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Report of the second

TECHNICAL CONSULTATION ON STOCK ASSESSMENT IN THE EASTERN MEDITERRANEAN

Athens, Greece, 28 March - 1 April 1988

Rapport de la deuxième

CONSULTATION TECHNIQUE SUR L'ÉVALUATION DES STOCKS DANS LA MÉDITERRANÉE ORIENTALE

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

APPENDIX/ANNEXE O

Fishery and Biology of the Swordfish Xiphias gladius, L., 1758 in Greek Waters

by

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ABSTRACT

The results of investigations on the swordfish fishery in the Greek seas from July 1986 to September 1987 are presented. A total of 334 boats out of 486 fishing for large pelagics, were involved in this fishery with a total annual catch of 1 500 tons. Fishing for swordfish is carried out throughout most of the year in almost all Greek seas. The greatest annual catch per vessel of 13.2 tons was registered in Kalymnos, which also recorded the highest percentage of individuals longer than 105 cm. In Kythnos the catch mainly consisted of individuals smaller than 105 cm. In general the mean weight per individual caught in Kalymnos was the highest in all Greek ports. Observations on swordfish maturation show that the most active spawning occurs during June to July. In most cases, males reach sexual maturity at the end of their second year while females reach sexual maturity at the end of their third year.

1. INTRODUCTION

Among all large Scombroidei exploited in Greece, the swordfish (Xiphias gladius) fishery is the most important. Fishing for swordfish started in 1969 by a group of fishermen from the island of Kalymnos, who set up the first long-line, copying that used by Sicilian fishermen. Although a recent activity, it is already widespread and expanding all the time to involve a progressively increasing number of operators and boats.

Only fragmentary information on this activity exist so far, obtained mainly from official statistics, which, however, are unable to give a satisfactory picture of the situation. Therefore, it was considered necessary to set up a project plan with the following objectives: (a) appraisal of fishing effort and the corresponding catch, (b) distribution of the swordfish stocks, size composition and maturity process.

The aim of this investigation is to contribute to the management of the swordfish stocks in the Mediterranean with the cooperation of all countries involved.

This programme of collaboration between the Istituto Comunale di Biologia Marina in Nardo, the Fisheries Division of the Greek Ministry of Agriculture and the Biology Department of the University of Crete, got underway precisely in the light of this consideration, hoping that Italy and Greece would certainly be able to produce a set of basic data for swordfish fisheries in the Aegean and Ionian Seas in order to set up a common strategy for this fishery.

2. MATERIALS AND METHODS

Data on number of fishing vessels, the corresponding catch, and location of the fishing grounds were obtained through direct investigations at each fish port during the years 1986-87. Estimates of the total catch were obtained through direct investigations and interviews with fishermen.

1/ "This study does not necessarily reflect the opinion of the Commission of European Communities and does not prejudice their future attitude in this field"

Total fishing effort (f) was calculated using the following formula:

f = No. of hooks operated daily x No. of fishing days/1 000

Fork length (from the tip of lower jaw to the fork of caudal fin) was measured in 3 045 swordfish. The sex and stage of maturity was determined from the gonads of 1 393 fish according to the Holden and Raitt (1974) scale. The gonadosomatic index was calculated for 219 fish from the eviscerated animal weight by the use of the formula:

G.I. = Gonad weight x 100/Eviscerated animal weight

Pieces taken from 69 gonads were fixed either in Bouin fluid or in 10% formaldehyde solution. Sections of gonads (5-7 μ thick) were stained either with Hematoxylin - Eosin or with Azan - Mallory.

3. RESULTS

3.1 Fish Ports

The investigation showed that a total of 486 boats from 78 ports, allocated in 15 major areas, fished for large pelagic fish in Greece during 1986-87. The number of boats, grouped by size, horse power, main locality and kind of fishery, is shown in Table 1.

Accurate grouping of the total number of boats, in accordance with the target species to which each group directed its fishing activity, showed that 334 boats out of 486, viz. 68.2%, were involved in the swordfish fishery.

Table 1 shows that Chalkidiki is the area with the greatest number of boats, followed in turn by the fleet of the Sporades islands, the Saronikos Gulf, the Dodecanese islands and the coasts of Peloponnesus. Among these major areas the highest number of boats over 14 meters in length worked in the Dodecanese area, while the highest number of boats of less than 9 meters worked in the vicinity of Sporades islands.

Concerning the engine power of the fishing boats, Thessalonike is evidently the area of the highest engine power per boat, however, vessels from this area direct their activities mainly to the tuna fishery. Also the same comment applies to some other groups of boats with relatively high engine power, such as those fishing the north coasts of Greece. Among the boats fishing for swordfish, the highest engine power per vessel is mainly represented by the Cretan and Dodecanese fleets. This is obviously due to boats from these latter areas extending their activities much further from port.

3.2 Fishing Grounds

Fishing for swordfish occurs practically throughout the whole Aegean Sea except for the most northerly areas (Figure 1). Swordfish fishing is also carried out in the Ionian Sea and particularly in the area extending from a few miles to 10-20 miles off the west coasts of the islands and the mainland. The fishing boats of Crete operate mainly in the Cretan sea from the island of Kythira in the west, to the Dodecanese islands in the east, and to the Cyclades islands in the north. Moreover some Cretan boats carry out excursions of a few days, mainly in spring and summer, both in the Ionian and Levant Seas, reaching as far as Cyprus. The Dodecanese fishing boats on the other hand, concentrate their activities mainly around the Dodecanese Islands but often they also reach as far as Cyprus, particularly during spring. The Cyclades fishing boats mainly carry out their activities around the islands of this archipelago.

3.3 Fishing Period

In general, fishing for swordfish in Greece is carried out throughout most of the year, particularly in the southern regions, with the most active period, May-September (Table 2). During the rest of the year fishing activity is reduced, both in terms of the number of vessels and number of fishing days per boat, due to the worsening meteorological conditions.

Another reason for the concentration of fishing activities during summer, is that most of the boats involved in the swordfish fishery work as trawlers during the rest of the year.

3.4 Systems of Capture

Swordfish fishing in Greece is exclusively carried out by drifting longline, copied from that of Sicilian fishermen. It is made up of a single nylon thread about 35-40 km long, from which a thousand sidelines lead off at intervals of about 35 m. They are 4-5 m long and made of the same

monofilament nylon and armed with hook numbers 1 and 2. At 3-4 km intervals marker buoys are attached to the longline. These consist of poles with pieces of black plastic attached on the open like flags, for ease of visibility together wtih radar reflectors.

In some Ionian Sea ports (Parga) and in Crete (Chania), where some boats direct their fishing effort mainly to young fish, the equipment is modified and presents the same features as the gear for albacore (Thunnus alalunga),

Setting of longlines begins at about 17.00 h and hauling at about 05.00 h the next day. The bait used is generally Scomber scombrus L. or Scomber japonicus colias GM. However, Sardina pilchardus Walb or Sardinella aurita Val are also used in the case of fishing young fish.

3.5 Total Catch

In 1986 the total landings of Xiphias gladius in Greece reached 1 530 tons (Table 3) putting Greece second after Italy and before Spain, among Mediterranean countries involved in the swordfish fishery. The Dodecanese area seems to be the most productive one among the 15 major areas into which the fishing grounds in the Greek seas have been arbitrarily divided for statistical reasons. Nearly half the total swordfish catch in Greece in 1986 came from this area where the catch per boat reached 13.2 tons compared with the lowest of 0.9 tons boat for the east Aegean islands and the overall average of 4.6 tons/boat for all Greek seas (Table 3).

3.6 Fishing Effort and cpue

Among the 15 major areas, the ports of Kalymnos in the Dodecanese area, Chania in Crete, and Kythnos in the Cyclades islands, were selected as pilot ports for collecting precise effort and corresponding catch.

Table 4 shows that the greatest effort both in 1986 and 1987 was by the Kalymnos fleet. On average, it was 12 times that of Chania and 80 times that of Kythnos.

Considering the parameters on which effort depends, the variable that played an important role was that related to the size of the boats in conjunction with the engine power. The larger the boat the longer the voyages, increasing therefore the fishing effort of the fleets consisted of larger boats. Also other factors such as the tradition and experience of the fishermen influenced the outcome in favour of Kalymnos.

Cpue in biomass of swordfish registered relatively high values (Table 4). In both Kalymnos and Chania in 1986 the cpue was higher than that registered in the Gulf of Taranto (De Metrio et al., 1987) or in the South Adriatic (Marano, 1985). A slight drop, however, of cpue in biomass from 1986 to 1987 in the prementioned areas, is probably due to the yearly fluctuations observed also in other regions of the Mediterranean (De Metrio and Megalofonou, 1987).

As far as the cpue in number of individuals is concerned, the much higher value of this parameter in Kythnos is obviously related to the much lower value of the mean weight per individual caught in this area (Table 4).

The situation of Kythnos, however, is remarkable in that although fishing effort was directed to small individuals, cpue in biomass registered in 1987 was higher than that in other ports (Table 4). This was probably the result of high recruitment of a particularly successful year class.

3.7 Size Distribution

The fork lengths were measured in 1986 of 301 and 780 swordfish caught in the sea areas of Chania, and Kalymnos respectively. As shown in Figure 2a most of the catch, namely 50.9% in Chania and 53.2% in Kalymnos, was made up of individuals ranging in length from 105 to 135 cm while the percentage of individuals longer than 135 cm were 32.9% and 38.1% in Chania and Kalymnos respectively. During the same year a relatively small percentage (16.2%) in Chania were less than 105 cm and only 8.7% in Kalymnos.

In 1987 the fork length of 642, 1 100 and 223 swordfish were measured in the catches from the sea areas of Chania, Kalymnos and Kythnos correspondingly. The size distribution of those individuals was notably different between the areas (Figure 2b). In particular, most of the catch (73.0%) in Kalymnos was made up of individuals longer than 135 cm, while only 10.8% of the individuals caught in Kythnos and 33.9% in Chania were longer than 135 cm. On the contrary individuals of lengths less than 105 cm comprised most of the catch (66.6%) in Kythnos and only 0.6% in Kalymnos and 32.0% in Chania. Middle sized fish (105-135 cm), on the other hand, in the areas under consideration comprised 26.4%, 34.1% and 22.6% of the catch in Kalymnos, Chania and Kythnos respectively.

Considering the size of swordfish caught in the course of a year it has been noticed that the number of relatively smaller fish in the catch of winter and early spring was higher than that in the rest of the year, however, the available data so far do not make it clear whether this was due to a higher concentration of young fish during winter and early spring, or to the fact that the fishing boats usually work inshore during that period of the year.

The difference in the size distribution of swordfish between the samples from the pilot ports could be better realized, however, if we compare the mean weight per individual caught over the course of a year. Such a comparison suggests that in general, individuals unloaded in the port of Kalymnos were the largest of those in the pilot ports (Figure 3).

3.8 Length-Weight Relationship

The length-weight relationship for 960 eviscerated individuals with sword sawn off approximately at the extremity of the lower jaw and FL ranged between 90 and 206 cm was calculated giving the following equation for the sexes combined.

$$W = 4.751 \times 10^{-6} \times L^{3.171}$$

where W is expressed in kilograms and L in centimetres.

3.9 Reproduction Biology

3.9.1 Sex ratio

A total of 1 323 swordfish were examined for studying the progressive development of gonad maturity and the sex ratio during the years 1986 and 1987.

The sex ratio in the catch of Chania in 1986 showed a slight margin of males over females (54.8%) during the fishing season. In 1987, however, the sex ratio of samples from the same port was nearly 1:1, while in samples from Kythnos females were slightly over males.

As regards size in relation to sex, a prevalence (75.4%) of females with FL over 150 cm was noticed in samples from Chania during 1986.

3.9.2 Maturity

State of gonads was recorded from samples collected in Chania during 1986 and 1987 and in Kythnos during 1987. Females with mature gonads (stage IV) were observed in relatively small percentages during June and July (Table 5) whereas no mature female was observed during the rest of the year. Concerning the maturity process of males, mature males (stage IV) were much more abundant than mature females and distributed over a longer period, namely from June to September, with a progressively decreasing percentage from month to month (Table 5). Though only small percentages of mature and spent females were found during the period of the investigation it may be concluded that spawning of swordfish probably occurs during summer time. On the other hand, regarding the higher percentages of mature males than females observed during the same period, it can be concluded that this is probably because: (a) most individuals examined were less than 135 cm long (Figure 3), and (b) males reach first sexual maturity earlier than females (Megalofonou *et al.*, 1985 and Megalofonou, De Metrio and Lenti, 1987).

Correlating the stage of maturity with the size of individual, it was observed that 20% of males with FL 82 to 105 cm had reached sexual maturity, whereas in females of the same dimensions the gonads were still in stages I or II (Table 6). In individuals with FL between 106 and 135 cm, the percentage of mature males was 67.2% while only 8.6% of females in the same length range had mature or emptied gonads. Regarding individuals longer than 135 cm the percentage of mature or spent males was still higher than for the females (86.6% and 57.1% respectively).

On the basis of the above data and according to De Metrio and Megalofonou (1987) females reach sexual maturity at the end of the second year while most of them are mature at the end of their third year.

3.9.3 Gonado-somatic index

The gonado-somatic index of 219 individuals in relation to the maturity process, calculated on samples caught in Chania during 1986, is shown in Figure 4. The increase from stage III to IV is more rapid for females than for males, while the rapid decrease of the gonado-somatic index from stage IV to V is obviously due to spawning. Concerning average values of the gonado-somatic index in the course of a year it was found that the highest value for both sexes was observed in July, namely 1.90 for females and 0.29 for males.

4. DISCUSSION

Although the fishery for large scombroids is a relatively new activity in Greece, a fleet of about 500 fishing boats engaged in this fishery is noteworthy. However, despite of the numerous fishing boats the effort is greatly affected due to the small size of most of them, a fact that restrains their potential for long trips. Only a few boats with autonomy of 20-30 days are able to carry out trips in more distant seas, for example the Levant Sea, where catches are much higher. Probably this is the reason why the Dodecanese area with 4 ports and 54 boats has the highest average yearly catch of swordfish per boat.

As it was stated earlier, the fishing period for swordfish normally covers the whole year, however, the main activity is concentrated in a well defined period namely from late spring to autumn, reaching its climax in the months of July and August. This is for two main reasons:

(a) Most of the boats are involved in multiple activities of which trawl-fishing is the most important, so that from May to September, when this kind of fishing is interrupted, many fishermen turn their attention to swordfish.

(b) In the late autumn and winter months the meteorological conditions become prohibitive even for big boats.

From data on the three pilot ports it is easy to see that Kalymnos is the port with the highest percentage of large individuals (longer than 105 cm), whereas Kythnos, on the contrary, has the highest percentage of small ones (smaller than 105 cm).

Considering the reasons for such a size distribution of swordfish it is easy to deduce that the greater number of small individuals in Kythnos is due to the constant actviity near the coasts of the Cyclades isles while the capture of relatively bigger fish in Kalymnos is due to fishing off the coasts of the Dodecanese isles. Chania, on the other hand, represents an intermediate situation where fishing is carried out both in areas close to the coasts and at distances of 15-30 miles.

From the study of the distribution of sizes during the course of the fishing period it also becomes clear that quite high numbers of young fish are caught mainly in early spring and late autumn, either occasionally during fishing for adults, or, as occurs in some localities, during other fishing activities, such as for albacore. This problem, which is not exclusively Greek but also concerns the Italian swordfish fishery (De Metrio and Megalofonou, 1987), has given rise to the decision of the Greek Ministry of Agriculture to issue a decree prohibiting fishing for swordfish in Greek territorial waters from the 1st October to the 31st January.

Actually, this decision seems to be not the most effective action for a number of reasons. Firstly the decree does not apply in waters beginning six miles from the coast and therefore cannot be extended to fishermen from other countries, such as Italy, which operate in international waters close to the Greek territorial seas. Secondly the decree applies indiscriminately to both fishermen who catch young fish purposefully and those who catch them accidentally. Thirdly, from February on, there are still elevated numbers of young fish in coastal waters which are not protected at all. The authors are of the opinion that a more suitable measure at least for the time being, would be to fix either a minimm size of fish or a minimum sizse of hook on the longline.

In any case it would be desirable for countries which share common resources, to come to an international agreement regarding the protection of large scombroid fish.

Regarding our findings on the reproduction biology of swordfish we can point out the following:

(a) The presence of spent fish during the period from June to September suggests that swordfish have a rather extensive spawning period. This would explain the sporadic findings of various sizes of young individuals at various times of the year. It has also been observed that the swordfish ovary at stage V is still very large. Its walls are very thick and hard to touch, so much so that only by a certain pressure by the fingers it is possible to feel the presence of a central cavity without mature elements. Histological examinations made it possible to demonstrate that, after spawning, the reticular periplast of the lamellae still contains high number of oocytes of various size from 11.7 μ to 719.5 μ with an average of 72.1 μ in the various developmental phases. These observations would lead to the conclusion that swordfish, in the course of its reproductive period, may deposit several times.

(b) The males are more precocious than females and, at the end of the first year, their testicles still show complete spermatogenesis. The examination of one year old males with partly mature but not emptied gonads suggests that the germinal products are probably reabsorbed in young fish. So, the first reproductive period should coincide with the end of their second year. Instead, for females, such a situation occurs at the end of their third year even if some may already have mature ovaries at the end of their second year.

(c) The presence of swordfish individuals with mature gonads, together with the catch of young fish, in all the ports considered, from the northernmost stretches of the Ionian Sea to the easternmost parts of the Aegean suggests that the reproduction area of swordfish in the Mediterranean is rather larger than was formerly believed.

5. REFERENCES

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Table 1

Division of vessels according to the size and engine power, in groups for each major region or fishing port

Major region or fishing port	Number of boats	LENGTH (m)			ENGINE POWER (HP)			
		9	9.1-14	14	MIN	MAX	MED	SUM
DODECANESE	54	6	16	29	20	450	171.8	9277
CYCLADES	29	5	21	2	11	190	72.5	2103
CRETE	39	8	22	2	36	425	207.6	8096
IONIAN SEA ISLANDS	27	6	14	1	15	250	98.4	2657
EPIRUS	20	14	5	1	10	180	60.6	1213
PELOPONNESUS	45	15	25	4	5	370	104.3	4694
SPORADES	65	42	21	2	10	150	51.6	3354
MAGNISIA	11	/	3	8	100	240	168.0	1848
KAVALA	33	19	15	3	6	320	100.3	3310
RODOPE	4	/	4	/	100	135	125.2	501
THESSALONIKE	5	/	/	5	280	525	340.0	1700
CHALKIDIKI	80	17	35	7	3	270	152.0	12160
EVIA	7	3	4	/	32	116	79.0	553
SARONIKOS GULF	56	3	27	3	30	124	68.6	3842
ISOLE EGEO ORIENTALE	11	4	7	/	25	120	79.8	878
TOTAL	486	142	215	67	3	525	115.6	56186

Table 2

Monthly distribution of vessels fishing for Xiphias gladius during the years 1986-87

Major region	TOTAL	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
DODECANESE	54	-	3	26	28	39	50	52	40	34	24	2	1
CYCLADES	29	-	12	16	23	26	15	15	15	14	11	-	-
CRETE	39	20	21	25	30	34	36	34	34	31	29	24	19
IONIAN SEA ISLANDS	27	12	12	14	14	14	14	13	13	18	24	12	12
EPIRUS	20	12	12	11	11	13	14	13	12	16	16	15	14
PELOPONESUS	45	21	21	25	27	31	33	35	36	37	33	23	23
SPORADES	11	-	-	-	-	-	-	4	9	8	5	3	-
MAGNISIA	11	-	-	11	11	11	11	11	11	11	10	-	-
KAVALA	5	-	-	-	-	-	1	3	3	5	5	2	-
CHALKIDIKI	24	-	-	-	-	24	24	24	24	24	-	-	-
EVIA	2	-	-	-	-	-	2	2	2	2	-	-	-
SARONIKOS GULF	56	-	-	-	-	29	28	29	29	29	29	14	14
ISLANDS OF EAST AEGEAN SEA	11	-	-	-	1	2	4	4	5	6	4	4	4
TOTAL	334	65	81	128	145	223	232	239	233	235	190	99	87

Table 3

Total swordfish catches per region and average annual catch per boat in 1986

Major region	Number of boats	Total Catch (tons)	Average annual catch per boat (tons)
CRETE	39	140.40	3.6
CYCLADES	29	43.50	1.5
IONIAN SEA ISLANDS	27	67.50	2.5
EPIRUS	20	46.00	2.3
SARONIKOS GULF	56	117.60	2.1
MAGNISIA	11	67.10	6.1
ISLANDS OF EAST AEGEAN	11	10.34	0.9
EVIA	2	2.00	1.0
DODECANESE	54	712.80	13.2
PELOPONNESUS	45	207.00	4.6
SPORADES	11	12.10	1.1
CHALKIDIKI	24	103.20	4.3
KAVALA	5	-	-
TOTAL	334	1529.54	4.579

Table 4

Summarized catch and effort data in the pilot ports in 1936 and 1987

DATA	KALYMNOS		CHANIA		KYTHNOS	
	1986	1987	1986	1987	1986	1987
Number of boats	27	30	11	12		9
Work days	779	2004	153	179		87
Mean number of hooks	1118	1148	801	877		329
Number of individuals	4343	6209	756	998		361
Weight of catch (kg)	141693.5	217689	17457	17972	No	3920
Mean weight per individual (kg)	32.6	35.1	23.1	18	Data	10.8
Fishing Effort (x 1000 hooks)	870.8	2300.1	122.5	156.9		28.6
CPUE (Number of indiv.)	5	2.7	6.2	6.4		12.6
CPUE (Weight)	162.7	94.6	142.5	114.5		136.9

Table 5

Frequency of gonad maturity stages during the period of June to September in samples of swordfish from Chania and Kythnos combined for the years 1986 and 1987

Maturity Stages	JUNE				JULY				AUGUST				SEPTEMBER			
	M		F		M		F		M		F		M		F	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	41	18.5	60	29.4	75	39.9	73	46.8	23	32.4	26	37.1	23	32.4	26	37.1
2	30	13.5	56	27.5	23	12.2	33	21.2	12	16.9	17	24.3	12	16.9	17	24.3
3	48	21.6	38	18.6	29	15.4	37	23.7	25	35.2	25	35.7	25	35.2	25	35.7
4	80	36.0	33	16.1	39	20.8	5	3.2	6	8.4	-	-	6	8.4	-	-
5	23	10.4	17	8.4	22	11.7	8	5.1	5	7.1	2	2.9	5	7.1	2	2.9
Total	222	100	204	100	188	100	156	100	71	100	70	100	71	100	70	100

Table 6

Frequency of gonad maturity stages in relation to the length of swordfish

	Fork Length in cm					
Maturity stages	82 - 105		106 - 135		136 - 207	
	M	F	M	F	M	F
1	20	47.4	4.9	11.4	0	0
2	28	52.6	9.8	42.9	6.7	8.2
3	32	0	18.1	37.1	6.7	34.7
4	8	0	39.3	5.7	56.6	26.5
5	12	0	27.9	2.9	30.0	30.6

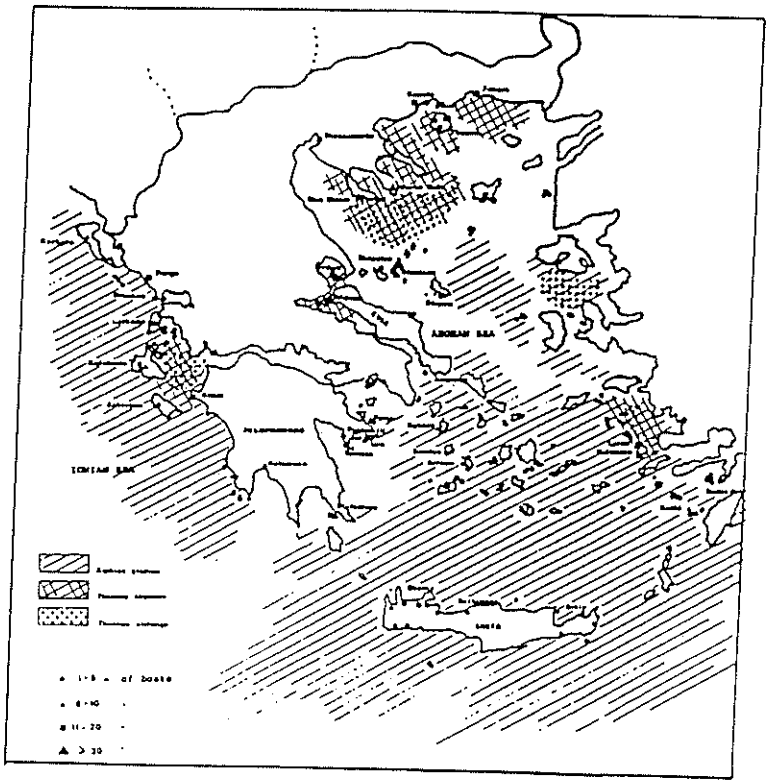

Figure 1 Distribution of fishing activities for large scombroidei in the Greeck seas

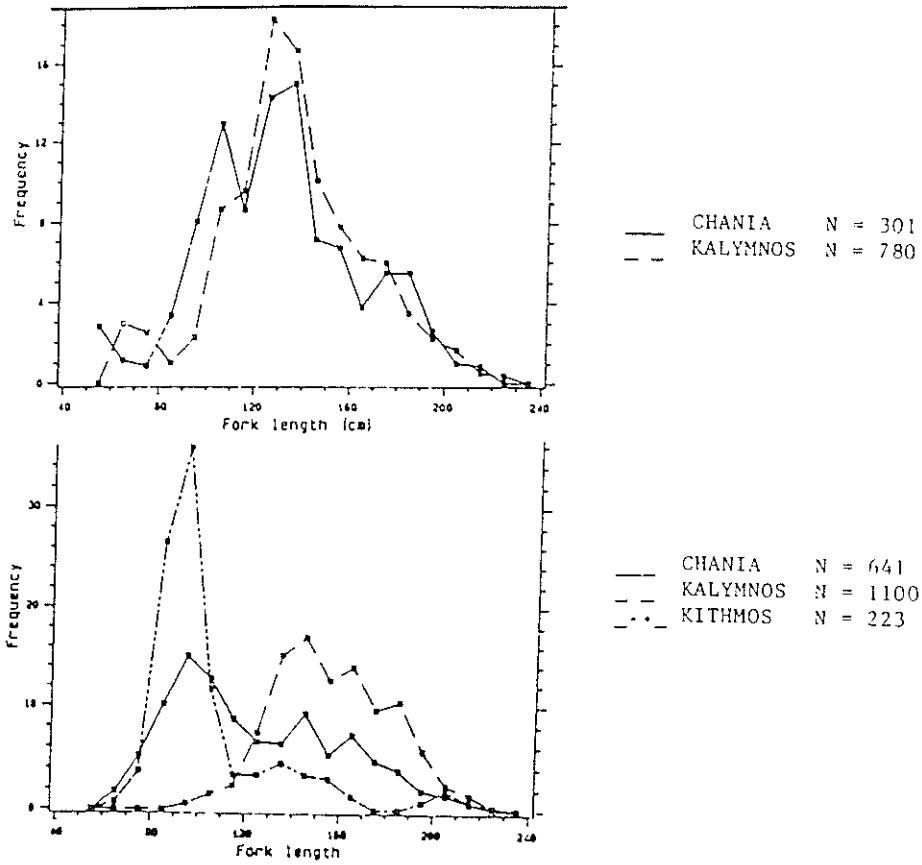

Figure 2 Length frequency distribution of swordifish in samples taken from the catches at the pilot ports during the years 1986 and 1987

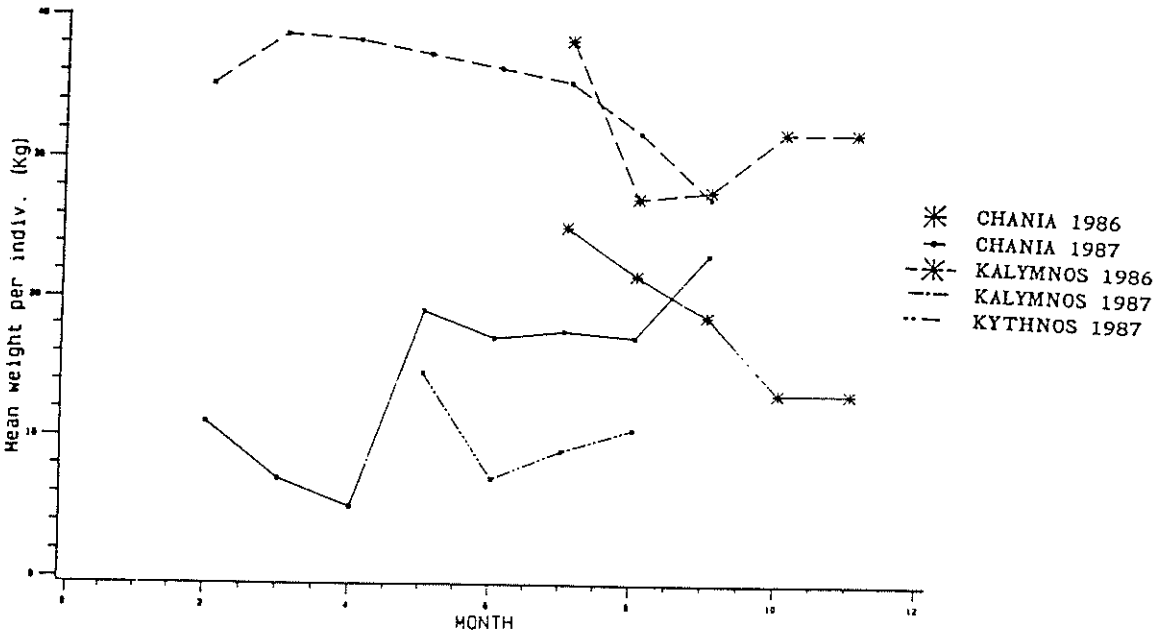

Figure 3 Distribution of mean weight per individual swordfish in samples from catches unloaded at the pilot ports during 1986-87

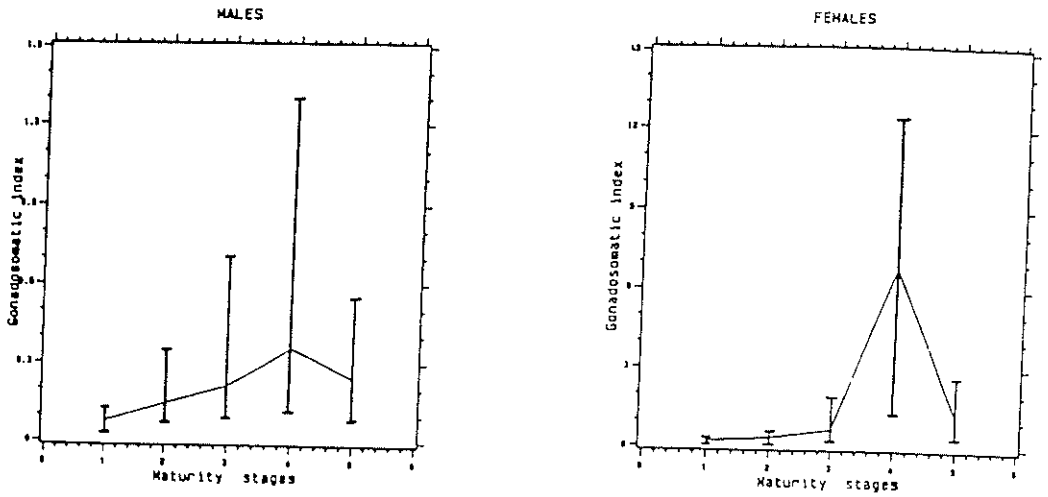

Figure 4 Variation of the average gonadosomatic index values of swordfish during the course of the maturation process. The vertical lines represent the range of the index in each maturity stage