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Diet of Flemish Cap Cod with Particular Reference to Predation on Redfish: 1988-93

by

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Abstract

The food and feeding of Flemish Cap cod in summer are described for six years utilizing 3315 stomachs. The feeding intensity was high and the prey spectrum was narrow in all years. Hyperiids and redfish stand out in the diet of Flemish Cap cod. *Illex illecebrosus* and polychaetes had a high annual variability. Invertebrates (crustaceans and polychaetes) were dominant in juvenile cod diets, while the most important prey in adult cod was fish, mainly redfish. The cannibalism rate has strong year to year fluctuations on the Flemish Cap. There is a positive relation between predator size (cod) and prey size (redfish). The Condition Factor variation is closely related with the predation intensity on *Sebastes*. A change in the diet composition is observed in the last two years. This change consisted of an increase of hyperiids in the adult cod diet and a decline of *Sebastes sp*.

Key words: cod, feeding variability, condition factor, predation on redfish, Flemish Cap.

Introduction

The quality and quantity of food intake by fish are known to be important factors for their growth, maturity and fecundity changes.

Cannibalism and predation on other juvenil fishes are also important factors in recruitment patterns of fish stocks. Predation by cod on smaller cod and redfish may produce variable mortalities in juveniles, and contribute to variations in year-class strength (Akenhead, 1978; Lilly, 1985).

In recent years decreases of biomass were observed for several commercial species in the Northwest Atlantic. The declines in biomass were paralleled in most cases, by declines in abundance (Atkinson, 1993). Trends in the biomass of cod compared with all other species combined are generally similar (Atkinson, op. cit.). For some species (e.g. redfish, Greenland Halibut, American plaice) previous assessments have reported that the declines in biomass observed from the surveys cannot be explained by the fisheries.

The trends from 1989 through 1991 are particularly dramatic and suggest not only a decline, but a concentration of the remaining biomass in the offshore areas away from the coast (Atkinson, op. cit.).

The declines in biomass are indicative of "ecosystem stress", (Rätz, 1992) although the nature of the stress is unclear. It may encompass a number of factors including fishing pressure, environment and predator-prey relationships. One of underlying factors in these changes may be the severe cooling of the Northwest Atlantic (Drinkwater 1993).

Changes were observed recently on Flemish Cap too. The biomass decrease (e.g. cod and a. plaice) mainly due to overfishing, has been accompanied by a strong increase in shrimp biomass, which has resulted in a new fishery in this area.

This study is aimed at determining possible changes in the food and feeding patterns of cod on Flemish Cap in recent years. Although sampling was limited to the summer period, the months studied correspond to the period of highest feeding intensity (Turuk, 1981). It is also known that the diet of cod on Flemish Cap is not very different during the rest of the year (Albikovskaya et al., 1993).

Materials and Methods

Random-stratified bottom trawl surveys were carried out by the European Union on Flemish Cap NAFO Div. 3M (fig. 1). Although the vessels were different, standardized survey procedures were realized. They are described by Vázquez (1990, 1991). Biological samples were collected during research surveys, and they included some small cod fry caught in a few pelagic trawls in 1990. Total length of cod were measured to the nearest cm and each individual was weighed, to ± 5 gr. Otoliths were extracted and used to age the cod in the laboratory.

Stomach totals collected and frozen on board in the period 1989-92 appear in table 1. In the laboratory the stomachs were dissected out by cutting the oesophagus and the intestine behind the pyloric sphincter. Stomach contents were examined and the food components were separated and identified as far as possible in the laboratory.

Food items in each taxon were placed briefly on absorbent paper to remove excess liquids, and then weighed to ± .01 g.

Some data for 1988 (Paz et. al., 1989), 1993 (R. Marín. com. pers), and also winter 1992 (E. de Cárdenas et. al., 1993) were including in the study.

For each stomach the Repletion Index (RI) was noted following the subjective scale used by Walsh and Rankine (1979). The degree of digestion (D.G.) was recorded according to Aloncle and Delaporte (1970).

For cod in each age-class and length group, the following indices were calculated:

The feeding intensity index is obtained from:

$$F.I. = \frac{SN_f}{SN_t}$$

where "SN_f" is the number of stomachs with some food and "SN_t" is the total number of stomachs analyzed.

Prey Occurrence index (OI) is the relation between the number of stomachs with a prey *"pi"* in the total number of stomachs analyzed.

A Gravimetric index (GI) is obtained from the expression: total weight of a specific prey in all stomachs as a percentage of total weight of all prey.

Stomach fullness index, calculating the **Mean Total Fullness Index (TFI)**:

$$TFI = \frac{1}{n}\sum_{f=1}^{n}\frac{fw}{l^3}10^4$$

where "n" is the number of stomachs examined, "fw" is weight of stomach contents of the fish f, and "l" is the length of the fish f.

and the **Mean Partial Fullness Index** of prey *"p"* (**PFIp**):

$$PFI = \frac{1}{n}\sum_{f=1}^{n}\frac{fp}{l^3}10^4$$

where "fp" is weight of the prey *p* in the stomach of the fish *f*.

The **Simpson diversity feeding index** (**D**) is obtained from

$$D = 1 - \sum_{i=1}^{s}\frac{N_i(N_i-1)}{N(N-1)}$$

where "Ni" is the number of times in which the type of prey appears in the total number of stomachs.

"N" is the number of times in which all prey appear in the total number of stomachs, and "s" is the number of types of prey.

The Condition Factor was studied with Fulton's expression:

$$CF = \frac{W * 100}{l^3}$$

where "W" is demigutted fish weight, and "l" is the length of the fish.

Diet overlap index is obtained from the Schoener diet overlap index (**R_0**) (Linton et al., 1981) given as:

$$R_0 = 1 - \frac{1}{2}\sum_{i=1}^{n}\left|P_{ij} - P_{ik}\right|$$

where "P_{ij}" is the frequency of appearance of prey i in individuals of class j.

"P_{ik}" is the frequency of appearance of prey i in individuals of class k.

The diet overlap was calculated intraspecifically (Wallace and Ramsey, 1983). This index was calculated between three cod size groups: prerecruits: A, <24 cm; immature recruits: B, 24-65 cm; matures: C, >65 cm. Following Mathur (1977) the value accepted as a limit to consider that diets overlapped was $R_0 > 0.6$.

The cannibalism Index was calculated as an occurrence index for cod prey. The rates were compared with data from similar surveys obtained in 1988 (Paz et al., 1989), winter 1992 (E. de Cárdenas et. al., 1993) and 1993 (Rodríguez Marín com. pers.). For these three years O.I. of main prey groups were also utilized.

The stomach number collected by length groups showed an abnormal distribution. For this reason we used **the Kruskall-Wallis test** to study if the feeding patterns of cod for the years analyzed in this work could be considered similar or not. The Kruskal-Wallis one-way analysis of variance provide test of the null hipothesis that the summer feeding cod on Flemish Cap is not different in the years 1989-1992. The analysis was focused on the prey behaviour each year considering their Gravimetric Index in the cod stomachs as the variable to analyze and processed with standard statistical program 3S (BMDP) (Dixon et. al., 1990).

To avoid the variability of the wide cod size range , as well as their different distributions in the four years, the analysis was repeated with length groups of 10 cm. Furthermore for the most important prey (hyperiids and redfish), the same test was done, but in this case all comparisons by year pairs were carried out. In this case the null hypothesis is rejected if "ZSTAT" is larger than the critical value "ZC", where 1-PHI(ZC)=ALPHA/(K(K-1)), PHI is the cumulative standard normal distribution function, K is the number of groups compared. With 4 groups, the critical values are: 2.39 for overall ALPHA of 0.10

2.64 for overall ALPHA of 0.05

Whenever stomach content data on redfish were not seriously affected by digestion, the feeding patterns of cod upon redfish were studied utilizing total lengths of redfish measured to the nearest cm. When this was not possible, the jaw bones of redfish in the stomach contents were measured to the nearest mm and a linear regression was used to obtain the relationship of jaw length to total length. Small juvenile redfish length frequency in the survey trawls (Vazquez, 1992) was compared with redfish recovery in the stomach contents and plotted for the years studied.

Results and Discussion

The summer feeding intensity (Table 1), was higher than 83% in all years. In winter 1992 the feeding intensity was lower: 71% (E. de Cardenas et al., 1993). This corresponds to the cod seasonal feeding cycle, with maximum intensity in summer and minimum in winter.

Table 2 shows the food components distributed into cod length groups. The variety of prey organisms is small, and accords with the narrow Flemish Cap cod prey spectrum (Konstantinov et al., 1985).

The Occurrence Index (**OI**), Gravimetric Index (**GI**) and Fullness Index (**PFI**) (Table 3) indicate hyperiid dominance in the cod diet in all years. Its importance was greater in juvenile cod and decreases when cod length increases (Fig.2a). The value of the Gravimetric Index for the hyperiids was larger than 56% in all years.

Fig. 2 shows the evolution of Occurrence Index by length groups. Hyperiids and *Sebastes sp.* have an complementary evolution (fig. 2a, 2b) where the hyperiids decrease with increased cod size and fish (mainly Redfish) increase with length in all years. This feeding pattern by length remained similar in the period studied.

In winter the *Sebastes sp*. and *Pandalus borealis* **OI** were similar to summer, but the **OI** of Hyperiidae was lower (De Cárdenas et al, 1993) (Fig. 3). This seems related with the annual life cycle of the Amphipods on Flemish Cap (Konstantinov et al. ,1985). Also of outstanding important are Myctophids: O.I.= 29.5 (E. de Cardenas et al., 1993).

1992 and 1993 years shown differences with the years before. The most important difference was the increase of the hyperiids percentage and the decrease of the redfish percentage in the cod diet (fig. 3).

In the last years the importance of the hyperiids spread to all length groups (fig. 2a) reaching the highest index values: O.I.=91.76, G.I.=84.4 and P.F.I.= 2.332. In these years the importance of fish in the cod diet decreased markedly (fig. 2b).

Fish were incorporated into the cod diet at larger lengths than 21 cm, and their presence in all years increases with cod size (Fig. 2b). Redfish was the more important fish prey (Table 3, Fig.3) appearing in cod larger than 33 cm. It is interesting to note that "0" group age cod caught in a few pelagic trawls in 1990 also prey on redfish larvae although age group 1 do not prey on redfish and age group 2 had very low predation rates.

The presence of polychaetes was very variable in all length group diets (fig. 2c). The high index values of squids (mainly *Illex illecebrosus*) in 1990 and 1991 (Table 3) corresponds with the greater catch abundance in the surveys of these years (Vázquez ,1991 and 1992).

A **Kruskall-Wallis test** was done to compare the similarity or differences in the cod summer diet during the years 1989-1992. The less important prey in the cod diet: Anarhichadidae (p=0.24), Myctophidae (p=0.20), Macruridae (p=0.55), Gasteropoda and Bivalva (p=0.09), Echinodermata (p=0.19), did not present significant differences over time.

The prey with a high occurrence index (Hyperiids, Shrimp, Redfish), and others prey like Cod, Polychaeta, Cephalopoda, Other Crustacea, Other Pisces shown significant differences ($p < 0.001$, 3df).

The **Kruskall-Wallis test** done with cod length group of 10 cm. showed the same results. Only prey less common in the cod diet had a similar behaviour in the four years.

Also from the **Kruskall-Wallis test**, all comparison by year pairs done for redfish and hyperiids showed than greatest differences were between 1992 and the others years (Table 4). Since these prey constitute more than 75% of the summer cod diet, 1992 was a year where the feeding behaviour of cod changed notably.

The feeding diversity in the period studied is shown in Table 5. The mean index increased with cod length. In 1990 and 1991 the average feeding diversity is larger than in other years, probably due to the rise in the presence of squids and shrimps.

The Condition factors by age groups are given in Table 6. Their values were high for all ages. For the recruit age groups (4+), the values of the condition factor were highest in 1990.

Figure 4 presents the Condition Factor values of the 1984-1986 year-classes in the period studied. They decline from 1990 and show a similar trend to P.F.I. values of *Sebastes sp*. over time.

The 1987 and 1988 year-classes are not present in the figure because theirs age range only include juvenile ages and predation upon *Sebastes spp.* is very low in this age range (1 - 4 old years).

The similar trend of the Condition Factor and P.F.I. of *Sebastes spp.* reflect a close relation between the consumption of redfish and the condition of adult cod. Otherwise the increase of hyperiids in 1992 and 1993 in the cod diet is not energetically sufficient to support the condition level of the earlier years.

Lilly (1979) deduced that the slow growth of cod in the 1950's may have been due to a very low abundance of juvenile redfish and gave particular importance to the presence of redfish of intermediate size (15-20 cm): "These redfish should enable the cod to bridge the large gap in size between the small crustaceans (hyperiid amphipods and shrimp) and the large redfish.".

Another recent studys on the North-east Arctic cod stock (Jorgensen 1992) suggested that reduced growth and condition factor was a direct result of a sharp decline in the capelin stock.

In the same way the declines in redfish predation may have affected the Flemish Cap cod population (e.g. condition factor). However a longer period of study would be necessary to confirm this hypothesis.

Declines in the condition factors were also found by Bishop and Baird (1993) for 2J3KL Cod, the NAFO Division adjacent to Flemish Cap. This suggests a common large scale factor underlies the cod diet change such as the cooling of Northwest Atlantic sea water.

The Diet Overlap calculated intraspecifically provides a better idea of the feeding similarities between the three groups considered: prerecruits: A, <24 cm; immature recruits: B, 24-65 cm; matures: C, >65 cm. The results obtained for the years 1989-1992 are shown in Table 7.

Following the Mathur criterion (Mathur 1977), in the years 1989 and 1990 there is overlap only between A and B groups. This indicates the similar trophic habits of the prerecruits and immature recruits. These trophic habits change between group B and C, mainly due to the beginning of predation on small redfish. It could be associated with the energetics of sexual maturation and the spawning process .

For 1991 and 1992 there was overlap between A-B and B-C groups. Also the overlap index between the groups A and C increases in these years. This variation of the overlap pattern corresponds to the feeding behaviour change described above (increase of the presence of Hyperiidae in all length groups).

The cannibalism rate was very variable in the years studied (Table 8). It has a strong year-to year fluctuation. The mean rate is higher than that obtained by Lilly (1982), however, his results refer to winter conditions. In summer 1993 the cannibalism was zero. (Com. pers. E. R.-Marín).

Predation on redfish

Redfish is the dominant prey of adult cod on the Flemish Cap in summer. However, although from 1992 the biomass estimated of the small juvenile redfish *(Sebastes spp.)* was bigger than the years before (Vázquez 1992), the occurrence of this prey in the cod stomach was lowest. The Hyperiids was the main prey in cod diet for all size groups in 1992 and 1993 (Fig 2a, 2b).

The relationship between redfish jaw length and total length was obtained with the 1990 data by the regression:

Total L = 6.77 + 6.639 Ljaw (N = 22, r = 0.95, p< 0.001)

Thus, we can estimate the length of redfish from jaw length when the direct measure of fish was not possible due to decomposition in the cod stomach.

The correlation parameters for the predator length (cod) and prey length (redfish) were calculated for each year. The results are:

1989:	N= 136, r = 0.69, p< 0.001, y = 0.426 + 0.239x
1990:	N= 58, r = 0.52, p< 0.001, y = 4.865 + 0.205x
1991:	N= 84, r = 0.62, p< 0.001, y = 0.668 + 0.171x
1992:	N= 44, r = 0.56, p< 0.001, y = 1.693 + 1.467x
1989-92:	N= 322, r = 0.62, p< 0.001, y = 0.224 + 0.223x

These values indicates that the length increase of the redfish was related to predator length. Small juvenile redfish length frequency in the survey trawls was compared with redfish recovery in the stomach contents (Fig. 5). For the years 1989 and 1990 (fig. 5a, 5b) the most abundant length groups of small juvenile redfish were those most preyed upon. This suggest a positive relation between the small redfish abundance and its predation intensity by Flemish Cap cod. The gap in the modal length may be due to some undetermined bias in measurement. It could also reflect selection toward small redfish by the cod or selection toward large redfish by the trawl. Although the exact cause in the modal gap is not known, it is clear that this difference is small and that the abundance of small redfish recovered from cod stomachs should adequately reflect annual differences in the size of these redfish on the Flemish Cap (Lilly , 1981).

However 1991 and 1992 (fig. 5c, 5d) data do not show this relationship clearly. 1991 and 1992 show bimodal size distributions of small redfish but cod predation only affects the first mode. The most abundant juvenile redfish correspond to 19-22 cm, and these are not preyed upon so intensively. Furthermore, although 1992 shows very strong juvenile redfish year-classes, the occurrence in the adult cod diet is lower than in other years.

The difference abundance, bathimetric distribution and behaviour of each three species (*S. marinus, S. fasciatus, S. mentella*) which constitute redfish group on Flemish Cap (Saborido-Rey, 1993) can affect the cod predation on these species.

Thus, it is not always possible to compare relative strengths of redfish year-classes with their occurrence in the diet.

The recovery rate of small redfish founded in the stomach of cod is inadequate for quantifying abundance because the recovery rate for an area is highly dependent on the size of cod caught. There is also the possibility that the cod distribution may not adequately cover the redfish distribution (Lilly 1981). Furthermore the massive presence of alternative prey like hyperiids can induce change in the cod diet.

Conclusion

It is possible to identify a common evolution of the feeding pattern with cod length in all years studied. The size associated evolution of the main prey groups (Hyperiidae and *Sebastes spp.*) is similar. However in 1991 and mainly 1992 there was an important change of the diet corroborated with the Kruskall-Wallis test. In the Flemish Cap this new situation is related to the increase of Hyperiidae in the adult cod diet and the lesser importance of small redfish.

The change of diet is also reflected in the Overlap Index which is different for the last two years. Also, the decrease in Condition Factors in all year-classes except for 8 years old, is related with the low presence of *Sebastes spp.* in the diet.

This study confirms the conclusions established in previous papers (Paz, et al., 1991):

a) Cod feeding intensity is high in summer. The hyperiids and small redfish are the most important prey of Flemish Cap cod.

b) The cannibalism rate has strong year-to-year fluctuations on the Flemish Cap.

c) The variation of some species (e.g. *Illex illecebrosus*) may reflect their availability in the area.

d) There is a change in diet at maturity age, nearly 65 cm. (Zamarro et. al., 1993) in Flemish Cap cod.

e) Predation on small redfish length is particularly important. It begins in "0" group cod. There is a relationship between cod length and redfish length. There is a positive relationship between redfish year-class abundance and the predation intensity upon them by Flemish Cap cod, but one can not quantify the relative strength of annual year-classes lonely from recovery rates in cod stomach .

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Table 1.- Stomach samples of cod taken between 1988-1993 on Flemish Cap, NAFO Div.3M.

Year	Sampling dates	Sampling Platform	Number of hauls	Depth range (m)	Stomach numbers by age 1	2	3	4	5	6	7	>8	Total	% Fullness stomach
1988 *	1 Jul - 27 Jul	"Cornide de Saavedra"	67	128-548	3	66	164	144	53	13	22	3	468	83.5
1989	6 Jul - 12 Aug	"Cryos"	58	144-459	7	7	242	467	387	55	9	8	1182	92.6
1990	12 Jul - 8 Aug	"Ignat Pavlyuchenkov"	64	128-428	30	85	44	106	103	86	28	34	530	95.5
1991	14 Jun - 17 Jul	"Cornide de Saavedra"	44	144-406	52	38	70	16	111	67	18	8	380	90.8
1992**	20 Feb-17Jul	"Atlantida"	58	239-798									377	71
1992	23 Jun - 24 Jul	"Cornide de Saavedra"	54	128-640	147	269	91	88	22	113	23	2	755	87.4
1993***	15 Jun - 18 Jul	"Cornide de Saavedra"											960	96

* Paz et. al., 1988.
** Cárdenas et. al., 1993.
*** R. Marín, com. pers.

Table 2: Food items observed in the stomachs of cod, by size group in Div. 3M in summer 1989-1992.

Food Items	Size Group							
	<20	21-30	31-40	41-50	51-60	61-70	71-80	>80
Class Anthozoa				*				
Class Ctenophora					*			
Class Polychaeta								
O. Errantia		*	*	*	*	*		
Fam. Aphroditidae		*	*		*		*	
Class Gasteropoda					*	*		
Class Bivalva				*				
Class Cephalopoda								
Illex illecebrosus					*		*	*
Onychoteuthis banksii					*			
Semirrossia sp.			*			*		
Others		*	*	*	*	*	*	*
Class Crustacea								
O.Copepoda	*	*	*	*	*			
O.Isopoda				*				
O.Amphipoda								
Fam. Hyperidae	*	*	*	*	*	*	*	*
Fam. Gammaridae	*	*	*	*	*	*		
O. Decapoda								
Pandalus borealis	*	*	*	*	*	*	*	*
Parasiphaea tarda	*	*	*	*	*	*	*	*
Spirontocaris lilljeborgi		*	*		*	*		
Pagurus pubescens					*	*		
Chionocetes opilio			*	*	*	*	*	*
Lithodes maja					*	*		*
Class Ophiuroidea		*	*	*	*	*		*
Class Asteroidea				*				
Class Echinoidea					*			
Class Holoturoidea						*		
Class Ascidiacea						*		
Class Pisces								
Fam. Scorpenidae								
Sebastes sp.		*	*	*	*	*	*	*
Fam. Gadidae								
Gadus morhua			*	*	*	*	*	*
Fam. Serrivoeridae				*	*	*		
Fam. Anarhichadidae								
Anarhichas sp.				*	*	*	*	*
Anarhichas lupus				*	*			
Anarhichas denticulatus					*			
Fam. Myctophidae		*	*	*	*			
Fam. Paralepididae		*	*	*	*			
Fam. Macrouridae								
Nezumia bairdi					*			*
Fam. Stichaeidae								
Lumpenus lumpretaeformis		*	*	*	*	*		
Fam. Cottidae								
Triglops murrayi		*	*	*	*			
Fam. Pleuronectidae								
Reinhardthius hippoglosoides								*
Fam. Raidae								
Raia sp.						*		
Fam Nemichthyidae								*
Nemichthys scolopaceus								

Table 3: Gravimetric Index (%), Fullness Index and Ocurrence Index of food items of cod in Div. 3M in July 1989-1992.

Food items	1989			1990			1991			1992			1993***
	G.I.	F.I.	O.I.	G.I.	F.I.	O.I	G.I.	F.I.	O.I	G.I.	F.I.	O.I	O.I.
Class Anthozoa													
O. Actinida	*	*	0.27	-	-		-	-		-	-		
Class Ctenophora	0.1	*	0.18	-	-		-	-		-	-		
Class Polychaeta	0.4	0.002	0.64	0.9	0.011	8.30	1.7	0.011	6.38	0.4	0.009	2.28	6.1
Phy. Echinodermata	0.1	*	0.55	*	*	0.59	*	*	2.31	-	-	-	
Phylum Mollusca													
Class Cephalopoda	0.7	0.007	1.55	1.5	0.046	5.14	2.7	0.055	8.11	0.6	0.023	2.15	
Other mollusca	0.2	*	0.27	0.1	*	0.79	*	*	0.29	-	-	-	
Mollusca Total	0.9	0.007	1.82	1.6	0.046	6.23	2.7	0.055	6.40	0.6	0.023	2.15	1.6
Class Crustacea													
O. Copepoda	0.2	*	1.73	0.2	0.004	2.57	0.9	0.003	1.16	1.5	0.015	6.46	
Fam. Hyperidae	59.1	0.649	66.82	65.4	1.077	75.49	56.3	0.846	70.14	84.4	2.332	91.76	84.2
O. Decapoda													
Shrimp **	3.7	0.021	12.16	6.9	0.052	26.38	6.6	0.071	33.04	2.7	0.049	14.44	6.5
Other crustacea	0.5	0.006	1.46	0.7	0.018	4.55	1.3	0.013	7.83	0.5	0.007	2.28	
Crustacea Total	63.5		82.17	73.2		108.99	65.1		112.17	89.1		114.94	94.7
Class Pisces													
Sebastes spp	17.5	0.464	19.10	17.5	0.545	19.57	20.6	0.380	30.72	3.3	0.105	7.10	5.6
Gadus morhua	0.2	0.002	0.27	1.8	0.056	2.96	4.0	0.087	6.08	2.4	0.103	3.04	
Anarhichias sp.	0.7	0.018	1.55	0.2	0.005	0.79	1.9	0.005	1.16	0.2	0.008	0.63	
Fam. Myctophidae	0.1	*	0.64	*	0.003	0.79	1.0	*	0.29	*	0.002	1.38	
Fam. Cottidae	*	*	0.09	0.1	0.006	0.20	-	-	-	1.3	0.034	2.28	
Fam. Macrouridae	*	0.003	0.18	*	*	0.20	-	-	-	-	-	-	
Other pisces	0.6	0.015	1.00	0.4	0.005	0.99	1.4	0.013	1.74	0.9	0.018	1.65	4.4
Unidentified	9.6	0.111	6.21	3.0	0.034	7.91	3.5	0.045	10.43	1.3	0.025	5.70	
Pisces Total	28.7		29.04	23.0		33.41	32.4		50.42	9.4		21.78	22.7
Unidentified	5.9	0.019		1.0	0.004		0.6	0.002		0.2	0.002		
N° stomachs	1094	1094	1094	506	506	506	345	345	345	789	789	789	911
% empty stomachs	7.44	7.44	7.44	4.5	4.5	4.5	9.2	9.2	9.2	0.4	0.4		38

* Traces.
** Mainly *Pandalus borealis*.
*** R. Marín, com. pers.

Table 4.- Non Parametric Comparison by Kruskal-Wallis test for Cod prey (Hiperiids and Redfish) in the years 1989-1992.

	Hiperiids	**Redfish**
K-Wallis Test Statistic (1989-92)	171.91	106.77
Level of significance	< 0.0001*	< 0.0001*
Degrees of freedom	3	3
Comparisons by year pairs	**ZSTAT**	**ZSTAT**
1989-1990	0.49	0.41
1989-1991	3.06*	4.06*
1989-1992	10.65*	7.49*
1990-1991	2.35	3.29*
1990-1992	9.26*	6.57*
1991-1992	10.63*	9.30*

*The null hipothesis (predation on redfish and hiperiids are not dissimilar) is rejected.

Table 5: The Diversity Index by cod length class (cm) in Div. 3M 1989-1992.

Year	<20	21-30	31-40	41-50	51-60	61-70	71-80	MEAN±S.D.
1989	0	0.50	0.33	0.43	0.68	0.59	0.75	0.55±0.16
1990	0.59	0.60	0.58	0.53	0.61	0.77	0.58	0.61±0.08
1991	0.46	0.56	0.54	0.75	0.74	0.78	0.85	0.7±0.13
1992	0.35	0.35	0.48	0.57	0.62	0.62	0.72	0.56±0.13

Table 6: The Condition Factor (C.F.) of cod by age in Div. 3M in July 1988-1992.

Age	1988		1989		1990		1991		1992	
	C.F.	N°	C.F.	N°	C.F.	N°	C.F.	N°	C.F.	N°
0					0.794	14				
1	0.97	3	0.989	7	0.812	30	0.848	52	0.916	147
2	0.95	66	1.153	7	0.979	85	0.875	38	0.915	269
3	0.92	164	0.921	242	0.918	44	0.921	70	0.901	91
4	0.93	144	0.918	467	0.960	106	0.945	16	0.909	88
5	0.94	53	0.910	387	0.936	103	0.927	111	0.914	22
6	1.02	13	0.911	55	0.936	86	0.898	67	0.897	113
7	0.97	22	0.906	9	0.937	28	0.902	18	0.831	23
8+	0.94	3	0.916	8	0.937	34	0.960	8	1.017	2

Table 7: The Overlap Index of Schoener in Div. 3M, in summer 1989-1992 for three groups of cod: Group A (<24 cm), Group B (24-65), Group C (>65) (*).

	1989	1990	1991	1992
(A-B)	0.727	0.857	0.663	0.731
(B-C)	0.424	0.370	0.713	0.631
(A-C)	0.290	0.263	0.383	0.453

(*) Mean length at age 2: 24 cm; at age 6: 65 cm.

Table 8: Cannibalism rate (%) of Flemish Cap cod: 1988-93.

Cannibalism						
1988*	1989	1990	1991	1992** (winter)	1992 (summer)	1993***
3.8%	0.2%	1.9%	3.4%	0.4%	2.2%	0

* Paz et al., 1988.
** Cárdenas et al., 1992.
*** R. Marín, com. pers.

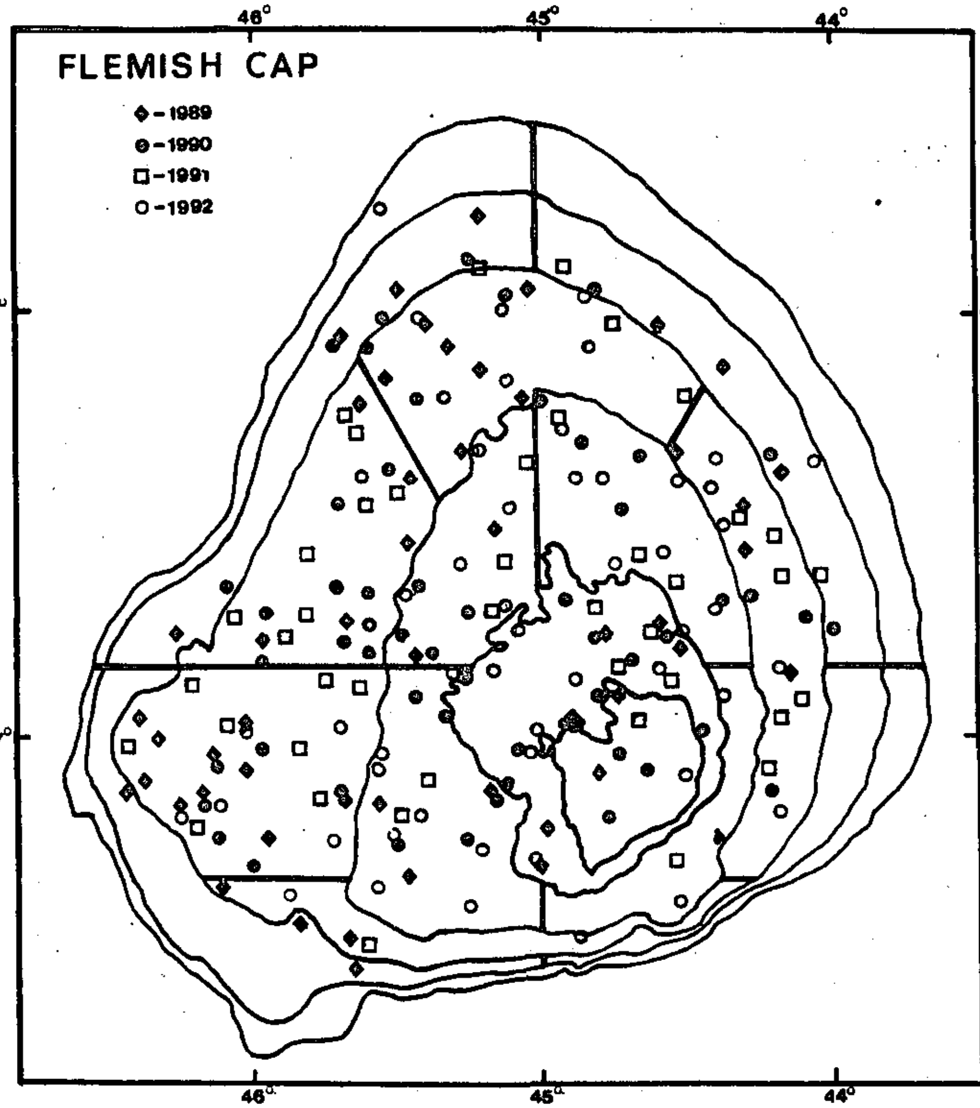

Figure 1.- Flemish Cap Bank showing the locations where cod stomach samples were collected from 1989 to 1992.

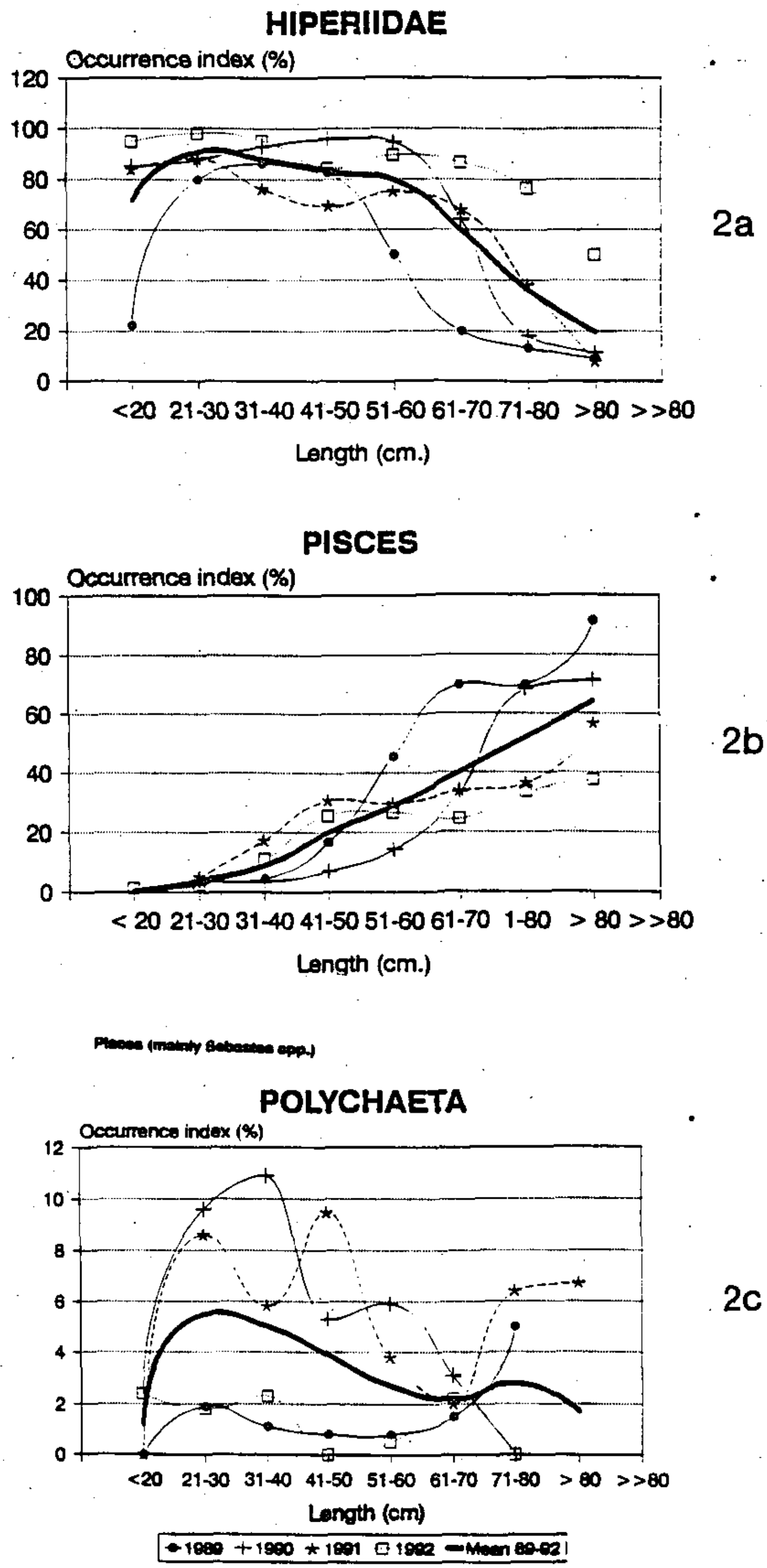

Figure 2.- Hiperiidae (a), Pisces (b) and Polichaeta (c) Occurrence Index by cod length groups in the period 1989-1993.

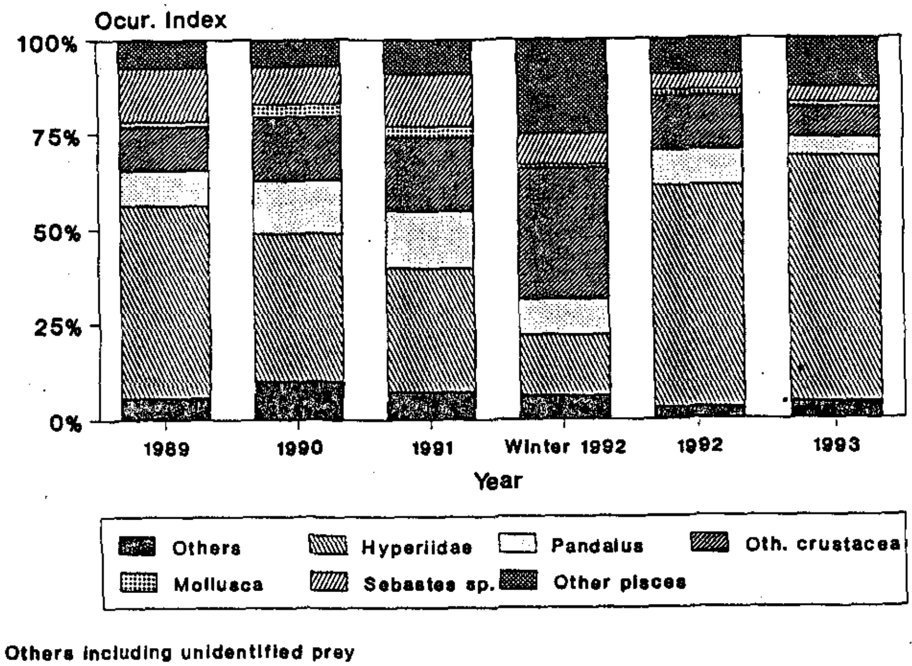

Figure 3.-Main prey groups Occurrence Index. Summer 1989-1993 and winter 1992.

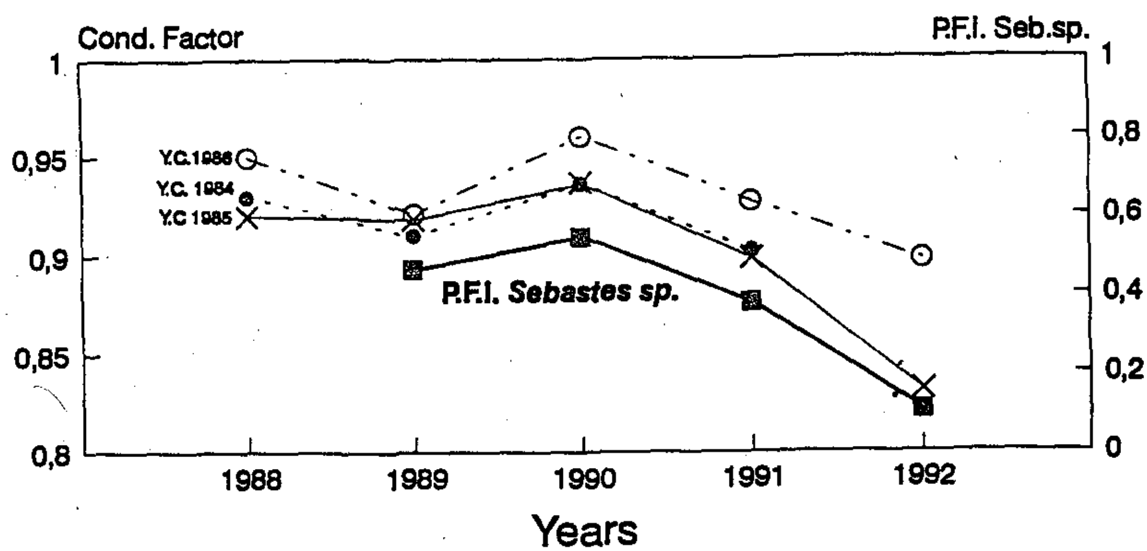

Figure 4.- Condition Factor for 1984, 1985 and 1986 cod year class and Partial Fullness Index (P.F.I.) for redfish (*Sebastes sp.*) in cod stomach in the years 1988-1992.

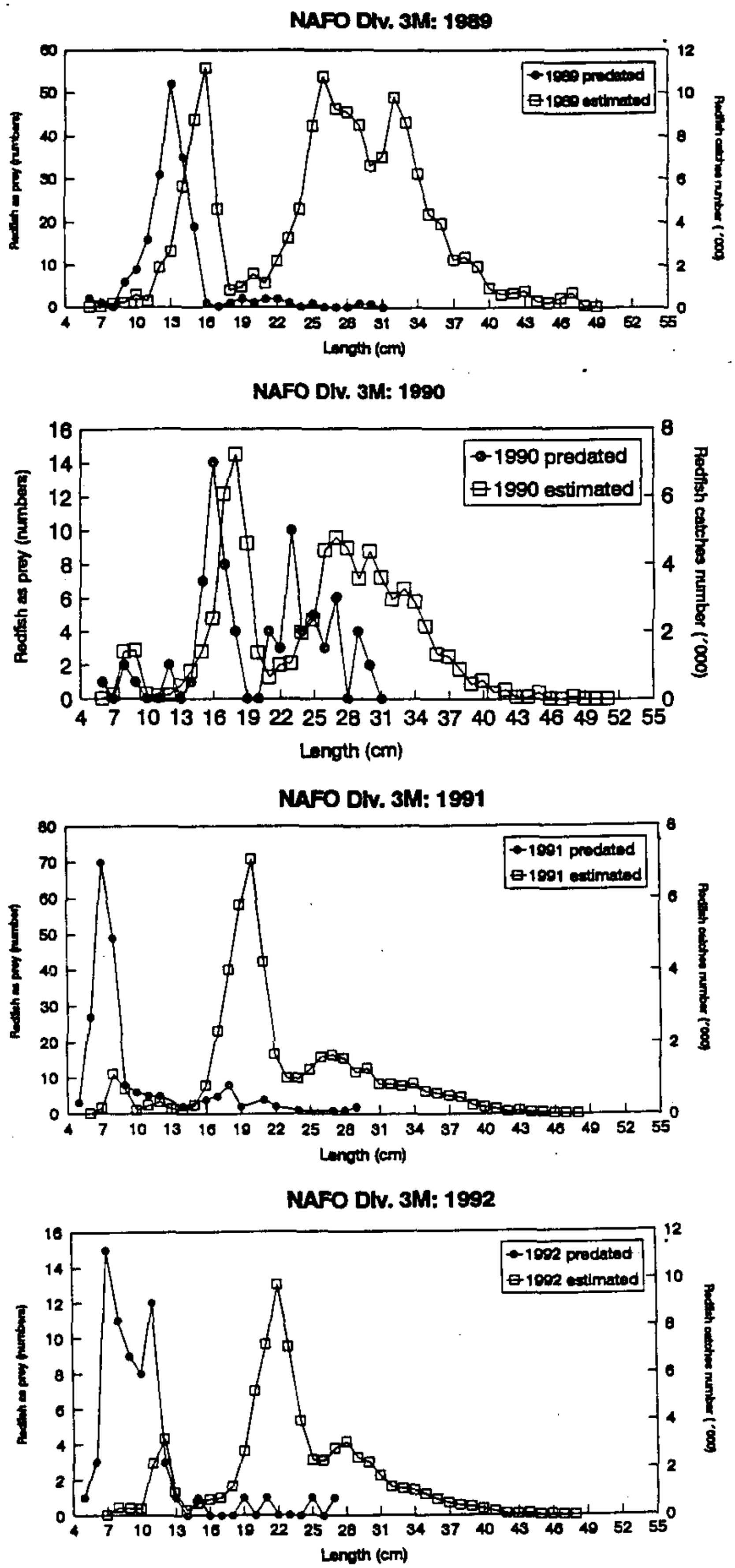

Figure 5.- Comparison of small-juvenile redfish abundance with redfish recovery in the stomach contents of cod for 1989-1992.