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Feeding Habits and Diet Overlap of Skates (*Amblyraja radiata*, *A. hyperborea*, *Bathyraja spinicauda*, *Malacoraja senta* and *Rajella fyllae*) in the North Atlantic

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Abstract

The contents of 5 061 stomach of five skate species - thorny (*Amblyraja radiata*), Arctic (*A. hyperborea*), spinytail (*Bathyraja spinicauda*), smooth (*Malacoraja senta*) and round skates (*Rajella fyllae*) obtained from Spanish Bottom Trawl Research Surveys in northwest and northeast Atlantic (NAFO, Divisions 3NO and Div. 3M; ICES, Div. IIb) in the period 1996-2005 were analyzed to study the feeding intensity and food habits.

Feeding intensity was high in all skate species and areas, slightly higher in Div. IIb, showing a general trend to decrease according to the predator size increase.

Importance of prey was based in weight percentage. The main prey groups for thorny and Arctic skates were Pisces and Crustacea, but the importance of each group and prey species changed with area. Pisces has turn out to be the dominant prey taxa for spinytail skate in Div. 3NO and 3M. Crustacea have been the dominant prey group for smooth skate. Round skate has changed its main prey group in each area, but polychaetes have been prominent in Div. 3NO. Predation on fishing processed remnant was important for Arctic skate. Predation on several species of commercial importance was mainly relevant in Div. 3M.

Intra-specific diet overlap showed a different pattern varying with skate species and area. Inter-specific diet overlap reached its highest level in the Arctic area. Thorny skate showed a high diet overlap with the majority of the skate species studied in the NAFO Area, and round skate did not show diet overlap with other skate species in Div. 3NO. Thorny skate appear as dominant predator in NAFO Div. 3NO.

Introduction

The drop of traditional resources in northwest Atlantic has led fishing activity to new bottoms and species. Skates, mainly thorny skate, have become an increasingly important fishing resource in the last years. A fishery focused in this species is developed in the second half of the year on Grand Bank (NAFO Regulatory Area, Div. 3NO) by vessels from several countries (Junquera and Paz, 1998; Vinnichenko *et al*., 2002). The drastic decrease of Atlantic cod (*Gadus morhua*) in the last decades in this area could have caused changes in the dynamics of species distributed there; their abundance and high predatory capacity had a great importance on Grand Bank ecosystem, and currently other species such as thorny skate could be taking their trophic place.

Feeding of thorny skate has been studied (Templeman, 1982; Rodríguez-Marín *et al*., 1994; Rodríguez-Marín, 1995; Bowman *et al*., 2000; Skjæraasen and Bergstad, 2000; Torres *et al*., 2000; Vinnichenko *et al*, 2002; Packer *et al*., 2003a; Román *et al*. 2004). However, studies on diet and feeding habits of other skate species distributed in the north Atlantic are scarce (McEachran *et al*., 1976; Berestovskiy, 1989; Bowman *et al*., 2000; Dolgov, 2002; Packer *et al*. 2003b). This fact is probably due to the limited commercial interest and catches of these skate species. However, the knowledge of complementarily or competition among the different skate species is nevertheless interesting for the management of thorny skate and other fish resources where skates are predators.

Diet study of five skate species distributed on both sides of north Atlantic is presented: thorny (*A. radiata*), Arctic (*A. hyperborea*), spinytail (*B. spinicauda*), smooth (*M. senta*) and round skates (*R. fyllae*). Spatial and size range variation in food habits was examined. Intra-specific and inter-specific diet overlaps in each area were analyzed.

Four of these skate species are distributed in both sides of the north Atlantic. Thorny skate, in the northwestern Atlantic, ranges from western Greenland, Daves Straits, Hudson straits, Hudson Bay and Labrador to South Carolina. In the northeastern Atlantic, it ranges from Iceland, eastern Greenland, Barents Sea and off the coast of Spitzbergen to the English Channel and the southwestern coasts of Ireland and England, and from the White Sea and Barents Sea to the North Sea, Dutch coast, and western part of Baltic. And in the eastern South Atlantic it is found off South Africa (Packer *et al*., 2003a). Arctic or northern skate is distributed in the northwest Atlantic: Davis Strait between southwestern Greenland and Canada. In the northeast Atlantic: Spitsbergen to the Greenland-Iceland-Faroe-Shetland Ridge to northern Norway. Spinytail skate occurs in the western Atlantic in the Greenland side of Davis Strait and off the east coast of Newfoundland, Canada to off Georges Bank. In the eastern Atlantic: Barents Sea, Norway, Iceland-Faroes-Shetland Rise and eastern Greenland. Round skate is distributed in northeast Atlantic from Spitsbergen to southern Norway, southern Greenland, Iceland, Faeroe Islands to Shetlands, western coasts of British Isles and Bay of Biscay; and in the northwest Atlantic it occurs from Greenland to Nova Scotia. Smooth skate occurs in northwest Atlantic. It is boreal species whose center of abundance is in the Gulf of Maine, but it occurs along the north Atlantic coast from the Gulf of St. Lawrence and Labrador Shelf to South Caroline (Packer *et al*., 2003b).

Material and Methods

Individuals sampled were taken in the NAFO Area Div. 3NO by the Spanish Bottom Trawl Research Survey *Platuxa* 2002-2005 in spring (González Troncoso *et al*., 2006a), the UE Survey *Flemish Cap* 1996-2005 in Div. 3M in summer (González Troncoso *et al*., 2006b), and in ICES Area Div. IIb by the Spanish Bottom Trawl Research Survey *Fletán Ártico* 2004-2005 in autumn (Paz *et al.,* 2006) (Fig. 1). Stomach contents of 5 061 individuals of five skate species distributed in north Atlantic were analyzed: 4 120 of thorny skate, 568 of Arctic skate, 181 of spinytail skate*,* 86 of smooth skate and 106 of round skate (Table 1). The depth range (m), median, percentiles, extreme values and outliers of the samples carried out for each species and area are shown in Fig. 2.

Sampling was performed randomly and was stratified by predator size range. Size groups of 10 cm were established (0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-99, 100-109 and ≥110 cm). Stomach contents were analyzed on board. Fish whose stomach were 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 index.

Data collected for each predator were: total length (TL) to the nearest lower cm; volume of 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 to the lowest possible taxonomic level.

Data analysis

Feeding intensity was evaluated using the Feeding Intensity Index (*FI*): percentage of individuals with stomach content. Differences in feeding intensity by fish size and area were tested by χ^2.

$$FI = (n / N) * 100$$

n was the individual number with stomach content
N was the total individual number sampled

The importance of each prey taxa in the stomach contents was evaluated using the weight percentage of each prey item of the total weight of stomach contents by each size range (W_{pi}). Thus, we can analyze the preference of predators according to size (Hansson, MS, 1980; Hyslop, 1980; Amezaga, 1988; Cortés, 1997). These measures reflect dietary nutritional value (Macdonald and Green*,* 1983).

$$W_{pi} = w_{pi} / W_{ti} * 100$$

w_{pi} was the weight (g) of the prey item p in the size range i.
W_{ti} was the weight (g) of total prey in the size range i.

The degree of diet overlap was measured using the Simplified Morisita´s Index (C_H) (Horn, 1966; Krebs, 1989; Hall *et al*., 1990) – based on *%W*. This index is used when resources are expressed as proportions (Caillet and Barry, 1979; Cortés, 1997). This index, with quantitative measures, is not influenced by the food category number considered. 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 (Zaret and Rand, 1971; Wallace, 1981). We used C_H to measure the diet overlap inter-specific and among size classes in each area. Food categories in the diet were considered at the higher taxonomic levels: 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) (Bowman *et al.,* 2000).

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

C_H was the Simplified Morisita´s Index.
j, k was the predator groups (size classes or area).
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

These five skate species presented a very high feeding intensity index, more than 70%, in the three studied geographical areas, being slightly higher in Div. IIb and 3M (Table 2).

Thorny skate (*Amblyraja radiata*)

Feeding Intensity. The feeding intensity was high (*FI* = 84%), but significantly different among three areas ($\chi^2_{(2)}$ = 148.01 p<0.000). The highest FI was in Div. IIb (93%) and the lowest in Div. 3NO (79%). *FI* value was slightly higher in females in these three areas (Table 2).

This index presented high values in all size ranges with a general trend to decrease slightly when predator size increased and significantly different among size ranges in Div. 3NO and 3M ($\chi^2_{(8)}$ = 50.49 $p \leq 0.000$, $\chi^2_{(7)}$ = 14.87 $p \leq 0.05$, respectively). An opposite trend was observed in Div. IIb (Table 3).

Food habits. This species showed a wide prey spectrum in Div. 3M and 3NO (90 and 83 different items) and less wide spectrum in Div. IIb (35 different prey), but most of prey with a low percentage in weight. The main prey groups were Pisces and Crustacea. Predation on fish and molluscs increased with predator size, whereas Crustacea and *Other Groups* decreased (Fig. 3). In Div. 3NO, Pisces and Crustacea highlighted (58 and 34%, respectively) due to predation on northern sand lance (*Ammodytes dubius*) (43%) and snow crab (*Chionocetes opilio*) (23%). In Div. 3M, Pisces and Crustacea reached 30 and 56%, respectively, being prominent the predation on redfish (*Sebastes* sp.) (7%) and northern shrimp (*Pandalus borealis*) (43%). In Div. IIb, Pisces (44%), Crustacea (28%), followed by Mollusca (21%) were again important prey groups. By species the predation on Greenland halibut (*Reinhardtius hippoglossoides*) (9%), blue ling (*Micromesistius poutassou*) (8%), northern shrimp (9%) and *Bathypolypus arcticus* (9%) were important. Thorny skate ate on offal (fishing processed remnant) on Grand Bank and Svalbard area (Table 4).

Diet overlap. In Div. 3M, diet overlap had high values in all size range; however in Div. 3NO the change in diet was observed in individuals <30 cm with a similar diet and high diet overlap among sizes class >30. In Div. IIb, except individuals <20 cm, all the individuals showed a diet overlap, with high values in consecutive size ranges (Table 5).

Arctic skate (*Amblyraja hyperborea*)

Feeding Intensity. *FI* total value for Arctic or northern skate was high (87%) (Table 2). Feeding intensity was significantly different among size ranges in Div. 3NO ($\chi^2_{(7)}$ = 20.86 p <0.05) and in Div. 3M ($\chi^2_{(10)}$ = 23.10 $p \leq 0.01$) with a decrease trend with size (Table 3).

Food habits. Arctic skate showed a smaller prey number than thorny skate (29, 39 and 31 items in Div. 3NO, 3M and IIb, respectively), mainly on the group of Pisces. The main prey groups on the Grand Bank were Pisces and Crustacea (43 and 25%, respectively), highlighting redfish (13%), small crustaceans (euphausids, mysids and hyperiids) and crustacean Natantia. On the Flemish Cap, Pisces was the main food component (67%) with roughhead grenadier (*Macrourus berglax*) (32%). In Div. IIb, feeding based on fish increased (82%) with haddock (*Melanogrammus aeglefinus*) (12%) and blue ling (11%). Offal consumption was remarkable in the three areas, mainly in Div. 3NO (23%) (Table 4). Predation on fish increased with size, being especially clear in Div. IIb, where individuals ≥20 cm started feeding on this group. Individuals <40 cm fed mainly on polychaetes in Division 3M, and on small crustaceans and polychaetes in Divisions 3NO (Fig. 3).

Diet overlap. Similarity in diet showed three size groups in Div. IIb, individuals <20 cm, those between 20-29 cm, and the diet overlap occurring in all sizes ≥30 cm with values ≥0.95. In the other two areas several different groups were observed. These groups had a more irregular pattern and some size range that did not overlap the following size range; diets of individuals ≥60 cm overlapped with C_H values between 0.60 and 1 (Table 5).

Spinytail skate (*Bathyraja spinicauda*)

Feeding Intensity. Feeding intensity was high (87%) and significantly different among the three divisions ($\chi^2_{(2)}$ = 15.13 p <0.001). The highest value was in Div. IIb (94%) and the lowest in Div. 3NO (70%). By sex, the index was slightly lower in females on Grand Bank (Table 2).

Food habits. Prey spectrum was lower than in the former two species (21 types of prey in Div. 3NO, 37 in Div. 3M and 19 in Div. IIb). Echinoderms were not part of its diet. On the Grand Bank, the main prey group was Pisces (90%), mainly redfish (28%), roughhead grenadier (20%) and Greenland halibut (19%). On the Flemish Cap, this species ate on Pisces and Crustacea (75 and 18%, respectively), with redfish (43%) and northern shrimp (14%) as principal species. In Arctic area, these groups were also the main diet components (Crustacea, 53% and Pisces, 42%), being small crustaceans an important prey, mainly gammaridean amphipods (23%) (Table 4). Consumption of crustaceans was observed in small individuals in all areas, but the size range with this diet was different. Predation on fishes had an increase trend with predator size gradually in Div. 3M and IIb, however this group was the most important prey in individuals ≥60cm in Div. 3NO (Fig. 4).

Diet overlap. Similarity in diet showed four different size groups in Div. 3NO; individuals <20 cm, between 30-49 cm, 50-59 cm and individuals ≥60 cm; diet overlap occurred only in the latter groups with values ≥0.98. In Div. 3M, diet overlap was observed in consecutive sizes in individuals between 30-59 cm and among all size ranges ≥60 cm with C_H values between 0.64 and 1. Individuals <20 cm also showed a different diet in this division. In Div. IIb the diet overlap occurred in almost every size range sampled (20-59 cm) with values C_H >0.9 between consecutive size ranges and this value decreased when comparing widely separated size ranges (Table 6).

Smooth skate (*Malacoraja senta*)

Feeding Intensity. The number of smooth skate specimens sampled was small. Feeding intensity was high (97%) (Tables 2 and 3). Differences in the results by sex and size are not conclusive due to the low size of the sampled obtained.

Food habits. Prey spectrum decreased in relation to the previous species, with 22 and 19 different types in Div. 3NO and 3M, respectively. Crustacea was the most important prey group, and this species did not showed predation on either molluscs or echinoderms. On Grand Bank, crustaceans reached 72%, feeding on small crustaceans (gammaridean amphipods, 9%) and big crustaceans (snow crab, 23%). On Flemish Cap, the crustacean predation (97%) was mainly northern shrimp (57%) (Table 4). Consumption on crustaceans was observed in individuals of all sizes, whereas consumption on fish occurred in individuals of medium sizes on Grand Bank (Fig. 4).

Diet overlap. This measure was irregular and had no pattern in Div. 3NO; however, diet overlap reached maximum values (C_H =1) among all individuals in Div. 3M (Table 7).

Round skate (*Rajella fyllae*)

Feeding Intensity. Feeding Intensity was high (91%), slightly low in females than males (Table 2). Differences among sex and size are not conclusive in this species due to the small sample obtained.

Food habits. Round skate was the species with the smallest prey spectrum (12, 13 and 5 different items in Div. 3NO, 3M and IIb, respectively). Its diet showed neither echinoderms nor molluscs, as it happened with *M. senta*. Main prey group varied with geographical area. On the Grand Bank the most important prey were polychaetes (80%). Consumption of polychaetes occurred in all size ranges, and crustaceans were found in medium sizes. On the Flemish Cap, this species preyed on polychaetes (44%) and crustaceans (42%). The main crustaceans were northern shrimp (15%) and euphausids (10%). By size, small individuals preyed on crustaceans, individuals of medium sizes ate on polychaetes, and big individuals ate crustaceans and fish. However in Svalbard area, fish showed a greater importance in the diet (39%), followed by small crustaceans (gammaridean amphipods, 29%); polychaetes had little importance (Table 4 and Fig. 4).

Diet overlap. This species showed a high diet overlap ($C_H \geq 0.96$) among all size ranges in Div. 3NO. In Div. 3M, this feature showed two size groups, individuals <20 and individuals ≥20 cm (Table 7).

Inter-specific diet overlaps in each area

On Grand Bank, thorny skate showed a high diet overlap with Arctic skate. These two species had a lower overlap with spynitail and smooth skates. No diet overlap of *R. fyllae* was found with other skate species.

On Flemish Cap, *A. radiata* showed diet overlap with all skate species, but with lower values than the ones showed on Grand Bank; with regard to the other skate species we could only find a high diet overlap between *A. hyperborea* and *B. spinicauda*, and slightly overlap between *M. senta* and *R. fyllae*.

The four skate species distributed in Arctic area showed diet overlap among all of them (Table 8).

Predation on commercial species

Predation on commercial species was 29% in Div. 3NO, 56% in Div. 3M and 33% in Div. IIb according to the total stomach contents of the five skate species studied here (Table 9).

The most important prey of the commercial species on Flemish Cap were northern shrimp (*P. borealis*) and redfish (*Sebastes* sp., *S. mentella*, *S. marinus*); and haddock (*M. aeglefinus*) and blue ling (*M. poutassou*) in Svalbard area. On Grand Bank, snow crab and redfish were the most frequently prey of commercial interest preyed. In this area, the incidence on commercial species was less important, but it affects a greater number of species, such as wolffishes (*Anarhichas lupus*, *A. minor*, *A. denticulatus*), roughhead grenadier (*M. berglax*), Greenland halibut (*R. hippoglossoides*), American plaice (*Hipoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*) and skates.

Discussion

The results obtained confirm some known aspects about the skate feeding habits. The five studied skate species showed a high feeding intensity in the three geographic areas, which has already been reported by other studies (Torres *et al*., 2000; Dolgov, 2002; Román *et al*., 2004). This intensity was in some skate species higher in Svalbard area (Div. IIb) and lower in Grand Bank (Div. 3NO). Samples were collected in autumn and spring-summer respectively, while the samples in Flemish Cap (Div. 3M) were carried out in summer. Berestovskiy (1989) observed that thorny skate (*A. radiata*) feeds throughout the year, but a great number of larger skates had empty stomachs in April-May-June when the skates are spawning and the feeding of females was significantly decreasing.

Prey spectrum was significantly higher in thorny skate in NAFO Divisions, possibly because it was sampled in a very wide depth range, from shallow waters to deep waters while in Div. IIb, a lower bathymetric depth range was sampled, never lower than 500 m, and also due to the fact that it is an area with less specific biodiversity. Round skate (*R. fyllae*) was specialist species measuring of the different prey number. All the other skate species, except spinytail skate (*B. spinicauda*), showed a lower variety of prey in the Arctic area.

Size-dependent predation was observed: prey size increased (mainly crustaceans), fish consumption increased, and polychaetes occurrence decreased with increasing predator size.

Feeding studies on thorny skate agree in the wide prey spectrum found in its stomach contents, however most prey are found in low occurrence and only a few prey have relevance (Rodríguez-Marín *et al*., 1994; Vinnichenko *et al*, 2002; Román *et al*., 2004). This skate species is an opportunistic feeder on most abundant and available prey species in an area (McEachran *et al*., 1976; Bowman *et al*., 2000; Packer *et al*., 2003a). This fact explains why fishery waste (offal) is often found in their stomach contents in areas where fishing activity is developed (Templeman, 1982; Walker and Hyslop, 1998; Dolgov, 2002; Packer *et al*., 2003a;). Fishes and crustaceans are the most important prey groups independently of the area studied. The importance of these groups and their species changes according to abundance. There are also ontogenic changes and they are linked to size-dependent bathymetric distribution, as it is shown in the results obtained. Consumption of small food prey (small crustaceans, polychaetes and other prey) decreased and predation on fishes increased when predator size increasing. This changes in diet according to size had already been reported in several studies carried out in different geographic areas such as in North Sea and Skagerrak (Skjæraasen and Bergstad, 2000), Barents Sea (Berestovskiy, 1989; Dolgov, 2002), and north Atlantic (McEachran *et al*., 1976; Templeman, 1982; Rodríguez-Marín *et al*., 1994; Packer *et al*., 2003a; Román *et al*., 2004).

Coincidence in the most important prey in the diet of thorny skate and Atlantic cod (*G. morhua*) is remarkable, particularly in adult individuals, both in Grand Bank and in Flemish Cap. Adult cod diet in Flemish Cap from 1970 to 1988 was mainly shrimp (occurrence percentage between 17% and 39%) and young redfish (occurrence percentage between 11% and 45%) (Konstantinov *et al*., 1985; Albikovskaya and Gerasimova, 1993); redfish (W = 18 to 21%) and hyperiids (W = 59 to 84%) were the most a important prey in the period 1998-93 (Casas and Paz, 1994); hyperiids (Volume = 44 to 16%), redfish (Vol = 16 to 23%) and shrimp (Vol = 25 to 10%) were the main components in the period 1993-2003 (Torres *et al*., 2000; Román *et al*., 2004). Two of these prey were the main components in thorny skate diet in the period 1993-2005, shrimp (Vol = 34 to 38%) and redfish (Vol = 13 to 19%) (Torres *et al*., 2000; Román *et al*., 2004). Similar results were found out in this study.

On Grand Bank, the adult cod diet in the late 1980s and at the beginning of the 1990s was mainly composed of northern sand lance (W = 76%) and capelin (*Mallotus villosus*) (W = 20%) (Paz, 1992). In the last years (2002-2005), the main prey of thorny skate were northern sand lance (W = 43%) and snow crab (*Chionoecetes opilio*) (W = 24%), and the main components in the cod diet were northern sand lance (W = 40%), capelin (V = 13%) and snow crab (W= 11%). Diet overlap was found between these fish species mainly in the shallow waters, but it was not in all the depth ranges (González *et al*., 2006).

Robichaud *et al*. (1991) studied the differential selection of snow and toad crabs as prey of Atlantic cod and thorny skate in the early 1980s in the northwestern coast of Cape Breton Island. Their results showed that predation on toad crab was similar for both predators; however consumption of snow crab was greatly higher by thorny skate being the abundance of this prey much higher than toad crab abundance. This fact showed that thorny skate is a more opportunistic predator.

Arctic skate (*A. hyperborea*) fed mainly on Pisces in the three areas, and often fed on offal. Spinytail skate was also a piscivorous species. However contrary to Arctic skate, it fed less on Pisces in Svalbard area, where crustaceans were more important in its diet, possibly because individuals caught and sampled were smaller size than the ones sampled in other areas, and diet of small sizes in the three areas of study was mainly composed of crustaceans. Dolgov (2002) reached similar results about Artic skate in his study carried out in the area of Barents Sea, but spinytail skate in such study showed a diet mainly based on fishes.

The round skate diet (*R. fyllae*) changes with reference to the latter skate species. This species fed mainly on crustaceans and polychaetes. These results confirm that this species is benthophage (Berestovskiy, 1989; Dolgov, 2002). Smooth skate (*M. senta*) was a crustacean feeder, and this fact agrees with other studies carried out about this species and showing that its diet is limited to epifaunal crustaceans, with shifts from amphipods and mysids to decapods and euphausids related to the predator size, and showing small geographical changes (McEachran *et al.,* 1976; Packer *et al.,* 2003b).

Intra-specific diet overlap in the different size ranges changed with area; in some cases occurred in almost every size, for example in thorny and smooth skates in Div. 3M, round skate in Div. 3NO, and spinytail skate en Div. IIb. In other cases, three (small, medium and large) or even four different size groups were found; this behavior was more common in Arctic and spinytail skates. Thorny skate showed two different groups in the Svalbard area (very small individuals, and the rest of the sizes). This fact showed slight differences in connection with results obtained in the North Sea and Skagerrak, where little diet overlap was found among juveniles, adolescents and adults (Skjæraasen and Bergstad, 2000). These results could be influenced by the bathymetric range sample in each skate species and area. Regarding the inter-specific overlap, we can observe that the feeding of all these skate species overlaps in Div. IIb, where the sampled individuals come from a lower depth range and similar mean depth. In NAFO Area, a greater feeding link between Arctic and thorny skate was found, and the same happened between

Arctic and spinytail skates. Thorny skate showed a high inter-specific diet overlap in all areas. This fact along with its wide bathymetric distribution shows its great capacity for adaptation.

Competition about food in sympatric species which feed on the same big taxa often shows that predator effort is targeted towards different species. This fact was observed in the diets of thorny and smooth skates, which at low taxonomic level, were significantly different (McEachran, 1976). Similar results are shown here: thorny skate had a more diversified diet than smooth skate, both in number of prey species and in habitats. Thorny skate preyed both infauna (polychaetes), crustaceans (snow crab) and fish (northern sand lance) and smooth skate fed mostly on crustaceans (decapod natantia and snow crab) and fish (capelin) (Table 4). Similar behavior can be noticed among the other species.

Thorny skate is remarkable for its capacity for spatial adaptation (geographic and bathymetric distribution). Walker and Hyslop (1998) stated that the changes observed in the specific composition of skates in some areas in the North Sea showed that the species with the lowest length and/or age maturity (i.e. thorny skate) were dominant; this species was the least sensitive to changes in parameters such as fecundity and age at maturity, and fishing exploitation. Results on food and feeding could support that thorny skate could be taking today a similar ecological role played by cod in the shallow area of the Grand Bank as dominant predator.

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Table 1. No. individuals sampled of *A. radiata*, *A. hyperborea*, *B. spinicauda*, *M. senta* and *R. fyllae* by Division and year with minimum and maximum depth of samples and survey (NAFO Div. 3NO in 2002-2005, 3M in 1996-2005, and ICES Div. IIb in 2004-2005).

Species	Year	No. individuals 3NO	3M	IIb	*Total*
Amblyraja radiata	1996		60		60
	1997		69		69
	1998		68		68
	1999		65		65
	2000		102		102
	2001		118		118
	2002	634	93		727
	2003	876	371		1 247
	2004	570	251	93	914
	2005	522	146	82	750
	Total	*2 602*	*1 343*	*175*	*4 120*
Depth range (m) of samples		38-1 476	83-830	543-1 310	
Amblyraja hyperborea	2002	5	1		6
	2003	24			24
	2004	45	32	150	227
	2005	41	60	210	311
	Total	*115*	*93*	*360*	*568*
Depth range (m) of samples		290-1 476	493-1 438	576-1 436	
Bathyraja spinicauda	2002	11	11		22
	2003	9	30		39
	2004	17	26	31	74
	2005	10	21	15	46
	Total	*47*	*88*	*46*	*181*
Depth range (m) of samples		245-1 400	249-1 651	543-954	
Malacoraja senta	2002	1	3		4
	2003	13	24		37
	2004	7	24		31
	2005	9	5		14
	Total	*30*	*56*		*86*
Depth range (m) of samples		88-1 196	144-1 257		
Rajella fyllae	2002	7	3		10
	2003	9	8		17
	2004	25	22	5	52
	2005	21	5	1	27
	Total	*62*	*38*	*6*	*106*
Depth range (m) of samples		165-1 400	300-1 412	579-699	
Depth range (m) of survey		38-1 666	83-1 651	523-1 436	
Total		***2 856***	***1 618***	***587***	***5 061***

Table 2. No. individuals sampled and Feeding Intensity (FI %) by sex and Division (NAFO Div. 3NO in 2002-2005, 3M in 1996-2005, and ICES Div. IIb in 2004-2005).

Species	Div	Males No. indv	Males FI (%)	Females No. indv	Females FI (%)	*Total FI (%)*
Amblyraja radiata	3NO	1 234	77.2	1368	79.6	*78.5*
	3M	714	92.3	629	93.8	*93.0*
	IIb	66	89.4	109	95.4	*93.1*
	Total	*2 014*	*83.0*	*2 106*	*84.7*	*83.8*
Amblyraja hyperborea	3NO	59	83.1	56	85.7	*84.3*
	3M	46	82.6	47	91.5	*87.1*
	IIb	227	90.7	133	83.5	*88.1*
	Total	*332*	*88.3*	*236*	*85.6*	*87.1*
Bathyraja spinicauda	3NO	21	76.2	26	65.4	*70.2*
	3M	39	92.3	49	91.8	*92.0*
	IIb	26	88.5	20	100	*93.5*
	Total	*86*	*87.2*	*95*	*86.3*	*86.7*
Malacoraja senta	3NO	15	100	15	86.7	*93.3*
	3M	28	96.4	28	100	*98.2*
	Total	*43*	*97.7*	*43*	*95.3*	*96.5*
Rajella fyllae	3NO	24	87.5	38	84.2	*85.5*
	3M	23	100	15	93.3	*97.4*
	IIb	6	100			*100*
	Total	*53*	*94.3*	*53*	*86.8*	*90.6*

Table 3. No. individuals sampled and Feeding Intensity (FI %) by size range and Division (NAFO Div. 3NO in 2002-2005, 3M in 1996-2005, and ICES Div. IIb in 2004-2005).

Division	Size range (cm)	*A. radiata*		*A. hyperborea*		*B. spinicauda*		*M. senta*		*R. fyllae*	
		No. indivs.	FI (%)	No. indivs.	FI (%)	No. indivs.	FI (%)	No. indivs.	FI (%)	No. indivs.	FI (%)
3NO	0-9									2	100
	10-19	110	99.1	1	0.0	1	100			14	100
	20-29	81	93.8	3	66.7	1	0.0	4	100	8	100
	30-39	218	83.0	4	100	2	100	1	0.0	9	66.7
	40-49	599	76.8	23	91.3	2	100	8	100	19	79.2
	50-59	609	77.0	32	93.8	2	100	15	93.3	5	80.0
	60-69	508	75.4	17	82.4	3	100	2	100		
	70-79	383	77.8	13	92.3	5	80.0				
	80-89	89	69.7	12	66.7	5	60.0				
	90-99	5	80.0	9	66.7	9	77.8				
	100-109			1	0.0	6	66.7				
	≥110					11	45.5				
3M	10-19	58	87.9	9	88.9	2	100	9	100	9	100
	20-29	39	97.4	5	100			3	100	8	100
	30-39	134	96.3	2	100	2	100	2	100	5	80
	40-49	364	95.9	7	100	3	100	9	100	10	100
	50-59	492	91.7	13	100	7	71.4	33	97.0	6	100
	60-69	220	90.5	15	93.3	14	100				
	70-79	31	87.1	12	100	17	94.1				
	80-89	5	100	15	73.3	11	81.8				
	90-99			10	70.0	9	100				
	100-109			4	50.0	8	100				
	≥110			1	0.0	15	86.7				
IIb	10-19	8	87.5	79	83.5					2	100
	20-29	16	93.8	5	80.0	9	88.9			1	100
	30-39	65	92.3	28	92.9	19	94.7			1	100
	40-49	54	92.6	53	88.7	7	100			1	100
	50-59	29	96.6	52	98.1	7	100			1	100
	60-69	2	100	57	87.7	3	100				
	70-79	1	100	67	86.6						
	80-89			19	78.9						
	100-109					1	0.0				

Table 4. Prey (% weight) in the stomach contents of the *A. radiata, A. hyperborea*, *B. spinicauda*, *M. senta* and *R. fyllae* in NAFO Div. 3NO (spring 2002-2005), 3M (summer 1996-2005) and ICES Div. IIb (autumn 2004-2005). (* in values <1%).

Prey	*A. radiata*			*A. hyperborea*			*B. spinicauda*			*M. senta*		*R. fyllae*		
	3NO	**3M**	**IIb**	**3NO**	**3M**	**IIb**	**3NO**	**3M**	**IIb**	**3NO**	**3M**	**3NO**	**3M**	**IIb**
Other Groups (total)	**5.3**	**3.6**	4.5	**4.7**	**3.7**	**0.3**	**1.4**	**0.2**	**2.0**	**2.7**	**0.3**	**80.8**	**46.2**	**3.2**
Annelida	4.5	3.6	4.5	4.2	2.4	*	*	*	2.0	2.7	*	79.5	43.9	3.2
Anthozoa	*	*												
Aphroditidae	*													
Ascidiae	*	*												
Bryozoa												1.3		
Chaetognatha	*	*		*	*			*					*	
Cnidaria						*								
Ctenophora	*					*								
Priapulida		*												
Porifera		*												
Scyphozoa	*	*		*	1.3	*	*	*					2.0	
Sipunculida		*												
Mollusca (total)	**0.4**	**9.8**	**20.7**	**2.4**	**6.4**	**3.3**	**3.3**	**1.4**	**0.3**					
Gastropoda														
Buccinum sp	*													
Unid. and dig. Gastrop.	*	*												
Bivalvia	*	*			*		*	*						
Cephalopoda (total)	*0.2*	*9.7*	*20.7*	*2.4*	*6.1*	*3.3*	*2.8*	*1.4*	*0.3*					
Semirossia sp		*						*						
Sepiolidae		*												
Illex coindetii		*												
Illex illecebrosus	*	*		*										
Unid. Oegopsida	*	*	4.6			2.1		*	*					
Octopoda	*	2.0	5.9	1.3	*			*						
Histioteuthis sp		*												
BathypoYipus arcticus	*	2.8	9.1		4.4									
Bathypolypus sp		*												
Unid. Cephalop. Decap.		*					2.8							
Unid. and dig. Cephalop.	*	2.2	1.1	*	*	1.2		*						
Unid. and dig. Mollusca	*													
Echinodermata (total)	**0.1**	**0.1**	**0.0**		**0.3**	**0.0**								
Asteroidea	*					*								
Echinodermata	*													
Echinoidea	*	*			*									
Holothurioidea	*													
Ophiuroidea	*	*	*			*								
Crustacea (total)	**34.3**	**56.0**	**28.0**	**25.2**	**16.0**	**11.8**	**4.7**	**17.5**	**53.1**	**71.5**	**96.6**	**13.2**	**42.0**	**32.9**
Copepoda	*	*			*	*		*			*			
Euphausiacea	*	*	1.7	4.0	*	*	*	*	4.0	*	*	*	9.8	
Mysidacea	*	*	*	4.2	*		*	*	1.9	5.3	*	*	*	
Cumacea	*		*											
Isopoda	*	*			*		*						*	
Amphipoda (total)	*4.0*	*1.7*	*2.4*	*4.7*	*3.1*	*0.2*	*2.6*	*0.4*	*22.6*	*9.5*	*2.6*	*9.6*	*10.3*	*28.6*
Gammaridea	3.5	*	1.6	*		*	1.6	*	22.6	9.4	1.4	5.4	6.5	28.6
Caprellidae	*		*		*									
Hyperiidea	*	1.0	*	4.6	3.0		1.0	*		*	1.2	4.2	3.8	
Unid. and dig. Amphip.	*													
Decapoda Natantia (total)	*1.7*	*47.2*	*14.3*	*6.5*	*2.6*	*8.1*	*1.2*	*15.2*	*16.7*	*23.3*	*80.7*	*2.7*	*18.0*	
Acanthephyra pelagica		*		1.1	*									
Acanthephyra purpurea		*			*									
Acanthephyra sp		*		1.1	*									
Argis dentata	*	*								5.4				
Crangonidae		*												
Gennades sp		*		*										
Lebbeus polaris	*	*									1.1			
Pandalus borealis	*	42.5	9.0			*		14.4	5.3	3.0	56.6		15.2	
Pandalus propinquus	*									3.3	1.2			
Pasiphaea tarda	*	*	2.3	*	*	6.7			6.3					
Pontophilus norvegicus	*	*	*			*	*	*	2.4	7.5	*			
Sabinea sarsi		*						*			19.0			
Sergestes arcticus	*	2.6	*	1.7	1.2	*	1.0	*	*	1.3	*	1.6		
Sergia robusta		*		*	*			*					2.7	
Spirontocaris lilljeborgi		*									1.6			
Spirontocaris sp		*												
Spirontocaris spinosus	*													
Unid. and dig. Pasiphaeidae	*			*								1.2		
Unid. and dig. Natantia	*	*	1.5	1.5	*	*		*	2.0	2.7	*			
Decapoda Brach. (total)	*26.6*	*4.1*	*4.0*	*1.2*	*5.4*		*0.1*			*25.3*				
Chionocetes opilio	23.2	3.8								23.2				
Neolithodes grimaldi				1.2	5.4									
Hyas sp	2.9	*	*							1.5				
Unid. and dig. Brachyura	*	*	3.4				*			*				
Dec. Anomura (Pag.)	1.1	*	*						1.1	*	*			
Galatheidae					*									
Unid. and dig. Dec. Crust.	*	*	3.6	2.5	1.0	2.3	*	*	2.3	1.9	3.6			
Unid. and dig. Crustacea	*	1.3	1.6	1.7	1.7	1.1	*	1.4	4.5	5.1	7.8	*	2.5	4.4

Table 4 (cont). Prey (% weight) in the stomach contents of the *A. radiata*, *A. hyperborea*, *B. spinicauda*, *M. senta* and *R. fyllae* in NAFO Div. 3NO (spring 2002-2005), 3M (summer 1996-2005) and ICES Div. IIb (autumn 2004-2005). (* in values <1%).

Prey	*A. radiata*			*A. hyperborea*			*B. spinicauda*			*M. senta*		*R. fyllae*		
	3NO	**3M**	**IIb**	**3NO**	**3M**	**IIb**	**3NO**	**3M**	**IIb**	**3NO**	**3M**	**3NO**	**3M**	**IIb**
Pisces (total)	**58.1**	**29.8**	**43.8**	**43.4**	**66.9**	**81.9**	**90.4**	**74.9**	**42.1**	**25.6**	**1.0**		**8.6**	**39.2**
A. monopterygius	*	*												
Alepisaurus ferox								3.3						
Ammodytes dubius	42.8	*												
Ammodytes sp	*	*												
Anarhichas denticulatus	*													
Anarhichas lupus	*	1.5												
Anarhichas minor		*						4.9						
Anarhichas sp		1.3												
Anoplogaster cornuta								1.6						
Antimora rostrata		*			*									
Argyropelecus hemigymnus										3.8				
Artediellus atlanticus	*													
Batilagus euriops								1.0						
Boreogadus saida	*													
Borostomias antarcticus	*													
Ceratias holboelli	*						1.0							
Ceratoscopelus maderensis	*	*												
Chauliodus sloani		*												
Cottunculus microps			*											
Cottunculus sp			*		14.4									
Cyclothone sp		*		*										
Gadidae			3.2			2.2			1.4					
Gaidropsarus ensis	*	*			1.6									
Glyptocephalus cynoglossus	*													
H. platessoides	*		*			2.2			2.5					
Lampadena speculigera		*						*						
Larva of fish	*	*												
Leptagonus (agonus) decagonus	*													
Limanda ferruginea	*													
Liparidae	*									*				
Lophius sp	*													
Lumpenus lumpretaeformis	*	1.2						*						
Lycodes reticulatus	*	*												
Lycodes sp		1.0	*		2.9	1.8		*	4.7					
M. atlanticum	*													
Macrourus berglax	*	*		7.2	32.1		19.7	4.5						
Macruridae	*	*			*		4.2							
Magnisudis (paralepis) atlantica		*												
Malacosteus niger					*									
Mallotus villosus	2.9	*								7.5				
Melanogrammus aeglefinus			4.3			11.8			3.4					
Micromesistius poutassou			7.5			11.0								
Myctophidae	*	*						*						
Myctophum punctatun		*												
N. scolopaceus		*												
Nezumia bairdi	*	*		2.5				2.3						
Notolepis risso		*												
Notoscopelus sp		*												
Phycis chesteri		*												
Phycis sp	*													
Pleuronectiformes	*													
Rajidae	*													
Reinhardtius hippoglossoides		*	8.5		4.9	3.2	18.5	*						
Scomberesox saurius		*												
Sebastes marinus						*								
Sebastes mentella		1.2												
Sebastes sp	2.9	6.9		12.5	1.2	2.5	27.5	43.0						
Serrivomer beani		1.9						2.3						
Stomias boa		*												
Triglops murrayi	*	*												
Tryglops sp	*													
Urophycis sp.		*												
Unid. and dig. fish	4.8	8.1	20.1	21.1	7.9	47.1	19.6	9.8	30.0	13.4	1.0		8.6	39.2
Other groups	**1.8**	**0.7**	**3.0**	**24.3**	**6.7**	**2.7**	**0.2**	**6.0**	**2.4**	**0.2**	**2.0**	**6.0**	**3.2**	**24.6**
Offal	1.2		2.5	22.6	6.5	1.9		5.8						
Eggs	*	*	*	*	*	*						*		
Vitelo	*	*	*		*	*						2.7		
Unidentified	*	*	*	1.4	*	*	*	*	2.4	*	2.0	2.5	3.2	24.6
No. indivs. sampled	2602	1343	175	115	93	360	47	88	46	30	56	62	38	6
No. of prey	83	90	35	29	39	31	21	37	19	22	19	12	13	5

Table 5. Niche overlap of *A. radiata* and *A. hyperborea* among size ranges in Div. 3NO (2002-2005), 3M (1996-2005) and Div. IIb (2004-2005).

A. radiata

3NO	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**
20-29	0.99							
30-39	0.84	0.89						
40-49	0.57	0.63	0.91					
50-59	0.47	0.52	0.84	0.99				
60-69	0.35	0.41	0.75	0.95	0.98			
70-79	0.51	0.56	0.86	0.99	0.99	0.98		
80-89	0.54	0.60	0.88	0.99	0.99	0.97	1.00	
90-99	0.36	0.41	0.74	0.94	0.98	1.00	0.98	0.97

3M	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**
20-29	0.99						
30-39	0.99	1.00					
40-49	0.95	0.98	0.98				
50-59	0.84	0.89	0.90	0.97			
60-69	0.71	0.77	0.80	0.89	0.96		
70-79	0.55	0.63	0.65	0.77	0.90	0.95	
80-89	0.81	0.86	0.89	0.95	0.97	0.98	0.88

IIb	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**
20-29	0.00					
30-39	0.00	0.93				
40-49	0.00	0.81	0.88			
50-59	0.00	0.82	0.96	0.95		
60-69	0.00	0.70	0.89	0.68	0.87	
70-79	0.00	0.43	0.66	0.48	0.69	0.91

A. hyperborea

3NO	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**
30-39	0.54						
40-49	0.43	0.71					
50-59	0.34	0.94	0.85				
60-69	0.12	0.33	0.82	0.59			
70-79	0.08	0.20	0.73	0.47	0.99		
80-89	0.26	0.57	0.92	0.73	0.75	0.68	
90-99	0.08	0.23	0.75	0.50	0.99	1.00	0.69

3M	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**
20-29	1.00								
30-39	1.00	1.00							
40-49	0.32	0.32	0.31						
50-59	0.17	0.18	0.17	0.45					
60-69	0.26	0.26	0.26	0.82	0.65				
70-79	0.04	0.04	0.04	0.26	0.60	0.71			
80-89	0.13	0.13	0.12	0.31	0.76	0.75	0.97		
90-99	0.01	0.01	0.01	0.16	0.47	0.62	0.98	0.90	
100-109	0.00	0.00	0.00	0.03	0.39	0.49	0.93	0.83	0.98

IIb	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**
20-29	0.26						
30-39	0.31	0.47					
40-49	0.25	0.49	1.00				
50-59	0.14	0.41	0.97	0.99			
60-69	0.11	0.38	0.96	0.97	1.00		
70-79	0.10	0.39	0.96	0.97	1.00	1.00	
80-89	0.12	0.38	0.96	0.98	1.00	1.00	1.00

Table 6. Niche overlap of *B. spinicauda* among size ranges in Div. 3NO (2002-2005), 3M (1996-2005) and Div. IIb (2004-2005).

B. spinicauda

3NO	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-109**
30-39	0.00									
40-49	0.00		1.00							
50-59	0.00		0.69	0.69						
60-69	0.00		0.13	0.13	0.09					
70-79	0.00		0.10	0.10	0.08	1.00				
80-89	0.00		0.13	0.13	0.10	1.00	1.00			
90-99	0.00		0.00	0.00	0.00	0.99	0.99	0.99		
100-109	0.00		0.08	0.08	0.06	1.00	1.00	1.00	1.00	
>=110	0.00		0.00	0.00	0.10	0.98	0.98	0.98	0.98	0.98

3M	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100-109**
30-39	0.99									
40-49	0.99		0.99							
50-59	0.70		0.77	0.73						
60-69	0.60		0.69	0.61	0.86					
70-79	0.76		0.83	0.77	0.90	0.97				
80-89	0.29		0.39	0.30	0.70	0.93	0.81			
90-99	0.09		0.19	0.09	0.49	0.80	0.65	0.95		
100-109	0.24		0.34	0.24	0.61	0.89	0.77	0.99	0.98	
>=110	0.08		0.17	0.08	0.49	0.79	0.64	0.95	1.00	0.98

IIb	**20-29**	**30-39**	**40-49**	**50-59**
30-39	0.95			
40-49	0.77	0.93		
50-59	0.75	0.91	1.00	
60-69	0.40	0.62	0.86	0.89

Table 7. Niche overlap of *M. senta* and *R. fyllae* among size ranges in Div. 3NO (2002-2005), 3M (1996-2005) and Div. IIb (2004-2005).

R. fyllae

3NO	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**
10-19	0.97				
20-29	0.99	0.99			
30-39	0.98	1.00	0.99		
40-49	0.96	1.00	0.99	1.00	
50-59	1.00	0.97	0.99	0.98	0.96

3M	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**
20-29		0.88			
30-39		0.42	0.77		
40-49		0.52	0.85	0.97	
50-59		0.88	0.98	0.71	0.83

IIb	**0-9**	**10-19**	**20-29**	**30-39**	**40-49**
20-29		0.00			
30-39		0.00	0.53		
40-49		0.00	0.11	0.06	
50-59		0.00	1.00	0.53	0.11

M. senta

3NO	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**
40-49		0.40			
50-59		0.96		0.59	
60-69		1.00		0.40	0.96

3M	**10-19**	**20-29**	**30-39**	**40-49**
20-29	1.00			
30-39	1.00	1.00		
40-49	1.00	1.00	1.00	
50-59	1.00	1.00	1.00	1.00

Table 8. Niche overlap among *A. radiata*, *A. hyperborea*, *R. fyllae*, *B. spinicauda* and *M. senta* in each Division (NAFO Div. 3NO 2002-2005, 3M 1996-2005, and ICES Div. IIb 2004-2005).

3NO	***A. radiata***	***A. hyperborea***	***B. spinicauda***	***M. senta***
A. hyperborea	1.00			
B. spinicauda	0.85	0.85		
M. senta	0.77	0.75	0.38	
R. fyllae	0.15	0.17	0.02	0.18
3M	***A. radiata***	***A. hyperborea***	***B. spinicauda***	***M. senta***
A. hyperborea	0.66			
B. spinicauda	0.64	0.99		
M. senta	0.80	0.23	0.23	
R. fyllae	0.68	0.32	0.28	0.62
IIb	***A. radiata***	***A. hyperborea***	***B. spinicauda***	
A. hyperborea	0.80			
B. spinicauda	0.86	0.71		
R. fyllae	0.91	0.83	0.98	

Table 9. Commercial species prey (%weight) in the stomach contents of *A. radiata*, *A. hyperborea*, *R. fyllae*, *B. spinicauda* and *M. senta* in each Div. (NAFO Div. 3NO 2002-05, 3M 1996-05, and ICES Div. IIb 2004-05).

Prey	Predator														Total		
	A. radiata			*A. hyperborea*			*B. spinicauda*			*M. senta*		*R. fyllae*					
	3NO	3M	IIb	3NO	3M	IIb	3NO	3M	IIb	3NO	3M	3NO	3M	IIb	3NO	3M	IIb
A. denticulatus	0.9														0.8		
A. lupus	0.0	1.5													0.0	1.0	
A. minor		0.1						4.9								0.6	
Anarhichas sp		1.3														0.9	
G. cynoglossus	0.0														0.0		
Ch. opilio	23.2	3.8								23.2					21.6	2.7	
Gadidae			3.2			2.2			1.4								2.4
H. platessoides	0.6		0.0			2.2			2.5						0.6		1.8
M. aeglefinus			4.3			11.8			3.4								10.0
M. berglax	0.1	0.2		7.2	32.1		19.7	4.5							0.8	5.7	
M. poutassou			7.5			11.0			0.0								10.0
P. borealis	0.4	42.5	9.0			0.4		14.4	5.3	3.0	56.6		15.2		0.4	32.5	2.3
Pleuronectiformes	0.1														0.1		
R. hippoglossoides		0.4	8.5		4.9	3.2	18.5	0.7	0.0						0.4	1.1	4.2
Rajidae	0.0														0.0		
S. marinus			0.0			0.2			0.0								0.2
S. mentella		1.2														0.8	
Sebastes sp	2.9	6.9	0.0	12.5	1.2	2.5	27.5	43.0	0.0						3.8	10.4	1.9
Total	*28.2*	*57.9*	*32.5*	*19.8*	*38.2*	*33.4*	*65.7*	*67.5*	*12.7*	*26.2*	*56.6*		*15.2*		*28.5*	*55.9*	*32.7*

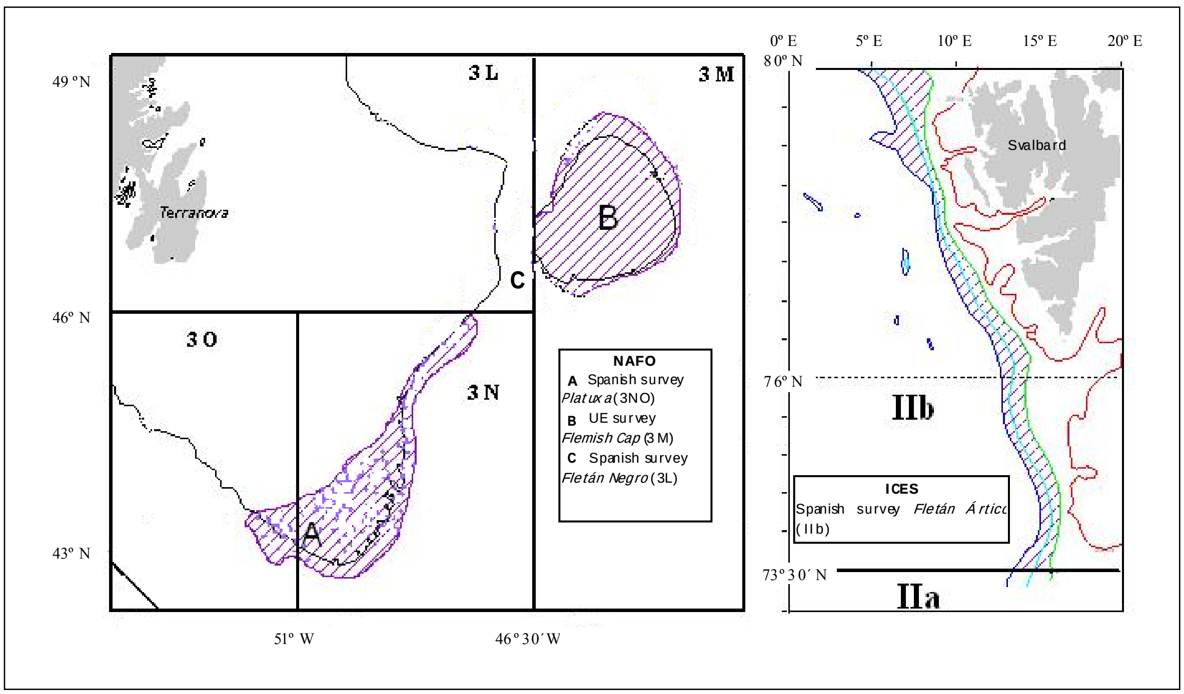

Fig. 1. NAFO and ICES Areas where the bottom trawl research surveys were carried out.

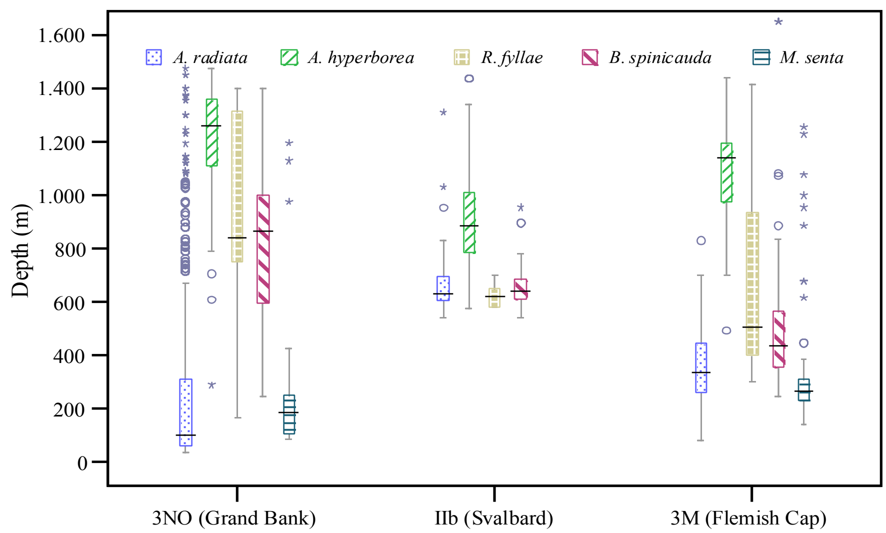

Fig. 2. Depth (m) of samplings of skate species by Division showing median, percentiles, extreme values and outliers (NAFO Div. 3NO in 2002-2005; 3M in 1996-2005; and ICES Div. IIb in 2004-05 with depth range of survey 500-1450 m.

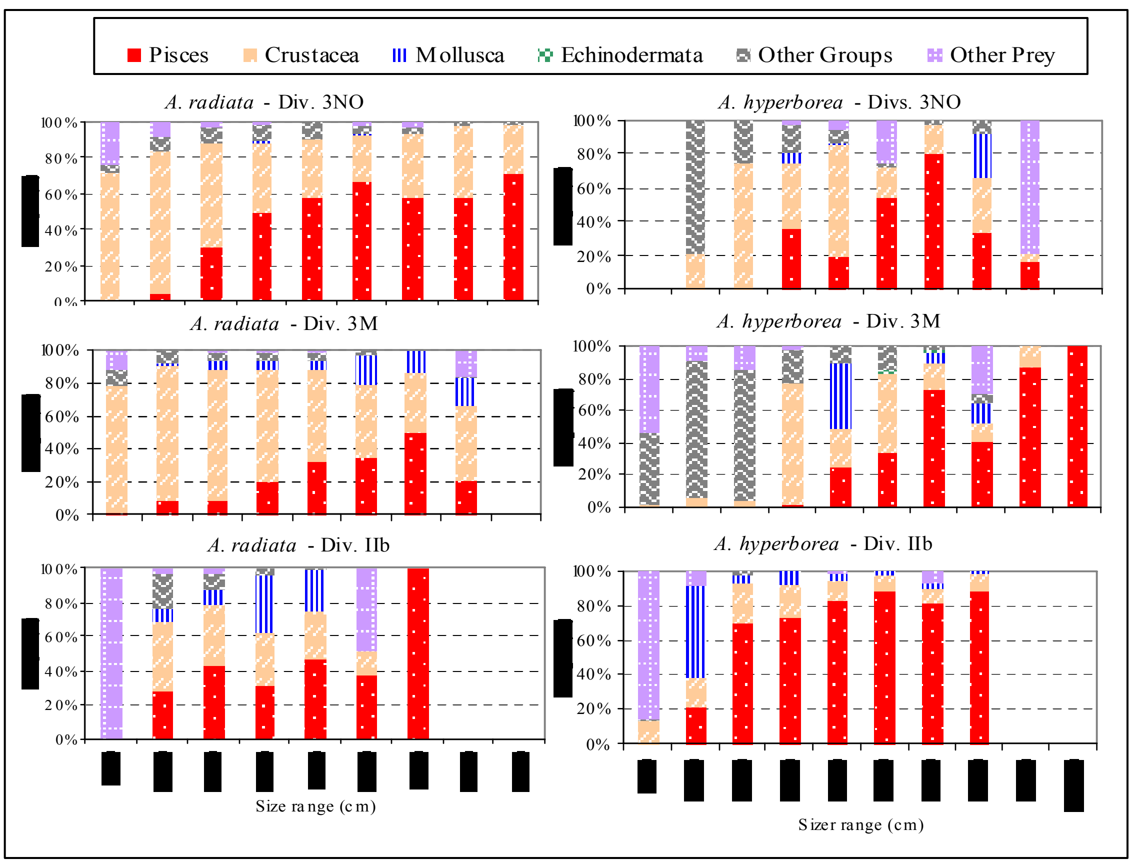

Fig. 3. Weight (%) of prey groups of *A. radiata* and *A. hyperborea* in Div. 3NO 2004-2005, 3M 1996-2005 and IIb 2004-2005.

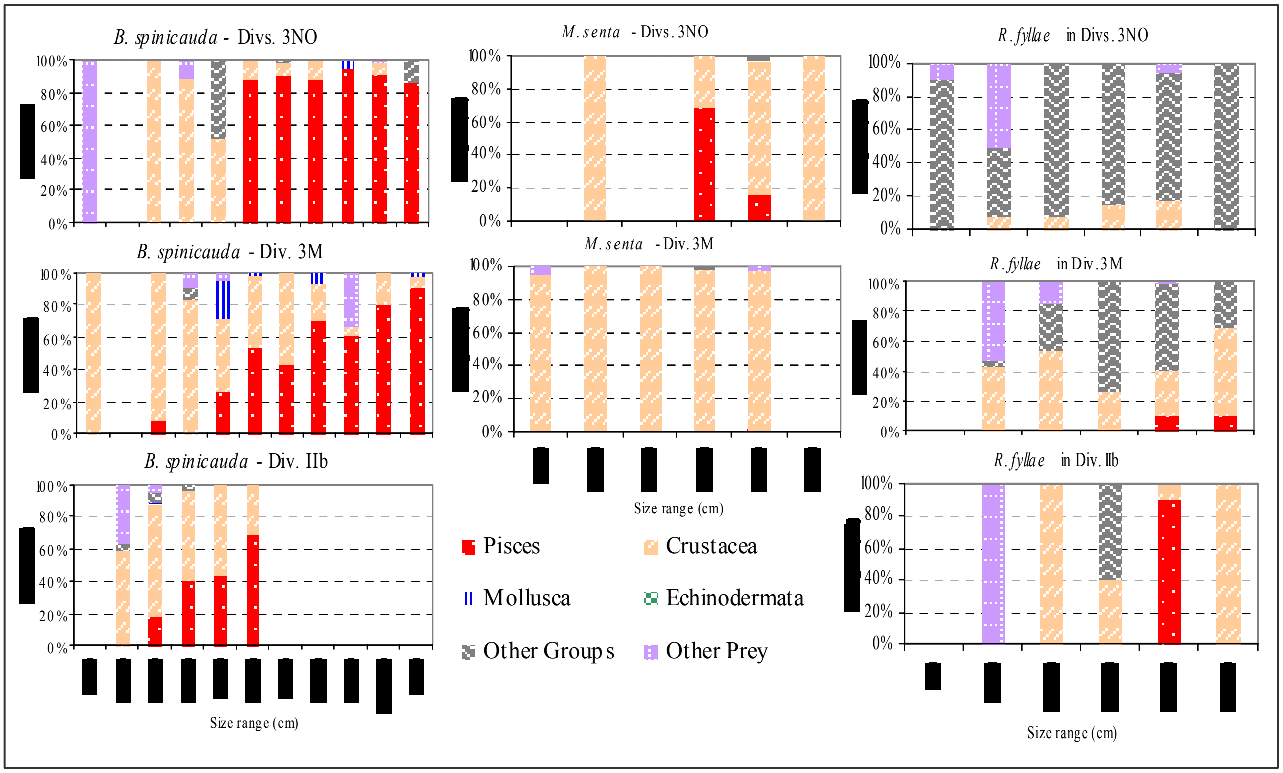

Fig. 4. Weight (%) of prey groups of *B. spinicauda*, *M. senta* and *R. fyllae* in Div. 3NO 2002-2005, 3M 1996-2005 and IIb 2004-2005.