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Food and Feeding of Most Abundant Fish Species in Flemish Cap.

by

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Abstract

Food and feeding of the 15 fish species taken by bottom trawl from Flemish Cap Bank in summer during the period 2001-2003 were analysed. The stomach contents of 17 773 fish were collected in depths from 83 to 730 m. In general, the feeding intensity was high in all the species with a maximum value for *Gadus morhua* (96.3%) and minimum for *Lycodes reticulatus* (35.0%).

The prey spectrum was width, with a total of 134 items for all the stomachs analysed. In frequency of occurrence, the crustaceans were the most important preys (FO = 80.4%), while in volume (V = 39.4%) they were less significant than fishes (V = 43.5%). The main prey group in frequency of occurrence were Hyperiidea, Copepoda, *Pandalus borealis* and Chaetognata.

The niche width index was also calculated for these species.

Introduction

In 1988, a series of research cruises was initiated in Flemish Cap by the UE with the aim of studying the fishing resources and to reflect changes in the fish populations in this area. A study of stomach contents of the main fish species has been developed since the first survey (Paz *et al*., 1989; Vázquez *et al*., 1989).

Numerous and diverse monospecific feeding studies has been carried out in Flemish Cap (Lilly, 1985; Paz *et al*., 1993; Casas and Paz, 1994; 1996) and for some species together (Vázquez *et al*., 1989; Albikovskaya and Gerasimova, 1993). In the survey of summer 1993, the number of species sampled was amplified with the aim of obtaining a wider vision of the trophic flow in Flemish Cap, and a study of the feeding habits of the 15 main fish species was initiated (Rodríguez-Marín *et al*., 1994; Rodríguez-Marín, 1995; Rodríguez-Marín and Gil, 1997; Torres *et al*., 2000). The objective of this paper was to continue with the study of the feeding habits of these 15 fish species during the period 2001-2003, describing the differences in the feeding habits with size. These fifteen species were: *Reinhartius hippoglossoides*, *Gadus morhua*, *Hippoglossoides platessoides*, *Macrourus berglax*, *Sebastes* juvenile, *S. mentella* , *S. marinus*, *S. fasciatus*, *Glyptocephalus cynoglossus*, *Amblyraja radiata*, *Anarhichas denticulatus*, *A. minor*, *A. lupus*, *Nezumia bairdii*, *Phycis chesteri* and *Lycodes reticulatus*.

Material and Methods

The stomachs of fifteen fish species were obtained from depths between 83 and 730 m, and analysed on board, during three random stratified bottom-trawl surveys in Flemish Cap (NAFO, Div. 3M) in summer from 2001 to 2003 (Casas, 2004). These species were selected because they presented the greatest biomass abundance and/or

number according to the data estimated from previous surveys (Vázquez, 1993). The used methodology was the same used in 1993 (Rodríguez-Marín *et al*., 1994).

In each haul, a maximum of ten stomachs from each 10 cm length range were analysed for the commercial species, while for the remaining species, only ten randomly selected specimens were analysed per haul. Fish whose stomach were everted or contained preys ingested in the fishing gear were discarded. Specimens that presented total or partial regurgitation were taken into account to estimate the emptyness indice.

For each predator, the data collected were: total length to the nearest lower cm, except for the Macrouridae that it was to the beginning of the anal fin length to the nearest half cm; volume of the stomach content, quantified in c.c. using a trophometer (Olaso, 1990); the percentage of each prey in the total volume, and digestion stage number of each prey. Preys were identified by species when digestion stage permitted it, or to the lowest possible taxonomic level.

The Feeding Intensity Index (FI) is the percentage of individuals with stomach content and is calculated in order to analyse the feeding intensity for each predator: $FI = N_s / N_t * 100$, where N_s is the number of individuals with stomach content and N_t is the total number of individuals sampled.

The importance of each prey taxa in the stomach contents was evaluated using:

* Percentage by number*:* $N = n_p / N_p * 100$, where n_p is the number of a specific prey and N_p is the total number of preys. The numerical method is relatively fast and simple if the identification of the prey items is known. In some situations, it could be the most appropriate method, for example, where the prey items of different species are in the same range (Hyslop, 1980).

* Percentage by volume: $V= v_p / V_t * 100$, where v_p is volume of a determined prey, and V_t is the total volume of preys. The volumetric method overvalues the importance of large organisms (Hyslop, 1980).

* Frequency of occurrence (percentage): $FO = n_s / N_s * 100$, where n_s is the number of stomachs with a specific prey and N_s is the number of individuals with stomach content. This method does not give quantitative information, but is quick and requires the minimum of apparatus (Hyslop, 1980).

To calculate diet breadths, the niche width index (B) was used, as described by Levins (1968): $B = [\Sigma p_i^2]^{-1}$, where p_i is the proportion of the i_{th} item in the diet. Low values indicate specialist and high values generalist.

Results and Discussion

From the fifteen demersal fish selected, 17 773 stomachs were analysed from 2001 to 2003. Characteristics of the stomach samplings are shown in detail in the Table 1. In general, the feeding intensity was high in all the species (Fig. 1), with a maximum value for *Gadus morhua* (96.3%) and minimum for *Lycodes reticulatus* (35.0%). These high values of the feeding activity are characteristic of summer (Vázquez *et al*., 1989; Albikovskaya and Gerasimova, 1993; Rodríguez-Marín *et al*., 1994; Rodríguez-Marín, 1995; Rodríguez-Marín and Gil, 1997; Torres *et al*., 2000). The feeding intensity in all the species was significantly different among years, except for *Macrourus berglax* ($\chi 2 = 1.81$, d.f. 2, $p>0.05$) , *Phycis chesteri* ($\chi 2 = 1.26$, d.f. 2, $p>0.05$) and *Amblyraja radiata* ($\chi 2 = 2.18$, d.f. 2, $p>0.05$) (Fig. 1).

In the Table 2, it is listed the frequency of occurrence of the total preys found in the 15 fish species sampled. The prey spectrum was wide, with a total of 134 items for all stomachs analysed, however, the most items showed a minimum FO. *Reinhardtius hippoglossoides* was the predator that presented the wider preys spectrum in all the years (81 items), although *Amblyraja radiata*, *Macrourus berglax* and *Gadus morhua* also presented great variety of preys (Table 1). Preys such as hyperiids (FO = 32.4%), copepods (FO = 23.5%), *Pandalus borealis* (FO = 20.7%) and chaetognaths (FO = 11.1%) were very important in the diet in Flemish Cap during this period (Torres *et al*., 2000). *Sebastes* spp. was the most important prey in the Pisces group.

The number of individuals in each food category was recorded for all the stomachs and expressed as percentage in the Table 3. Crustacea (hyperiids and copepods) was the most important taxonomic group in number. All the preys

presented similar *N*(%) throughout the three years sampled, except hyperiids and copepods. The differences in the importance of these two preys, copepods and hyperiids, were due to the predation of the *Gadus morhua* on hyperiids and the predation of *Sebastes* spp. on copepods. Both preys were replaced with *Pandalus borealis* in the case of *Sebastes* spp. and *Pandalus borealis* and redfish in the case of the cod. These changes in the numerical percentage could be due to the increase of the *Pandalus borealis* biomass in Flemish Cap observed in the last years (del Rio *et al.*, 2003) and also to the period of sampling that was earlier in the year 2003.

Table 4 shows a summary of the main preys by volume (%) found for each predator and for each prey as a whole, in this way, Pisces (V = 43.52%) and Crustaceans (V = 39.37%) were the main food resource for the 15 fish species in all these years (Fig. 2). Preys such as *Pandalus borealis* (V = 22.5%), hyperiids (V = 6.7%) and *Sebastes* spp. (V = 18.2%) were the most important preys in volume in the group of crustaceans and fish respectively. The presence of *Pandalus borealis* and hyperiids in all the feeding groups confirmed that these preys undertake extensive vertical migrations throughout the water column. *Sebastes* spp. was also other prey with great capacity for vertical displacement. These three prey items represent a connecting link between the pelagic and benthic ecosystems (Rodríguez-Marín, 1995). Cannibalism was observed only in *Reinhardtius hippoglossoides*, *Sebastes fasciatus*, *S. marinus* and the three species of the Anarhichas. Levins index (*B*) was also calculated and three categories of fish were established with respect to their feeding (Table 4):

a.- Specialist species, that have a high overlap percentage between the different length groups. There are no differences in feeding habits with size and a very small number of main prey taxa. They present one prey taxa with a percentage by volume between 50-70%, that is, they have low values of Levins index (*B*): from 1.55 to 2.53. These species are *Glyptocephalus cynoglossus*, *Anarhichas denticulatus*, *Phycis chesteri* and *Sebastes* juvenile (Table 4 and Fig. 3).

Witch flounder (*Glyptocephalus cynoglossus*).- From the analysis of 370 stomachs, 93.5% contained food. The main food items in the witch flounder diet are the polychaetes and crustaceans (gammarideam), it is a typical benthic predator. Molluscs, Pisces and echinoderms were consumed in smaller quantities (V <1.5%). Overall, polychaetes (V = 79%) were by far the most important food item, followed by gammarideam (V = 13.5%).

Results of our data for the period 2001-03 coincide with other studies (Rodríguez-Marín *et al.*, 1994; Rodríguez-Marín, 1995; Cargnelli *et al*., 1999, Bowman *et al*, 2000; Link *et al*., 2002), but some of these studies indicate ontogenetic and geographic area shifts in the feeding habits (Cargnelli *et al*., 1999).

Northern wolffish (*Anarhichas denticulatus*).- From the analysis of 193 stomachs, 54.4% contained food. It is the most pelagic feeder of the three wolffish species and its basic diet was made up of a great consumption of ctenophores (V = 73.2%), thus indicating a lesser connection of this species with the bottom. Northern wolffish fed more intensely in the summer than the others wolffishes (Fig. 1). The Figure 3 shows the prey groups by size found in the diet. Fish acquired a higher importance in the diet of individuals >70 cm. Cannibalism was observed, but not in all the years.

These results agree with other studies (Rodríguez-Marín *et al.*, 1994; Rodríguez-Marín, 1995; Torres *et al*., 2000), but some of these studies indicate ontogenetic and geographic area shifts in the feeding habits. Albikovskaya (1983) found that Atlantic and spotted wolffishes fed more intensely than the northern wolffish in the spring-summer period.

Longfin hake (*Phycis chesteri*).- From the analysis of 347 stomachs, 88.5% contained food. Its diet was based almost exclusively on *Pandalus borealis* (V = 70.1%), although the individuals <20 cm fed primarily on mysids (Fig. 3). The longfin hake feeding habits follows the pattern of a benthopelagic predator (Rodríguez-Marín, 1995; Torres *et al.*, 2000). Rodríguez-Marín (1995) classified longfin hake like a low diversity feeder, that can indicate a change in the feeding during the last years and an increase of predation on *Pandalus borealis*.

Redfish juvenile (*Sebastes* spp.).- From the analysis of 1 720 stomachs, 64.2% contained food. Its diet was essentially based on small crustaceans, copepods (V = 60.9%) and a small proportion of hyperiids (V =

10.9%) were the main prey taxa (Fig. 3). These results agree with other previous studies carried out in Flemish Cap (Rodríguez-Marín *et al.*, 1994; Torres *et al*., 2000).

b.- Low diversity feeders, species with few dietary categories, with changes throughout their lives. There is a dominant taxa in their diet with a percentage by volume between 30 and 50%. They present intermediate values of Levins index (3.75-5.69). Low diversity feeders are *Anarhichas minor*, *Lycodes reticulatus*, *Amblyraja radiata*, *Nezumia bairdii* and *Sebastes fasciatus* (Table 4 and Fig. 4).

Spotted wolffish (*Anarhichas minor*).- The analysis of the 347 individuals showed 49% fish with full stomach. The main food items in the spotted wolffish diet were *Sebastes* spp. (V = 48.8%), ctenophores (V = 10.7%) and *Pandalus borealis* (V = 8.4%). It was the most ichthyophagous of the three wolffish species (V = 63.2%) and presented changes in the diet with the age, individuals <40 cm fed primarily on crustaceans and >40 cm fed almost exclusively on *Sebastes* spp. and ctenophores (Fig. 4). Cannibalism was only observed in fish 60-70 cm but not in all the years.

Some differences are observed with previous studies in Flemish Cap, in which this species showed to be a high diversity feeder (Rodríguez-Marín, 1995; Torres *et al.*, 2000). Our results for this period indicated that fish and crustaceans consumption increased throughout these years and the consumption of the others invertebrates fell.

Arctic eelpout (*Lycodes reticulatus*).- From 871 stomachs analysed, 35% contained food. It presented the lowest value of feeding intensity of the 15 sampled species. *Pandalus borealis* (V = 39.1%), polychaetes (V = 25.8%) and euphausiids (V = 15.6%) constituted the main food of arctic eelpout (Fig. 4).

This specie also showed changes in its feeding habits with regard to previous studies in this area, in which it seemed to be a specialist feeder consuming mainly ophiurans (Rodríguez-Marín, 1995; Torres *et al.*, 2000).

Thorny skate (*Amblyraja radiata*).- The analysis of 582 stomachs in this period showed high feeding intensity (90.7%). It presented a great variety of food organisms and at the same time each stomach contained a great variety of different preys, although only some of them were the main components. *Pandalus borealis* was the main prey (V = 38.2%) followed by *Sebastes* spp. (V = 12.5%). The diet changed with the size range, *Pandalus borealis* decreased and fish increased in individuals >50 cm, while cephalopods were the most important prey in the individuals >60 cm. It was the most predator of cephalopods (V = 9.5%) of the all studied species (Fig. 4).

Thorny skate is an opportunistic feeder on the most abundant prey species in each area and each season, this would explain some differences of our results (high consumption of *Pandalus borealis*) with other studies (Templeman, 1982; Vinnichenko *et al.*, 2002; Packer *et al.*, 2003). Rodríguez-Marín (1995) also found that this species was a high diversity feeder in Flemish Cap.

Marlin-spike grenadier (*Nezumia bairdii*).- From the analysis of 699 stomachs, 87.3% contained food. Its basic diet was primarily made up of crustaceans (V = 81.2%) and polychaetes (V = 9.5%). *Nezumia bairdii* fed as much on pelagic as on benthic preys: small crustaceans, such as hyperiids (V = 34.8%) and mysids (V = 16.7%), and polychaetes respectively. Fish contributed little to diet (V = 2.7%). The main prey groups are shown in the Fig. 4. These results showed increase of FI, and also in the consumption of hyperiids in relation to other studies (Rodríguez-Marín, 1994).

Acadian redfish (*Sebastes fasciatus*).- The proportion of stomachs with content was high (63%) from the 2 281 sampled individuals. Its diet was almost exclusively of crustaceans. Copepods (V = 31.9%), euphausiids (V = 17%), *Pandalus borealis* (V = 16%) and hyperiids (V = 10.6%) constituted its main food resource. *Sebastes fasciatus* is the most consumers of copepods of the three species of redfish, observing a slight shift in the consumption from copepods towards *Pandalus borealis,* hyperiids and fishes, with the increment of the size (Fig. 4). The proportion of fish in the diet was positively correlated with body size in the three species of *Sebastes (*Pikanowski *et al*., 1999). The copepods biomass increases in summer in Flemish Cap and it contitutes the main food (Albikovskaya and Gerasimova, 1993). Furthermore, the prey

size is proportional to fish size, and a positive correlation exists between the number of feeding redfish (*S. fasciatus* and *S.mentella*) and the size of the catch, implying that redfish concentrate where its prey concentrate (Pikanowski *et al.*, 1999).

c.- High diversity feeders. Species with a high diversified diet and feeding differ between size-classes. They present high values of Levins index (6.53-10.12) and the percentage by volume of their preys does not reach 30%. These species are *Reinhardtius hippoglossoides*, *Hippoglossoides platessoides*, *Anarhichas lupus*, *Gadus morhua*, *Sebastes marinus*, *Macrourus berglax* and *S. mentella* (Table 4 and Fig. 5).

Greenland halibut (*Reinhardtius hippoglossoides*).- From the analysis of 3 252 stomachs, 60.9% contained food. *Pandalus borealis* (V = 25.6%), *Sebastes* spp. (V = 23.7%), *Lampadena speculigera* (V = 11.6%) and *Serrivomer beani* (V = 7.2 %) were the main preys in the diet of this species. Cephalopods were consumed in small quantities (4.7%), also described by Rodríguez-Marín *et al.* (1997). Changes in the diet with size of Greenland halibut were observed in Flemish Cap, crustaceans (hyperiids and *Pandalus borealis*) were dominant in the diet of the fish smaller than 40 cm and fish were dominant in the individuals bigger than 40 cm (Fig. 5). Cannibalism was only observed in fish 30-40 cm but not in all the years. Greenland halibut presented the higher variety of food organisms in its diet in Flemish Cap (81 preys) and the geographic area influenced the prey spectrum.

Our observations have shown changes in the Greenland halibut predation in relation to previous years (Rodríguez-Marín, 1994; Rodríguez-Marín *et al.,* 1995; Torres *et al.,* 2000).

American plaice (*Hippoglossoides platessoides*).- The analysis of 670 stomachs during 2001-2003 showed 68.5 % of stomachs with food. It fed mainly on hyperiids (V = 22.1%), ctenophores (V = 21.4%), *Pandalus borealis* (V = 18.4%) and brittle stars (V = 13.5%). Changes in the diet with size were observed in Flemish Cap, *Lumpenus lampretaeformis* (V = 81.8%) was very important in the diet of the fish smaller than 20 cm and crustaceans were dominant in the individuals bigger than 20 cm. Brittle stars were important in the intermediate sizes and the ctenophores in the individuals >50 cm (Fig. 5). Changes in the American plaice diet were also observed with regard to previous years, diminishing the consumption of some preys (ophiurans) and increasing the consumption of others (crustaceans and ctenophores). Moreover, these authors described this species like a specialist feeder and in our study American plaice appeared like a high diversity feeder (Rodríguez-Marín *et al.*, 1994; Rodríguez-Marín, 1995; Torres *et al*., 2000). Size, season and geographic area are significant factors to determine the diet (Zamarro, 1992; Johnson *et al*., 1999; González *et al.*, 2001).

Atlantic wolffish (*Anarhichas lupus*).- From the analysis of 1 213 stomachs, 36.2% contained food (the lowest value together with *Lycodes reticulatus)*. The main preys were *Pandalus borealis* (V = 30.8%) and redfish (V0 11.8%). The diet changes with the size range, individuals < 10 cm ate brittle stars (V = 37.5%) and hyperiids (V = 20.6%); specimens >20 cm fed mainly on *Pandalus borealis*, while fish of the size range 10-19 cm fed on polychaetes (V = 18.1%), *Pandalus borealis* (V = 17.1%) and bivalves (V = 16%). Pisces and ctenophores ingestion increased in the largest individuals. Cannibalism was observed on individuals > 20 cm in all the years (Fig. 5). The Atlantic wolffish is a benthic and visual feeder. The diet is typically varied and appears to be influenced by availability of prey at different locations (Methven, 1999).

Atlantic cod (*Gadus morhua*).- From the analysis of 779 stomachs, 96.3% contained food. This species presented the highest fullness value. It presented a great variety of food organisms and at the same time each stomach contained a great variety of different preys (sixty prey taxa), although only some of them were the main components: *Pandalus borealis* (V = 24.9%), *Sebastes* spp. (V = 16.1%) and hyperiids (V = 16%). With respect to the percentage by volume by length, crustaceans and fish had inverse trends with the increase of the length. Specimens smaller than 19 cm fed almost exclusively on crustaceans (hyperiids and copepods) and fish increased in the individuals > 40 cm (Fig. 5). These results are in agreement with other previous studies in Flemish Cap (Albikowskaya *et al.*, 1993; Paz *et al*., 1993). This species is a high diversity feeder while in the Torres *et al*. (2000) studies it turned out to be a low diversity feeder.

Golden redfish (*Sebastes marinus*).- The analysis of the 1 293 individuals showed 69.8% fish with full stomach. It was the most ichthyophagous of the three redfish species (V = 27.9%). Its diet was based

mainly on *Pandalus borealis* (V = 22.4%), Gonostomathidae (V =16.1%), hyperiids (V = 13.5%), copepods (V = 11.1%) and chaetognaths (V = 7.1%). The consumption of fish increased with the age. Cannibalism was observed in all the sizes but not in all the years (Fig. 6). The importance of *Pandalus borealis* increased with regard to previous years (Rodríguez-Marín *et al.*, 1994; Torres *et al.*, 2000).

Roughhead grenadier (*Macrourus berglax*).- From the analysis of 1 026 stomachs, 77.7% contained food. It is the third predator that presented a high spectrum of preys: *Pandalus borealis* (V = 24.0%), Scyphozoa (V = 16.5%) and *Lampadena speculigera* (V = 8.6%) were some of the most important preys in its diet. There are some differences in food with the increasing of the size, crustaceans and fish had opposite trends with regard to the length of roughhead grenadier. Scyphozoa increased in the individuals >10 cm (Fig. 6). Prominent changes in the diet the last years have not been observed.

Deepwater redfish (*Sebastes mentella*).- From the analysis of 2 130 stomachs, 68.2% contained food. Euphasiids (V = 16.3%), hyperiids (V = 15 %), Copepods (V = 13.5%) and Pisces (V = 14.7%) were the main preys in its diet (Fig. 6). It presented a wider prey spectrum than the other two redfish species (40 items), being the only one that preyed upon cephalopods (Torres *et al.*, 2000; Rodriguez Marin *et al.*, 1994).

Redfish is acknowledged to be a typical plankton-eater (Konstantinov *et al.*, 1985; Albikovskaya and Gerasimova, 1993). Copepods, amphipods and eufausiids constitute the main food in summer, *Pandalus borealis* is also important. They feed most actively at night when they rise off the bottom following the vertical migration of their primary euphausiid prey (Pikanowski *et al.*, 1999).

Conclusions

With respect to previous studies during this period, important changes were not observed on the diet of the most of the studied species in this area. Preys such as hyperiids, *P. borealis*, and *Sebastes* spp. still have great importance in the diet of fish in Flemish Cap.

However, some differences have been found in this study with regard to the previous ones. *Phycis chesteri*, *Lycodes reticulatus*, and *Reinhardtius hippoglossoides* had fed more on *Pandalus borealis* than in the past, emphasizing its importance on the diet of these species. American plaice and *Anarhichas minor* have changed ophiurans for *P. borealis* and Pisces respectively. *Sebastes marinus* increased the consumption of *P. borealis* and fishes.

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References

ALBIKOVSKAYA, L. K., and O.V. GERASIMOVA. 1993. Food and feeding patterns of cod (*Gadus morhua* L.) and beaked redfish (*Sebastes mentella* Travin) on Flemish Cap. *NAFO Sci. Coun. Studies*, **19**: 31-39.

BOWMAN, R. E., C.E. STILLWELL, W. L. MICHAELS, and M. D. GROSSLEIN. 2000. Food of Northwest Atlantic fishes and two common species of squid. *NOAA Tech. Memo.* NMFS-NE-155.

CARGNELLI, L. M., S. J. GRIESBACH, D. B. PACKER, P. L. BERRIEM, W. W. MORSE, and D. L. JONHSON. 1999. Essential fish habitat source document: Witch flounder, *Glyptocephalus cynoglossus*, life history and habitat characteristics. *NOAA Tech. Memo.* NMFS-NE-139.

CASAS, J. M., and J. PAZ. 1994. Diet of Flemish Cap cod with particular reference to predation on redfish: 1988-93. *NAFO SCR Doc.*, No. 24, Serial No. N2390, 21 p.

CASAS, J. M., and J. PAZ. 1996. Recent changes in the feeding of cod (*Gadus morhua*) off the Flemish Cap, Newfoundland: 1988-93. *ICES J. Mar. Sci.*, **53**: 750-756

CASAS, J. M. 2004. Results from bottom trawl survey of Flemish Cap of July 2003. *NAFO SCR Doc*., No. 21, Serial No. N4969, 36 p.

DEL RÍO, J. L., J. M. Casas, and D González Troncoso. 2003. Northern shrimp (*Pandalus borealis*) on Flemish Cap in June 2003. *NAFO SCR Doc*., No. 80, Serial No. N4921, 18 p.

GONZÁLEZ, C., E. ROMÁN, and X. PAZ. 2003. Food and feeding of American plaice (*Hippoglossoides platessoides*) in the North Atlantic. *NAFO SCR Doc*., No. 23, Serial No. N4832, 21 p.

HYSLOP, E. J.. 1980. Stomach contents analysis a review of methods and their application. *J. Fish. Biol.,* **17**: 411-429

JONHSON, D. L., P. L. BERRIEN, W. W. MORSE, and J. J. VITALIANO. 1999. Essential fish habitat source document: American plaice, Hippoglossoides platessoides, life history and habitat characteristics. *NOAA Tech. Memo.* NMFS-NE-123.

KONSTANTINOV, K. G., T. N. TURUCK, and N.A. PLEKHANOVA. 1985. Food links of some fishes and invertebrates on Flemish Cap. *NAFO Sci. Coun. Studies*, **8**: 39-48.

LEVINS, R. 1968. Evolution in Changes Environments. University Press. Princeton.

LILLY, G. R. 1985. Cod (*Gadus morhua*) on the Flemish Cap feed primarily on redfish (*Sebastes* sp.) in winter 1984. *NAFO SCR Doc.,* No. 72, Serial No. N1027, 7 p.

LINK, J. S., K. BOLLES, and C. G. MILLIKEN. 2002. The feeding ecology of flatfish in the Northwest Atlantic. *J. Northw. Atl. Fish. Sci*., **30**: 1-7.

METHVEN, D. A. 1999. Annotated bibliography of demersal fish feeding with emphasis on selected studies from the Scotian Shelf and Grand Banks of the Northwest Atlantic. *Can Tech. Rep. Fish Aquat. Sci.*, No. 2267. iv, 106 p.

OLASO, I. 1990. Distribución y abundancia del megabentos invertebrado en fondos de la plataforma cantábrica. *Bol. Inst. Esp. Oceanogr. Publ. Esp.*, No. **5**. 128 p.

PACKER, D.B., C. A. ZETLIN, and J. J. VITALIANO. 2003. Essential fish habitat source document: Thorny skate, *Amblyraja radiata*, life history and habitat characteristics. *NOAA Tech. Memo.* NMFS-NE-178.

PAZ, J., F. J. VÁZQUEZ, A. FERNÁNDEZ–ARROYO, and J. M. CASAS. 1989. The feeding of American plaice (*Hippoglossoides platessoides*), Redfish (*Sebastes marinus*) and Cod (*Gadus morhua*) in the Flemish Cap during July 1988. *NAFO SCR Doc*., No. 45, Serial No. N1622, 15 p.

PAZ, J., J. M. CASAS, AND G. PÉREZ-GANDARAS. 1993. The feeding of Cod (*Gadus morhua*) on Flemish Cap 1989-90. N*AFO Scientific Coun. Studies,* **19**: 41-50.

PIKANOWSKI, R. A., W. W. MORSE, P. L. BERRIEN, D. L. JOHNSON, and D. G. MACMILLAN. 1999. Essential fish habitat source document: Redfish, *Sebastes* spp., life history and habitat characteristics. *NOAA Tech. Memo.* NMFS-NE-132.

RODRÍGUEZ-MARÍN, E., A. PUNZÓN, J. PAZ, and I. OLASO. 1994. Feeding of the most abundant fish species in Flemish Cap in summer 1993. *NAFO SCR Doc*., No. 35, Serial No. N2403. 33 p.

RODRÍGUEZ-MARÍN, E. 1995. Feeding relationships of demersal fish in Flemish Cap in summer, 1993-1994. *NAFO SCR Doc*., No. 104, Serial No. N2627, 15 p.

RODRÍGUEZ-MARÍN, E., E. DE CÁRDENAS, and J. PAZ. 1997. Feeding of Greenland halibut (*Reinhardtius hippoglossoides*) in 3LMNO NAFO Regulatory Area Divisions (Northwest Atlantic), 1991-94. *NAFO SCR Doc*., No. 37, Serial No. N2869.

RODRÍGUEZ-MARÍN, E., and J. GIL. 1997. Informe preliminar de contenidos estomacales realizado durante la campaña Flemish Cap-96. Informe Final Flemish Cap 1996.

TEMPLEMAN, W. 1982. Stomach contents of the thorny skate, *Raja radiata*, from the Northwest Atlantic. *J. Northw. Atl. Fish. Sci.,* **3**: 123-12.

TORRES, P., E. RODRÍGUEZ-MARÍN, and I. LOUREIRO. 2000. Preliminary results feeding analysis for the most abundant demersal fishes in Flemish Cap during summer (1993-2000). *NAFO SCR Doc*., No. 60, Serial No. N4302, 9 p.

VÁZQUEZ, F.J., F. J. PAZ, J. M. CASAS, E. DE CÁRDENAS, E. ÁLVAREZ, and A. FERNÁNDEZ-ARROYO. 1989. La alimentación de la platija americana, fletán negro, gallineta nórdica y el bacalao en Flemish Cap en julio de 1988. *Bol. Inst. Esp. Oceanogr*., **5**(2): 43 - 56

VAZQUEZ, A. 1993. Results from bottom trawl survey of Flemish Cap in July 1992. *NAFO SCR Doc.,* No. 19, Serial No. N2196, 22 p.

VINNICHENKO, V. I., V. N. MASHKOR, and V. N. KHLIVNOY. 2002. Brief results of Russian investigations and fishery for thorny skate (*Raja radiata*) in NAFO Regulatory Area in 2000-2001. *NAFO SCR Doc*., No. 11, Serial No. N4612.

ZAMARRO, F. J. 1992. Comportamiento alimenticio y reproducción de la platija americana (*Hippoglossoides platessoides*, Fabricius 1780) (Pisces, Pleuronectidae) en el sur del Gran Banco de Terranova. Tesis doctoral. Universidad de Santiago de Compostela. Facultad de Ciencias Biológicas. departamento de Biología Fundamental.

Table 1.- Characteristics of stomach sampling. Nº empty = Number of empty stomachs; % FI = Feeding intensity; Nº Reg. = Number of regurgitated stomachs; % FI: Feeding intensity; Nº hauls = Number of hauls.

SPECIES	No. Empty	No. Full	No. Reg.	Total	% FI	Size range (cm)	Depth range (m)	No. hauls	No. Prey Items
Amblyraja radiata	54	520	8	**582**	90.7	11-82	83-696	191	75
Anarhichas denticulatus	88	104	1	**193**	54.4	6-103	148-730	125	27
Anarhichas lupus	774	439	0	**1213**	36.2	4-83	83-586	156	48
Anarhichas minor	177	170	0	**347**	49.0	10-113	130-585	140	41
Gadus morhua	29	721	29	**779**	96.3	15-106	130-449	140	62
Glyptocephalus cynoglossus	24	346	0	**370**	93.5	20-57	130-677	126	25
Hippoglossoides platessoides	211	459	0	**670**	68.5	12-59	130-631	145	44
Lycodes reticulatus	566	305	0	**871**	35.0	8-38	208-618	111	29
Macrourus berglax	229	775	22	**1026**	77.7	2-34	247-730	113	64
Nezumia bairdii	89	600	10	**699**	87.3	1-9	226-708	109	35
Phycis chesteri	40	294	13	**347**	88.5	7-44	156-586	75	22
Reinhardtius hippoglossoides	1272	1978	2	**3252**	60.9	12-68	83-730	212	81
Sebastes fasciatus	845	1331	105	**2281**	63.0	11-35	130-704	152	33
Sebastes mentella	677	1255	198	**2130**	68.2	13-42	147-707	140	40
Sebastes juvenile	615	1007	98	**1720**	64.2	4-18	83-643	141	19
Sebastes marinus	391	803	99	**1293**	69.8	14-51	83-643	141	38
TOTAL:	***6081***	***11107***	***585***	***17773***	***65.8***		***83 - 730***		***134***

Table 2.- Prey items found in the stomachs of the 15 fish species sampled. F.O. (%) = Frequency of occurrence percentage.

SPECIES	F.O. (%)
CRUSTACEA	**80.35**
Hyperiidea	32.38
Copepoda	23.51
Pandalus borealis	20.70
Unidentified Crustacea	10.52
Mysidacea	9.35
Unidentified Euphausiacea	8.53
Gammaridea	4.03
Sergestes arcticus	4.01
Unidentified Natantia	3.33
Lebbeus polaris	2.10
Spirontocaris lilljeborgi	0.48
Sergia robusta	0.47
Chionoecetes opilio	0.39
Meganyctiphanes norvegica	0.35
Bentheuphausia amblyops	0.30
Paguridea	0.26
Isopoda	0.25
Sabinea sarsi	0.24
Acanthephyra spp.	0.18
Pontophilus norvegicus	0.15
Acanthephyra pelagica	0.10
Unidentified Brachyura	0.08
Unidentified Decapoda Crust.	0.06
Caprellidae	0.05
Pasiphaea tarda	0.05
Hyas spp.	0.04
Pycnogonidae	0.04
Cumacea	0.04
Parapasiphaea sulcatifrons	0.03
Acanthephyra purpurea	0.02
Lithodes maja	0.02
Unidentified Amphipoda	0.01
Ostracoda	0.01
Unidentified Pasiphaeidae	0.01
Gennadas elegans	0.01
Argis dentata	0.01
ECHINODERMATA	**5.62**
Ophiuroidea	3.96
Echinoidea Irregularia	0.93
Echinoidea Regularia	0.86
Asteroidea	0.82
Unidentified Echinoidea	0.12
Unidentified Echinodermata	0.05
Holothuroidea	0.02
MOLLUSCA	**5.56**
Unidentified Bivalvia	2.33
Unidentified Cephalopoda	1.30
Unidentified Gasteropods	0.54
Oegopsida	0.53
Unidentified Decapoda Cefalp.	0.50
Pectinidae	0.14
Semirossia spp.	0.12
Histioteuthis spp.	0.05
Scaphopoda	0.05
Bathypolypus arcticus	0.05
Unidentified Octopoda	0.04
Opistobranchia	0.03
Histioteuthis reversa	0.02
Gonatus sp.	0.01
Illex illecebrosus	0.01
Onichotheuthys banksii	0.01
Sepiolidae	0.01
PISCES	**15.80**
Unidentified Pisces	7.72
Sebastes spp.	3.17
Lumpenus lumpretaeformis	1.54
Unidentified Myctophidae	0.86
Lampadena speculigera	0.80
Anarhichas sp.	0.51
Serrivomer beani	0.39
Nezumia bairdi	0.36
Anarhichas lupus	0.36
Triglops murrayi	0.26
Unidentified Gonostomatidae	0.25
Notolepis rissoi	0.17
Phycis chesteri	0.14
Macrourus berglax	0.13
Chauliodus sloani	0.12
Nemichthys scolopaceus	0.11
Paralepididae	0.10
Ceratoscopelus maderensis	0.09
Lycodes reticulatus	0.06
Gaidropsarus ensis	0.06
Magnisudis atlantica	0.05
Unidentified Macrouridae	0.05
Lycodes spp.	0.05
Stomias boa	0.05
Poromitra sp.	0.05
Malacosteus niger	0.05
Benthosema glaciale	0.05
Reinhardtius hippoglossoides	0.04
Mallotus villosus	0.04
Batilagus euriops	0.04
Aspidophoroides monopterygius	0.04
Argyropelecus sp	0.04
Anguilliformes indet.	0.04
Anarhichas denticulatus	0.04
Poromitra megalops	0.03
Notoscopelus spp.	0.03
Cyclothone microdon	0.03
Urophycis sp.	0.02
Scomberesox saurius	0.02
Lycodes esmarki	0.02
Ceratoideos	0.02
Antimora rostrata	0.02
Anarhichas minor	0.02
Ammodytes sp.	0.02
Normichthys operosus	0.01
Myctophum punctatun	0.01
Lycodes vahli	0.01
Liparis spp.	0.01
Fish larvae	0.01
Pisces eggs	0.01
Gaidropsarus spp.	0.01
Unidentified Gadidae	0.01
Cottunculus spp.	0.01
Amblyraja hyperborea	0.01
OTHER INVERTEBRATES	**23.12**
Chaetognata	11.10
Unidentified Polychaeta	5.62
Polychaeta Sedentaria	2.44
Polychaeta Errantia	1.80
Scyphozoa	1.05
Ctenophora	0.93
Anthozoa	0.52
Aphroditidae	0.36
Sipunculida	0.20
Ascidia	0.10
Porifera	0.09
Unidentified Cnidaria	0.02
Bryozoa	0.01
Priapulida	0.01
OTHERS	**3.35**
Unidentified	2.42
Stones	0.60
Unidentified eggs	0.32
Offal	0.02
Vessel waste	0.01
Sand	0.01

Table 3.- Percentage by number (N(%)) of the most characteristic preys in the period 2001-2003.

	N (%)			
	2001	2002	2003	Total
PISCES	***1.59***	***1.19***	***4.60***	***1.63***
Sebastes spp.	0.29	0.20	1.45	0.34
Unidentified Pisces	0.51	0.42	1.76	0.57
Unidentified Myctophidae	0.13	0.18	0.07	0.15
Lumpenus lumpretaeformis	0.20	0.05	0.60	0.15
CRUSTACEA	***85.92***	***93.41***	***74.77***	***89.33***
Hyperiidea	51.81	32.72	24.79	37.88
Sergestes arcticus	0.46	1.26	2.00	1.08
Unidentified Natantia	0.96	0.01	0.10	0.31
Unidentified Crustacea	0.50	0.55	4.46	0.90
Gammaridea	0.51	0.29	4.50	0.76
Mysidacea	2.12	2.15	5.37	2.44
Euphausiacea	0.77	1.48	4.37	1.54
Copepoda	24.00	52.64	15.26	40.24
Lebbeus polaris	1.34	0.88	0.59	1.00
Pandalus borealis	3.23	1.29	12.36	2.94
MOLLUSCA	***0.79***	***1.88***	***1.57***	***1.52***
Pectinidae	0.00	0.26	0.00	0.15
Gasteropodos	0.07	1.17	0.01	0.72
Bivalvia	0.47	0.38	0.78	0.45
ECHINODERMATA	***4.77***	***0.87***	***12.50***	***3.18***
Ophiuroidea	4.46	0.51	11.72	2.79
Echinoidea regularia	0.21	0.11	0.33	0.16
Asteroidea	0.04	0.14	0.34	0.13
OTHER INVERTEBRATES	***6.57***	***2.55***	***5.54***	***4.08***
Polychaeta	1.65	0.52	3.86	1.19
Ctenophora	1.45	0.52	0.52	0.81
Scyphozoa	0.22	0.07	0.04	0.12
Chaetognata	3.16	1.38	0.90	1.89
OTHERS	***0.36***	***0.10***	***1.03***	***0.27***
Unidentified	0.14	0.07	0.92	0.17

Table 4.- Percentage by volume of the most characteristic preys and diet breadths (Levins index, B) for each predator.

	Cyptocephalus cynglossus	*Arnarhichas denticulatus*	*Hyds chesteri*	*Sebastes juvenil*	*Anarhichas minor*	*Lycodes reticulatus*	*Antbyrgia radiata*	*Neamia bairdi*	*Sebastes fasciatus*	*Reinhardtius hippoglossoides*	*Hippoglossoides plœssoides*	*Anarhichas lupus*	*Gadus morhua*	*Sebastes marinus*	*Macrourus berglax*	*Sebastes mentella*	TOTAL
Lenvins index (B) =	**1.55**	**1.80**	**1.99**	**2.53**	**3.75**	**4.04**	**5.62**	**5.66**	**5.69**	**6.53**	**6.61**	**7.31**	**7.56**	**9.08**	**9.64**	**10.12**	
PISCES	**0.08**	**16.97**	**3.77**	**0.42**	**63.17**	**2.40**	**36.16**	**2.69**	**4.94**	**65.15**	**7.64**	**28.64**	**40.27**	**27.90**	**32.92**	**14.69**	**43.52**
Sebastes sp.		12.20			48.79		12.49		0.30	23.68	0.21	11.78	16.07	4.71	1.75		18.24
Serrivomer beani		0.41			2.66		0.53			7.23					3.49		2.65
Unidentified Pisces	0.08	1.11	1.43	0.42	1.22	0.51	9.99	1.37	2.38	10.23	0.32	0.08	4.46	10.49	6.38	10.19	6.37
Anarhichas sp.		1.79					0.55			0.46			7.01				1.81
Anarhichas lupus		0.18				1.47	1.91			0.37	1.35	8.42	7.15				2.17
Lampadena speculigera					0.62		0.73		0.88	11.62				5.16	8.64	1.14	4.15
CRUSTACEA	**18.32**	**5.83**	**95.54**	**94.82**	**10.36**	**60.87**	**52.07**	**81.24**	**88.72**	**29.62**	**45.29**	**38.18**	**55.81**	**62.65**	**34.90**	**73.99**	**39.37**
Hyperiidea	0.11	3.96	3.88	10.92	1.34	0.67	1.68	34.78	10.57	2.62	22.13	3.85	15.96	13.48	0.90	15.00	6.71
Sergestes arcticus	0.30	0.17	0.62	0.56		0.44	3.87	2.09	4.43	0.15	0.71	1.38	5.09	2.32	1.36	3.94	2.01
Unidentified Crustacea	0.33	0.01	4.21	7.58	0.04	1.95	1.83	10.53	5.15	0.29	0.15	0.50	0.80	4.11	1.50	6.67	1.09
Gammaridea	13.51		0.43	0.49		1.44	0.52	2.82	0.14	0.01	0.17	0.08	0.17	0.06	0.25	0.09	0.22
Mysidacea	0.15		7.00	4.09		0.27	0.06	16.70	1.79	0.04	0.07		0.09	0.42	0.46	1.29	0.24
Euphausiacea	0.90	0.02	1.17	5.27	0.04	15.59	1.45	2.33	17.03	0.26	1.80	0.15	1.73	7.03	1.42	16.68	1.70
Copepoda	0.04		1.01	60.87		0.01	0.02	4.35	31.87	0.00	0.07		0.06	11.07	0.13	13.47	1.77
Lebbeus polaris		0.01	2.04	0.09		0.59	0.12		0.19	0.05	0.12	0.31	5.81		0.28		1.28
Pandalus borealis	2.53	1.64	70.08	2.92	8.38	39.10	38.18	1.56	16.02	25.59	18.36	30.79	24.89	22.42	24.01	9.67	22.50
MOLLUSCA	**0.34**	**2.49**	**0.16**	**0.00**	**1.03**	**4.11**	**9.46**	**1.78**	**0.65**	**4.71**	**1.37**	**5.51**	**1.45**	**1.92**	**5.57**	**5.88**	**3.86**
ECHINODERMATA	**0.97**	**0.30**	**0.00**	**0.00**	**6.64**	**3.80**	**0.01**	**0.49**	**0.00**	**0.06**	**17.81**	**18.15**	**0.07**	**0.00**	**3.13**	**0.00**	**1.84**
Ophiuroidea	0.89	0.02			0.15	3.15	0.01	0.49		0.02	13.49	1.40			1.61		0.46
Asteroidea		0.21			5.25	0.13				0.03		5.80	0.07		0.44		0.75
Echinoidea irregularia		0.07			1.04	0.33				0.01	1.09	9.54			0.91		0.49
OTHER INVERTEBRATES	**79.66**	**74.12**	**0.14**	**4.43**	**12.34**	**26.65**	**2.03**	**10.31**	**5.43**	**0.43**	**27.63**	**8.64**	**2.16**	**7.37**	**22.44**	**3.62**	**10.51**
Polychaeta	79.02	0.01	0.14	0.08	0.33	25.77	1.89	9.45	0.03	0.01	3.47	0.98	0.17		3.21		1.10
Ctenophora		73.23			10.65				0.11		21.37	5.72	0.64	0.02	0.23	0.02	7.54
Scyphozoa		0.85			1.01		0.05	0.07	0.31	0.01	0.00	0.00	0.14	0.28	16.49	0.37	0.79
Chaetognata	0.13	0.03		4.34	0.20		0.05	0.60	4.98	0.37	1.91	1.24	1.21	7.08	0.14	3.23	0.92
OTHER	**0.63**	**0.29**	**0.38**	**0.33**	**6.46**	**2.16**	**0.27**	**3.49**	**0.26**	**0.02**	**0.27**	**0.88**	**0.24**	**0.16**	**1.04**	**1.82**	**0.89**
Unidentified	0.44	0.29	0.18	0.32	6.10	2.07	0.27	3.49	0.21	0.02	0.18	0.80	0.06	0.10	0.77	1.78	0.80

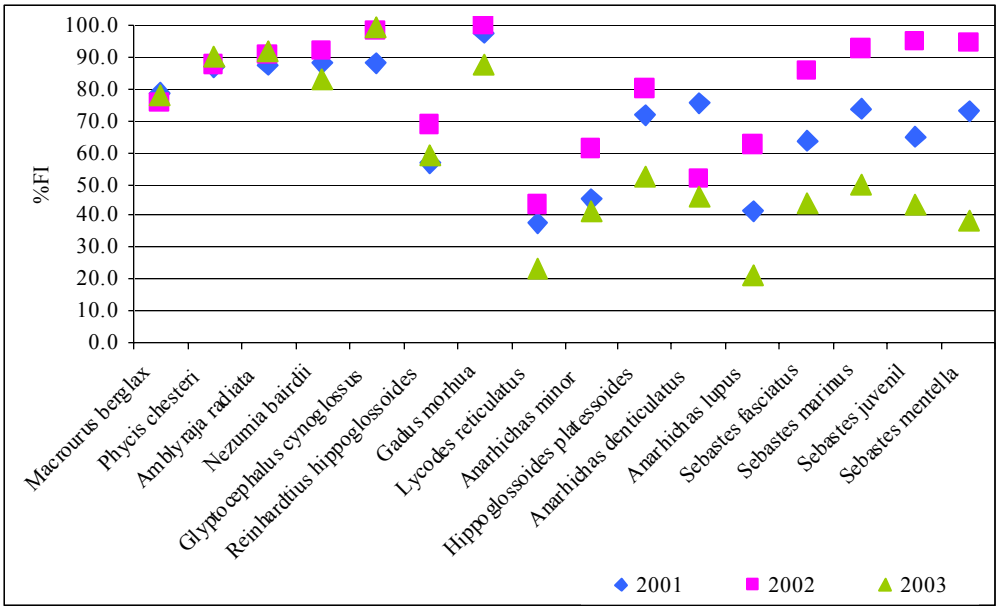

Fig. 1.- Feeding intensity (%FI) of the 15 fish species sampled in Flemish Cap in the period 2001-2003.

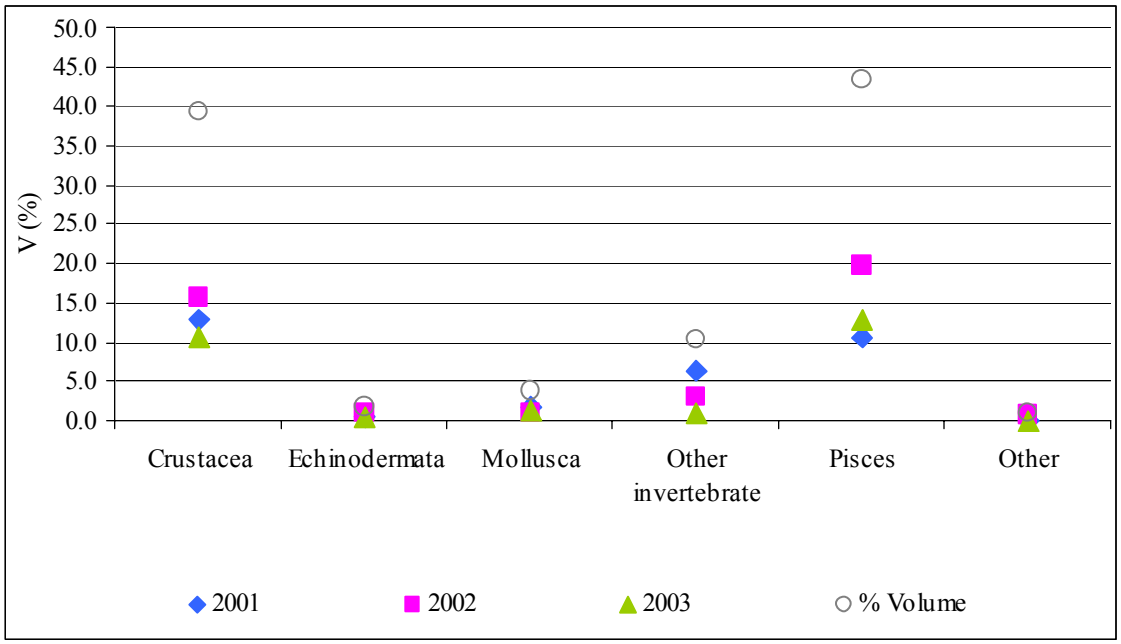

Fig. 2.- Percentage by volume (%V) of the main prey groups. Flemish Cap 2001-2003.

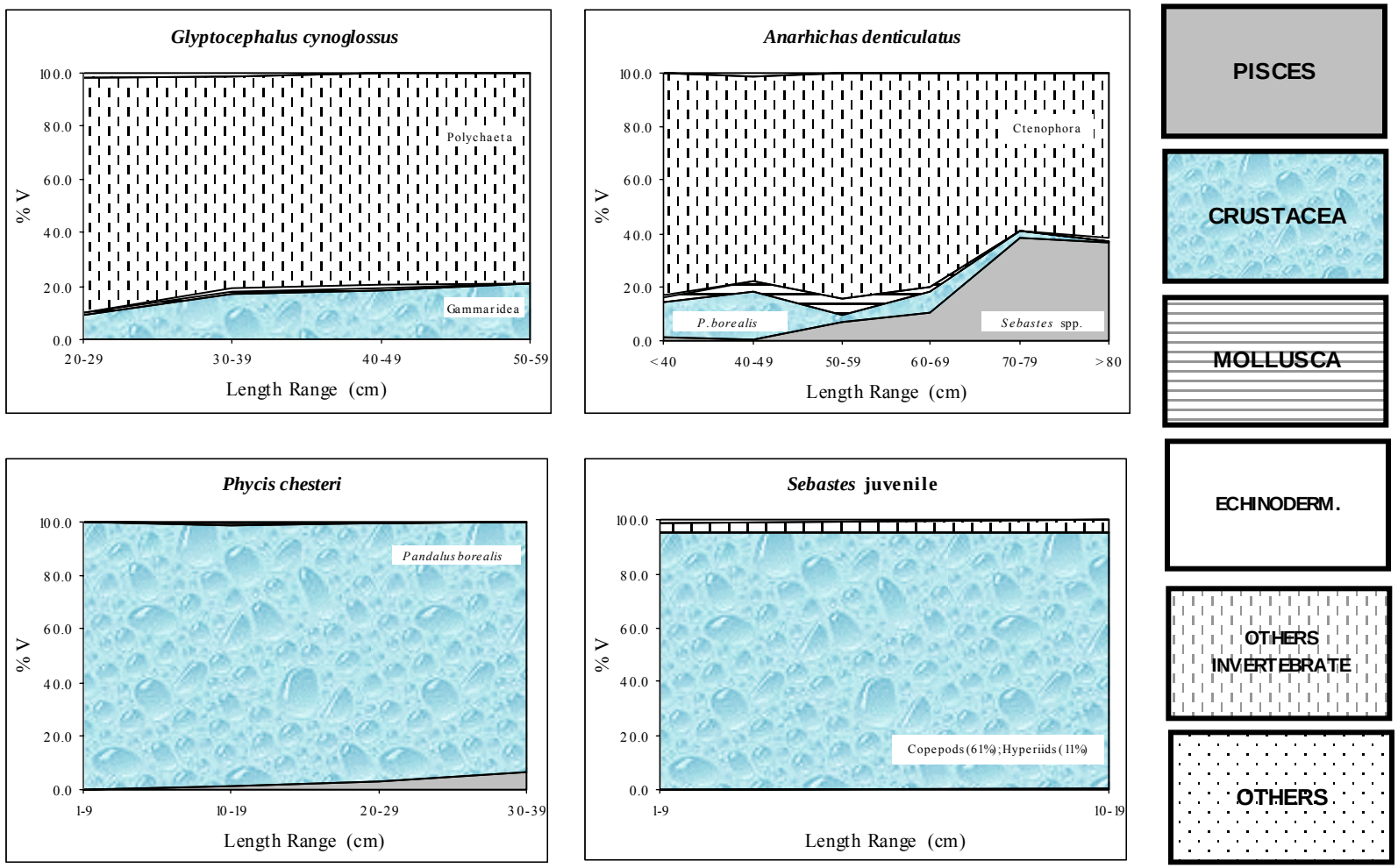

Fig. 3.- Percentage by volume of the main prey groups of *Glyptocephalus cynoglossus, Anarhichas denticulatus, Phycis chesteri* and *Sebastes* juvenile by size range (cm).

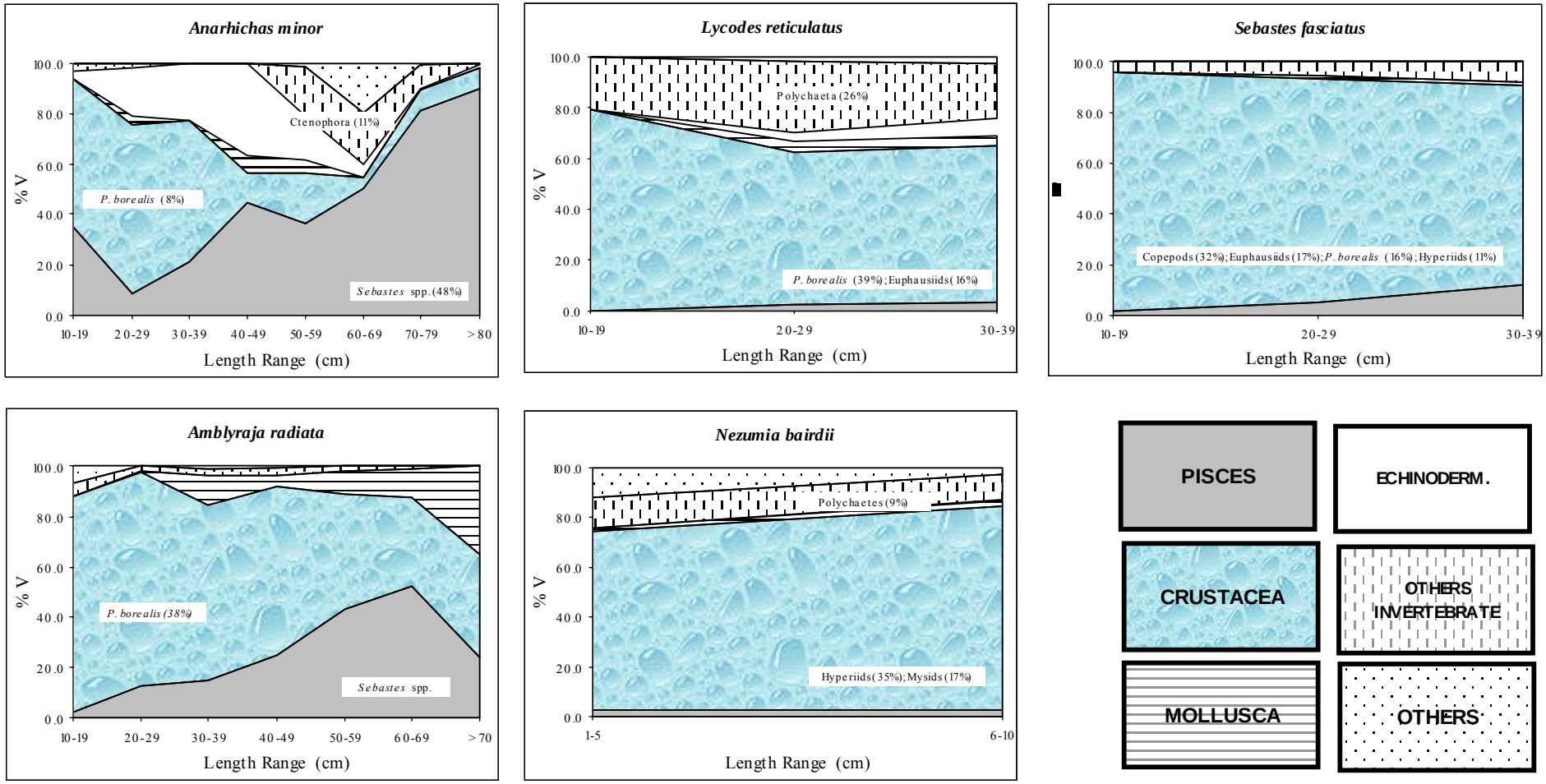

Fig. 4.- Percentage by volume of the main prey groups of *Anarhichas minor, Lycodes reticulates, Amblyraja radiata* and *Nezumia bairdii* by size range (cm).

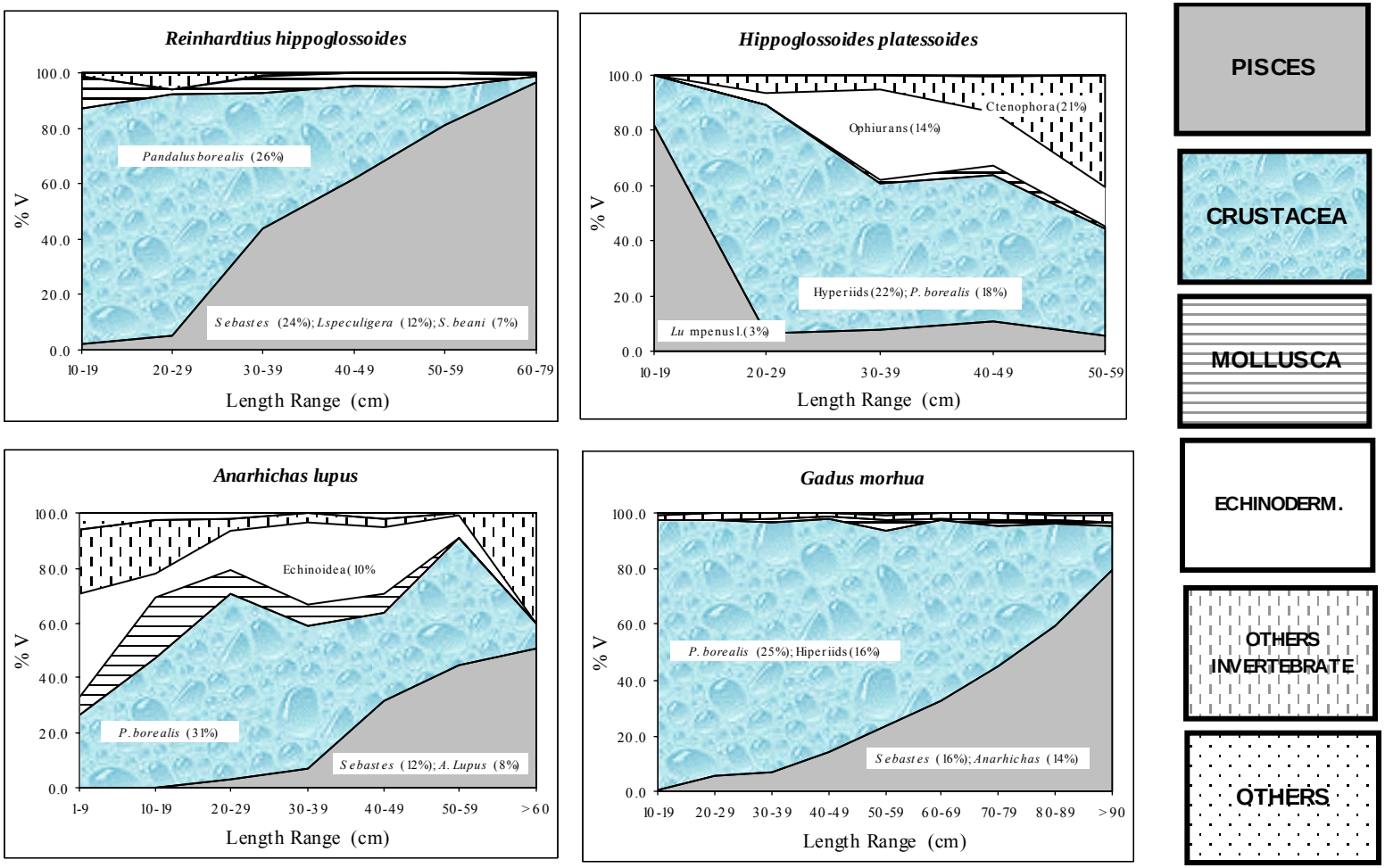

Fig. 5.- Percentage by volume of the main prey groups of *Reinhardtius hippoglossoides, Hippoglossoides platessoides, Anarhichas lupus, Gadus morhua, Sebastes marinus, Macrourus berglax* and *Sebastes mentella* by size range (cm).

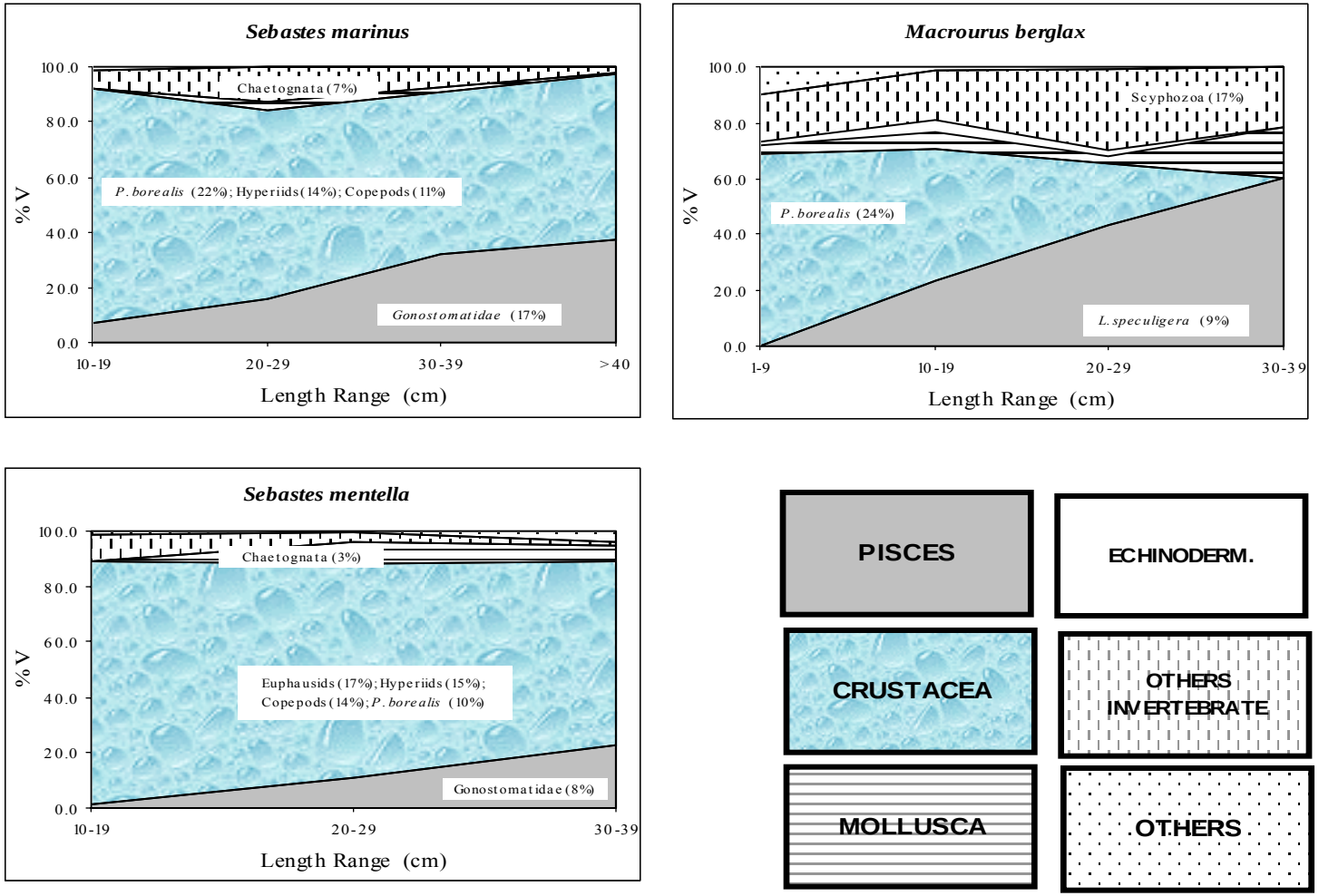

Fig. 6. Percentage by volume of the main prey groups of *Reinhardtius hippoglossoides, Hippoglossoides platessoides, Anarhichas lupus, Gadus morhua, Sebastes*