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Distribution, Abundance and Biomass Trends of the Genus *Sebastes* on Flemish Cap (Division 3M)

by

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INTRODUCTION

In recent years redfish biomass has decreased substantially, at the same time as catches have increased considerably. The redfish resource is managed like a single stock, though it is formed of three species, *Sebastes marinus*, *S. mentella* and *S. fasciatus* are different, not only in their abundance, but also in their distribution and behaviour. A correct analysis should consider these aspects.

In 1988 the EEC started bottom trawl surveys on Flemish Cap. In this paper, redfish distributions obtained in the last five years, and a year class analysis are presented.

MATERIALS AND METHODS

During the period 1988-1992, five stratified bottom trawl surveys were conducted in Flemish Cap in summer.

In the 1988, 1989 and 1990 surveys redfish catches were separated into two different groups, *S. marinus* and beaked redfish (*S. mentella* and *S. fasciatus* combined). In 1991 and 1992, the experience acquired allow us to identify in the catch both *S. mentella* and *S. fasciatus*, so the three species were identified in the last two surveys. Since 1990 individuals less than approx. 18 cm, for which species identification is not possible in routine work, were included in a independent category named "juveniles".

Age was determined by scales in the 1988 and 1989 surveys (Vazquez, 1989, 1990), as described by Kosswig (1980). In subsequent years (Vazquez, 1991, 1992, 1993), age was determined by reading otoliths. These otoliths were kept dried inside envelopes. Later, the otoliths were heated in a conventional oven at 200° C for one hour. This procedure permits a more accurate reading. An alcohol and glycerin mixture was used for cleaning the otolith. Independent aging for *S. mentella* and *S. fasciatus* was possible in the 1991 and 1992 surveys.

RESULTS

The age of the 8-9cm individuals, in all years where age readings were possible, was interpreted as age two. This age reading is consistent with that of most others authors (Gavaris et al, 1981; Anderson, 1984; Atkinson, 1985; ICES, 1991; Borovkov, 1992). The 1985 and 1986 year classes, which for years have been relatively important, allow us to follow the modal evolution in the length distribution (Fig. 1) and validate the age readings in the last years. Figure 5 shows the age distribution (to age 16+) in 1991 and 1992 of *S. mentella* joined with the group named "juveniles", which we suppose is compose mainly *S. mentella*. In the 1992 survey, the 1986 year class seems to be more abundant than the 1985 year class (Age 6 and 7 respectively), but in the 1991 survey both cohorts were similar in abundance (age 5 and 6 years respectively), because redfish is not totally recruited to the survey gear until approximately age 6 (≈20 cm). In the 1988 survey, these two year classes would have been 2 and 3 years old, and as we can see in Figure 1, these classes correspond to the 8.9 cm and 11-13 cm modal groups. Following this modal progression allow us to validate the age reading from age 2 on. A similar progression appear in the last two surveys with the 1989 year class, which is evident in 1991, with 8-9 cm (age 2) which in 1992 had grown to 11-13 cm, 3 years old in the age-length key.

An unresolved question concerns the assignment of age 2 fish to the 8-9 cm modal group in July. No surveys have yielded the modal group corresponding to age 1, which should measure around 4-5 cm, taking into account the growth rate between age 2 and 6, which is 3 cm per year. This growth rate is in agreement with that calculated by Anderson (1984). However, redfish intermediate in modal size between larvae (2 cm, *S. mentella* in August) and juveniles (8-9 cm) caught by bottom trawl in summer have not been taken in midwater hauls, nor ichthyoplankton surveys, nor from cod stomachs on Flemish Cap. Thus, one-year old redfish have not been ound so far. Besides, the 5 cm modal group is possibly found in autumn in the birth year (0-group) in others areas like West Greenland (Wieland, 1992).

S. mentella, the more abundant species on the bank, are born late April and larvae are around 6 mm (±0.5 mm) in length; the mean size increased to 12 mm in late June and to 28 mm in late August (Anderson, 1984; and observed in 1990 survey). The average growth rate estimated for this period is 0.136 mm per day, small redfish subsequently reached 44.3 mm in January. Then the growth rate decreased notably, both in juveniles and adults. This growth retardation can be observed in the next example: in late January 1981 and 1982, the first modal group ranged in size between 7 and 8 cm (Lilly et al, 1982) 1 cm less than in summer; In 1992 the abundant 1989 year class size increased from a mean of 11.34 cm in February (1992 marked survey) to 11.8 cm in July (summer survey). So in the winter-spring period, growth rates are considerably slower: 1 cm at age 2 and only 0.5 cm at age 3. So, redfish reach around 5 cm the first year, according to retrospective calculation using this parameter. For Flemish Cap redfish to be 5 and 8 cm in length at age 1 and 2 respectively supposes a growth differences between populations. Barsukov (1990) observed that Flemish Cap *S. mentella* grow more slowly than adjacent populations in 3L, 3N and 3O. In Labrador waters (Bainbridge y Cooper, 1971) and in the Gulf of Maine (Kelly and Barker, 1961)

redfish larvae growth rates are considerably higher than those for Flemish Cap. Svalbard *S. mentella* measure 8 cm in the first year of life and around 20 cm at age 6 (Nedreaas, 1990), i.e. between 8 and 20 cm there are six year classes, while in Flemish Cap only five, though at 20-21 cm both populations are 6 years old. Resolution of this problem is essential to determine in what years the abundant year classes are produced. In this paper the 8-9 cm modal group individuals are referred to as age-group 1 and so on.

Biomass

Redfish biomass estimated (in mT) in each survey following the swept area method are:

		Beaked redfish			
	S. marinus	*S. mentella*	*S. fasciatus*	Juveniles	Total
1988	15289	142933			158222
1989	22918	113675			136633
1990	14699	72893		16601	104193
1991	4093	48554	7198	4001	63846
1992	4130	71810	5308	23229	104477

These values underestimate the total biomass due to the partially pelagic character of these species, especially *S. mentella*, therefore these figures must be interpreted like abundance indices.

During recent years, the bottom redfish biomass (the three species combined) has suffered an important decrease on Flemish Cap. The total biomass of redfish declined by 50%, from 136.633 mT in 1989 to 63.846 mT calculated in 1991 (Vazquez, 1992). This decline is even more pronounced in the Russian data for the bottom redfish biomass (Rikhter,1991). In such data the biomass calculated in 1989 was around 83300 mT and only 17700 mT the next year. These data indicate a reduction of 78,7%. In 1992 the total biomass increased to the 1990 level. But the redfish biomass depression did not influence the three species equally.

In 1988, the biomass of *S. marinus* was less than in the next two years. This difference can be explained by inexperience in the classification of redfish in the first survey. Then, many *S. marinus* was classified as beaked redfish.

The biomass of *S. marinus* declined from 22958 mT in 1989 to 17487 mT in 1990, 23,8% less than previous year. Beaked redfish descended 23,7%, from 113675 mT in 1989 to 86706 mT in 1990. The biomass decline in both groups was similar. We might think the fishing effort was distributed homogeneously on S. *marinus* and Beaked redfish. However, in 1991 the biomass of *S. marinus* had descended 75% with regard to the previous year, 4366 mT, while beaked redfish declined "only" 32,4% and its biomass was 59480 mT.

In 1983, 1986, 1991 and 1992, the proportions of beaked redfish species (*S. mentella y S. fasciatus)* on Flemish Cap were calculated as follows (Figure 7):

Year	*S. mentella*	*S. fasciatus*	Source
1983	64	36	Penney, 1984
1986	80.5	19.5	Barsukov et al., 1990
1991	87	13	Vazquez, 1992
1992	93.1	6.9	Vazquez, 1993

On Flemish Cap, the three redfish species are distributed at different depths (Saborido-Rey,

1991). *S. mentella* lives in depths below 350 m, *S. fasciatus* is distributed between 250 and 400 m, mainly around 300 m, finally *S. marinus* is the shallower species living from 150 m to 300 m (fig. 8).

In recent years, redfish catches have increased considerably:

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Russia	10441	10430	10434	10916	14517	15005	15703	15045	19875	13747	13937	34581	24661
Portugal	666	985	659	1408	1667	2123	1306	10783	21823	7101	12849	11673	3787
Others	9002	4552	2798	2360	3343	3100	3273	3045	2713	2341	2863	20640	12466
Total	20109	15967	13891	14684	19527	20228	20282	28873	44411	23189	29649	66894	40914
Estima.						20000	20000	29000	44500	23000	58000	83000	55000

Until 1985, the redfish fishery was carried out mainly by the USSR using midwater trawling gear (Power et al., 1989). Since then the bottom trawl fishery developed strongly, mainly by the Portuguese redfish fleet (perhaps also by NAFO non-members fleets), which increased until it constituted about 50% of the total catches. In 1989, the Portuguese fleet directed for redfish trawled in depths below 400 m, and caught mainly *S. mentella* (Ávila, 1990). However, in 1990 the redfish fishery above 400 m intensified by 42,8%, while that below 400 m increased by only 16,5% (Godinho, 1991). Besides, in 1990 cod by-catch in the fisheries directed for redfish increased (50% of the catch). This supports the idea that the increment of fishing effort in depths above 400 m on Flemish Cap, affected *S. marinus* y *S. fasciatus* populations more than *S. mentella*.

Redfish by-catches in the Spanish pair trawlers directed for cod are shown in Figure 6. The increment in 1990 is evident. Of those three species which live on Flemish Cap, *S. marinus* and secondarily *S. fasciatus* coexist with cod and American plaice (Figure 8), so logically the redfish by-catch in those fisheries was composed predominantly by *S. marinus* and *S. fasciatus*, mainly the former.

Perhaps, the same occur with the other fleets (mainly NAFO non-members which are difficult to control), which direct their fishing effort to that area looking for multispecies fisheries (cod, flatfish and redfish). All these points confirm that *S. marinus* y *S. fasciatus* populations on Flemish Cap suffered more pressure than *S. mentella*.

Juvenile biomass fluctuation is due to the cohorts which recruit to each species considered in the surveys. So the 1986 year class, which in 1990 belonged to the juvenile group, recruited in 1991 to adults groups, this explains the decrease in its biomass, though the 1989 cohort already stood out, and this year class provoked the important increase in the juvenile biomass in the 1992 survey.

But the more conspicuous change was produced in *S. mentella* biomass, which increased by 20,000 mT from 1991 to 1992, due to increments in the ages 8 to 12 biomass. Among the three species, *S. mentella* is more pelagic in character; Russia, for example, has a midwater fishery directed to *S. mentella*. It is very unusual to catch *S. marinus* or *S. fasciatus* with pelagic gear. The same is true elsewhere in the Atlantic Ocean. On Reykjanes Ridge, *S. marinus* and *S. mentella*

occur together on the bottom, but there is an oceanic *S. mentella* stock (ICES, 1992). Vertical movements of Flemish Cap *S. mentella* are unknown, but accessibility to the bottom survey varies from year to year, and would explain the rise in the 1992 adult biomass between age 8 and 12 of *S. mentella*.

Abundance

Figures 1, 2 and 3 show length frequencies in the catches for the three groups considered in this paper, i.e. juveniles, *S. marinus* and beaked redfish. In recent years there have been relatively abundant year classes in 1979 and 1980, age 8 and 9 in 1988 surveys (Atkinson, 1985), in 1985 and 1986, age 2 and 3 respectively in 1988 survey, and in 1989, age 2 in 1991.

The 1979, 80, 85 and 86 year classes were similar at age 5, when it is possible to compare them, because until then redfish are not totally recruited to the survey gear, and since at that age they are totally recruited to the fishery. The 1989 year class seems be the most abundant, the 1990 (8-9 cm in 1992) year class also seems be abundant, though less than that of 1989. Intermediate year classes are, in general, poor, overall 1982, 83, 84 and 87.

Figure 1shows an increase in frequency with length, until around 20 cm (5-6 cm), at which size the recruitment to the survey gear is total. The 1988 year class trebled the number of individuals between the 1990 survey (age 2/8-9 cm) and the 1992 survey (age 4/15-16 cm). Juvenile biomass is underestimated due to this recruitment. The 1989 year class appears to be very abundant.

Figure 4 shown the *S. mentella* and *S. fasciatus* length frequency distribution observed in the 1992 survey. *S. fasciatus* abundance decreased notably after age 10 ((≈30 cm), but this decrease do not happen in *S. mentella*. Taking into account that size at maturity (50%) in beaked redfish females is 29.61 cm (Ni and Templeman, 1987), most of the *S. fasciatus* females are immature. The reproductive stock of *S. fasciatus* (age 9+) has decreased considerably.

Distribution

Figures 9 and 10 show the mean catches per depth range (25 m) in the 1991 and 1992 surveys. Most of the juvenile catches were taken in depths around 300 m. Those of *S. marinus* between the lower depth on the bank (120 m) and 350 m. *S. fasciatus* between 250 y 400 m and finally *S. mentella* between 300 y 700 m, the deepest in the survey. These depth distributions have been constant during the last five years (Saborido-Rey, 1991), with slight variations year to year, due to the entry of juvenile year classes in each adult group.

Figure 11 (a-d) shows the mean depth by size for each group considered in this paper: juveniles (11a), *S. marinus* (11b) and beaked redfish (11c), also shown is the mean depth by size for *S. mentella* and *S. fasciatus* in 1992 (11d).

The juvenile distribution (Fig. 11a) shows that older fish are distributed at greater depths. Thus, the 1986 cohort was founded in 1988 (age 2) in depths around 270 m, at age 3 around 300 m, a depth which increased to 280 m in 1990 (age 4), 325 m at age 5 and finally to around 350 m at age 6 (in 1992).

With increasing age, redfish juveniles move to deeper waters, though the different sizes of

each cohort are at the same mean depth. For this reason Fig. 10a shows a stepwise distribution. These features are recognized in the 1985, 1988 and 1989 cohorts. This movement to different depths depends not only on cohort age but also on the distribution of other cohorts. Very abundant cohorts displace others towards different depths. Hence, the 1989 year class at age 2 (in 1991) is situated around 310 m, and displaces the previous cohort (1988 cohort, age 3 and 12 cm in length in 1991) toward 290 m in depth, when the trend at that age is to occupy greater depths. This can be seen in the 1989 and 1992 surveys, where the year classes with 3 years of age (1986 and 1989 respectively) occupy depths around 310 m. The 1987 year class was also displaced towards shallow depths at age 3 (1990 survey) because of the appearance of the more abundant 1988 class. This cohort, that of 1987, is the least abundant in the last decade, and in all surveys always occupied shallower waters than the rest of the juveniles.

Because the juvenile group is formed by all three species, it is difficult to know where each species is, but taking into account that juveniles are found in a depth range intermediate between *S. marinus* and *S. mentella*, and that most of the juveniles belong to the latter species, it is reasonable to think that movement to deeper depths in juveniles is provoked by small *S. mentella*, while small *S. fasciatus* juveniles stay in the same depths as the adults. *S. marinus*, perhaps, is the part of the juvenile group in shallow waters.

This movement to greater depths with age, is also observed in *S. marinus*.

During the 1992 survey it was possible analyze the separate distributions of the two species of beaked redfish. *S. fasciatus* (Fig. 11c) does not move to different depths, perhaps because they are in a very narrow depth range. Nevertheless, in *S. mentella* this behaviour is evident, since it inhabits a total depth range of 400 m. The proportion of *S. fasciatus* is very low (Fig. 11c) and does not influence the curves of Figure 12. So, the mean depth per size curves for all surveys can be applied to *S. mentella*. The movement mentioned above is manifest in this species. The homogeneity in the distribution from year to year is conspicuous, though the dispersion is higher at larger sizes.

CONCLUSIONS

Redfish on Flemish Cap present different growth patterns compared with other areas in the Atlantic Ocean. While in other populations, a length of about 5 cm is reached in winter of 0 year, it is probable that in Flemish Cap such length is reached in summer of first year. In general, Flemish Cap redfish seem grow more slowly in their early stages. More studies should be carried out to clarify this subject.

The abundance fluctuations of the year classes during the last decade are obvious. The 1985 and 1986 year classes, and particullary that of 1989, not yet totally recruited, are relatively abundant.

The three species of *Sebastes* on Flemish Cap are not found in the same depth ranges: *S.*

marinus occupies shallower waters, between 150 y 300 m, *S. fasciatus*, is situated preferentially between 250 y 400 m, while *S. mentella*, is found in a wider depth range, always below 350 m. The juvenile group (three species combined), live between 150 and 400 m. It is possible the three species in this group are distributed in the same way as the adults.

The individuals of each species move to different depths as they grow. This phenomenon is evident in *S. mentella*, but not in *S. fasciatus*.

Redfish spawn in the pelagic zone. Here the larvae remain and grow during the first year. Between age 1 and 2 small redfish migrate to the bottom, to depths around 270 and 300 m. After age 2, *S. marinus* and *S. fasciatus* hardly migrate to other depths, but *S. mentella* migrates to deeper depths each year.

Redfish can live as long as 60 years, though in the EEC surveys the highest age was 36 years. They grow very slowly, and the females are sexualy mature at age 9-10, when around 29 cm in length.

However, fishing effort on Flemish Cap, both that directed to redfish and other species, is concentrated in shallow-intermediate depths, between 150 and 400 m. This means that fishing effort on *S. marinus* and *S. fasciatus* is considerably higher than on *S. mentella*. For this reason the biomass of the former two species has decreased more than the last. The three redfish species are considered as a single stock, and the agreed quotas exceed that allowed for the shallower species, *S. marinus* and *S. fasciatus*.

REFERENCES

Anderson, J. T. 1984. Early life history of Redfish (*Sebastes spp.*) on Flemish Cap. Can J. Fish. Aquat. Sci. **41** (7): 1106-1116.

Atkinson, D. B. 1985. The Redfish in NAFO Div. 3M. NAFO SCR Doc. **85/48**. Serial No. N997.

Ávila de Melo, A.M., Godinho, L., R. Alpoim and M. Carneiro. 1990. Portuguese Research Report for 1989. NAFO SCS Doc. **90/12**.

Bainbridge, V., and G.A. Cooper. 1971. Populations of *Sebastes* larvae in the North Atlantic. ICNAF Res Bull. **8**:27-35

Barsukov, V.V., I.A. Oganin and A.I. Pavlov. 1990. Morphological and Ecological differences between *Sebastes fasciatus* and *S. mentella* on the Newfoundland and Flemish Cap. Voprosy Ikhtiologii, **30** (5): 791-803.

Borovkov, V., S. Kovalev, P. Savvatimsky, V.A. Rikhter and I.K. Sigaev. 1992. Russian research report for 1991. NAFO SCS Doc. **92/12**.

Gavaris, C. A. and W. E. Legge. 1981. Distribution and abundance of small redfish on the Flemish Cap. NAFO SCR Doc. **81/IX/119**. Serial No. N425.

Godinho, L., R. Alpoim, M. Carneiro and A. M. Ávila de Melo. 1991. Portuguese research report for 1990. NAFO SCS Doc. **91/15**.

ICES. 1991. Report of the Workshop on Age determination of Redfish. ICES C.M. 1991/G:79

ICES. 1992. Report of the Study Group on Redfish Stocks. ICES C.M. 1992/G:14

Kelly, G.F., and A. M. Barker. 1961. Vertical distribution of young redfish in the Gulf of Maine. ICNAF Spec. Publ. Nº 3: 220-233.

Kosswig, K. 1980. On the method and results of age determination of Redfish in Subarea I. NAFO SCR Doc. **80/91**.

Lilly, G. R. and C. A. Gavaris. 1982. Distribution and Year-class Strength of Juvenile Redfish, *Sebastes sp.*, on Flemish Cap in Winters of 1978-82. J. Northw. Atl. Fish. Sci., Vol. 3:115-222.

Nedreaas, K. 1990. Age determination of Northeast Atlantic *Sebastes* species. J. Cons. Int. Explor. Mer, **47**: 208-230

Penney, R. W., D. J. Power and D. B. Atkinson. 1984. Species proportion and some reproductive aspects of three redfish species (*Sebastes marinus, S. fasciatus* and *S. mentella*) on Flemish Cap, March 1983. NAFO SCR Doc. **84/VI/22**. Serial No. N797.

Rikhter, V.A., I.K. Sigaev, V. Borovkov, S. Kovalev and P. Savvatimsky. USSR Research Report for 1990. NAFO SCS Doc. **91/5**.

Saborido-Rey, F. 1991. Redfish distribution in Flemish Cap during the period 1988-1990. NAFO SCR Doc. **91/32**.

Vazquez, A. 1989. Results from bottom-trawl survey of Flemish Cap in July, 1988. NAFO SCR Doc. **.89/60**

Vazquez, A. 1990. Results from bottom-trawl survey of Flemish Cap in July, 1989. NAFO SCR Doc. **90/68**

Vazquez, A. 1991. Results from bottom-trawl survey of Flemish Cap in July, 1990. NAFO SCR Doc. **91/28**

Vazquez, A. 1992. Results from bottom-trawl survey of Flemish Cap in July, 1991. NAFO SCR Doc. **92/27**

Vazquez, A. 1993. Results from bottom-trawl survey of Flemish Cap in July, 1992. NAFO SCR Doc.

Wieland, K. 1992. Distribution of Larval and 0-group fish off West Greenland in summer and autumn 1989 and 1990. NAFO SCR Doc. **91/35**

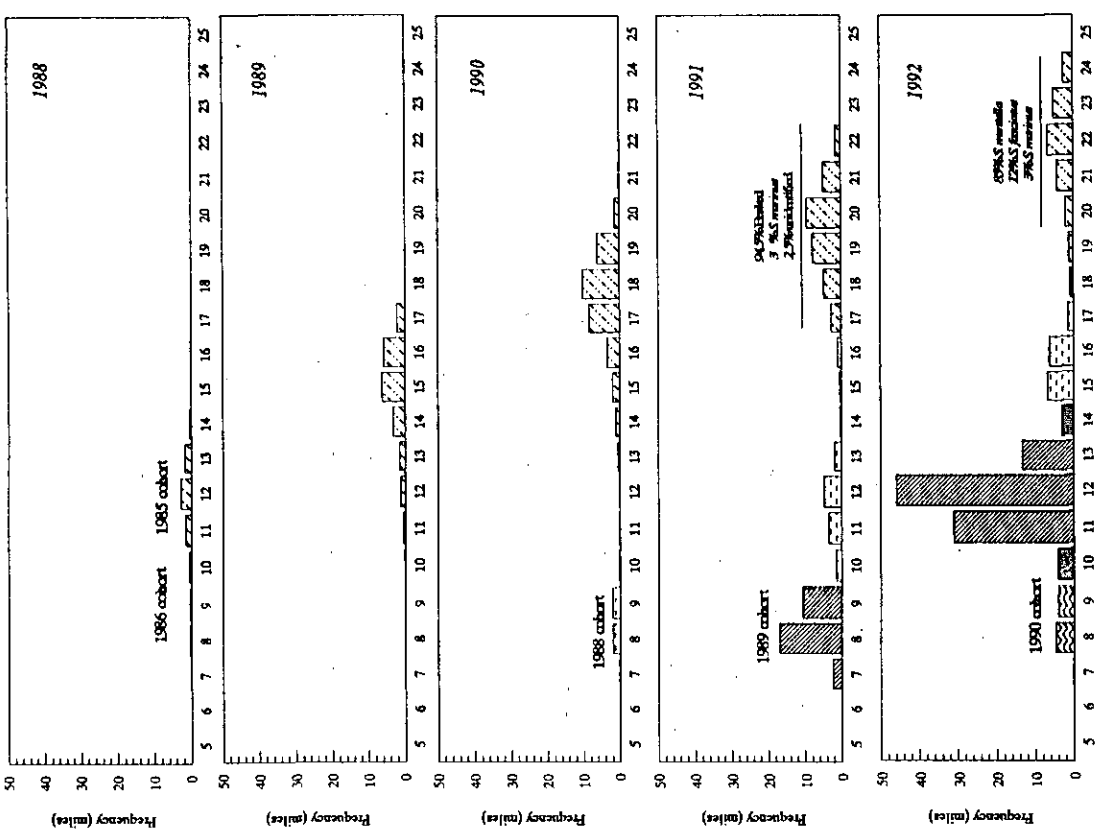


Fig. 1.- Length frequency of juveniles group (in the catch) in 1988-1992 in Flemish Cap. 18-25 cm size show also for following yera-classes)

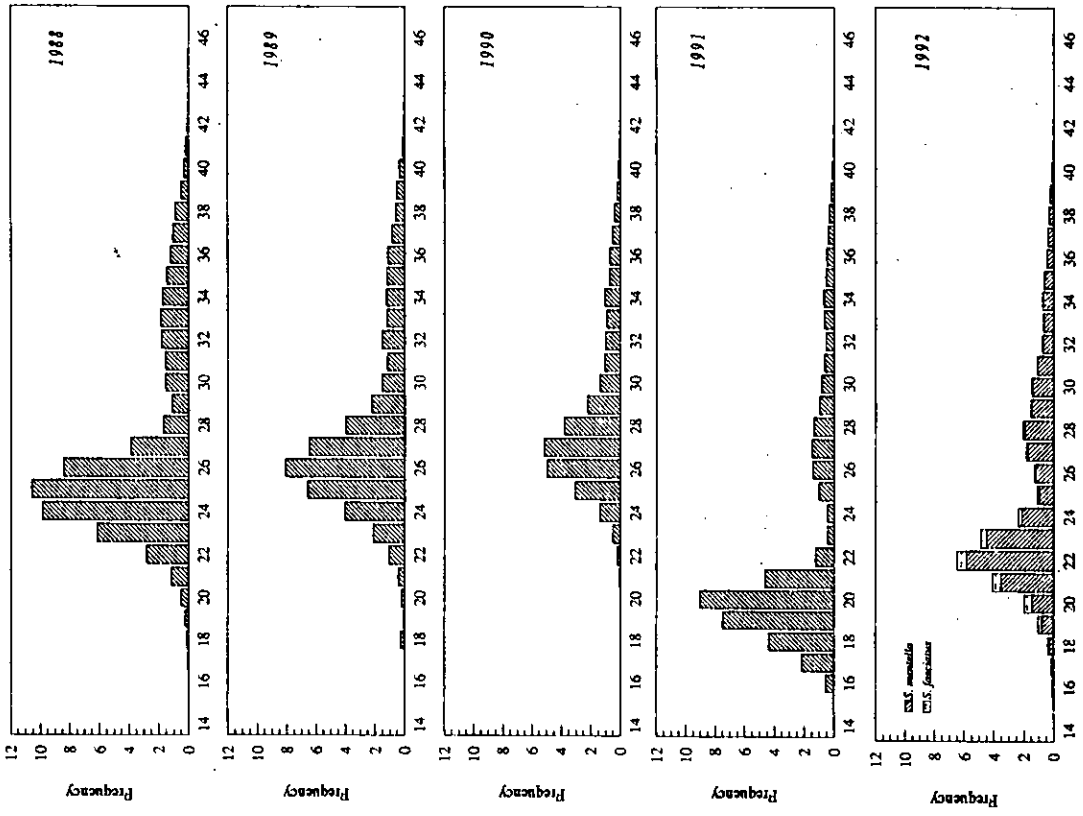


Fig. 3.- Length frequency of beaked redfish (in the catch) in Flemish Cap, 1988-1992
In 1992 plot is shown *S. mentella* and *S. fasciatus* proportions

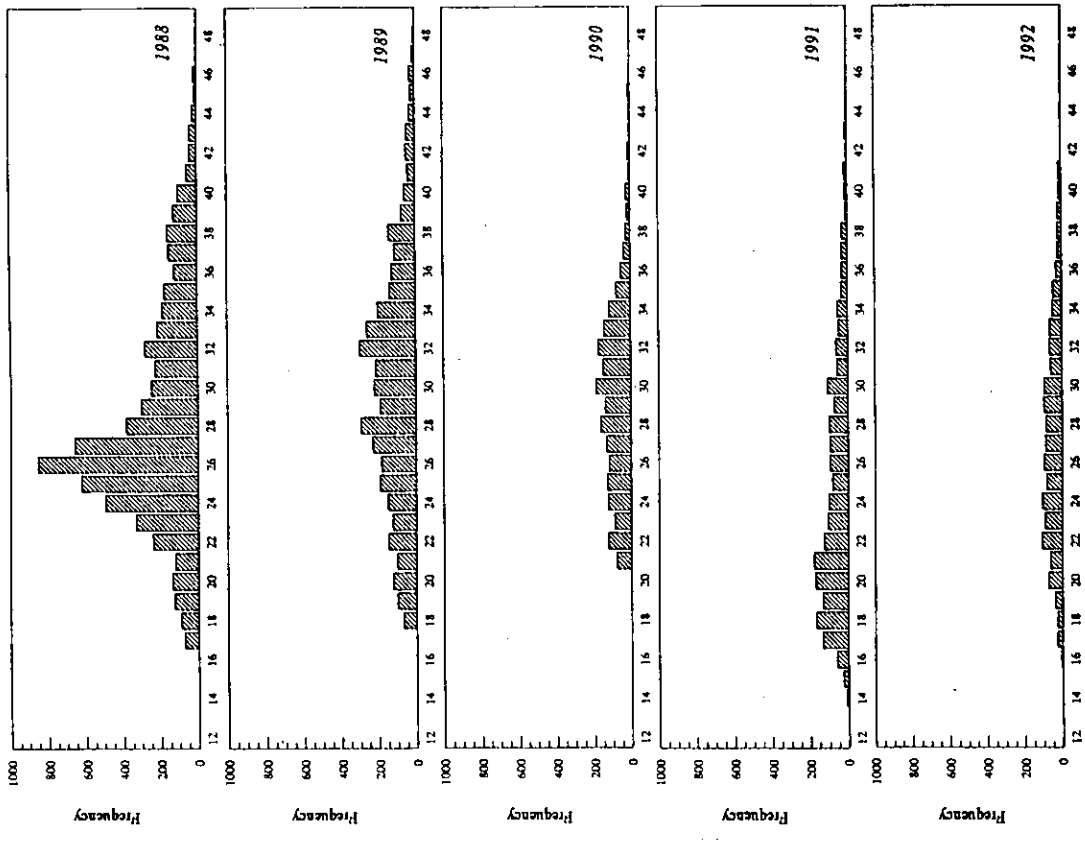


Fig. 2 .- Length frequency of *S. marinus* in Flemish Cap in 1988-1992.

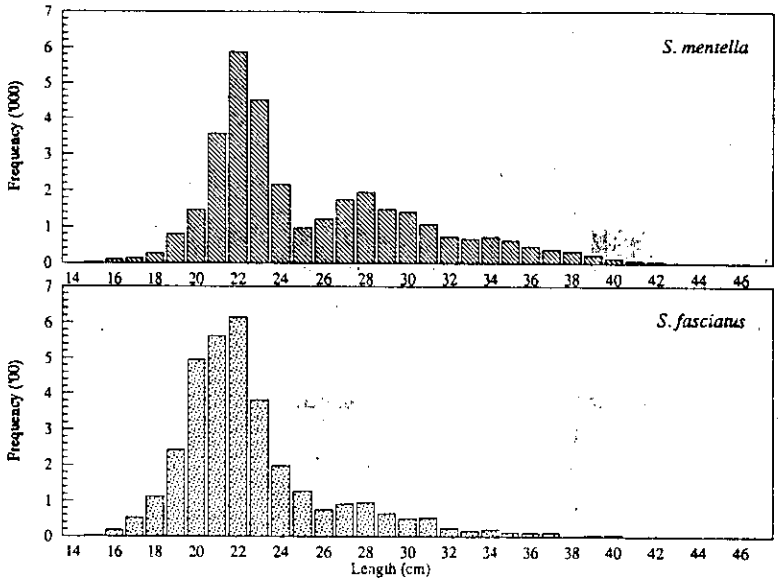


Fig. 4.- Length frequency of *S. mentella* and *S. fasciatus* in Flemish Cap in summer 1992

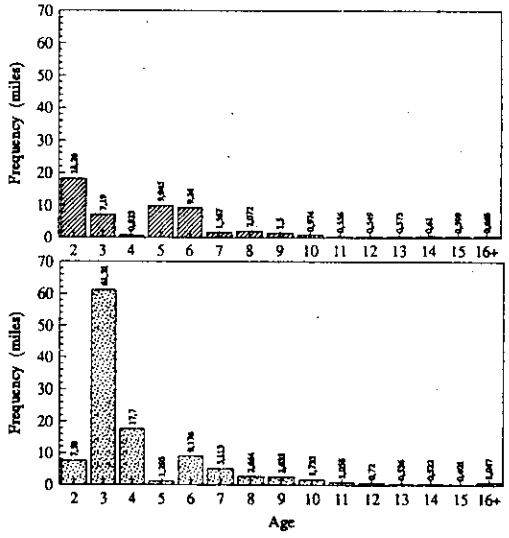


Fig. 5.- Age frequency of *S. mentella* (all juveniles included) in 1991 and 1992.

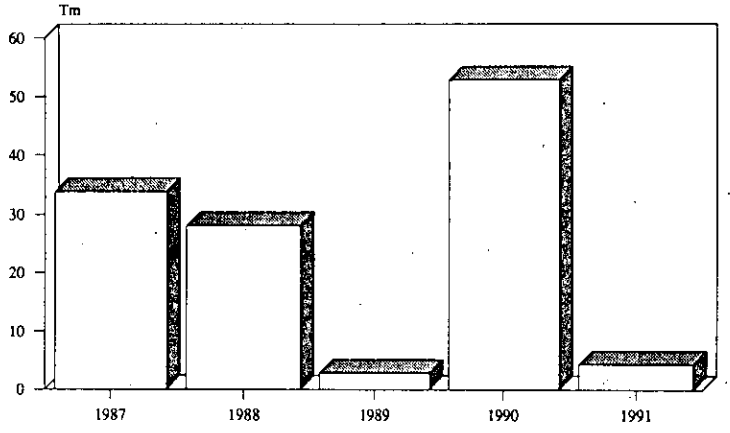


Fig. 6.- Redfish by-catch in the spanish cod pait trawlers (vessesls with observers onboard) in Flemish Cap

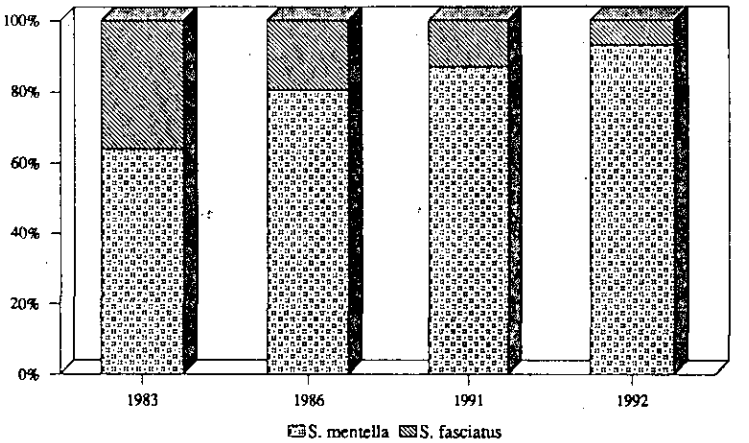
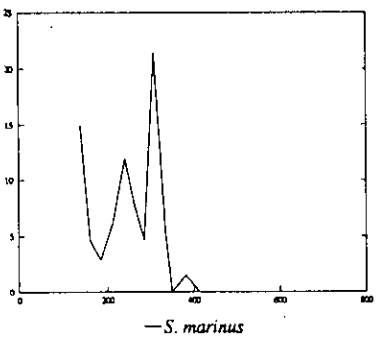
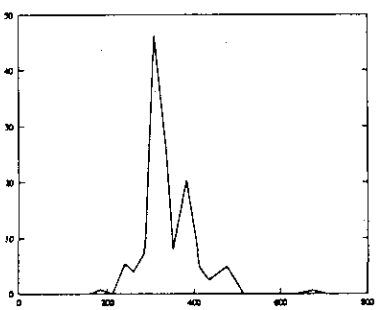


Fig 7.- Beaked redfish proportions in Flemish Cap

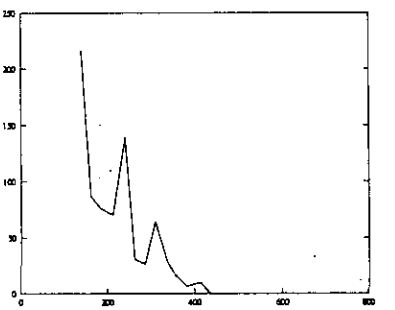


—*S. marinus*

Fig. 8.- Depth distribution for the three redifsh species, cod and American plaice in Flemish Cap
X-Axis=Depth in meters



—*S. fascianus*



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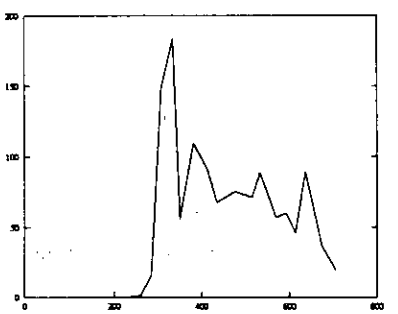
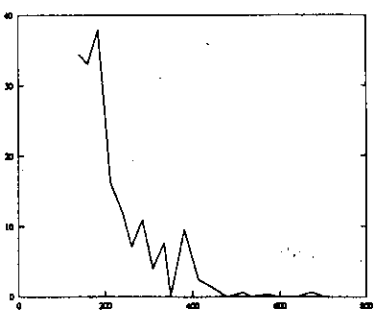


—*S. mentella*



—American Plaice

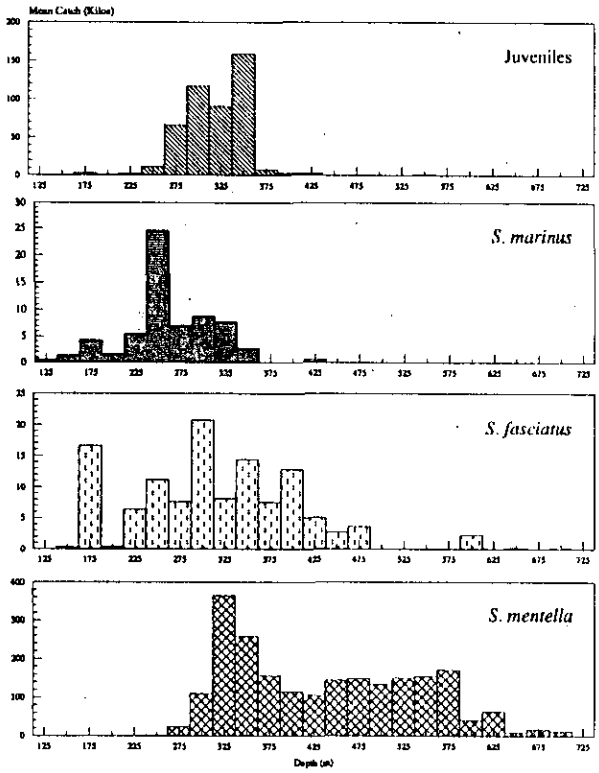


Fig. 9.- Mean catch (in Kilograms) per depth range in 1991 Flemish Cap EEC survey

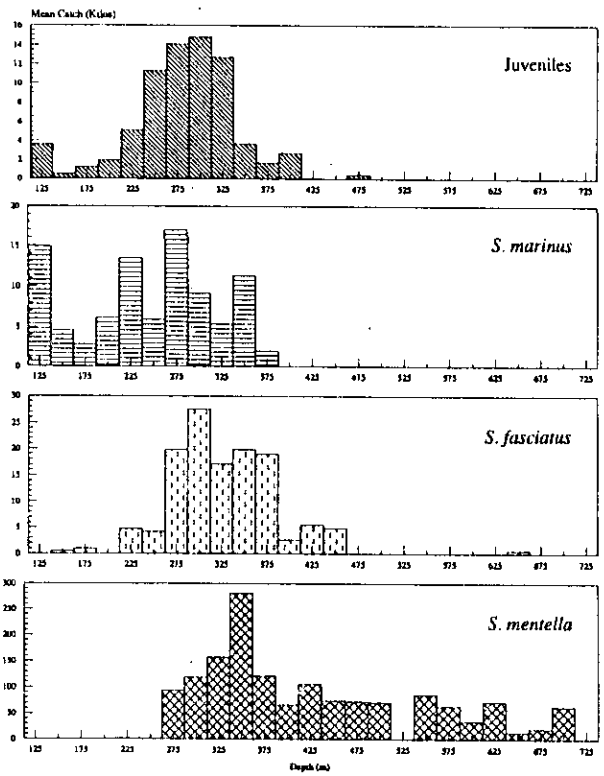


Fig. 10.- Mean Catch (in Kilograms) per depth range in 1992 Flemish Cap EEC survey

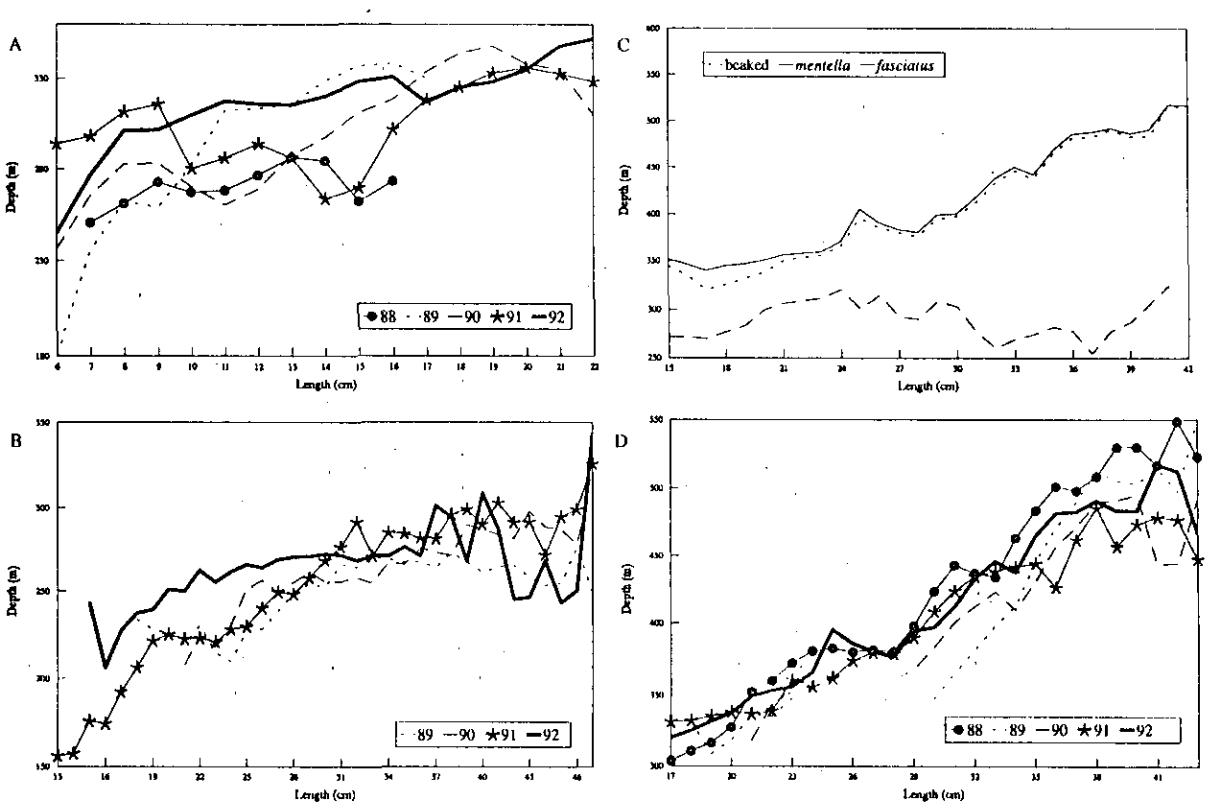


Fig. 11.- Mean depth per size class in Flemish Cap in 1988-1992
A.- Juveniles B.- *S. marinus* C.- *S. mentella* and *S. fasciatus* in 1992 D.- beaked redfish