2007 MEDITERRANEAN SWORDFISH STOCK ASSESSMENT SESSION

(*Madrid, Spain - September 3 to 7, 2007*)

1. Opening, adoption of Agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat offices in Madrid. Dr. George Tserpes, meeting Chairman, opened the meeting. Mr. Driss Meski, Executive Secretary, welcomed participants ("the Group").

The Agenda (**Appendix 1**) was adopted with some changes. The Group noted the reduced number of participants and regretted the lack of participants from countries traditionally involved in the swordfish fisheries. The List of Participants is attached as **Appendix 2** and the List of Documents presented at the meeting is attached as **Appendix 3**. The following participants served as rapporteurs:

Section	*Rapporteurs*
1, 9, and 10	P. Pallarés
2	J.M. Ortiz de Urbina
3	A. Di Natale
4	P. Kebe and G. Tserpes
5	P. Peristeraki
6	G. Tserpes
7	G. Tserpes and V Restrepo
8	J. Neilson

2. Description of fisheries

Mediterranean swordfish fisheries are characterized by high catch levels. It should be noted that average annual reported catches (on average about 15,177 t from 1984 to 2005; **Table 1**) are similar to those of the North Atlantic. The Mediterranean is a much smaller body of water compared to the North Atlantic. However, the potential reproductive area in the Mediterranean is probably relatively larger than that in the Atlantic. Further, the productivity of the Mediterranean Sea is thought to be very high.

Swordfish fishing has been carried out in the Mediterranean using harpoons and driftnets (drifting gillnets) at least since Roman times. Currently, swordfish fishing is carried out throughout the Mediterranean Sea. The biggest producers of swordfish in the Mediterranean Sea in the recent years (1997-2005) are Italy (44%), Morocco (23%), Greece (10%), and Spain (9%). Also, Algeria, Cyprus, Malta, Tunisia, and Turkey have fisheries targeting swordfish in the Mediterranean. Incidental catches of swordfish have also been reported by Albania, Croatia, France, Japan, Libya, and Portugal. The Group recognized that there might be additional fleets taking swordfish in the Mediterranean, for example, Israel, Lebanon, Egypt and Monaco, but the data are not reported to ICCAT or FAO. Furthermore, a paper presented at this meeting (SCRS/2007/115, by Orsi Relini *et al.*) provides information about the activity of a French gillnet fishing fleet which operates in the Ligurian Sea, also within the marine "Pelagos" Mammal Sanctuary. According to this report, the total number of driftnetters has grown constantly, from 46 vessels in year 2000 to more than 100 vessels in 2006, in the studied area, and these vessels are reported to catch also swordfish. The SCRS points out that catches from this fleet have never been reported to ICCAT.

Mediterranean total swordfish landings showed an upward trend from 1965-1972, stabilized between 1973-1977, and then resumed an upward trend reaching a peak in 1988 (20,365 t; **Table 1, Figure 1**). The sharp increase between 1983 and 1988 may be partially attributed to improvement in the national systems for collecting catch statistics. Since 1988, the reported landings of swordfish in the Mediterranean Sea have declined, and since 1990, they have fluctuated between about 12,000 to 16,000 t. In 2005 catches were 14,601 t.

In recent years, the main fishing gears used are surface longline (56% of the total catch) and gillnet. Most of the previously mentioned countries operate longline fisheries, and in 2005 driftnet fisheries reported were mostly limited to Morocco. There are also other countries known to be fishing with driftnets that do not report their catches. Swordfish are also caught with harpoons and traps, but traps do not target swordfish. It should be noted that since the beginning of 2002 driftnet fishing has been banned in EU countries and this will influence the catch data beginning in 2002.

There is a high demand for swordfish for fresh consumption in most Mediterranean countries.

A description follows for fisheries of those nations that attended the meeting. See **Figure 2** for reference to particular locations mentioned below). For additional information about fisheries for some nations not attending the meeting see the 2003 Detailed Report.

EC- Greece

The Greek swordfish fleets exclusively use drifting longlines and operate throughout the eastern Mediterranean basin. About 250 vessels were involved in the swordfish fishery in 2006. Most of them entered the fishery occasionally, mainly during the summer months.

The swordfish fishing season lasts from February to the end of September, as there is a closed season in the Greek Seas from October to January, aiming to protect recruits.

Swordfish comprises the main bulk of large pelagic catches in the Greek seas and its production during the 2006 fishing season was estimated at 1,375 t. The Greek swordfish production is rather stable over the last decade.

EC- Italy

The Italian swordfish fishery has a long historical tradition. Recent catches usually account for a total between 6,000 to over 7,000 t per year, with slight variability from year to year, according to various factors. The largest fishery, in terms of number of vessels, is the longline fishery with about 1200 vessels from 7 to over 30 meters in length. The fishery is currently carried out from late February to December, in many Mediterranean areas. The most significant changes in the fishing strategies occurred in the last ten years, due to the increase in tuna longlining in the spring, implying a parallel decrease in swordfish longlining. This is changing again since 2006, when the swordfish fishery became more relevant due to different conditions in the bluefin tuna fishery. In the last two years, some vessels have started fishing trials using very deep longline in the southern Tyrrhenian Sea but information on this activity is not available. The swordfish target longline fishery provides the highest catch, while smaller quantities are provided by the tuna longline fishery as by-catch. The driftnet fishery was formerly the most important fishery for swordfish but, according to the EC Regulation, it has been banned since January 2002. Recent catches now come from unclassified nets. The traditional harpoon fishery in the Strait of Messina catches very small quantities of swordfish, while even smaller catches are reported in tuna traps.

The former EC legislation concerning the minimum size for Mediterranean swordfish (120 cm LJFL) was cancelled in 2000 and since then the previous measure, which already existed in the Italian regulation (140 cm UJFL), came into force again.

EC- Spain

The Spanish swordfish fishery in the Mediterranean dates back to the early 20th century. Its expansion was initiated in the 1960-1970 period, and it has been stable since the 1980s (SCRS/2003/042). Fishing is carried out mainly by surface longline. Swordfish are also caught occasionally by semi-pelagic longline ("piedri-bola") and as by-catch of the longline fishery that targets bluefin tuna and albacore.

The Spanish swordfish fishery in the Mediterranean is characterized by the heterogeneity of the fleet and by the composition of the gears, as well as by the changes in fishing strategy. The fleet, which can be comprised by as many as 145 vessels, has evolved and currently presents the following average characteristics: 16 m in length, 166 hp engines, and 28 GRT. In addition, the traditional longline gear is being substituted by the American style longline, which is being used by about 29% of the vessels. The fishing area extends from the Iberian Peninsula to 06ºE and up to the limits of the Moroccan and Algerian territorial waters. The major activity takes place in the summer and autumn months.

In 2006, swordfish catches amounted to 1,592 t (of which 1,190 t were caught by surface longline), similar to the catch level for the period 2000-2002. The American style longlines showed an increase in the mean weight of the catch. As regards fishing effort, it has been stable recently.

Swordfish fishing by surface longline in the Mediterranean is subject to regulation by the Decree of 27 July 2006 (APA/2521/2006) that regulates the technical characteristics of the gears and the minimum size for the catch (90 cm LJFL), among others.

Morocco

The Moroccan swordfish fishery in the Mediterranean Sea has been developed since 1983. About 320 vessels are currently involved in this fishery, using mainly driftnet and surface longline (SCRS/2006/125). The boats are, on average, 13 m in length, 13 GRT, and have 110 hp engines.

The most important fishing grounds are located in the Strait of Gibraltar and the southern Alboran Sea. The first area remains the most important in terms of the size of the fleet targeting swordfish. In the Strait of Gibraltar, swordfish fishing takes place throughout the year, with a highest activity from April to October. In the southern Alboran Sea, fishing occurs almost the entire year. Minor catches of swordfish are also taken occasionally by traps and purse seiners.

After the peak landings of 4,900 t registered in 1997, the swordfish catch dropped to stabilize around 3,000 t. In 2005, the catch decreased by about 22% with respect to the previous year. The remarkable change in this fishery during the five last years is the significant reduction in driftnet catches and the increase in longline catches, due to the implementation of the National Plan for banning the driftnet activity following the ICCAT Resolution related to the ban of driftnets in the Mediterranean Sea .

The by-catches of this fishery include mainly small tunas, sharks, billfishes and bluefin tuna.

The size of the landed fish varies according to the fishing area. In the Strait of Gibraltar, the mean size of swordfish is about 145 cm. In the Alboran Sea, the fish have a smaller mean size (106 cm) (SCRS/2003/053).

In Morocco, the regulation of swordfish fishing concerns the establishment of a minimum commercial size of 120cm (25kg) (Decree No.1154-88 of 3 October 1988); the establishment of 2.5 km maximum length for driftnets; the prohibition of mesh size less than 400 mm (Circular No.1232 of 11 March 1991), and a freeze on fishing effort through the suspension of the investments for vessel construction since 1992(Circular note No. 3887 of 18 August 1992).

3. Biological data

According to the available information (Anon. 1996), in previous years only a few swordfish from the Mediterranean are reported to exceed 200 kg. In recent times, a slightly higher percentage of large swordfish has been reported from several fisheries. The majority of the Mediterranean catch is comprised of individuals less than 3 years old and the average size is much lower than in the Atlantic. The fact that the fishery is still mostly based on 2-3 young year-classes makes it vulnerable to recruitment changes.

Growth studies of swordfish in the Mediterranean, carried out by several teams, using both anal fin spines and length frequency data, all show a similar pattern of growth. It is also well known that Mediterranean swordfish have sexually dimorphic growth, with males having a lower length-at-age, and achieving a smaller asymptotic size than do females. The growth equations adopted by the GFCM/ICCAT Working Group in 1995 are those published by Tserpes and Tsimenides (1995) and still used as follows:

$L_{inf} = 238.60\ (1 - e^{-0.185\ (t + 1.404)})$ for sexes combined
$L_{inf} = 203.08\ (1 - e^{-0.241\ (t + 1.205)})$ for males
$L_{inf} = 226.53\ (1 - e^{-0.210\ (t + 1.165)})$ for females.

A very recent paper (SCRS/2007/117, by Valeiras *et al.*) found different growth rates in the swordfish present in the western Mediterranean. This paper provided growth equations by sex, based on anal spines reading. It is important to note that the sampling was conducted in an area where mixing between the Atlantic stock and the

Mediterranean stock is possible. According to this paper, the growth rate is lower compared to previous studies, particularly at young ages. SCRS considers that the situation on this crucial area of the Mediterranean should be further investigated, due to its relevance for the understanding of the mixing between the two stocks.

Spawning generally occurs in spring and summer, with peaks in June and July, and variations in timing may be due to a variety of environmental and oceanographic influences. The most important spawning areas in the Mediterranean, according to current knowledge, are around the Balearic Islands, the southern and central Tyrrhenian Sea, the Ionian Sea and the Strait of Messina, and there is a strong indication that spawning areas also exist in the eastern Mediterranean. Juveniles are found throughout the Mediterranean but often tend to concentrate close to the coast, mostly in autumn.

According to a review of the biological information available for the Mediterranean swordfish (SCRS/2001/050), major differences with the Atlantic stock have been noticed. Mature females as small as 110 cm LJFL have been observed and the estimated size at which 50% of the female population is mature occurs at 142 cm (SCRS/95/045). According to the growth curves used by SCRS in the past for Mediterranean swordfish, these two sizes correspond to 2 and 3.5 year-old fish, respectively. At 125 cm about 20% of the females in the Mediterranean would be mature. Males reach sexual maturity at smaller sizes.

Table 2 summarized biological information available for the Mediterranean swordfish.

Environmental factors

It is well known that swordfish catches are highly affected by prevailing environmental factors. For example, the catches of swordfish are affected mainly by the presence of a stable thermocline during late spring and summer. In fact, when using driftnets, all catches are done just above the thermocline, where spawning occurs. Swordfish catches are also affected by the moon phase. In the presence of a full moon, higher catches are recorded for traditional longlines, whilst lower catches are recorded for driftnets (SCRS/94/86, SCRS/91/65). Areas characterized by higher turbulence also seem important for swordfish. Higher catches are recorded in the Tyrrhenian and Alboran Seas.

A paper presented at this meeting (SCRS/2007/115 by Orsi Relini *et al.*) provides a study about the correlation between winter North Atlantic Oscilation (NAO) and the longline CPUE series in the Ligurian Sea over the period 1990-2006. According to this study, an inversely related correlation has been detected, even if other environmental factors should be possibly taken into account. This study also reports that swordfish recruitment in the Ligurian Sea does not show any correlation with the winter NAO index. Temporal differences of SST have been also related to the growth rate of 0 group swordfish in the eastern Mediterranean (Peristeraki *et al.*, 2007).

During this meeting, it was discussed that other possible correlations could be explored and studied, including those between the apparent distribution and concentration of swordfish and the eastern Mediterranean Transient (EMT) index, which seems a very important factor to be taken into account in the Mediterranean, able to induce relevant changes in the pelagic environment, in the spatial and temporal distribution of many pelagic species including swordfish and, then, in the fishery.

It was recommended that more work should be carried out in order to identify better the effects of the environment on swordfish biology, ecology and fishery.

4. Catch data

Two documents related to catch data were presented.

Document SCRS/2007/106 summarized the information on the by-catches and discards data in the Greek swordfish fishery. Landed swordfish represent 84% of the total catch in weight.

SCRS/2007/108 described the discards of undersized swordfish in the Greek longline swordfish fishery. It was noted that between 15 to 17 tons were discarded yearly. After some discussion the Group noted that discards information was not reported in general to the Secretariat in the Mediterranean area, by countries other than Greece.

4.1 Task-1

In **Table 1** the Secretariat presented the Mediterranean swordfish catch data reported to ICCAT for the years 1950 to 2006 by flag, fleet and gear. The Group decided to focus only on data up to 2005 as the 2006 reported information is incomplete. During the revisions of the catch table, the lack of the Tunisian catch for 2005 and the Algerian catch for 2003 was noted. The Group was also very concerned about the low level of swordfish reported by Italy for some past years. In order to fill the gaps in the catch time series the Group decided:

- To carry forward the 2004 Tunisian catch (791 t) to 2005.
- To use the 665 t reported in the Algerian Annual Report for 2003 in the assessment and as unofficial data in the Task I database.
- To re-adjust the Italian catches in 1990 (from 5,224 t to 9,104 t), 1991 (from 4,789 t to 8,538 t) and 1995 (from 6,725 t to 7,350 t) following the Italian scientists' advice.

In addition, the ICCAT Task I and FAO FIGIS data were compared and found to be in agreement for the period after 1967, but showed discrepancies for the period from 1950 to1967. The Group decided to adopt the higher catch figures held in the FIGIS database and recommended that the ICCAT and FAO datasets be harmonized for the period 1950-1967 as they already are for later periods and other species.

Accordingly, **Table 1** was updated and presented again by the Secretariat and approved by the Group.

4.2 Size and catch at size

The catalog of all Task I and Task II had been distributed earlier (April 2007) to all potentials participants in order to review the gaps and deficiencies and to submit revisions to the Secretariat. Unfortunately, no feedback was received. During the meeting, the same file was updated and presented again to the Group. At the beginning of the meeting, new Task II size information were available for Moroccan gillnet for the years 1999-2005 and also for Italian gillnet and longline by month. According to the new Italian size sample available by fleets, the Group decided to breakdown the Italian catch reported by area in order to match it with the size samples.

The Secretariat presented the substitution rules used (**Table 3**) to create the catch at size following the rules adopted in 2003 (SCRS/2003/015 and SCRS/2003/050). The catch-at-size file summarized in **Table 4** for the years 1985 to 2005 were converted to catch at age (**Table 5**) by applying the same slicing procedure used in 2003 and the same growth equation (inverse Von-Bertalanffy equation) .

5. Relative abundance indices

Five papers concerning catch rate data were presented.

SCRS/2007/118 presented the updated standardized catch rates for swordfish from the Spanish longline fleet in the Mediterranean Sea for the years 1988-2005. Data included 18,630 observations that were analyzed by means of GLM techniques. The effects of year, area and quarter were considered, and all factors (including interactions) were significant. Annual standardized CPUEs declined rapidly from 1988 to 1992, and more gradually until 1999. It has remained stable thereafter.

SCRS/2007/107 presented annual standardized catch rates from the Italian and Greek fleets operating in the central eastern Mediterranean. The analysis included data from the Greek longline fisheries operating in the eastern Mediterranean and the Sicilian longline fisheries operating in the Tyrrhenian Sea and the Straits of Sicily, for the years 1987-2005. Indices were estimated by means of GLM techniques and results did not demonstrate the presence of any particular trend over time.

SCRS/2007/115 presented a time series of nominal catch rates from the Italian swordfish longline fleets operating in the Ligurian Sea, from 1990 to 2006. No significant trend was observed during the studied period of time. An inverse relation of the swordfish CPUE with the NAO index values was also observed. The Group was pleased to receive this contribution dealing with environmental effects on catch rates, an area where the state of knowledge has been considered deficient. However, the Group encourages further investigation about the effects of environmental and oceanographic factors specifically related to the Mediterranean Sea.

SCRS/2007/116 presented an analysis of the standardized catch rates of the Moroccan driftnet fishery from the Mediterranean Sea. Nominal CPUE, by month and boat, from 1998 to 2006 were analyzed by means of GLM techniques. Standardized catch rates did not show any trend throughout the years. It was commented that high CPUE values were observed compared with other Mediterranean driftnet fisheries, which might be attributed to specific characteristics of the exploited area, which extends around the Gibraltar Straits.

SCRS/2007/119 presented a detailed description of the Italian nominal CPUE time series (1985-2006) from the southern Italian gillnet and longline fleets. The gillnet CPUEs showed a slightly increasing trend, while the longline CPUEs showed a moderately decreasing trend. The exploitation pattern of the fleets was considered stable for the last two decades.

6. Stock status results

6.1 Production model evaluations

6.1.1 ASPIC

The non-equilibrium surplus production model (ASPIC, cataloged version 5.16) was applied to catch and effort data for Mediterranean swordfish. The input data used in these analyses are presented in **Table 6** In order to better inform the model, recorded catches from 1950 to 2005 were used. The ICCAT Task I and FAO FIGIS data were compared and found to be in agreement for the period after 1967, but showed discrepancies for the period from 1950 to1967. The Group decided to adopt the higher catch figures held in the FIGIS database and recommended that the ICCAT and FAO datasets be harmonized for the period 1950-1967 (they are already harmonized for later periods and other species). For these analyses, a composite CPUE pattern was developed as the weighted average of the Italian longline (SCRS/2007/107), Greek longline (SCRS/2007/107), Moroccan gillnet (SCRS/2007/116), Italian Gillnet (Anon. 2004), Spanish longline (SCRS/2007/118), and Japanese longline (see Anon, 1996) catch rate time series. It was noted that the Japanese data are related to the swordfish by-catch in the tuna longline fishery. Weighting was used in this case, due to concerns that some of the fleets from which time series were available represented a relatively small area of fishing and/or typically represented small volumes of the total Mediterranean catch of swordfish. In this case, a weight of 4 was assigned to the Italian and Moroccan indices, a weight of 2 to the Greek and Spanish time-series, and a weight of 1 to the Japanese time-series. The resulting CPUE pattern is shown in **Figure 3**.

The production model was first fit to catch and effort for the period 1968-2005 (reflecting the assessment conducted in 2003). In this case, there was insufficient information in the data with which to freely estimate all model parameters. The model convergence could be achieved by fixing the initial biomass ratio, but the Group considered that assuming the biomass was at an unfished level (K) in 1968 was an incorrect one in light of the reported catches since 1950. The Group decided to fix B_{1968} at .75K for this run as a better representation of the situation at that time. In order to inform the model and possibly improve estimates of stock productivity and current status, the data from 1950 through 2005 were then fit. In this case, it was possible to freely estimate all model parameters, although when doing so the modeled stock dynamics prior to the mid 1980s was unexpected, showing a build-up of biomass from very low levels in the early 1950s. Therefore, the Groupdecided to also conduct a run assuming the stock was at an unfished level in 1950 even though some catches are known to have occurred before that time. Across the models, (see **Figure 4** and **Appendix 4** for details supporting the model fits), the estimates of population status in the most recent year indicated a stock that was at or somewhat below the ICCAT Convention objective while recent fishing mortality was somewhat above the level that would permit the stock to attain the level necessary to attain the Convention objective (MSY levels). While the uncertainty in these results based on bootstrapping is large (**Figure 5**), the weight of the evidence supports these conclusions (**Table 7**). The median results of the model outcomes (**Figures 6a, b**) indicate that the fishery underwent a rapid expansion in the 1980s resulting in F's likely at or above F_{MSY} and a slowly declining stock which has recently likely fallen below the level which can support MSY over the long-run (**Figures 7a, b**).

6.1.2 Tserpes and McAllister Method (TSM)

A non-equilibrium production model was applied based on the approach followed in SCRS/2007/109. The model used total catch data for the 1987-2005 period and a combined CPUE series, the same as used in ASPIC. The XSA estimates of average F were used to estimate the harvest rate at the beginning of the examined period and consequently the initial biomass fraction

Based on the ICCAT XSA assessment the values of F and M for the beginning of the period were fixed to 0.42 and 0.20 respectively. The best fit was provided for r = 0.67 and k=90547mt. Observed and predicted indices are shown in **Figure 8**. Based on the above estimates equilibrium *MSY* was found to be equal to 15166mt. The corresponding rates for fishing mortality and biomass are: $F_{msy} = r/2 = 0.33$ and $B_{msy} = k/2 = 45273$ mt. Annual catches in the latest years are around to *MSY*, while stock biomass levels are stable but about 12% lower than B_{msy} (**Figure 9**).

6.2 Age structured models

6.2.1 XSA assessment

The XSA model was implemented using the code developed in R-language (see **Appendix 5**) under the auspices of the FLR-project (Kell *et al.*, 2007; http://www.flr-project.org/). Catch-at-age tables included ages 0 to 10 (plus group) and six tuning data sets were available from the following fleets: Italian longliners–ITLL (SCRS/2007/107), Greek longliners-GLL (SCRS/2007/107), Moroccan gillnetters-MODN (SCRS/2007/116), Italian gillnetters-ITDN (SCRS/2003/040), Spanish longline-SPLL (SCRS/2007/118), and Japanese longliners-JALL (see Anon, 1996). Greek, Italian, and Spanish longline CPUE series were considered as representative of 2-9 age-group abundances, while for the rest, the 3-9 age-group was assumed. Full maturity was assumed from age 4 onwards and 50% at age 3. Zero maturity was assumed for the younger ages.

A series of preliminary runs with different parameterization were performed and based on the fleet catchability diagnostics the final model was based on runs assuming q independent of year-class size for all ages except 0 and 1, constant q after age 6, as well as population and F shrinkage. Natural mortality was considered equal to 0.2. **Figure 10** llustrates the catchability residuals by fleet and age. In general, residuals do not show any specific pattern for the younger more abundant age-classes, while they are positively biased in the older ages.

Tables 8 and 9 present the estimates of fishing mortality and population numbers-at-age, respectively. As in the 2003 assessment, recruitment appears to be consistent without any especially strong or weak year classes. The mean Fs for ages 2-5 are plot against year in **Figure 11**.

Both total and spawning stock biomass estimates remained stable during the last decade (**Figure 12**).

6.2.2 VPA

The software VPA-2BOX was used to conduct a sequential population analysis using the same input data as in the XSA analyses. The following assumptions were made:

- Indices: A lognormal error structure was assumed for all indices. The index selectivities were estimated using the partial catches (including all ages, from 0 to 10+).
- F ratios: $F_{10+}/F_9 = 1.0$ in all years.
- Terminal year Fs: Estimated for ages 5 and 8. Assumed values: $F_0=0.01*F_5$, $F_1=0.4*F_5$, $F_2=F_5$, F_3=F5, $F_4=F_5$, $F_6=F_8$, $F_7=F_8$, $F_9=F_8$.

The fit to the data was poor. The coefficients of variation for the estimates of F5 and F8 in 2005 were 15% and 81% respectively. The fits to the individual indices were rather poor in some cases (see **Figure 13**).

The Group examined the estimated selectivities at age for the various indices (**Figure 14**) and concluded that they seemed reasonable, given the size composition of the catches for the corresponding fleets.

The overall results of the model fit are given in **Table 10** and **Appendix 6**. In terms of stock size, the estimated recruitment (age 0) trend is rather constant at slightly above one million fish per year, and the trend for ages 2 to 8 is a declining one (**Figure 15**). The estimated trend in spawning biomass shows an overall decline of 40% between 1985 and 2005, but the level of exploitable biomass is estimated to have varied without a trend (**Figure 16**).

The estimates of fishing mortality (apical values) are shown in **Figure 17**, suggesting that it has varied without a trend during the last decade. The estimated selectivities at age by 5-year time periods are shown in **Figure 18**, suggesting that selectivity has remained relatively constant since 1990.

6.2.3 Comparison of the age-structured results

XSA and VPA-2BOX are different implementations of sequential population analyses. For this Mediterranean swordfish assessment, they were used with the same data and similar, although not identical, assumptions.

The Group compared the results obtained with both methods in terms of recruitment, fishing mortality, and biomass trends, and found them to be very similar (**Figure 19**). Small discrepancies are evident only for older ages (e.g., F at age 9). But, overall, both methods provide a very similar perception of stock status.

6.2.4 Equilibrium yield-per-recruit analyses

The VPA-2Box and XSA results were used as the basis for yield-per-recruit analyses which are a form of long-term projection. The input age-specific vectors are given in **Table 11**. The resulting equilibrium estimates for several biological reference points are given in **Table 12**. These are per-recruit results, scaled to a recruitment level of 1,059,533 age-0 swordfish (the mean 1985-2002 level estimated in the VPA-2box). **Figure 20** shows the equilibrium yield levels obtained for different fishing mortality multipliers of the current selectivity vector.

Bootstraping (1,000 iterations) was used to characterize the uncertainty in the VPA-2BOX assessment of recent status for Mediterranean swordfish. There is a high degree of variability in the estimates of recent status, but all of the bootstrap outcome indicate this stock is both overfished and undergoing overfishing (**Figure 21**).

6.2.5 Summary of age-structured assessment results.

The two age-structured models used in the assessment give very consistent results. During the past 20 years, fishing mortality has fluctuated at high levels, usually doubling the value of natural mortality. The value of natural mortality is sometimes used as a proxy for F_{MSY} in data-poor situations, which would suggest that overfishing has occurred during this time. Both models estimate that spawning biomass has declined between 1985 and 2005 (a decline between 24% and 38%, depending on the model). On the other hand, recruitment has varied (CV $\approx$ 12%) during this time period without a trend.

Results of equilibrium yield-per-recruit analyses that are based on age-structured assessments also indicate that growth overfishing is taking place. Depending on the model used, current (2005) fishing mortality is 1.7 or 2.1 times higher than the value that would maximize yield per-recruit. In the case of the VPA, assuming a constant level of recruitment, a 69% reduction in fishing mortality to the Fmax level would result in a modest (7%) increase in long-term yield and a substantial (more than double) increase in spawning biomass.

In addition, current F is expected to result in a spawning stock biomass per recruit (SPR) at about 8% of the unfished condition, a level which is considered to result in a non-negligible risk of rapid stock decline. Fishing at F_{MAX} given the current selectivity would be expected to result in an SPR of 20%.

Using F_{MAX} as a proxy for Fmsy, the Convention's objective, suggests that the Mediterranean swordfish stock is in an overfished condition and that overfishing is taking place (**Figure 22**). Note, however, that these conclusions are based on deterministic analyses of the available data. The level of uncertainty in these estimates has not been evaluated.

6.3 Stock status summary

Two forms of assessment, both with high degree of uncertainty, gave a consistent view of declining stock abundance, but differed in the extent of the decline, in the sense that some models suggested little changes in the last decade. Estimates of population status from production modeling using a longer time-series of catch and effort for which we have less confidence indicated a stock level that was most likely about 10% below that necessary to achieve the ICCAT Convention objective while recent fishing mortality was about 25% above the level that would permit the stock to attain MSY levels. The results of the production model assessment indicate that the fishery underwent a rapid expansion in the 1980s resulting in Fs likely at or above F_{MSY} and a slowly declining stock biomass which has recently most likely fallen below the level which can support MSY. Estimates of stock status from virtual population analysis using a shorter time series of catch and effort data for which we have more confidence, indicated a relatively stable spawning stock level and stable recruitment over the past 20 years, but that level is less than half that necessary to achieve the ICCAT Convention objective and estimates of recent fishing mortality rates from this form of assessment are about twice that which, if continue into the future, is expected to drive the spawning biomass to a very low level (about 8% SPR) within a generation.

Those low levels are considered to give rise to non negligible risks of rapid declines in the stock, although no such a signal has yet been observed in the Mediterranean swordfish fisheries.

7. Projections

7.1 Production model projections

The combined production model bootstrap outcomes were projected forward under several different future constant catch scenarios. Catches in years 2006 and 2007 were assumed to have been at the 2005 level (14,600 t) and catches in subsequent years through 2015 were assumed to equal either 10,000, 12,000, 14,300 (the approximate MSY) or 16,000 t. The projections indicate that catches in excess of 12,000 t starting in 2008 are likely to result in future decline in stock status (**Figure 23**).

7.2 VPA Scenarios

The VPA-2BOX model bootstrap outcomes were projected forward under several different future constant catch scenarios. Projected recruitment was taken as a random draw from the 1985-2002 time series and the recruitments (and cohort strengths for the corresponding ages) for 2003-2005 year classes were also assumed to be of the same dimension. Catches in years 2006 and 2007 were assumed to have been at the 2005 level (14,600 t) and catches in subsequent years through 2015 were assumed to equal either 10,000, 12,000, 14,300 (the production model approximate MSY) or 16,000 t. The projections indicate that catches in excess of 14,000 t starting in 2008 are likely to result in future decline in stock status (**Figure 24**).

Using the Fisheries Library in R (FLR) framework that was developed in the frames of the European Fisheries Management System (EFIMAS) project (http://www.flr-project.org/), four exploitation scenarios were applied.

The operational model used in all scenarios was based on the estimated (through XSA) stock population at age at the beginning of the year 2000. This was used as a starting population and each projection scenario was simulated 250 times for a period of 20 years by assuming:

a) Natural mortality equal to 0.2
b) An empirically estimated Beverton-Holt S/R model. As VPA results has not allowed estimation of model parameters (due to low contrasts), those were estimated empirically (Hilborn & Walters, 1992) assuming that half of the current stock sized will produce about half of the maximum recruitment.

The initial vector of abundance at age and the predicted recruitment from the S/R model, were modelled by assuming normally distributed errors with CVs equal to 15% and 10%, respectively. Thus, the corresponding values were drawn randomly from the assumed distributions.

All scenarios apart from the first one, attempt to examine the effects of global fishery closures during the recruitment period. Recruitment extends from September to February, with its peak from October-January. Such closures have been extensively discussed in the past (Di Natale *et al*., 2002) and it has been assumed that they will mainly affect the fishing mortality of age 0 fish (up to 71cm of LJFL in the catch-at-age table).

Scenario 1: The current exploitation pattern

It was assumed that Fs at age will be equal to the average values estimated for the 1995-1999 period for the whole of the projection period. Based on YPR, this F level is about twice that which would permit the stock to attain MSY level and in the long-run, the expected spawning stock biomass would be around 50% of B_{MSY} or around 10% of the unfished biomass, which is considered very low and resulting in non-negligible risk of rapid stock decline although such a signal has not yet been observed in the Mediterranean swordfish fisheries.

Results are summarized in **Figure 24**. The scenario indicates a stable production pattern with annual catches being around to 14,000-15,000 t (probability > 50%) of which juveniles equal 5,800-6,200 t. The number of juvenile fish in the catch will mostly vary from 380,000-420,000 fish corresponding to 72-74% of the total catch number. In general, the reported rates for the period 2000-2004 are in the range of the model predicted values.

Scenario 2: A two-month closure during the peak of the recruitment period

As the Mediterranean swordfish spawns from May-July (Rey 1988, Cavalaro *et al.*, 1991, Tserpes *et al.*, 2001), it was assumed that such a closure would reduce fishing mortality of the 0-age fish (those having LJFL < 71cm) in the catch at age matrix) by 50%. Taking into account that throughout the Mediterranean much more fishing pressure is exerted on the stock from late spring to middle autumn (Anon. 2004), it was considered that this closure will reduce global fishing effort by 10%. Assuming that fishing effort is proportional to fishing mortality infers that a similar reduction in fishing mortality is expected for the rest age classes.

Results are summarized in **Figure 25**. The scenario indicates that application of such a closure would initially result to a small decrease of the current production levels, which however will be after 6-7 years stabilized around to 15,800-16,200 t. Juvenile catches will be stabilized to 5,700-6,100 t and their number will be around 370,000-400,000 fish, representing as much as 67-71% of the total catch. This projected F level is about 1.8 times higher than that which would permit the stock to attain MSY level and the expected spawning stock biomass in the long-term would be around 12% of the unfished biomass and about 60% of B_{MSY}.

Scenario 3: A four-month closure during the peak of the recruitment period

It was assumed that such a closure would reduce fishing mortality of the 0-age fish by 90% and the global fishing effort by 20%.

Results are summarized in **Figure 26**. The closure would initially result in a 10-15% decrease of the current production levels, which however will be after 7-8 years stabilized around to 17,000-17,800 t. Juvenile catches will be stabilized to 5,600-6,000 t and their number will be around 350,000-380,000 fish, representing as much as 65-67% of the total catch. This projected F level is about 1.6 times higher than that which would permit the stock to attain MSY level and the expected spawning stock biomass in the long-term would be around 13% of the unfished biomass and about 70% of B_{MSY}.

Scenario 4: Closure for the whole recruitment period

It was assumed that such a closure would practically eliminate fishing mortality of the 0-age fish and reduce the global fishing effort by 40%.

Results are summarized in **Figure 27**. Initially the closure would result in an important decrease (about 40%) of the current production levels. Production will be stabilized after 8-10 years at about 18,500-20,000 t. Similarly, juvenile catches will be stabilized at around 4,800-5,100 t and their number will be around 310,000-330,000 fish, representing as much as 59-63% of the total catch. This projected F level is the outcomes closest to F_{MAX}, which would permit the stock to attain an MSY-proxy level and the expected spawning stock biomass in the long-term would be around 20% of the unfished biomass and about B_{MSY}.

Conclusions

Results indicate that seasonal closures will be beneficial in increasing the catch levels and reducing the volume of juvenile catches in the medium term. As the Group believes that discards included in the catch-at-age table are underestimated, there is a possibility of fishing mortality underestimations of the 0-group. Hence, in reality, seasonal closures might be more beneficial than currently estimated. In addition to the yield considerations reported here, seasonal closures would also be expected to result in a greater economic return for the fishery, since small fish obtain lower prices for fishermen on a per kilogram basis. However, such economic benefits have not yet been quantified.

Results demonstrated that the longer the closure, the more beneficial it will be in the long-term (**Figure 28**), although production decreases are always expected in the short term. Such decreases are most important in the case of Scenario 4, which is the closest to reducing F to F_{MAX}. The positive effects of Scenario 2 may be smaller than currently estimated especially if the two-month closure is applied in months of low fishing activity (December-January) resulting in lower mortality reductions than currently assumed.

7.3 Summary of projections

The assessment of Mediterranean swordfish indicates the stock is below the level which can support MSY and that current fishing mortality exceeds F_{MSY}. The degree to which biomass is below B_{MSY} and F is above F_{MSY}

differs between assessment models. In any case, fishing mortality (and near-term catches) needs to be reduced to move the stock toward the Convention objective of biomass levels which could support MSY and away from levels which are considered to result in a non-negligible risk of rapid stock decline. While one modeling approach indicates the current stock status is only about 12% below B_{MSY}, it also indicates that future catches in excess of 12,000 t will not result in improvement in stock status. In contrast, the modeling approach that provides a more pessimistic view of current status, indicates future catches that allow rebuilding are somewhat higher, up to about 14,000 t, assuming that the current high selectivity for juvenile fish continues and recruitment does not improve.

Seasonal closure projections that assume no compensation in effort, no interaction with other management actions in place and an improvement in recruitment with increasing spawning stock biomass (SSB), are forecast to be beneficial in moving the stock condition closer to the Convention objective, resulting in increased catch levels in the medium term, and reductions in the volume of juvenile catches. Seasonal closures, however, especially the longer ones, would result in significant catch reductions within the first few years after their application. A six-month (September through February) closure of the Mediterranean to swordfish fishing is projected to permit the stock to rebuild to about MSY levels within a generation (about 7 years) and could result in sustainable catches on the order of 18,500 t if recruitment improves with gains in SSB. A four-month closure (October-January) projects some improvement in SSB, to about 65% of B_{MSY} within a generation and could result in sustainable catches on the order of 18,500 t if recruitment improves with gains in SSB. A two-month closure (October-November) projects a much smaller gain in SSB to about 50% of B_{MSY} and a catch level near the average of the past 20 years, if recruitment does not decline. These effects would be diminished, especially if closure is applied in months of low fishing activity (December-January). Results of the seasonal closure projections are summarized in **Figure 29**.

8. Recommendations

8.1 Statistics and research

- *Data submission.* Data must be reported by the ICCAT deadlines, even when no analytical stock assessment is scheduled. Historical catch, effort and CPUE data, if revised or when requested by the Secretariat, should also be provided, if possible. If the catch and size data are provided to the Secretariat by the specified deadlines, then the Secretariat will provide the catch-at-size and the adopted substitution table to the relevant scientists for review in advance of the meeting. This will then allow the stock assessment session to proceed immediately with analyses, without the delay associated with recalculating the catch-at-size during the meeting due the late submission of new data on the first day of the meeting. This continuing problem caused difficulty for the current assessment, requiring the Group to make assumptions such as the carry-forward of catch from one year to the next or substitutions for Task II data for those countries that did not report as required.

- *Participation by ICCAT Contracting Parties in the assessment Group.* The Group noted that several Contracting Parties, in spite of having significant swordfish fisheries, did not send national scientists to the 2007 assessment. This has obvious negative consequences for the Group's ability to accurately interpret fisheries trends, and provide better advice to the Commission.

- *Sampling schemes.* The Group noted that the COPEMED Program, which has greatly improved the collection of data on statistics and biology, has ended and new national and international initiatives are needed. There remain several areas for improvement in provision of basic catch and effort data and size samples. The Group noted the improvements in the data obtained in several countries, due to the new EC data collection regulations.

- *Catch*. All countries catching swordfish (directed or by-catch) should report catch, catch-at-size (by sex) and effort statistics by as small an area as possible (5-degree rectangles for longline, and 1-degree rectangles for other gears), and by month. It is recommended that at least the order of magnitude of unreported catches be estimated. The Group noted that it is important to collect size data together with the catch and effort data to provide meaningful CPUEs. After comparing the ICCAT Task I and FAO FIGIS data, the Group decided to adopt the higher catch figures held in the FIGIS database for years prior to 1968 and recommended that the ICCAT and FAO datasets be harmonized for the period 1950-1967 as they already are for later periods and other species.

- *Discards*. Participating countries improve their estimates of discards of juvenile swordfish, when applicable, and submit such information to the ICCAT Secretariat.

- *CPUE*. CPUE series should be developed 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 (5-degree rectangles for longline, and 1-degree rectangles for other gears). Although CPUE by age is the usual input for the age-structured analyses, the Group recognized that this must be based on an increased level of sampling, not merely substitution of the current data. Therefore, it is recommended that increased sampling take place so that CPUEs can be developed by age. To achieve this goal, the Group noted that it is important to collect size data together with the catch and effort data to provide meaningful CPUEs.

- *Environment.* The Group recommended continued work to better identify the effects of the environment on swordfish biology, ecology and fisheries. Future CPUE analyses should focus on developing additional methods to explicitly incorporate environmental variability into the model, and the influence of environment on the distribution of spawners and juveniles.

- *Age determination*. The Group noted new research that indicated estimates of age at length from direct ageing studies vary within the Mediterranean on a geographic basis. To avoid the possibility that such variation results from differences in age determination methods, national scientists were encouraged to exchange spine sections and share age determination methodology.

- *Gear selectivity studies.* Further research on gear design and use is encouraged in order to minimize catch of age-0 swordfish and increase yield and spawning biomass per recruit from this fishery.

- *Stock mixing and management boundaries.* As noted in the 2006 Swordfish Stock Structure workshop, further research including tagging investigations in defining the extent of mixing near stock boundaries such as the one between the Mediterranean and Atlantic stocks would be useful, and potentially improve the assessment of both stocks.

- *Next Mediterranean swordfish stock assessment.* It is recommended that the next swordfish stock assessment be conducted no sooner than 2010 so long as there is no signal from the stock indicating a dramatic decline. This allows time to increase the time series of catch and effort data, and to advance basic research and assessment methods. It should be noted that the data required for that session should be up to and including the year prior to the meeting.

8.2 Management

The Commission should adopt a Mediterranean swordfish fishery management plan with the goal of rebuilding the stock to levels that are consistent with the ICCAT Convention objective. One technical measure the Committee has thus far evaluated is fishing closures which could initiate rebuilding, depending on their duration and timing. The Committee recommends the Commission consider adoption of such measures which will move the stock condition to the level which will support MSY.

Following the results from recent studies (SCRS/2006/163), technical modifications of the longline fishing gears as well as the way they are operated can be considered as an additional technical measure in order to reduce the catch of juveniles. The Committee recommends this type of measures be considered as part of a Mediterranean swordfish management plan.

It is evident from the stock status evaluation that the current capacity in the Mediterranean swordfish fishery exceeds that needed to efficiently extract MSY. Management measures aimed at reducing this capacity should also be considered part of a Mediterranean swordfish management plan adopted by the Commission.

9. Other matters

The Group drafted the Executive Summary in preparation for the 2007 SCRS Swordfish Species Group.

10. Report adoption and closure

The report was adopted and the meeting was closed.

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Table 1. Estimated catches (t) of swordfish *(Xiphias gladius)* in the Medditerranean Sea, by major area, gear and flag.

		1983	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
TOTAL		6896	13666	15292	16765	18320	20365	17762	16018	15746	14709	13265	16082	13015	12053	14693	14369	13699	15569	15006	12814	15674	14405	14601
Landings	Longline	6313	6749	6493	7505	8007	9476	7065	7184	7393	7631	7377	8985	6319	5884	5389	6496	6097	6963	7180	7697	10415	11054	11274
	Other surf.	583	6917	8799	9260	10313	10889	10697	8834	8353	7078	5888	7097	6696	6169	9304	7873	7602	8606	7826	5117	5259	3343	3214
Discards	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
	Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13	13	13	0	0	0	0	0	0
	Algerie	877	884	890	847	1820	2621	590	712	562	395	562	600	807	807	807	825	709	816	1081	814	665	564	635
	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3	0	0	0	0	0	0	0	0
	Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20	0	0	0	0	0	0
	EC.Cyprus	28	63	71	154	84	121	139	173	162	56	116	159	89	40	51	61	92	82	135	104	47	49	53
	EC.España	1322	1245	1227	1337	1134	1762	1337	1523	1171	822	1358	1503	1379	1186	1264	1443	906	1436	1484	1498	1226	951	910
	EC.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	27	0	19	0
	EC.Greece	772	1081	1036	1714	1303	1008	1120	1344	1904	1456	1568	2520	974	1237	750	1650	1520	1960	1730	1680	1230	1120	1311
	EC.Italy	3026	9360	10863	11413	12325	13010	13009	9101	8538	7595	6330	7765	7310	5286	6104	6104	6312	7515	6388	3539	8395	6942	7460
	EC.Malta	59	94	172	144	163	233	122	135	129	85	91	47	72	72	100	153	187	175	102	257	163	195	362
	EC.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	115	8	1	120	14
	Japan	6	19	14	7	3	4	1	2	1	2	4	2	4	5	5	7	4	2	1	1	0	3	5
	Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	8	6	0	10	2	0
	Maroc	43	39	38	92	40	62	97	1249	1706	2692	2589	2654	1696	2734	4900	3228	3238	2708	3026	3379	3300	3253	2523
	NEI-2	532	771	730	767	828	875	979	1360	1292	1292	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tunisie	15	15	61	64	63	80	159	176	181	178	354	298	378	352	346	414	468	483	567	1138	288	791	791
	Turkey	216	95	190	226	557	589	209	243	100	136	292	533	306	320	350	450	230	370	360	370	350	386	425
Discards	EC.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	113

Table 1. Estimated catches (t) of swordfish *(Xiphias gladius)* in the Medditerranean Sea, by major area, gear and flag.

Flag	Gear	1950	1951	1952	1954	1955	1956	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Albania	UN																		
Algerie	GN																		
	HL																		
	LL																		
	FS																		
	TL																		
	UN																		
Chinese Taipei	LL																		
Croatia	LL																		
EC.Cyprus	LL																		
EC.España	GN																		
	HL																		
	LL	586	580	337	452	340	383	414							1200	1000	700	1000	1100
	SU																		
	TP																		
	TW																		
	UN																		
EC.France	FS																		
	UN																		
EC.Greece	LL																		
EC.Italy	GN																		
	HP																		
	LL																		
	FS																		
	SP																		
	TP																		
	UN																	1568	2260
EC.Malta	LL																		
	UN																		
EC.Portugal	LL																		
Japan	LL																		
Libya	LL																		
	UN														226	226	166	560	
Maroc	GN																		
	LL										94	188	94	282	323	192	169	196	250
	FS																		
	TP														1		1	1	
NEI-2	GN																		
	LL																		
	UN																		
Tunisie	LL																		
	FS																		
	TP																		
	TW																		
Turkey	GN																		
	LL																		
	FS																		
	UN							500	200	112	112	112	224	112	112	336	111	115	133
TOTAL		586	580	337	452	340	383	914	200	112	106	300	318	394	1760	1752	1317	3440	3723

Flag	Gear	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Albania	UN																				
Algerie	GN																				
	HL																				
	LL				100	196	500	348	370	320	521	650	760	870	877	884	890	947	1020	1621	590
	FS																				
	TL																				
	UN																				
Chinese Taipei	LL																				
Croatia	LL																				
EC.Cyprus	LL						5	59	95	82	96	72	78	103	28	63	71	154	84	121	134
EC.España	GN																				87
	HL																1				
	LL	900	1100	1300	1105	700	89	89	667	720	800	750	1120	900	1321	1240	1219	1337	1134	1780	1250
	SU																2				
	TP														1	2	3			2	
	TW																1				
	UN																1				
EC.France	FS																				
	UN																				
EC.Greece	LL												91	773	772	1081	1056	1714	1303	1008	1120
EC.Italy	GN															1459	1560	1620	1749	1846	2542
	HP							302	417	756	475	501	461	356	366						
	LL							3435	3330	3750	3455	3642	3362	2583	2660	2759	2490	2622	2881	2989	2989
	FS																				
	SP																				
	TP															3					
	UN	2016	3268	4144	3136	3730	3362									5139	6850	7171	7745	8175	7478
EC.Malta	LL														59	94	172	144	165	233	122
	UN	112	224	224	224	192	214	175	223	136	151	222	192	177							
EC.Portugal	LL																				
Japan	LL							1		2	3	1		5	6	19	14	7	3	4	1
Libya	LL																				
	UN																				
Maroc	GN																				
	LL	214	326	229	183	193	118	186	144	172					43	39	38	92	40	62	97
	FS																				
	TP		1	1		3															
NEI-2	GN															219	231	263	262	277	301
	LL													517	532	552	499	524	566	598	598
	UN											738	672								
Tunisie	LL					5	3	5					7	19	15	15	61	64	63	80	159
	FS																				
	TP																				
	TW																				
Turkey	GN																190	226	557	589	209
	LL																				
	FS																				
	UN	99	76	68	59	15	10	7	34	20	44	13	70	40	216	95					
TOTAL		3341	4875	5958	4897	5036	4301	4637	5280	5958	5547	6579	6813	6343	6896	13666	15292	16765	18320	20365	17762

Flag	Gear	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Albania	UN							13	13	13	13							
Algerie	GN									590	531	599	642	467		233	311	87
	HL															112	175	72
	LL	173	173	6	173	185	247	247	247				133	99		52	88	466
	FS															45	56	47
	TL									57	52	51						
	UN	539	389	389	389	415	560	560	560	178	126	166	306	348	685	122		
Chinese Taipei	LL				1	1		1	3									
Croatia	LL									10	20							
EC.Cyprus	LL	173	162	56	116	159	89	40	51	61	92	82	135	104	47	49	53	43
EC.España	GN	85	39															
	HL																	
	LL	1438	1132	790	1293	1402	1351	1040	1186	1409	867	1396	1402	1421	1165	930	860	1535
	SU							10		24	10	16	5	19				
	TP						2	2	1	2	3	1	4	2	3	1	3	1
	TW																	
	UN			32	65	101	26	134	79	8	26	23	73	56	58	20	46	56
EC.France	FS						0											
	UN												12	27		19		
EC.Greece	LL	1344	1904	1456	1568	2520	974	1237	750	1650	1510	1960	1730	1080	1230	1129	1424	
EC.Italy	GN	4353	3142	4077	3070	3921	4264	2657	3632	3632	3632	4663						2342
	HP							10	12	12		8			7	5	6	
	LL	3454	2470	3518	3260	3844	3035	2617	2658	2658	2680	2439	2236	1841	5844	5452	5560	5253
	FS																	32
	SP														2	2	2	
	TP							2	2	2		2			2	1	2	
	UN	2294	2816				11					3	4152	1698	2540	1483	1891	
EC.Malta	LL	135	129	85	91	47	72	72	100	153	187	175	102	257	163	195	302	239
	UN																	
EC.Portugal	LL											13	115	8	1	120	14	16
Japan	LL	2	1	2	4	2	4	5	5	7	4	2	1	1		3	5	
Libya	LL									11		8	6		10	2		
	UN																	
Maroc	GN	866	1186	1888	2058	2109	1518	2461	4653	2905	1979	2500	2366	2230	1629	1299	722	
	LL	371	508	807	517	527	169	273	245	323	259	305	754	1149	1670	1954	1881	
	FS												4					
	TP	12	12	2	4	18	9		2				2		1			
NEI-2	GN	442	559	559														
	LL	918	733	733														
	UN																	
Tunisie	LL	176	181	178	354	298	378	352	346	414	468	483	567	1138	285	791	791	
	FS														2			
	TP														0			
	TW														0			
Turkey	GN	243	100	136	282	333	306	320	350	450	236	370	360					
	LL															386	425	
	FS														350			
	UN													370				
TOTAL		16018	15746	14708	13265	16082	13015	12053	14681	14569	13699	15569	15006	12814	15674	14405	14681	10219

Table 2. Biological parameters and conversion factors for Mediterranean swordfish.

Growth parameters used by the SCRS for Atlantic and Mediterranean swordfish.

	Reference	*N*	*LJ-FL (cm)*	*Method*	*Stock*
<u>*Sexes combined*</u> $L_t = 238.58\,(1 - e^{-0.185\,(t+1.404)})$	Tserpes and Tsimenides (1995)	1100	62-210	Spines	Med.

Size-weight relationships used by the SCRS for Mediterranean swordfish.

	Reference	*N*	*LJ-FL (cm)*	*Stock*
$GWT = 5.70 \times 10^{-6} \times LJ - FL^{3.16}$	De Metrio (1987)	462	64-205	Mediterranean
$RWT = 8.90493 \times 10^{-7} \times LJ - FL^{3.554738}$	Mejuto and De la Serna (1993)	1006	62-237	Mediterranean

LJ-FL: length from lower jaw to fork
RWT: round weight
GWT: gutted weight

Conversion factors among the different types of weight for the swordfish

Equation	Reference	Geographic area
$RWT = 1.12 \times GWT$	Anon. (2004)	Mediterranean

Estimated size of initial sexual maturity for Mediterranean swordfish.

	Reference	*Stock*
50% of the females are mature at 142 cm (3.5 years)	de la Serna *et al.*, (1996)	Mediterranean

Fraction mature at age:

Age	0	1	2	3	4	>=5
	0	0	0	0.5	1	1

Natural mortality: 0.2 for all ages
2005 Catch Weight (kg) at age

Age:	0	1	2	3	4	5	6	7	8	9	10^+
	2.5	7.7	16.8	30.5	48.4	68.2	87.4	106.7	125.7	142.5	181.4

Table 3. Substitution table for Mediterranean swordfish.

t1Yr	t1FleetC	t1GearG	t1Yt	RF	szYr	szFleetC	szGearG	Lrng	Lmed	Wmed	szYt	szNt	szInt	szFrqT	TPerGrp	remarks
1990	EC.ITA	UN	2294	62.98687358	1990	EC.ITA-IT-TYRR	GN	86-210	130	31	36	1159	1	6	mm	subs-raise
1990	EC.ITA-IT-IONI.S	GN	62	1.702347935	1990	EC.ITA-IT-TYRR	GN	86-210	130	31	36	1159	1	6	mm	subs-raise
1990	EC.ITA-IT-LIGUF	GN	59	1.61997626	1990	EC.ITA-IT-TYRR	GN	86-210	130	31	36	1159	1	6	mm	subs-raise
1991	EC.ITA	UN	2926	40.48377679	1991	EC.ITA-IT-TYRR	GN	62-230	133	36	72	2016	1	6	mm	subs-raise
1995	EC.ITA-IT-ADRI.	LL	170	13.976613	1995	EC.ITA-IT-IONI.N	LL	30-260	89	13	12	970	5	6	mm	subs-raise
1995	EC.ITA-IT-IONI.S	GN	350	15.77571387	1995	EC.ITA-IT-IONI.N	GN	35-220	119	32	22	697	5	6	mm	subs-raise
1995	EC.ITA-IT-SARD	LL	65	4.711000973	1995	EC.ITA-IT-TYRR	LL	62-186	103	14	14	980	1	6	mm	subs-raise
1999	MAR	GN	2979	12.51815901	1999	MAR	GN	80-230	140	45	238	5293	5	6	mm	raise
2000	MAR	GN	2503	19.27522164	2000	MAR	GN	55-250	141	45	130	2870	5	6	mm	raise
2000	JPN	LL	2	0.577737854	2000	EC.ESP	LL	70-220	144	51	3	68	5	6	mm	subs-raise
2001	DZA	GN	642	18.52497019	2001	MAR	GN	95-235	143	48	35	724	5	6	mm	subs-raise
2001	DZA	LL	133	0.095014876	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	DZA	UN	306	0.218605655	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.CYP	LL	135	1.484889248	2001	EC.GRC	LL	51-258	134	40	91	2300	1	6	mm	subs-raise
2001	EC.ESP	LL	27	0.018931535	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.ESP	LL	20	0.914813878	2001	EC.ESP	LL	95-230	159	72	22	311	5	6	mm	raise
2001	EC.ESP	LL	40	2.500815303	2001	EC.ESP	LL	40-160	89	9	16	1676	5	6	mm	raise
2001	EC.ESP	SU	5	0.003643428	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.ESP	TP	4	0.002571831	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.ESP	UN	73	0.052151022	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.ESP-ES-SW	LL	1315	0.939718557	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	raise
2001	EC.FRA	UN	12	0.008572771	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	EC.GRC	LL	1730	18.98330204	2001	EC.GRC	LL	51-258	134	40	91	2300	1	6	mm	raise
2001	EC.ITA-IT-SIC.S	LL	1632.28	136.812913	2001	EC.ITA-IT-SIC.S	LL	75-190	115	21	12	573	5	6	mm	raise
2001	EC.ITA-IT-TYRR	LL	603.72	88.22543291	2001	EC.ITA-IT-TYRR	LL	75-165	103	13	7	508	5	6	mm	raise
2001	EC.ITA-IT-IONI.N	UN	62	0.778710293	2001	EC.ITA-IT-TYRR	GN	80-220	138	41	80	1969	5	6	mm	subs-raise
2001	EC.ITA-IT-IONI.S	UN	332	4.153121563	2001	EC.ITA-IT-TYRR	GN	80-220	138	41	80	1969	5	6	mm	subs-raise
2001	EC.ITA-IT-LIGUF	UN	21	0.259570098	2001	EC.ITA-IT-TYRR	GN	80-220	138	41	80	1969	5	6	mm	subs-raise
2001	EC.ITA-IT-TYRR	UN	3737	46.72261758	2001	EC.ITA-IT-TYRR	GN	80-220	138	41	80	1969	5	6	mm	raise
2001	EC.MLT	LL	102	6.113752796	2001	EC.MLT	LL	95-145	115	19	17	856	5	6	mm	raise
2001	EC.PRT-PT-MAI	LL	115	0.08222716	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	JPN	LL	1	0.000714398	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	LBY	LL	6	0.003974908	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	MAR	GN	2266	65.38564245	2001	MAR	GN	95-235	143	48	35	724	5	6	mm	raise
2001	MAR	LL	754	0.538655764	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	MAR	PS	4	0.00285759	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	MAR	TP	2	0.001428795	2001	EC.ESP-ES-SW	LL	55-210	106	16	1400	86908	5	6	mm	subs-raise
2001	TUN	LL	567	47.52427382	2001	EC.ITA-IT-SIC.S	LL	75-190	115	21	12	573	5	6	mm	subs-raise
2001	TUR	GN	360	123.8681733	2001	TUR	GN	70-185	120	26	3	111	5	6	yy	raise
2002	DZA	GN	467	4.136204952	2002	MAR	GN	75-235	144	50	113	2277	5	6	mm	subs-raise
2002	DZA	LL	99	0.065343006	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	DZA	UN	248	0.16368753	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.CYP	LL	104	1.136627953	2001	EC.GRC	LL	51-258	134	40	91	2300	1	6	mm	subs-raise
2002	EC.ESP	LL	43	0.028513312	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.ESP	LL	6	10.55588309	2002	EC.ESP	LL	70-210	133	41	1	13	5	6	mm	raise
2002	EC.ESP	LL	25	0.968294278	2002	EC.ESP	LL	75-180	111	20	25	1283	5	6	mm	raise
2002	EC.ESP	SU	19	0.012540577	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.ESP	TP	2	0.00151807	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.ESP	UN	56	0.037027703	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.ESP-ES-SW	LL	1347	0.88932491	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	raise
2002	EC.FRA	UN	27	0.01782082	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	EC.GRC	LL	1680	18.43465169	2001	EC.GRC	LL	51-258	134	40	91	2300	1	6	mm	subs-raise
2002	EC.ITA-IT-SIC.S	LL	1344	62.86524395	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	raise
2002	EC.ITA-IT-TYRR	LL	497	23.25152859	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	EC.ITA-IT-IONI.N	UN	25	1.191414555	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	EC.ITA-IT-IONI.S	UN	136	6.354210962	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	EC.ITA-IT-LIGUF	UN	8	0.397138185	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	EC.ITA-IT-TYRR	UN	1528	71.48487333	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	EC.MLT	LL	257	15.46779879	2001	EC.MLT	LL	95-145	115	19	17	856	5	6	mm	subs-raise
2002	EC.PRT-PT-MAI	LL	8	0.005016231	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	JPN	LL	1	0.00066003	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	MAR	GN	2230	19.75104292	2002	MAR	GN	75-235	144	50	113	2277	5	6	mm	raise
2002	MAR	LL	1149	0.758374886	2002	EC.ESP-ES-SW	LL	60-210	102	14	1515	107751	5	6	mm	subs-raise
2002	TUN	LL	1138	53.23242105	2002	EC.ITA-IT-SIC.S	LL	75-160	111	18	21	1192	5	6	mm	subs-raise
2002	TUR	UN	370	4.060012575	2001	EC.GRC	LL	51-258	134	40	91	2300	1	6	mm	subs-raise
2003	DZA	UN	665	0.49015856	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.CYP	LL	47	1.238405357	2003	EC.GRC	LL	60-235	135	38	38	1000	5	6	yy	subs-raise
2003	EC.ESP	LL	78	0.057854189	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.ESP	LL	6	0.004088586	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.ESP	LL	24	0.017449645	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.ESP	TP	3	0.002102891	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.ESP	UN	58	0.04269539	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003	EC.ESP-ES-SW	LL	1057	0.77927914	2003	EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	raise
2003	EC.GRC	LL	1230	32.13312355	2003	EC.GRC	LL	60-235	135	38	38	1000	5	6	yy	raise
2003	EC.ITA-IT-SIC.S	LL	2468	152.1652768	2003	EC.ITA-IT-SIC.S	LL	40-185	114	20	16	796	5	6	mm	raise
2003	EC.ITA	SP	2	0.149184823	2003	EC.ITA-IT-TYRR	HP	75-190	126	30	13	448	5	6	mm	subs-raise
2003	EC.ITA	TP	2	0.149184823	2003	EC.ITA-IT-TYRR	HP	75-190	126	30	13	448	5	6	mm	subs-raise
2003	EC.ITA	UN	104	7.757610803	2003	EC.ITA-IT-TYRR	HP	75-190	126	30	13	448	5	6	mm	subs-raise
2003	EC.ITA-IT-ADRI.	LL	646	124.9697614	2003	EC.ITA-IT-ADRI.	LL	89-210	121	26	5	200	1	6	mm	raise
2003	EC.ITA-IT-ADRI.	UN	16	3.082874489	2003	EC.ITA-IT-ADRIA	UN	68-158	100	12	5	419	1	6	mm	raise
2003	EC.ITA-IT-IONI.N	LL	162	16.67757725	2003	EC.ITA-IT-IONIA	LL	51-221	98	18	10	551	1	6	mm	raise
2003	EC.ITA-IT-IONI.N	UN	41	19.0177795	2003	EC.ITA-IT-IONIA	GN	83-203	132	41	2	53	1	6	mm	raise
2003	EC.ITA-IT-IONI.S	LL	885	106.9129666	2003	EC.ITA-IT-IONIA	LL	52-208	96	16	8	508	1	6	mm	raise
2003	EC.ITA-IT-IONI.S	UN	273	225.5422618	2003	EC.ITA-IT-IONIA	GN	49-183	90	14	1	88	1	6	mm	raise
2003	EC.ITA-IT-LIGUF	LL	155	9.880504988	2003	EC.ITA-IT-TY.LI	LL	61-200	124	28	16	564	1	6	mm	subs-raise
2003	EC.ITA-IT-LIGUF	UN	22	0.359395677	2003	EC.ITA-IT-TYRR	GN	75-225	122	27	61	2236	5	6	mm	subs-raise
2003	EC.ITA-IT-SARD	LL	372	23.71321197	2003	EC.ITA-IT-TY.LI	LL	61-200	124	28	16	564	1	6	mm	subs-raise
2003	EC.ITA-IT-SARD	UN	68	1.110859366	2003	EC.ITA-IT-TYRR	GN	75-225	122	27	61	2236	5	6	mm	subs-raise
2003	EC.ITA-IT-TYRR	HP	7	0.484850675	2003	EC.ITA-IT-TYRR	HP	75-190	126	30	13	448	5	6	mm	raise
2003	EC.ITA-IT-TYRR	LL	1156	73.70410504	2003	EC.ITA-IT-TY.LI	LL	61-200	124	28	16	564	1	6	mm	raise
2003	EC.ITA-IT-TYRR	UN	2016	32.94024742	2003	EC.ITA-IT-TYRR	GN	75-225	122	27	61	2236	5	6	mm	raise
2003	EC.MLT	LL	163	10.0199725	2003	EC.ITA-IT-SIC.S	LL	40-185	114	20	16	796	5	6	mm	subs-raise

2003 EC.PRT-PT-MAI	LL	1	0.000449619	2003 EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003 LBY	LL	10	0.007417979	2003 EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003 MAR	GN	1629	54.35412019	2003 MAR	GN	85-225	134	38	30	784	5	6	mm	raise
2003 MAR	LL	1670	1.230924505	2003 EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003 MAR	TP	1	0.000737081	2003 EC.ESP-ES-SW	LL	60-215	113	20	1357	68028	5	6	mm	subs-raise
2003 TUN	LL	285	17.57182174	2003 EC.ITA-IT-SIC.S	LL	40-185	114	20	16	796	5	6	mm	subs-raise
2003 TUN	PS	2	0.148886453	2003 EC.ITA-IT-TYRR	HP	75-190	126	30	13	448	5	6	mm	subs-raise
2003 TUN	TP	0	0											ignore (<0.5t)
2003 TUN	TW	0	0											ignore (<0.5t)
2003 TUR	PS	350	9.143571741	2003 EC.GRC	LL	60-235	135	38	38	1000	5	6	yy	subs-raise
2004 DZA	GN	233	3.189360514	2004 MAR	GN	85-240	147	53	73	1390	5	6	mm	subs-raise
2004 DZA	HL	112	0.127439834	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 DZA	LL	52	0.059168494	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 DZA	PS	45	0.051203505	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 DZA	UN	122	0.13881839	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.CYP	LL	49	0.584518276	2004 EC.GRC	LL	60-235	134	38	84	2225	5	6	yy	subs-raise
2004 EC.ESP	LL	23	0.026351599	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.ESP	LL	6	0.007127528	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.ESP	LL	11	0.012812255	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.ESP	TP	1	0.001612341	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.ESP	UN	20	0.023133743	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.ESP-ES-SW	LL	889	1.011423966	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	raise
2004 EC.FRA	UN	19	0.021619258	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 EC.GRC	LL	1129	13.43885021	2004 EC.GRC	LL	60-235	134	38	84	2225	5	6	yy	raise
2004 EC.ITA-IT-SIC.S	LL	2473	57.58625719	2004 EC.ITA-IT-SIC.S	LL	45-235	121	28	43	1525	5	6	mm	raise
2004 EC.ITA	SP	2	0.66535069	2004 EC.ITA-IT-TYRR	HP	90-180	136	39	3	77	5	6	mm	subs-raise
2004 EC.ITA	TP	1	0.332675345	2004 EC.ITA-IT-TYRR	HP	90-180	136	39	3	77	5	6	mm	subs-raise
2004 EC.ITA	UN	27	8.982234312	2004 EC.ITA-IT-TYRR	HP	90-180	136	39	3	77	5	6	mm	subs-raise
2004 EC.ITA-IT-ADRI.	LL	589	21.45004487	2004 EC.ITA-IT-ADRI.	LL	82-191	120	27	12	460	1	6	qu	join-raise
2004 EC.ITA-IT-ADRI.	LL		21.45004487	2004 EC.ITA-IT-ADRI.	LL	69-200	121	26	15	592	1	6	qu	join-raise
2004 EC.ITA-IT-ADRI.	UN	4	0.045675724	2004 EC.ITA-IT-TYRR	GN	85-230	133	36	88	2453	5	6	mm	subs-raise
2004 EC.ITA-IT-IONI.	LL	154	6.1753519	2004 EC.ITA-IT-IONIA	LL	49-265	103	21	25	1200	1	6	qu	raise
2004 EC.ITA-IT-IONI.	UN	11	0.125608241	2004 EC.ITA-IT-TYRR	GN	85-230	133	36	88	2453	5	6	mm	subs-raise
2004 EC.ITA-IT-IONI.S	LL	831	33.32284045	2004 EC.ITA-IT-IONIA	LL	49-265	103	21	25	1200	1	6	qu	subs-raise
2004 EC.ITA-IT-IONI.S	UN	178	2.032569716	2004 EC.ITA-IT-TYRR	GN	85-230	133	36	88	2453	5	6	mm	subs-raise
2004 EC.ITA-IT-LIGUF	LL	149	9.287437263	2004 EC.ITA-IT-TY.LI	LL	63-206	122	28	16	581	1	6	qu	raise
2004 EC.ITA-IT-LIGUF	UN	2	2.265579191	2004 EC.ITA-IT-TY.LI	GN	76-240	130	42	1	21	1	6	qu	raise
2004 EC.ITA-IT-SARD	LL	298	95.56649206	2004 EC.ITA-IT-SARD	LL	106-223	142	45	3	70	1	6	qu	raise
2004 EC.ITA-IT-SARD	UN	5	0.057094655	2004 EC.ITA-IT-TYRR	GN	85-230	133	36	88	2453	5	6	mm	subs-raise
2004 EC.ITA-IT-TYRR	HP	5	1.763179328	2004 EC.ITA-IT-TYRR	HP	90-180	136	39	3	77	5	6	mm	raise
2004 EC.ITA-IT-TYRR	LL	957	263.3556496	2004 EC.ITA-IT-TYRR	LL	80-155	97	11	4	324	5	6	mm	raise
2004 EC.ITA-IT-TYRR	UN	1256	14.33726718	2004 EC.ITA-IT-TYRR	GN	85-230	133	36	88	2453	5	6	mm	raise
2004 EC.MLT	LL	195	1.566489573	2005 EC.MLT	LL	52-184	101	17	125	7520	1	6	mm	subs-raise
2004 EC.PRT-PT-MAI	LL	120	0.13677025	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 JPN	LL	3	0.002876499	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 LBY	LL	2	0.00277523	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 MAR	GN	1299	17.78102707	2004 MAR	GN	85-240	147	53	73	1390	5	6	mm	raise
2004 MAR	LL	1954	2.223369959	2004 EC.ESP-ES-SW	LL	60-235	104	17	879	52643	5	6	mm	subs-raise
2004 TUN	LL	791	18.41698518	2004 EC.ITA-IT-SIC.S	LL	45-235	121	28	43	1525	5	6	mm	subs-raise
2004 TUR	LL	386	4.594071808	2004 EC.GRC	LL	60-235	134	38	84	2225	5	6	yy	subs-raise
2005 DZA	GN	311	3.657412701	2005 MAR	GN	90-260	156	64	85	1320	5	6	mm	subs-raise
2005 DZA	HL	175	0.223963785	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 DZA	LL	93	0.119020754	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 DZA	PS	56	0.071668411	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.CYP	LL	53	0.558458101	2005 EC.GRC	LL	85-225	133	37	95	2577	5	6	qu	subs-raise
2005 EC.ESP	LL	24	0.030349013	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.ESP	LL	13	0.016563082	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.ESP	LL	64	0.081594486	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.ESP	TP	3	0.004037747	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.ESP	UN	46	0.059388797	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 EC.ESP-ES-SW	LL	760	0.972444355	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	raise
2005 EC.GRC	LL	1424	15.06418033	2005 EC.GRC	LL	85-225	133	37	95	2577	5	6	qu	raise
2005 EC.ITA-IT-SIC.S	LL	2608	115.1733727	2005 EC.ITA-IT-SIC.S	LL	75-185	113	19	23	1187	5	6	mm	raise
2005 EC.ITA	SP	2	0.410364194	2005 EC.ITA-IT-TYRR	HP	85-200	144	47	5	109	5	6	mm	subs-raise
2005 EC.ITA	TP	2	0.332199586	2005 EC.ITA-IT-TYRR	HP	85-200	144	47	5	109	5	6	mm	subs-raise
2005 EC.ITA	UN	68	13.19027767	2005 EC.ITA-IT-TYRR	HP	85-200	144	47	5	109	5	6	mm	subs-raise
2005 EC.ITA-IT-ADRI.	LL	564	0.395484091	2005 EC.ITA-IT-ADRI.	LL	77-230	146	58	1426	24722	1	6	qu	raise
2005 EC.ITA-IT-ADRI.	UN	6	0.15811225	2005 EC.ITA-IT-TYRR	GN	75-250	135	40	38	955	5	6	mm	subs-raise
2005 EC.ITA-IT-IONI.	LL	171	7.989980555	2005 EC.ITA-IT-ADRI.	LL	75-205	124	28	21	766	5	6	qu	raise
2005 EC.ITA-IT-IONI.	UN	41	2.58394223	2005 EC.ITA-IT-IONIA	UN	45-190	97	15	16	1066	5	6	qu	raise
2005 EC.ITA-IT-IONI.S	LL	815	35.98726335	2005 EC.ITA-IT-SIC.S	LL	75-185	113	19	23	1187	5	6	mm	subs-raise
2005 EC.ITA-IT-IONI.S	UN	253	6.674181576	2005 EC.ITA-IT-TYRR	GN	75-250	135	40	38	955	5	6	mm	subs-raise
2005 EC.ITA-IT-LIGUF	LL	153	0.303356474	2005 EC.ITA-IT-TY.LI	LL	72-194	133	37	504	13672	1	6	qu	raise
2005 EC.ITA-IT-LIGUF	UN	49	1.291250038	2005 EC.ITA-IT-TYRR	GN	75-250	135	40	38	955	5	6	mm	subs-raise
2005 EC.ITA-IT-SARD	LL	266	3.84705977	2005 EC.ITA-IT-TYRR	LL	80-240	153	64	69	1085	5	6	mm	subs-raise
2005 EC.ITA-IT-SARD	UN	34	0.895969414	2005 EC.ITA-IT-TYRR	GN	75-250	135	40	38	955	5	6	mm	subs-raise
2005 EC.ITA-IT-TYRR	HP	6	1.082579827	2005 EC.ITA-IT-TYRR	HP	85-200	144	47	5	109	5	6	mm	raise
2005 EC.ITA-IT-TYRR	LL	982	14.20866692	2005 EC.ITA-IT-TYRR	LL	80-240	153	64	69	1085	5	6	mm	raise
2005 EC.ITA-IT-TYRR	UN	1440	37.94852103	2005 EC.ITA-IT-TYRR	GN	75-250	135	40	38	955	5	6	mm	raise
2005 EC.MLT	LL	73	0.588656012	2005 EC.MLT	LL	52-184	101	17	125	7520	1	6	mm	subs-raise
2005 EC.MLT	LL	289	2.31637296	2005 EC.MLT	LL	52-184	101	17	125	7520	1	6	mm	raise
2005 EC.PRT-PT-MAI	LL	14	0.017804481	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 JPN	LL	5	0.006154525	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 MAR	GN	722	8.490842347	2005 MAR	GN	90-260	156	64	85	1320	5	6	mm	raise
2005 MAR	LL	1801	2.304907294	2005 EC.ESP-ES-SW	LL	50-220	110	18	781	42742	5	6	mm	subs-raise
2005 TUN	LL	791	34.92751572	2005 EC.ITA-IT-SIC.S	LL	75-185	113	19	23	1187	5	6	mm	subs-raise
2005 TUR	LL	425	4.496697606	2005 EC.GRC	LL	85-225	133	37	95	2577	5	6	qu	subs-raise

Table 4. Catch at size, in number of fish, of Mediterranean swordfish.

Size (cm)	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
10															41						
30											102										
35											1013										
40	49		807		3490	82		54		173	1246	1	1				10		1438		
45	496	332		440	1996	82		157			274						20		226	116	23
50	1268	1721		757	3715	175	231	1333	676	520	284			679	275		105	24	2467	1195	925
55	732	1453	2262	1636	5249	205	443	2466	1272	829	2230	133	44	5950	52	93	218	71	3672	2869	3726
60	1039	2996	1570	2091	8461	498	1713	6088	3419	3506	7934	210	1032	7289	510	401	405	154	9877	3880	972
65	2572	2965	6060	4798	6532	2452	2907	10565	6565	8855	7942	1387	1985	3327	2437	1213	812	808	13028	14401	893
70	4000	3965	9856	17416	12701	4357	8725	12271	11006	19596	9961	12286	8954	10004	11940	3725	10942	2235	10117	20594	1546
75	7351	4286	15570	20722	16227	8395	11145	12600	17584	21730	15047	10465	9893	16843	11467	5285	7018	9451	6579	12661	2992
80	14266	6855	22931	36847	22965	15621	13127	16968	22807	16438	22578	14524	13687	23804	12777	12971	12306	22051	8133	19693	8959
85	15203	11290	21179	33964	22505	29901	19676	17974	28555	11403	32709	19746	17651	47539	18334	23308	20539	35570	14535	36247	16627
90	23075	15964	34150	53565	36622	45180	26301	17817	33716	23079	40882	32765	26167	53251	30274	38664	31562	65227	31567	74126	35610
95	22770	19756	29244	51714	36975	41135	33195	26830	40528	31967	52035	39212	31493	46525	35183	40952	39155	50924	40235	44466	46099
100	34296	21578	34523	62083	48641	51963	41551	48117	56454	65700	58235	39652	38909	43977	40204	49383	45477	56134	61056	43680	61005
105	28847	19395	19941	45087	47257	50078	43173	60415	64008	59031	46353	37649	32642	37139	45542	41023	43974	56007	62920	34927	56929
110	30257	33073	24176	36776	39544	64052	42074	65567	72395	73148	40637	34490	34439	39861	39276	43291	49167	68031	78404	43299	68569
115	26992	34814	33384	40707	40861	60707	43728	55991	46493	62386	34593	32068	41396	38572	39972	39997	46150	55710	61124	37028	50229
120	29897	42255	23781	36050	37933	73117	46435	43702	35408	50955	37230	38290	43432	32689	33230	42564	42730	34555	55377	35034	34862
125	29454	39849	29188	32290	37531	56973	35736	31799	28727	37168	27193	32510	45167	27857	28551	34305	38671	33908	42236	32462	31854
130	25013	32335	26908	27267	23868	39333	36012	25736	22606	29773	30273	28908	38824	24333	22205	33224	32692	26446	34825	29991	28606
135	25216	24557	28630	25745	26480	26854	32724	19956	14886	25879	21606	22359	31330	17825	21371	24598	26259	17683	26154	22801	21957
140	20227	22025	20742	18736	25653	21701	25548	15992	13699	17948	17130	19094	25039	16370	17439	21076	21920	11511	20327	17544	16470
145	20607	14890	16738	25916	22039	12398	18183	13649	9978	13071	10317	12268	14484	12715	14595	16108	18493	9355	15756	13488	13124
150	16353	20485	23857	24549	17897	12603	15988	13425	9251	10976	8095	11787	17263	11458	13732	15983	13967	6349	13781	13100	12389
155	14281	11603	17741	23569	18766	8162	13852	9361	8041	8818	9047	8867	10172	11590	13736	12262	9676	5974	10898	10637	9683
160	14760	14619	19574	16304	16830	9053	10482	10119	7497	9728	8391	6246	17504	9967	9526	12126	8596	6435	9067	9682	8822
165	9999	15121	19225	20563	15231	5194	8100	7546	6525	7060	5307	5420	7547	9678	8779	9425	8206	5488	6216	8402	7639
170	12454	14798	15095	12372	9931	5611	9020	7579	5916	6991	5576	4884	5180	8750	7781	9212	5367	4130	5411	7687	6044
175	9401	9491	13803	13137	7855	5011	5463	5158	4077	6405	4458	3949	4337	6183	5193	5423	4773	3121	2655	4703	4935
180	11154	10106	11439	7480	5964	3885	3707	4718	3776	4628	3481	2606	4609	5925	5705	5420	3488	2406	3305	4620	3475
185	3457	4977	5016	4948	2840	1530	3366	2965	2384	3823	3576	2547	2915	3601	3718	3585	3198	2195	1889	2593	3662
190	2907	4359	3146	2955	3878	1689	2150	2087	2353	2926	1332	1602	839	2959	3001	3375	2979	1405	2038	2402	1693
195	1468	688	1419	2444	3334	1306	1688	2423	1697	2304	1343	1277	729	2304	991	1741	1842	1317	1197	1643	1459
200	1215	1196	1746	2473	1187	886	1379	2359	1384	1417	1071	920	915	1186	949	1139	802	910	774	1346	1268
205	839	2406	1255	666	661	243	1076	938	718	729	872	666	467	801	460	1051	749	439	1163	829	799
210	395	2185	659	1975	1141	469	512	215	519	963	512	501	230	603	546	476	1261	574	578	563	620
215	612	363	1809	1060	644	313	146	95	104	389	434	181	143	426	255	212	750	237	93	309	829
220	571	110	451	451	10	66	222	98	161	196	186	266	99	175	165	341	312	214	85	315	504
225		5	8	13	511	74	182	133	174	292	64	8	58	181	48		143	237	89	96	271
230		5	807	442	2		254	183	34	166	16	2	86	143	42	58	114	95		114	163
235							55	36	15	62	51	4		36	7	88	209	71	43	192	124
240	3	4						29	2	61	25	1	1	28	7	44				23	77
245									44	7	42			23	96	4					12
250	3				3						25			0		44					59
255									21		25	1	1		48		20	24			12
260											25	1	1	62	41						12
265														0						39	
270												1	1		17						
280												1	1	0							
285		1	0													4					
295																4					
Grand	463497	468876	538688	710008	633928	661357	560269	575512	585477	641094	571761	479749	529665	582627	500517	554196	555077	597474	659337	609796	566529

Total	

Table 5. Catch at age, in number of fish, of Mediterranean swordfish.

Age	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	2003	*2004*	*2*
0	6956	10260	12669	13206	31982	4320	7039	23117	14134	17802	23486	4943	5447	19237	5703	2541	3599	1319	35011	27356	6
1	81312	57372	125110	200401	138059	135680	103688	96640	143891	113441	158900	116850	99162	186668	110510	115895	111760	175122	98087	193664	102
2	142885	138165	132141	216626	206460	279271	205034	261677	268701	299377	214501	175107	175012	188768	192234	207824	218564	267177	305739	189784	267
3	99727	122451	102534	107217	113313	161486	133993	101367	85861	118543	101570	109047	146535	89276	92402	117320	123261	96208	134199	106013	102
4	60524	57874	67234	80562	70340	43836	60258	44158	33884	41780	34615	41219	54040	43398	49690	54575	53357	27395	49567	45355	42
5	32604	37985	48388	46531	39786	18046	24862	22567	17993	21857	17913	15476	31916	25547	23974	27689	20875	14760	19485	23423	20
6	23564	24430	29722	25046	17394	10545	12879	12535	9888	13108	9861	7997	8986	14932	13542	14084	9971	6910	7991	11776	10
7	9652	11631	11477	9713	7550	3955	6043	6108	5315	7429	5727	4625	5450	7649	7753	7773	6360	3977	4375	5950	5
8	2636	2434	2679	3625	4885	2166	2645	3257	2636	3476	1836	1934	1115	3488	2029	3031	2968	1803	2058	2650	2
9	1547	2158	2248	2737	1452	957	1794	2734	1672	1715	1574	1320	1085	1575	1162	1545	1090	1071	1272	1673	1
10+	2089	4116	4486	4342	2707	1095	2033	1352	1503	2568	1776	1232	916	2088	1518	1920	3271	1730	1553	2154	3
	463497	468876	538688	710008	633928	661357	560269	575512	585477	641094	571761	479749	529665	582627	500517	554196	555077	597474	659337	609796	566

Table 6. .Inputs used for production modeling of the Mediterranean swordfish stock. Note that negative CPUE values indicate missing data which were not used in the model fitting. (*) negative values represent missing values.

Year	*CPUE**	*Yield (t)*	*Year*	*CPUE*	*Yield (t)*
1950	-9.00	1586.0	1978	1.47	5958.0
1951	-9.00	1580.0	1979	3.02	5547.0
1952	-9.00	1837.0	1980	0.77	6579.0
1953	-9.00	1500.0	1981	0.42	6813.0
1954	-9.00	1952.0	1982	-9.00	6343.0
1955	-9.00	1840.0	1983	0.61	6896.4
1956	-9.00	1893.0	1984	1.31	13665.6
1957	-9.00	2000.0	1985	2.17	15292.0
1958	-9.00	2914.0	1986	0.83	16764.9
1959	-9.00	2200.0	1987	0.53	18320.0
1960	-9.00	3112.0	1988	0.68	20365.4
1961	-9.00	3206.0	1989	1.07	17761.9
1962	-9.00	3300.0	1990	0.78	16017.5
1963	-9.00	3318.0	1991	0.59	15746.3
1964	-9.00	2394.0	1992	0.47	14709.4
1965	-9.00	3760.0	1993	0.41	13264.9
1966	-9.00	3752.0	1994	0.54	16082.2
1967	-9.00	3217.0	1995	0.58	13014.8
1968	-9.00	3440.0	1996	0.57	12052.8
1969	-9.00	3723.0	1997	0.41	14693.3
1970	-9.00	3341.0	1998	0.64	14368.9
1971	-9.00	4975.0	1999	0.64	13698.6
1972	-9.00	5958.0	2000	0.42	15568.8
1973	-7.80	4807.0	2001	0.55	15006.1
1974	-9.00	5034.0	2002	0.59	12814.3
1975	0.22	4301.0	2003	0.50	15674.1
1976	0.74	4637.0	2004	0.52	14405.4
1977	-9.00	5280.0	2005	0.53	14601.1

Table 7. Summary of production model estimates of current stock status based on bootstrap (999) results from three production model outcomes (see **Appendix 4** for details).

$P(F>F_{MSY})$	0.70
$P(B<B_{MSY})$	0.64
$P(B<B_{MSY}, F>F_{MSY})$	0.64

	Median	10%-tile	90%-tile
B/B_{MSY}	0.87	0.50	1.38
F/F_{MSY}	1.27	0.64	2.54
MSY	14,254	9,306	16,823

Table 8. Fishing mortality by age estimates obtained from the XSA model.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.01	0.01	0.01	0.01	0.04	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.03	0.03	0.01
1	0.12	0.10	0.17	0.24	0.17	0.21	0.15	0.13	0.17	0.15	0.22	0.18	0.16	0.26	0.16	0.17	0.14	0.21	0.15	0.23	0.15
2	0.29	0.30	0.33	0.51	0.42	0.61	0.56	0.69	0.65	0.65	0.49	0.39	0.46	0.49	0.48	0.52	0.54	0.58	0.70	0.48	0.55
3	0.36	0.44	0.39	0.48	0.56	0.69	0.68	0.60	0.51	0.68	0.48	0.49	0.68	0.45	0.48	0.60	0.69	0.49	0.66	0.56	0.53
4	0.39	0.37	0.45	0.60	0.69	0.44	0.60	0.50	0.41	0.51	0.43	0.37	0.49	0.43	0.49	0.59	0.61	0.31	0.50	0.49	0.47
5	0.43	0.45	0.61	0.66	0.69	0.37	0.48	0.47	0.40	0.51	0.43	0.35	0.55	0.45	0.45	0.57	0.47	0.34	0.39	0.47	0.44
6	0.60	0.68	0.78	0.76	0.56	0.39	0.50	0.48	0.39	0.56	0.46	0.34	0.35	0.54	0.45	0.53	0.41	0.28	0.31	0.43	0.41
7	0.65	0.69	0.82	0.64	0.55	0.24	0.40	0.47	0.38	0.57	0.52	0.40	0.42	0.58	0.60	0.52	0.48	0.29	0.28	0.40	0.40
8	0.34	0.34	0.33	0.68	0.79	0.29	0.25	0.39	0.38	0.46	0.27	0.33	0.16	0.52	0.30	0.50	0.38	0.24	0.23	0.28	0.26
9	0.48	0.51	0.60	0.67	0.65	0.34	0.43	0.44	0.36	0.46	0.39	0.31	0.31	0.35	0.33	0.39	0.34	0.23	0.27	0.30	0.26
10	0.48	0.51	0.60	0.67	0.65	0.34	0.43	0.44	0.36	0.46	0.39	0.31	0.31	0.35	0.33	0.39	0.34	0.23	0.27	0.30	0.26

Table 9. Estimates of stock abundance (numbers) at the beginning of the year, obtained from the XSA model.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	858436	1059774	1266447	1192898	998972	996250	1050985	1234377	1078160	1112449	957806	930276	1086685	1001879	1016078	1141916	1227789	944378	1322151	1033050	992349
1	797601	696545	858403	1025437	964736	789016	811759	854116	989748	869958	894720	762979	757181	884782	802898	826743	932627	1001978	772000	1050874	821091
2	621285	579714	518539	590113	659254	665501	523854	571183	612186	680732	610051	589513	519444	530583	556513	557802	572480	662851	662717	543677	686098
3	359138	380215	350448	305825	289114	354544	295131	245383	233945	261085	289799	307254	325503	268391	265271	283343	270574	273027	303651	269566	275048
4	206550	204492	201474	194893	154309	135289	146042	121949	110237	114633	107875	146248	153851	135595	139697	134376	127051	111435	137326	128691	125822
5	101496	114786	115466	104674	87509	63513	71453	65672	60285	59854	56429	57275	82731	77537	72092	69853	61194	56307	66617	68028	64722
6	56812	53856	59920	51264	44125	36109	35799	36220	33541	33210	29426	30133	32994	39164	40575	37530	32412	31390	32842	37053	34703
7	21924	25438	22272	22551	19628	20559	20099	17772	18420	18586	15459	15251	17488	18944	18696	21079	18115	17590	19486	19707	19774
8	10149	9324	10439	8007	9780	9311	13274	11033	9075	10310	8570	7528	8337	9428	8666	8373	10296	9132	10826	12021	10796
9	4420	5941	5448	6140	3317	3651	5676	8488	6110	5064	5325	5365	4426	5821	4595	5271	4140	5765	5854	7012	7459
10	5969	11331	10871	9741	6184	4178	6432	4198	5492	7583	6008	5007	3737	7717	6003	6551	12423	9313	7148	9028	15108

Table 10. Results obtained with VPA-2Box for Mediterranean swordfish.

```
                ****************************************
                                VPA-2BOX
                SUMMARY STATISTICS AND DIAGNOSTIC OUTPUT
                ****************************************

Med SWO 1985-2005
10:11,  6 September 2007

=======================================================================
Total objective function =        -22.01
      (with constants)   =         45.07
Number of parameters (P) =             8
Number of data points (D)=            73
AIC : 2*objective+2P     =        106.14
AICc: 2*objective+2P(...)=        108.39
BIC : 2*objective+Plog(D)=        124.46
Chi-square discrepancy   =        219.10

Loglikelihoods (deviance)=         22.01 (       192.39)
   effort data           =         22.01 (       192.39)

Log-posteriors           =          0.00
   catchability          =          0.00
   f-ratio               =          0.00
   natural mortality     =          0.00
   mixing coeff.         =          0.00

Constraints              =          0.00
   terminal F            =          0.00
   stock-rec./sex ratio  =          0.00

Out of bounds penalty    =          0.00
=======================================================================


TABLE 1. FISHING MORTALITY RATE FOR SWO Med
====================================================================================
          1      2      3      4      5      6      7      8      9     10     11
------------------------------------------------------------------------------------
 1985   0.009  0.119  0.294  0.370  0.387  0.433  0.609  0.605  0.270  0.202  0.202
 1986   0.011  0.096  0.304  0.441  0.382  0.450  0.681  0.702  0.298  0.370  0.370
 1987   0.011  0.176  0.331  0.388  0.464  0.640  0.777  0.819  0.340  0.494  0.494
 1988   0.012  0.242  0.518  0.490  0.603  0.687  0.833  0.635  0.673  0.696  0.696
 1989   0.036  0.169  0.422  0.568  0.702  0.689  0.601  0.654  0.784  0.636  0.636
 1990   0.005  0.209  0.603  0.692  0.450  0.387  0.390  0.262  0.393  0.338  0.338
 1991   0.007  0.150  0.558  0.662  0.607  0.499  0.528  0.406  0.280  0.663  0.663
 1992   0.021  0.131  0.682  0.599  0.477  0.482  0.509  0.516  0.400  0.522  0.522
 1993   0.015  0.175  0.639  0.499  0.409  0.363  0.404  0.422  0.441  0.369  0.369
 1994   0.018  0.156  0.658  0.658  0.485  0.507  0.493  0.607  0.541  0.579  0.579
 1995   0.027  0.217  0.491  0.489  0.406  0.397  0.453  0.416  0.292  0.507  0.507
 1996   0.006  0.185  0.393  0.499  0.375  0.320  0.309  0.398  0.240  0.353  0.353
 1997   0.006  0.159  0.462  0.673  0.498  0.561  0.311  0.359  0.156  0.206  0.206
 1998   0.022  0.270  0.508  0.455  0.429  0.466  0.562  0.475  0.411  0.343  0.343
 1999   0.006  0.166  0.492  0.504  0.497  0.448  0.485  0.649  0.220  0.232  0.232
 2000   0.003  0.171  0.533  0.640  0.639  0.576  0.519  0.575  0.574  0.260  0.260
 2001   0.003  0.144  0.557  0.711  0.688  0.543  0.421  0.471  0.451  0.418  0.418
 2002   0.002  0.217  0.597  0.512  0.333  0.409  0.346  0.295  0.235  0.290  0.290
 2003   0.028  0.148  0.717  0.694  0.546  0.419  0.407  0.384  0.244  0.259  0.259
 2004   0.039  0.213  0.471  0.589  0.535  0.543  0.485  0.607  0.425  0.321  0.321
 2005   0.005  0.203  0.507  0.507  0.507  0.507  0.507  0.483  0.483  0.483  0.483
```

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR [BY AREA] FOR SWO Med

	1	2	3	4	5	6	7	8	9	10	11
1985	853462.	796739.	616580.	353546.	206569.	101617.	56464.	23221.	12247.	9290.	12545.
1986	1053587.	692476.	579010.	376370.	199924.	114802.	53956.	25155.	10380.	7657.	14604.
1987	1263362.	853340.	515207.	349874.	198335.	111734.	59934.	22353.	10210.	6310.	12593.
1988	1205321.	1022910.	585970.	303101.	194424.	102113.	48229.	22561.	8072.	5953.	9443.
1989	999786.	974910.	657188.	285737.	152087.	87127.	42043.	17168.	9789.	3370.	6283.
1990	1005953.	789684.	673827.	352859.	132539.	61708.	35799.	18865.	7309.	3658.	4186.
1991	1064293.	819703.	524399.	301905.	144673.	69209.	34325.	19845.	11888.	4040.	4579.
1992	1230363.	865015.	577687.	245826.	127453.	64558.	34390.	16570.	10826.	7355.	3637.
1993	1071362.	986457.	621109.	239228.	110598.	64773.	32632.	16928.	8096.	5941.	5340.
1994	1114172.	864388.	678038.	268342.	118939.	60148.	36876.	17844.	9091.	4264.	6385.
1995	955786.	896127.	605493.	287611.	113771.	59940.	29666.	18447.	7966.	4331.	4887.
1996	911834.	761327.	590663.	303538.	144462.	62089.	32999.	15447.	9965.	4871.	4547.
1997	1064216.	742080.	518092.	326443.	150822.	81272.	36928.	19831.	8496.	6419.	5419.
1998	990080.	866387.	518225.	267288.	136359.	75067.	37976.	22159.	11342.	5952.	7890.
1999	997147.	793237.	541468.	255196.	138796.	72716.	38559.	17728.	11286.	6157.	8043.
2000	1121672.	811247.	549896.	271075.	126162.	69118.	38038.	19435.	7585.	7414.	9214.
2001	1210564.	916051.	559797.	264130.	117071.	54510.	31813.	18529.	8957.	3498.	10498.
2002	958634.	987873.	649287.	262697.	106203.	48193.	25940.	17102.	9470.	4672.	7546.
2003	1395125.	783675.	651177.	292608.	128903.	62341.	26214.	15032.	10427.	6131.	7485.
2004	779565.	1110620.	553233.	260198.	119717.	61163.	33561.	14292.	8380.	6685.	8607.
2005	1497990.	613560.	734974.	282844.	118194.	57406.	29106.	16925.	6380.	4484.	9082.
2006		1220249.	410140.	362450.	139484.	58287.	28310.	14354.	8546.	3222.	6850.

TABLE 3. CATCH OF SWO Med

	1	2	3	4	5	6	7	8	9	10	11
1985	6956.	81312.	142885.	99727.	60524.	32604.	23564.	9652.	2636.	1547.	2089.
1986	10260.	57372.	138165.	122451.	57874.	37985.	24430.	11631.	2434.	2158.	4116.
1987	12669.	125110.	132141.	102534.	67234.	48388.	29722.	11477.	2679.	2248.	4486.
1988	13206.	200401.	216626.	107217.	80562.	46531.	25046.	9713.	3625.	2737.	4342.
1989	31982.	138059.	206460.	113313.	70340.	39786.	17394.	7550.	4885.	1452.	2707.
1990	4320.	135680.	279271.	161486.	43836.	18046.	10545.	3955.	2166.	957.	1095.
1991	7039.	103688.	205034.	133993.	60258.	24862.	12879.	6043.	2645.	1794.	2033.
1992	23117.	96640.	261677.	101367.	44158.	22567.	12535.	6108.	3257.	2734.	1352.
1993	14134.	143891.	268701.	85861.	33884.	17993.	9888.	5315.	2636.	1672.	1503.
1994	17802.	113441.	299377.	118543.	41780.	21857.	13108.	7429.	3476.	1715.	2568.
1995	23486.	158900.	214501.	101570.	34615.	17913.	9861.	5727.	1836.	1574.	1776.
1996	4943.	116850.	175107.	109047.	41219.	15476.	7997.	4625.	1934.	1320.	1232.
1997	5447.	99162.	175012.	146535.	54040.	31916.	8986.	5450.	1115.	1085.	916.
1998	19237.	186668.	188768.	89276.	43398.	25547.	14932.	7649.	3488.	1575.	2088.
1999	5703.	110510.	192234.	92402.	49690.	23974.	13542.	7753.	2029.	1162.	1518.
2000	2541.	115895.	207824.	117320.	54575.	27689.	14084.	7773.	3031.	1545.	1920.
2001	3599.	111760.	218564.	123261.	53357.	20875.	9971.	6360.	2968.	1090.	3271.
2002	1319.	175122.	267177.	96208.	27395.	14760.	6910.	3977.	1803.	1071.	1730.
2003	35011.	98087.	305739.	134199.	49567.	19485.	7991.	4375.	2058.	1272.	1553.
2004	27356.	193664.	189784.	106013.	45355.	23423.	11776.	5950.	2650.	1673.	2154.
2005	6866.	102412.	267135.	102803.	42959.	20865.	10579.	5926.	2234.	1570.	3180.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT OF SWO Med

year	spawning biomass	recruits from VPA
1985	34910.	853462.
1986	35546.	1053587.
1987	35038.	1263362.
1988	31432.	1205321.
1989	26051.	999786.
1990	23069.	1005953.
1991	24349.	1064293.
1992	22123.	1230363.
1993	20860.	1071362.
1994	21923.	1114172.
1995	21033.	955786.
1996	23114.	911834.
1997	25760.	1064216.
1998	25279.	990080.
1999	24768.	997147.
2000	24068.	1121672.
2001	21667.	1210564.
2002	19699.	958634.
2003	22199.	1395125.
2004	22031.	779565.
2005	21468.	1497990.

Table 11. Inputs for the equilibrium per-recruit analyses.

Age	*WeightVPA*	*WeightXSA*	*SelectivityVPA*	*Sel.XSA*	*M*	*Maturity*
0	2.514321	3.32	0.024095	0.03	0.2	0
1	7.735611	7.81	0.289941	0.4	0.2	0
2	16.80517	16.98	0.915818	0.9	0.2	0
3	30.47185	30.84	1	1	0.2	0.5
4	48.35025	49.01	0.868821	0.9	0.2	1
5	68.15898	68.83	0.798131	0.9	0.2	1
6	87.37038	89.29	0.698365	0.8	0.2	1
7	106.7164	107.98	0.74868	1	0.2	1
8	125.7099	126.75	0.6183	0.6	0.2	1
9	142.5164	144.02	0.494168	0.7	0.2	1
10	181.3714	180.177	0.494168	0.7	0.2	1

Table 12. Equilibrium catch (numbers), yield (t) and spawning stock biomass (t) corresponding to the 2005 level of fishing mortality and other biological reference points. Absolute quantities reflect an assumed level of recruitment of 1,059,533 fish.

VPA	*F*	*Catch*	*Yield*	*SSB*	***XSA***	*F*	*Catch*	*Yield*	*SSB*
F2005	0.51	539,062	14,917	22,629	F2005	0.56	572,218	14,339	16,319
Fmax	0.30	437,174	16,010	54,401	Fmax	0.26	425,023	16,570	58,957
F20%	0.29	432,577	16,008	56,109	F20%	0.27	432,168	16,564	56,320
F30%	0.21	363,444	15,461	84,164	F30%	0.19	361,622	16,146	84,481
F40%	0.16	302,236	14,223	112,218	F40%	0.14	299,814	14,946	112,641

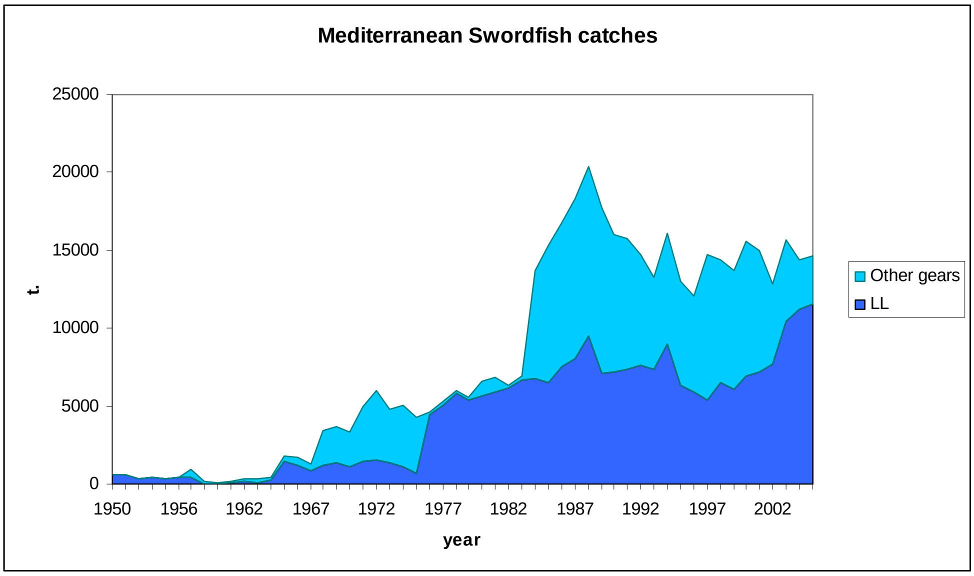


Figure 1. Cumulative estimates of swordfish catches (t) in the Mediterranean by major gear type, 1950-2005.

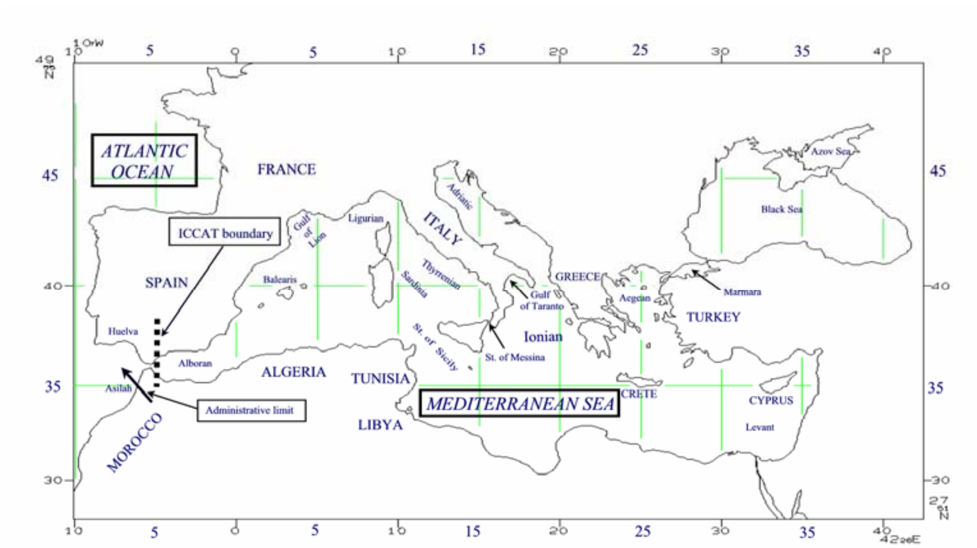


Figure 2. Map of the Mediterranean Sea with the locations referred to in the Report. The Mediterranean/Atlantic boundary used by ICCAT is at 5ºW longitude. The approximate provincial administrative limit for the Mediterranean used by Morocco is also shown.

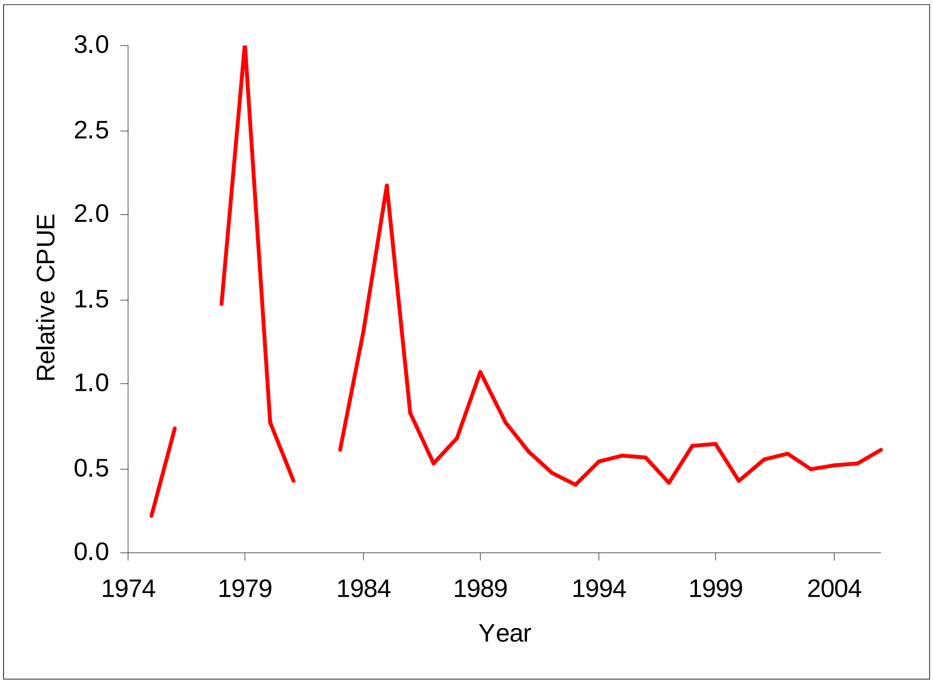


Figure 3. The relative CPUE time series used in production modeling, which results from the combined information in the Italian longline, Greek longline, Spanish longline, Japanese longline, Moroccan gillnet, and Italian gillnet time series.

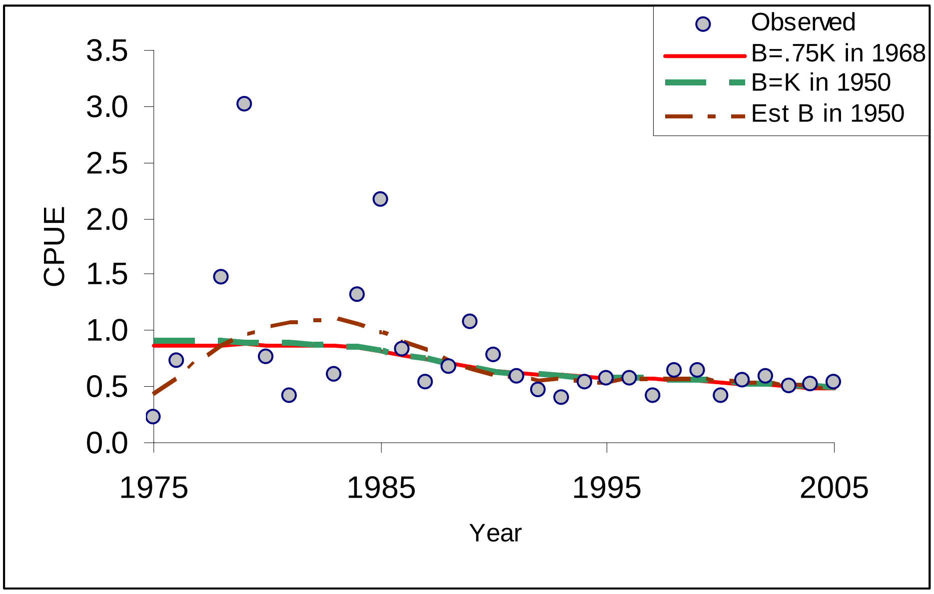


Figure 4. Fits of the three productions models (ASPIC) with different model structures to the observed CPUE data.

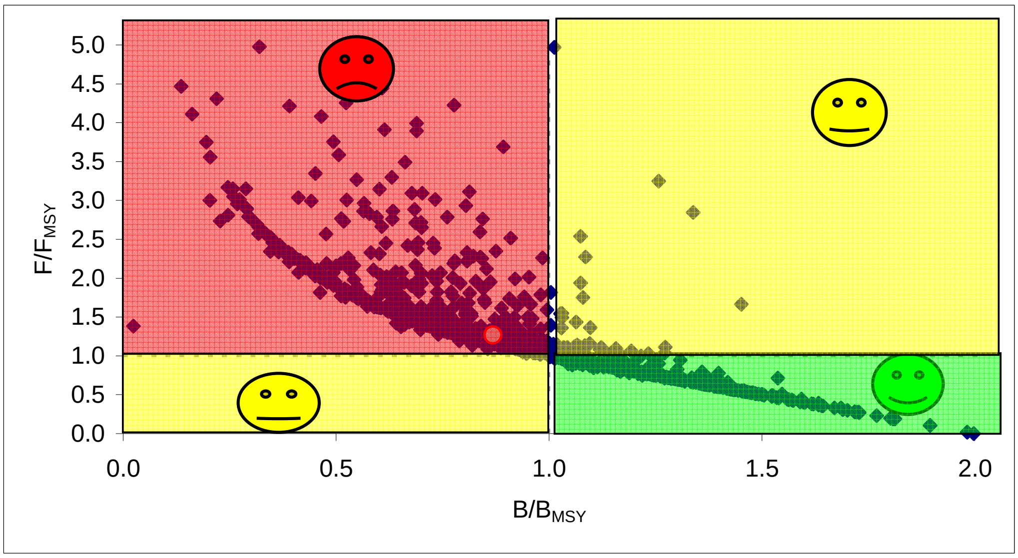


Figure 5. Scatter of stock status results for 2005 from 1500 bootstrap results using three model formulations (ASPIC, see **Appendix 4**) for the Mediterranean swordfish. The median outcome is indicated as the large closed circle in the center of the distribution of points.

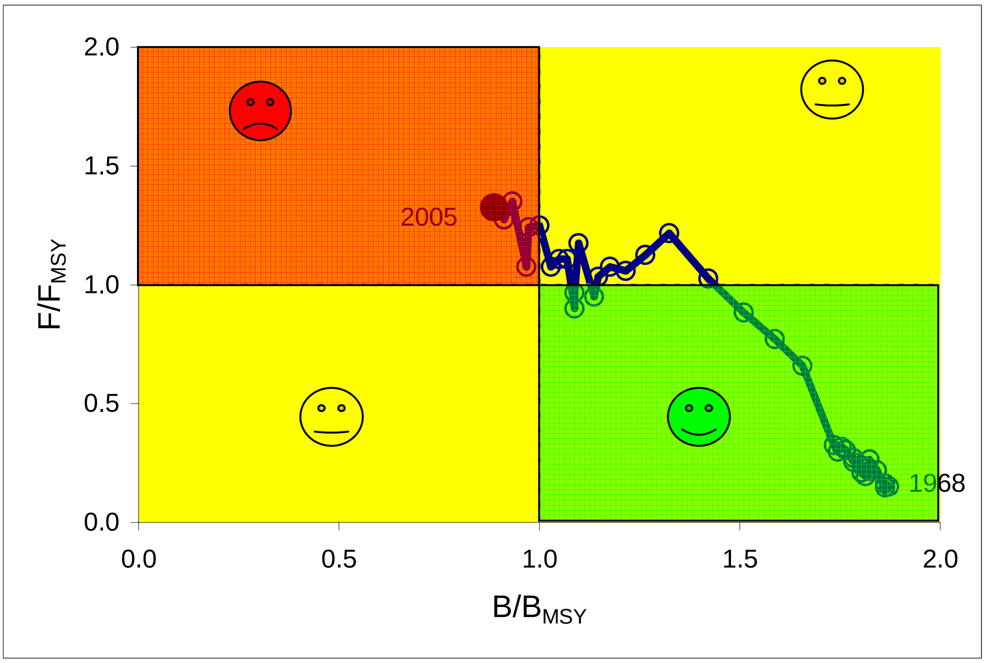


Figure 6.a. The median estimated trajectory of B- and F-ratios expressed relative to MSY for the period 1968-2005. The results are amalgamated from the three production model scenarios described in the **Appendix 4**.

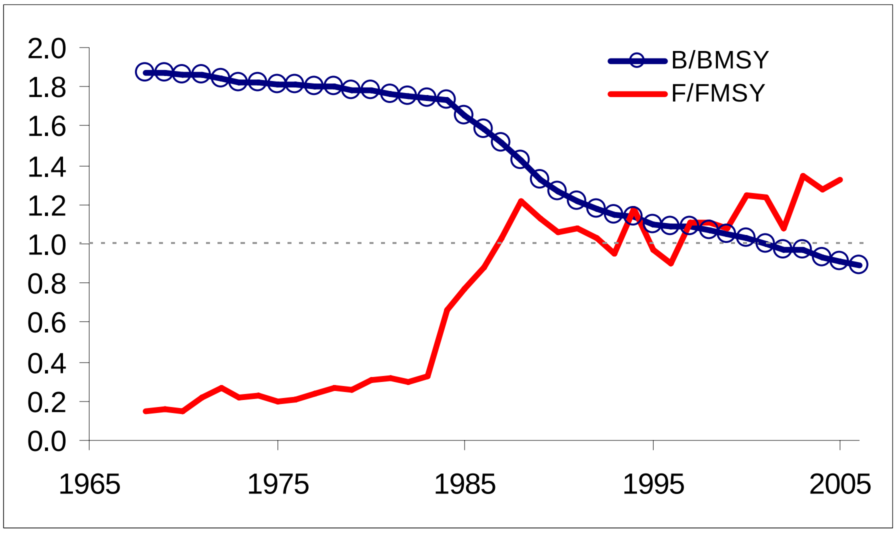


Figure 6.b. The time trajectory of estimated median relative biomass and relative F starting from 1968 based on the combined bootstrap outcomes of the ASPIC production model.

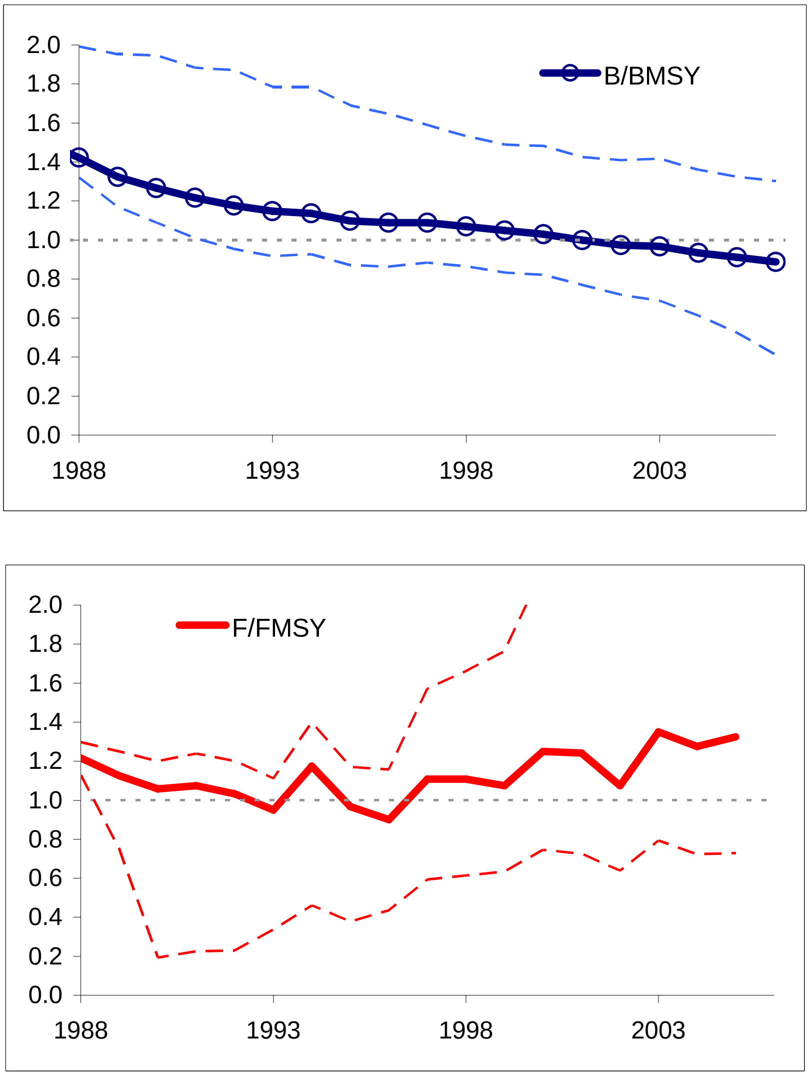


Figure 7. Estimates of B/B_{MSY} (upper plate) and F/F_{MSY} (lower plate) with associated 80% bootstrap confidence limits (dashed lines) based on the combined bootstrap outcomes of the ASPIC production model.

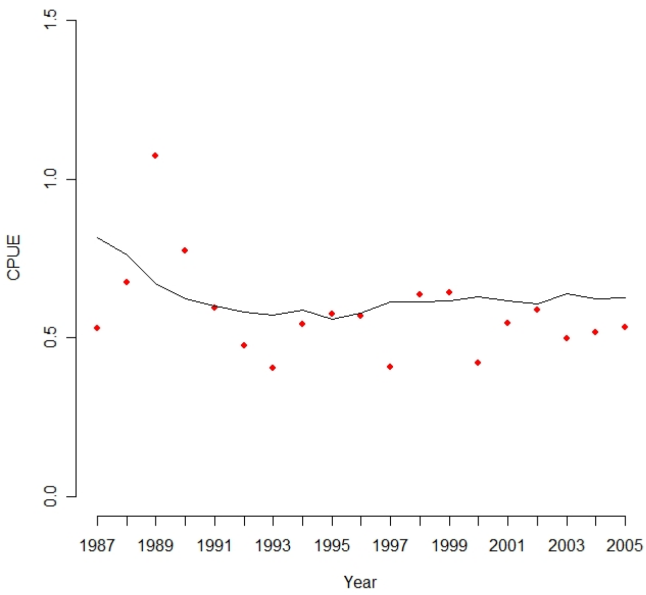


Figure 8. Observed abundance indices and model fitted line based on the predicted indices, for the TSM production model.

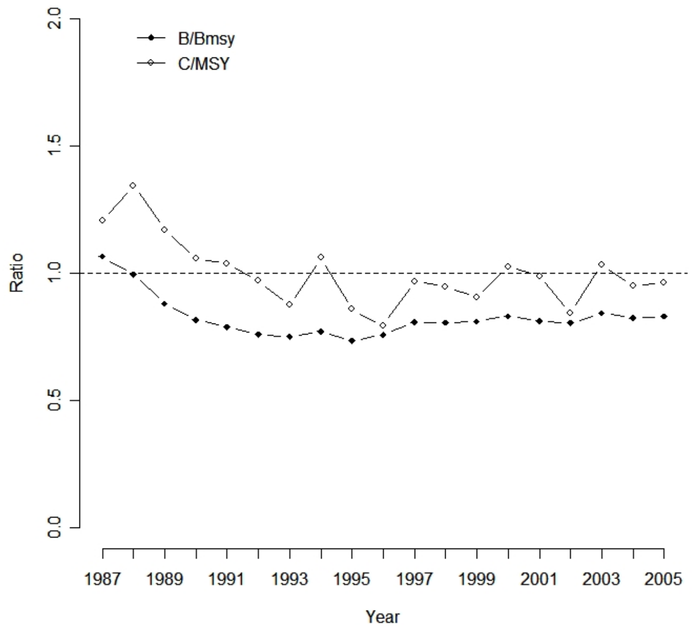


Figure 9. Relative biomass and catch rate estimates from the TSM production model.

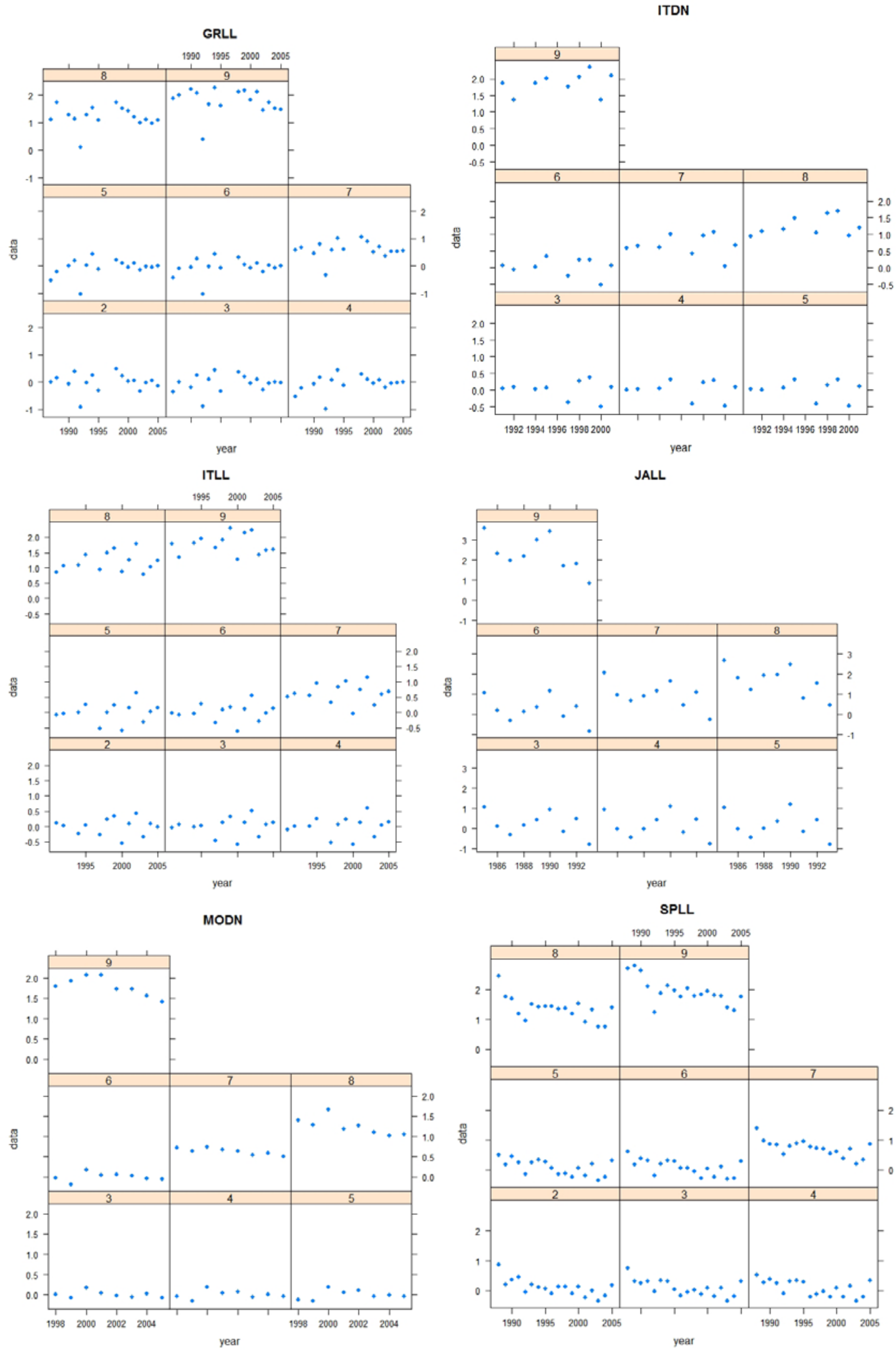


Figure 10. Estimated catchability residuals by fleet from the XSA model.

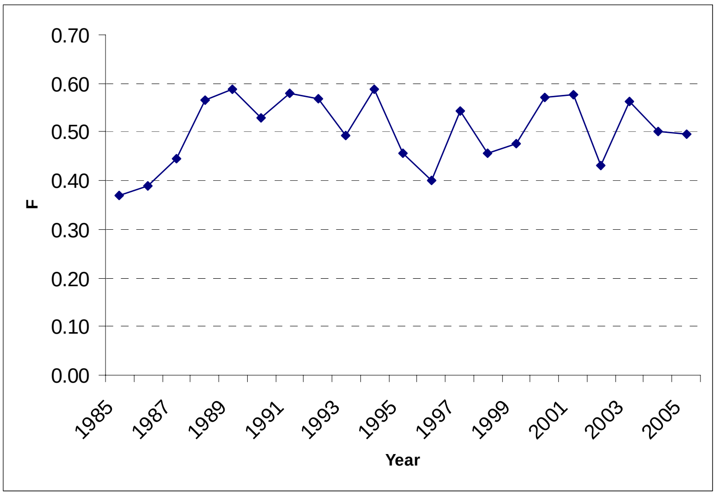


Figure 11. Mean Fs (ages 2-5) by year estimates obtained with the XSA model.

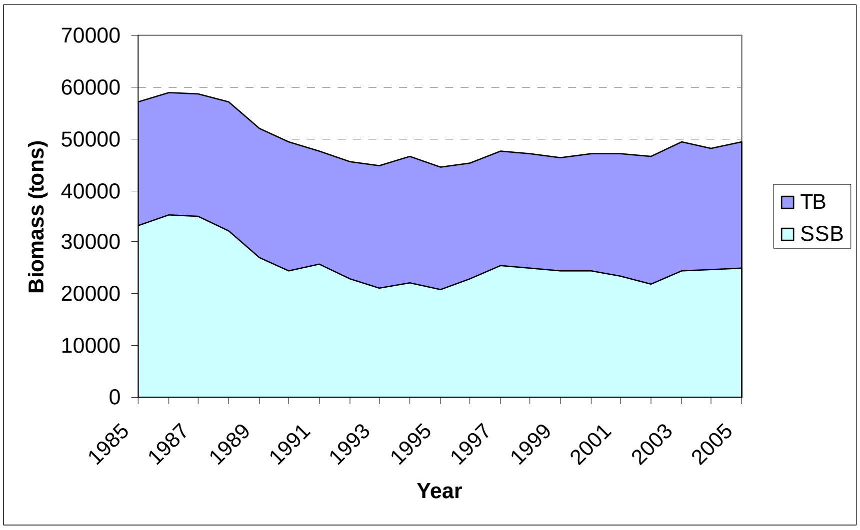


Figure 12. Total (TB) and spawning stock biomass (SSB) estimates obtained with the XSA model.

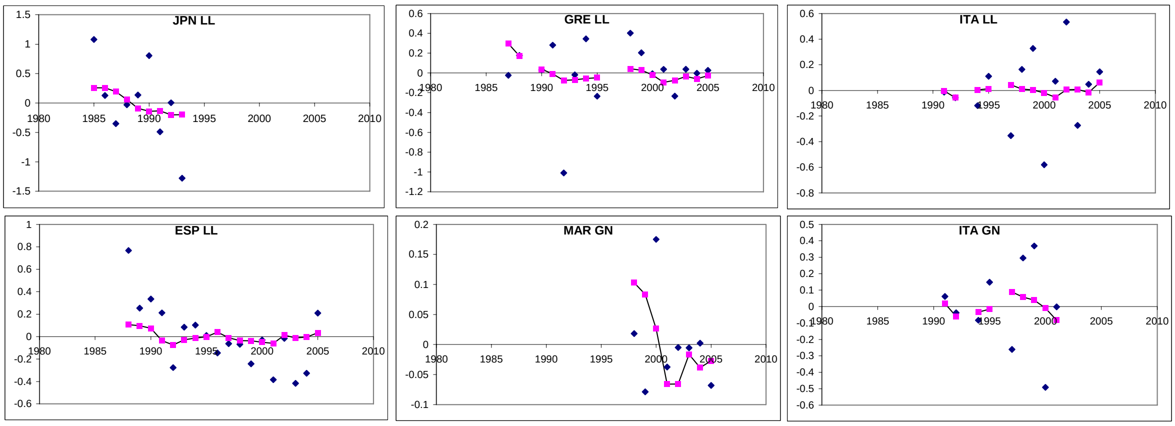


Figure 13. Fits to the available CPUE indices obtained using VPA-2Box, in log scale. The diamonds are the observed data and the squares connected with a line are the predicted ones.

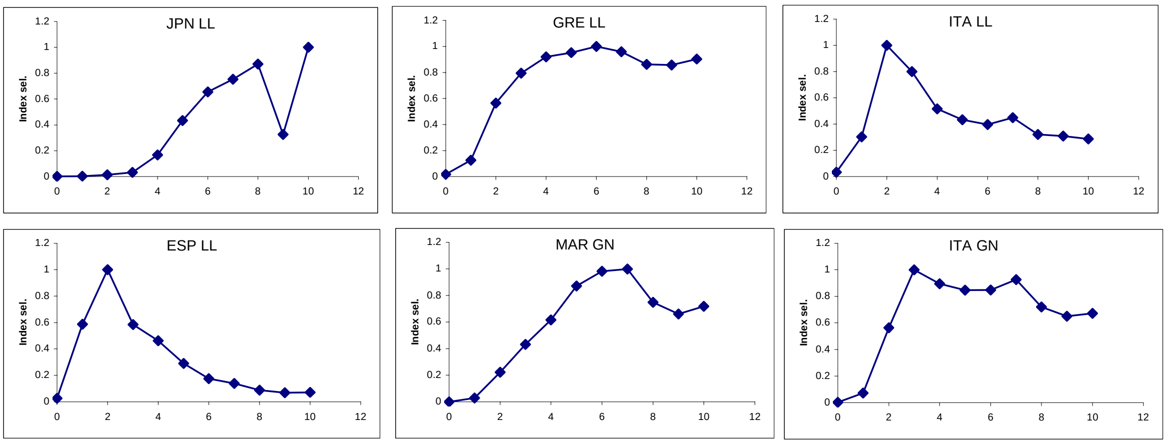


Figure 14. Estimated selectivities at age for each index used in the VPA-2Box analyses.

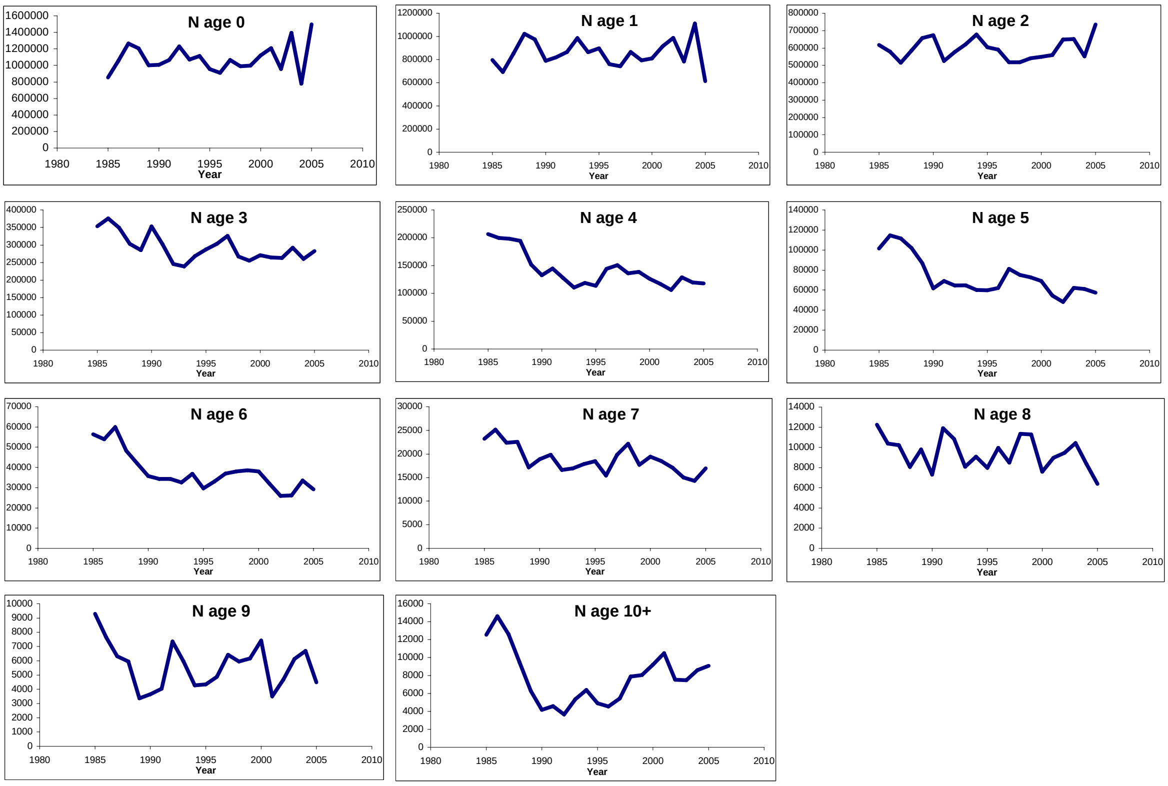


Figure 15. Estimated populations sizes at age for Mediterranean swordfish obtained with the VPA-2Box analyses.

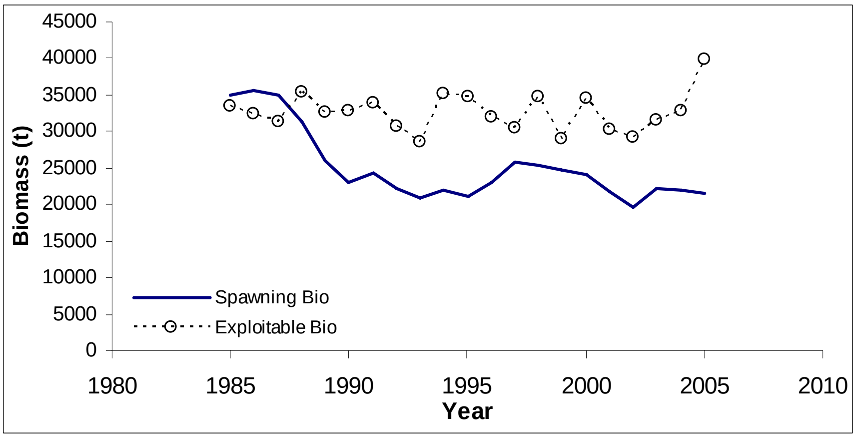


Figure 16. Estimated spawning and exploitable biomass for Mediterranean swordfish obtained with the VPA-2Box analyses.

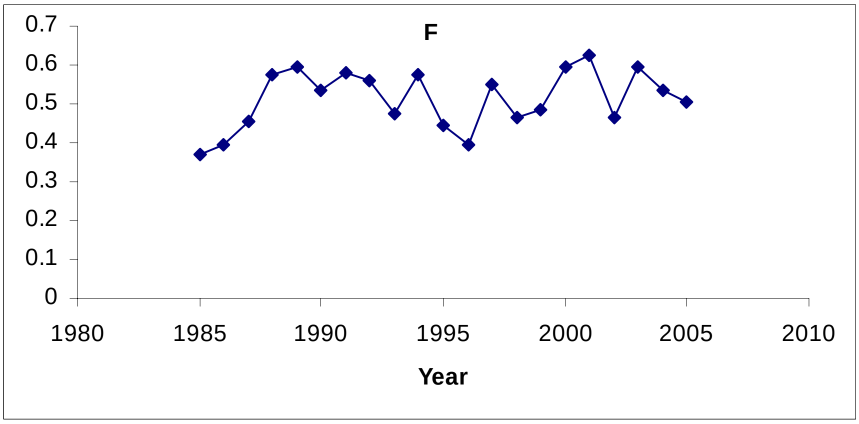


Figure 17. Estimated fishing mortality rates for Mediterranean swordfish obtained with the VPA-2Box analyses.

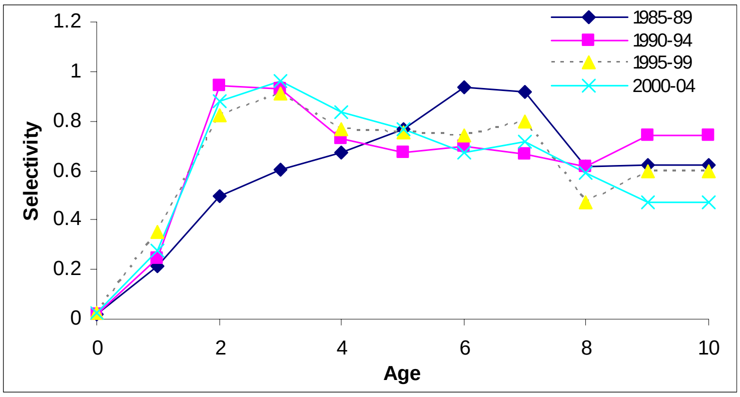
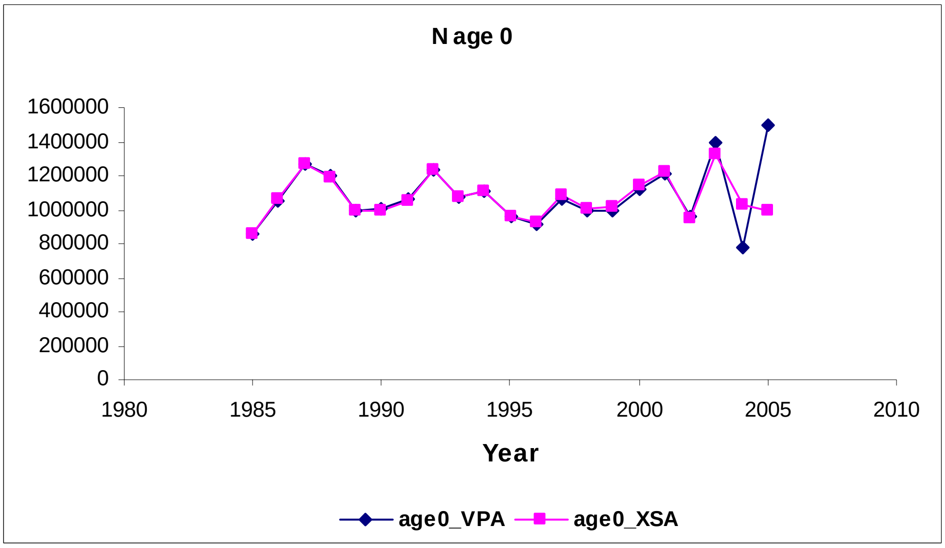
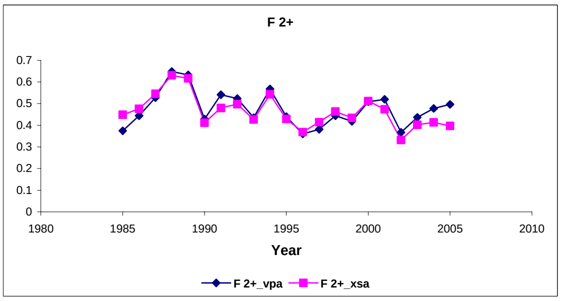
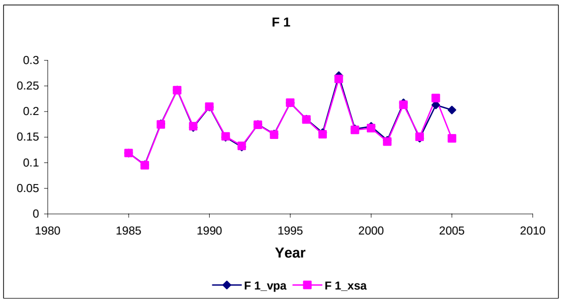


Figure 18. Estimated selectivity patterns for Mediterranean swordfish obtained with the VPA-2Box analyses, by 5-year blocks.


N age 0
Year
age0_VPA
age0_XSA


F 2+
Year
F 2+_vpa
F 2+_xsa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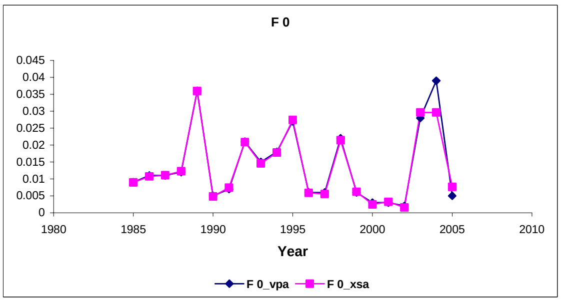
Year
F 1_vpa
F 1_xsa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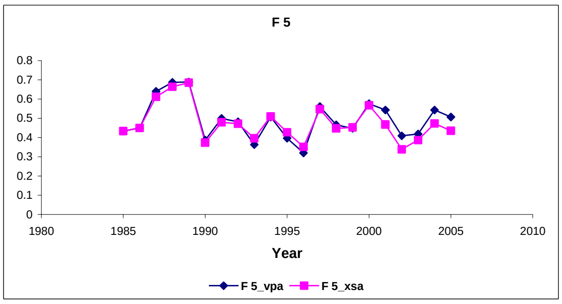
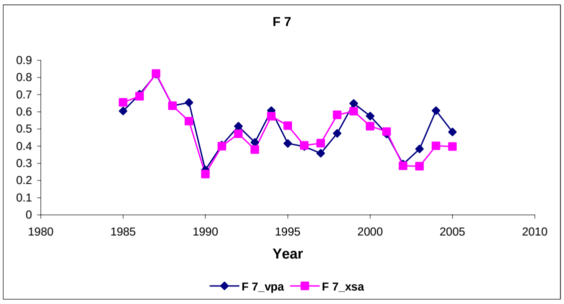
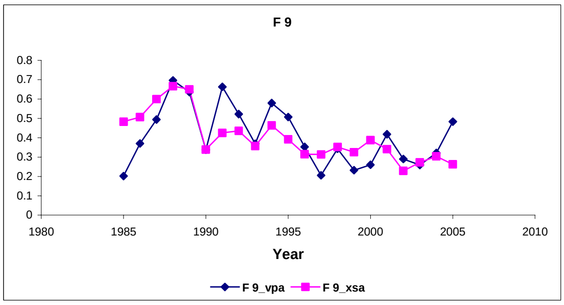
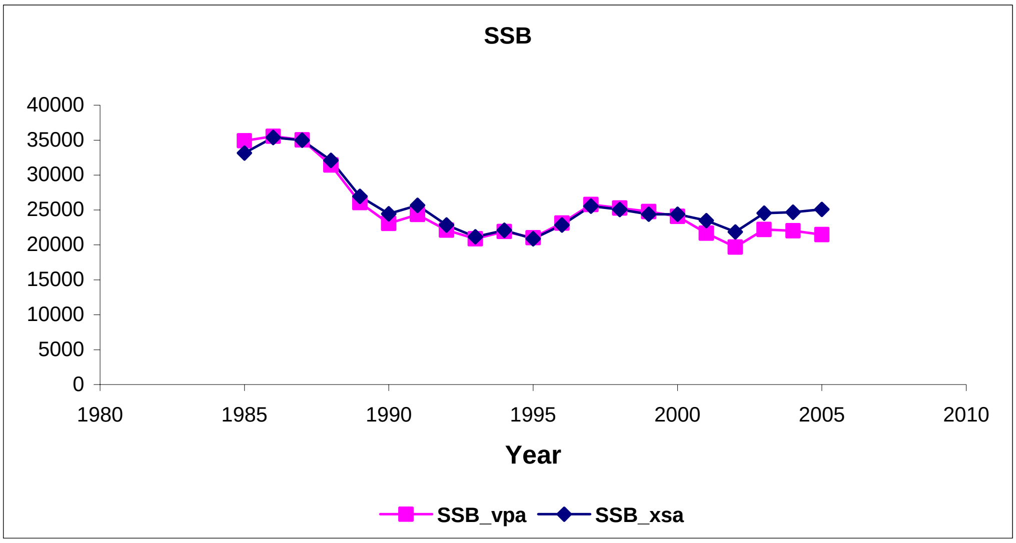
Year
F 0_vpa
F 0_xsa


F 5
Year
F 5_vpa
F 5_xsa


F 7
Year
F 7_vpa
F 7_xsa


F 9
Year
F 9_vpa
F 9_xsa



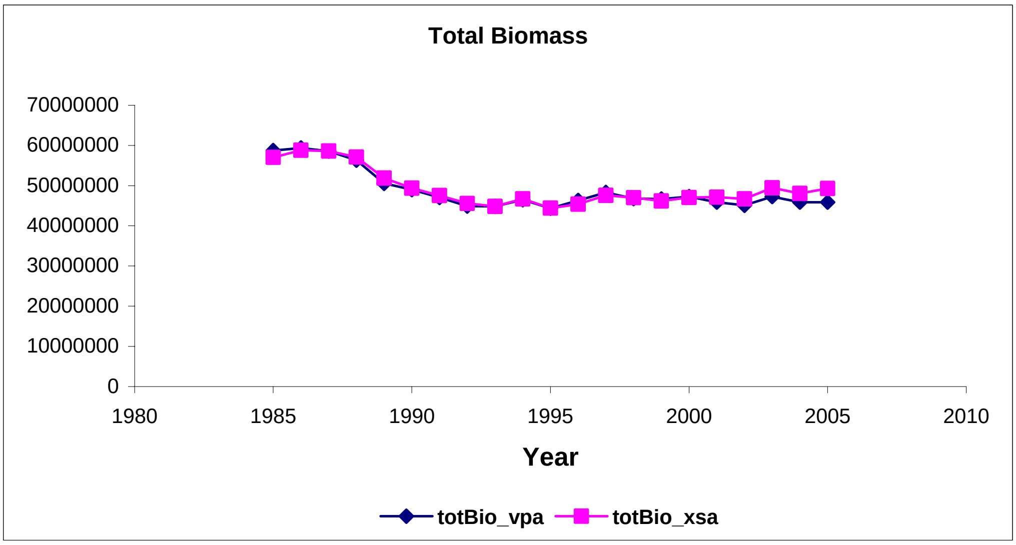


Figure 19. Comparison of some results obtained with two different age-structured assessment methods applied to Mediterranean swordfish. Top: Recruitment; Middle: Fishing mortality at age. Bottom: Spawning biomass (t) and total biomass (kg).

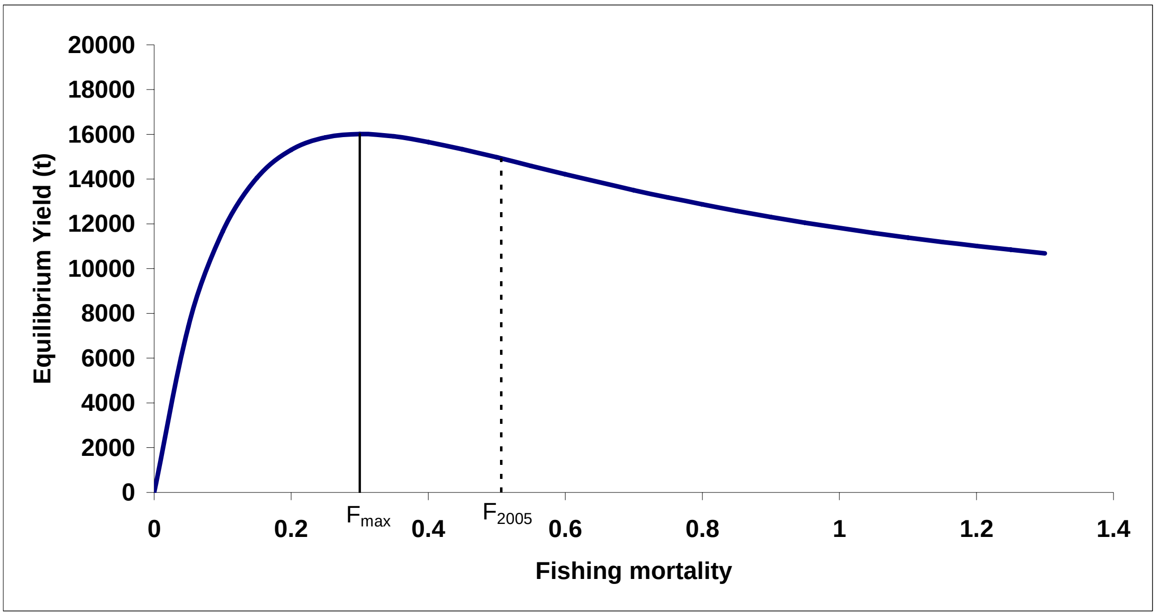


Figure 20a. Equilibrium yield – F relationship for Mediterranean swordfish based on VPA-2box (scaled assuming a level of recruitment of 1,059,533 fish).

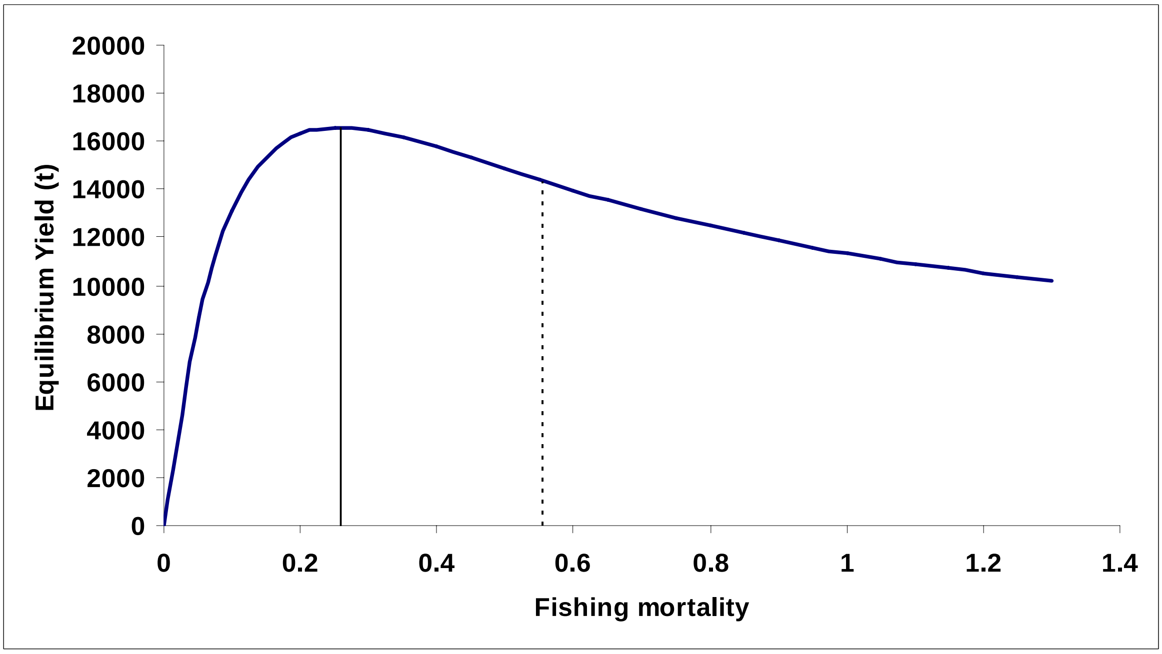
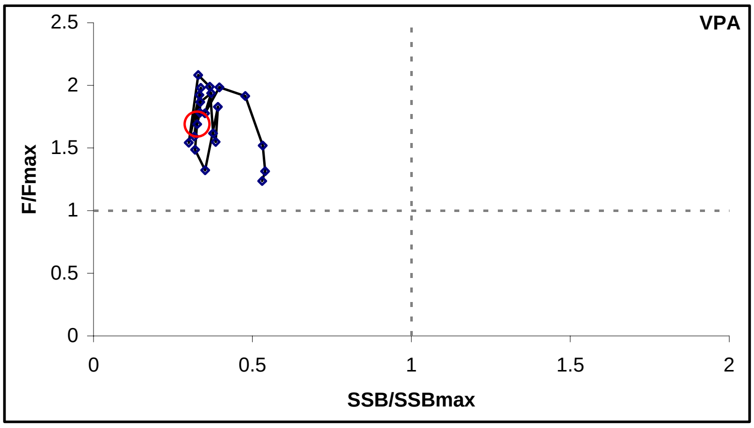


Figure 20b. Equilibrium yield – F relationship for Mediterranean swordfish based on XSA (scaled assuming a level of recruitment of 1,059,533 fish).



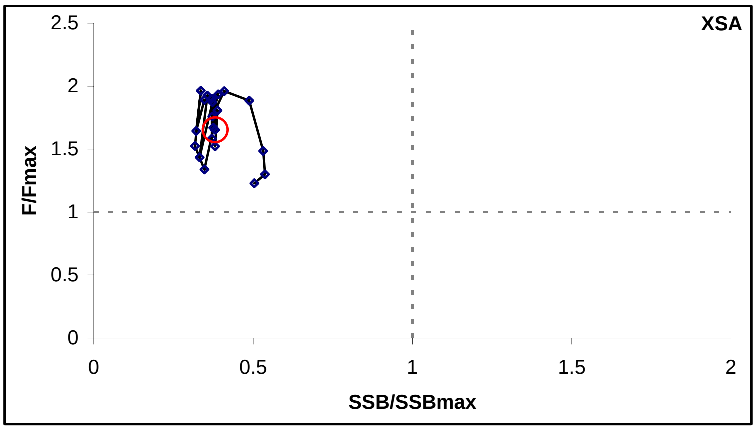


Figure 21. Trends in the estimated ratios of fishing mortality relative to the F that maximizes yield per recruit (F_{max}) against the estimated ratios of spawning biomass relative to the level that would result from fishing at $F_{max.}$ Top: VPA-2Box results. Bottom: XSA results. The large open circles indicate the position of the 2005 data point.

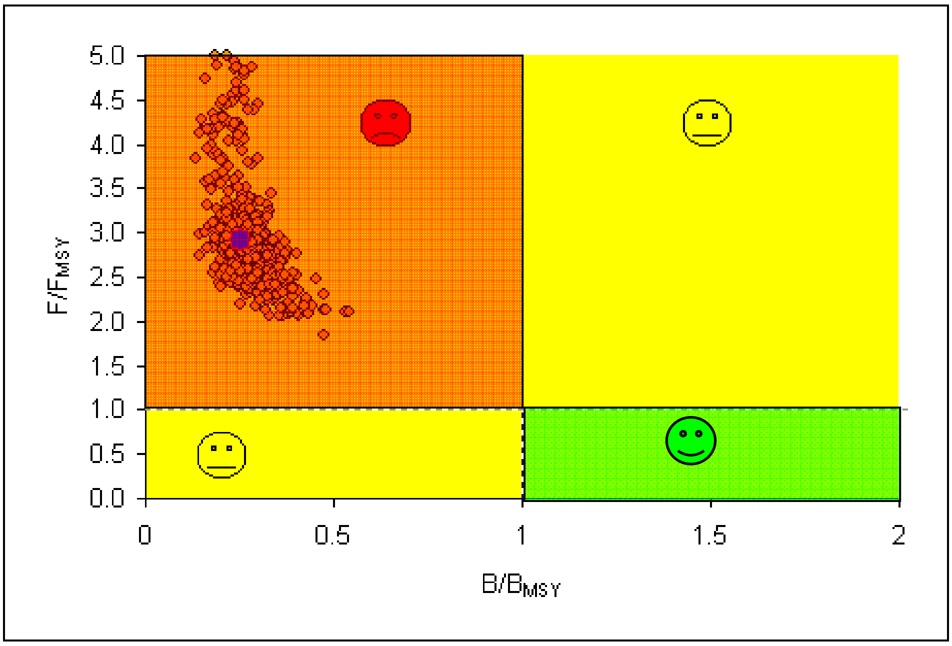


Figure 22. The range of bootstrap outcomes from the VPA-2BOX status evaluations. The large, closed circle represents the deterministic outcome. Although the uncertainty in the outcomes is high, all of the estimates indicate the stock is overfished and undergoing overfishing

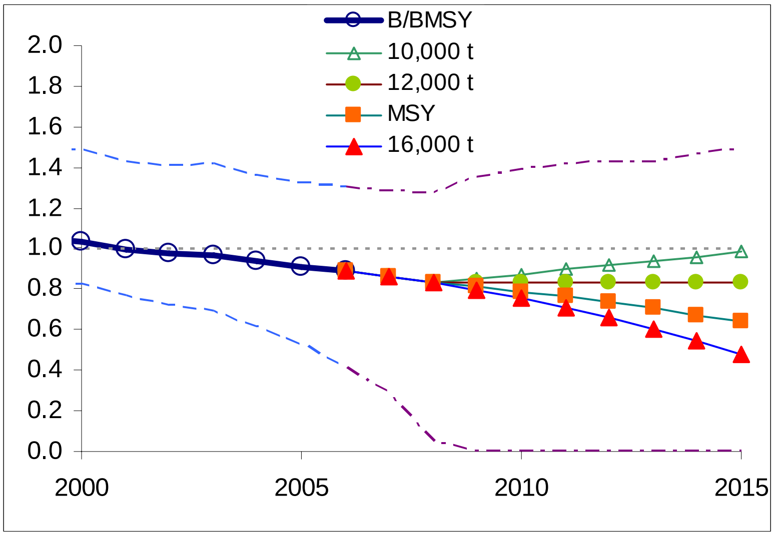


Figure 23a. Forecasts of B/B_{MSY} for the different constant catch scenarios shown based on the combined bootstrap outcomes from the ASPIC production model. The lines with symbols represent median outcomes. The assumed constant catch for the MSY scenario was 14,300 t. The confidence interval reflects the upper 80% bound for the 10,000 t scenario and the lower boundary is that from the 16,000 t scenario.

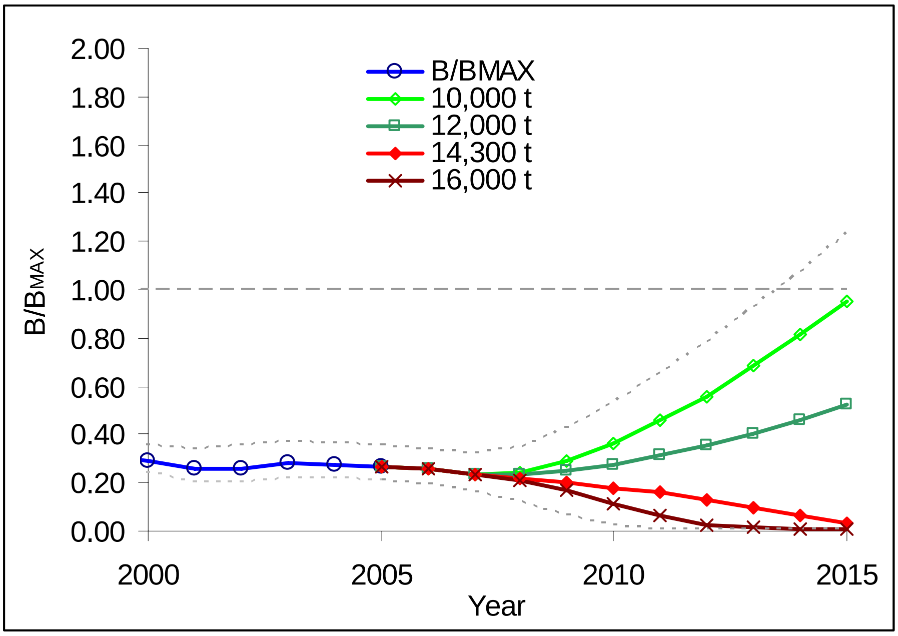


Figure 23b. Forecasts of B/B_{MAX} (B_{MAX} is a proxy for B_{MSY}) for the different constant catch scenarios shown based on the combined bootstrap outcomes from the VPA-2BOX model. The lines with symbols represent median outcomes. The confidence interval reflects the upper 80% bound for the 10,000 t scenario and the lower boundary is that from the 16,000 t scenario.

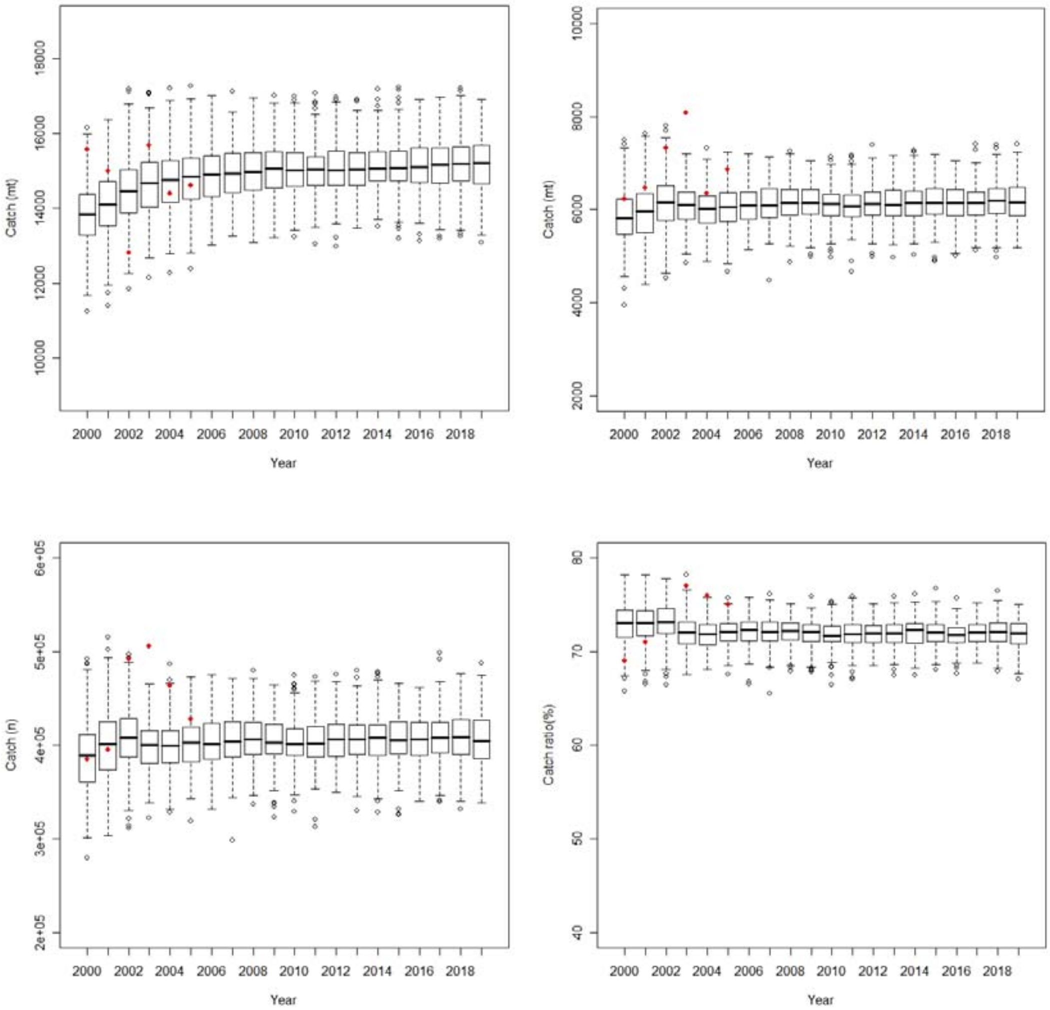


Figure 24. From left to right and top to bottom: Box-whisker plots by year, for the total catch (weight), juvenile catch (weight), juvenile catch (number) and juvenile catch ratio (number) estimates obtained from the VPA Scenario 1 simulations. Solid circles indicate the corresponding reported rates for the years 2000-2005.

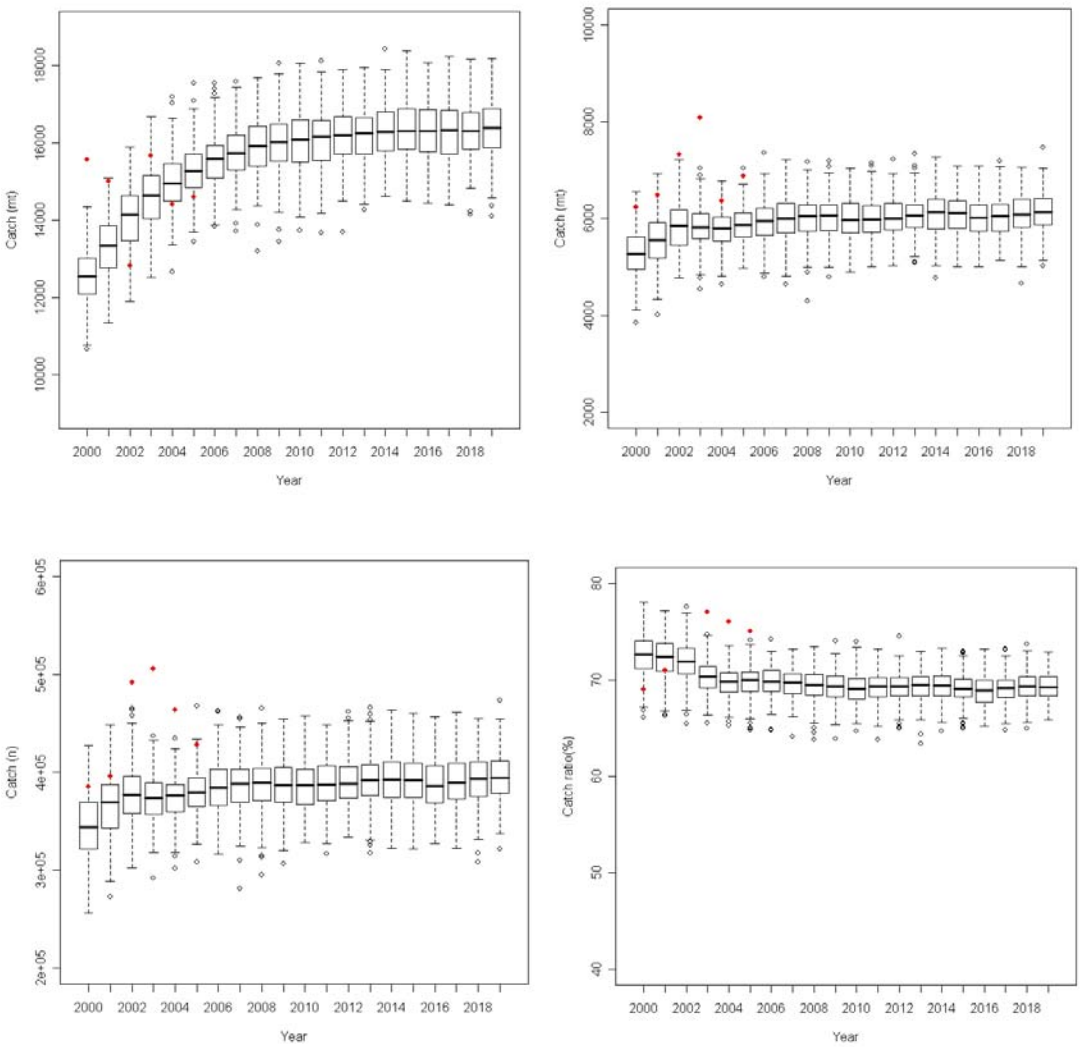


Figure 25. From left to right and top to bottom: Box-whisker plots by year, for the total catch (weight), juvenile catch (weight), juvenile catch (number) and juvenile catch ratio (number) estimates obtained from the VPA Scenario 2 simulations. Solid circles indicate the corresponding reported rates for the years 2000-2005.

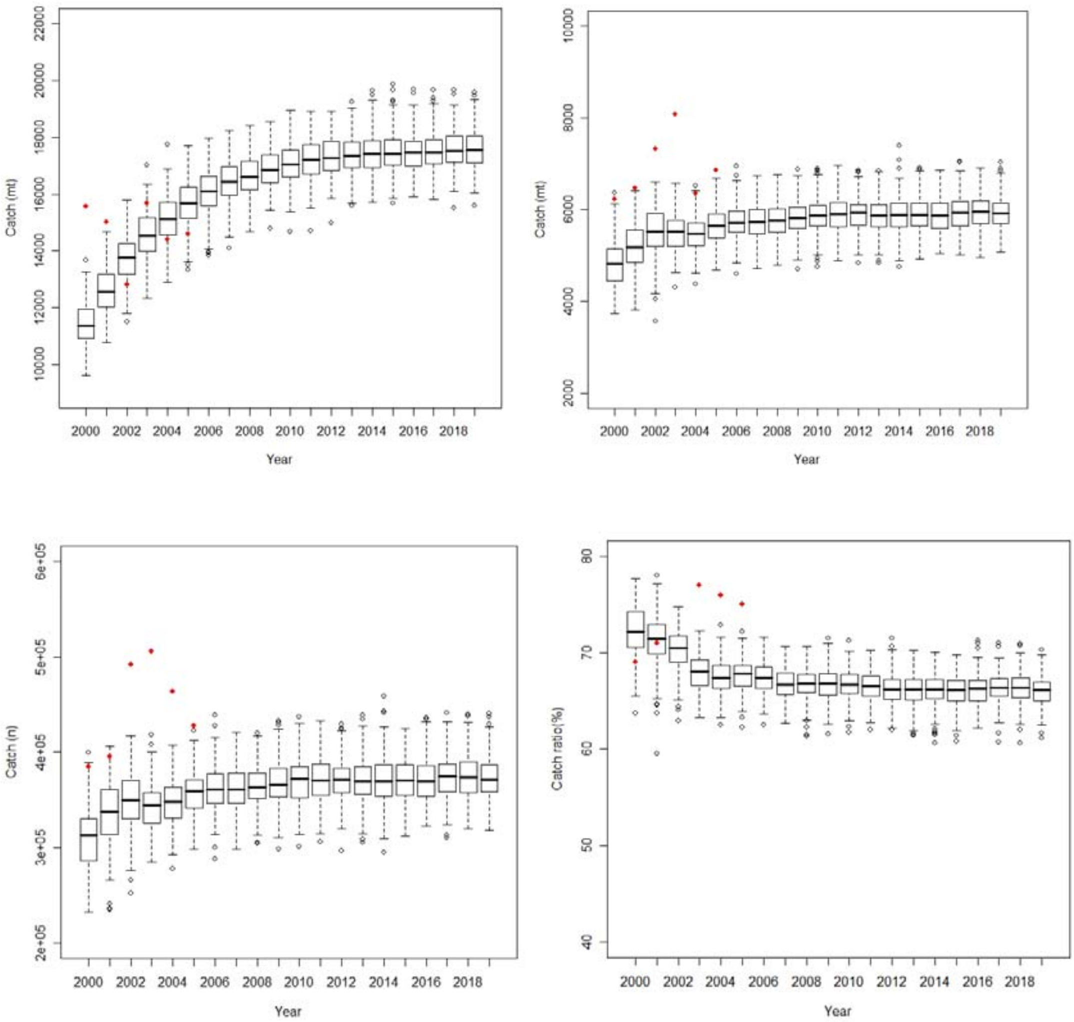


Figure 26. From left to right and top to bottom: Box-whisker plots by year, for the total catch (weight), juvenile catch (weight), juvenile catch (number) and juvenile catch ratio (number) estimates obtained from the VPA Scenario 3 simulations. Solid circles indicate the corresponding reported rates for the years 2000-2005.

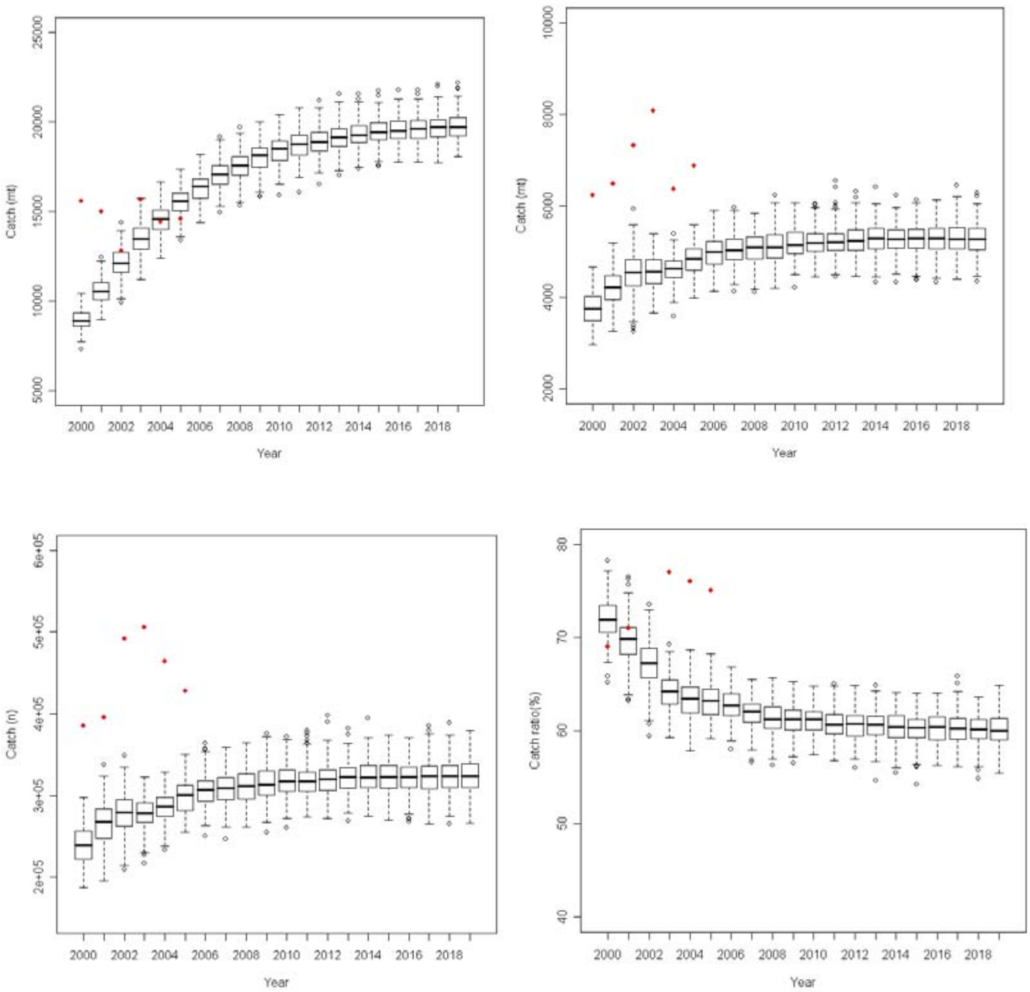


Figure 27. From left to right and top to bottom: Box-whisker plots by year, for the total catch (weight), juvenile catch (weight), juvenile catch (number) and juvenile catch ratio (number) estimates obtained from the VPA Scenario 4 simulations. Solid circles indicate the corresponding reported rates for the years 2000-2005.

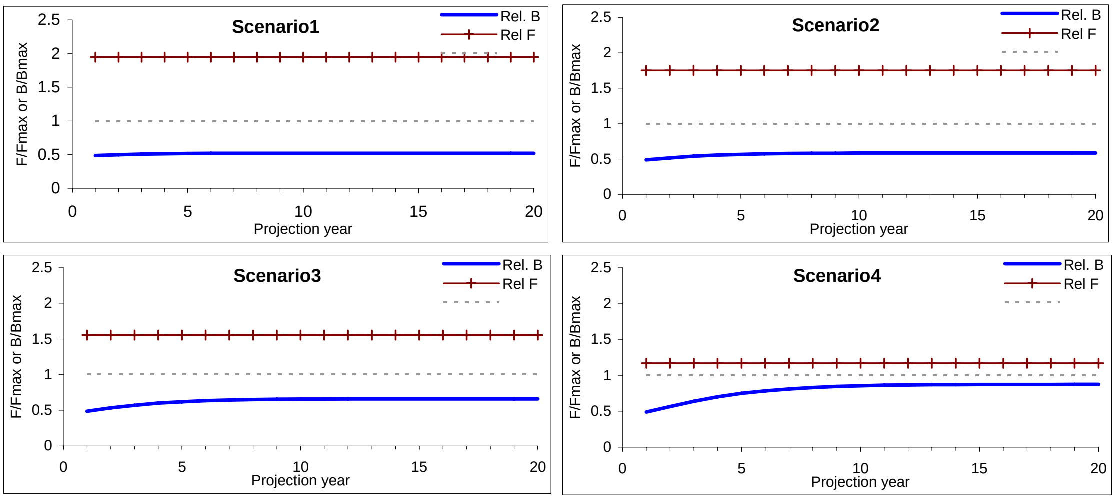


Figure 28. Projections results in terms of fishing mortality and biomass relatives to F_{max} and B_{max} for the four VPA scenarios considered.

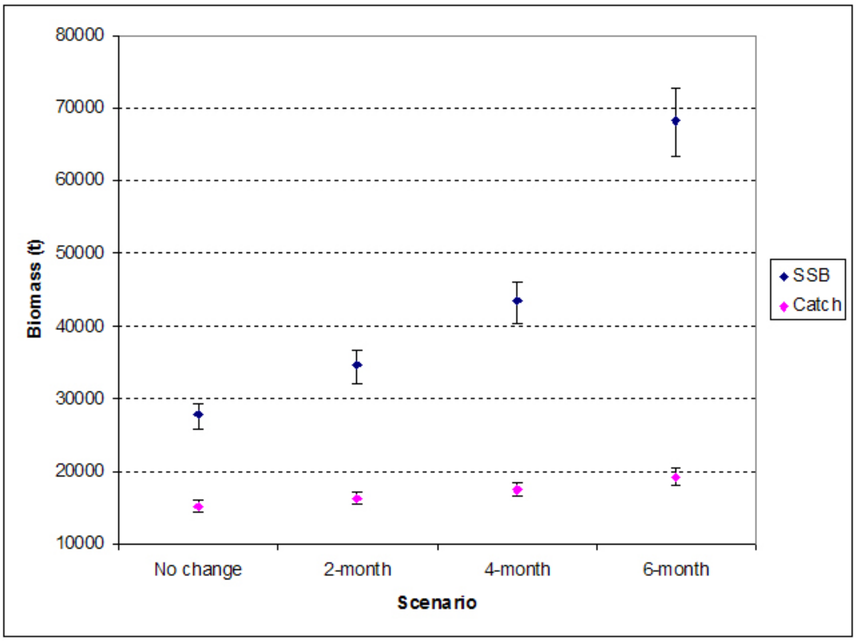


Figure 29. Median SSB and annual catch levels with the associated 80% confidence limits as predicted by the seasonal closure scenarios. Estimates refer to the last ten years of the projection period, i.e. after stabilization.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Descriptions of fisheries
3. Biological data
4. Catch data
5. Relative abundance indices
6. Stock status results
7. Projections
8. Recommendations
   8.1 Research and statistics
   8.2 Management
9. Other matters
10. Adoption of the report and closure

Appendix 2

List of Participants

CONTRACTING PARTIES

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Kebe, Papa
Pallarés, Pilar
Palma, Carlos

Appendix 3

List of Documents

SCRS/2007/106 By catches and discards of the Greek swordfish fishery. PERISTERAKI, P., N. Kypraios, G. Lazarakis and G. Tserpes.

SCRS/2007/107 Standardization of swordfish *(Xiphias gladius)* catch rates from the Greek and Italian Mediterranean longline fisheries. TSERPES, G., P. Peristeraki and A. Di Natale.

SCRS/2007/108 Discards of undersized swordfish individuals in the Greek swordfish fisheries. TSERPES, G. and P. Peristeraki.

SCRS/2007/109 Estimates of Mediterranean swordfish stock by means of a non-equilibrium surplus production model approach. TSERPES, G.

SCRS/2007/115 A time series of swordfish longline CPUE in the northwestern Mediterranean: search for exploitation and/or climatic factors influencing fish abundance. ORSI RELINI, L., G. Palandri, F. Garibaldi, C. Cima, L.Lanteri, M. Relini.

SCRS/2007/116 Standardized catch rates of swordfish *(Xiphias gladius)* from the Moroccan driftnet fishery operated in the Mediterranean Sea, period: 1998- 2006. ABID, N., and M. Idrissi.

SCRS/2007/117 Age and growth of swordfish (*Xiphias gladius*) in western Mediterranean Sea. VALEIRAS, X., J.M. de la Serna, D. Macías, M. Ruiz, S. García-Barcelona, M.J. Gómez and J.M. Ortíz de Urbina.

SCRS/2007/118 Updated standardized catch rates in number and weight for swordfish (*Xiphias gladius* L.) caught by the Spanish longline fleet in the Mediterranean Sea, 1988- 2005. ORTIZ DE URBINA, J. M., J. M. de la Serna, J. Mejuto and D. Macías.

SCRS/2007/119 CPUE series (1985-2006) for swordfish (*Xiphias gladius* l.) by gear type in the Tyrrhenian Sea and in the Strait of Sicily. DI NATALE, A. and A. Mangano.

Appendix 4

Details of Production Modeling (ASPIC) for Mediterranean Stock Assessment

2007 Mediterranean swordfish stock assessment

AllCPUEcombined fix b1 at .75k,including Sicilian index series

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.16). BOT program mode, LOGISTIC model mode, YLD conditioning, SSE optimization

Author: Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research
101 Pivers Island Road; Beaufort, North Carolina 28516 USA
Mike.Prager@noaa.gov

Reference: Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin 92: 374-389.

(ASPIC User's Manual is available from the author).

CONTROL PARAMETERS (FROM INPUT FILE)   Input file: correctedshortseries.inp

---

Operation of ASPIC: Fit logistic (Schaefer) model by direct optimization with bootstrap.

Number of years analyzed:	38	Number of bootstrap trials:	333	
Number of data series:	1	Bounds on MSY (min, max):	1.000E+03	5.000E+06
Objective function:	Least squares	Bounds on K (min, max):	1.000E+04	4.000E+07
Relative conv. criterion (simplex):	1.000E-08	Monte Carlo search mode, trials:	0	50000
Relative conv. criterion (restart):	3.000E-08	Random number seed:	673221	
Relative conv. criterion (effort):	1.000E-04	Identical convergences required in fitting:	6	
Maximum F allowed in fitting:	8.000			

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

Normal
convergence

GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1 > K	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1) Combined Series	6.330E+00	29	2.344E-01	1.000E+00	1.000E+00	0.140

....

TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 6.32978787E+00 2.435E-01 4.934E-01
Estimated contrast index (ideal = 1.0): 0.3911 C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - |min(B-Bmsy)|/K

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1968)	7.500E-01	7.500E-01	2.514E-01	0	1

MSY	Maximum sustainable yield	1.214E+04	8.750E+04	9.339E+03	1	1
K	Maximum population size	2.346E+05	1.000E+06	5.604E+04	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1

--------- Catchability Coefficients by Data Series ---------------

q(1)	Combined Series	4.344E-06	1.800E-06	1.710E-04	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.214E+04	----	----
Bmsy	Stock biomass giving MSY	1.173E+05	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	1.035E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2006)/Bmsy	9.374E-01	----	----
F./Fmsy	Ratio: F(2005)/Fmsy	1.269E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2005)	7.881E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2006	1.138E+04	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	9.374E-01	----	----
Ye.	Equilibrium yield available in 2006	1.209E+04	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	9.961E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Combined Series	2.382E+04	Fmsy/q(1)	Fmsy/q(1)

MedSWO2007AllCPUEcombined fix b1 at .75k,including Sicilian index series

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1968	0.019	1.760E+05	1.787E+05	3.440E+03	3.440E+03	8.813E+03	1.860E-01	1.500E+00
2	1969	0.020	1.814E+05	1.837E+05	3.723E+03	3.723E+03	8.256E+03	1.959E-01	1.546E+00
3	1970	0.018	1.859E+05	1.881E+05	3.341E+03	3.341E+03	7.717E+03	1.716E-01	1.584E+00
4	1971	0.026	1.903E+05	1.915E+05	4.975E+03	4.975E+03	7.293E+03	2.511E-01	1.622E+00
5	1972	0.031	1.926E+05	1.932E+05	5.958E+03	5.958E+03	7.068E+03	2.981E-01	1.642E+00
6	1973	0.025	1.937E+05	1.947E+05	4.807E+03	4.807E+03	6.853E+03	2.385E-01	1.651E+00
7	1974	0.026	1.957E+05	1.965E+05	5.034E+03	5.034E+03	6.604E+03	2.475E-01	1.668E+00
8	1975	0.022	1.973E+05	1.984E+05	4.301E+03	4.301E+03	6.348E+03	2.095E-01	1.682E+00
9	1976	0.023	1.994E+05	2.001E+05	4.637E+03	4.637E+03	6.096E+03	2.239E-01	1.699E+00
10	1977	0.026	2.008E+05	2.012E+05	5.280E+03	5.280E+03	5.942E+03	2.537E-01	1.712E+00
11	1978	0.030	2.015E+05	2.014E+05	5.958E+03	5.958E+03	5.899E+03	2.858E-01	1.717E+00
12	1979	0.028	2.014E+05	2.016E+05	5.547E+03	5.547E+03	5.878E+03	2.659E-01	1.717E+00
13	1980	0.033	2.017E+05	2.014E+05	6.579E+03	6.579E+03	5.905E+03	3.157E-01	1.720E+00
14	1981	0.034	2.011E+05	2.007E+05	6.813E+03	6.813E+03	6.014E+03	3.281E-01	1.714E+00

15	1982	0.032	2.003E+05	2.001E+05	6.343E+03	6.343E+03	6.090E+03	3.063E-01	1.707E+00
16	1983	0.035	2.000E+05	1.996E+05	6.896E+03	6.896E+03	6.163E+03	3.338E-01	1.705E+00
17	1984	0.070	1.993E+05	1.957E+05	1.367E+04	1.367E+04	6.719E+03	6.748E-01	1.699E+00
18	1985	0.081	1.923E+05	1.884E+05	1.529E+04	1.529E+04	7.679E+03	7.844E-01	1.639E+00
19	1986	0.093	1.847E+05	1.805E+05	1.676E+04	1.676E+04	8.613E+03	8.975E-01	1.575E+00
20	1987	0.107	1.766E+05	1.720E+05	1.832E+04	1.832E+04	9.496E+03	1.029E+00	1.505E+00
21	1988	0.125	1.678E+05	1.626E+05	2.037E+04	2.037E+04	1.033E+04	1.211E+00	1.430E+00
22	1989	0.115	1.577E+05	1.542E+05	1.776E+04	1.776E+04	1.094E+04	1.113E+00	1.344E+00
23	1990	0.108	1.509E+05	1.485E+05	1.602E+04	1.602E+04	1.128E+04	1.043E+00	1.286E+00
24	1991	0.109	1.462E+05	1.440E+05	1.575E+04	1.575E+04	1.151E+04	1.057E+00	1.246E+00
25	1992	0.105	1.419E+05	1.404E+05	1.471E+04	1.471E+04	1.167E+04	1.013E+00	1.210E+00
26	1993	0.096	1.389E+05	1.381E+05	1.326E+04	1.326E+04	1.176E+04	9.281E-01	1.184E+00
27	1994	0.119	1.374E+05	1.352E+05	1.608E+04	1.608E+04	1.186E+04	1.149E+00	1.171E+00
28	1995	0.098	1.332E+05	1.326E+05	1.301E+04	1.301E+04	1.193E+04	9.485E-01	1.135E+00
29	1996	0.091	1.321E+05	1.320E+05	1.205E+04	1.205E+04	1.195E+04	8.823E-01	1.126E+00
30	1997	0.113	1.320E+05	1.306E+05	1.469E+04	1.469E+04	1.198E+04	1.087E+00	1.125E+00
31	1998	0.112	1.293E+05	1.281E+05	1.437E+04	1.437E+04	1.204E+04	1.084E+00	1.102E+00
32	1999	0.109	1.269E+05	1.261E+05	1.370E+04	1.370E+04	1.207E+04	1.050E+00	1.082E+00
33	2000	0.126	1.253E+05	1.235E+05	1.557E+04	1.557E+04	1.211E+04	1.218E+00	1.068E+00
34	2001	0.125	1.218E+05	1.204E+05	1.501E+04	1.501E+04	1.213E+04	1.205E+00	1.039E+00
35	2002	0.108	1.190E+05	1.186E+05	1.281E+04	1.281E+04	1.214E+04	1.044E+00	1.014E+00
36	2003	0.135	1.183E+05	1.165E+05	1.567E+04	1.567E+04	1.214E+04	1.300E+00	1.008E+00
37	2004	0.127	1.148E+05	1.136E+05	1.441E+04	1.441E+04	1.213E+04	1.226E+00	9.781E-01
38	2005	0.131	1.125E+05	1.112E+05	1.460E+04	1.460E+04	1.211E+04	1.269E+00	9.587E-01
39	2006		1.100E+05				9.374E-01		

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Combined Series

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Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1968		7.76E-01	0.0192	3.44E+03	3.44E+03	0	1.00E+00
2	1969		7.98E-01	0.0203	3.72E+03	3.72E+03	0	1.00E+00
3	1970		8.17E-01	0.0178	3.34E+03	3.34E+03	0	1.00E+00
4	1971		8.32E-01	0.026	4.98E+03	4.98E+03	0	1.00E+00
5	1972		8.39E-01	0.0308	5.96E+03	5.96E+03	0	1.00E+00
6	1973		8.46E-01	0.0247	4.81E+03	4.81E+03	0	1.00E+00
7	1974		8.54E-01	0.0256	5.03E+03	5.03E+03	0	1.00E+00
8	1975	2.21E-01	8.62E-01	0.0217	4.30E+03	4.30E+03	1.35957	1.00E+00
9	1976	7.36E-01	8.69E-01	0.0232	4.64E+03	4.64E+03	0.16637	1.00E+00
10	1977		8.74E-01	0.0262	5.28E+03	5.28E+03	0	1.00E+00
11	1978	1.47E+00	8.75E-01	0.0296	5.96E+03	5.96E+03	-0.52011	1.00E+00
12	1979	3.02E+00	8.76E-01	0.0275	5.55E+03	5.55E+03	-1.23656	1.00E+00
13	1980	7.68E-01	8.75E-01	0.0327	6.58E+03	6.58E+03	0.12981	1.00E+00
14	1981	4.22E-01	8.72E-01	0.034	6.81E+03	6.81E+03	0.72588	1.00E+00
15	1982		8.69E-01	0.0317	6.34E+03	6.34E+03	0	1.00E+00
16	1983	6.09E-01	8.67E-01	0.0345	6.90E+03	6.90E+03	0.35317	1.00E+00

17	1984	1.31E+00	8.50E-01	0.0698	1.37E+04	1.37E+04	-0.43346	1.00E+00
18	1985	2.17E+00	8.18E-01	0.0812	1.53E+04	1.53E+04	-0.97529	1.00E+00
19	1986	8.33E-01	7.84E-01	0.0929	1.68E+04	1.68E+04	-0.06057	1.00E+00
20	1987	5.31E-01	7.47E-01	0.1065	1.83E+04	1.83E+04	0.34106	1.00E+00
21	1988	6.76E-01	7.06E-01	0.1253	2.04E+04	2.04E+04	0.04408	1.00E+00
22	1989	1.07E+00	6.70E-01	0.1152	1.78E+04	1.78E+04	-0.47153	1.00E+00
23	1990	7.75E-01	6.45E-01	0.1079	1.60E+04	1.60E+04	-0.18418	1.00E+00
24	1991	5.94E-01	6.25E-01	0.1094	1.58E+04	1.58E+04	0.05185	1.00E+00
25	1992	4.75E-01	6.10E-01	0.1048	1.47E+04	1.47E+04	0.24991	1.00E+00
26	1993	4.05E-01	6.00E-01	0.096	1.33E+04	1.33E+04	0.39261	1.00E+00
27	1994	5.42E-01	5.87E-01	0.1189	1.61E+04	1.61E+04	0.08022	1.00E+00
28	1995	5.76E-01	5.76E-01	0.0982	1.30E+04	1.30E+04	0.00082	1.00E+00
29	1996	5.68E-01	5.73E-01	0.0913	1.21E+04	1.21E+04	0.00975	1.00E+00
30	1997	4.08E-01	5.67E-01	0.1125	1.47E+04	1.47E+04	0.32847	1.00E+00
31	1998	6.37E-01	5.56E-01	0.1122	1.44E+04	1.44E+04	-0.13483	1.00E+00
32	1999	6.43E-01	5.48E-01	0.1086	1.37E+04	1.37E+04	-0.16024	1.00E+00
33	2000	4.20E-01	5.37E-01	0.126	1.56E+04	1.56E+04	0.2458	1.00E+00
34	2001	5.47E-01	5.23E-01	0.1247	1.50E+04	1.50E+04	-0.04437	1.00E+00
35	2002	5.86E-01	5.15E-01	0.108	1.28E+04	1.28E+04	-0.1293	1.00E+00
36	2003	4.99E-01	5.06E-01	0.1346	1.57E+04	1.57E+04	0.01448	1.00E+00
37	2004	5.17E-01	4.93E-01	0.1268	1.44E+04	1.44E+04	-0.04657	1.00E+00
38	2005	5.32E-01	4.83E-01	0.1313	1.46E+04	1.46E+04	-0.09636	1.00E+00

* Asterisk indicates missing value(s).

Appendix 5

R-code used for the XSA assessment

```
library(FLCore)
library(FLEDA)
library(FLAssess)
library(FLXSA)

# read stock data
swo <- read.FLStock("swo.idx")

# set catch = landings (there are no discard data)
catch(swo) <- landings(swo)
catch.n(swo) <- landings.n(swo)
catch.wt(swo) <- landings.wt(swo)

# set units
for (i in c("stock.n","catch.n","landings.n","discards.n")) units(slot(swo,i)) <- "thousands"
for (i in c("stock.wt","catch.wt","landings.wt","discards.wt")) units(slot(swo,i)) <- "kg"
for (i in c("catch","landings","discards")) units(slot(swo,i)) <- "tonnes"
units(swo@harvest)<-"year-1"

# read tuning file
swo.ind <- read.FLIndices("swo.tun")

# define plusgroup
swo@range["plusgroup"]<- 10
```

```
# XSA control
swo.xsactl <- FLXSA.control(fse = 0.3, rage = 1, qage = 6, shk.n = TRUE, shk.f = TRUE,
shk.yrs = 5, shk.ages = 5, window = 100, tsrange = 20, tspower = 3, vpa = TRUE)

# Selecting the fleets
swo.ind00 <- swo.ind[c(1,2,3,4,5,6)] # the number of fleets
swo.ind00[["SPLL"]]@range[] <- c(2,9,9,1988,2005,0,1)
swo.ind00[["GRLL"]]@range[] <- c(2,9,9,1987,2005,0,1)
swo.ind00[["ITLL"]]@range[] <- c(2,9,9,1991,2005,0,1)
swo.ind00[["MODN"]]@range[] <- c(3,9,9,1998,2005,0,1)
swo.ind00[["JALL"]]@range[] <- c(3,9,9,1985,1993,0,1)
swo.ind00[["ITDN"]]@range[] <- c(3,9,9,1991,2001,0,1)

# VPA
swo.xsa <- FLXSA(swo, swo.ind00, swo.xsactl, "Assessment in 2006")

# Diagnostic plots
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$SPLL, main="SPLL", pch=19)
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$GRLL, main="GRLL", pch=19)
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$MODN, main="MODN", pch=19)
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$JALL, main="JALL", pch=19)
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$ITLL, main="ITLL", pch=19)
xyplot(data~year|as.factor(age), data=swo.xsa@index.res$ITDN, main="ITDN", pch=19)


# Abundance & Mortality plots
fm <- swo.xsa@harvest
stock.n <- swo.xsa@stock.n

ttl <- list(label="Mediterranean Swordfish stock abundance", cex=1)
yttl <- list(label="Number of fish", cex=0.9)
xttl <- list(cex=0.9)
i <- 0:10

xyplot(data~year|as.factor(age), data=swo.xsa@stock.n[i], type="p", pch=19, main=ttl, ylab=yttl, xlab=xttl)
xyplot(data~year|as.factor(age), data=swo.xsa@harvest[i], type="p", pch=19, main=ttl, ylab=yttl, xlab=xttl)

# updated stock object
swo <- swo+swo.xsa

# Total and spawning biomass estimates
stock.n <- swo@stock.n
stock.wt <- swo@stock.wt
mat <- swo@mat
spbio <- stock.n*stock.wt*mat
totbio <- stock.n*stock.wt
swo@m.spwn <- spbio

# Diagnostics (inspect the diagnostics in the old style)
diagnostics(swo.xsa)
```

Appendix 6

VPA-2BOX Modeling: Fits to Index Data for SWO Med

5.1 JPN LL

Lognormal dist.
average numbers
Ages 1 - 11
log-likelihood = -27.48
deviance = 84.11
Chi-sq. discrepancy= 118.61

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1985	1.084	0.256	0.828	0.198	0.517E-05	1.595	0.697	38.728
1986	0.127	0.258	-0.132	0.198	0.517E-05	0.612	0.698	0.492
1987	-0.352	0.192	-0.544	0.198	0.517E-05	0.379	0.653	4.641
1988	-0.031	0.058	-0.089	0.198	0.517E-05	0.523	0.572	0.263
1989	0.136	-0.089	0.225	0.198	0.517E-05	0.618	0.494	1.296
1990	0.805	-0.143	0.948	0.198	0.517E-05	1.207	0.468	58.527
1991	-0.491	-0.133	-0.358	0.198	0.517E-05	0.330	0.472	2.472
1992	0.004	-0.201	0.204	0.198	0.517E-05	0.542	0.441	1.030
1993	-1.282	-0.199	-1.083	0.198	0.517E-05	0.150	0.442	11.157

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1985	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1986	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1987	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1988	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1989	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1990	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1991	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1992	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000
1993	0.001	0.003	0.013	0.032	0.167	0.433	0.656	0.752	0.870	0.326	1.000

5.2 GRE LL

Lognormal dist.
average biomass
Ages 1 - 11
log-likelihood = 7.11
deviance = 37.59
Chi-sq. discrepancy= 26.18

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1987	-0.024	0.295	-0.319	0.198	0.425E-07	0.937	1.289	2.060
1988	0.176	0.171	0.005	0.198	0.425E-07	1.144	1.139	0.005
1990	0.031	0.037	-0.006	0.198	0.425E-07	0.990	0.996	0.016
1991	0.280	-0.010	0.290	0.198	0.425E-07	1.270	0.950	2.410
1992	-1.012	-0.075	-0.937	0.198	0.425E-07	0.349	0.890	9.476
1993	-0.018	-0.069	0.051	0.198	0.425E-07	0.942	0.896	0.025
1994	0.344	-0.056	0.400	0.198	0.425E-07	1.354	0.908	5.345
1995	-0.235	-0.050	-0.186	0.198	0.425E-07	0.759	0.913	0.861
1998	0.401	0.042	0.359	0.198	0.425E-07	1.433	1.001	4.095
1999	0.203	0.029	0.175	0.198	0.425E-07	1.176	0.988	0.703
2000	-0.008	-0.021	0.013	0.198	0.425E-07	0.952	0.940	0.001
2001	0.036	-0.096	0.133	0.198	0.425E-07	0.995	0.872	0.359
2002	-0.234	-0.073	-0.161	0.198	0.425E-07	0.760	0.892	0.680
2003	0.038	-0.035	0.074	0.198	0.425E-07	0.997	0.926	0.077
2004	-0.003	-0.060	0.057	0.198	0.425E-07	0.957	0.904	0.036
2005	0.025	-0.027	0.052	0.198	0.425E-07	0.985	0.935	0.027

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1987	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1988	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1990	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1991	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1992	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1993	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1994	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1995	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1998	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
1999	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2000	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2001	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2002	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2003	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2004	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903
2005	0.017	0.126	0.564	0.795	0.920	0.952	1.000	0.960	0.862	0.857	0.903

5.3 ITA LL

Lognormal dist.
average biomass
Ages 1 - 11

log-likelihood   =   8.22
deviance   =   25.67
Chi-sq. discrepancy=   25.07

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1991	-0.013	-0.003	-0.010	0.198	0.502E-07	0.950	0.959	0.021
1992	-0.057	-0.057	0.000	0.198	0.502E-07	0.909	0.910	0.010
1994	-0.119	0.003	-0.122	0.198	0.502E-07	0.855	0.966	0.439
1995	0.110	0.013	0.097	0.198	0.502E-07	1.074	0.975	0.162
1997	-0.353	0.044	-0.397	0.198	0.502E-07	0.676	1.006	2.903
1998	0.163	0.010	0.153	0.198	0.502E-07	1.133	0.972	0.507
1999	0.327	0.004	0.323	0.198	0.502E-07	1.335	0.967	3.134
2000	-0.580	-0.019	-0.561	0.198	0.502E-07	0.539	0.944	4.845
2001	0.072	-0.054	0.126	0.198	0.502E-07	1.034	0.912	0.313
2002	0.533	0.006	0.527	0.198	0.502E-07	1.640	0.968	10.901
2003	-0.273	0.008	-0.281	0.198	0.502E-07	0.733	0.970	1.684
2004	0.047	-0.016	0.063	0.198	0.502E-07	1.010	0.948	0.049
2005	0.145	0.061	0.083	0.198	0.502E-07	1.113	1.024	0.108

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1991	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1992	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1994	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1995	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1997	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1998	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
1999	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2000	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2001	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2002	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2003	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2004	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287
2005	0.033	0.303	1.000	0.800	0.516	0.433	0.396	0.448	0.321	0.309	0.287

5.4 ESP LL

Lognormal dist.
average biomass
Ages 1 - 11
log-likelihood   =   14.58
deviance   =   29.13
Chi-sq. discrepancy=   35.75

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1988	0.768	0.107	0.661	0.198	0.541E-07	2.064	1.065	20.230
1989	0.254	0.096	0.158	0.198	0.541E-07	1.234	1.054	0.548
1990	0.334	0.074	0.260	0.198	0.541E-07	1.337	1.031	1.844
1991	0.211	-0.037	0.248	0.198	0.541E-07	1.182	0.922	1.641
1992	-0.276	-0.075	-0.201	0.198	0.541E-07	0.726	0.888	0.979
1993	0.084	-0.028	0.112	0.198	0.541E-07	1.041	0.931	0.232
1994	0.102	-0.013	0.115	0.198	0.541E-07	1.059	0.944	0.250
1995	0.010	-0.001	0.011	0.198	0.541E-07	0.966	0.956	0.002
1996	-0.146	0.040	-0.186	0.198	0.541E-07	0.827	0.996	0.864
1997	-0.064	-0.010	-0.054	0.198	0.541E-07	0.898	0.947	0.124
1998	-0.068	-0.036	-0.032	0.198	0.541E-07	0.894	0.923	0.063
1999	-0.242	-0.038	-0.204	0.198	0.541E-07	0.752	0.921	1.001
2000	-0.030	-0.050	0.019	0.198	0.541E-07	0.928	0.911	0.000
2001	-0.385	-0.060	-0.325	0.198	0.541E-07	0.651	0.901	2.127
2002	-0.016	0.012	-0.029	0.198	0.541E-07	0.942	0.969	0.056
2003	-0.416	-0.011	-0.405	0.198	0.541E-07	0.631	0.946	2.992
2004	-0.328	-0.005	-0.322	0.198	0.541E-07	0.690	0.952	2.098
2005	0.209	0.034	0.174	0.198	0.541E-07	1.179	0.991	0.700

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1988	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1989	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1990	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1991	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1992	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1993	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1994	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1995	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1996	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1997	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1998	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
1999	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2000	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2001	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2002	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2003	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2004	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071
2005	0.027	0.587	1.000	0.584	0.462	0.291	0.175	0.139	0.088	0.069	0.071

5.5 MAR GN

Lognormal dist.
average biomass
Ages 1 - 11
log-likelihood   =   12.14
deviance   =   1.62

Chi-sq. discrepancy= 1.56

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1998	0.018	0.103	-0.085	0.198	0.672E-07	1.015	1.106	0.248
1999	-0.079	0.083	-0.162	0.198	0.672E-07	0.922	1.084	0.690
2000	0.175	0.027	0.148	0.198	0.672E-07	1.188	1.024	0.471
2001	-0.038	-0.066	0.028	0.198	0.672E-07	0.961	0.934	0.002
2002	-0.005	-0.066	0.061	0.198	0.672E-07	0.992	0.934	0.044
2003	-0.006	-0.016	0.011	0.198	0.672E-07	0.992	0.981	0.002
2004	0.002	-0.038	0.041	0.198	0.672E-07	0.999	0.960	0.011
2005	-0.068	-0.027	-0.041	0.198	0.672E-07	0.932	0.971	0.087

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1998	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
1999	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2000	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2001	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2002	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2003	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2004	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718
2005	0.000	0.028	0.223	0.432	0.615	0.872	0.982	1.000	0.748	0.661	0.718

5.6 ITA GN

Lognormal dist.
average biomass
Ages 1 - 11
log-likelihood = 7.44
deviance = 14.27
Chi-sq. discrepancy= 11.94

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1991	0.061	0.018	0.043	0.198	0.447E-07	1.032	0.988	0.015
1992	-0.038	-0.060	0.022	0.198	0.447E-07	0.934	0.914	0.000
1994	-0.083	-0.034	-0.049	0.198	0.447E-07	0.892	0.937	0.111
1995	0.148	-0.016	0.165	0.198	0.447E-07	1.125	0.954	0.609
1997	-0.261	0.089	-0.350	0.198	0.447E-07	0.748	1.060	2.382
1998	0.296	0.057	0.239	0.198	0.447E-07	1.304	1.027	1.501
1999	0.369	0.039	0.331	0.198	0.447E-07	1.404	1.008	3.326
2000	-0.492	-0.010	-0.482	0.198	0.447E-07	0.593	0.961	3.892
2001	-0.002	-0.083	0.082	0.198	0.447E-07	0.968	0.893	0.102

Selectivities by age

Year	1	2	3	4	5	6	7	8	9	10	11
1991	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1992	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1994	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1995	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1997	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1998	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
1999	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
2000	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672
2001	0.003	0.073	0.564	1.000	0.895	0.847	0.848	0.926	0.720	0.651	0.672

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TOTAL NUMBER OF FUNCTION EVALUATIONS = 258