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# SUR L'ÉVALUATION DES STOCKS DANS L'ADRIATIQUE ET LA MER IONIENNE

Report of the fifth technical consultation

# ON STOCK ASSESSMENT IN THE ADRIATIC AND THE IONIAN SEAS

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ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

# CATCH, SIZE DISTRIBUTION, GROWTH AND SEX RATIO OF SWORDFISH (Xiphias gladius L.) IN THE GULF OF TARANTO

by

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## 1. INTRODUCTION

Since 1984 we have been investigating in the south Ionian Sea all the area along both the Apulian and the Calabrian coasts from Otranto to Capo Spartivento, as part of a vast research project on stock assessment of big Scombroidei exploited by Italian Fishery set up and financed by the Ministry of the Merchant Navy.

Preliminary results concerning the whole area and referring to investigations carried out on the size of the fleet, equipment and fishing areas, on the total catch, fishing effort and cpue have been reported elsewhere (De Metrio et al., 1986).

Here, we think it of interest to report data for Xiphias gladius L. concerning only Porto Cesareo, situated on the Ionian coast of the Salento in the Gulf of Taranto which, independently of the above-mentioned project, has been the object of our studies since 1978 (De Metrio et al., 1981, 1982, 1984). Therefore this study, on the basis of data collected over nine years, enables us today to draw certain conclusions as to the tendency of the catches and also to arrive at conclusions concerning the biology of the species.

## 2. MATERIALS AND METHODS

The number and weight of swordfish caught by the vessels of Porto Cesareo regularly effectuating fishery were taken daily during the fishing season from 1978 to 1986. The number of hooks and fishing days was also recorded. In 1985 and 1986 data concerning lower jaw fork length in centimetres and eviscerated weight in kilogrammes of 779 specimens were recorded. In the same years the gonads of 233 specimens were examined in order to estimate the sex and sexual maturity.

## 3. RESULTS AND DISCUSSION

### 3.1 Fishing Season

From the investigations carried out in the course of nine years it results that the fishing season can cover the period from the second ten days of April to the end of August or, at most, to the second ten days of September (Figure 1). Beginning of activity is conditioned by:

(a) meteomarine conditions,
(b) results of trial catches by vessels.

The end of the fishing season is determined by:

(a) poor catch,
(b) the beginning of albacore fishing.

However, as observed in Figure 1, since 1982 the fishing season has shortened considerably and activity is mainly concentrated in the months of July and August.

### 3.2 Fishing Areas

The fishing area is situated in the Gulf of Taranto at a distance of between 20 to 40 miles from the coast (Figure 2). Fishery takes place at a depth range from approximately 550 to 750 m.

### 3.3 Fishing Equipment

Only the longline is used. Both its length and number of hooks have increased considerably. In 1978 it was 25 km long and supplied with 700 hooks; now it is 35 km long with about 1 000 hooks.

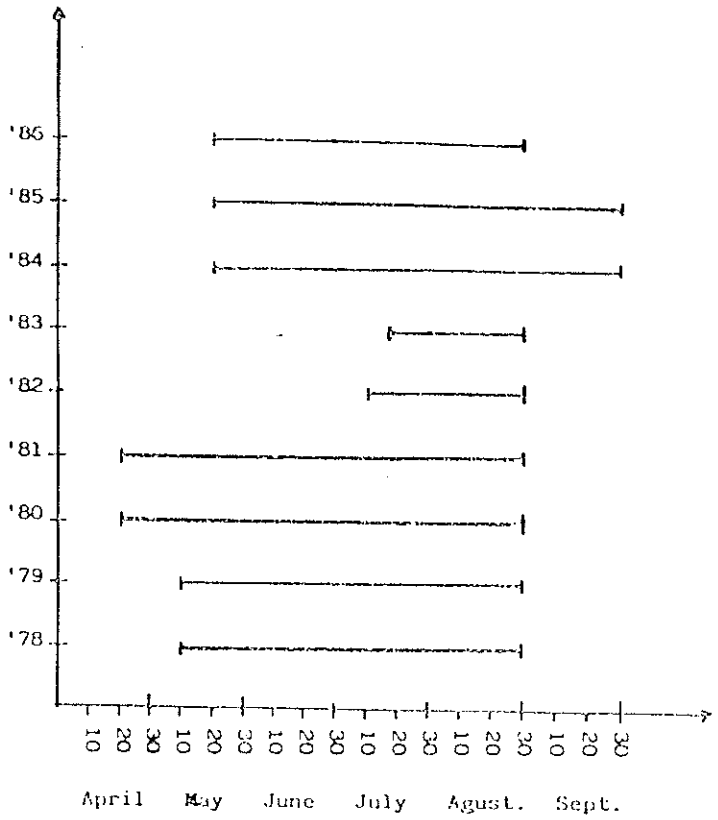


Figure 1 Period of longline fishery operates by the fleet of P. Cesareo during 1978-86 in the Gulf of Taranto

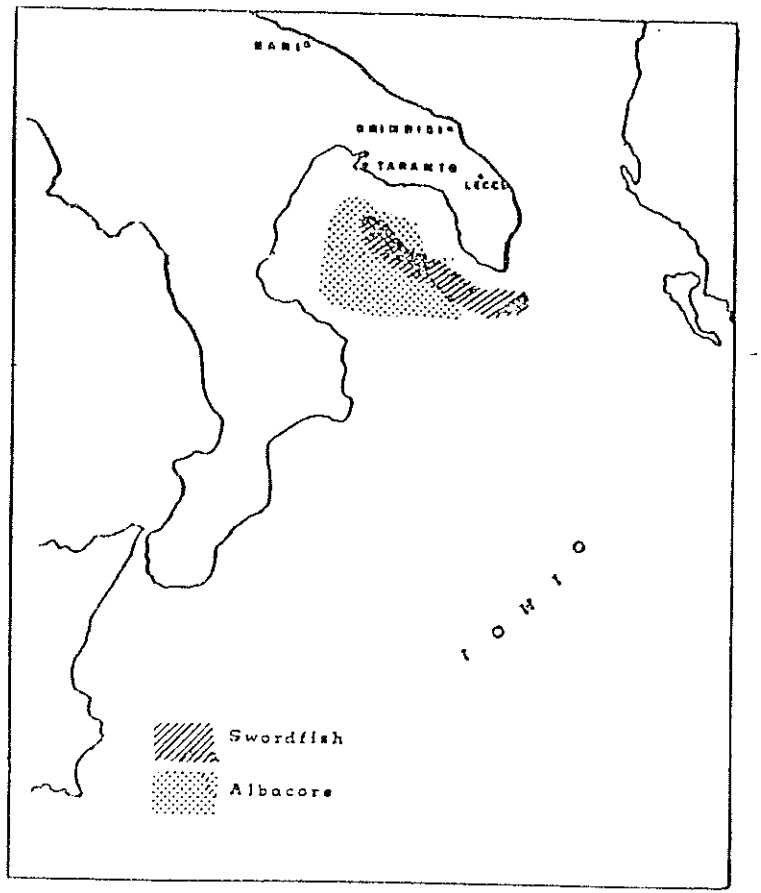


Figure 2 Swordfish and albacore fishing areas in the Gulf of Taranto

3.4 Fishing Effort and cpue

The fishing effort has been obtained with the formula

$$E = \frac{\bar{a}}{1\,000} \times g$$

where $\bar{a}/1\,000$ represents the average number of hooks placed daily in the sea divided by the unit of measure of the effort considered in 1 000 hooks and g the number of fishing days. The cpue were calculated in biomass and in the number of specimens with the formulae

$$\frac{kg}{E} \qquad e \qquad \frac{N^{o}.\ specimens}{E}$$

In Figure 1 data referring to the nine years under consideration are summarized. Total number of hooks, total catch in kilogrammes, total number of specimens, cpue in biomass and in number of specimens, average weight are reported for each year. It can be seen that the greatest fishing effort was in 1980 with 560 000 hooks at sea corresponding in cpue to 98.3 kg also the highest figure in the nine years under study. The minimum effort is found in 1983 with 116 250 hooks corresponding to 54.2 kg in cpue which, although low, does not however represent the minimum found.

The entity of fishing effort in total number of hooks and total quantity of fish caught in kilogrammes, over the years, is illustrated in Figure 3. In the first three years the effort is more or less constant while in 1981 it decreases suddenly. This is more accentuated in 1982 and 1983 where it touches minimum to then show an upward trend in 1984 with greater increase in 1985. A certain drop is evident in 1986.

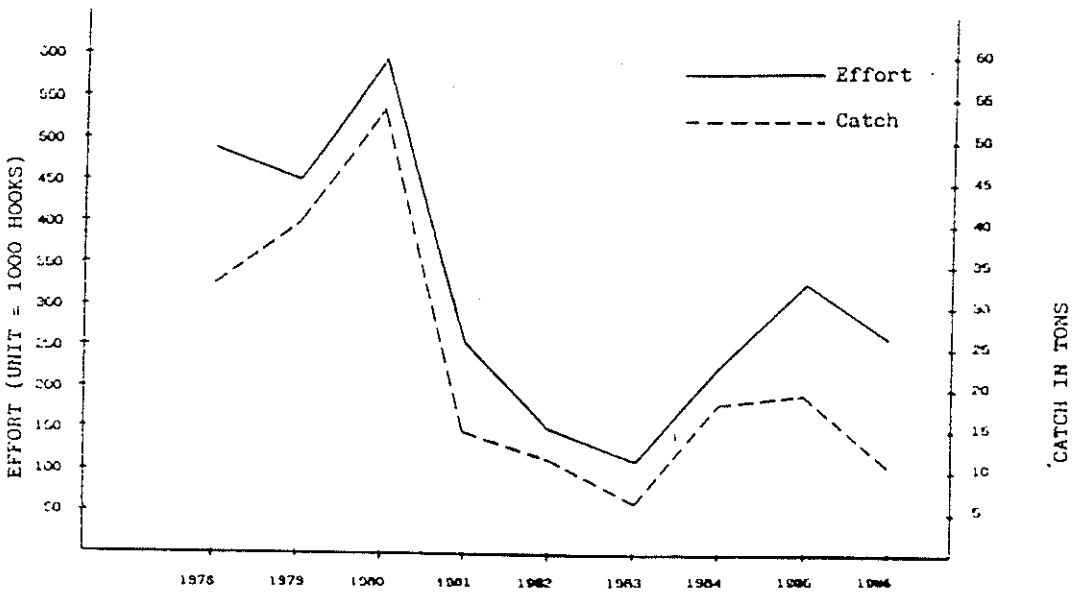


Figure 3 Total quantity catches and fishing effort for swordfish caught by the vessels of P. Cesareo during 1978-86

Comparing this graph with the one for the fishing period it can be noticed that the variations in effort are related to the time span during which fishing has been carried out. This would reasonably lead to the conclusion that the variations in effort are to be attributed to bad atmospheric conditions. Poor catches will also certainly have forced fishermen to look to other species.

The total quantity of fish caught is clearly in proportion to the effort and the highest figure reported is in 1980 with 53 888 kg of production while the minimum is in 1983 with 6 340 kg. Observing the overall period of nine years it is evident that maximum production was obtained in the three year period 1978-80, the minimum in the three year phase 1981-83 followed by a certain pick-up in the last three years, even though production still falls way behind that of the first period.

Analysing the graph (Figure 4) for the cpue in biomass it is clear that they underg considerable shifts in the course of the years with highest peaks in 1979, 1980, 1982, and 1984 an lowest points in 1981, 1983, 1985 and 1986 and from 1980, high and low points alternate yearl interrupted in 1980. However, it is important to notice that increases reported in 1982 and 198 respectively with 77.5 and 78.18 kg/Unit Effort have never reached the levels in 1979 and 1980 agai with, respectively 88.9 and 98.3 kg/Unit Effort.

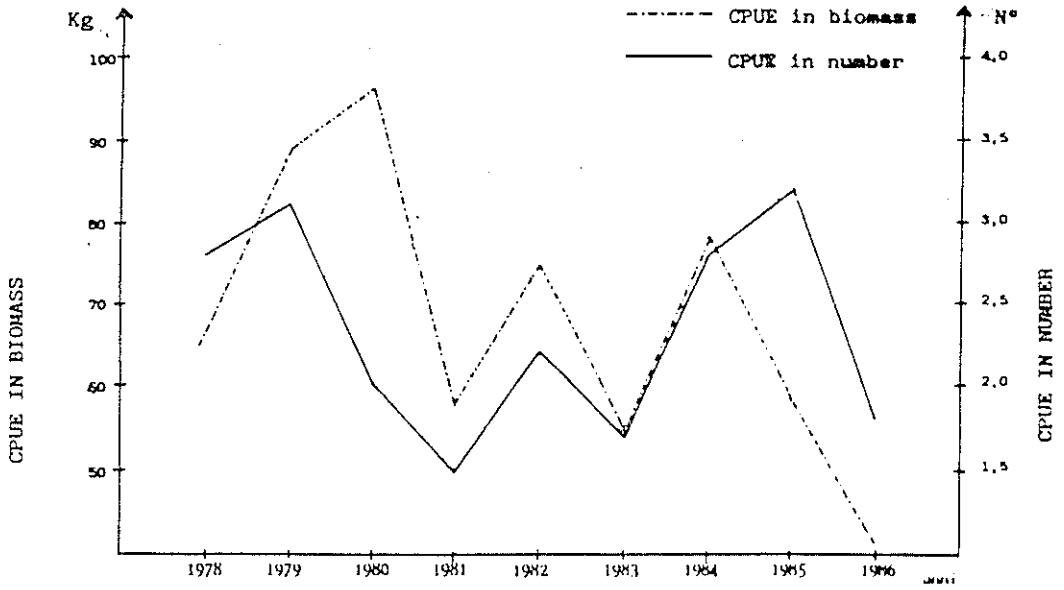


Figure 4 Catches-per-unit-effort in biomass and in number of specimens in 1978-86 for swordfish. Unit effort = 1 000 hooks

Comparing this graph with the one for cpue in number of specimens it appers clear that maximu and minimum figures do not always correspond. Sometimes they are even in contrast. This is ver evident in 1980 and 1985.

In the first case a low cpue in numbers contrasts with a high cpue in biomass together with high average weight of specimens. It is clear that this depends on the fact that the catch was mad up of big fish which, when compared to data for other years, must be considered an exceptio difficult to account for.

In the second case the opposite is found: the highest cpue in number of specimens with a average weight of 18.5 kg, the lowest recorded, corresponds to a fairly low cpue in biomass. Fro this it is clear that catches were mainly of young fish.

The explanation for this lies in the fact that in the summer of 1984, as we were able t observe from the frequency of the catches of very young specimens in the months of September an October during the fishing period, there was a vast production and high survival rate for young fis in the area that contributed to the stock on which the fishing effort was directed in 1985. This can also be deduced from the distribution of the frequency of sizes. A similar situation must hav come about between 1977 and 1978 and probably between 1978 and 1979 as well.

Table 2 and Figure 5 present the data and the tendency of cpue in biomass in different months. The lowest values are generally observed in June.

3.5 Average Weight

The maximum average weight, 48.2 kg, was recorded in 1980 while the minimum weight of 18.4 kg was in 1985. Observing the graph relative to weight variation over the years a sudden rise is evident from 1978 to 1980 followed by a constant decrease up to 1985. In 1986 a slight gain is reported.

Table 1

Summarized results of swordfish fishery data from the port of Porto Cesareo from 1973 to 1986

| Year | Effort Number hooks /1 000 | Catch in kg | Catch in number | Average weight in kg | Average weight geometr. in kg | cpue in kg per 1 000 hooks | cpue in number per 1 000 hooks |
|---|---|---|---|---|---|---|---|
| 1978 | 491.17 | 32 646 | 1 375 | 23.74 | 18.2 | 66.5 | 2.80 |
| 1979 | 451.50 | 40 047 | 1 387 | 28.87 | 21.7 | 88.9 | 3.10 |
| 1980 | 559.50 | 53 888 | 1 118 | 48.20 | 40.4 | 98.3 | 2.00 |
| 1981 | 256.94 | 14 805 | 397 | 37.29 | 28.8 | 57.8 | 1.50 |
| 1982 | 150.10 | 11 632 | 325 | 35.79 | 28.8 | 77.5 | 2.20 |
| 1983 | 116.25 | 6 340 | 192 | 33.00 | 28.1 | 54.2 | 1.70 |
| 1984 | 232.80 | 18 200 | 660 | 30.53 | 25.5 | 78.18 | 2.83 |
| 1985 | 334.40 | 19 674 | 1 084 | 19.45 | 14.6 | 58.83 | 8.24 |
| 1986 | 264.75 | 10 871 | 476 | 24.05 | 19.1 | 41.07 | 1.80 |

Table 2

Capture per unit effort in biomass of swordfish caught by the vessels of Porto Cesareo in different months during the nine-year period 1978-86

| Year | April | May | cpue kg June | July | August | September |
|---|---|---|---|---|---|---|
| 1978 | - | 70.59 | 26.84 | 71.67 | 83.91 | - |
| 1979 | - | 58.88 | 77.63 | 102.70 | 136.75 | - |
| 1980 | 119.41 | 102.36 | 48.23 | 100.51 | 102.53 | - |
| 1981 | 62.07 | 54.58 | 51.19 | 53.15 | 69.51 | - |
| 1982 | - | - | - | 80.14 | 75.63 | - |
| 1983 | - | - | - | 65.59 | 42.44 | - |
| 1984 | - | 67.34 | 88.56 | 68.3 | 82.92 | 86.0 |
| 1985 | - | 28.70 | 39.96 | 50.14 | 64.45 | 70.38 |
| 1986 | - | 55.49 | 23.61 | 48.1 | 36.45 | - |

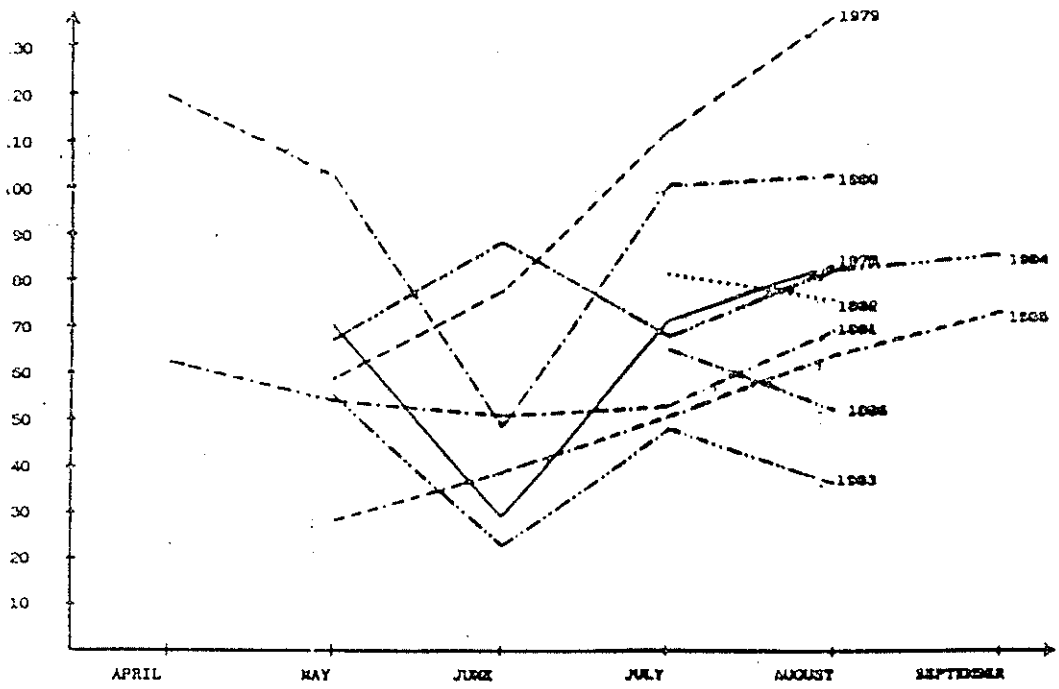


Figure 5 Monthly variations of cpue in biomass of swordfish during the nine-year period 1978-86

For closer study of yearly variations it would seem advisable to consider the drop in 1980 as casual and examine the curve from 1981. From that moment there is a decrease in average weight which was gradual until the heavy recruitment on specimens born in 1984. A recovery follows, to be expected, which would confirm with its low figure, the general tendency to gradual decrease of average weight during the years. The low average weight values recorded in 1978 and 1979 also appear to be the results of a former drop caused by the same reasons as those in 1985.

Taking into consideration that the weight generally follows a loglinear distribution, the geometrical average values were computed to

$$x = \ln (kg)$$

These values were transformed in kilogrammes (Figure 6)

$$kg = e^{x}$$

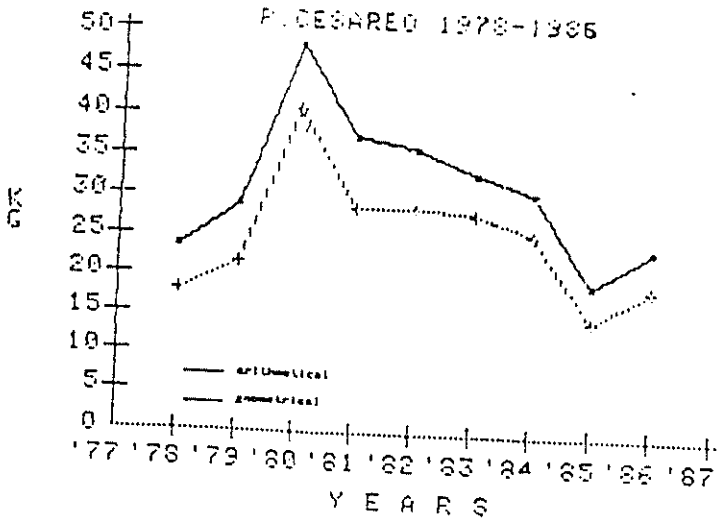


Figure 6 Annual variations of average weight (arithmetic and geometric) of swordfish from 1978 to 1986

## 3.6 Size Distribution

The study of the distribution of sizes was carried out on 1985 and 1986 catches.

In 1985 the fork length of 462 specimens was measured. The smallest fish in the sample was 64 cm and the biggest 205 cm. The main bulk of the catches came from specimens with FL up to 110 cm (69.2%). The most frequent class was the one with FL between 95 and 105 cm. Swordfish with FL between 110 and 135 cm made up 17% while those with FL 135 were only 13.8%.

In 1986, 317 specimens with minimum FL 75 cm and maximum 225 cm were measured. The specimens with FL up to 110 cm were 40.4% while the most frequent class was the one with a FL between 115 and 125 cm with a percentage of 21.5%. The class from 95 to 105 cm were present with 18.3%. Fish with FL between 110 and 135 cm represented 38.5% while those with FL 135 cm, 21.1%.

Considering that the fish with FL up to 110 cm belong to the first age class and those with FL between 110 and 135 cm to the second class it may be concluded that, in both years, most of the catch, 86.2% in 1985 and 78.9% in 1986 was made up of the first two age classes.

## 3.7 Length-Weight Relationship

A total of 462 swordfish was measured during the fishing period in 1985 and the relationship between fork length and eviscerated weight was computed. The smallest fish in the sample was 64 cm and the biggest 205 cm.

We found the following relationship:

$$W = 5.701 \times 10^{-6} \times FL^{3.16} \qquad r = 0.953$$

where W is the eviscerated weight in kilogrammes
FL is the lower jaw fork length in centimetres
r is the regression coefficient

In Figure 8 the graph demonstration of the weight-length relationship is reported.

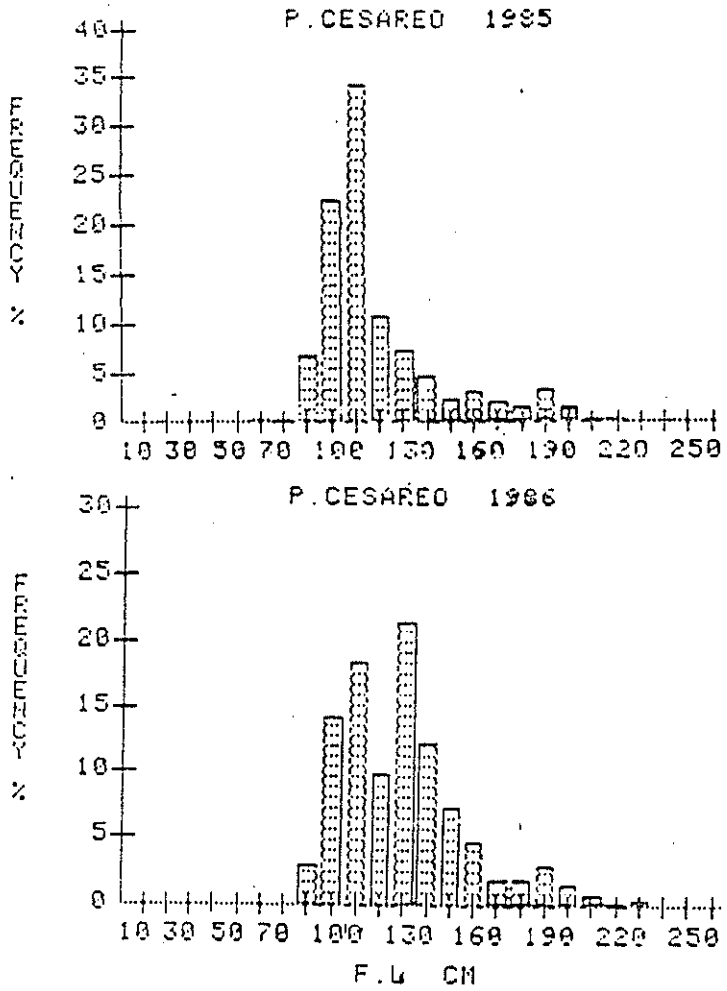


Figure 7 Length frequency distributions of 462 and 317 swordfish caught by the longline vessels of Porto Cesareo in 1985 and 1986 respectively

3.8 Growth Rate

Information on swordfish growth is limited and somewhat contradictory. Attempts at ageing have been made by using several techniques. Until recently, most preliminary size-at-age or growth estimates have been based on modal analysis of size frequency distributions (Yabe et al., 1959; Kume and Joseph 1969; Beckett 1974; Ovchinnikov et al., 1980).

In this study following the Petersen method, an approximate monthly and annual growth rate of swordfish has been estimated as well as the length at first and second years of life.

Figure 9 presents the length frequency distributions of swordfish caught by the longline vessels of Porto Cesareo in different months during the period of 1985-86. Each mode usually corresponds to individual age groups. Due to a successful spawning in the summer of 1984 the first two modes (a) and (b) are clearly evident.

In June 1985 the first mode (b) at 87.5 cm corresponds to the young individuals which were spawned during the summer of 1984. This mode moves on to 97.5 cm in July and arrives at 102.5 cm in September. At the same time, in September, the mode (a) appears at 62.5 cm corresponding to the small fish spawned during the summer of the same year (1985).

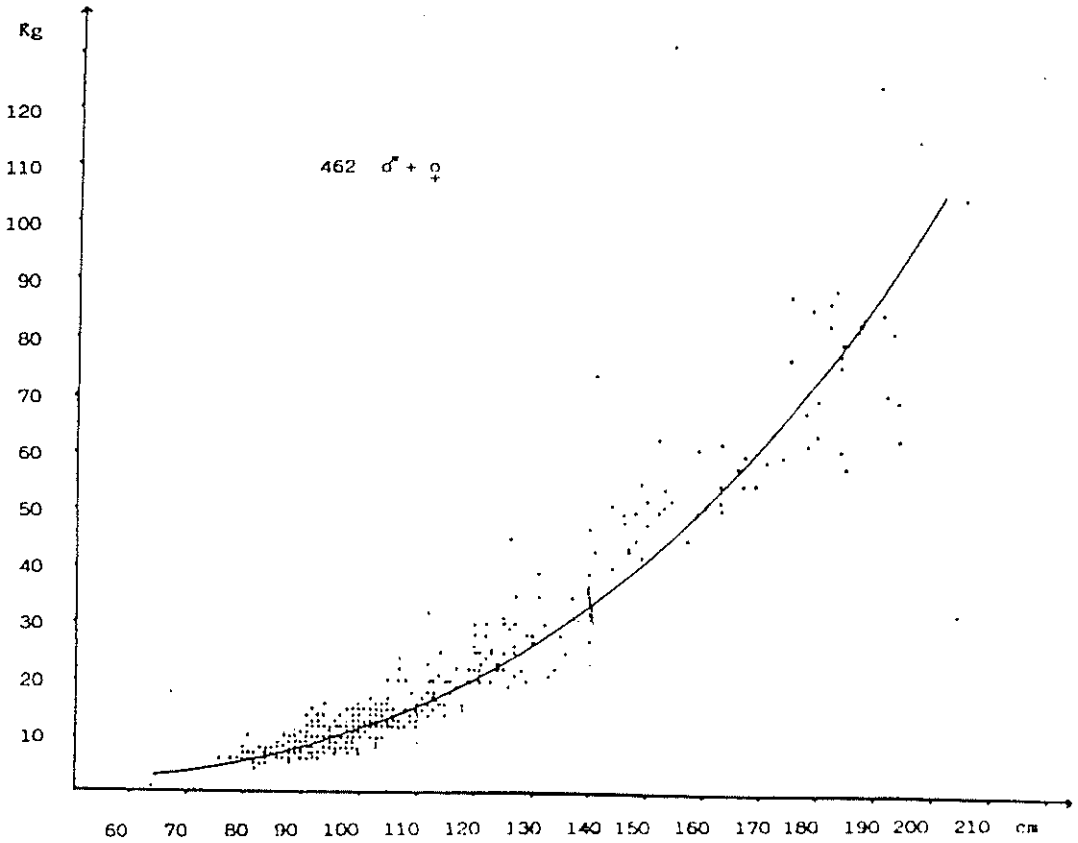


Figure 8 Length-weight correlation of swordfish from Gulf of Taranto

In June 1986 the mode (b) is at 122.5 cm, it stays at 122.5 cm in July and moves on to 132.5 in August. Mode (a) in 1986 follows the same progression of mode (b) in 1985. In June it is found at 87.5 cm, in July at 97.5 cm and arrives at 102.5 cm in August.

Taking into consideration; first the fact that swordfish spawn from June through August with the peak of the spawning season in July (Sella, 1911; Sanzo, 1922; Cavaliere, 1963) and second the above length frequencies, it is possible to estimate approximately the size at the first two years of life. Thus the average size of swordfish in the first year is about 97.5 cm and it reaches 122.5 cm in the second year of age. Besides fairly reasonable estimates are obtained for growth rates:

Table 3

The growth pattern of swordfish derived from the interpretation of the length frequency distributions

| Months | Growth (cm) | Monthly growth rate (cm) | Monthly growth rate on annual basis (cm) |
|---|---|---|---|
| From July 84-September 84 (2-3) | 62.5 | 20.8 - 31.2 | |
| September 84-June 85 (9) | 25 | 2.7 | |
| June 85-September 85 (3) | 15 | 5 | 3.3 (40) |
| September 85-June 86 (9) | 20 | 2.2 | |
| June 86-August 86 (2) | 10 | 5 | 2.7 (32.7) |

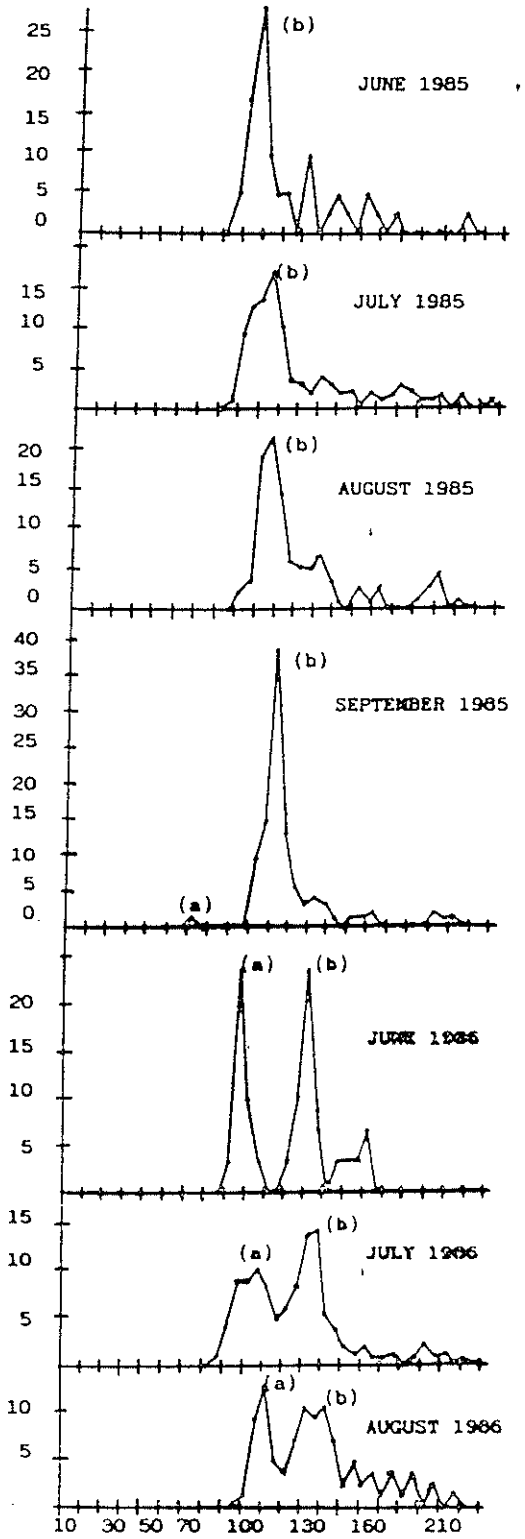


Figure 9 Length frequency curves of swordfish in varied months during the two year period 1985-1986

It is evident that the individuals of 62.5 cm grow about 40 cm after one year with an average monthly growth rate of 3.3 cm. After one more year the same individuals increase in size about 32.7 cm with an average monthly growth of 2.7 cm. Besides the growth rate in summer is higher than that in other months.

3.9 Recruitment

The size at first capture by longline in the Gulf of Taranto is between 55 and 65 cm. These young specimens, born from the end of June to the end of July, begin their recruitment during September and October, so that at time of capture they are two or three months old. The reasons for such a precocious recruitment are mainly due to:

(a) accidental capture coinciding with adult swordfish catch and above all with long line fishing of albacore;

(b) specific fishing for sport;

(c) specific professional fishing, this latter in minor degree.

For the fisherman of Porto Cesareo recruitment of young fish is due exclusively to factor (a) while factors (b) and (c) concern the ports of the Ionian coast of Calabria.

The phenomenon interests all of the Gulf of Taranto and it is quite widely spread (De Metrio et al., 1983, 1984, 1986) even if it does not lend itself to assessment given the difficulty in collecting data. It is, in fact, illegal fishing, inasmuch as Italian law fixes minimum size of capture at TL not inferior to 140 cm (including sword). Howver, we have calculated that along the Ionian coast of Calabria about 650 000 small swordfish were captured in 1984, of which about 2/3 were to be attributed to sport fishery. In the same year 3 309 fish were captured accidentally by the Porto Cesareo vessels during albacore longline fishery.

3.10 Sex-Ratio

During the two year period 1985-86 the gonads of 233 specimens were examined. It was observed that females outnumbered males. The sex-ratio, as males/females was found to be 0.70 in 1985 and 0.47 in 1986.

Taking into accont the size, it is noted that the proportion of females to males was roughly equal over the size range 60-135 cm (51.4-48.6%) but above this range the proportion of females becomes higher (16.7%-83.3%) (Figure 10). The gonad examination also indicated that males begin to reach sexual maturity at the end of their first year. The smaller swordfish with mature testes was 90 cm long. No mature female under two years old was found.

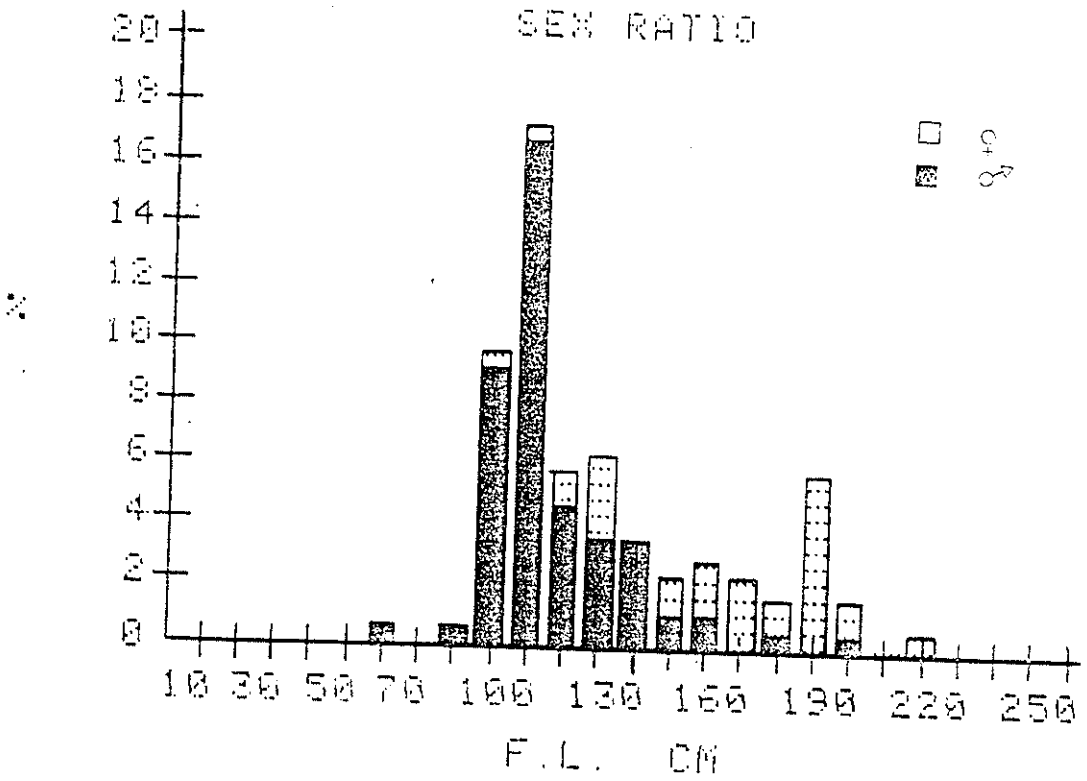


Figure 10 Size frequency distributions of male and female swordfish caught by the vessels of Porto Cesareo in 1985

## 4. CONCLUSIONS

Although nine years of observation have given a considerable quantity of information it must be remembered that P.C. is only one of the ports in the Mediterranean and therefore cannot be considered representative enough to be able to reach general conclusion, on the basis of collected data, on a species which, for its biology, is subject to frequent and vast migration. Perhaps this will be possible when the other investigation we are carrying out at the moment in the rest of the Ionian Sea and in the Aegean will allow us to collect a vaster quantity of data. It seems necessary to examine some considerations further.

The quantities of total catch are in proportion to the fishing effort which varies according to marine conditions. In fact, the vessels are relatively small (12 to 14 m long) and therefore their activity is considerably limited by bad weather conditions.

Capture per unit effort oscillations shown over the years may, very probably, be partly attributed to differing conditions in temperature and in the density of the waters in the various years which may have affected the presence and the permanence of spawning swordfish in the area and partly to the lesser or greater survival of juveniles. The catch of the latter in the following year contributed on one hand to raise the values of cpue in number but on the other hand to diminish the values of cpue in biomass and so cause sudden drops in average weights.

From an examination of the size frequency distribution it can be deduced that in 1984 production and survival rate of juveniles were high and this increased the stock on which fishing effort was carried out in 1985 and 1986. In fact the main bulk of the catch in these years was made up of fish, one or two years old.

A study of the catches in the fishing port of Croton, in the Gulf of Taranto and in Creta in the Aegean gave the same results so it can be concluded that the 1984 phenomenon concerned vast areas of the Mediterranean.

Growth rate in the first two years of life is very rapid. At the end of the first year we found a FL of 97.5 cm and at the end of the second, a FL of 122.5 cm.

Our results agree perfectly with those of Berkeley and Houde (1983) who calculated the age of swordfish in the straits of Florida using the spines of the anal pin.

The size at first capture is between 55 and 65 cm when the age of the fish is about two or three months.

Recruitment begins in September and continues throughout October and November. The capture of young fish is abundant particularly when longlines are used with small hooks (Longline for albacore fishing) and this fact is beginning to worry professional fishermen who are urging for measures to be taken. The problem concerns vast areas of the Mediterranean and would require solutions, the results of the elaboration of a common strategy agreed on by the different countries interested in the exploitation of this resource.

The determination of the sex carried out with gonad examinations both in 1985 and 1986 revealed a higher number of females.

In a sample of 233 specimens the proportion between males and females was almost equal up to a FL size of 135 cm while, over that size, females predominated.

The gonad examination also enabled us to establish that males reach sexual maturity at the end of their first year. Instead, no females in their first or second years have been observed to have mature gonads.

## 5. SUMMARY

The results of investigations carried out from 1978 to 1986 on the swordfish longline fishery in the Gulf of Taranto by the fishing fleet of the pilot port of Porto Cesareo, situated on the Ionian coast of the Salento, are reported.

For the nine years studied, the yearly variations of the fishing effort and the cpue both in biomass and in number of specimens are reported. A constant tendency to average weight decrease in the specimens caught is reported from 1980.

The size distribution and weight/length relationship were also studied in the last two years (1985-86) on representative samples of the catch (462 in 1985 and 317 in 1986). It is noted that

the main bulk of the catch comes from specimens aged up to two years and that age at recruitmen coincides with the second-third month of life. A rough estimation of the size at first capture i between 55-65 cm.

A growth pattern of swordfish is given, according to the Petersen method, from th interpretation of the frequency of the sizes. Swordfish 97.5 cm long is considered one year ol while 122.5 cm two years old. Specimens between 62 cm and 132 cm grow about 36 cm/year.

The gonad examination of 233 specimens indicated that males mature at a smaller size thar females. Males begin to reach sexual maturity at the end of the first year at a length of around 90 cm.

Lastly, the sex ratio was computed. It is found that females outnumber males with 58.9% in 1985 and 67.9% in 1986. The proportion of females to males was roughly equal over the size range 60-135 cm.

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