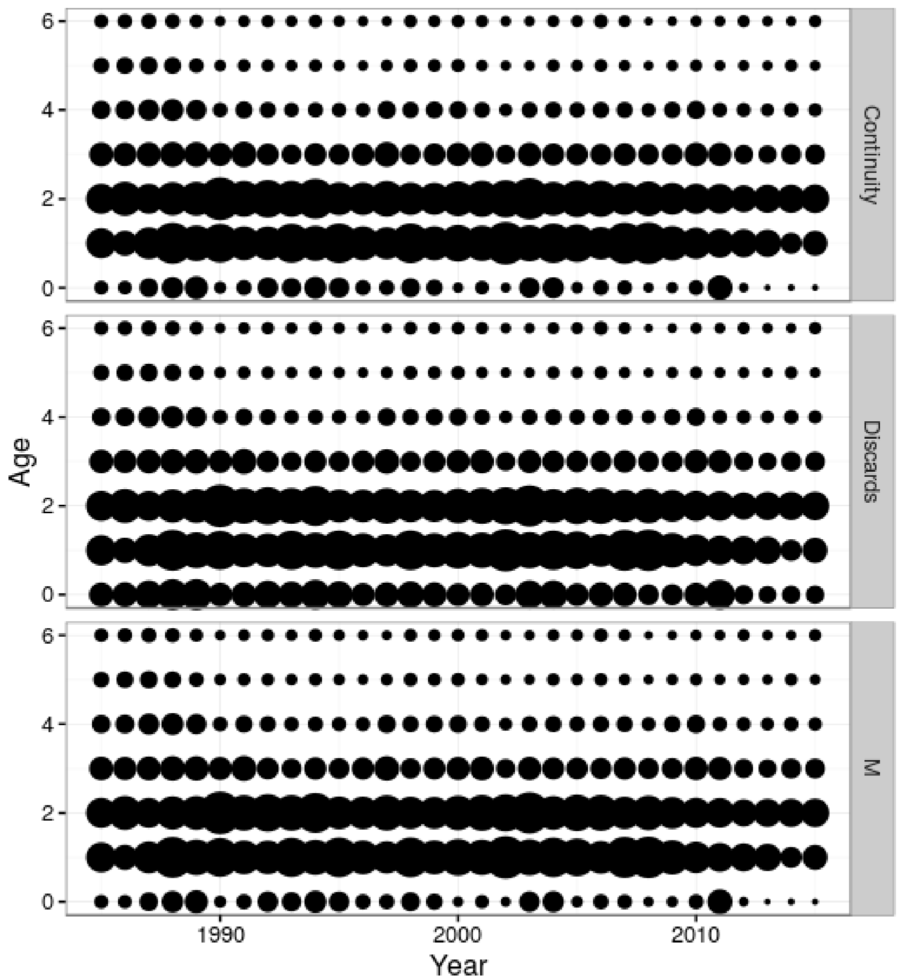

Figure 13. Catch-at-age matrices for the three scenarios, bubbles proportional to number

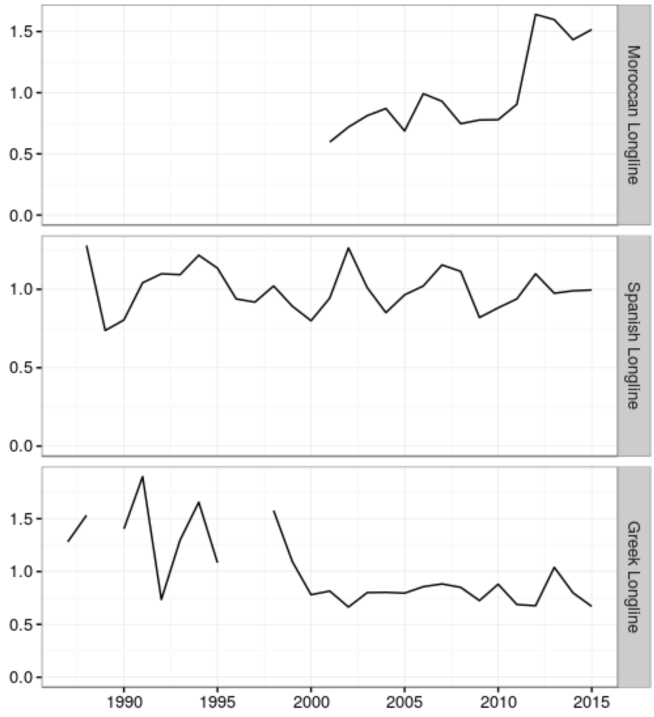

Figure 14. CPUE series used for the XSA.

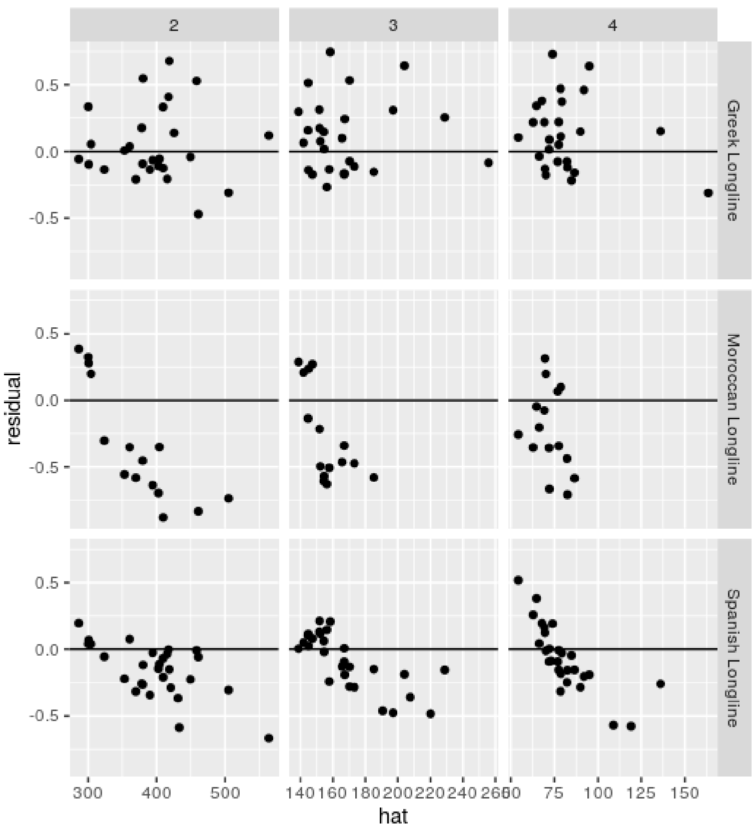

Figure 15. XSA diagnostics from continuity run; residuals plotted against fitted value by age (row) and series (column). Ideally residuals should be randomly distributed around y=0 with no systematic pattern if model assumptions are satisfied.

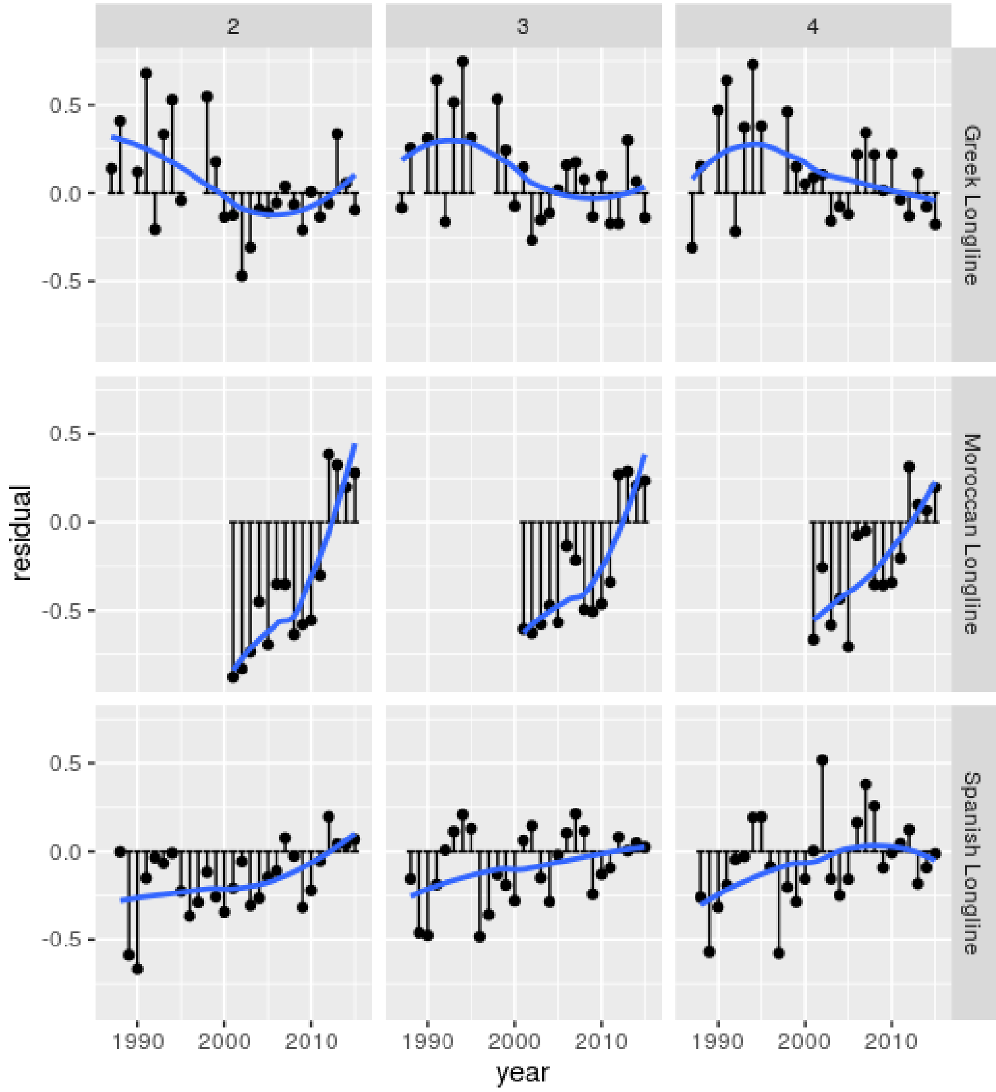

Figure 16. XSA diagnostics from continuity run; residuals against year to identify systematic patterns that may indicate that indices are not tracking relative abundance, e.g. to changes in catchability.

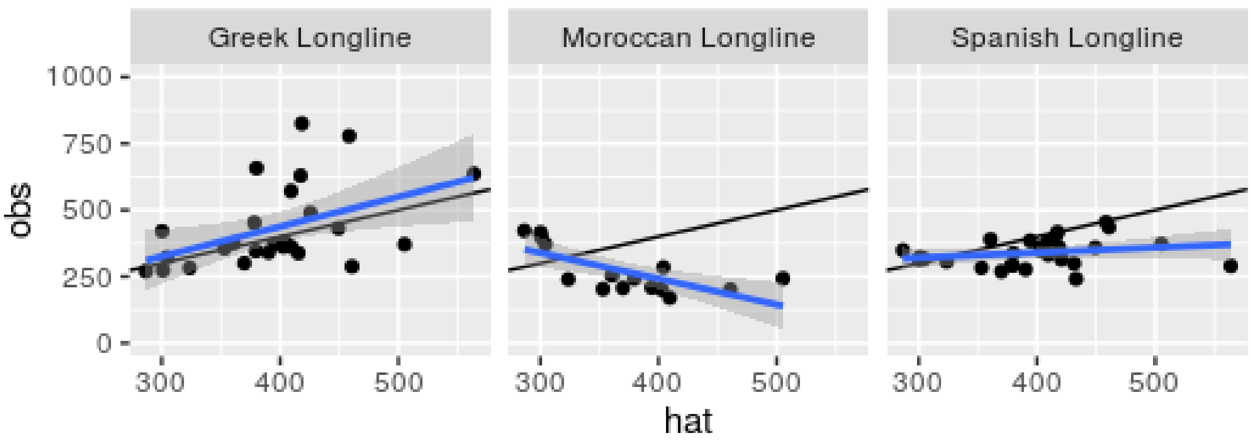

Figure 17. XSA diagnostics from continuity run; Calibration regression plots for age 2. Blue line is a linear regression fitted to the residual pairs and the black line is the y=x line. If the index is proportional to stock abundance then the blue and black lines should coincide.

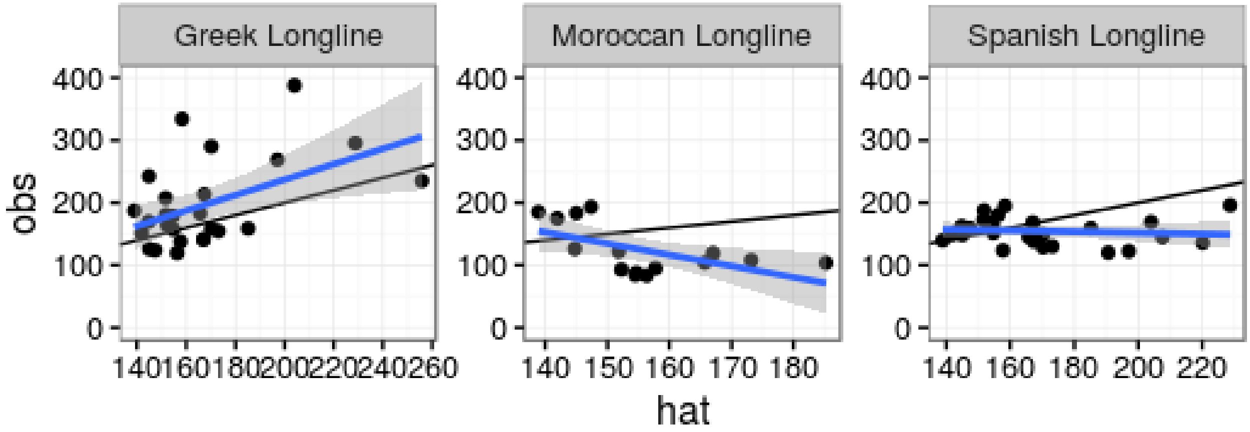

Figure 18. XSA diagnostics from continuity run; Calibration regression plots for age 3. Blue line is a linear regression fitted to the residual pairs and the black line is the y=x line. If the index is proportional to stock abundance then the blue and black lines should coincide.

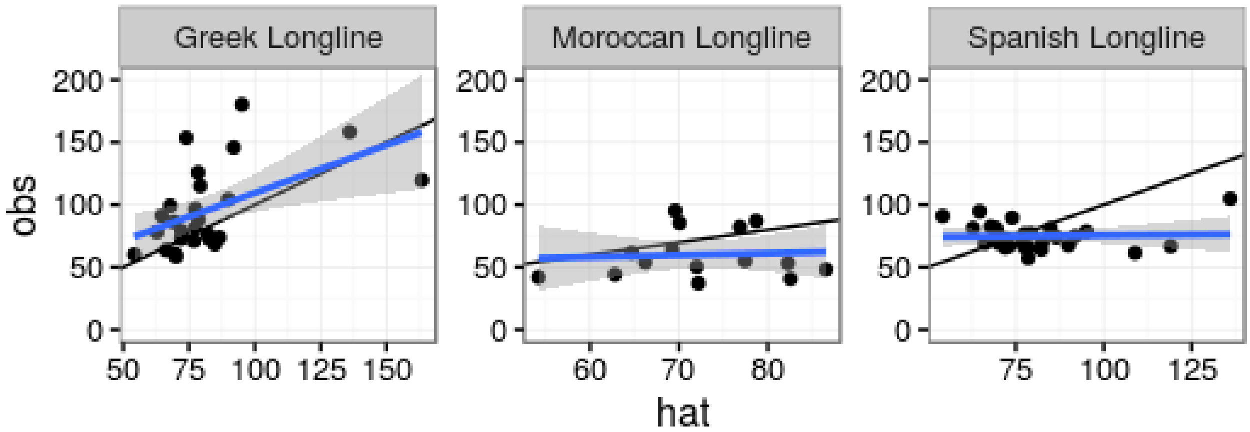

Figure 19. XSA diagnostics from continuity run; Calibration regression plots for age 4. Blue line is a linear regression fitted to the residual pairs and the black line is the y=x line. If the index is proportional to stock abundance then the blue and black lines should coincide.

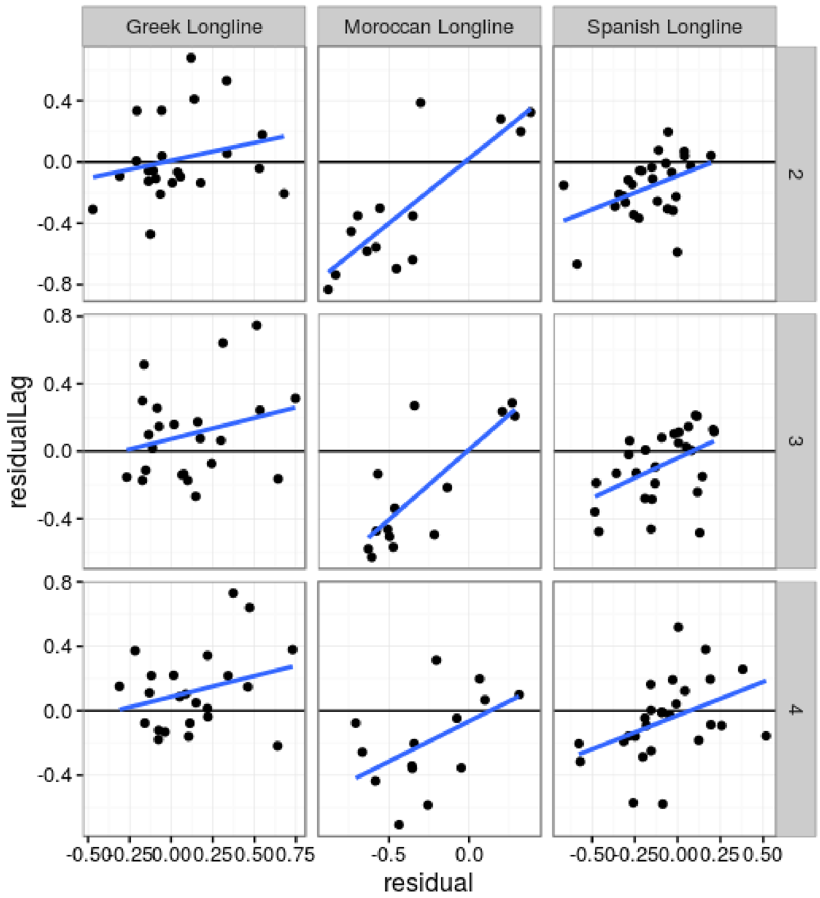

Figure 20. XSA diagnostics from continuity run; plots of lagged residuals, blue line is a regression fitted to the data pairs. If residuals are uncorrelated then the slope of the regression should be 0.

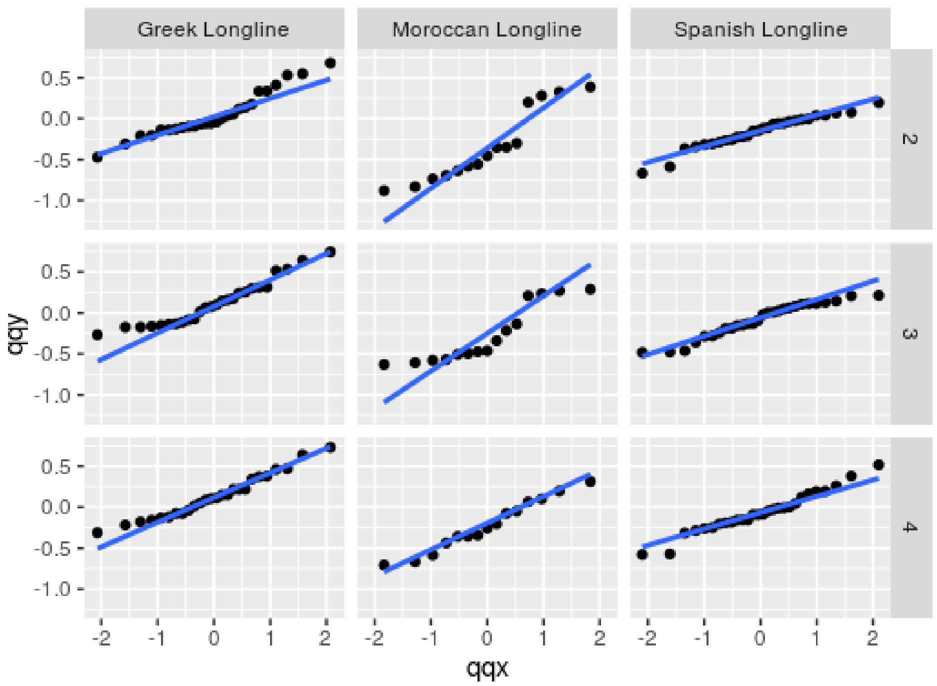

Figure 21. XSA diagnostics from continuity run; QQ plots to check for log normality, i.e. points and line should coincide.

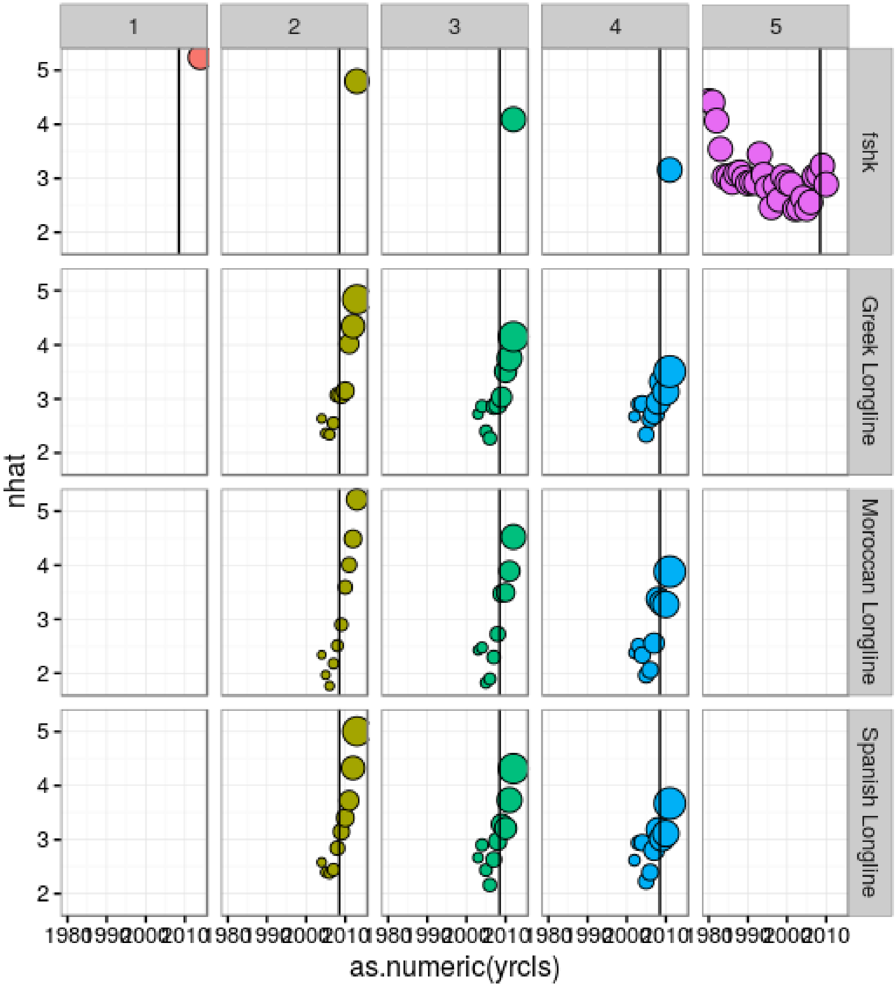

Figure 22. XSA diagnostics from continuity run; showing relative weighting for terminal year Ns for each CPUE (column) and age (row) observation and shrinkage to the mean F(fshk). Vertical line identifies the age range used for shrinkage to age in the terminal ages. Points correspond to individual cohorts.

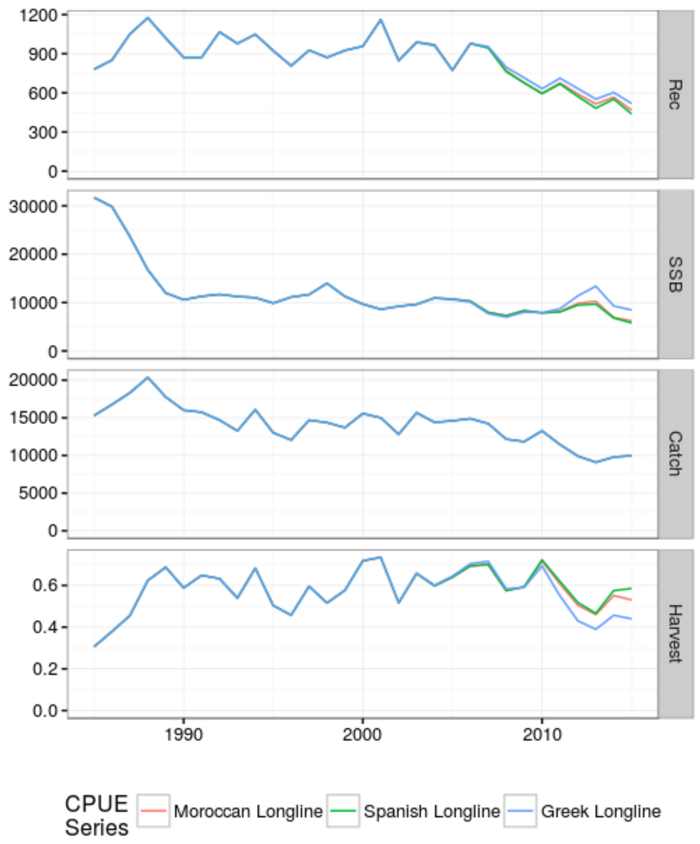

Figure 23. XSA historic estimates for continuity run by CPUE series, i.e. runs are for a single series. Time series are for recruitment, SSB, Catch and Fishing mortality (harvest).

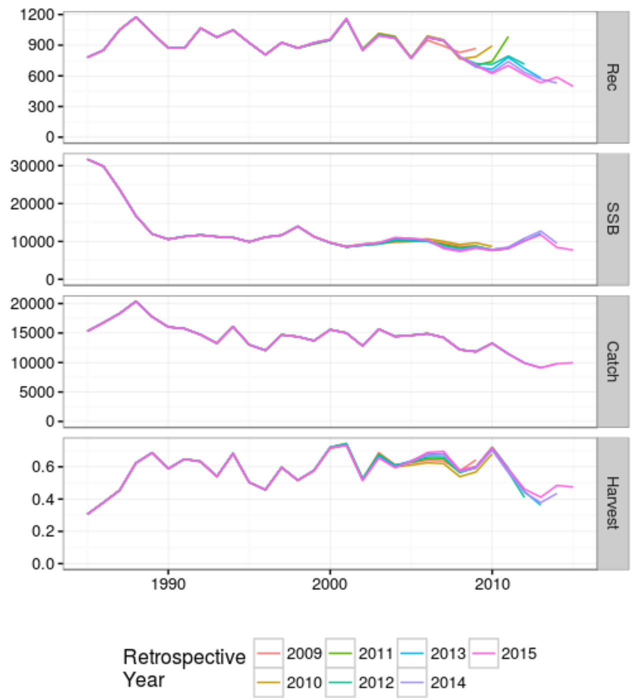

Figure 24. Retrospective XSA using only the three CPUE series used in the assessment scenario continuity run; time series are for recruitment (Rec), spawning stock biomass (SSB), Catch and fishing mortality (harvest).

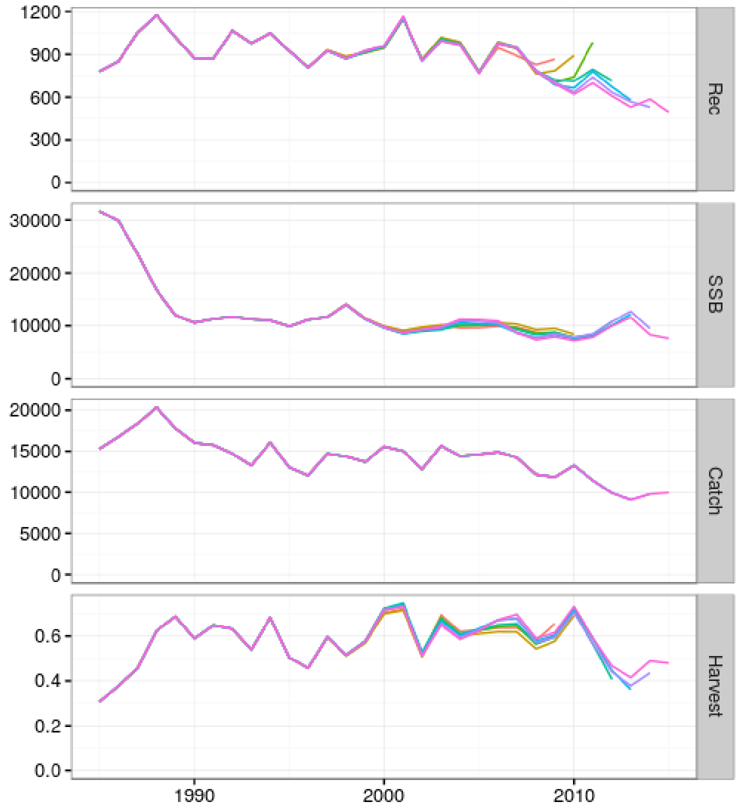

Figure 25. Retrospective XSA using all CPUE series available, XSA settings and data are the same as continuity run scenario; time series are for recruitment (Rec), spawning stock biomass (SSB), Catch and fishing mortality (harvest).

a) r = 0.60 b) r= 0.45 c) r = 0.40

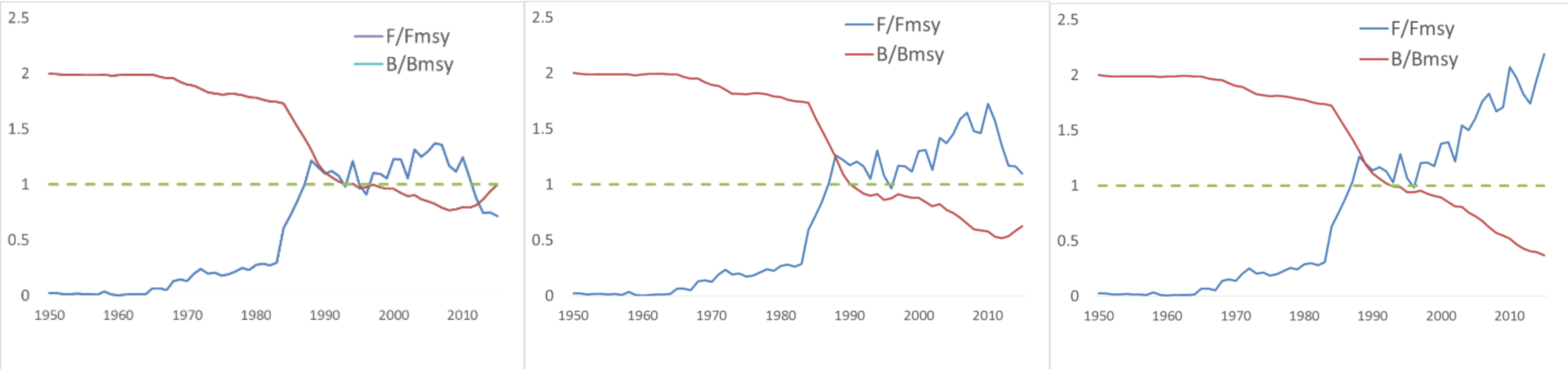

Figure 26. Predicted evolution of the stock according to a production model with a) r = 0.6 and K = 90,000 b) r = 0.45 and K = 120,000 and c) r = 0.4 and K = 130,000, when reported catches are considered to represent biomass removals.

a) r = 0.60 b) r= 0.45 c) r = 0.40

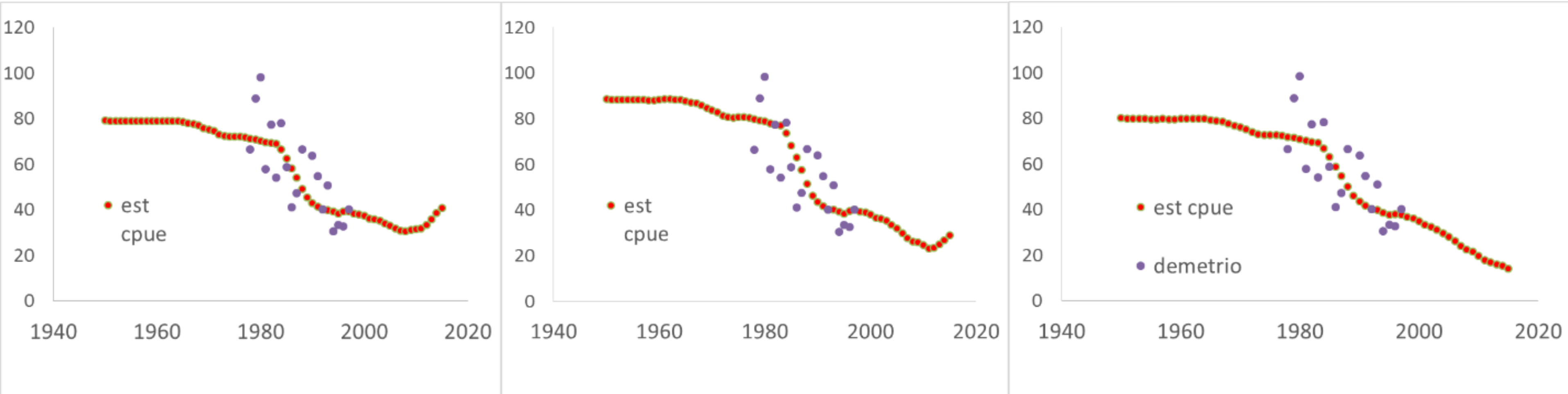

Figure 27. Predicted evolution of the stock according to a production model superimposed to nominal catch rates from Demetrio et al (1999). a) r = 0.6 and K = 90,000 b) r = 0.45 and K = 120,000 and c) r = 0.4 and K = 130,000.

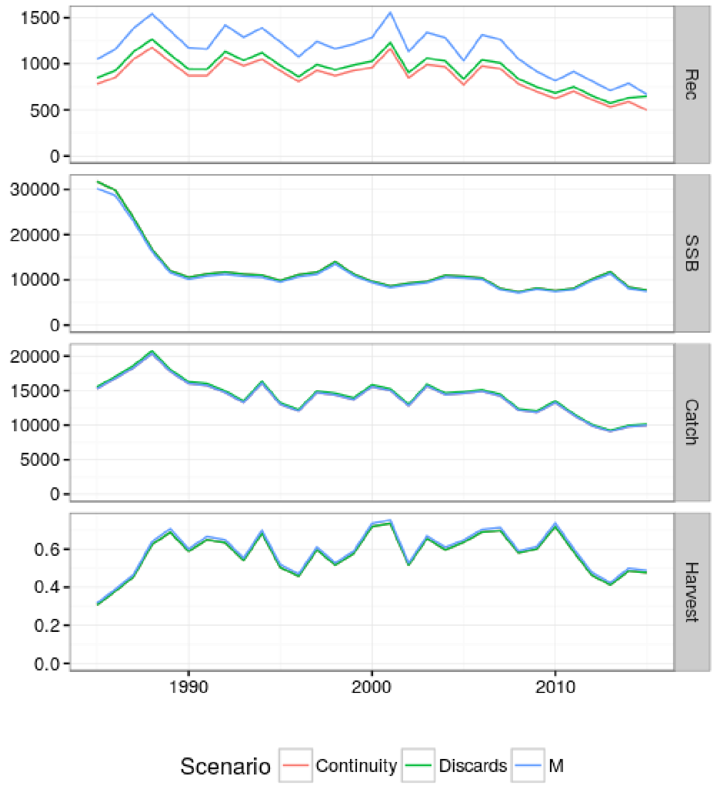

Figure 28. XSA estimates of historic time series of recruitment (Rec), spawning stock biomass (SSB), catch and fishing mortality (Harvest) for the three XSA scenarios.

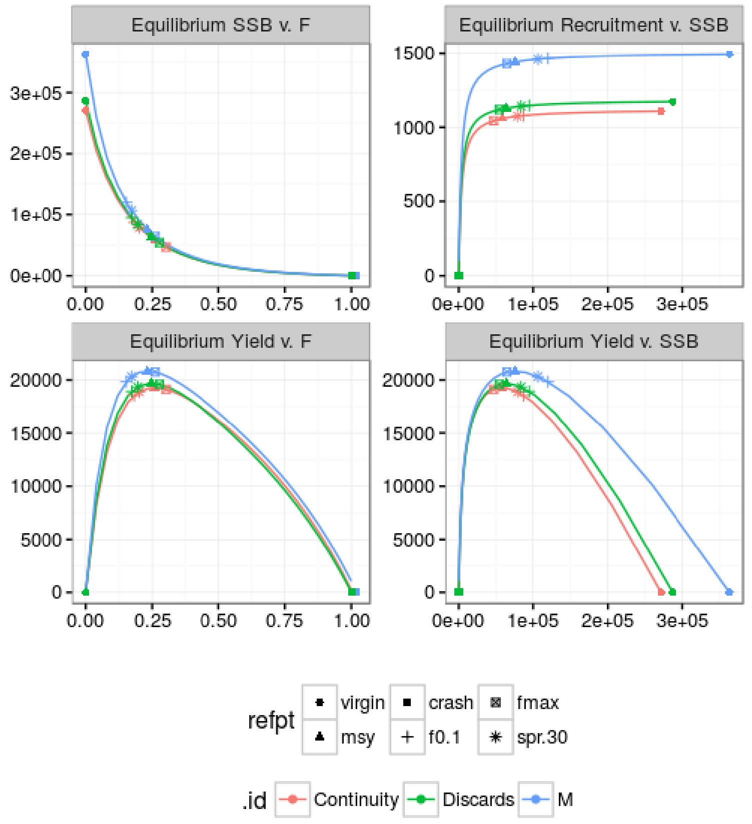

Figure 29. Equilibrium curves based on expected weight, maturity, m-at-age, selection pattern and SRR.

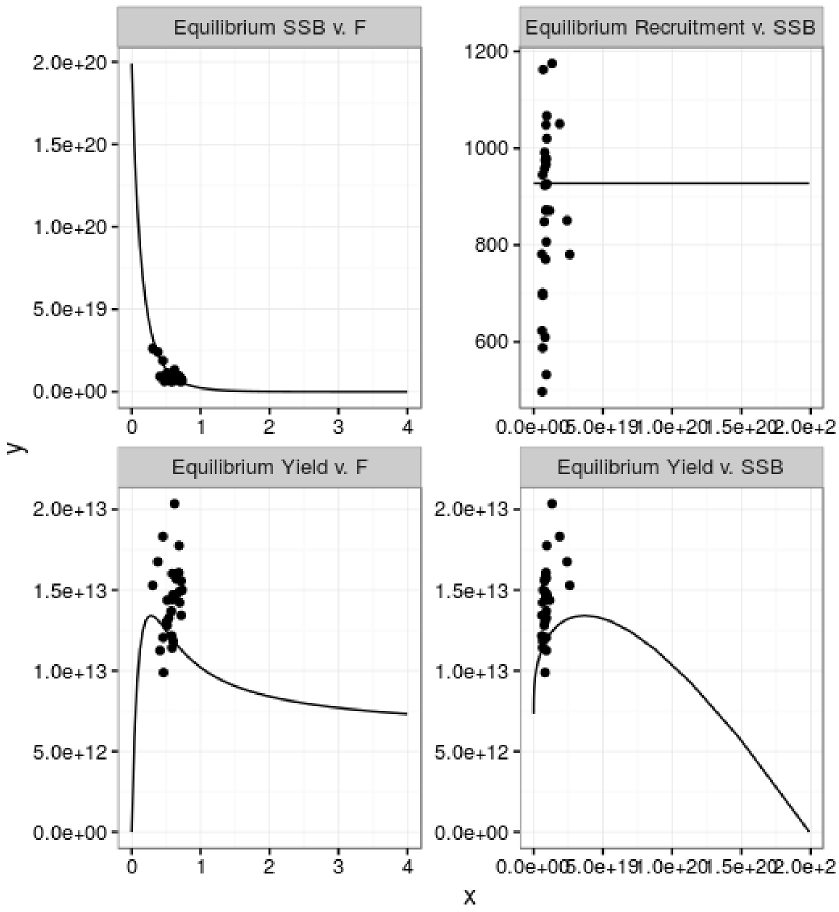

Figure 30. Equilibrium Analysis, as in previous figure with data pairs estimated by XSA.

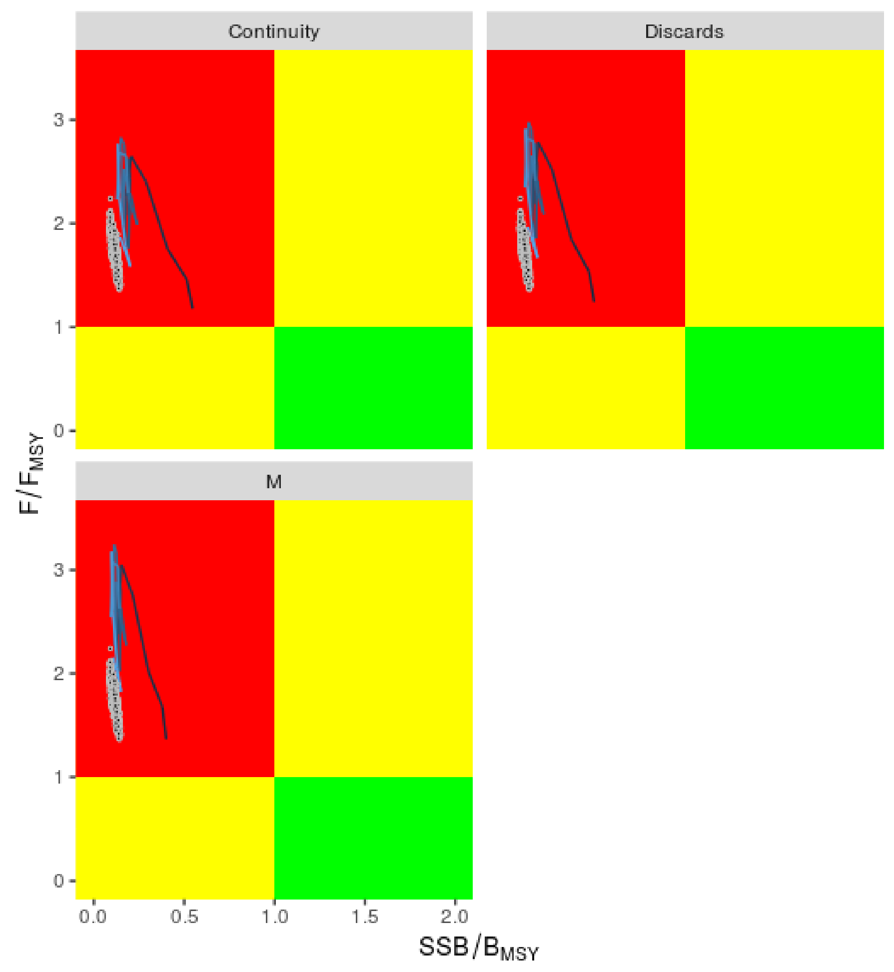

Figure 31. Kobe Phase Plot, showing trajectories by XSA scenario; points represent the error in the 2015 estimates derived from a Monte Carlo simulation of the internal standard errors of the terminal N-at-age in the last year.

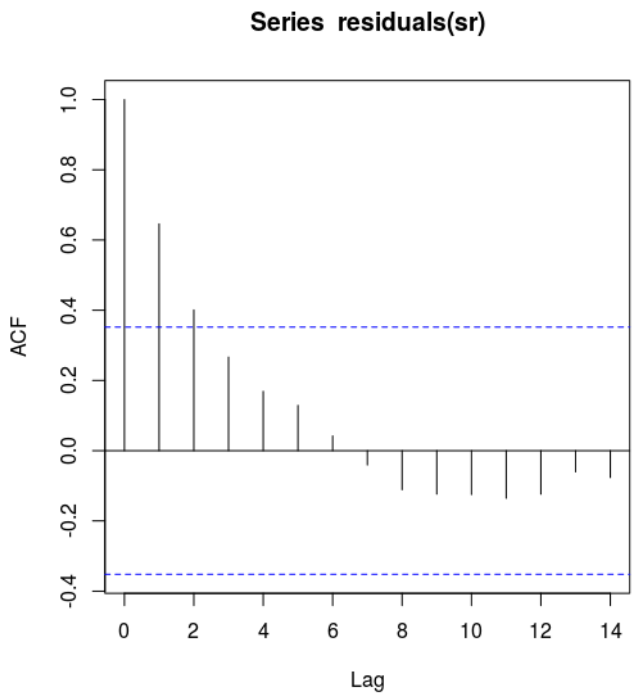

Figure 32. Autocorrelation in recruitment residuals, showing strong autocorrelation.

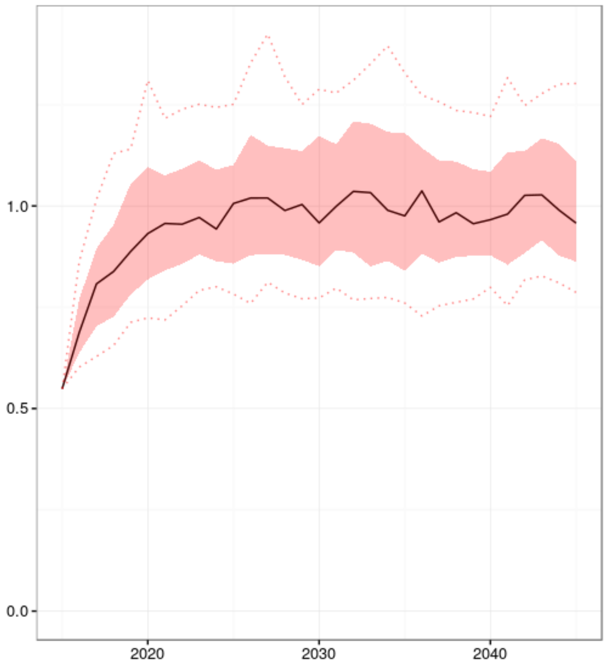

Figure 33. Simulated recruitment deviates, back line is the median, ribbon the inter-quartile range and the hatched lines the 10^{th} to 90^{th} percentiles.

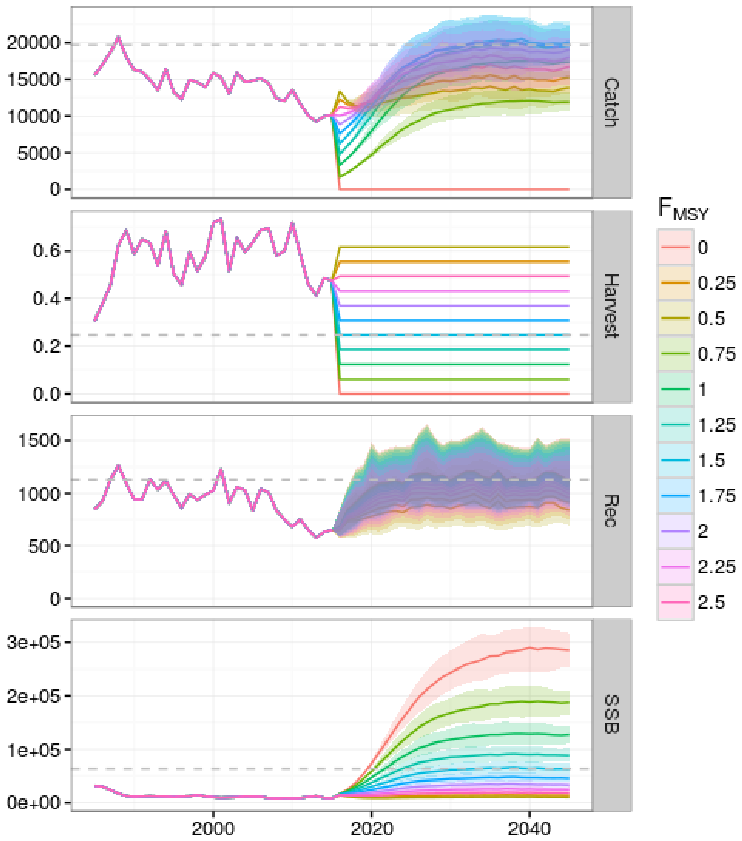

Figure 34. Projections from 0 to 2.5 times F_{MSY}; showing catch and fishing mortality (Harvest), simulated recruitment (Rec) and spawning stock biomass (SSB); lines are medians and ribbons inter-quartiles.

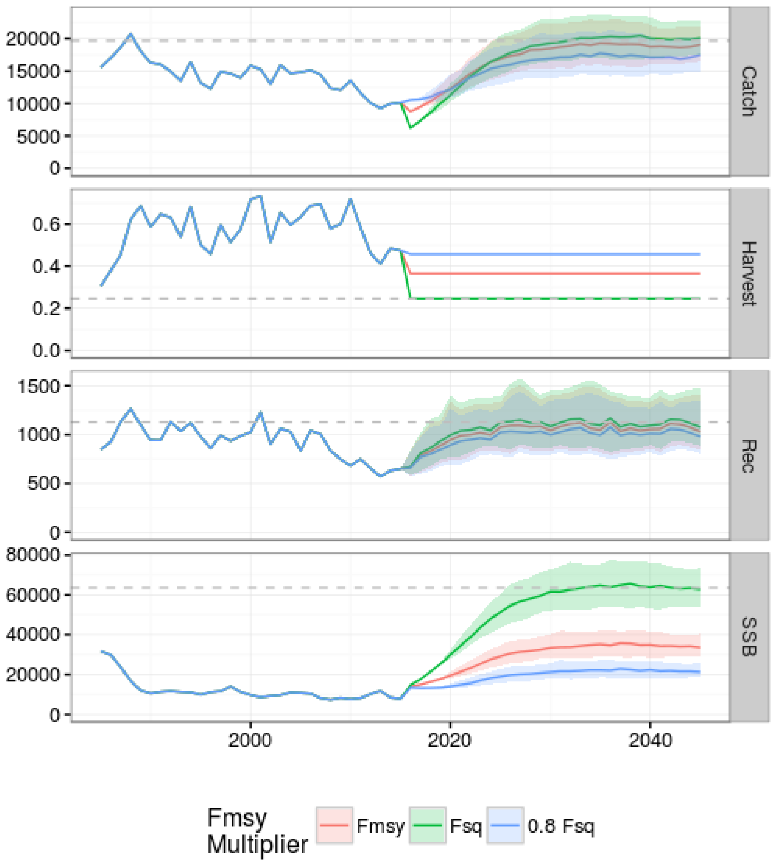

Figure 35. Projections for $F_{status\ quo}$, $0.8F_{staus\ quo}$ and F_{MSY}; showing catch and fishing mortality (Harvest), simulated recruitment (Rec) and spawning stock biomass (SSB); lines are medians and ribbons inter-quartile.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Summary of available data for assessment
    - 2.1. Biology
    - 2.2. Catch, effort, and size
    - 2.3. Relative abundance estimates (CPUEs)
3. Stock Assessment
    - 3.1. Methods
    - 3.2. Diagnostics
    - 3.3. Stock Status relative to benchmarks (e.g., MSY)
    - 3.4. Projections
4. Recommendations
    - 4.1. Research and Statistics
    - 4.2. Management advice
5. Other matters
6. Adoption of the report and closure

Appendix 2

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Appendix 3

List of documents

Reference	Title	Authors
SCRS/2016/096	Updated standardized catch rates in number and weight for swordfish (*Xiphias gladius* L.) caught by the Spanish longline fleet in the Mediterranean Sea, 1988- 2014	Ortiz de Urbina J., Macías D., and Saber S.
SCRS/2016/112	On the length-weight relationships of the Mediterranean swordfish	Tserpes G, Ortiz de Urbina J., Abid N., Ceyhan T., and Di Natale A.
SCRS/2016/113	Swordfish abundance trends in the drifting surface longline Greek fisheries	Tserpes G., and Peristeraki P.
SCRS/2016/114	Preliminary study on the diet of juvenile swordfish (*Xiphias gladius*) in the Aegean Sea	Ceyhan T., and Akyol O.
SCRS/2016/117	Distribution des fréquences de taille et relation taille/poids de l'espadon de la cote Algerienne	Kouadri Krim A., Selmani R., and Ferhani K.
SCRS/2016/119	Updated standardised abundance index for swordfish caught by Moroccan Artisanal fishery in the Strait of Gibraltar, 1999-2015	Abid N., Mhamed A.B., and Idrissi M.M.
SCRS/2016/120	An update of the swordfish fishery in the Ligurian Sea (Western Mediterranean)	Garibaldi F.

Appendix 4

XSA outputs and diagnostics for the XSA scenarios (i.e. continuity, discards and Lorenzen M)

Table 1a. Stock numbers-at-age as estimated by the XSA continuity scenario.

	Year										
Age	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
0	780.399	850.892	1050.256	1175.201	1019.844	871.408	871.518	1066.691	977.924	1048.344	923.284
1	766.963	619.549	678.048	819.818	905.208	767.882	699.611	688.788	822.561	757.992	797.183
2	493.337	506.812	425.663	417.428	433.035	563.853	418.472	415.57	409.233	458.386	449.323
3	318.498	283.02	255.774	228.76	190.673	197.075	204.016	167.041	144.878	158.363	151.67
4	216.623	189.64	163.414	135.995	108.898	78.525	95.079	84.849	79.297	73.958	67.854
5	135.581	138.985	114.59	80.144	52.883	40.597	42.288	44.968	42.185	43.65	36.926
6	93.115	92.554	77.135	56.385	41.357	29.492	35.104	44.142	41.845	46.671	36.373

	Year										
Age	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
0	806.827	926.534	871.098	925.607	958.026	1162.508	848.314	991.199	966.498	770.436	975.815
1	707.582	635.639	734.575	671.379	729.233	775.13	933.174	686.235	760.379	736.759	617.934
2	431.249	420.647	380.115	378.264	390.246	409.446	460.829	505.215	379.553	402.688	404.022
3	220.118	207.592	170.233	167.353	170.274	154.514	156.332	185.226	173.179	154.701	144.762
4	73.124	119.038	91.959	89.969	77.426	72.203	54.218	86.542	82.274	82.552	69.222
5	34.838	39.067	61.011	46.153	42.084	29.39	32.736	28.458	43.657	38.898	41.888
6	34.321	23.721	53.661	38.895	36.644	34.157	33.678	27.536	38.172	39.197	48.381

	Year								
Age	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
0	944.901	781.008	695.805	623.11	700.901	609.759	532.363	587.478	497.034
1	774.438	751.572	630.766	558.169	486.424	495.083	491.776	434.238	478.594
2	360.71	394.277	369.825	352.978	323.612	286.595	300.209	304.358	300.932
3	151.822	152.271	157.752	165.694	167.023	147.381	138.898	141.942	145.003
4	64.705	62.813	72.009	77.448	66.218	69.578	78.687	76.849	70.083
5	28.674	25.195	32.021	29.627	26.046	33.022	36.891	48.005	41.877
6	32.443	16.222	20.115	23.462	25.208	41.267	38.733	27.049	62.815

Table 1b. Stock numbers-at-age as estimated by the XSA discards scenario.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	847.727	924.714	1130.885	1264.792	1097.928	941.965	940.843	1131.417	1036.307	1119.074	980.544
1	766.963	619.549	678.048	819.818	905.208	767.882	699.611	688.788	822.561	757.992	797.183
2	493.337	506.812	425.663	417.428	433.035	563.853	418.472	415.57	409.233	458.386	449.323
3	318.498	283.02	255.774	228.76	190.673	197.075	204.016	167.041	144.878	158.363	151.67
4	216.623	189.64	163.414	135.995	108.898	78.525	95.079	84.849	79.297	73.958	67.854
5	135.581	138.985	114.59	80.144	52.883	40.597	42.288	44.968	42.185	43.65	36.926
6	93.115	92.554	77.135	56.385	41.357	29.492	35.104	44.142	41.845	46.671	36.373

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	859.898	991.238	934.316	985.926	1026.632	1228.631	904.784	1060.151	1029.859	834.742	1041.405
1	707.582	635.639	734.575	671.379	729.233	775.13	933.174	686.235	760.379	736.759	617.934
2	431.249	420.647	380.115	378.264	390.246	409.446	460.829	505.215	379.553	402.688	404.022
3	220.118	207.592	170.233	167.353	170.274	154.514	156.332	185.226	173.179	154.701	144.762
4	73.124	119.038	91.959	89.969	77.426	72.203	54.218	86.542	82.274	82.552	69.222
5	34.838	39.067	61.011	46.153	42.084	29.39	32.736	28.458	43.657	38.898	41.888
6	34.321	23.721	53.661	38.895	36.644	34.157	33.678	27.536	38.172	39.197	48.381

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	1007.563	834.608	747.961	681.476	751.142	653.437	572.453	630.644	648.521
1	774.438	751.572	630.766	558.169	486.424	495.083	491.776	434.238	478.594
2	360.71	394.277	369.825	352.978	323.612	286.595	300.209	304.358	300.932
3	151.822	152.271	157.752	165.694	167.023	147.381	138.898	141.942	145.003
4	64.705	62.813	72.009	77.448	66.218	69.578	78.687	76.849	70.083
5	28.674	25.195	32.021	29.627	26.046	33.022	36.891	48.005	41.877
6	32.443	16.222	20.115	23.462	25.208	41.267	38.733	27.049	62.815

Table 1c. Stock numbers-at-age as estimated by the XSA Lorenzen M scenario.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	1049.326	1156.32	1385.2	1541.469	1355.442	1172.421	1158.603	1418.835	1287.154	1388.312	1236.028
1	842.185	682.564	748.12	895.022	994.798	836.551	766.228	751.385	897.631	822.936	872.083
2	497.432	512.76	431.113	423.403	438.712	572.356	423.367	422.119	416.496	465.37	454.141
3	306.411	274.579	249.669	223.651	186.126	192.152	199.294	162.485	140.853	154.5	147.69
4	203.751	179.823	156.567	131.234	105.001	74.97	90.959	80.96	75.544	70.607	64.672
5	127.58	131.861	109.581	76.975	50.754	38.75	40.455	42.847	40.155	41.695	35.187
6	87.619	87.81	73.763	54.156	39.693	28.15	33.583	42.06	39.832	44.579	34.66

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	1076.466	1239.81	1162.162	1212.747	1284.921	1554.919	1133.058	1338.151	1282.919	1032.558	1313.474
1	775.486	697.823	805.698	733.751	795.221	850.937	1023.428	746.57	835.374	802.319	672.78
2	437.818	425.675	386.672	384.701	396.679	414.453	469.459	513.621	385.93	410.013	410.956
3	213.78	203.045	165.984	164.237	166.597	151.678	152.042	181.356	169.114	151.662	141.856
4	69.842	113.77	88.206	86.535	74.854	69.2	51.886	82.878	79.022	79.166	66.706
5	33.164	37.386	58.327	44.344	40.478	28.238	31.209	27.269	41.806	37.325	40.247
6	32.672	22.701	51.3	37.37	35.246	32.819	32.106	26.386	36.553	37.612	46.487

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	1262.654	1050.603	914.513	815.788	914.402	811.643	709.951	788.153	664.83
1	847.115	818.015	689.621	609.816	530.511	537.944	533.467	474.372	523.954
2	366.88	402.243	376.358	357.879	326.693	288.951	302.707	306.918	304.407
3	148.671	149.474	154.879	162.363	163.134	142.582	134.054	137.658	141
4	62.342	60.233	69.6	75.062	63.494	66.41	74.824	73.139	66.839
5	27.512	24.042	30.73	28.583	24.995	31.669	35.283	46.161	40.047
6	31.128	15.48	19.304	22.635	24.191	39.576	37.044	26.01	60.07

Table 2a. Fishing mortality-at-age as estimated by the XSA continuity scenario.

					Year						
Age	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
0	0.030813	0.027067	0.047707	0.061029	0.083769	0.019587	0.035304	0.059893	0.054759	0.073882	0.066083
1	0.214299	0.175345	0.285105	0.438264	0.273372	0.407027	0.320874	0.320648	0.384712	0.322931	0.414399
2	0.355676	0.483845	0.420976	0.583552	0.587235	0.816595	0.718371	0.85376	0.749394	0.906004	0.513578
3	0.31849	0.349228	0.431676	0.542263	0.68715	0.528871	0.677323	0.545037	0.472388	0.647537	0.529554
4	0.243793	0.303767	0.512465	0.744545	0.78672	0.418919	0.548755	0.498811	0.396986	0.49458	0.466652
5	0.281142	0.326497	0.47207	0.643404	0.736935	0.473895	0.613039	0.521924	0.434687	0.571059	0.498104
6	0.281142	0.326497	0.47207	0.643404	0.736935	0.473895	0.613039	0.521924	0.434687	0.571059	0.498104

					Year						
Age	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
0	0.038478	0.032159	0.06042	0.038457	0.011844	0.019743	0.012032	0.065097	0.071419	0.020576	0.031135
1	0.320061	0.314157	0.4637	0.342558	0.377189	0.320004	0.413609	0.392227	0.435655	0.400792	0.338307
2	0.531113	0.704624	0.620367	0.598186	0.726493	0.762824	0.711453	0.870656	0.6975	0.823071	0.778761
3	0.414723	0.614235	0.437704	0.570785	0.65793	0.847278	0.391355	0.611519	0.540902	0.604169	0.605246
4	0.426875	0.468385	0.489369	0.559807	0.768681	0.59099	0.444586	0.484272	0.549125	0.478428	0.681336
5	0.4208	0.541312	0.463539	0.565301	0.713317	0.719154	0.41799	0.547932	0.545073	0.541388	0.643467
6	0.4208	0.541312	0.463539	0.565301	0.713317	0.719154	0.41799	0.547932	0.545073	0.541388	0.643467

					Year				
Age	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
0	0.028913	0.01365	0.020407	0.047643	0.147642	0.015041	0.003733	0.004986	0.004569
1	0.475083	0.509136	0.380529	0.345116	0.329011	0.300246	0.279819	0.166707	0.228315
2	0.662411	0.716027	0.602888	0.548278	0.586527	0.524329	0.549059	0.541449	0.570399
3	0.682552	0.548869	0.511424	0.717184	0.675673	0.427543	0.391897	0.505746	0.487567
4	0.74322	0.473779	0.688093	0.889731	0.495796	0.434475	0.294162	0.407117	0.367436
5	0.702615	0.465733	0.577148	0.868506	0.657761	0.537151	0.343555	0.467623	0.328206
6	0.702615	0.465733	0.577148	0.868506	0.657761	0.537151	0.343555	0.467623	0.328206

Table 2b. Fishing mortality-at-age as estimated by the XSA discard scenario.

	Year										
Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	0.113567	0.110267	0.121673	0.134498	0.157544	0.097444	0.111843	0.118804	0.112746	0.139172	0.126254
1	0.214299	0.175345	0.285105	0.438264	0.273372	0.407027	0.320873	0.320648	0.384712	0.322931	0.414399
2	0.355676	0.483845	0.420976	0.583552	0.587235	0.816595	0.718371	0.85376	0.749394	0.906004	0.513577
3	0.31849	0.349228	0.431676	0.542263	0.68715	0.528871	0.677323	0.545037	0.472388	0.647537	0.529554
4	0.243793	0.303767	0.512465	0.744545	0.78672	0.418919	0.548755	0.498811	0.396986	0.49458	0.466652
5	0.281142	0.326497	0.47207	0.643404	0.736935	0.473895	0.613039	0.521924	0.434687	0.571059	0.498104
6	0.281142	0.326497	0.47207	0.643404	0.736935	0.473895	0.613039	0.521924	0.434687	0.571059	0.498104

	Year										
Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.102183	0.099663	0.130481	0.101589	0.081007	0.075064	0.076476	0.132349	0.134917	0.100742	0.096188
1	0.32006	0.314157	0.4637	0.342558	0.377189	0.320004	0.413608	0.392227	0.435655	0.400792	0.338307
2	0.531113	0.704624	0.620367	0.598186	0.726493	0.762824	0.711452	0.870656	0.6975	0.823071	0.778761
3	0.414723	0.614235	0.437704	0.570785	0.65793	0.847278	0.391355	0.611519	0.540902	0.604169	0.605246
4	0.426875	0.468385	0.489369	0.559807	0.768681	0.59099	0.444586	0.484272	0.549125	0.478427	0.681336
5	0.4208	0.541312	0.463539	0.565301	0.713317	0.719154	0.41799	0.547932	0.545072	0.541388	0.643467
6	0.4208	0.541312	0.463539	0.565301	0.713317	0.719154	0.41799	0.547932	0.545072	0.541388	0.643467

	Year								
Age	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.093123	0.080027	0.092689	0.137181	0.216869	0.084222	0.076338	0.075889	0.073891
1	0.475083	0.509136	0.380529	0.345116	0.329011	0.300246	0.279819	0.166707	0.228315
2	0.662411	0.716027	0.602888	0.548278	0.586527	0.524329	0.549059	0.541449	0.570399
3	0.682552	0.548869	0.511424	0.717184	0.675673	0.427543	0.391897	0.505746	0.487567
4	0.74322	0.473779	0.688093	0.889731	0.495796	0.434475	0.294161	0.407117	0.367436
5	0.702615	0.465733	0.577148	0.868506	0.657761	0.537151	0.343555	0.467623	0.328206
6	0.702615	0.465733	0.577148	0.868506	0.657761	0.537151	0.343555	0.467623	0.328206

Table 2c. Fishing mortality-at-age as estimated by the XSA Lorenzen M scenario.

	Year										
Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	0.025178	0.021978	0.039544	0.050571	0.069177	0.016047	0.029155	0.04942	0.045552	0.061024	0.054225
1	0.202686	0.165512	0.268513	0.414988	0.257954	0.386176	0.303161	0.303342	0.364145	0.307259	0.391640
2	0.358952	0.485865	0.422268	0.584969	0.589347	0.817387	0.721961	0.855824	0.749534	0.907724	0.517112
3	0.333246	0.362016	0.444506	0.558026	0.710625	0.546965	0.700361	0.56545	0.489824	0.670409	0.548458
4	0.258158	0.319109	0.534297	0.773329	0.81938	0.438386	0.574622	0.523323	0.416212	0.518483	0.489873
5	0.295702	0.340562	0.489402	0.665678	0.765003	0.492675	0.637492	0.544387	0.453018	0.594446	0.519166
6	0.295702	0.340562	0.489402	0.665678	0.765003	0.492675	0.637492	0.544387	0.453018	0.594446	0.519166

	Year										
Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.031621	0.0264	0.049739	0.032011	0.00971	0.016216	0.009928	0.053116	0.059041	0.016938	0.025512
1	0.302793	0.296244	0.437121	0.32388	0.357654	0.301554	0.390107	0.371619	0.410169	0.379451	0.32045
2	0.531754	0.707361	0.619356	0.598107	0.725321	0.76635	0.710205	0.870689	0.696692	0.821309	0.777881
3	0.430102	0.633308	0.451652	0.585427	0.678426	0.87224	0.405203	0.629778	0.558321	0.620878	0.622188
4	0.446547	0.490014	0.509813	0.582017	0.797162	0.618058	0.464298	0.505693	0.571961	0.498463	0.708348
5	0.438325	0.561662	0.480734	0.583725	0.737802	0.745164	0.434765	0.567764	0.565188	0.559744	0.665414
6	0.438325	0.561662	0.480734	0.583725	0.737802	0.745164	0.434765	0.567764	0.565188	0.559744	0.665414

	Year								
Age	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.023839	0.011194	0.016948	0.039666	0.123181	0.012449	0.003077	0.004093	0.003765
1	0.447891	0.481777	0.360035	0.327362	0.312597	0.285892	0.266705	0.158176	0.216455
2	0.661232	0.713341	0.602187	0.549662	0.591816	0.530107	0.553864	0.545541	0.573547
3	0.703279	0.562941	0.523883	0.738658	0.698621	0.445354	0.408622	0.525352	0.505355
4	0.774538	0.493892	0.712472	0.921754	0.517027	0.454787	0.307767	0.426843	0.384345
5	0.729292	0.48438	0.597045	0.897344	0.681704	0.555597	0.354669	0.480817	0.339156
6	0.729292	0.48438	0.597045	0.897344	0.681704	0.555597	0.354669	0.480817	0.339156

Table 3a. XSA diagnostics from continuity run.

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CPUE data from indices

Catch data for 31 years 1985 to 2015. Ages 0 to 6.

	fleet	first age	last age	first year	last year	alpha	beta
1	Moroccan Longline	2	4	2001	2015	<NA>	<NA>
2	Spanish Longline	2	4	1988	2015	<NA>	<NA>
3	Greek Longline	2	4	1987	2015	<NA>	<NA>

Time series weights :

Tapered time weighting applied
Power = 1 over 10 years

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 10 years or the 2 oldest ages.

S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

age \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Fishing mortalities

age \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.031	0.029	0.014	0.020	0.048	0.148	0.015	0.004	0.005	0.005
1	0.338	0.475	0.509	0.381	0.345	0.329	0.300	0.280	0.167	0.228
2	0.779	0.662	0.716	0.603	0.548	0.587	0.524	0.549	0.541	0.570
3	0.605	0.683	0.549	0.511	0.717	0.676	0.428	0.392	0.506	0.488
4	0.681	0.743	0.474	0.688	0.890	0.496	0.434	0.294	0.407	0.367
5	0.643	0.703	0.466	0.577	0.869	0.658	0.537	0.344	0.468	0.328
6	0.643	0.703	0.466	0.577	0.869	0.658	0.537	0.344	0.468	0.328

XSA population number (Thousand)

year \ age	0	1	2	3	4	5	6
2006	976	618	404	145	69	42	48
2007	945	774	361	152	65	29	32
2008	781	752	394	152	63	25	16
2009	696	631	370	158	72	32	20
2010	623	558	353	166	77	30	23
2011	701	486	324	167	66	26	25
2012	610	495	287	147	70	33	41
2013	532	492	300	139	79	37	39
2014	587	434	304	142	77	48	27
2015	497	479	301	145	70	42	63

Estimated population abundance at 1st Jan 2016

year \ age	0	1	2	3	4	5	6
2016	0	405	312	139	73	40	25

Fleet: Moroccan Longline

Log catchability residuals.

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	-0.879	-0.832	-0.735	-0.453	-0.695	-0.350	-0.352	-0.637	-0.581	-0.556
3	-0.606	-0.629	-0.579	-0.473	-0.569	-0.135	-0.215	-0.495	-0.507	-0.464
4	-0.665	-0.257	-0.585	-0.436	-0.707	-0.076	-0.047	-0.354	-0.357	-0.342

age	2011	2012	2013	2014	2015
2	-0.302	0.386	0.324	0.199	0.279
3	-0.339	0.271	0.288	0.209	0.236
4	-0.203	0.314	0.101	0.067	0.198

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.2094	-4.4721	-3.7612
S.E_Logq	0.3652	0.3652	0.3652

Fleet: Spanish Longline

Log catchability residuals.

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	-0.002	-0.588	-0.667	-0.152	-0.035	-0.068	-0.009	-0.226	-0.367	-0.289
3	-0.156	-0.462	-0.476	-0.188	0.008	0.113	0.208	0.130	-0.483	-0.359
4	-0.260	-0.570	-0.316	-0.191	-0.046	-0.029	0.192	0.195	-0.087	-0.578

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	-0.117	-0.257	-0.343	-0.210	-0.058	-0.306	-0.265	-0.146	-0.111	0.076
3	-0.132	-0.191	-0.280	0.063	0.146	-0.150	-0.286	-0.020	0.104	0.213
4	-0.204	-0.286	-0.156	0.004	0.517	-0.156	-0.249	-0.158	0.164	0.381

age	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.026	-0.317	-0.221	-0.056	0.196	0.041	0.040	0.069
3	0.116	-0.242	-0.130	-0.093	0.081	0.004	0.049	0.025
4	0.257	-0.092	-0.008	0.043	0.124	-0.183	-0.092	-0.012

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.4197	-4.6824	-3.9715
S.E_Logq	0.2195	0.2195	0.2195

Fleet: Greek Longline

Log catchability residuals.

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	0.139	0.409	NA	0.120	0.679	-0.206	0.333	0.529	-0.042	NA	NA
3	-0.085	0.255	NA	0.310	0.642	-0.164	0.514	0.746	0.314	NA	NA
4	-0.311	0.152	NA	0.471	0.639	-0.218	0.372	0.730	0.379	NA	NA

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	0.548	0.177	-0.137	-0.126	-0.471	-0.310	-0.093	-0.108	-0.056	0.038
3	0.533	0.244	-0.074	0.147	-0.268	-0.153	-0.113	0.018	0.159	0.175
4	0.461	0.149	0.051	0.088	0.104	-0.159	-0.076	-0.120	0.218	0.342

age	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.066	-0.210	0.007	-0.136	-0.058	0.335	0.055	-0.097
3	0.076	-0.135	0.098	-0.174	-0.174	0.299	0.064	-0.140
4	0.217	0.015	0.220	-0.038	-0.131	0.112	-0.077	-0.178

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4

```
Mean_Logq -5.6502 -4.9129 -4.202
S.E_Logq   0.2730  0.2730  0.273

 Terminal year survivor and F summaries:

 ,Age 0 Year class =2015

source
    scaledWts survivors yrcls
fshk     0.107        55  2015
nshk     0.893       516  2015

 ,Age 1 Year class =2014

source
    scaledWts survivors yrcls
fshk         1       189  2014

 ,Age 2 Year class =2013

source
                  scaledWts survivors yrcls
Moroccan Longline     0.139       184  2013
Spanish Longline      0.327       149  2013
Greek Longline        0.327       126  2013
fshk                  0.208       121  2013

 ,Age 3 Year class =2012

source
                  scaledWts survivors yrcls
Moroccan Longline     0.187        92  2012
Spanish Longline      0.314        75  2012
Greek Longline        0.314        63  2012
fshk                  0.184        60  2012

 ,Age 4 Year class =2011

source
                  scaledWts survivors yrcls
Moroccan Longline     0.284        48  2011
Spanish Longline      0.284        39  2011
Greek Longline        0.284        33  2011
fshk                  0.148        24  2011

 ,Age 5 Year class =2010

source
    scaledWts survivors yrcls
fshk         1        18  2010
```

Table 3b. XSA diagnostics from run used to formulate advice that includes discards.

FLR XSA Diagnostics 2016-07-18 15:49:00

CPUE data from indices

Catch data for 31 years 1985 to 2015. Ages 0 to 6.

	fleet	first age	last age	first year	last year	alpha	beta
1	Moroccan Longline	2	4	2001	2015	<NA>	<NA>
2	Spanish Longline	2	4	1988	2015	<NA>	<NA>
3	Greek Longline	2	4	1987	2015	<NA>	<NA>

Time series weights :

Tapered time weighting applied
Power = 1 over 10 years

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F of the final 10 years or the 2 oldest ages.

S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

year / age		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	

Fishing mortalities

year / age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.096	0.093	0.080	0.093	0.137	0.217	0.084	0.076	0.076	0.074
1	0.338	0.475	0.509	0.381	0.345	0.329	0.300	0.280	0.167	0.228
2	0.779	0.662	0.716	0.603	0.548	0.587	0.524	0.549	0.541	0.570
3	0.605	0.683	0.549	0.511	0.717	0.676	0.428	0.392	0.506	0.488
4	0.681	0.743	0.474	0.688	0.890	0.496	0.434	0.294	0.407	0.367
5	0.643	0.703	0.466	0.577	0.869	0.658	0.537	0.344	0.468	0.328
6	0.643	0.703	0.466	0.577	0.869	0.658	0.537	0.344	0.468	0.328

XSA population number (Thousand)

age / year	0	1	2	3	4	5	6
2006	1041	618	404	145	69	42	48
2007	1008	774	361	152	65	29	32
2008	835	752	394	152	63	25	16
2009	748	631	370	158	72	32	20
2010	681	558	353	166	77	30	23
2011	751	486	324	167	66	26	25
2012	653	495	287	147	70	33	41
2013	572	492	300	139	79	37	39
2014	631	434	304	142	77	48	27
2015	649	479	301	145	70	42	63

Estimated population abundance at 1st Jan 2016

age / year	0	1	2	3	4	5	6
2016	0	493	312	139	73	40	25

Fleet: Moroccan Longline

Log catchability residuals.

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	-0.879	-0.832	-0.735	-0.453	-0.695	-0.350	-0.352	-0.637	-0.581	-0.556
3	-0.606	-0.629	-0.579	-0.473	-0.569	-0.135	-0.215	-0.495	-0.507	-0.464
4	-0.665	-0.257	-0.585	-0.436	-0.707	-0.076	-0.047	-0.354	-0.357	-0.342

age \ year	2011	2012	2013	2014	2015
2	-0.302	0.386	0.324	0.199	0.279
3	-0.339	0.271	0.288	0.209	0.236
4	-0.203	0.314	0.101	0.067	0.198

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.2094	-4.4721	-3.7612
S.E_Logq	0.3652	0.3652	0.3652

Fleet: Spanish Longline

Log catchability residuals.

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	-0.002	-0.588	-0.667	-0.152	-0.035	-0.068	-0.009	-0.226	-0.367	-0.289
3	-0.156	-0.462	-0.476	-0.188	0.008	0.113	0.208	0.130	-0.483	-0.359
4	-0.260	-0.570	-0.316	-0.191	-0.046	-0.029	0.192	0.195	-0.087	-0.578

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	-0.117	-0.257	-0.343	-0.210	-0.058	-0.306	-0.265	-0.146	-0.111	0.076
3	-0.132	-0.191	-0.280	0.063	0.146	-0.150	-0.286	-0.020	0.104	0.213
4	-0.204	-0.286	-0.156	0.004	0.517	-0.156	-0.249	-0.158	0.164	0.381

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.026	-0.317	-0.221	-0.056	0.196	0.041	0.040	0.069
3	0.116	-0.242	-0.130	-0.093	0.081	0.004	0.049	0.025
4	0.257	-0.092	-0.008	0.043	0.124	-0.183	-0.092	-0.012

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.4197	-4.6824	-3.9715
S.E_Logq	0.2195	0.2195	0.2195

Fleet: Greek Longline

Log catchability residuals.

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	0.139	0.409	NA	0.120	0.679	-0.206	0.333	0.529	-0.042	NA	NA
3	-0.085	0.255	NA	0.310	0.642	-0.164	0.514	0.746	0.314	NA	NA
4	-0.311	0.152	NA	0.471	0.639	-0.218	0.372	0.730	0.379	NA	NA

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	0.548	0.177	-0.137	-0.126	-0.471	-0.310	-0.093	-0.108	-0.056	0.038
3	0.533	0.244	-0.074	0.147	-0.268	-0.153	-0.113	0.018	0.159	0.175
4	0.461	0.149	0.051	0.088	0.104	-0.159	-0.076	-0.120	0.218	0.342

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.066	-0.210	0.007	-0.136	-0.058	0.335	0.055	-0.097
3	0.076	-0.135	0.098	-0.174	-0.174	0.299	0.064	-0.140
4	0.217	0.015	0.220	-0.038	-0.131	0.112	-0.077	-0.178

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.6502	-4.9129	-4.202
S.E_Logq	0.2730	0.2730	0.273

Terminal year survivor and F summaries:

,Age 0 Year class =2015

source

scaledWts		survivors	yrcls
fshk	0.107	340	2015
nshk	0.893	516	2015

,Age 1 Year class =2014

source

scaledWts		survivors	yrcls
fshk	1	189	2014

,Age 2 Year class =2013

source

scaledWts		survivors	yrcls
Moroccan Longline	0.139	184	2013
Spanish Longline	0.327	149	2013
Greek Longline	0.327	126	2013
fshk	0.208	121	2013

,Age 3 Year class =2012

source

scaledWts		survivors	yrcls
Moroccan Longline	0.187	92	2012
Spanish Longline	0.314	75	2012
Greek Longline	0.314	63	2012
fshk	0.184	60	2012

,Age 4 Year class =2011

source

scaledWts		survivors	yrcls
Moroccan Longline	0.284	48	2011
Spanish Longline	0.284	39	2011
Greek Longline	0.284	33	2011
fshk	0.148	24	2011

,Age 5 Year class =2010

source

scaledWts		survivors	yrcls
fshk	1	18	20

Table 3c. XSA diagnostics from run with Lorenzen natural mortality.

FLR XSA Diagnostics 2016-07-18 15:49:03

CPUE data from indices

Catch data for 31 years 1985 to 2015. Ages 0 to 6.

	fleet	first age	last age	first year	last year	alpha	beta
1	Moroccan Longline	2	4	2001	2015	<NA>	<NA>
2	Spanish Longline	2	4	1988	2015	<NA>	<NA>
3	Greek Longline	2	4	1987	2015	<NA>	<NA>

Time series weights :

Tapered time weighting applied
Power = 1 over 10 years

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 10 years or the 2 oldest ages.

S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

age \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Fishing mortalities

age \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0.026	0.024	0.011	0.017	0.040	0.123	0.012	0.003	0.004	0.004
1	0.320	0.448	0.482	0.360	0.327	0.313	0.286	0.267	0.158	0.216
2	0.778	0.661	0.713	0.602	0.550	0.592	0.530	0.554	0.546	0.574
3	0.622	0.703	0.563	0.524	0.739	0.699	0.445	0.409	0.525	0.505
4	0.708	0.775	0.494	0.712	0.922	0.517	0.455	0.308	0.427	0.384
5	0.665	0.729	0.484	0.597	0.897	0.682	0.556	0.355	0.481	0.339
6	0.665	0.729	0.484	0.597	0.897	0.682	0.556	0.355	0.481	0.339

XSA population number (Thousand)

year \ age	0	1	2	3	4	5	6
2006	1313	673	411	142	67	40	46
2007	1263	847	367	149	62	28	31
2008	1051	818	402	149	60	24	15
2009	915	690	376	155	70	31	19
2010	816	610	358	162	75	29	23
2011	914	531	327	163	63	25	24
2012	812	538	289	143	66	32	40
2013	710	533	303	134	75	35	37
2014	788	474	307	138	73	46	26
2015	665	524	304	141	67	40	60

Estimated population abundance at 1st Jan 2016

year \ age	0	1	2	3	4	5	6
2016	70	442	315	136	70	38	24

Fleet: Moroccan Longline

Log catchability residuals.

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	-0.880	-0.840	-0.741	-0.459	-0.703	-0.357	-0.359	-0.646	-0.588	-0.559
3	-0.612	-0.629	-0.585	-0.476	-0.577	-0.143	-0.220	-0.505	-0.518	-0.469
4	-0.664	-0.256	-0.584	-0.438	-0.709	-0.080	-0.049	-0.355	-0.365	-0.350

age	2011	2012	2013	2014	2015
2	-0.299	0.391	0.327	0.201	0.279
3	-0.341	0.277	0.294	0.212	0.236
4	-0.205	0.316	0.103	0.072	0.200

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.2037	-4.4370	-3.7181
S.E_Logq	0.3683	0.3683	0.3683

Fleet: Spanish Longline

Log catchability residuals.

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	-0.005	-0.590	-0.672	-0.152	-0.038	-0.073	-0.013	-0.225	-0.371	-0.291
3	-0.162	-0.463	-0.478	-0.190	0.009	0.114	0.208	0.130	-0.482	-0.364
4	-0.265	-0.573	-0.313	-0.188	-0.041	-0.025	0.196	0.201	-0.085	-0.576

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	-0.125	-0.263	-0.351	-0.211	-0.065	-0.312	-0.272	-0.154	-0.118	0.069
3	-0.136	-0.201	-0.285	0.057	0.145	-0.156	-0.289	-0.028	0.097	0.208
4	-0.206	-0.290	-0.163	0.005	0.518	-0.155	-0.251	-0.160	0.159	0.379

age	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.036	-0.324	-0.225	-0.052	0.201	0.044	0.041	0.069
3	0.106	-0.253	-0.135	-0.095	0.087	0.011	0.052	0.026
4	0.256	-0.101	-0.016	0.042	0.126	-0.180	-0.088	-0.011

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.4140	-4.6473	-3.9284
S.E_Logq	0.2204	0.2204	0.2204

Fleet: Greek Longline

Log catchability residuals.

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	0.136	0.406	NA	0.115	0.678	-0.210	0.328	0.526	-0.041	NA	NA
3	-0.090	0.249	NA	0.309	0.641	-0.162	0.516	0.746	0.314	NA	NA
4	-0.313	0.146	NA	0.473	0.642	-0.213	0.377	0.734	0.385	NA	NA

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	0.540	0.171	-0.144	-0.127	-0.479	-0.316	-0.100	-0.116	-0.063	0.030
3	0.529	0.234	-0.078	0.141	-0.268	-0.159	-0.116	0.010	0.151	0.169
4	0.459	0.144	0.044	0.089	0.105	-0.159	-0.078	-0.122	0.214	0.341

age	2008	2009	2010	2011	2012	2013	2014	2015
2	-0.076	-0.217	0.003	-0.133	-0.053	0.338	0.057	-0.097
3	0.066	-0.146	0.093	-0.175	-0.168	0.306	0.067	-0.140
4	0.216	0.007	0.212	-0.039	-0.128	0.114	-0.073	-0.176

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-5.6445	-4.8778	-4.1589
S.E_Logq	0.2737	0.2737	0.2737

Terminal year survivor and F summaries:

,Age 0 Year class =2015

source

	scaledWts	survivors	yrcls
fshk	0.108	59	2015
nshk	0.892	563	2015

,Age 1 Year class =2014

source

	scaledWts	survivors	yrcls
fshk	1	191	2014

,Age 2 Year class =2013

source

	scaledWts	survivors	yrcls
Moroccan Longline	0.137	179	2013
Spanish Longline	0.327	145	2013
Greek Longline	0.327	123	2013
fshk	0.209	118	2013

,Age 3 Year class =2012

source

	scaledWts	survivors	yrcls
Moroccan Longline	0.182	88	2012
Spanish Longline	0.315	71	2012
Greek Longline	0.315	61	2012
fshk	0.188	58	2012

,Age 4 Year class =2011

source

	scaledWts	survivors	yrcls
Moroccan Longline	0.283	47	2011
Spanish Longline	0.283	38	2011
Greek Longline	0.283	32	2011
fshk	0.150	23	2011

,Age 5 Year class =2010

source

	scaledWts	survivors	yrcls
fshk	1	17	