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Feeding Habits of Fish Species Distributed on the Grand Bank (NAFO Divisions 3NO, 2002-2005)

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Abstract

24 917 stomach contents corresponding to 17 fish species of the Grand Bank in the period 2002-2005 were analyzed. Importance of prey was based in weight percentage. Feeding intensity was high for most species (>75%). Greenland halibut and northern wolffish were the species with the lowest feeding intensity (<45%). This index showed a trend to decrease with the increase of predator size and depth range. Round skate and witch flounder were specialist species with a little niche width, and black dogfish turned up to be the most generalist species in feeding habits.

A high number of prey in stomach contents was common, but most part of stomach contents were compound of between 2 and 8 prey, which supplied >70% of the total weight. Greenland halibut, Arctic and spynitail skates were piscivorous species. Roundnose grenadier, redfish and smooth skate showed pelagic, bathypelagic or epifaunal crustacean feeding habits, and northern wolffish was pelagic invertebrate organism feeder on ctenophores.

Roughhead grenadier and yellowtail flounder were benthic predators on different prey species, scyphozoans and crustaceans respectively, and polychaetes were common in the diet of both species. Witch flounder and round skate were polychaete feeders on bottom benthos.

Atlantic and spotted wolffish showed a diet primarily based on benthic and bottom organisms with predominance of different prey in each species. Black dogfish preyed on benthic groups (crustaceans, scyphozoans and fishes), like American plaice (echinoderms, fishes and crustaceans). Thorny skate and Atlantic cod showed similar diets based on fishes and crustaceans. Specific predation and diet overlap observed among some species changed with depth.

Introduction

Nowadays, the ecosystem model approach is a main challenge to improve the marine resource management. Thus, we need to know the trophic relationship among taxons and the predator-prey relationship, besides other aspects. This approach combines multispecific study, interaction among species and interaction of the species and the environment with the supply of abiotic data in bioenergetic models (Aydin *et al*., 2002; Morissette *et al*., 2003).

Ecological studies, including the development of Ecological Quality Objectives (EcoQOs) for fish communities, assemblages, and other aspects of fish ecology such as feeding habits and habitat requirements, can provide advice in relation to ecosystem, biodiversity and nature conservation issues. The analysis of community dynamics depends partly on the measurement of how organisms utilize their environment. One way to do this is to measure the niche parameters of a population and to compare them. Since food is one of the most important dimensions of niche (Krebs, 1989). Many species show great flexibility in their trophic ecology; diversity and flexibility of fish diets can generate complex food webs. Fish display a wide adaptive range of feeding habits, and it is rare for fish to specialize in one particular prey category throughout their entire life cycle. It is usual that fish show ontogenetic changes in feeding habits and prey selection (Jobling, 1995). Seasonal changes in food availability may be caused by changes in the available habitats for foraging, changes resulting from the life-history patterns of food organisms and changes in the predator species (Wootton, 1999).

Studies on feeding ecology of species community distributed in the Northwest Atlantic have been carried out (Bowman *et al*., 2000; Garrison, 2000; Link *et al*., 2002; Román *et al*., 2004), and studies on food and feeding of commercial fishes in the Northwest Atlantic have been reported as well: Atlantic cod (*Gadus morhua*) (Fahay *et al*., 1999), American plaice (*Hippoglossoides platessoides*) (Pitt, 1973; Johnson *et al*., 1999a; González *et al*., 2003; González *et al*., 2005), yellowtail flounder (*Limanda ferruginea*) (Langton, 1982; Johnson *et al*., 1999b; Bruno *et al*., 2000), Greenland halitut (*Reinhardtius hippoglossoides*) (Rodríguez-Marín *et al*., 1995). We present the study on feeding habits focused on Grand Bank.

Diet study of the main species in the catch of the Spanish Bottom Trawl Research Survey *Platuxa* carried out on the Grand Bank of Newfoundland (NAFO, Div. 3NO) in the period 2002-2005 is presented in order to know the possible trophic relationships established in the area. These species represented between 77% and 88% of the fish total catch (Table 1) and are the following species: Greenland halibut (*R. hippoglossoides*), American plaice (*H. platessoides*), yellowtail flounder (*L. ferruginea*), witch flounder (*Glyptocephalus cynoglossus*), Atlantic cod (*G. morhua*), redfish (*Sebastes* sp.), roundnose grenadier (*Coryphaenoides rupestris*), roughhead grenadier (*Macrourus berglax*), black dogfish (*Centroscyllium fabricii*), thorny skate (*Amblyraja radiata*), Arctic skate (*Amblyraja hyperborea*), spinytail skate (*Bathyraja spinicauda*), smooth skate (*Malacoraja senta*), round skate (*Rajella fyllae*), spotted wolffish (*Anarhichas minor*), Atlantic wolffish (*Anarhichas lupus*), northern (*Anarhichas denticulatus*). Variation in food habits with predator size and depth range was examined.

Materials and Methods

Stomach contents of 24 917 individuals of 17 species distributed in the Grand Bank (NAFO Area, Div. 3NO, 2002-2005) were analyzed. Number of sampled individuals of every species and year are shown in Table 2. These samplings were carried out on board R/V *Vizconde de Eza* in the Spanish Bottom Trawl Research Survey *Platuxa* in spring in the period 2002-2005 (González Troncoso *et al*., 2005). Characteristics of this survey (dates, gear, depth range and haul number) and the characteristics of the stomach content samplings carried out are shown in Table 3. Depth (m), median, extreme values and outliers of samplings of each species are shown in Fig. 1.

Samples were gathered through a random sampling which was stratified by predator size; individuals were grouped by size ranges of 10 cm (0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-99, 100-109 cm, etc.), except the grenadiers, which were grouped every 5 cm (0-4.5, 5-4.9, 10-14.5 cm, etc). Minimum and maximum lengths sampled and size ranges taken into in every species are shown in Table 2. Fish whose stomach was everted or contained prey ingested in the fishing gear were discarded. Specimens that presented total or partial regurgitation were taken into account to estimate the emptiness indices.

The data collected for each predator were the following: total length (TL) to the nearest lower cm (in grenadiers pre-anal length, PAL, to the nearest lower ½ cm); volume of the stomach content, quantified in c.c. using a trophometer (Olaso, 1990); percentage of each prey in the total volume, and digestion stage and number of each prey. Prey were identified by species when digestion stage permitted it, or to the lowest possible taxonomic level.

Data analysis

The feeding intensity (*FI*) was evaluated with the percentage of individuals with stomach content, where *n* was the number of individuals with stomach content and *N* was the total number of individuals sampled.

$$FI = (n / N) \times 100$$

Differences in feeding intensity by size range, sex and depth range were tested by χ^2.

Prey were grouped by functional higher groups (Bowman *et al.,* 2000). These groups were: Pisces, Crustacea, Mollusca (Gastropoda, Bivalvia and Cephalopoda), Echinodermata (Asteroidea, Echinoidea, Ophiuroidea); *"Other Groups"* (Annelida, Anthozoa, Cnidaria, Ctenophora, Scyphozoa); Other Prey (offal, eggs, vitellus, unidentified/digested prey). Diet was characterized in terms of percentage by weight. The percentage of total weight (or volume) has the advantage of having some relationship to the caloric value of food (Wallace, 1981). The importance of each individual prey or prey group in stomach contents was based on weight percentage of each prey item of the total weight of stomach contents for predator specie, size range or depth range (W_{pi}) (Hyslop, 1980; Amezaga, 1988); where w_{pi} was the weight (g) of the prey item p in the specie, size range, prey group or depth range i; and W_{ti} was the weight (g) of total prey in the specie, size range, prey group or depth range i.

$$W_{pi} = w_{pi} / W_{ti} \, x \;\; 100$$

Measure of diet used in niche breadth and overlap indexes greatly influences the resulting value, and resource availability of prey and the food category established also influence (Wallace, 1981). Niche breadth was calculated using Levins´ Measure (B) (Krebs, 1989); where p_j was the proportion of individuals found using prey j, using diet measures in percentage of occurrence and percentage of total number and weight. Low values (<3.5) imply specialist species, and high values (>6) imply generalist species (Rodríguez-Marín, 1995). Mean value of the three index values was calculated.

$$B = 1 / \sum p^2_j$$

The degree of diet overlap was measured by using the Simplified Morisita´s Index (C_H) (Krebs, 1989) based on *%W*. C_H vary between 0 (no categories in common) and 1 (identical categories). Overlap is generally considered to be biological significant when the value exceeds 0.60 (Wallace, 1981). We used C_H to measure the diet overlap among some fish species studied.

$$C_H = \frac{2 \sum p_{ij} * p_{ik}}{\sum p^2_{ij} + \sum p^2_{ik}}$$

C_H was the Simplified Morisita´s Index.
j, k were the predators.
p_{ij} was the proportion of food category i in the diet of predator j.
p_{ik} was the proportion of food category i in the diet of predator k.
i (i = 1,2,3,…n) was the number of food category.

Results and Discussion

Feeding Intensity

Most of the species showed high feeding intensity levels (*FI*) (>75%), such as black dogfish (77%), Atlantic cod (81%), witch flounder (87%), Arctic skate (83%), round skate (86%) and smooth skate (93%). Greenland halibut and northern wolffish were the species with the lowest feeding intensity (42% and 43% respectively). Both sexes presented a similar feeding intensity, and we only found a significant difference in redfish, American plaice and yellowtail flounder ($\chi^2_{(1)} = 4.6$ p<0.05; $\chi^2_{(1)} = 45.5$ p<0.000; $\chi^2_{(1)} = 4.4$ p<0.05) (Table 4).

Some species seem to show a trend to decrease *FI* when size increase. This pattern was noticed in American plaice, Greenland halibut, Arctic and thorny skates, redfish, roughhead and roundnose grenadiers and Atlantic cod. The opposite trend was observed in northern and Atlantic wolffishes. Black dogfish, witch and yellowtail flounders showed a similar feeding intensity in all sizes. However, the only species that did not show significant differences in this index in the different size ranges were northern wolffish, black dogfish, round and spinytail skates (Fig. 2).

Feeding intensity changed with depth in some species; it showed a trend to decrease when depth increased. This pattern was observed in most of species, except in northern wolffish, witch flounder, black dogfish, grenadiers and some skates. Feeding intensity was significantly different in all depth ranges, except in northern wolffish, roundnose grenadier, and Arctic, round and smooth skates (Fig. 3).

The annual changes of *FI* found in this period can be also influenced by the variation of the samples taken every year in relation to the number of individuals sampled per depth range, taken into account that *FI* depends on size and depth (Fig. 1).

Food Habits

The order followed to present the species was done beginning with the species with the lowest values of niche width (specialist species) and at the end of the list we find those species with the highest values (generalist species), measuring mean niche breadth value (Table 5).

Round skate (*Rajella fyllae*). It was the species with the lowest number of prey items (12). Low value of the niche width (Table 5). Only 2 prey were ≥5% of the stomach contents by weight, and they represented the 85% of the total. This species did not show a predation on molluscs nor echinoderms. Its diet was mainly based on polychaetes (80%). The second most important prey was gammarid amphipods (5%). Individuals <20 cm showed a significant quantity of vitellus (Table 6, Fig. 4 and 5). Round skate is benthophage feeder; it feeds primarily on bottom benthos (Berestovskiy, 1989; Dolgov, 2002; Bergstad *et al*., 2003).

Witch flounder (*Glyptocephalus cynoglossus*). 28 prey items were identified. Low value of the niche breadth (Table 5). Only 3 prey were ≥5%, and they represented the 92% of the total weight of stomach contents. Benthophage predator; it mainly preyed on polychaetes (77%). The consumption of Crustacea (12%) was primarily based on gammarid amphipods (11%). Predation on polychaetes and gammarid amphipods was common in all individuals. Individuals <10 cm also fed on small crustaceans (gammarid amphipods and mysids); individuals with size between 20 cm and 49 cm virtually presented only polychaetes; and individuals ≥50 cm showed in their diet, apart from polychaetes, a slight predation on fishes and brittle stars (Ophiura) (Table 6, Fig. 4 and 5). This species is typically benthonic (Langton, 1982; Bowman *et al*., 2000; Gibson, 2005) with ontogenetic shift in diet, polychaetes increasing in importance and crustaceans decreasing with predator size; there is also little variation in diet with geographic area (Cargnelli *et al*., 1999; Bergstad *et al*., 2003).

Roundnose grenadier (*Coryphaenoides rupestris*). It presented 25 prey items. Medium value of niche width measured in weight of prey, but it showed a small niche breadth when measures of prey number and occurrence were taken into account, turning out to be a specialist species according to these latter measurements (Table 5); 4 prey were ≥5%, and they represented the 87% of the total. Roundnose grenadier based its diet mainly on crustaceans (94%), and among them the most important prey were copepods (28%) and bathypelagic shrimp (*Pasiphaea tarda*) (28%) which were consumed by individuals <10 and ≥15 cm, respectively. Medium size individuals preyed on both types of crustaceans with a transitional diet (Table 6, Fig. 4 and 5). Studies carried out in other areas of north Atlantic (Skagerrak, northeastern North Sea) also showed this species as a crustacean feeder and with the same pattern as far as the predator size is concerned. Therefore, it goes from feeding on small crustaceans (euphausids) to benthopelagic decapod crustaceans (*Pandalus borealis*) when size increases (Bergstad *et al*., 2003).

Northern or broadhead wolffish (*Anarhichas denticulatus*). 28 prey items were found. Low value of the niche width (measured in number and weight of prey) (Table 5); 4 prey were ≥5%, and they represented the 89% of stomach contents. *"Other Groups"* was the most important prey group (63%), mainly ctenophores (60%). Pisces was the second most important prey group (26%), primarily due to predation on redfish (*Sebastes*) (18%). Offal was also found, but in a very low percentage (1%). Ctenophores were the main components in the diet of individuals <70 cm, individuals with a bigger size presented a more varied diet, where fishes (redfish and roughhead grenadier; *Macrourus bexglax*) and brittle stars stand out (Table 6, Fig. 4 and 5). Pelagic organisms (ctenophores) occur frequently in the diet of northern wolffish (Albikovskaya, 1983; Torres *et al*., 2000; Román *et al*., 2004).

Yellowtail flounder (*Limanda ferruginea*). It presented 43 items, but few prey were important (% weight). Niche breadth with medium value measured in number and weight of prey (Table 5); 5 prey were ≥5% of the total weight of stomach contents, and they represented the 86%. Pisces was the most important prey group (45%); almost exclusively northern sand lance (41%). Crustacea (27%) was compounded by gammarid amphipods (18%) and mysids (8%). And in the *"Other Groups"* (24%), polychaetes and anthozoos were the 15% and 7%, respectively. Yellowtail flounder fed on benthic macrofauna. The consumption of small crustaceans (gammarid amphipods and mysids) and anthozoos decreased in individuals ≥30 cm, and predation on fishes (mainly northern sand lance, *Ammodytes dubius*), and polychaetes increased (Table 6, Fig. 4 and 5). Bruno *et al.* (2000) observed the same diet (gammarid amphipods, 20%; northern sand lance, 10%; Anthozoa, annelids and mysids, 6% each one) and similar preferences according to size. The difference between the two studies, carried out in the same area, lies in the remarkable increase in the consumption of northern sand lance observed in this study. Yellowtail flounder is a polychaete and crustacean feeder that forage primarily for benthic prey at the sediment surface (Pitt, 1976; Langton, 1983; Methven, 1999; Link *et al*., 2002; Gibson, 2005). However, other studies had different results, showing that adult individuals fed mostly on crustaceans while juveniles eat mostly polychaetes (Johnson *et al*., 1999b) or showing a greater importance of Crustacea (Hacunda, 1981).

Spotted wolffish (*Anarhichas minor*). 19 prey items were considered. Medium value of niche width measured in number and weight of prey (Table 5); 6 prey were ≥5%, and they represented the 79% of total weight of stomach contents. The main prey group was Echinodermata (65%), where sand dollar (*Echinarachnius parma*) stood out (41%). The next most important prey were redfish and starfish (Asteroidea) (17% and 14% respectively). Individuals <40 cm fed preferably on brittle stars. Individuals ≥60 cm fed on snow crab, sand dollar, starfish and fishes; the consumption of these three prey increased with predator size. Individuals with sizes within both size ranges showed a transitional diet, and they also fed on other prey not found in the other sizes, such as sea urchins (Echinoidea) and a small quantity of toad crab (*Hyas* sp) and northern shrimp (*P. borealis*) (Table 6, Figures 4 and 5). This species is considered a bottom organism feeder (Albikovskaya, 1983), but it showed a predation increase on redfish or northern shrimp in recent years and in some areas in the northwest Atlantic (Rodríguez-Marín *et al*., 1994; Torres *et al*., 2000; Román *et al*., 2004).

Spinytail skate (*Bathyraja spinicauda*). 21 prey items were considered. Niche breadth with medium value measured in number and weight of prey, but if prey occurrence is taken into account, this species turns out to be highly specialist (Table 5); 4 prey were ≥5%, representing 85% of stomach contents. It did not present predation on echinoderms. It was a piscivorous species (90%), whose main prey were redfish (28%), roughhead grenadier (20%) and Greenland halibut (*R. hippoglossoides*) (19%). Individuals <50 cm fed on crustaceans (gammarid amphipods, hyperids and *Sergestes arcticus*), from this size on it fed virtually on pisces (Table 6, Fig. 4 and 5). It was the most piscivorous species of the species analyzed here, which is a behavior that has already been reported (Dolgov, 2002).

American plaice (*Hippoglossoides platessoides*). It showed 56 prey items. Niche width with medium value measured in weight, but this species turn out to be much more specialist if we observe the number of different prey (Table 5). Six prey were ≥5% of stomach contents, and they represented the 83%. Pisces was the main prey group (53%), while Crustacea, Mollusca and Echinodermata represented a 14% each. Northern sand lance (39%) and bivalves (14%) stood out, followed by capelin (*Mallotus villosus*) (11%) and mysids (10%). Although cannibalism was found, it was in minimum percentage. Individuals <20 cm preyed primarily mysids; fish consumption increased with predator size between sizes 20 cm and 59 cm; however individuals ≥60 cm virtually fed on bivalves and echinoderms (brittle star and sand dollar) (Table 6, Fig. 4 and 5). These prey and diet within the different sizes had already been reported on Grand Bank, but predation on northern sand lance was greater (72%) (Bruno *et al*., 2000).This species can fed on a wide variety of prey types, but only a very small number of them were important, and there were seasonal and geographical variations caused by the changes in prey abundance (Langton, 1982; Zamarro, 1992; Methven, 1999). Other studies on northwest Atlantic reported a lower importance of fish in their diet (Bowman *et al*., 2000). This species is considered specialist in echinoderms and bivalves (Link *et al*., 2002; Gibson, 2005), but it feeds on forage fishes (mainly capelin and northern sand lance) and benthic forms (primarily ophiuroids) (Pitt, 1973; Pitt, 1976), changing its diet with predator size, season and area (Link *et al*., 2002). González *et al*. (2003) found bigger diet overlap among individuals of Div. 3M (NAFO) and IIb (ICES) that individuals of Div. 3M and Div. 3LNO. A decreased in the consumption of echinoderms was observed in the last years in Div. 3M (González *et al*., 2005).

Thorny skate (*Amblyraja radiata*). It showed a wide spectrum of prey (78), but most of them were not very important (% weight). Niche breadth with medium values (Table 5). Only two prey were ≥5%, and they represented the 66% of the total weight of stomach contents. The main preyed group was Pisces (58%), where northern sand lance outstood (43%). Crustacea was the second most important prey group (34%), mainly snow crab (*Chionocetes opilio*) (23%). Offal was present in a low percentage (1%). Vitellus was found in individuals <20 cm. In the diet of individuals <30 cm small crustaceans (gammarid amphipods, mysids and *Argis dentata*) were predominant. Consumption of northern sand lance and snow crab increased with predator size, and polychaetes decreased. The predation on capelin was observed in medium size skates and predation on redfish was done by big size individuals (Table 4, Fig. 4 and 5). This species is considered an opportunistic feeder on the most abundant and available prey species (Templeman, 1982; Packer *et al*., 2003a; Román *et al*., 2004), and this fact would explain its great geographic and batimetric adaptation capacity. A similar feeding pattern was reported in northeast Atlantic areas (Bergstad *et al*., 2003).

Smooth skate (*Malacoraja senta*). It presented 22 prey items. Niche width with high value, measured in weight of prey, because if we analyze occurrence and number of prey, this species is specialist (Table 5); 8 prey were ≥5%, representing a 77%. It did not show predation on echinoderms nor molluscs. Crustacea was the main prey group (72%), preying mainly on snow crab (23%). Pisces was the second most important prey group (26%), where consumption of capelin was remarkable (8%). Individuals <29 cm fed mainly on mysids; and individuals ≥40 showed a more varied diet with snow crab, decapod natantia crustacean and capelin (Table 6, Fig. 4 and 5). Diet of smooth skate in northwest Atlantic is based on epifaunal crustaceans (Bowman *et al*., 2000; Packer *et al*., 2003b); however, like in other species, fish predation was more important on Grand Bank.

Atlantic cod (*Gadus morhua*). It was the species with the greatest prey spectrum (76 prey items), but most of them were not important, and only 5 were ≥5% representing the 74% of the total of stomach contents. Niche breadth with medium value (Table 5). The main prey groups were Pisces and Crustacea (64% and 31%, respectively). The most important prey were northern sand lance (40%), capelin (13%) and snow crab (11%). Offal was present in a very low percentage. Mysids were important prey in individuals <20 cm. Individuals between 20 and 50 cm fed on crustaceans (hyperids and northern shrimp) and fishes (capelin and northern sand lance). Predation on these fishes and snow crab increased from this size on (Table 6, Fig. 4 and 5). Atlantic cod has a varied diet by life history and area (Hacunda, 1981; Fahay *et al*., 1999; Methven, 1999). Changes in diet with respect to the end of the 90's are observed on the Grand Bank; the importance of capelin and northern sand lance has not changed, representing >50% of their stomach contents, and changing with predator size and season, however the importance of snow crab has increased considerably (Paz, 1992).

Redfish (*Sebastes* sp). This taxon showed 43 prey items. Niche width with high value measured in weight of prey, because if we take into account occurrence and number of prey, this species turn out to be specialist (Table 5); 5 prey were ≥5%, representing a 66% of stomach contents. Crustacea was the main prey group (69%). Hyperids, euphausiids and copepods were the main prey (21%, 20% and 11% respectively). Pisces reached a 20%, a great part of it was in an advanced stage of digestion (10%); and capelin (4%). Individuals <20 cm fed on small crustaceans (mysids and euphausiids and primarily copepods). Predation on fishes (capelin and northern sand lance), decapod crustaceans and hyperids increased with predator size from individuals ≥20 cm (Table 6, Fig. 4 and 5). Redfish feed on pelagic calanoid-euphausiid assemblage throughout ontogeny, and the proportion of fish in the diet is positively correlated with body size (Methven, 1999; Pikanowski *et al*., 1999). It is an important predator of northern shrimp in the areas where this crustacean is distributed (Pedersen and Riget, 1993; Torres *et al*., 2000; Román *et al*., 2004).

Arctic or northern skate (*Amblyraja hyperborea*). It presented 29 prey items (Table 6). Niche breadth with high value measured in weight of prey, but if we take into account occurrence of prey, this species was very specialist (Table 5); 5 items were ≥5% of the total weight of stomach contents, representing a 68%, with unidentified/digested fishes (21%) included. The main prey group was Pisces (43%), where redfish stood out (13%). Crustacea was the second most important prey group (25%), and the most remarkable prey in this group were hyperids (5%). Offal consumption reached a 23%. It did not feed on echinoderms. The small crustaceans (mysids, hyperids and euphausiids), bathypelagic shrimp (*P. tarda*), polychaetes and also redfish were predominant in the diet of individuals <60 cm. Individuals ≥60 cm increased the consumption of fishes such as macrurids (*M. berglax* and *Nezumia bairdi*) and redfish, octopus and offal (Fig. 4 and 5). Adult individuals are primarily piscivorous regardless of the geographical area. (Dolgov, 2002).

Atlantic or striped wolffish (*Anarhichas lupus*). It presented 46 prey items. Niche breadth with high value measured in weight of prey (Table 5); 5 prey were ≥5%, representing 75% of total weight of stomach contents. The main prey group was Mollusca (48%), but *"Other Groups"*, Echinodermata and Crustacea were present in stomach contents in similar amount (19%, 16% and 14%, respectively). Gastropods (45%) and ctenophores (15%) were the most remarkable prey. Consumption of hard prey increased with predator size, but the same happened with ctenophores. Individuals <30 cm fed on polychaetes, toad crab and brittle stars; individuals between 30 cm and 69 cm preyed mainly on gastropods, sand dollar and snow crab; and in individuals ≥70 cm the consumption of ctenophores was remarkable, and gastropods increased (Table 6, Fig. 4 and 5). Its predation on benthic invertebrates and bottom organisms is habitual in northwest Atlantic (Albikovskaya, 1983; Templeman, 1985; Methven, 1999; Bowman *et al*., 2000). Consumption of benthopelagic crustaceans (northern shrimp) has increased in some areas of northwest Atlantic such as Flemish Cap in the last years (Rodríguez-Marín *et al*., 1994; Torres *et al*., 2000; Román *et al*., 2004).

Roughhead grenadier (*Macrourus berglax*). This species had 59 prey items, but few prey were important. Niche width with high value measured in weight of prey (Table 5); 6 prey were ≥5%, representing the 72% of stomach contents. *"Other Groups"* and Pisces were the main prey group (45% and 28%, respectively), and scyphozoans were the main prey (33%), followed by polychaetes (12%). It showed cannibalism in minimum percentage. Individuals <5 cm fed on gammarid amphipods; individuals between sizes 5-15 cm primarily preyed on polychaetes, and consumption of scyphozoans and fishes increased from this size on (Table 6, Fig. 4 and 5). This species is a benthic predator, and crustaceans, primarily northern shrimp, were less importance in its diet on Grand Bank than on Flemish Cap; this fact was observed in other predator species (Rodríguez-Marín *et al*., 1994; Torres *et al*., 2000; Román *et al*., 2004).

Greenland halibut (*Reinhardtius hippoglossoides*). 54 prey items were considered. Niche breadth with high value measured in weight and occurrence of prey (Table 5); 5 types of prey were present in ≥5% of the total weight of stomach contents, represented a 64%. This species turn out to be primarily piscivore (70%) (Gibson, 2005). The next prey group was Mollusca (only Cephalopoda) (18%). The most important prey were: capelin (30%), Oegopsida (7%) and threadfin rockling (*Gaidropsarus ensis*) (6%), but the digested/non identified fishes reach a 15% of the total. Small crustaceans (mysids, euphausiids and hyperids) were the main prey for individuals <20 cm. Individuals between 20-49 cm fed on small fish (mainly capelin). And individuals ≥50 cm preyed on bigger fish (macrurids, threadfin rockling and blue antimora, *Antimora rostrata*), cephalops, and also on offal (2%) (Table 6, Fig. 4 and 5). Similar feeding trends and changes in relation to predator size has been reported in other areas of NAFO Regulatory Area, such as Davis Strait (Orr and Bowering, 1977), west Greenland (Pedersen and Riget, 1993), Divs. 3LMNO (Rodríguez-Marín *et al*., 1995; Rodríguez-Marín *et al*., 1997). A more piscivore diet was found on Grand Bank than in other areas of northwest Atlantic (Torres *et al*., 2000; Román *et al*., 2004).

Black dogfish (*Centroscyllium fabricii*). It presented 42 prey items. Niche breadth with high value measured in weight and number of prey (Table 5); 7 prey were ≥5% representing a 69% of the total. Main prey groups were Crustacea and Pisces (48% and 24%, respectively). The most important prey were *Acanthephyra* sp and scyphozoans (12% and 13%, respectively). Fishes were not identified in many cases due to the advanced stage of digestion (17%). Offal consumption was important (4%). Diet based on fishes, scyphozoans and offal increased with predator size (Table 6, Fig. 4 and 5). Similar diet, offal consumption, and change in feeding habits with size have been observed in other NAFO divisions (Punzón and Herrera, 1998).

Prey Predation and Competition by Depth Range

If the species studied are considered as a whole, predation on fishes decreased with depth. It was important up to 800 m representing almost the 59% in weight of the consumed prey among all the species under study. Consumption of *"Other Groups"* increased with depth, especially between 400 and 1 000 m. Crustacea was preyed in the shallowest areas due to snow crab and northern shrimp consumption, and in the deepest area due to decapod natantia crustacean (mainly *P. tarda*) consumption. Bivalve molluscs and echinoderms were mainly consumed at a depth <400 m, while molluscs preyed at great depth were cephalops (Fig. 6).

Prey consumed in the different depth strata can cause competition among some predators; however, we observed that each predator included in its diet other type of prey which helped to avoid a total overlap, and there was the possibility to prey on different sizes of prey species. It can also be observed that some predator species preferred prey for which there were little competence, this is the case of northern and spotted wolffish to 400 m, preying on ctenophores and echinoderms respectively. A similar situation to the one observed in the Georges Bank groundfish community could find where a trophic structure separating predators based upon prey size and location in the water column was observed; besides, ontogenetic changes in diets were an important feature in the trophic structure, and dietary overlap among predator was independent of either spatial overlap or depth preferences (Garrison, 2000).

In the shallow zone (<200 m), a competition and niche overlap were observed between witch flounder and round skate (C_H = 0.99) (Table 5). They competed for the consumption of polychaetes and bivalves-gastropods; between thorny skate and Atlantic cod (C_H = 0.94) due to northern sand lance and snow crab consumption; and between American plaice and yellowtail flounder (C_H = 0.86) preying on northern sand lance and bivalves-gastropods. However, these last species showed other components in their diet based on echinoderms and polychaetes respectively (Fig. 7).

The species that may have similar prey preference in depths of 200-399 m would be *A. lupus* and *A. minor* due to echinoderm consumption, but they also showed no common components in their diets (bivalves-gastropods and redfish respectively). Thorny skate and Atlantic cod showed different preferences at this depth (C_H = 0.69). However, when depth increased (400-599 m) they are again similar in the prey consumed (redfish and capelin) presenting diet overlap (C_H = 0.89). The two latter species also compete, although not so hard, with American plaice (Langton, 1982) and Greenland halibut due to predation on capelin.

From 600 m, species showed a quite varied predation, except flounder and round skate on polychaetes, which was the same in all depth strata with high diet overlap values (Table 5). Capacity for predation on macrurids in northern wolffish, arctic and spinytail skates was also remarkable in 1 000-1 199 m (Fig. 7).

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References

Albikovskaya, L. K. 1983. Feeding Characteristics of Wolffishes in the Labrador-Newfoundland Region. *NAFO Sci. Coun. Studies*, **6**: 35-38.

Amezaga, R. 1988. Análisis de los Contenidos Estomacales en Peces. Revisión Bibliográfica de los Objetivos y Metodología. *Inf. Tec. Ins. Esp. Oceanogr.*, **63**:74p.

Aydin, K. Y.; V. V. Lapko; V. I. Radchenko; and P. A. Livingston. 2002. A Comparison of the Eastern Bering and Western Bering Sea Shelf and Slope Ecosystems Through the Use of Mass-Balance Food Web Models. *NOAA Technical Memorandum* NMFS-AFSC-130.

Berestovskiy, E. G. 1989. Feeding in the Skates, *Raja radiata* and *Raja fyllae*, in the Barents and Norwegian Seas. *J. Ichthyol.* **29**:88-96

Bergstad, O. A.; Å. D. Wik; and Ø. Hildre. 2003. Predator-Prey Relationships and Food Sources of the Skagerrak Deep-Water Fish Assemblage. *J. Northw. Atl. Fish. Sci*., Vol. **31**: 165-180.

Bowman, R. E.; C. E. Stillwell; W. L. Michaels; and M. D. Grosslein. 2000. Food of Northwest Altlantic Fishes and Two Common Species of Squid. *NOAA Tech. Memo.* NMFS-NE-*155*.

Bruno, I; G. Costas; C. González; and X. Paz. 2000. Feeding Chronology of Yellowtail Flounder (*Limanda ferruginea*) and American Plaice (*Hippoglossoides platessoides*) on Grand Bank (NAFO Division 3N). *NAFO Sci. Coun. Studies*, **33**: 103–116.

Cargnelli, L. M.; S. J. Griesbach; D. B. Packer; P. L. Berrien; W. W. Morse; and D. L. Johnson. 1999. Essential Fish Habitat Source Document: Witch Flounder, *Glyptocephalus cynoglossus*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-139.

Dolgov, A. V. 2002. Feeding and Food Consumption by the Barents Sea Skates. *NAFO SCR Doc*. 02/93, Serial No. N4714.

Garrison, L. P. 2000. Spatial and Dietary Overlap in the Georges Bank Groundfish Community. *Can. J. Fish. Aquat. Sci.* **57**: 1679-1691.

Gibson, R. N. 2005. Flatfishes. Biology and Exploitation. *Edit.Blackwell Science*. 395p.

González C.; E. Román; and X. Paz. 2003. Food and Feeding Chronology of American Plaice (*Hippoglossoides platessoides*) in the North Atlantic. *NAFO SCR Doc*. 03/23, Serial No. N4832.

González C.; E. Román; and X. Paz. 2005. Condition and Feeding of American Plaice (*Hippoglossoides platessoides*) in the North Atlantic with Emphasis on Flemish Cap. *e-Journal of Northwest Atlantic Fishery Science*, Vol **37**, No. 8.

González Troncoso, D.; E. Román; and X. Paz. 2005. Results for Greenland Halibut of the Spanish Survey in NAFO Divisions 3NO: Biomass, Length Distribution and Age Distribution for the Period 1997-2004. *NAFO SCR Doc.* 05/27, Serial No. N5113.

Fahay, M. P.; P. L. Berrien; D. L. Johnson; and W. W. Morse. 1999. Essential Fish Habitat Source Document: Atlantic Cod, *Gadus morhua*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-124.

Hacunda, J. S. 1981. Trophic Relationships Among Demersal Fishes in a Coastal Area of the Gulf of Maine. *Fish. Bull*. Vol. **79**, No. 4: 775-788.

Hyslop, E. J. 1980. Stomach Contents Analysis- a Review of Methods and Their Application. *J. Fish. Biol*., **17**: 411-429.

Jobling, M. 1995. Environmental Biology of Fishes. *Edit. Chapman & Hall*. London, 455p.

Johnson, D. L.; P. L. Berrien; W. W. Morse; and J. J. Vitaliano. 1999a. Essential Fish Habitat Source Document: American Plaice, *Hippoglossoides platessoides*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-123.

Johnson, D. L.; W. W. Morse; P. L. Berrien; and J. J. Vitaliano. 1999b. Essential Fish Habitat Source Document: Yellowtail Flounder, *Limanda ferruginea*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-140.

Krebs, C. J. 1989. Ecological Methodology. *Edit. Harper Collins Publishers*. 666p.

Langton, R. W. 1982. Diet Overlap Between Atlantic Cod, *Gadus morhua*, Siver Hake, *Merluccius bilinearis*, and Fifteen Other Northwest Atlantic Finfish. *Fish. Bull*. Vol. **80**, No. 4: 745-759.

Langton, R. W. 1983. Food Habits of Yellowtail Flounder, *Limanda ferruginea* (Storer), from off the Northeastern United States. *Fishery Bulletin*, Vol **81** No. 1, p 15-22.

Link, J. S.; K. Bolles; and C. G. Milliken. 2002. The Feeding Ecology of Flatfish in the Northwest Atlantic. *J. Northw. Atl. Fish. Sci*., Vol **30**: 1-17.

Methven, D. A. 1999. Annotated Bibliography of Demersal Fish Feeding with Emphasis on Selected Studies from the Scotian Shelf and Grand Banks of the Northwestern Atlantic. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2267.

Morissette, L.; S.-P. Despatie; C. Savenkoff; M. O. Hammill; H. Bourdages; and D. Chabot. 2003. Data Gathering and Input Parameters to Construct Ecosystem Models for the Northern Gulf of St. Lawrence (mid-1980s). *Can. Tech. Rep. Fish. Aquat. Sci*. 2497: vi+94 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.

Orr, D. C.; and W. R. Bowering. 1997. A Multivariate Analysis of Food and Feeding Trends among Greenland Halibut (*Reinhardtius hippoglossoides*) sampled in Davis Strait, during 1986. *ICES Journal of Marine Science*, **54**: 819-829.

Packer, D. B.; C. A. Zetlin; and J. L. Vitaliano. 2003a. Essential Fish Habitat Source Document: Thorny Skate, *Amblyraja radiata*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-178.

Packer, D. B.; C. A. Zetlin; and J. L. Vitaliano. 2003b. Essential Fish Habitat Source Document: Smooth Skate, *Malacoraja senta*, Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-177.

Paz, F. J. 1992. A Ecoloxía do Bacallau (*Gadus morhua*, Linneo) no Sul do Grande Banco de Terranova, Divisions 3NO da NAFO. Tesis Doctoral. Universidad de Santiago de Compostela (Spain).

Pedersen, S. A.; and F. Riget. 1993. Feeding Habits of Redfish (*Sebastes* spp.) and Greenland Halibut (*Reinhardtius hippoglossoides*) in West Greenland Waters. *ICES J. mar. Sci*., **50**:445-459.

Pikanowski, R. A.; W. W. Morse; P. L. Berrien; D. L. Johnson; and D. G. McMillan. 1999. Essential Fish Habitat Source Document: Redfish, *Sebastes* spp., Life History and Habitat Characteristics. *NOAA Technical Memorandum* NMFS-NE-132.

Pitt, T. K. 1973. Food of American Plaice (*Hippoglossoides platessoides*) from the Grand Bank, Newfoundland. *Journal Fisheries Research Board of Canada*, Vol. **30**, No.9:1261-1273.

Pitt, T. K. 1976. Food of Yellowtail Flounder on the Grand Bank and a Comparison with American Plaice. *ICNAF Research Bulletin* No. **12**:23-27.

Punzón, A; and M. A. Herrera. 1998. Feeding of *Centroscyllium fabricii* (Reinhardt, 1828) and the Influence of the Fishery on its Diet in Flemish Pass (NAFO Divisions 3LM). *NAFO SCR Doc*. 98/34, Serial No. N3021.

Rodríguez-Marín, E. 1995. Feeding Relationships of Demersal Fish in Flemish Cap in Summer, 1993-1994. *NAFO SCR Doc*., No. 104. Serial No. N2627.

Rodríguez-Marín, E.; A. Punzón; J. Paz; and I. Olaso. 1994. Feeding of Most Abundant Fish Species in Flemish Cap in Summer 1993. *NAFO SCR Doc*. 94/35 Serial No. N2403.

Rodríguez-Marín, E.; A. Punzón; and J. Paz. 1995. Feeding Patterns of Greenland Halibut (*Reinhardtius hippoglossoides*) in Flemish Pass (Northwest Atlantic). *NAFO Sci. Coun. Studies*, **23**:43-54.

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*. 97/37 Serial No. N2869.

Román, E.; C. González; and E. Ceballos. 2004. Food and Feeding of Most Abundant Fish Species in Flemish Cap. *NAFO SCR* Doc. 04/58 Serial No. N5018.

Templeman, W. 1982. Stomach Contents of the Thorny Skate, *Raja radiata*, from the Northwest Atlantic. *J. Nortw. Atl. Fish. Sci.* Vol **3**:123-126.

Templeman, W. 1985. Stomach Contents of the Atlantic Wolffish (*Anarhichas lupus*), from the Northwest Atlantic. *J. Nortw. Atl. Fish. Sci.* Vol **8**: 49-51.

Torres, P.; E. Rodríguez-Marín; and I. Loureiro. 2000. Preliminary Results from Feeding Analysis for the Most Abundant Demersal Fishes in Flemish Cap during Summer (1993-2000). *NAFO SCR Doc*. 00/60 Serial No. 4302.

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 (Spain). Facultad de Ciencias Biológicas. Departamento de Biología Fundamental.

Wallace Jr., R. K. 1981. An Assessment of Diet-Overlap Indexes. *Transactions of the American Fisheries Society* **110**: 72-76.

Wootton, R. J. 1999. Ecology of Teleost Fishes. *Edit. Kluwer Ac. Publish.* London, 386 pp.

Table 1. Percentage of fish total catch of the fish species studied (Spanish Bottom Trawl Research Survey *Platuxa*, NAFO, Div. 3NO, 2002-2005).

	Percentage of the fish total catch			
	2002	**2003**	**2004**	**2005**
R. fyllae	0.01	0.01	0.02	0.01
M. senta	0.00	0.02	0.01	0.01
B. spinicauda	0.19	0.06	0.17	0.08
A. minor	0.02	0.07	0.19	0.13
A. hyperborea	0.03	0.18	0.23	0.19
A. denticulatus	0.08	0.25	0.19	0.36
A. lupus	0.93	1.28	0.93	0.41
G. cynoglossus	0.98	1.43	0.87	0.53
C. fabricii	0.64	0.58	0.57	0.70
R. hippoglossoides	1.04	1.71	1.05	0.75
G. morhua	6.82	1.93	0.93	1.08
M. berglax	2.13	2.26	3.46	2.41
A. radiata	10.39	6.06	7.86	5.76
H. platessoides	22.38	31.83	23.10	17.87
L. ferruginea	34.98	25.73	25.44	19.34
Sebastes sp	6.79	7.90	12.24	38.74
Total	87.4	81.3	77.3	88.3

Table 2. No. individuals of the different fish species sampled (NAFO, Div. 3NO, 2002-2005).

Specie	Length		Size ranges (cm)	No. individuals sampled				
	Min.	Max.		2002	2003	2004	2005	*Total*
Anarhichas denticulatus	20	111	20-29 to≥80	14	39	48	88	*189*
Anarhichas lupus	6	124	0-9 to ≥100	189	166	150	285	*790*
Anarhichas minor	11	102	10-19 to ≥90	4	9	65	36	*114*
Amblyraja hyperborea	10	104	<30 to ≥90	5	24	45	41	*115*
Amblyraja radiata	10	95	10-19 to >=80	634	876	570	522	*2 602*
Bathyraja spinicauda	18	150	<40 to ≥120	11	9	17	10	*47*
Cestroscyllium fabricii	32	79	30-39 to 70-79	160	187	236	332	*915*
Coryphaenoides rupestris	2.5	22	0-4.5 to 15-19.5	232	284	263	221	*1 000*
Glyptocephalus cynoglossus	6	61	0-9 to≥50	419	581	278	350	*1 628*
Gadus morhua	9	106	<20 to ≥90	400	303	522	489	*1 714*
Hipoglossoides platessoides	5	72	0-9 to ≥60	2 237	2 526	709	706	*6 178*
Limanda ferruginea	5	60	0-9 to >=50	645	777	527	536	*2 485*
Macrourus berglax	2.5	39	0-4.5 to 30-34.5	388	594	677	568	*2 227*
Malacoraja senta	24	60	20-29 to 60-69	1	13	7	9	*30*
Reinhardtius hippoglossoides	8	96	0-9 to ≥70	855	994	636	546	*3 031*
Rajella fyllae	9	55	<20 to 50-59	7	9	25	21	*62*
Sebastes sp	5	59	0-9 to ≥40	485	498	372	435	*1 790*
Total				*6 686*	*7 889*	*5 147*	*5 195*	*24 917*

Table 3. Characteristics of the Spanish Bottom Trawl Research Survey *Platuxa* 2002-2005 and stomach content sampling in Div. 3NO (NAFO).

Data of Spanish Bottom Trawl Research Survey *Platuxa*						Data of stomach content sampling		
RV/	Year	Gear	Date	No. valid hauls	Depth range (m)	No. samples	No. individuals	Depth range (m)
Vizconde de Eza	2002	*Campelen 1800*	29/04 to 19/05	125	38 – 1 540	117	6 686	38 – 1 449
Vizconde de Eza	2003	*Campelen 1800*	11/05 to 02/06	118	38 – 1 666	110	7 893	38 – 1 476
Vizconde de Eza	2004	*Campelen 1800*	06/06 to 24/06	120	43 – 1 460	113	5 147	43 – 1 403
Vizconde de Eza	2005	*Campelen 1800*	10/06 to 29/06	119	47 – 1 438	118	5 195	47 – 1 438

Table 4. No. individuals sampled and Feeding Intensity (%) by species, sex and year (NAFO, Div. 3NO, 2002-2005). (*)Total = males+females+indeterminates.

Specie	Year	Male		Female		Total (*)		Specie	Year	Male		Female		Total (*)	
		No. Indiv	FI (%)	No. Indiv	FI (%)	No. Indiv	FI (%)			No. Indiv	FI (%)	No. Indiv	FI (%)	No. Indiv	FI (%)
Sebastes sp	2002	249	44.2	221	30.8	485	39.0	*G. morhua*	2002	195	49.7	205	57.1	400	53.5
	2003	232	50.9	220	40.9	498	48.4		2003	147	79.6	156	83.3	303	81.5
	2004	152	88.8	167	80.2	372	83.6		2004	248	90.7	235	88.9	522	90.6
	2005	190	67.4	213	72.8	435	72.2		2005	236	91.5	214	92.1	489	91.8
	Total	*823*	*59.7*	*821*	*54.4*	*1 790*	*58.9*		*Total*	*826*	*79.3*	*810*	*80.6*	*1 714*	*80.7*
H. platessoides	2002	776	42.7	1 461	36.8	2 237	38.8	*L. ferrugiena*	2002	222	86.0	417	86.1	645	86.0
	2003	880	61.0	1 638	45.6	2 526	51.1		2003	273	86.8	496	83.7	777	84.3
	2004	226	66.8	373	67.6	709	70.4		2004	229	77.3	291	84.2	527	81.4
	2005	248	67.7	424	66.3	706	67.1		2005	251	66.9	271	73.8	536	70.3
	Total	*2 130*	*55.7*	*3 896*	*46.6*	*6 178*	*50.7*		*Total*	*975*	*79.3*	*1 475*	*82.6*	*2 485*	*81.2*
R. hippoglossoides	2002	341	43.4	513	42.5	855	42.9	*G. cynoglossus*	2002	161	79.5	235	78.3	419	80.0
	2003	379	49.6	615	44.1	994	46.2		2003	213	83.1	365	83.3	581	83.0
	2004	283	29.0	350	35.7	636	33.0		2004	102	95.1	169	93.5	278	94.2
	2005	239	47.7	307	44.0	546	45.6		2005	120	95.8	183	95.6	350	94.0
	Total	*1 242*	*42.8*	*1 785*	*42.0*	*3 031*	*42.4*		*Total*	*596*	*86.7*	*952*	*86.2*	*1 628*	*86.5*
C. rupestris	2002	117	55.6	115	69.6	232	62.5	*M. berglax*	2002	180	65.0	206	66.5	388	65.7
	2003	132	52.3	151	61.6	284	57.4		2003	222	77.5	370	68.4	594	71.9
	2004	113	91.2	110	90.9	263	91.6		2004	254	74.4	370	78.6	677	78.4
	2005	107	82.2	93	81.7	221	83.3		2005	200	68.5	323	66.3	568	67.6
	Total	*469*	*69.3*	*469*	*74.4*	*1 000*	*73.3*		*Total*	*856*	*71.8*	*1 269*	*70.5*	*2 227*	*71.7*
A. denticulatus	2002	9	44.4	5	60.0	14	50.0	*A. lupus*	2002	100	33.0	88	29.5	189	31.2
	2003	21	42.9	18	33.3	39	38.5		2003	85	52.9	81	54.3	166	53.6
	2004	29	27.6	19	36.8	48	31.3		2004	75	58.7	71	73.2	150	66.0
	2005	41	56.1	47	44.7	88	50.0		2005	138	63.8	139	59.0	285	61.8
	Total	*100*	*44.0*	*89*	*41.6*	*189*	*42.9*		*Total*	*398*	*52.8*	*379*	*53.8*	*790*	*53.5*
A. minor	2002	3	33.3	1	100	4	50.0	*A. radiata*	2002	300	63.7	334	68.9	634	66.4
	2003	4	0.0	5	60.0	9	33.3		2003	417	64.3	459	71.9	876	68.3
	2004	28	57.1	36	58.3	65	58.5		2004	276	85.9	294	80.6	570	83.2
	2005	20	70.0	14	64.3	36	66.7		2005	241	83.0	281	84.0	522	83.5
	Total	*55*	*56.4*	*56*	*60.7*	*114*	*58.8*		*Total*	*1234*	*72.6*	*1368*	*75.5*	*2602*	*74.1*
A. hyperborea	2002	3	66.7	2	100	5	80.0	*B. spinicauda*	2002	6	83.3	5	20.0	11	54.5
	2003	11	90.9	13	76.9	24	83.3		2003	2	0.0	7	57.1	9	44.4
	2004	17	76.5	28	85.7	45	82.2		2004	9	77.8	8	87.5	17	82.4
	2005	28	82.1	13	84.6	41	82.9		2005	4	75.0	6	83.3	10	80.0
	Total	*59*	*81.4*	*56*	*83.9*	*115*	*82.6*		*Total*	*21*	*71.4*	*26*	*65.4*	*47*	*68.1*
R. fyllae	2002	2	100	5	100	7	100	*M. senta*	2002			1	100	1	100
	2003	3	100	6	83.3	9	88.9		2003	7	100	6	83.3	13	92.3
	2004	12	91.7	13	69.2	25	80.0		2004	4	100	3	100	7	100
	2005	7	71.4	14	92.9	21	85.7		2005	4	100	5	80.0	9	88.9
	Total	*24*	*87.5*	*38*	*84.2*	*62*	*85.5*		*Total*	*15*	*100*	*15*	*86.7*	*30*	*93.3*
C. fabricii	2002	92	69.6	68	73.5	160	71.3								
	2003	84	59.5	103	76.7	187	69.0								
	2004	123	78.0	113	80.5	236	79.2								
	2005	156	85.9	176	81.3	332	83.4								
	Total	*455*	*75.6*	*460*	*78.9*	*915*	*77.3*								

Table 5. Niche breadth of each fish species and niche overlap in some fish species studied by depth range (NAFO, Div. 3NO, 2002-2005). Value marked indicates extreme values of niche breadth index using the three measures and mean.

Niche breadth (Levins´ Measure, *B*)				**Mean Niche Breadth**
Species	***B (1)***	***B (2)***	***B (3)***	
Rajella fyllae	1.57	2.91	1.32	1.9
Glyptocephalus cynoglossus	1.90	2.89	1.28	2.0
Coryphaenoides rupestris	4.97	1.29	1.83	2.7
Anarhichas denticulatus	2.52	2.17	3.44	2.7
Limanda ferruginea	4.38	3.52	1.43	3.1
Anarhichas minor	4.38	3.66	1.86	3.3
Bathyraja spinicauda	5.26	4.27	0.50	3.3
Hipoglossoides platessoides	5.06	1.59	3.87	3.5
Amblyraja radiata	3.94	4.07	3.94	4.0
Malacoraja senta	9.40	2.58	0.40	4.1
Gadus morhua	5.04	3.92	4.02	4.3
Sebastes sp	8.65	2.17	2.27	4.4
Amblyraja hyperborea	9.39	4.49	0.90	4.9
Anarhichas lupus	6.93	4.99	3.11	5.0
Macrourus berglax	7.00	5.55	3.11	5.2
Reinhardtius hippoglossoides	7.35	4.72	7.18	6.4
Cestroscyllium fabricii	11.58	8.67	3.50	7.9

B (1): using diet measures in percentage of total weight

B (2): using diet measures in percentage of total number

B (3): using diet measures in percentage of occurrence

Mean Niche Breadth: mean of the three previous values

Niche overlap (Simplified Morisita Index, C_H)			
Depth range (m)	***R. fyllae - G. cynoglossus***	***G. morhua - A. radiata***	***H. platessoides - L. ferruginea***
≤199	0.99	0.94	0.86
200-399		0.69	
400-599	0.91	0.89	
600-799	0.87	0.65	
800-999	1	0.19	
1000-1199	0.99	0.72	
≥1200	0.99	0.04	

Table 6. Prey (% weight) by fish species (NAFO, Div. 3NO, 2002-05). (*) means <1%.

Prey	*R. fyllae*	*G. cynoglossus*	*A. denticulatus*	*L. ferruginea*	*M. berglax*	*A. lupus*	*A. minor*	*H. platessoides*	*A. hyperborea*	*A. radiata*	*G. morhua*	*C. fabricii*	*Sebastes sp*	*M. senta*	*R. hippoglossoides*	*B. spinicauda*	*C. rupestris*
Other Groups (total)	***80.8***	***78.1***	***63.0***	***24.0***	***45.2***	***19.0***	***0.1***	***4.2***	***4.7***	***5.3***	***1.6***	***14.6***	***9.6***	***2.7***	***0.3***	***1.4***	***0.7***
Annelida	79.5	76.9	*	15.4	11.6	*	*	*	4.2	4.3	*	*	*	2.7	*	*	*
Anthozoa		*		7.5	*	*	*	*		*	*						
Aphroditidae		*			*	3.2		*		*	*						
Ascidiae		*		1.0	*	*		*		*	*						
Bryozoa	1.3																
Chaetognatha		*	*	*	0.0	*		*	*	*	*	*	1.6		*		*
Cnidaria				*							0.0						
Ctenophora		*	59.7	*	*	15.4		2.5		*	*	1.1	4.7				*
Priapulida					*												
Porifera					*			*			*				*		
Scyphozoa		*	3.1		32.7			*	*	*	*	13.4	3.3		*	*	*
Picnogonidae					*						*						
Sipunculida		*		*	*			*			*						
Mollusca (total)		***0.9***	***0.3***	***2.1***	***6.4***	***48.3***	***0.7***	***14.2***	***2.4***	***0.4***	***3.2***	***6.5***	***1.6***		***18.4***	***3.3***	***2.4***
Polyplacophora						*											
Gastropoda (total)		***0.0***		***0.1***	***1.1***	***45.0***	***0.7***	***0.2***		***0.2***	***0.3***	***0.1***	***0.1***				
Buccinum sp						19.8				*							
Scaphopoda		*															
Opisthobranchia						*		*									
Gastropoda indet.		*		0.1	1.1	25.2	*	*		*	*	*	*				
Bivalvia (total)		***0.7***		***1.9***	***0.7***	***3.3***	***0.0***	***14.0***		***0.0***	***0.6***					***0.5***	
Bivalvia indet.		*		1.8	*	2.7		7.3		*	*					*	
Lutraria sp				*				6.7			*						
Pectinidae		*				*	*										
Cephalopoda (total)			***0.3***	***0.2***	***4.5***			***0.0***	***2.4***	***0.2***	***2.3***	***6.4***	***1.5***		***18.4***	***2.8***	***2.4***
Semirossia sp					*												
Sepiolidae													*				
Illex illecebrosus					*				*	*	1.0	1.0			1.0		
Octopoda			*		*				1.3	*		*					
Histioteuthis sp															*		
Bathypolypus arcticus										*							
Bathypolypus sp					1.1												
Oegopsida					1.7					*	*	*	*		7.4		
Unid. Dec. Cephal.												*			5.2	2.8	1.2
Unid. Cephalopoda				0.2	*			*	*	*	1.0	4.4	1.0		4.1		1.3
Echinodermata (total)		***4.6***	***2.7***	***1.3***	***2.1***	***15.9***	***64.8***	***14.1***		***0.1***	***0.6***	***0.0***					
Asteroidea			*		*	*	13.7			*							
Crinoidea				*				*									
Echinoidea				*	*	*				*	*						
Echinarachnius parma				*	*	6.4	41.0	4.6									
Holothurioidea				*	*	*		*		*	*						
Ophiuroidea		4.6	2.1	*	1.0	4.4	6.9	9.3		*	*	*					
Unid. Echinodermata			*	*	*	4.3	3.2			*	*	*					

Table 6 (cont.). Prey (% weight) by fish species (NAFO, Div. 3NO, 2002-05). (*) means <1%.

Prey	***R. fyllae***	***G. cynoglossus***	***A. denticulatus***	***L. ferruginea***	***M. berglax***	***A. lupus***	***A. minor***	***H. platessoides***	***A. hyperborea***	***A. radiata***	***G. morhua***	***C. fabricii***	***Sebastes sp***	***M. senta***	***R. hippoglossoides***	***B. spinicauda***	***C. rupestris***
Crustacea (total)	***13.2***	***11.5***	***6.3***	***26.7***	***17.6***	***13.6***	***7.0***	***14.1***	***25.2***	***34.3***	***30.6***	***48.1***	***68.9***	***71.5***	***9.3***	***4.7***	***94.1***
Cumacea		*		*	*			*		*			*				*
Euphausiacea	*	*	*	*	*	*	*	*	4.0	*	1.0	3.3	19.8	*	*	*	*
Isopoda		*		*	*	*		*		*	*					*	
Maxilopoda (total)		***0.0***		***0.0***	***0.0***	***0.0***		***0.0***		***0.0***	***0.0***		***10.5***		***0.0***		***28.3***
Copepoda		*		*	*	*		*		*	*		10.5		*		28.3
Unid. Maxilopoda											*						
Mysidacea	*	*		7.5	*	*		9.7	4.2	*	1.6	*	1.0	5.3	*	*	*
Ostracoda																	*
Amphipoda (total)	***9.6***	***10.6***	***4.8***	***18.4***	***1.3***	***0.4***	***0.0***	***1.7***	***5.1***	***4.1***	***8.4***	***0.1***	***21.4***	***9.9***	***2.0***	***2.6***	***0.9***
Gammaridea	5.4	10.5		18.0	*	*		1.3	*	3.5	1.9	*	*	9.4	*	1.6	*
Caprellidae		*	*	*	*	*		*		*	1.5		*				
Hyperiidea	4.2	*	4.6	*	*	*	*	*	4.6	*	5.0	*	21.2	*	1.9	1.0	*
Unid. Amphipoda		*		*		*		*		*							
Decapoda Natantia (total)	***2.7***		***1.1***	***0.0***	***12.6***	***0.5***	***0.4***	***0.3***	***6.4***	***1.7***	***6.5***	***29.8***	***12.8***	***23.2***	***5.5***	***1.2***	***39.1***
Acanthephyra pelagica									1.1			1.3	*				
Acanthephyra purpurea			*									*			*		
Acanthephyra sp					*				1.1		*	11.7	*		*		2.1
Argis dentata								*		*	*			5.3	*		
Metacrangon jacqueti						*					*				*		*
Gennades sp									*		*		*				*
Lebbeus polaris						*				*	*						
Pandalus borealis				*	1.8	*	0.4	*		*	5.0	*	2.5	3.0	*		
Pandalus montagui						*											
Pandalus propinquus										*			*	3.3			
Pasiphaeidae	1.2				*				*	*	*	3.1	3.3		1.0		6.2
Pasiphaea tarda					8.9				*	*	*	7.8	*		4.0		27.8
Pontophilus norvegicus										*	*		*	7.5	*	*	
Sabinea hystrix											*		*		*		
Sergestes arcticus	1.6		*		*	*			1.7	*	*	2.1	4.2	1.3	*	1.0	1.5
Sergia robusta			*						*		*	1.4	*		*		*
Spirontocaris lilljeborgi											*						
Spirontocaris spinosus					*					*							
Unid. and dig. Natantia			*	*	*			*	1.5	*	*	1.9	*	2.7	*		*
Decapoda Reptantia												*					
Decapoda Brach. (total)		***0.0***	***0.2***	***0.1***	***1.5***	***4.1***	***6.4***	***1.5***	***1.2***	***26.5***	***12.3***	***0.1***	***0.1***	***25.1***		***0.1***	
Chionocetes opilio			*	*	1.0	2.3	4.1	1.3		23.2	10.8			23.2			
Neolithodes grimaldi									1.2								
Hyas sp			*		*	1.8	2.3	*		2.9	1.2			1.5			
Unid. and dig. Brachyura		*		*	*	*		*		*	*	*	*	*		*	
Dec. Anomura (Pag.)				*		8.5		*		1.1	*			*			
Unid. and dig. Crustacea	*	*	*	*	*	*	*	*	1.7	*	*	6.6	2.5	5.1	*	*	24.4

Table 6 (cont.). Prey (% weight) by fish species (NAFO, Div. 3NO, 2002-05). (*) means <1%.

	R. fyllae	*G. cynoglossus*	*A. denticulatus*	*L. ferruginea*	*M. berglax*	*A. lupus*	*A. minor*	*H. platessoides*	*A. hyperborea*	*A. radiata*	*G. morhua*	*C. fabricii*	*Sebastes sp*	*M. senta*	*R. hippoglossoides*	*B. spinicauda*	*C. rupestris*
Pisces (total)		***4.0***	***25.8***	***44.6***	***27.7***	***2.4***	***27.4***	***53.0***	***43.4***	***58.1***	***63.5***	***23.6***	***19.6***	***25.6***	***69.5***	***90.4***	***1.8***
Aspidophoroides monopterygius										*							
Ammodytes dubius		3.6		41.0	4.9	*		39.3		42.8	39.7	*	1.7		3.9		
Ammodytes sp						*				*							
Anarhichas denticulatus										*							
Anarhichas lupus					*					*							
Anarhichas sp											*						
Antimora rostrata															3.9		
Argyropelecus hemigymnus													*	3.8			
Artediellus atlanticus										*	*						
Batilagus euriops												*			*		
Benthosema glaciale			*								*				*		
Boreogadus saida										*							
Borostomias antarcticus															*		
Ceratias holboelli												*				1.0	
Ceratoscopelus maderensis										*							
Chauliodus sloani											*						
Corypheanoides rupestris					*							*			2.3		
Cottunculus microps							*		*								
Cyclothone sp												*					
Gadus morhua															*		
Gaidropsarus ensis					*		4.9			*					6.2		1.6
Glyptocephalus cynoglossus										*							
Gonostomatidae												*					
Hippoglossoides platessoides				*		*		*		*	*						
Fish larva				*		*		*		*	*		*		*		
Leptagonus (agonus) decagonus										*							
Limanda ferruginea										*	*						
Liparidae			*	*	*			1.2		*	*			*	*		
Lophius sp										*							
Lumpenus lumpretaeformis					*			*		*	*				*		
Lycodes polaris											*						
Lycodes reticulatus										*	*						
Lycodes sp								*			*						
M. atlanticum															*		
Macrourus berglax			5.8		*				7.2	*	*				1.6	19.7	
Macruridae					1.6					*			*		2.4	4.2	
Malacosteus niger													*		*		
Mallotus villosus				0.3	7.5	*		10.8		2.9	13.2		3.8	7.5	30.4		
Myctophidae			*					*		*		*	1.1		*		
Nezumia bairdi					2.4			*	2.5	*	*				1.6		
Notolepis risso					*							*	*				
Phycis sp																	
Pleuronectiformes								*		*	*		*		*		
Protomyctophum arcticum															*		
Rajidae										*							
Reinhardtius hippoglossoides			*					*			*					18.5	
Sebastes marinus				*				*									
Sebastes sp			18.3			*	17.0	*	12.5	2.9	3.8	5.0			*	27.5	
Serrivomer beani													*				
Stomias boa													*				
Synaphobranchus kaupi					2.4												
Triglops murrayi								*		*	*						
Tryglops sp				*				*		*	*				*		
Urophycis sp.											*						
Urophycis tenuis							4.9										
Unid. and dig. fish		*	*	2.4	7.3	*	*	*	21.1	4.8	3.5	16.5	10.1	13.4	15.0	19.6	*
Other preys	**6.0**	**0.7**	**1.9**	**1.2**	**1.0**	**0.8**		**0.3**	**24.3**	**1.7**	**0.6**	**7.0**	**0.4**	**0.2**	**2.6**	**0.2**	**0.9**
Offal			1.1					*	22.6	1.2	*	3.7			2.1		
Eggs	*		*	*	*	*		*	*	*	*	*			*		
Vitelo	2.7							*									
Vegetal				*							*						
Unidentified	2.5	*	*	1.2	1.0	*		*	1.4	*	*	3.3	*	*	*	*	*
No. indivs. sampled	**62**	**1628**	**189**	**2485**	**2227**	**790**	**114**	**6178**	**115**	**2602**	**1714**	**915**	**1790**	**30**	**3031**	**47**	**1000**
No. of preys	**12**	**28**	**28**	**43**	**59**	**46**	**19**	**56**	**29**	**78**	**76**	**42**	**43**	**22**	**54**	**21**	**25**

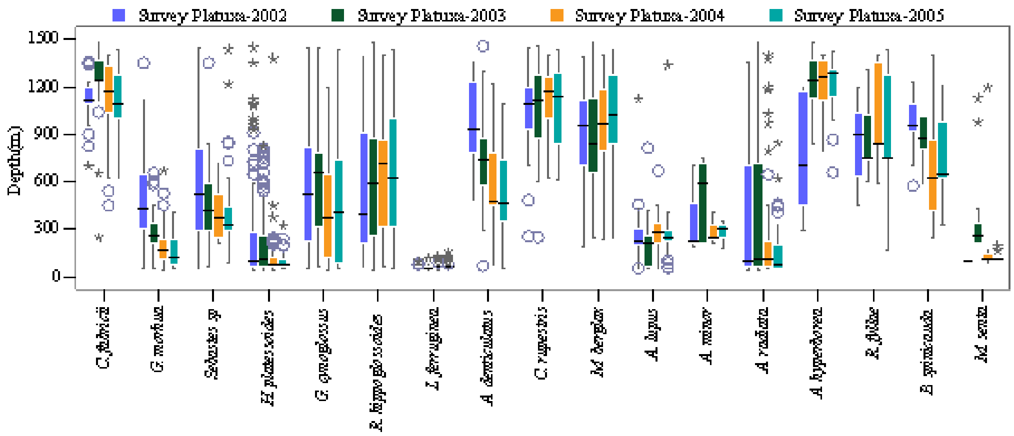

Fig. 1. Depth (m), median, extreme values and outliers of samplings of each fish species (NAFO, Div. 3NO, 2002-2005).

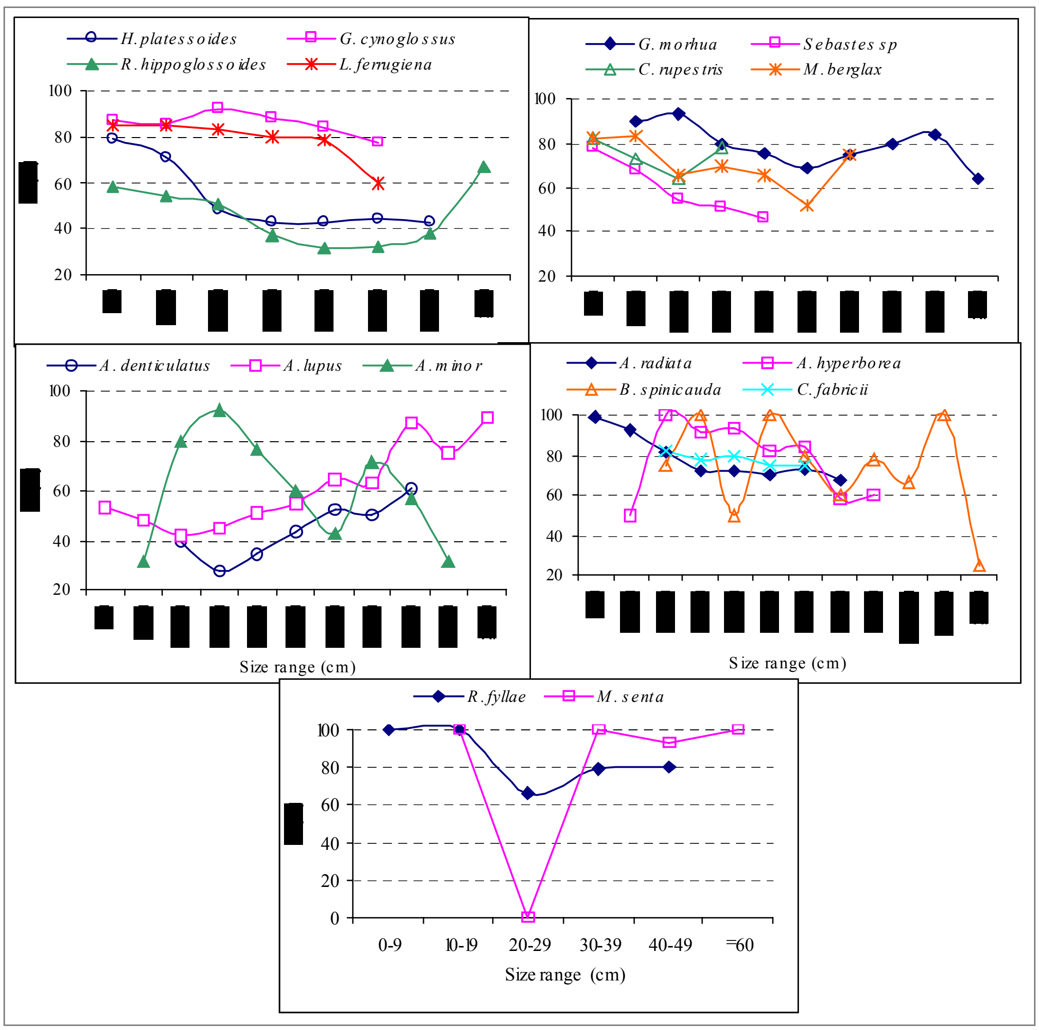

Fig 2. Feeding Intensity (%FI) by size range (cm) in each fish species (NAFO, Div. 3NO, 2002-2005).

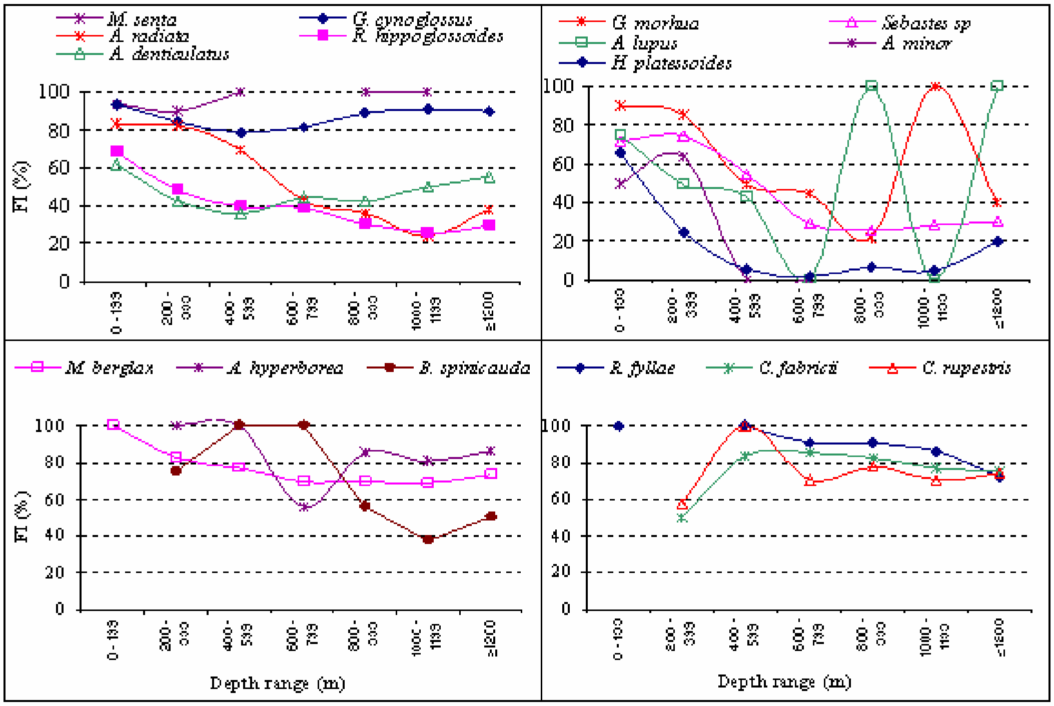

Fig. 3. Feeding Intensity (%FI) by depth range (m) in each fish species (NAFO, Div. 3NO, 2002-2005).

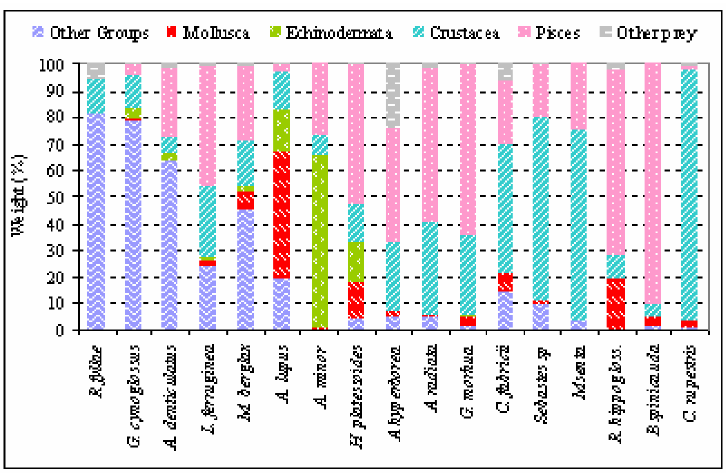

Fig. 4. Weigh (%) of the group prey in each fish species (NAFO, Div. 3NO, 2002-2005).

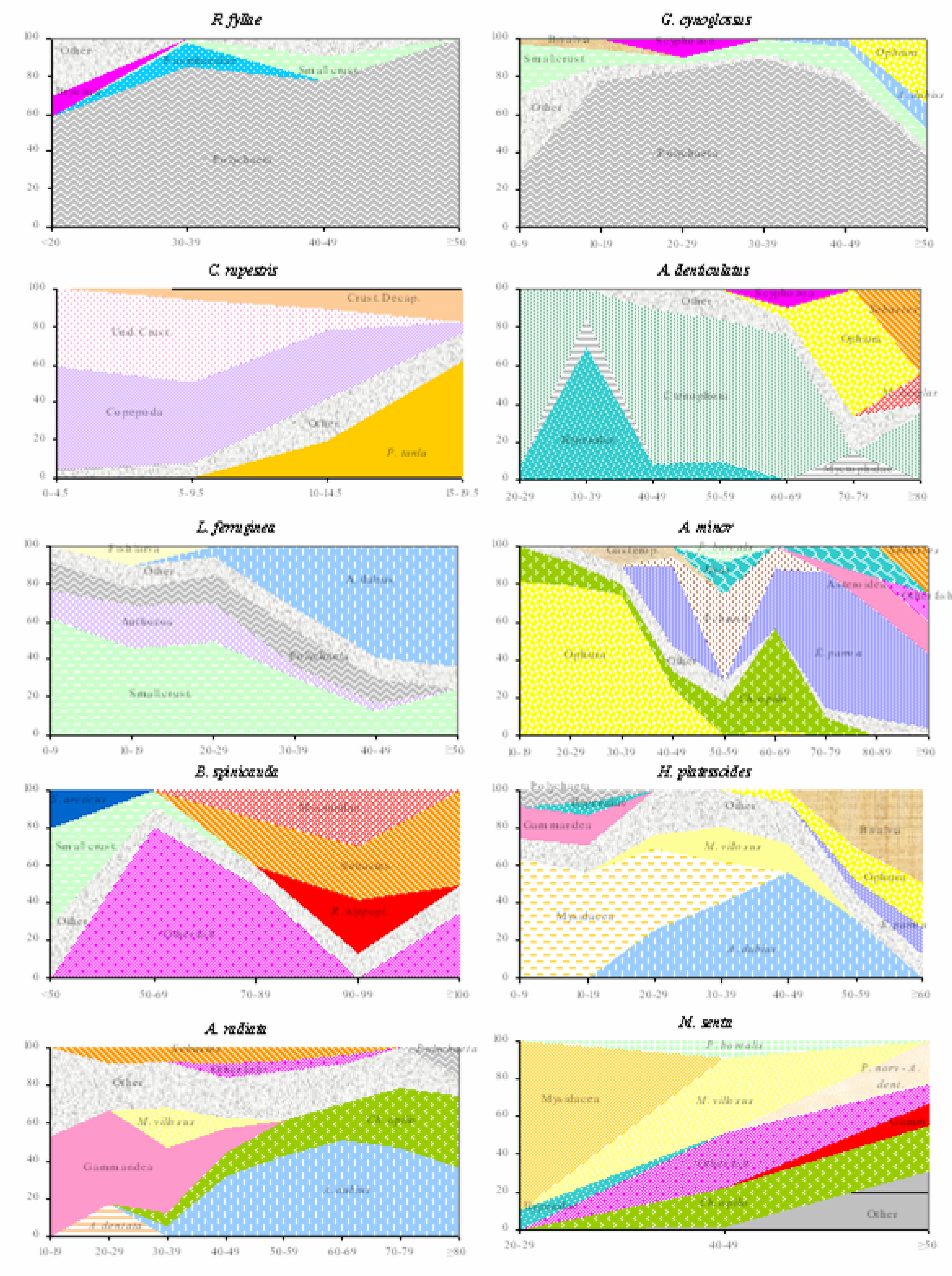

Fig. 5. Weigh (%) of the main prey in each predator species by size range (cm) (NAFO, Div. 3NO, 2002-2005).

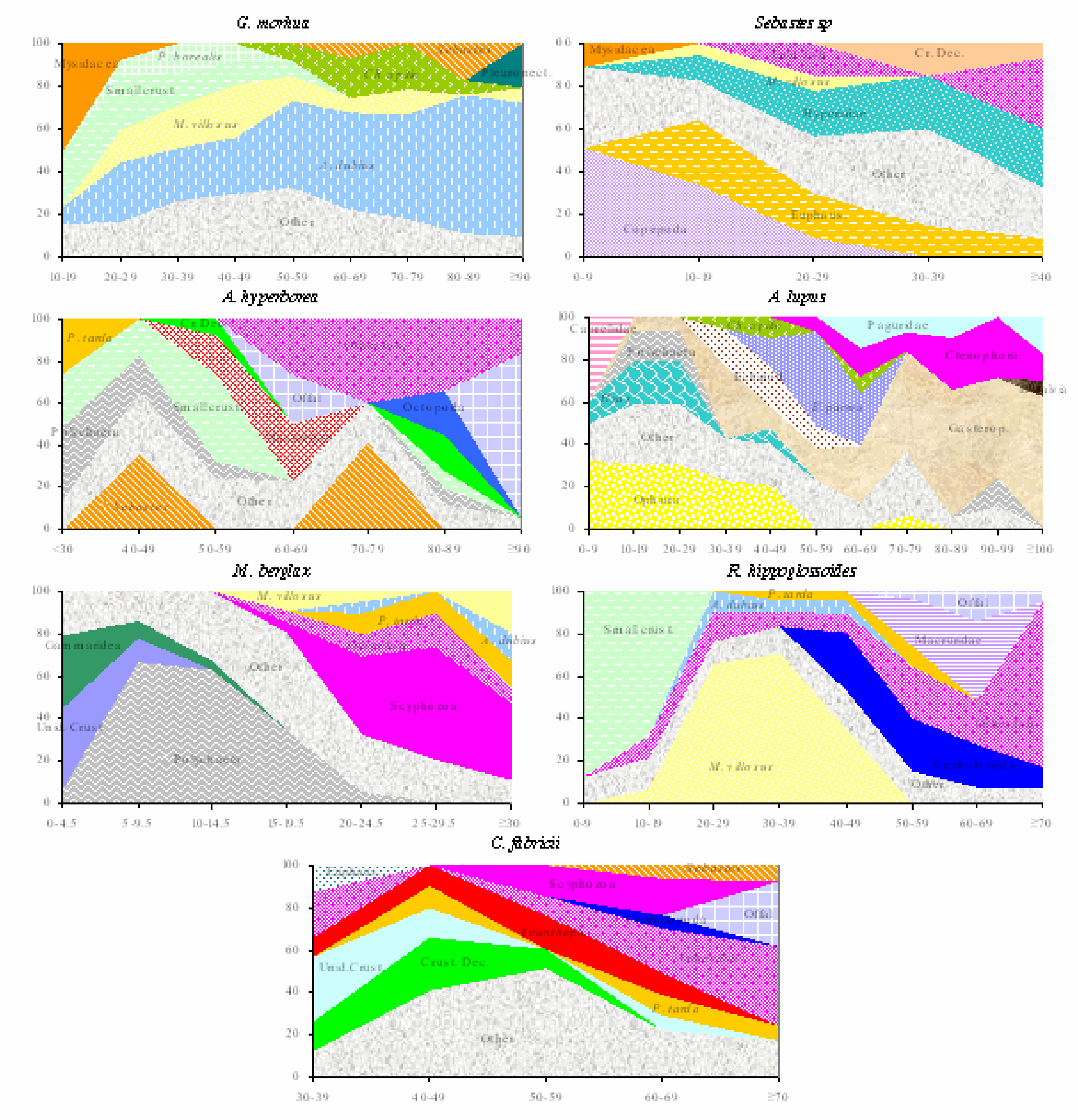

Fig. 5 (cont.). Weigh (%) of the main prey in each predator species by size range (cm) (NAFO, Div. 3NO, 2002-05).

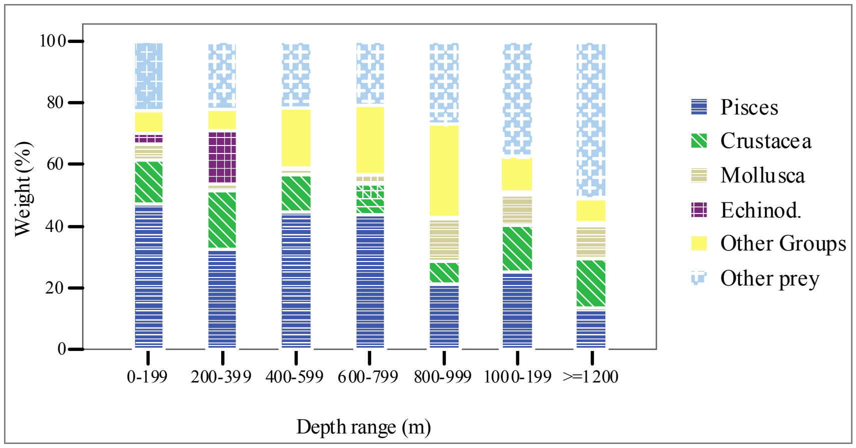

Fig. 6. Weight (%) of the group prey by size range (m) in all predator species combined (NAFO, Div. 3NO, 2002-2005).

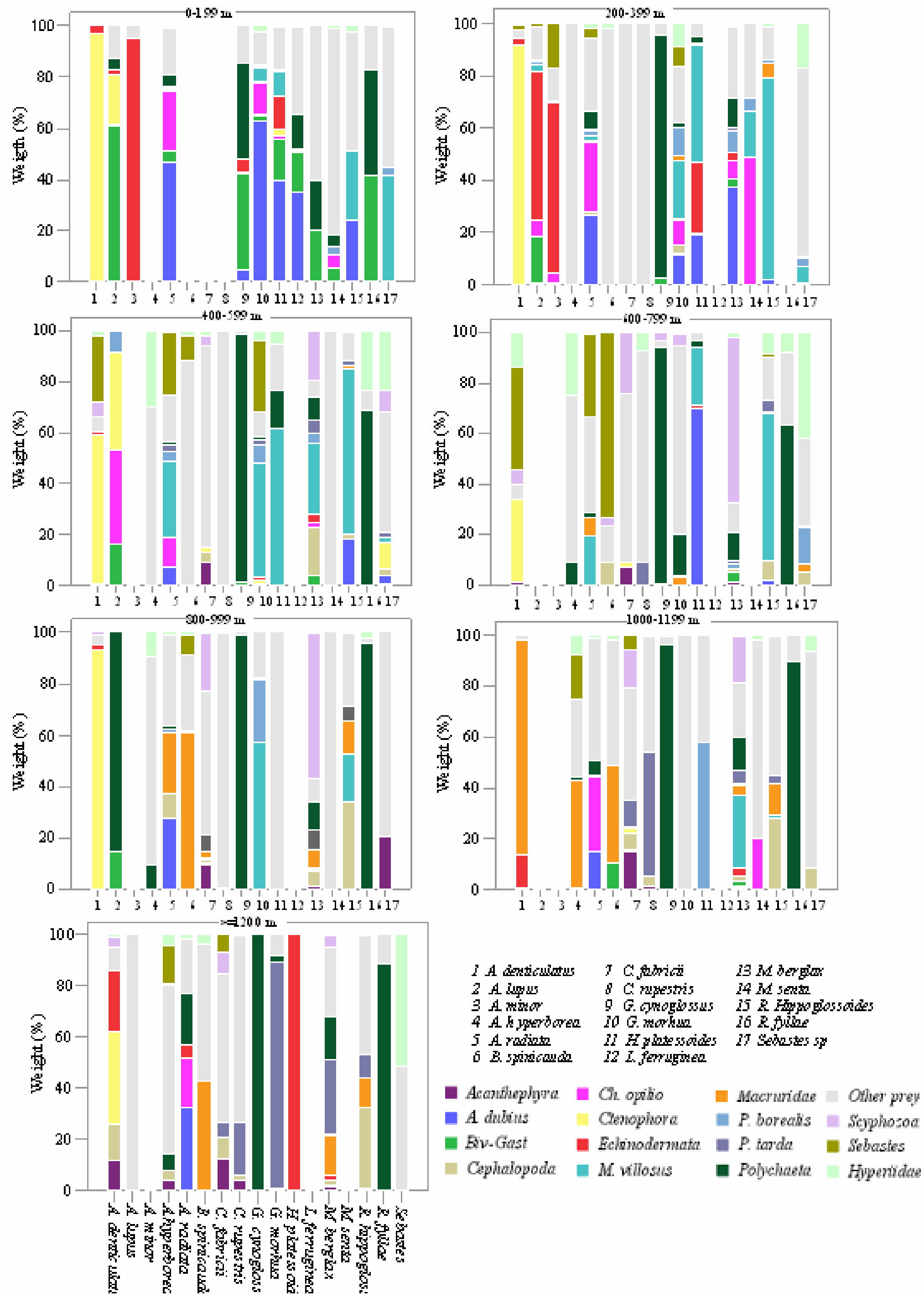

Fig. 7. Weight (%) of main prey by range depth (m) for 17 fish species studied (NAFO, Div. 3NO, 2002-2005).