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Feeding Relationships of Demersal Fish in Flemish Cap in Summer, 1993-1994)

by

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Abstract

The feeding patterns of 15 fish species taken by demersal trawl from Flemish Cap in summer 1993 and 1994 are described. An examination of diet breadth and changes in feeding habits with size distinguished three groups : 1) Specialists (4 species) having no differences in feeding habits with size and a very small number of main prey taxa. 2) High diversity feeders (7 species) with a highly diversified diet and feeding differences between size classes. 3) Low diversity feeders (4 species) with few dietary categories which nevertheless present changes throughout their lives. To measure overlap, cluster analysis of percentage volumetric data using Czekanowski's index produced distinct groups which reflected the greater or lesser proximity to the bottom of the trophic niches of fish and the ontogenic changes in diet.

Introduction

The obvious need of modern fisheries management to quantify the predator-prey relationships which affect commercially important fish stocks has brought about research into the feeding of commercial fish stocks in several North Atlantic countries (Anon., 1980; 1992), in order to establish the biological basis for species interaction models of fish stocks. Furthermore, analyses of feeding patterns are necessary to understand the mechanisms which structure assemblages or communities (Sedberry, 1983; Kotrschal & Thomson, 1986).

Numerous feeding studies have been carried out in Flemish Cap, several of which make reference to trophic relationships such as predation and competition (Turuk & Postolaky, 1980; Lilly and Evans, 1986; Lilly 1987; Albikovskaya *et al.*, 1988; Casas & Paz, 1994), parameters which play an important role in the dynamics of exploited populations. Nevertheless most of them refer to very few species and very few refer to the relationships between food resources and fishes in the ecosystem as a whole (Konstantinov *et al.*, 1985).

With the aim of increasing knowledge of the trophic flow in Flemish Cap, a study of the feeding of the 15 main fish species in this fishing area was initiated in 1993 within the summer surveys financed by the European Union. These fifteen species were, in order of decreasing abundance: redfish (*Sebastes mentella*, *Sebastes marinus* and *Sebastes fasciatus*, cod (*Gadus morhua*), wolffishes (*Anarhichas lupus*, *Anarhichas minor* and *Anarhichas denticulatus*), Greenland halibut (*Reinhardtius hippoglossoides*), American plaice (*Hippoglossoides platessoides*), thorny skate (*Raja radiata*), Grenadiers (*Nezumia bairdi* and *Macrourus berglax*) artic eelpout (*Lycodes reticulatus*), witch flounder (*Gliptocephalus cynoglosus*) and longfin hake (*Urophycis chesteri*). This paper describes the general feeding ecology of the most important demersal fish species with an emphasis on describing differences in feeding habits with size.

Material and Methods

The area of study was Flemish Cap Bank, situated to the east of Newfoundland. It is made up of sandy bottoms in the shallowest central part which becomes muddy at greater depth (Litvin & Rvachev, 1962). Hard bottoms (rock and coral) are not considered as they are not trawlable. Trawling was carried out at depths of between 140 and 700 m. Prospections were based on daytime bottom trawl fishing, of 30 minutes duration, and hauls were carried out from a random stratified sampling (Vazquez, 1995).

The stomachs of 15 species of demersal fish were obtained in two fishery prospection surveys carried out at the beginning of summer in 1993 and 1994. These species were selected because they presented the greatest biomass abundance and/or number according to estimates from previous surveys (Vazquez, 1995). Stomachs were analyzed on board, and in each haul a maximum of 10 stomachs from each 10 cm. length range were analyzed for the commercial species, while for the remaining species only 10 randomly selected specimens were analyzed per haul. Fish whose stomachs were everted or contained prey ingested in the fishing gear were discarded. The total length of each predator was taken, rounded down to the cm (to the beginning of anal fin and rounded down to the half cm in Macrouridae). The volume of each stomach content was quantified in cc using a trophometer (Olaso, 1990) and the percentage with respect to this volume, state of digestion and number of each prey were also noted. Prey were identified by species wherever the state of digestion permitted, or to the lowest possible taxonomic level.

The importance of each prey taxa in the stomach contents was evaluated using Percentage by volume: $V = v/V_t*100$, where v is the volume of a determined prey, and V_t is the total volume of prey. The volumetric method overvalues the importance of large organisms (Hyslop, 1980), nevertheless in terms of production, the biomass, estimated from volume, is determining.

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

The degree of overlapping between species was measured using a multivariate group analysis, in the form of hierarchical clusters. The matrix of dissimilarity was constructed by applying the Quantitative Index of Czekanowski (Bray & Curtis, 1957) to the percentage by volume of prey present in stomach contents. This index has the following expression:

$$CZ_{ik} = \frac{\sum_{j=1}^{s} |(x_{ij} - x_{kj})|}{\sum_{j=1}^{s} (x_{ij} + x_{kj})}$$

where CZ_{ik} is the dissimilarity in the diet of the set of predator length groups i to k; x_{ij} is the volumetric frequency of the prey j in length group i; x_{kj} is the volumetric frequency of the same prey in length group k; s is the number of different prey species in the set of samples. The index varies from 0 when diets are identical, to 1 when diets contain no common items.

As the feeding habits of most of the predators change as they grow, each species was divided into several length groups, these being treated as an entity. To establish the minimum number of stomachs for each length group (minimum size of the sample), the accumulated number of prey types versus the accumulated number of stomachs was used, in such a way that an adequate number is considered when the curve reaches the asymptote (Mauchline & Gordon, 1985; Arancibia, 1987; Gibson & Ezzi, 1987). To examine the effect of dietary changes with size, each species was divided into as many length groups as possible (Table 1). Czekanowski's Index (CZ) between these length groups was then calculated and if >0,25 the groups were kept separate; in the case of species with high CZ among the length groups, 50% of the maximum CZ was taken as a limit.

Czekanowski's index was chosen for its simplicity and is commonly used in studies of communities to compare the composition of species among different entities (Bloom, 1981). It is also used on data expressed in percentages, and is known as the Percent Similarity Index (Venrick, 1983). This index is not affected by joint absences and is therefore adequately robust for use with marine data while being very sensitive to abundant species (Field *et al.*, 1982; Jongman *et al.*, 1987). Furthermore, in comparison with other indices, it estimates overlap adequately over most of the potential range of overlap (Linton *et al.*, 1981) and reflects similarity most accurately (Bloom, 1981).

Czekanowski's index is algebraically equivalent to the Bray-Curtis index and Schoener's index (Bloom, 1981; Field *et al.*, 1982). This methodology has been used in other studies on fish feeding although with small differences: Sedberry (1983) and Houston (1983) use the percentage in number applying the Bray-Curtis index, Arancibia (1987) and Gibson & Ezzi (1987) apply Czekanowski's index and Schoener's index respectively, on the percentage by volume.

The algorithm of aggregation UPGMA (Sneath & Sokal, 1973) has been used, common in studies of distribution and also applied to feeding studies (Gibson & Ezzi, 1987; Houston, 1983; Olaso & Pereiro, 1991).

42 prey taxa were selected (Table 2) because of their presence in most of the diets and/or because of being volumetrically important. As unidentified items could have had, in some cases, a great effect on values of the dissimilarity index, e.g. other Crustacea or other Natantia, these items were omitted and shared proportionally among the respective taxonomic categories. Two new categories of fish were created for the same reason, pelagic fish (living in midwater zones) and benthic + benthopelagic fish (living on or above, but near the bottom), in such a way that rare fish prey species and unidentified fish were redistributed in these two categories as a function of the proportion of pelagic or benthic prey in the rest of the diet. Pelagic fish considered were those of the genus *Sebastes*, *Urophycis* sp., *Mallotus villosus*, *Chauliodus sloani*, *Nemichthys scolopaceus* and the families Myctophidae and Paralepididae; the rest of the fish species in Table 2, including Pleuronectiformes, *Rajiformes* and *Antimora rostrata* have been considered as benthic or benthopelagic.

Results

Detailed descriptions of the diets of individual species required too much space and had to be avoided. For detailed information see Rodríguez-Marín *et al.* (1994).

Of the 2 961 and 2 495 stomachs containing food analyzedin the years 1983 and 1984 respectively, 71 and 66 length groups of the 15 selected species were established (Table 1). This high number of groups was reduced to 32 in 1993 and 31 in 1994 using Czekanowski's Index (CZ) applied to each species in each year. The value of CZ considered to group the length classes varied from one species to another, as it is affected by the diet breadth (*B*) and the number of food categories (Table 3). In general the new length classes within each species coincided in the two years considered, except for cod, for which, due to the large consumption of hyperiids by all lengths in 1994, diet becomes homogenized, thus the number of classes is reduced from the original 11 to just 2.

From Table 3 three categories of fish are hence established with respect to their feeding:

a) Specialist species which have a high percentage overlap between the different length groups. There are no differences in feeding habits with size and a very small number of main prey taxa, that is to say, they have low values of Levins index (*B*). These species are witch flounder (*Gliptocephalus cynoglosus*), American plaice (*Hippoglossoides platessoides*), artic eelpout (*Lycodes reticulatus*) and northern wolffish (*Anarhichas denticulatus*).

b) High diversity feeders, species with a highly diversified diet and feeding differences between size classes, that is to say, low percentage similarity between length groups (high values of CZ). This group consists of Greenland halibut (*Reinhardtius hippoglossoides*), thorny skate (*Raja radiata*), cod (*Gadus morhua*), Atlantic and spotted wolffishes (*Anarhichas lupus, A. minor*) and common and roughhead grenadiers (*Nezumia bairdi* and *Macrourus berglax*).

c) Low diversity feeders, species with few dietary categories, around ten, but which present changes throughout their lives. These are the genus *Sebastes* (*S. mentella, S. marinus* and *S. fasciatus*) and longfin hake (*Urophycis chesteri*).

To compare diets a cluster was constructed (Fig. 1) with a total of 42 prey taxa (Table 2) and with the 63 new classes resulting from 1993 and 1994. It can be seen that there is coincidence in the diet of all species between the two years, except for *N. bairdi*. The cluster cophenetic correlation was 0,82. Taking as a limit value a similarity of 25% (1-CZ), seven clearly differentiated major clusters appear. In Table 4 the indicative preys of these clusters are shown, their value in percentage by volume has been obtained by calculating a mean of each prey type by cluster. This value must be taken as an indication of the importance of each prey rather than a fixed value. The clusters ordered from greater to lesser relationship with the bottom are:

Cluster I is formed by *H. platessoides, L. reticulatus* and small wolffishes: *A. minor* smaller than 60 cm, and *A. lupus* smaller than 40 cm in 1993 and smaller than 50 cm in 1994. They feed mainly on echinoderms, V=67%, which live on soft substrata like brittle stars, and even on irregular shallowly buried sea urchins.

Cluster II is made up of polychaete feeders: *G. cynoglossus, M. berglax* smaller than 14 cm and *N. bairdi* greater than 5 cm in 1993. Although grenadiers and witch flounder have the same proportion in the Polichaeta category, this may be somewhat misleading since grenadiers feed on errantia and witch flounder, mainly consume sedentaria, such as tube-dwelling polychaetes. The presence of pelagic items such as medusae and hyperiids is due to their being preyed on by grenadiers.

Cluster III consists of large predators: *G. morhua* greater than 69 cm and large wolffishes, *A. lupus* greater than 39 cm in 1993 and greater than 49 cm in 1994 and *A. minor* greater than 59 cm. They feed primarily on fish, V=69%, *Sebastes* sp., V=30%, being the characteristic prey. Echinodermata still represent 16% in volume.

Cluster IV is made up of *R. radiata, R. hippoglossoides* greater than 30 cm and *M. berglax* greater than 13,5 cm. They are also great consumers of fish, V=53% and shrimps, V=32%; notably *Serrivomer beani*, V=17%, and *Pandalus borealis* with V=30%.

Cluster V contains *G. morhua* smaller than 70 cm, *R. hippoglossoides* smaller than 30 cm, *S. marinus* greater than 29 cm in 1994 and greater than 34 cm in 1993 and *N. bairdi* (*N.*

bairdi <50 in 1993). They feed almost exclusively on crustaceans, V=70%, the main item category is hyperiid amphipods, V=51%.

Cluster VI is formed by *U. chesteri*, *S. fasciatus*, *Sebastes* juvenile and *S. marinus* smaller than 30 cm in 1994 and smaller than 35 cm in 1993 and *S. mentella*. They also prey mainly on crustaceans, V=79%, copepods primarily calanoid, hyperiid amphipods and euphausiids.

Cluster VII is made up of a great consumer of ctenophores: *A. denticulatus*.

The species of cluster VI, particularly the genus *Sebastes*, are differentiated, despite copepods being a large common prey group. Euphausiids, hyperiid amphipods and myctophids appear to a great extent in the diet of *S. mentella*; in the diet of small *S. fasciatus*, S. juvenile and *S. marinus*, copepods predominate; lastly in the diet of large *S. marinus*, hiperiids, chaetognaths and *P. borealis* stand out.

Discussion

Comparisons of fish diets are difficult, the initial problem being the estimation of the size of the sample of stomachs required to adequately define the diet (Hoffman, 1979; Mauchline & Gordon, 1985 Arancibia, 1987). Another source of variation in the quality of data is the subjective biases of the investigator because of lack of experience in identifying all organisms (Mauchline & Gordon 1984), and this, in turn, is highly related to the quantity and taxonomic level of prey categories used in diet comparisons (Langton & Bowman, 1980). Another question is the choice of the measure to evaluate the importance of a prey in volume, weight, number or occurrence. These difficulties must be carefully evaluated and resolved, the third of these, the quantity and taxonomic prey categories used, being that in which greatest variations are found between one investigator and another, as it is fundamental in determining diversity within diet, since broad taxonomic groupings increase the observed degree of overlap. In the present study the consistency when grouping the length groups of each species for 1993 and 1994, and the coincidence in the diet of species between the two years, appears to validate the methodology used.

The analysis of the diet of the main species of Flemish Cap permits the distinction of seven differentiated groups (Fig. 1). The cluster obtained has great ecological significance since, it not only reflects the greater or lesser proximity to the bottom of the trophic niches of fish, but also groups the specialists, separating the high diversity generalists and the group made up of the genus Sebastes, low diversity feeders. There is a tendency towards increasing dietary specialization, as species become more related to the bottom, as is the case of witch flounder, American plaice and arctic eelpout, whose gut contents are constant and monotonous in all length ranges. These species are totally dependent on benthos for food.

The case of northern wolffish must be studied more deeply as on one hand the limited number of stomachs analyzed does not provide knowledge of whether their food composition varies as it grows and on the other their main prey, the ctenophores, is overvalued, since they are only "big bags of water". Nevertheless, their feeding (Albikovskaya, 1983) and dental system (Barsukov, 1959; Barsukov and Nizovtsev, 1960) indicate a lesser connection with the bottom than the other two species of wolffishes.

The rest of the target species of this study present ontogenic changes in diet as is common in most fish (Sedberry, 1983). Wolffishes (*A. lupus* and *A. minor*) and small roughhead grenadier feed on epifauna which live on soft substrata, shifting as they grow to piscivorous, the former feed on fish which move within the water column (*Sebastes* sp. and *G. morhua*), while the latter prey on near bottom fish and shrimps. The diet of common grenadier is similar to that of roughhead grenadier, although the great presence of hyperiid amphipods in the stomachs of 1994 homogenizes the diet of those larger and smaller than 50 cm. Whichever the case, *N. bairdi* seems to have a more benthic behaviour as it grows. The differences found in the diet of common grenadier between 1993 and 1994 may reflect the opportunistic feeding strategy also found in other macrourid fish (Mauchline & Gordon, 1984).

The increase in the presence of hyperiids in the stomachs of cod in 1994 also greatly influences diet, despite its food spectrum being one of the broadest, many of its prey, such as near-bottom crustaceans and benthic organisms like crabs, echinoderms, polychaetes and gastropods were relatively unimportant, in fact the value of its diet breadth (*B*) is small. Lilly (1979) and Konstantinov *et al.*, (1985) also found this diversity in the diet of cod though with few really important preys in the diet. It is clear that cod greater than 69 cm are great consumers of fish, mainly *Sebastes* sp. and *Anarhichas* sp. as Casas & Paz (1994) also found.

Stomach contents of primarily benthopelagic origin, such as *S. beani* and shrimps *P. borealis* occurred in Greenland halibut greater than 30 cm, although *Sebastes* sp. and pelagic cephalopods are also an important part of diet, which confirms their displacement away from the bottom (Chumakov and Podrazhanskaya, 1986; Albikovskaya *et al.*, 1988). However, when it is young it feeds on hyperiid amphipods and shrimps *P. borealis*, and this is related, on one hand, to the different depth distribution of large and small fish (Bowering & Chumakov, 1989; Junquera *et al* , 1992) and to the predator/prey length relationship. Thorny skate do not greatly vary their feeding stanza (Tyler, 1972) throughout their lives, having a very diversified diet at all lengths. Their feeding is highly related to the bottom, and is noticeable for the great consumption of natant decapod *P. borealis* and benthopelagic fish.

It is clear that food partitioning does occur among members of the genus *Sebastes* sp. (Fig.1 clusters V and VI), but it is also true that, as a whole, this genus makes up a group differentiated from the rest by the consumption of small crustaceans which live in the water column (primarily calanoid copepods and hyperiid amphipods). These differences in feeding may be related to the different bathimetric distribution (Saborido-Rey, 1993; Paz & Casas 1995), in fact *S. mentella*, which is the species found at greatest depth, has a lower content of zooplankton organisms in its diet such as copepods and chaetognaths than the other two redfish species.

The presence of hyperiids in all feeding groups, including specialist infauna feeders such as witch flounder or epifauna feeders such as American plaice, confirms that these small amphipods undertake extensive vertical migrations throughout the water column (Roe *et al.*, 1984). There are two preys, a little less common than hyperiids, though with greater capacity for vertical displacement, such as *P. borealis* and *Sebastes* sp. These three prey items represent a connecting link between the pelagic and benthic ecosystems, and their abundance and availability makes them an important resource for non-specialist predators.

Information on the quantity and category of food consumed is necessary in order to estimate mortality by predation. Commercial species such as redfish and cod appear in the stomach contents in a great volume. It remains the challenge of further research to estimate this predation (only data on daytime feeding is available), taking into account the predator/prey length relationship and the biomass of each species in Flemish Cap.

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Species	Size class	1993 Mean length	1993 No. stom	1994 Mean length	1994 No. stom
Anarhichas denticulatus	-	-	-	61.1	15
Anarhichas lupus	<30	24	36	23.8	22
	30-39	34.1	30	35.2	18
	40-49	44.7	41	44.6	21
	>49	55.7	34	58.4	29
Anarhichas minor	<50	37.8	30	35.8	58
	50-59	54.6	30	54.5	17
	>59	69.7	21	70.8	24
Gadus morhua	<15	13.9	9	-	-
	15-19	16.4	62	17.8	99
	20-24	23.1	51	20.9	36
	25-29	27.1	162	27.3	60
	30-34	31.7	160	32.3	18
	35-39	37.5	62	37.4	91
	40-44	42.2	111	41.8	93
	45-49	46.9	89	46.7	33
	50-54	51.4	48	52.2	64
	55-59	56.6	16	56.7	33
	60-64	62.6	37	-	-
	65-69	66.6	30	-	-
	60-69	-	-	62.4	15
	>69	78.7	36	82.7	17
Glyptocephalus cygnoglossus	<25	22.3	25	-	-
	25-29	27.1	31	26.7	18
	30-34	31.6	24	31.9	27
	35-39	37.5	28	36.7	14
	40-44	41.9	34	42	32
	>44	49.4	36	49.3	18
Hippoglossoides platessoides	<25	22.6	20	-	-
	25-29	26.6	57	25.7	17
	30-34	31.6	45	32	73
	35-39	37.2	69	37.2	78
	40-44	42	68	41.7	57
	45-49	46.7	48	47	60
	50-59	52	31	52.5	38
Lycodes reticulatus	<25	22.8	12	-	-
	25-29	27.7	24	27.4	21
	30-34	-	-	32	23
	30-45	34.8	36	-	-
	35-45	-	-	38.4	33
Macrourus berglax	<14	81.1	18	91.3	15
	14-17.5	164.8	23	-	-
	>17.5	204.6	44	-	-
	14-28	-	-	179.8	32
Nezumia bairdi	<5	34	20	42.4	21
	5-5.5	55	18	53.8	44
	6-6.5	65	38	63.2	50
	>6.5	77.8	51	74.2	32
Raja radiata	<45	35	29	35.9	13
	45-54	50.2	33	49.9	10
	55-64	59.9	39	58.3	22
	>64	70.5	26	68.4	14
Reinhardtius hippoglossoides.	<15	13	19	-	-
	15-19	16.8	69	16.5	39
	20-24	23.2	24	23.6	7
	25-29	26.5	47	27	30
	30-34	32.8	32	32.8	23
	35-39	36.7	35	37.5	45
	40-44	42	42	42.1	61
	45-49	47.3	59	46.6	51
	50-54	51.9	38	51.7	28
	>54	59.4	27	58.8	26
Sebastes fasciatus	<20	17.9	17	18	67
	20-24	22.5	58	21.6	83
	>24	27.9	34	26.9	23
Sebastes sp. inmature	10-20	15	88	16.9	71
Sebastes mentella	<25	21.9	33	19.7	48
	25-29	26.5	68	27.3	81
	30-34	32	27	31.6	55
	>34	38.4	34	38.1	29
Sebastes marinus	<20	17.6	14	17.3	34
	20-24	22.2	41	21.8	35
	25-29	27.3	45	26.9	37
	30-34	31.5	24	32.1	25
	>34	37.4	18	42.5	15
Urophycis chesteri	12-32	21.3	46	24.6	57
Total			2961		2495

Table 1.- Number of stomachs containing food and length range (cm) used for each species.

1 Porifera
2 Cnidaria (Scyphozoa)
3 Ctenophora
Annelida
4 Polychaeta (Errantia + Sedentaria)
5 Sipuncula
5 Chaetognata
Crustacea
7 Copepoda (Calanoida)
Malacostraca
8 Mysidacea
9 Isopoda
Amphipoda
10 Gammaridea
11 Hyperiidea
12 Caprellidea
Decapoda
13 Anomura (Paguridea)
14 Brachyura (*Chionoecetes opilio, Hyas sp., Lithodes maja*)
Natantia
15 *Acanthephyra pelagica*
16 *Lebbeus polaris*
17 *Pandalus borealis*
18 *Pasiphaeidae (Parapasiphaea sulcatifrons, Pasiphaea tarda)*
19 *Sergestes arcticus*
10 *Spirontocaris lilljeborgi*
21 Crangonidae (*Pontophilus norvegicus, Sabinea sarsi*)
22 Euphausiacea
Echinodermata
23 Asteroidea
24 Ophiuroidea
25 Echinoidea (regular and irregular or bilateral)
Mollusca
26 Bivalvia
27 Cephalopoda
28 Gastropoda
Pisces
29 Anarhichadidae (*Anarhichas* sp.)
30 *Chauliodus sloani*
31 *Gadus morhua*
32 *Lumpenus lumpretaeformis*
33 *Lycodes* sp.
34 Macrouridae (*Nezumia bairdi*, Other Macrouridae)
35 *Mallotus villosus*
36 Myctophidae (*Lampadena speculigera*, other Myctophidae)
37 Paralepididae (*Paralepis atlantica, Notolepis rissoi*)
38 Pisces benthic
39 Pisces pelagic
40 *Sebastes* sp.
41 *Serrivomer beani*
42 *Triglops murrayi*

Table 2.- List of common prey of fish in Flemish Cap in summer 1993-94. Selection based on presence in the majority of diets and/or by volumetric importance.

	1993					1994				
	Orig. class	CZ	Rev. class	No. taxa	*B*	Orig. class	CZ	Rev. class	No. taxa	*B*
a) **Specialists:**										
Anarhichas denticulatus	-	-	-	-	-	1	-	1	7	1.8
Glyptocephalus cygnoglossus	6	0.17	1	11	1.5	5	0.12	1	9	1.4
Hippoglossoides platessoides	7	0.25	1	13	1.4	6	0.25	1	18	1.3
Lycodes reticulatus	3	0.16	2	7	2.6	3	0.20	1	6	1.7
b) **High diversity feeders:**										
Anarhichas lupus	4	0.30	3	20	4.3	4	0.32	3	16	3.8
Anarhichas minor	3	0.32	2	16	5.8	3	0.39	2	14	4.1
Gadus morhua	13	0.27	4	29	2.9	11	0.27	2	27	2.5
Macrourus berglax	3	0.12	2	14	3.5	2	-	2	16	5.3
Nezumia bairdi	4	0.41	2	15	7.2	4	0.31	2	14	3.5
Raja radiata	4	0.35	3	23	6.8	4	0.38	3	21	6.7
Reinhardtius hippoglossoides	10	0.42	3	20	5.9	9	0.39	3	19	4.8
c) **Low diversity feeders:**										
Sebastes fasciatus	3	0.26	2	9	3.4	3	0.20	2	10	3.8
Sebastes sp. juvenil	1	-	1	4	2.3	1	-	1	6	2.6
Sebastes mentella	4	0.24	3	13	9.7	4	0.21	3	11	6.1
Sebastes marinus	5	0.27	2	6	6.2	5	0.30	3	8	4.2
Urophycis chesteri	1	-	1	8	4.0	1	-	1	12	4.6
Total	71		32			66		31		

Table 3.- Original number of length classes, value of Czekanowski's dissimilarity index (CZ) used in grouping length classes, revised number of length classes, number of food categories, and diet breadths (Levin's index, *B*) for each species.

Group	Species	Prey taxa	%V
I	*H. platessoides* *L. reticulatus* *A. minor* <60 *A. lupus* <40 (93) *A. lupus* <50 (94)	Ophiuroidea *P. borealis* *S. beani* Asteroidea Echinoidea Polychaeta	61.1 12.7 3.4 3 2.8 2.5
II	*G. cynoglossus* *M. berglax* <14 *N. bairdi* >4,5 (93)	Polychaeta Ophiuroidea Hyperiidea Scyphozoa Gammaridea	59.6 14 7.6 3.7 2.5
III	*G. morhua* >69 *A. lupus* >39 (93) *A. Lupus* >49 (94) *A. minor* >59	*Sebastes* sp. *G. morhua* *Anarhichas* sp. Ophiuroidea Ctenophora *P. borealis* Echinoidea Hyperiidea	30 22.2 10.9 10.4 5.4 3.7 3.3 2.7
IV	*R. radiata* *R. hippoglossoides* >30 *M. berglax* > 13,5	*P. borealis* *S. beani* *Sebastes* sp. Pisces benthic *Anarhichas* sp. Cephalopoda Polychaeta *G. morhua* Myctophidae Hyperiidea	30.6 17.3 8.3 8 5.5 5.3 3 2.9 2.7 2.7
V	*G. morhua* <70 *R. hippoglossoides* <30 *S. marinus* >29 (94) *S. marinus* >34 (93) *N. bairdi* (94) *N. bairdi* <5 (93)	Hyperiidea *Sebastes* sp. Mysidacea Chaetognata Polychaeta *P. borealis* *Anarhichas* sp. Pisces pelagic Copepoda calanoida	50.9 5.7 5.6 5.4 4.8 4.5 4.4 3 3
VI	*U. chesteri* *S. fasciatus* *Sebastes* juvenile *S. marinus* <30 (94) *S. marinus* <35 (93) *S. mentella*	Copepoda Calanoida Hyperiidea Euphausiacea *P. borealis* Myctophidae Chaetognata Mysidacea	34.7 16.3 11.2 10.1 6.6 6.3 3.9
VII	*A. denticulatus*	Ctenophora Pisces Benthic Scyphozoa	73.6 9.7 7.2

Table 4.- Percentage by volume of characteristic prey of each feeding group obtained through cluster analysis. Number following species refers to length in cm, and number in brackets refers to year.

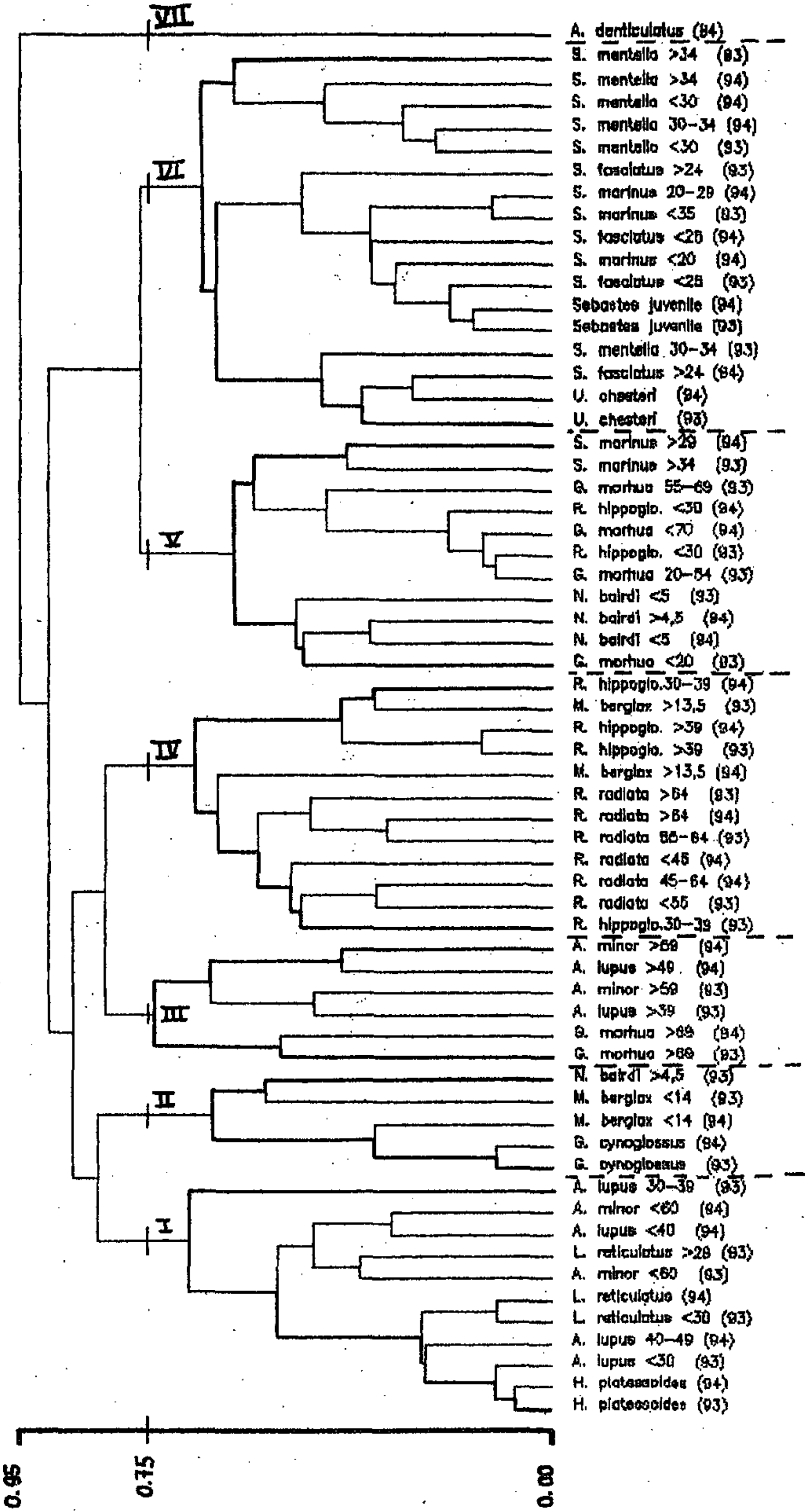

Figure 1.- Cluster analysis of diet dissimilarity (Czekanowski's index) between species, number following species refers to length in cm. and number in brackets refers to year.