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Evolution of the Portuguese fishery of Black Scabbard Fish (*Aphanopus carbo* Lowe, 1839) during the period 1984-1993

by

Maria Manuel Martins, Maria Rogélia Martins
and
Fátima Cardador

Instituto Português de Investigação Marítima
Av. Brasília, Algés, 1400 Lisboa
Portugal

ABSTRACT

This study describes the main aspects of Portuguese fishery of black scabbard fish, which had started in 1983, at Sesimbra waters (south of Lisbon).
During 1984-1993 there had been an increasing trend in landings (from 600 to 4500 tonnes) and in catch per unit effort (from 370 to 1200 kg/haul).

This fishery is mainly supported by adult fish. The length distributions of landings ranged from 72-136 cm, and modal lengths were at 100 - 112 cm.

The growth parameters and natural mortality adopted were the ones estimated in 1989 - Martins *et al* (1989): K = 0.11 and Linf = 145 cm and M=0.17. Total mortality rate (Z) and exploitation rate (E) were estimated resulting the values 0.60, and 0.70, respectively.

Estimations of yield per recruit were performed for different levels of fishing mortality (F) and it had provided a flat-topped shaped curve. Yield corresponding to F0.1 was adopted deriving a value of F close to the current level of fishing mortality. This result suggests that it is advisable to manage this fishery by keeping the present level of fishing effort.

RÉSUMÉ

Cet étude presente les principales caractéristiques de la pêcherie du sable noir dans les eaux continentales portuguaises à Sesimbra.

Depuis 1984 jusqu'à 1993 les débarquements ont eu un accroissement de 600 à 4500 tonnes aussi bien que la capture par unité d'effort de 300 à 1200 kg/voyage.

Les adultes constituent le soutient de cette pêcherie. La distribution des fréquences de longueur varie entre 72 et 136 cm et les longueurs modales sont comprises entre 100 et 112 cm.

Les paramétres de croissance et mortalité naturel adoptés sont les estimés en 1989 - Martins *et al* (1989): K = 0.11 et Linf = 145 cm et M = 0.17. De même, les valeurs de la mortalité totale (Z), et du taux d'exploitation (E) ont été estimés: 0.60 et 0.70, respectivement.

L'estimation du rendement par recrue indique une courbe aplatie. La capture correspondante à F0.1 a été adoptée et on a obtenu une valeur de F qui correspond aussi à la mortalité par pêche actuelle. Ces résultats suggérent que l'effort de pêche actuel ne doit pas être augmenté.

1. INTRODUCTION

The black scabbard fish (*Aphanopus carbo*) supports an important fishery in Portuguese continental waters (ICES Div. IXa). The exploitation of this species had become of commercial interest since the end of 1983. This fishery involves a fleet of small longliners fishing at "Sesimbra grounds" and landing at Sesimbra harbour (south of Lisbon - lat 38° 20'N).

The estimated landings of black scabbard fish at Sesimbra in 1983 was 67 tonnes. Since then the catches had increased greatly reaching around 4500 t in 1993. The annual landings provided from this fishery at Sesimbra harbour represent 23 % of the overall landings at this harbour. In economical terms the value of this species per kilogram is nearly equivalent to the value of mackerel (around 1 ECU).

The present study describes the trends and the evolution of this fishery since its beginning until 1993. An assessment is carried out to provide an estimation of the present levels of exploitation and long term yields forecasts for management purposes.

2. FISHERY DESCRIPTION

2.1. Fishing area

In Portuguese continental waters (ICES Div.IXa) the black scabbard fish is caught at a confined and deep area off Sesimbra waters (in front of Cape Espichel). The fishing area approximately corresponds to the areas from depths ranging 1000 to 1600 meters (Martins *et al*, 1989).

2.2. Fishing gear and fishing operation

The fishing gear used is the setting horizontal bottom longline. The main line can support 3600-4000 hooks (Nº 5), as reported in Martins *et al* (1989).

The longline is set and hauled at dawn and consequently each trip corresponds to one haul.

2.3. Fleet composition

The longliner fleet is composed by small artisanal boats being the majority of them registered at Sesimbra port.

The main characteristics of the fleet, fishing black scabbard fish as the target species in 1984-1992, are summarised in the table below:

The source of the information concerning the characteristics of this fleet has been provided by DGP (General Directorate of Fisheries).

Table 1 - Black Scabbard fish fleet composition (not available for 1993).

Year	Number boats	GRT Mean	HP Mean	Length over all Mean (m)
1984	15	16.6	128.3	11.2
1985	23	16.1	113.4	11.2
1986	28	16.1	116.9	11.3
1987	23	18.0	133.4	11.8
1988	27	20.1	144.9	12.4
1989	27	19.9	144.5	12.2
1990	27	19.9	144.5	12.2
1991	28	20.0	142.5	12.2
1992	27	20.0	142.5	12.2

2.4. Landings at Sesimbra fishing harbour

The annual landings, in tonnes, for the period 1984-1993 are summarised in the Table 2 and Figure 1:

Table 2 - Black Scabbard fish landings

Year	Landings
1984	613
1985	947
1986	2241
1987	2593
1988	2602
1989	3473
1990	3274
1991	3978
1992	4389
1993	4513

Table and Figure show that there was an increasing trend in the landings from 600 t in 1984 to 4500 t in 1993.

2.5. Fishing effort and c.p.u.e. (catch-per-unit-effort)

Fishing effort was estimated for 1984-1992 in number of boats and number of hauls. These data concern the fleet fishing directed to black scabbard fish and landing at Sesimbra harbour.

The data base was collected at Sesimbra harbour by IPIMAR personnel according to the following procedure: for each month it was registered the list of the boats, the corresponding landings and the number of trips. A complete list of boats, hauls and landings were obtained for each month and for 1984-1992. For 1988 this data was estimated based on the average fishing regime for 1984-1987 period.

It was not possible to collect these informations for 1993 due to logistic problems.

In this study boats were considered as directed to black scabbard fish provided the minimum numbers of trips per month and the minimum number of fishing months per year were six; this criteria is the same adopted in Martins *et al* (1989).

Table 3 gives fishing effort and c.p.u.e. estimated for the whole period considered. Figure 2 shows the c.p.u.e. trend for the period 1984-1992 in ton/boat and kg/haul.

Table 3 - Black Scabbard fish fishing effort and c.p.u.e..

Year	Haul	Boats	t/boat	Kg/ha
1984	1085	15	26.9	372.4
1985	1546	23	34.6	514.6
1986	2831	28	61.5	608.6
1987	2541	23	105.2	952.2
1988	2346 *	27	96.1	1106.2 *
1989	2773	27	93.1	906.7
1990	3220	27	94.5	792.0
1991	2516	28	88.5	985.0
1992	1843	27	84.6	1238.7

* estimated

Table and Figure indicate that the number of boats increased until 1988 and has remained stable since then; the same feature was observed in the c.p.u.e. trend.

The number of hauls per year increased attaining its maximum level in 1990 and has decreased from 1990 onwards. During this period there was an increasing trend in c.p.u.e. (kg/haul), with a particular exception in 1990.

The high value of fishing effort estimated in 1990 is explained by the commercial importance of the sharks in the by-catch black scabbard fish fishery in that year.

The analysis of landings and c.p.u.e. (kg/haul) indicates an important increase since the beginning of the fishery which may suggests an increase in the species abundance or an increase in the number of hooks per longline. This information was not available for the recent years (1990-1992).

The increase in c.p.u.e. must be further investigated to detect if the effort units used (number of hauls or trips) are an adequate measure of fishing effort in this fishery.

3. BLACK SCABBARD FISH LENGTH COMPOSITION OF LANDINGS

The annual 1984-1993 length compositions were estimated from the catch distribution by length of the available months raising them to the annual landings.

As individuals greater than 120 cm were scarce in recent years, a plus group of 120+ was set.

Table 4 gives the length composition of landings for 1984-1993 and Figures 3 (a-d) show the corresponding relative frequency per length group.

The graphs suggest stable length distribution patterns along the years, with modal lengths ranging from 100 cm (1993) to 112 cm (1984). The maximum length observed was 136 cm in 1990.

The length composition of landings for 1984-1993 (Table 4) indicate that fish smaller than 80 cm were present in the commercial landings in a very low quantity, not achieving 1% of the total catch. Only in 1984 landings it has been observed fish belonging to 72 cm length group.

The main feature concerning the length distributions of landings comprises the fact that juvenile fish are not caught and hence the catches are composed by adult fish - Mature male =78 cm and female =96 cm, *in* Martins *et al* (1989).

4. ASSESSMENT

4.1. Introduction

An assessment is performed in order to evaluate the state of exploitation of the black scabbard fish off Sesimbra waters and to compare with the results estimated in 1989 (Martins, *et al*, 1989). It is assumed that a stock unit is distributed off Sesimbra waters.

Total mortality coefficient (Z) and exploitation rate (E) were estimated and long term equilibrium yield estimates are provided.

4.2. Total mortality (Z) and exploitation rate (E) estimates

The estimation of total mortality has been performed by length based catch curve analysis as described by Sparre (1988).
This method requires estimates of the growth parameters Linf (infinity) and K to convert length groups to relative ages. Growth parameters adopted are the same as those estimated and presented in the previous study, e.g., Linf= 145 cm and K=0.11.

The application of the catch curve method to derive total fishing mortality (Z) requires the assumption that the stock is under equilibrium conditions and that recruitment has remain constant. In this fishery, the term "recruitment" should be interpreted as the overall number of fish measuring 72 cm entering in Sesimbra waters every year, which corresponds to the smallest length fish observed in the commercial landings (see Table 4).

An overall estimate of total mortality (Z) for the ten years period was calculated by using the average number caught per length group, provided by the length composition data for 1984-1993 given in Table 4. This technique tends to minimise the variations in "recruitment" and in exploitation pattern during the considered period.

To perform the overall estimation of total mortality (Z) the catch curve method was applied to length groups ranging from 110 to 120 cm. Fish smaller than 110 cm are not fully recruited to the fishery as it is suggested from the numbers caught.
A total mortality (Z) value of 0.60 was estimated with confidence limits of ± 0.02. The

linear regression performed was weighted by the square root of the numbers caught and the correlation coefficient (r^2) of 0.9952 was obtained.
Natural mortality was considered to be 0.17, value published in Martins *et al* (1989). This value was based in the Pauly (1980) empirical formula which relates natural mortality with growth parameters (Linf and K) and the mean environmental water temperature (10° Celsius).

A value of fishing mortality (F) of 0.43 was calculated, resulting in a exploitation rate (E) of 0.70. Results estimated in 1989 have indicated a value of 0.53 for F and consequently an exploitation rate of 0.75.

4.3 Long term yield and mean biomass estimates

Long term yields and mean biomasses were evaluated changing the levels of fishing effort or fishing mortality. These estimations were performed by using Thompson and Bell's method (1934) as described *in* Sparre(1988).
The input data is fishing mortality by length group and length-weight relationship. Recruitment is required but any number can be chosen since the results will be expressed in relative terms.

4.3.1. Fishing mortality vector

Fishing mortalities per length group (F-vector) have been estimated by length cohort analysis (Jones, 1984). This method assumes that stock is under equilibrium situation. The method was applied to 1984-1993 average length frequency distribution of landings. Growth parameters Linf and K and natural mortality (M) values used as input data were those previously mentioned, e.g. Linf = 145 cm, K = 0.11 and M = 0.17.
The terminal exploitation rate applied to the largest length group (E terminal) was 0.50. This value was considered adequate since the derived overall fishing mortality (F) for fish under full exploitation (L>=110cm) was 0.44 which is consistent with F value derived from catch curve method (F = 0.43).
The fishing mortality per length group (F-vector) are given in Table 5.

4.3.3. Results and discussion

The assessments were performed by changing the levels of fishing mortality per length group (F-vector) or fishing effort and evaluating the effects on yield and stock biomass.
Length-weight relationship used is the one estimated in 1989 (Martins, *el al*) and is the

following one:

W(Kg) = 0.000376 * L (cm)** 3.27

The calculations were made choosing 1 million as the number of fish at length group 72 cm ("recruitment"). Therefore the results are expressed in terms of yield and biomass per 1 million of recruits.

The changes in fishing mortality are expressed by factors (X) relating the simulated future fishing mortality with the current level of fishing mortality. By applying a range of X factors the yield and biomass have been calculated for different effort levels (or different F levels).

In this study fishing mortality has been modified by factors ranging from 0.1 to 2.0 values (step = 0.1). These changes are equivalent to variations from 90% reduction up to 200% increasing in fishing effort.

Tompson and Bell's method (1934) was applied in order to evaluate the long term yield and mean stock biomass per 1 million of recruits. This method uses the F-vector estimated in cohort analysis as the reference F-vector and assess the effects of changing all Fs by the X factor.

Table 6 gives the results of yield and mean biomass obtained for different levels of fishing mortality. Figure 4 shows the resultants yield and biomass curves for the whole set of X factors.

The yield curve has a rather flat-topped shape with a maximum which is not marked in Figure 4 because it corresponds to a very high level of fishing mortality. The maximum yield (Ymax) provided from the method is reached at the X factor value of 17.5 (Fmax = 7.7) and corresponds to a yield of 613 t and to a mean biomass of 2207 t per 1 million of recruits. At current level of fishing mortality (X = 1.0) the yield and biomass in equilibrium estimated per one million of recruits are 522 t and 4086 t, respectively,

This type of yield curve is a common feature on very lightly exploited stocks, where the individuals caught concern mainly adult fish. There are a whole range of fishing effort levels either side of Fmax all giving much the same yield. It means that for a very small increase in catch it requires a much greater increase in the fishing effort.

For example the results in table 6 indicate that an increase of 50% in fishing effort will produce a very small increase on yield **(8 %)** and if fishing effort is increased by 20% an increase of **4%** on yield is expected. Therefore taking into account economic aspects the point of Ymax is not, in the present case, the desirable objective for management because a slightly smaller catch can be obtained with considerable less fishing effort and consequently less costs involved.

Gulland and Borema (1973) indicate that for stocks with a flat top yield curve the management advice should be given in terms of fishing mortality corresponding to F0.1. F0.1 corresponds to a level of fishing mortality rate at which the slope of the yield per recruit curve is one-tenth of the slope at its origin. F0.1 is always less than Fmax but the implied reduction in fishing mortality rate is much greater and therefore catch per unit effort is higher with consequent economic benefits.

The value of F0.1 was estimated using a geometric procedure and the derived result indicate that current level of fishing mortality is similar to F0.1 value. This result indicate that if this stock is to be maintained at current exploitation pattern then fishing effort should not be increased.

Increases in the catches require heavy and disproportionate increases in fishing effort which lead to decreases in catch rates. This feature is not considered adequate in economical terms because the costs of the exploitation will be not compensated by the economic return.

5. CONCLUSIONS

Taking into consideration all the aspects described and the assessment performed one can formulate the main following conclusions about the black scabbard fish fishery at Sesimbra waters:

- the landings and c.p.u.e. had been increasing since 1984; the fishing effort (in number of boats) increased until 1988 and afterwards it has been stable;

- the number of hauls per year increased attaining its maximum level in 1990 and has decreased from 1990 onwards. During this period there was an increasing trend in c.p.u.e. (kg/haul), with a particular exception in 1990;

- the majority of the landings are composed by adult fish.

- the attempt to evaluate the state of exploitation of this fishery had provided a flat-top yield per recruit curve. The maximum yield (Ymax) will be reached at a very high level of fishing effort. The corresponding increase in yield would be around 17% but fishing effort should increase by 17 times when compared to the current level of fishing effort and the mean biomass would be reduced by 46%.

- the fishing mortality corresponding to F0.1 has been adopted resulting a fishing mortality similar to the current level of fishing mortality and a yield of 565 tonnes per 1 million of recruits.

Comparing these results with those presented in 1989 study one may conclude that the levels of current fishing mortality and of Fmax are very close to the values previous obtained. The long term equilibrium yield and biomass values are very similar which indicate that there was not a change in the state of exploitation of this stock.

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REFERENCES

Gulland, J. A. and Borema, L. K., 1973. Scientific advise on catch levels. Fish. Bull. 71 (2), 325:334.

Jones, R., 1984. Assessing the effects of changes in exploitation pattern using length composition data (with some notes on VPA and cohort analysis). FAO Fish. Tecn. Paper, 256, 117p.

Jones, R., 1986. Length composition analysis. The importance of choosing the correct input growth parameters. ICES Doc. C.M. 1986/G:4, 6p.

Martins, M. R.; Martins, M. M.; Cardador, F. 1989. Portuguese fishery Scabbard Fish (*Aphanopus carbo* Lowe, 1839) off Sesimbra waters. ICES Doc. C.M. 1989/G:38, 29p.

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and the mean environment temperature in 175 fish stocks . J. Cons. Int. Explo. Mer 39 (3): 179 - 192.

Pauly, D. , 1983. Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part I). Fishbyte 18(2): 9-13.

Sparre, P., 1988. Introduction to tropical fish stock assessment. FAO/DANIDA of Black Project training in Fish Stock Assessment. G.C.P. INT. /392/DEN, 384 p.

Tompson, W.F. and Bell, F. H., 1934. Biological statistics of the Pacific halibut fishery. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific Halibut) comm. 8:49p.

TABLE 4. BLACK SCABARDFISH

Length frequency distribution of the Sesimbra landings for 1988-1993

Length class	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
70	0	0	0	0	0	0	0	0	0	0
72	286	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	246	0	0	0	0	0
80	0	0	0	146	283	0	0	0	0	0
82	148	0	0	223	228	216	0	0	0	0
84	419	0	0	119	681	995	265	591	0	0
86	1134	0	0	717	966	2016	0	530	2724	2878
88	1412	719	308	4999	5672	2083	0	1386	4501	4755
90	4802	2377	2726	10513	14799	6667	7125	7824	20561	53653
92	9441	3779	5605	24546	26875	15189	17361	16019	43667	65645
94	10236	11716	17207	38976	45695	32038	21995	31812	70378	121947
96	19520	16397	26856	62968	69407	54097	32034	39498	94387	133023
98	15251	17086	48547	105251	109362	89963	71405	79704	119808	138209
100	17567	32971	77473	124879	150440	154349	132295	153686	276213	382469
102	24208	33528	101913	158778	158088	220568	191922	235767	285518	374890
104	33573	51297	120403	213019	218358	278578	252426	329317	376000	371836
106	40615	50922	142819	226228	224834	255247	258088	394202	354342	315739
108	30401	45310	151992	238561	243041	304372	294988	406982	340853	311759
110	40157	66279	158548	162343	172565	224508	233997	292751	281894	255455
112	40430	54136	135100	145927	129770	189701	195054	248292	200314	186789
114	30369	49449	102398	96822	99906	132350	156393	167994	203631	182910
116	17871	34618	85451	81843	82080	86335	105481	110928	103119	89709
118	9335	.23491	46039	57036	56886	65144	88841	95427	70049	84076
120+	22133	41100	87241	68294	69311	21625	28360	25263	31710	29364
Total	369308	535174	1310629	1822188	1879493	2136041	2088030	2637973	2879669	3105108
Weight (Kg)	613400	947000	2240800	2593300	2602200	3472644	3274068	3977963	4389044	4512552
Mean weight (g)	1661	1770	1710	1423	1385	1626	1568	1508	1524	1453

TABLE 5 - BLACK SCABBARD FISH

Fishing mortality per length group derived from Length Cohort Analysis

Linf= 145 cm   K= 0.11   M=0.17

E terminal = 0.5

Length group (cm)	72	74	76	78	80	82	84	86
F vector	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,001
Length group (cm)	88	90	92	94	96	98	100	102
F vector	0,002	0,010	0,019	0,034	0,048	0,072	0,146	0,192
Length group (cm)	104	106	108	110	112	114	116	118
F vector	0,274	0,327	0,423	0,435	0,465	0,515	0,478	0,17

TABLE 6 - BLACK SCABBARD FISH
LONG TERM YIELD AND MEAN BIOMASS
TOMPSON AND BELL´S METHOD
Recruits = 1 million of fish

Fishing mortality factor (X)	Yield (t)	Mean Biomass (t)
0,0	0,0	8018,3
0,1	130,5	7120,8
0,2	228,4	6428,4
0,3	302,9	5885,5
0,4	360,2	5453,5
0,5	404,8	5105,2
0,6	439,9	4821,1
0,7	467,7	4586,6
0,8	489,9	4391,0
0,9	507,8	4226,2
1,0	522,3	4086,0
1,1	534,2	3965,6
1,2	544,0	3861,4
1,3	552,1	3770,4
1,4	558,9	3690,3
1,5	564,6	3619,3
1,6	569,4	3555,8
1,7	573,5	3498,8
1,8	577,0	3447,2
1,9	580,1	3400,2
2,0	582,7	3357,3

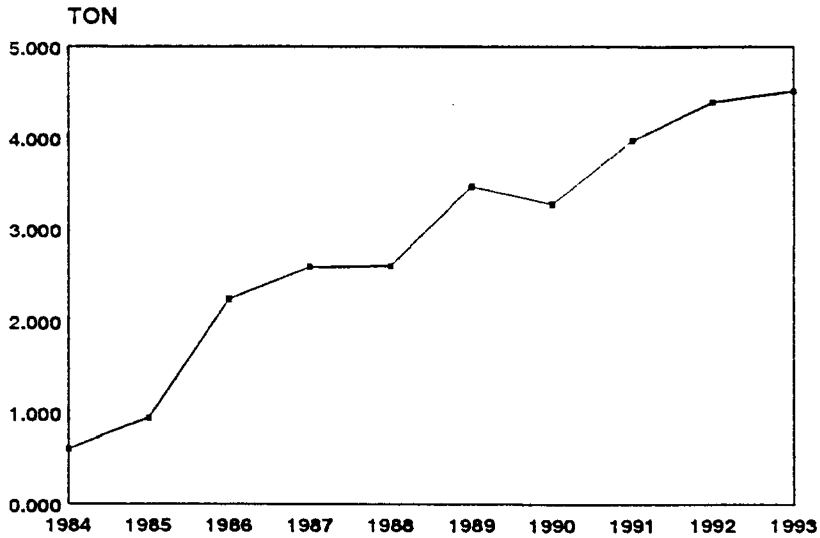

FIG 1 - Black Scabbard fish landings from 1984 - 1993

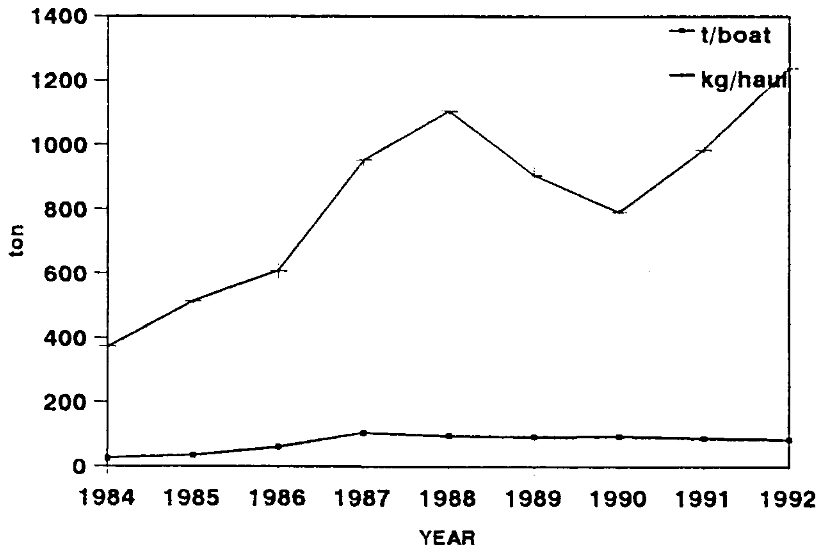

FIG 2 - Black Scabbard fish C.P.U.E. from 1984 to 1992

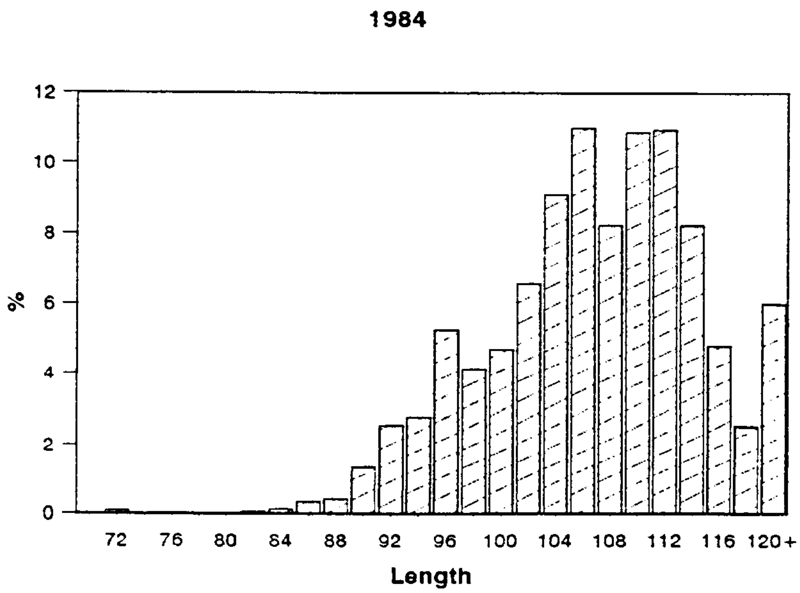

FIG 3a - Black Scabbard fish - length frequencies distributions in 1984

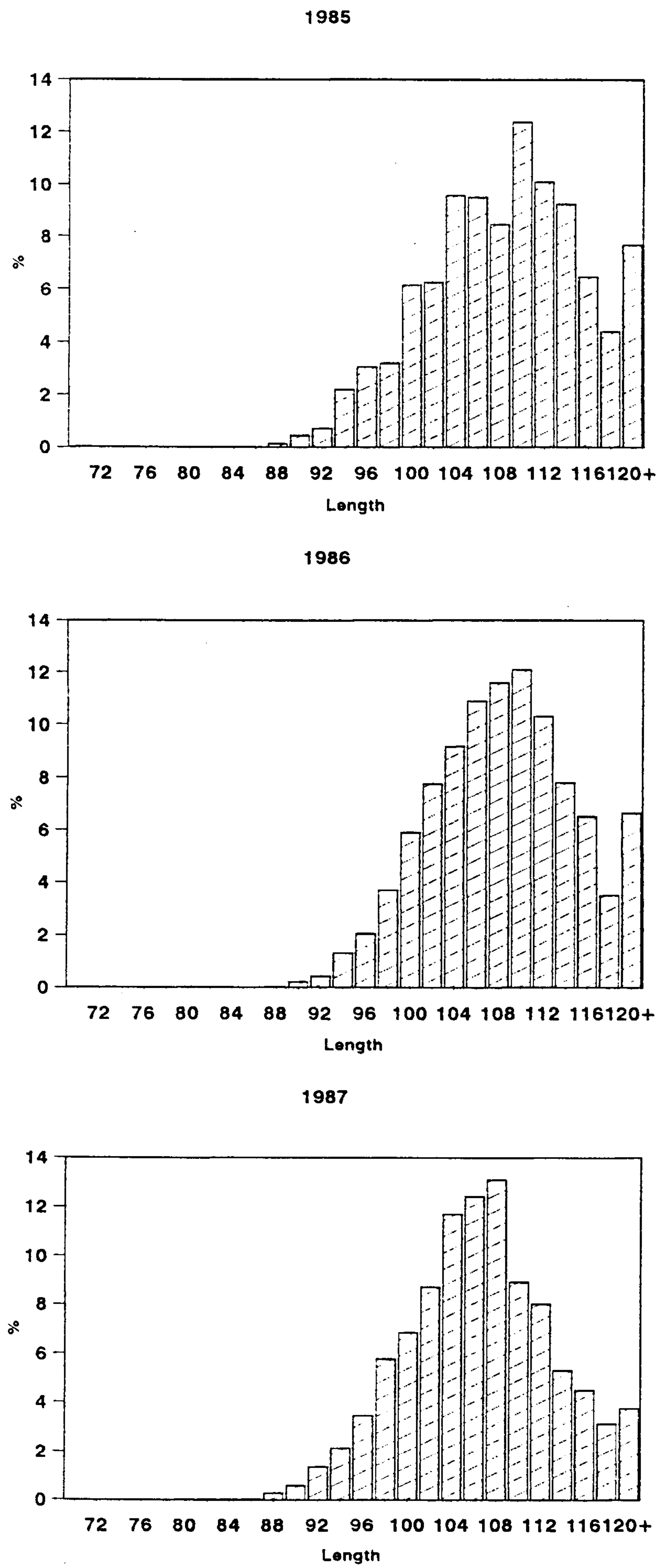

FIG 3b - Black Scabbard fish - length frequencies distributions in 1985 -1987

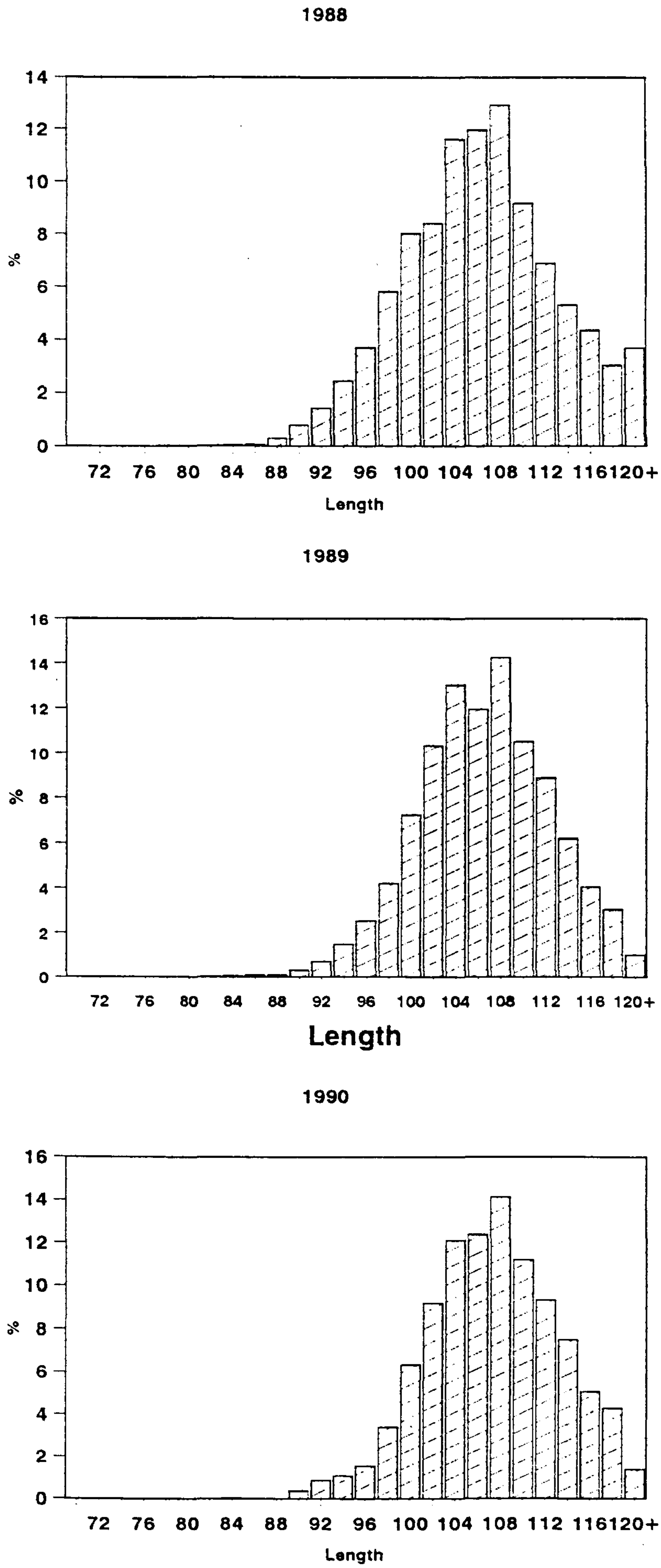

FIG 3c - Black Scabbard fish - length frequencies distributions in 1988 - 1990

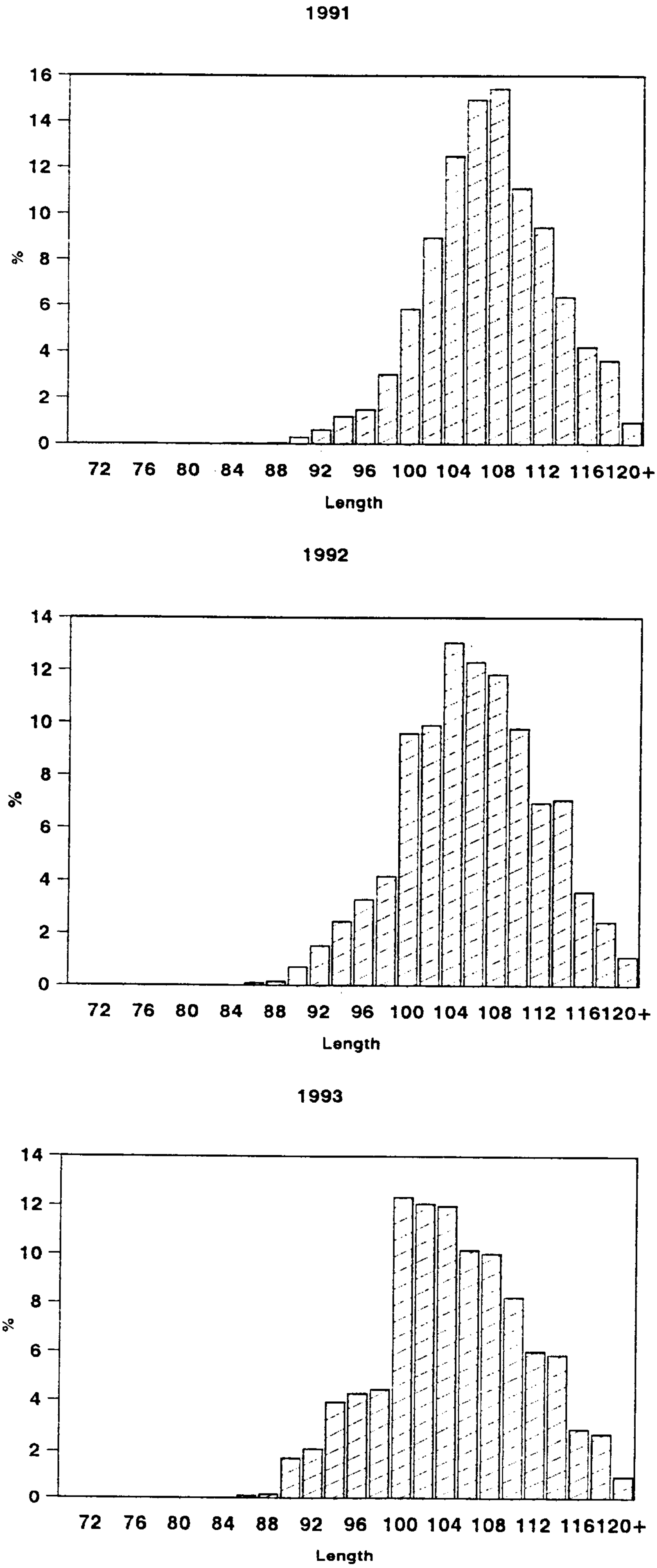

FIG 3d - Black Scabbard fish - length frequencies distributions in 1991 - 1993

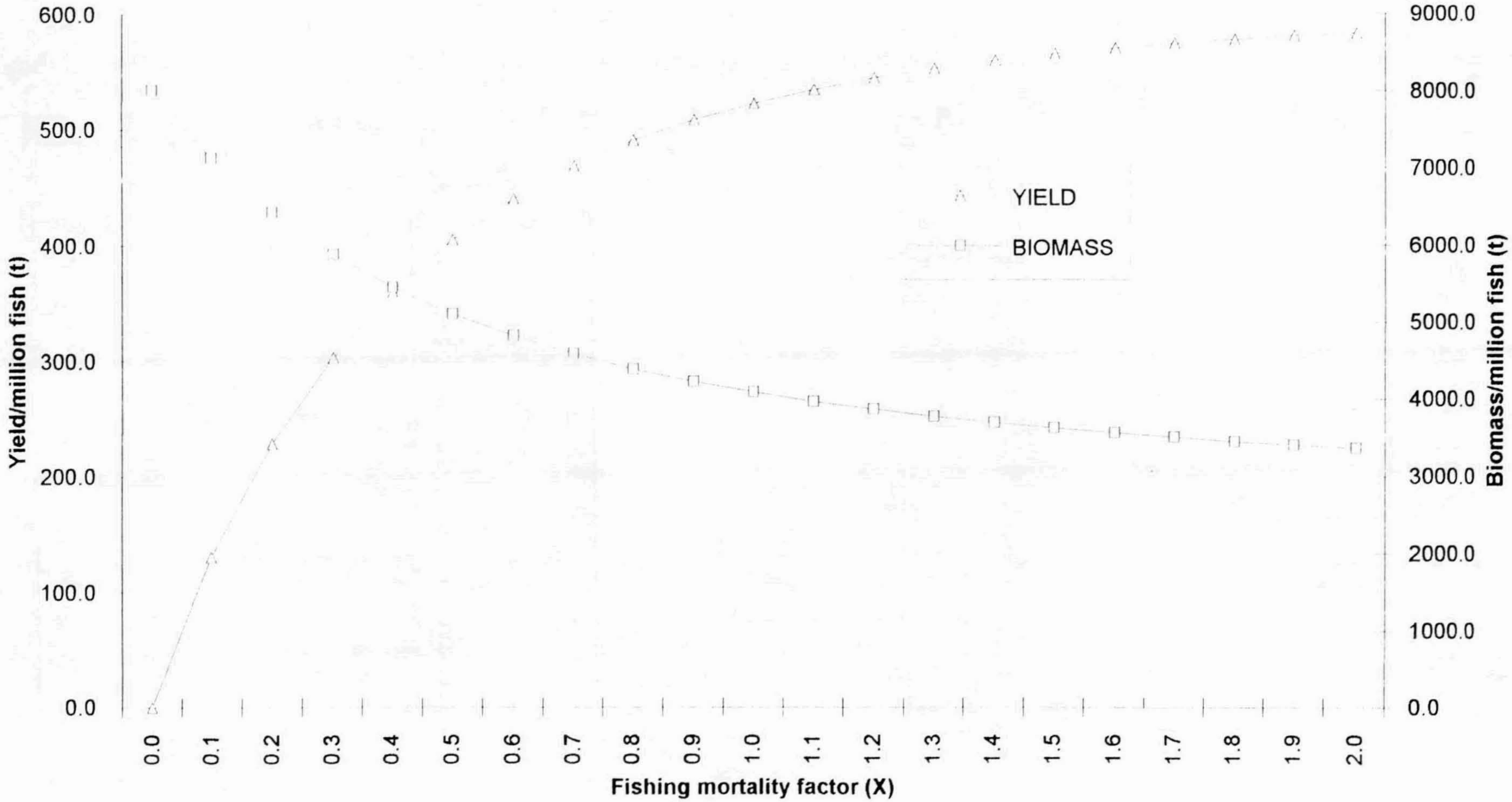

FIG 4 BLACK SCABBARD FISH - Long term yield and biomass