ICES CM 2011/A:04
Session A
Joint ICES/PICES Theme Session on Atlantic redfish and Pacific rockfish: Comparing biology, ecology, assessment and management strategies for Sebastes spp

Feeding of redfish *Sebastes mentella* in the Irminger Sea - what do the data on feeding show?

A.Dolgov, V.Popov and A.Rolsky

Polar Research Institute of Marine Fisheries and Oceanography (PINRO)
183763 Murmansk. Knipovich-St., 6
RUSSIA

Phone -+7 (8152) 47-22-31 Fax - +7 (8152) 47-33-31

e-mails – dolgov@pinro.ru, popov@pinro.ru, rolskiy@pinro.ru

Abstract

Based on the data from the qualitative and quantitative analysis of feeding the feeding rate and food composition of the redfish *Sebastes mentella* in the Irminger Sea and adjacent waters in the late XX – early XXI centuries were studied. Interannual, local and ontogenetic variability of this species feeding as well as the dependence of different feeding aspects on the food supply and climate changes were analyzed. A special attention was paid to the feeding characteristics of the redfish from different biotopes.

Introduction

Pelagic redfish S. mentella of the Irminger Sea and adjacent waters is an important commercial species in the North Atlantic. In the 1950-70s, Russian and foreign scientists discovered S. mentella in the pelagial over the oceanic depths outside the slopes of Iceland and Greenland (Templeman, 1959; Rikhter, 1961; Zakharov, 1964; Jones, 1970; Magnusson, 1977 et al.). Since 1981, the USSR had conducted comprehensive studies of S. mentella in that area on a regular basis (Noskov et al., 1984; Shibanov et al., 1984; Dushchenko, 1986; Bakay, 1988, 1989; Pavlov, 1988; Pavlov and Galuzo, 1989; Pavlov et al., 1989ab). Since 1982, large-scale Soviet and, later on, international fishery for that species has been conducted. Since then, many aspects of its distribution, ecology and life history (including diet) have been studied (Palsson, 1983; Pavlov, 1992; Bakay and Melnikov, 1992; Magnusson and Magnusson, 1995; Saborido-Rey et al., 2004; Melnikov, 2006; Melnikov et al., 2007; González et al., 2000). At the same time, the feeding of the species in this area of the North Atlantic has been studied poorly, especially as compared with a lot of investigations of its feeding in the adjacent areas of the Northwest (for example, Jones, 1970; Pedersen and Riget, 1991; 1993; Gorelova and Borodulina, 1997) and Northeast Atlantic (for instance, Dolgov and Drevetnyak, 1993, 1995).

Therefore, the main goals of this paper were revealing the main regularities in the redfish feeding in the Irminger Sea during many years and, especially, the last decade, to analyze diet of redfish in different oceanographic conditions (cold and warm years) as well as considering the question if the differences in the redfish feeding are the result of the food supply effect or they indicate biological peculiarities of the different stock units of this species. Due to very extensive materials, obtained results are preliminary and will be detailed later.

Material and methods

The paper uses two types of data on the redfish feeding. When making the field feeding analysis the stomach fullness was determined visually by the 5 point scale (from 0 (an empty stomach) to 4 (a completely filled with food and stretched stomach)) and the presence of different prey in the stomach was registered. The standard quantity-weight feeding analysis included weighting of the food bolus and determining the percentage of prey in it (or weighting different prey species individually), counting prey and determining their length.

Totally, in 1981-2010, 144,886 stomachs of the redfish were analyzed using the field analysis method, at that; the data were collected during the research surveys and onboard fishing vessels during the fishery. The quantitative data (in total, 5,910 stomachs) were collected from 2001 to 2009, only in the period of the international surveys (June-July), onboard the Russian vessels and by Russian observers at the foreign vessels.

As the indicators of feeding rate of the redfish used were the mean fullness and the mean stomach fullness index (the ratio of the total food weight and the fish weight multiplied by 10,000), as well as the percent of empty stomachs. To characterize the significance of some prey used were the occurrence frequency, %f (a percent of stomachs with the prey from the total number of stomachs with food) and the weight percent, %m (a ratio of the prey weight and the total food weight, in percent).

Taking into consideration the results from the feeding research having been published before which were indicative of the significant differences in feeding of the redfish at different depths when analyzing the results of our investigations the peculiarities of that species feeding were studied separately, for two layers, above 450 m and under 450 m, that approximately corresponded to the layer above the sound scattering layer, the sound scattering layer and deeper layers.

Statistical analysis of data was conducted using Statistica 6.0 software

Results

Total food composition

In 1980-2010, by the data on the field analysis of feeding, in the stomachs of the redfish the representatives of 35 taxons were found (Table 1). Among them, the three groups, hyperiids (38 %), copepods (29 %) and euphausiids (16 %) were the most frequently occurring. Besides, the occurrence frequency of squids, shrimps and fish was relatively high (6-8 %).

In 2001-2009, by the quantitative analysis of feeding, in the redfish stomachs found were the representatives of 34 taxons (Table 1). Feeding by weight was based on fish (23 %m), hyperiids (18 %m), shrimps (17 %m), squids (13 %m) an copepods (10 %). At the same time, the prevalence of those groups differed by the frequency of occurrence in that species diet - hyperiids (75 %), euphausiids (59 %), copepods (51 %), shrimps (42 %), squids (32 %) and fish (27 %).

As for fish, in the redfish food composition, a lot of species (not less than 20), mainly, the representatives of meso- and bathypelagic complexes occur.

Besides a great similarity in feeding of redfish from the Irminger Sea pelagial and bottom redfish from the slopes of Iceland and Greenland was revealed (Figures 1 and 7). The maximal similarity was noticed in 1991-2000 when the mass concentrations of redfish sank to the depths to 800-1000 m. Probably it was associated with the mass transport of mesopelagic fish caused by stronger advection of the Atlantic waters in the warm years.

At that, the predominance of the other plankton organism, euphausiids, and the primary consumption of the cold-water neritic fish species (polar cod, capelin) or the species related to the continental shelf slopes (smoothhead and others) are typical for the diet of *Sebastes mentella*.

Table 1. Food composition of the redfish *Sebastes mentella* in pelagial of the Irminger Sea in 1980-2010 гг. by the data from field and qualitative analysis of feeding

Food items	Field analysis	Qualitative analysis	
	%f	%m	%f
Cnidaria		2.39	1.8
Scyphozoa	1.3	1.35	6.8
Ctenophora	0.9	0.28	1.8
Polychaeta	0.1	0.24	1.8
Tomopteris sp.	+		
Gastropoda	0.1		
Pteropoda	1.3	0.05	+
Clionidae	0.6	+	+
Oegopsida	7.8	13.70	32.4
Copepoda	29.6	4.26	51.2
Pareuchaeta sp.	0.8		
Pareuchaeta norvegica		6.47	51.2
Mysidacea	0.2	0.81	5.1
Gammaridea	1.0	0.10	1.8
Hyperiidae	38.4	18.75	75.3
Euphausiidae	16.4	7.59	59.7
Meganyctiphanes norvegica		0.17	+
Decapoda		0.83	5.1
Caridea	6.8	12.36	42.6
Pasiphaea sp.		0.60	1.8
Pandalus borealis		4.81	22.1
Chaetognatha	0.1	0.21	6.8
Sagitta sp.	2.7	0.78	18.8
Pisces	7.6	9.31	27.3
Pisces (egg)	+		
Bathylagus sp.	0.1	0.60	+
Bathylagus euryops		7.26	1.8
Nansenia sp.		1.03	1.8
Gonostomatidae	0.2	0.10	+
Cyclothone sp.	+		
Maurolicus muelleri	0.1	0.03	+
Stomiidae		0.08	+
Stomias sp.	+		
Chauliodus sp.	0.1		
Searsidae	+		
Myctophidae	3.1	0.24	3.4
Lampanictus sp.	0.1	2.15	1.8
Lampanictus macdonaldi		0.51	+
Benthosema glaciale		0.02	+
Bythytes sp.		1.12	+
Melamphaeidae	+		
Scopelogadus sp.		0.28	+
Chiasmodon niger		0.26	+
Anguilliformes	+		
Serrivomer sp.	+		
Nemichthys sp.	+		
Paralepis sp.	0.1		
Micromesistius poutassu	+		
Sebastes sp.	0.6		
Fishing wastes		0.18	+
Digested food		1.10	13.6
Number of studied stomachs	144886	4241	
% of empty stomachs	72,1	19,6	
Mean fullness	0,6	0,8	
Mean index of fullness, $^0/_{000}$		76,78	

Seasonal and interannual variability

The data analysis of the frequency of occurrence of the main food items indicated a distinct clear seasonal dynamics of food composition in 1980 – 2010 (Figures 2-4).

Generally the process of spring-summer feeding of *Sebastes mentella* is as follows. Very early in the feeding season (April-May) small plankton crustaceans (copepods, euphausiids) which frequency of occurrence was dropping dramatically in June prevailed in *Sebastes mentella* feeding... In June and July larger predating planktonic invertebrates (hyperiids, chaetognathans, pteropods, ctenophores and jellyfish) were predominant. At the end of the summer period (July-August), *Sebastes mentella* feeding mainly included cephalopods and fish.

At the same time, in 1980-2010, clear changes of food composition and its seasonal dynamics were registered at the different depths in different years (Figures 2-4).

In the upper layer (up to 450 m), with a similar feeding in April of 1980-2000 (the predominance of copepods and less euphausiids), in the recent decade, that month, euphausiids and shrimps prevailed in *Sebastes mentella* feeding. Furthermore, in 1980-1990, the intensive consumption of pteropods in June (25%), cephalopods in July (23%) and juvenile *Sebastes mentella* in August (61%) was observed but, in the following years, the importance of those species in *Sebastes mentella* feeding was extremely negligible.

At the depth of more than 450 m, the interannual dynamics was more evident. In April 1980-1990, *Sebastes mentella* the redfish feeding was based on copepods, in 1991-2000, – on the other prey and, in 2001-2010, – on euphausiids and shrimps. In July 1980-2000, Sebastes mentella feeding mainly included plankton (copepods, euphausiids and copepods) and cephalopods and, in 2001-2010, – fish and shrimps. Moreover, a number of species in the certain periods was almost completely dropped out of the *Sebastes mentella* feeding, thus, the frequency of occurrence of pteropods and chaetognathans was at the high level only in 1980-1991 (to 13-25%), while, in the following years, it didn't exceed 1-2%.

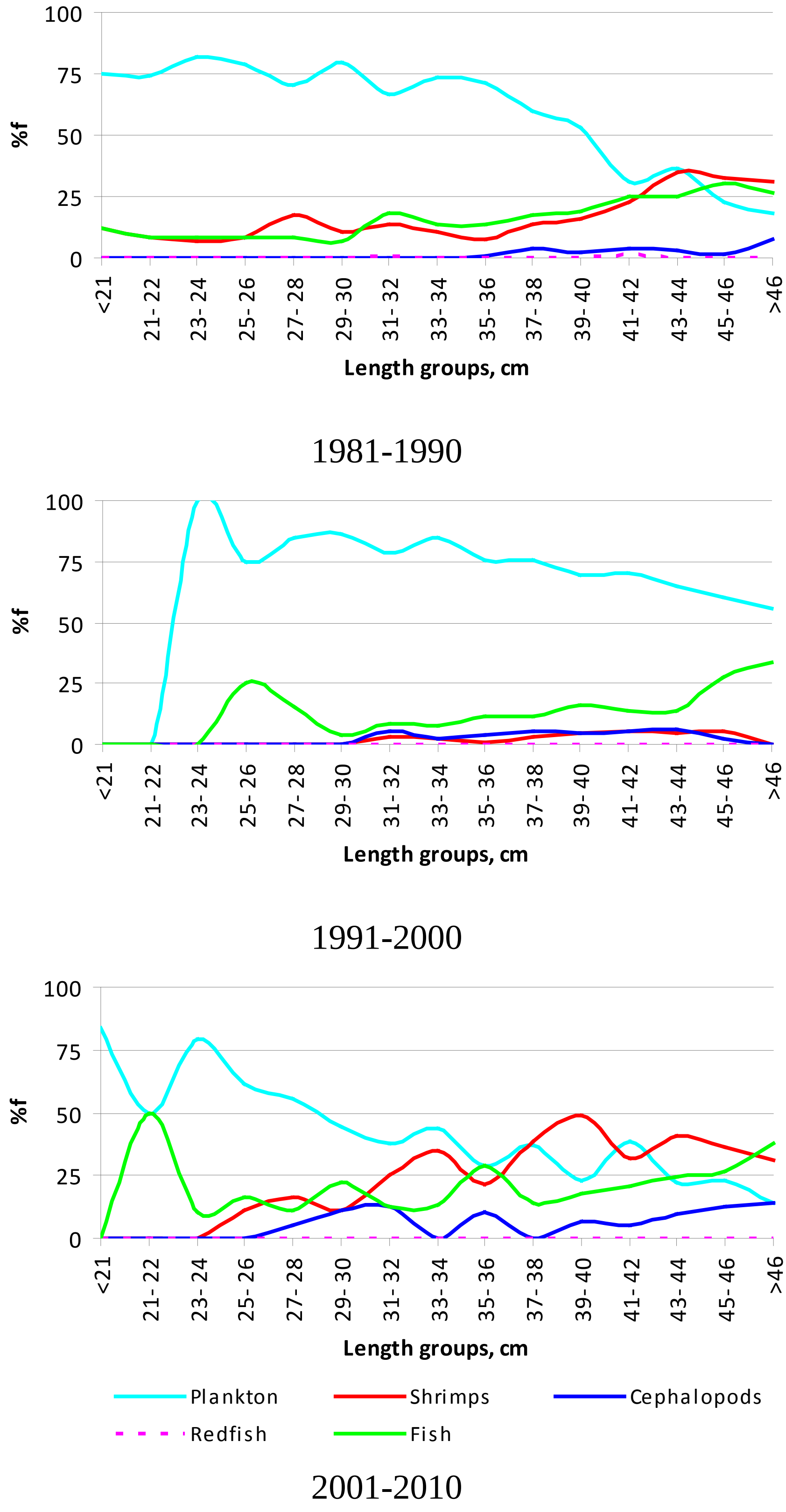

Figure 1. Food composition of different length groups of demersal *Sebastes mentella* on the slopes of Iceland and Greenland.

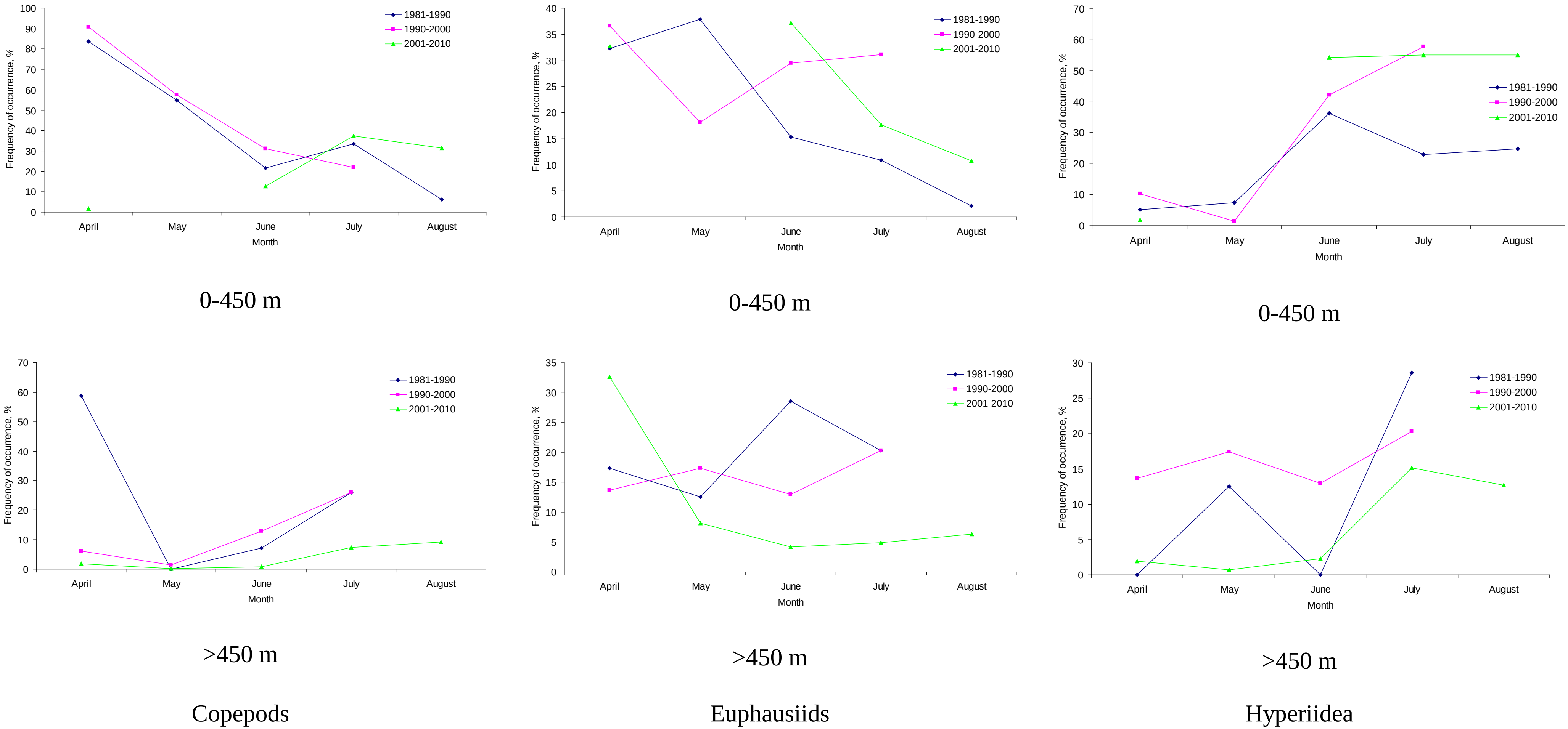

Figure 2. Seasonal dynamics of the frequency of occurrence of planktonic crustaceans in *Sebastes mentella* feeding in 1981-2010, % of feeding fish number

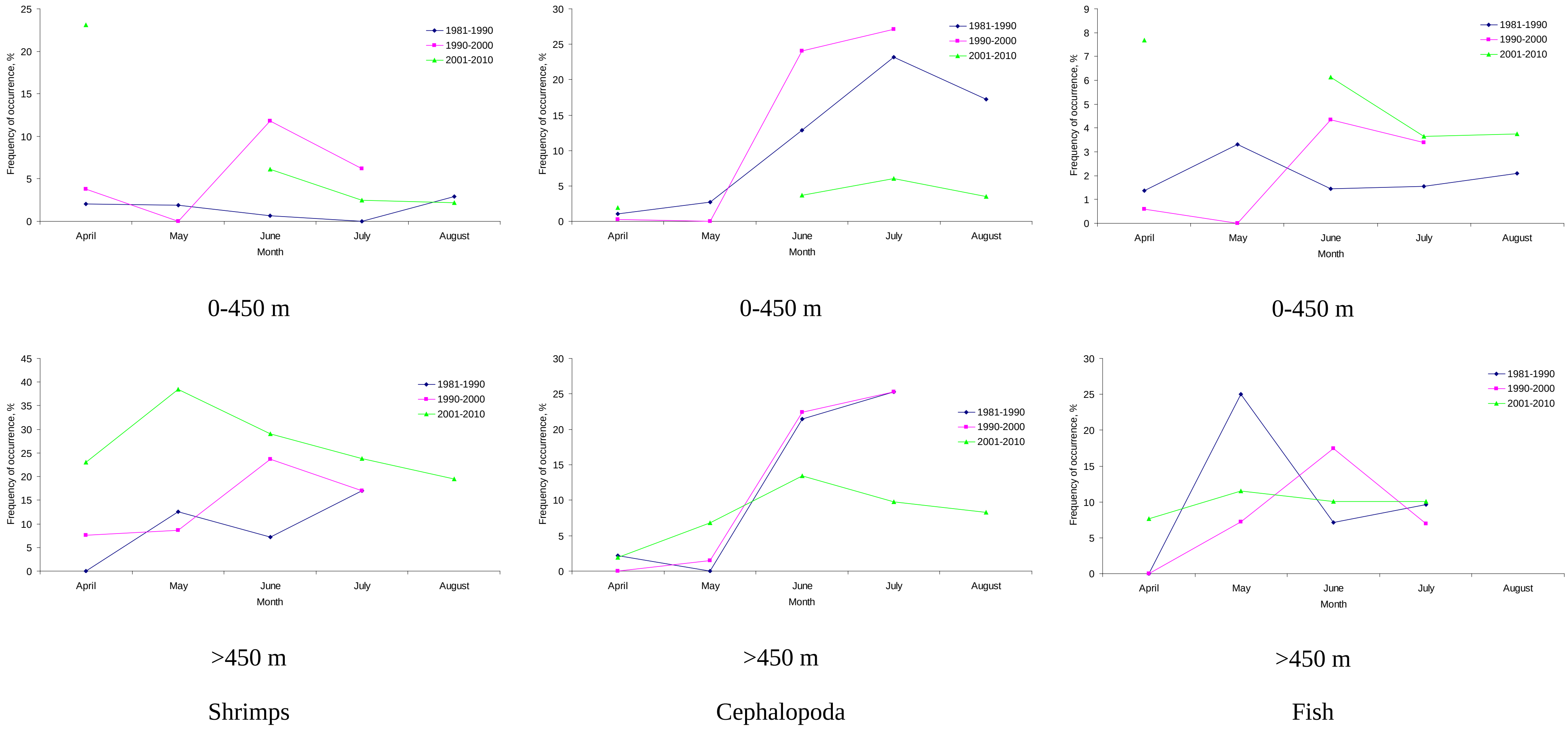

Figure 3. Seasonal dynamics of the frequency of occurrence of nektonic *invertebrata* and fish in *Sebastes mentella* feeding in 1981-2010, % of feeding fish number

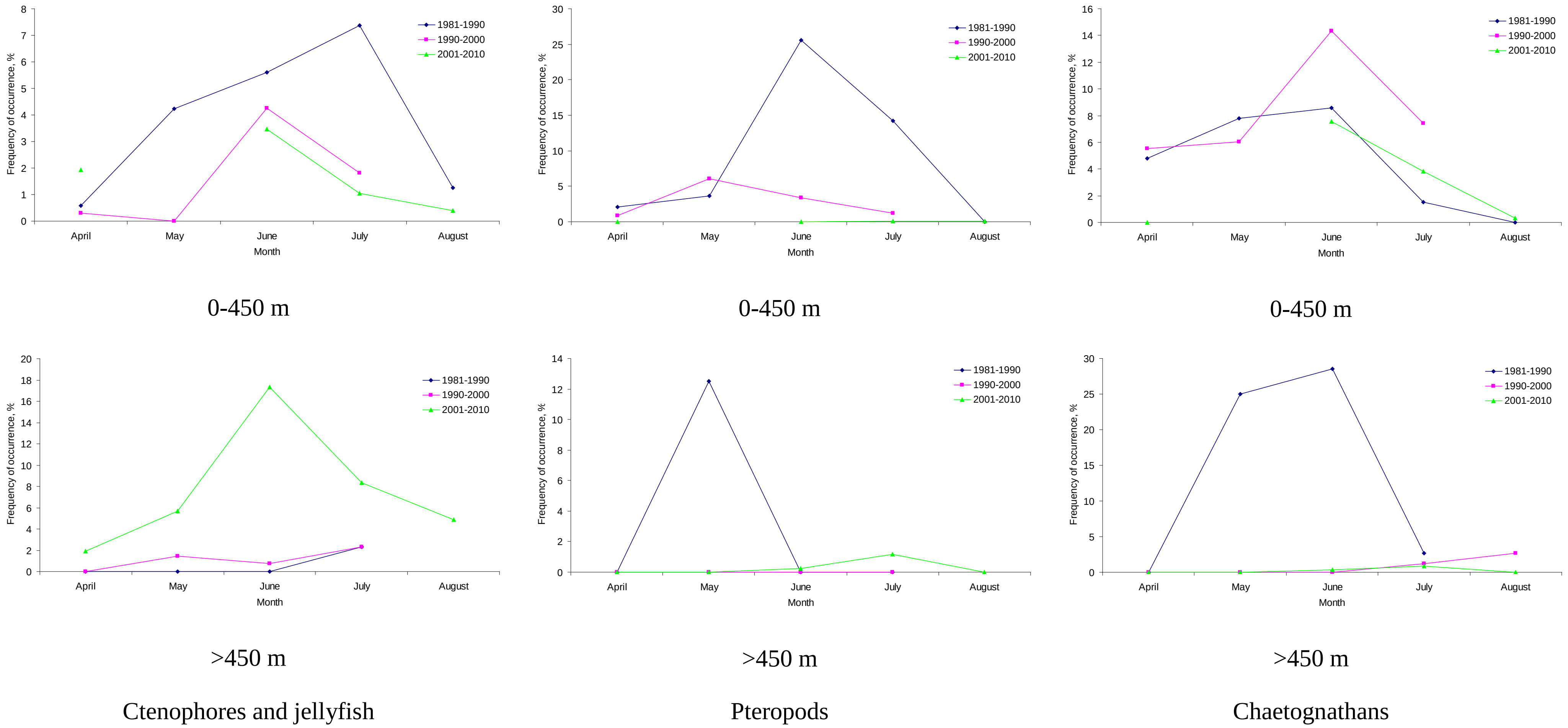

Figure 4. Seasonal dynamics of the frequency of occurrence of planktonic invertebrates in *Sebastes mentella* feeding in 1981-2010, % of feeding fish number

Their own larvae and juvenile fishes were found in *Sebastes mentella* stomachs mainly in the central areas of the Irminger and Labrador Seas (Figure 5). The larvae were recorded in April-June, mainly over the Reykjanes Ridge, where the spawning grounds of that species were located and the juveniles – in June and August in the currents, which helped to transport larvae from the spawning grounds.

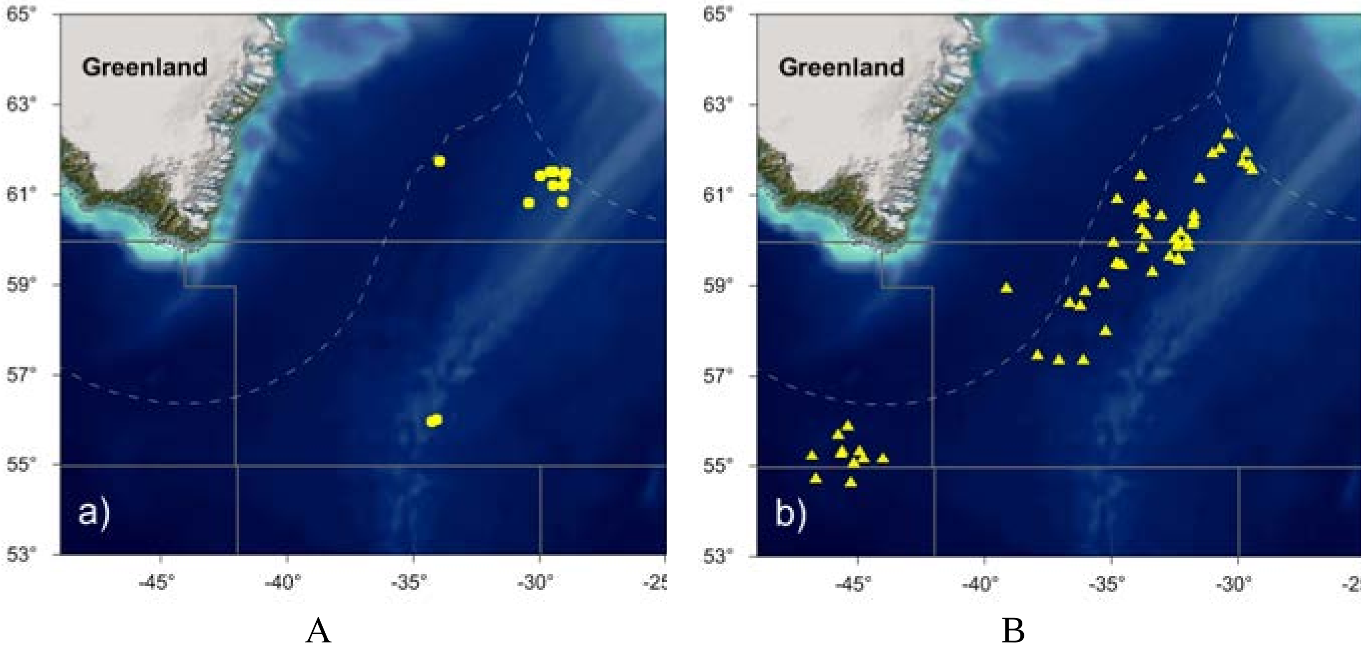

Figure 5. The occurrence of *Sebastes mentella* larvae (A) and juveniles (B) in the *Sebastes mentella* stomachs (according to the data from fishery and research cruises in 1980-2010)

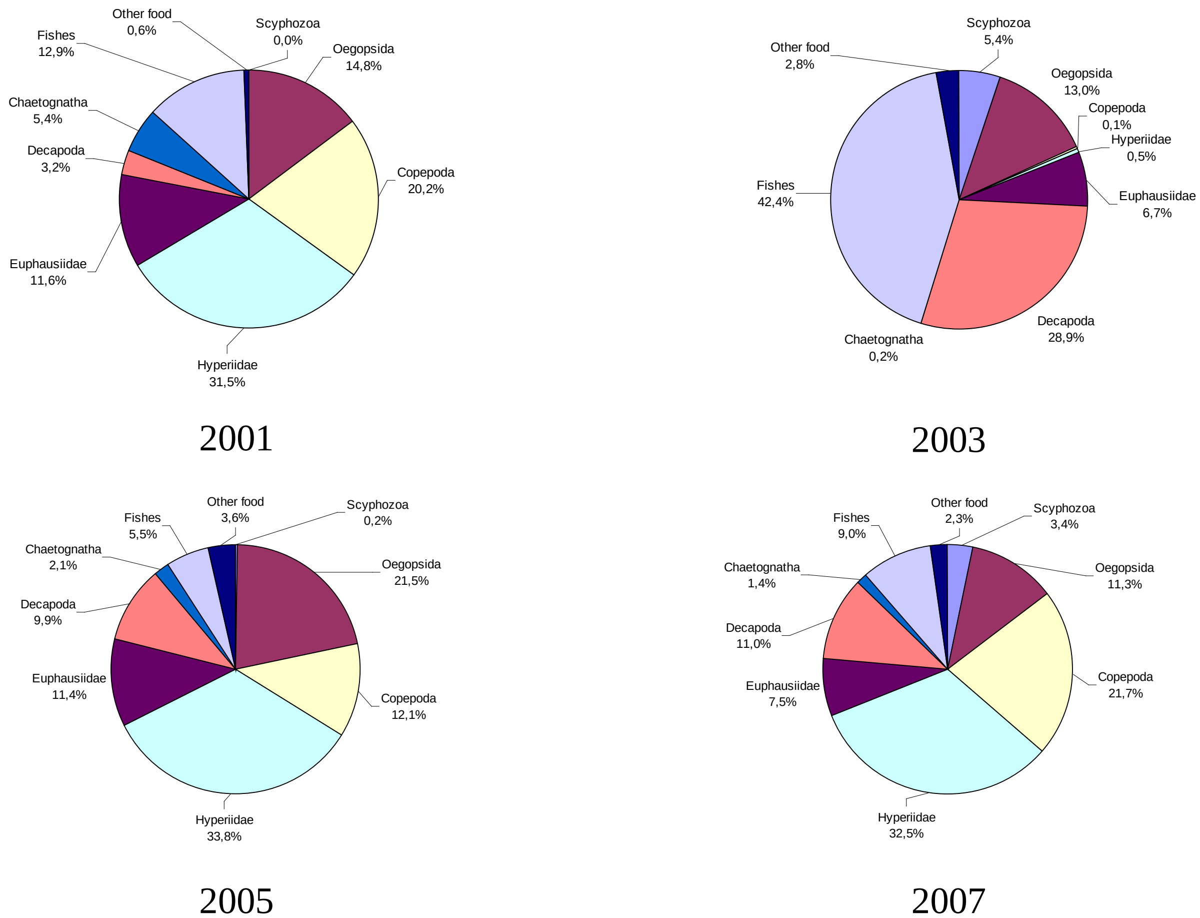

Figure 6. Food composition of *Sebastes mentella* in summer according to the quantitative feeding analysis

It must be emphasized that cannibalism was the highest in August of the 1990ss. After in 1995 Sebastes mentella concentrations had started to redistribute the redfish length composition changed significantly in the upper layer, *Sebastes mentella*, as a result of which the cannibalism decreased considerably.

Quantitative feeding analysis also shows significant interannual variability of *Sebastes mentella* food composition in summer 2001-2007 (Figure 6). During that period, cephalopods and euphausiids had relatively stable significance in Sebastes mentella feeding (11-21 and 6-11% by weight, respectively). At the same time, in 2003, there was a sharp decrease in the weight percent of copepods and hyperiids that resulted in their almost complete absence in *Sebastes mentella* diet (up to 0.1-0.5% by weight). That year, the role of shrimps and fishes in *Sebastes mentella* diet increased dramatically, from 5-10% m up to 30-40% m.

Ontogenetical variability

Analyzing the data on frequency of occurrence clear ontogenetic changes in food composition of *Sebastes mentella* were identified (Figure 7).

In general, plankton prevails in the frequency of occurrence in the diet of small *Sebastes mentella* with length up to 36 cm. Considering the feeding of larger species, the frequency of occurrence of larger invertebrates (shrimps and cephalopods) and fish is gradually increasing.

At the same time, there were significant differences in feeding of different size *Sebastes mentella* in the different periods of years. Thus, in 1981-1990, the feeding of the majority of size groups was based on plankton (up to 70-90% f of the fish up to 41 cm in length) and even in larger species the frequency of occurrence of fish was low (on average 3-5% f, maximum up to 20% f), as well as of shrimps and cephalopods.

In 1991-2000, the significance of plankton in the diet of nearly all the length groups decreased to 50-70% and, at the same time, the frequency of occurrence of fish, cephalopods and shrimps sharply increased (up to 10-20% in each group), even in small and medium sized *S. mentella* of 20-36 cm length.

In 2001-2010, plankton became predominant again in the diet of fish with the length of up to 40 cm (75-90%f), and the main diet components of larger specimens were fishes, shrimps and cephalopods, as well as in the previous decade.

It must be emphasized that the juveniles of S. *mentella* constituted a significant part of the diet of adult specimens only in 1981-1990 (up to 5-7%), and in the following periods they were rarely recorded as the redfish food items.

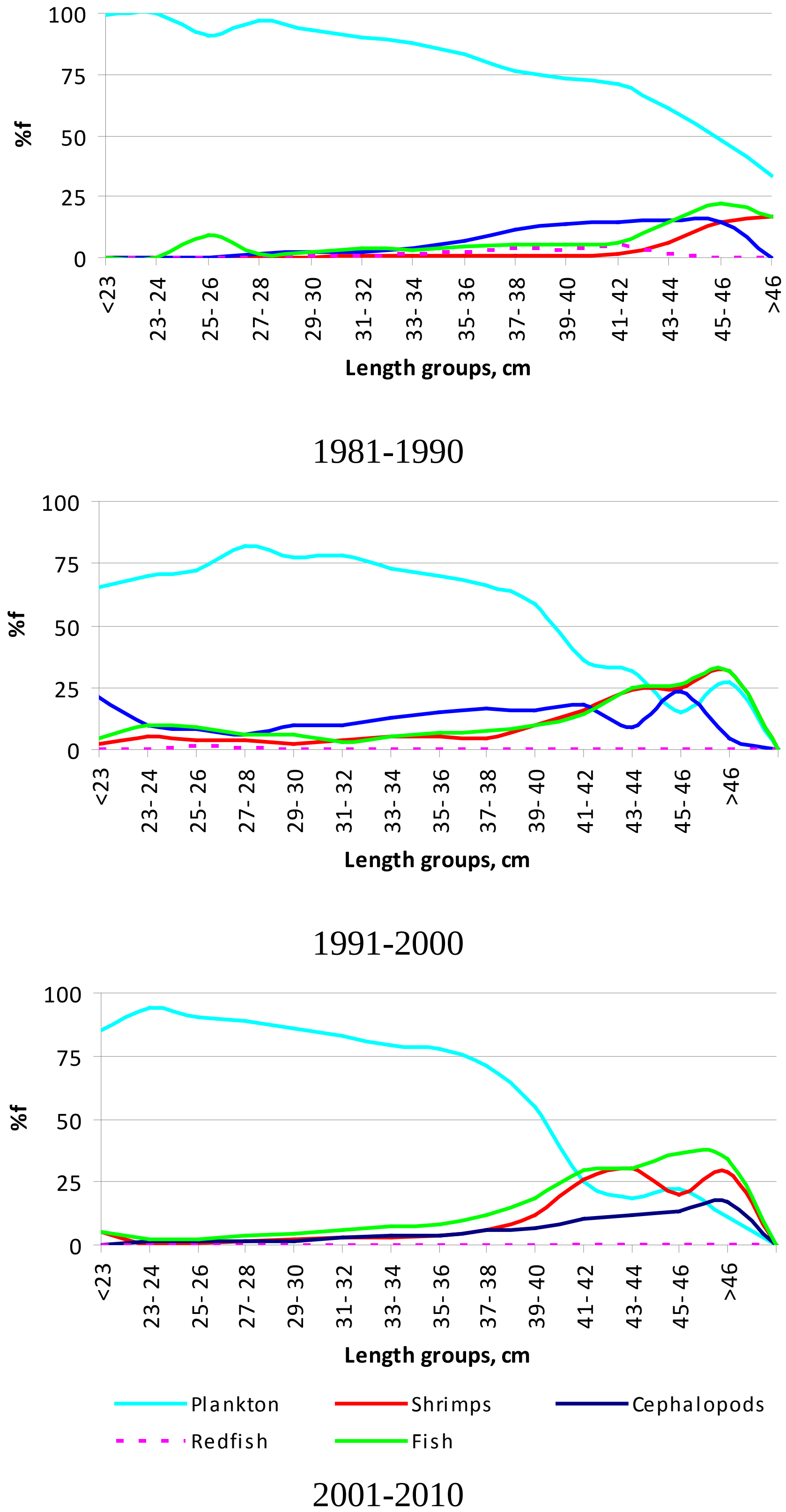

Figure 7. Food composition of different length groups of pelagic *S. mentella* in 1981-2010, frequency of occurrence (in % of the number of feeding fish)

According to the data from the quantitative feeding analysis plankton (Hyperiidea and in a less degree Copepoda and Euphausiidae) composed the diet of *S. mentella* up to 37 cm long (Figure 8). In the diet of larger fish plankton was less significant and the diet was composed basically of fishes, cephalopods and in a less degree of shrimps and jellyfishes (ctenophorans and Hydrozoa).

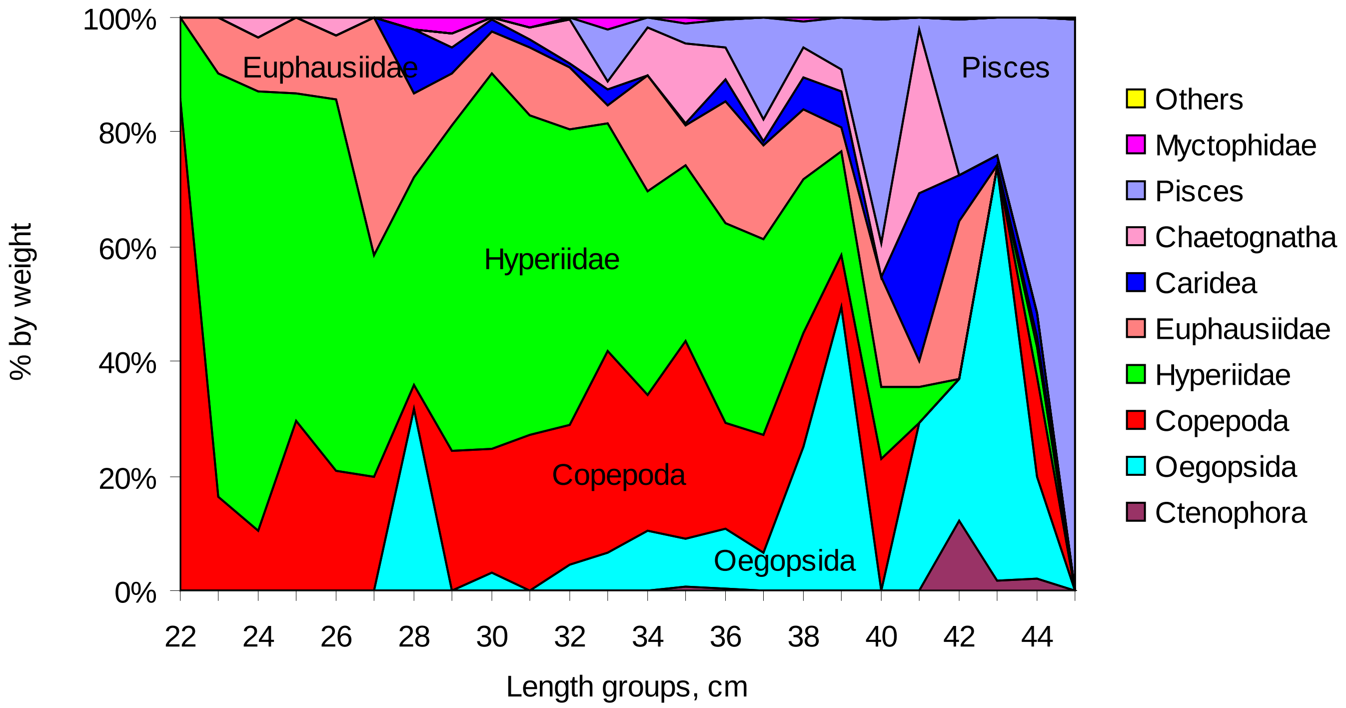

Figure 8. Food composition of different length groups of *S. mentella* in 2001-2009 (in quantity, % by weight)

Claster analysis of quantitative and qualitative data on diet of various length groups of pelagic redfish showed that three groups can be comsidered (Figures 9-10) – the smallest fishes with length less 21-22 cm (diet – mainly copepods), medium size fishes from 22 to 37-40 cm (diet –plankton and small fish) and large fishes with length more 37-40 cm (diet – mainly fish and squids).

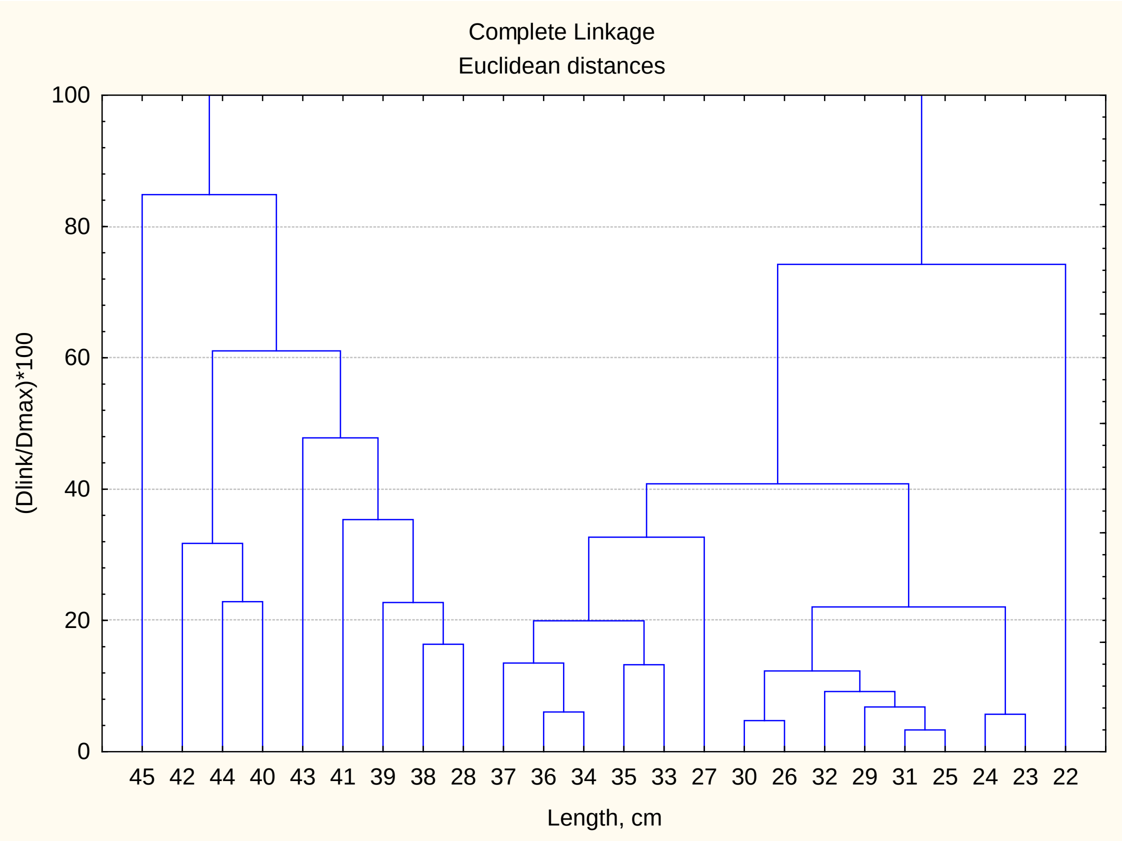

Figure 9. Claster analysis of quantitative data on diet of various length groups of pelagic redfish in 2001-2007.

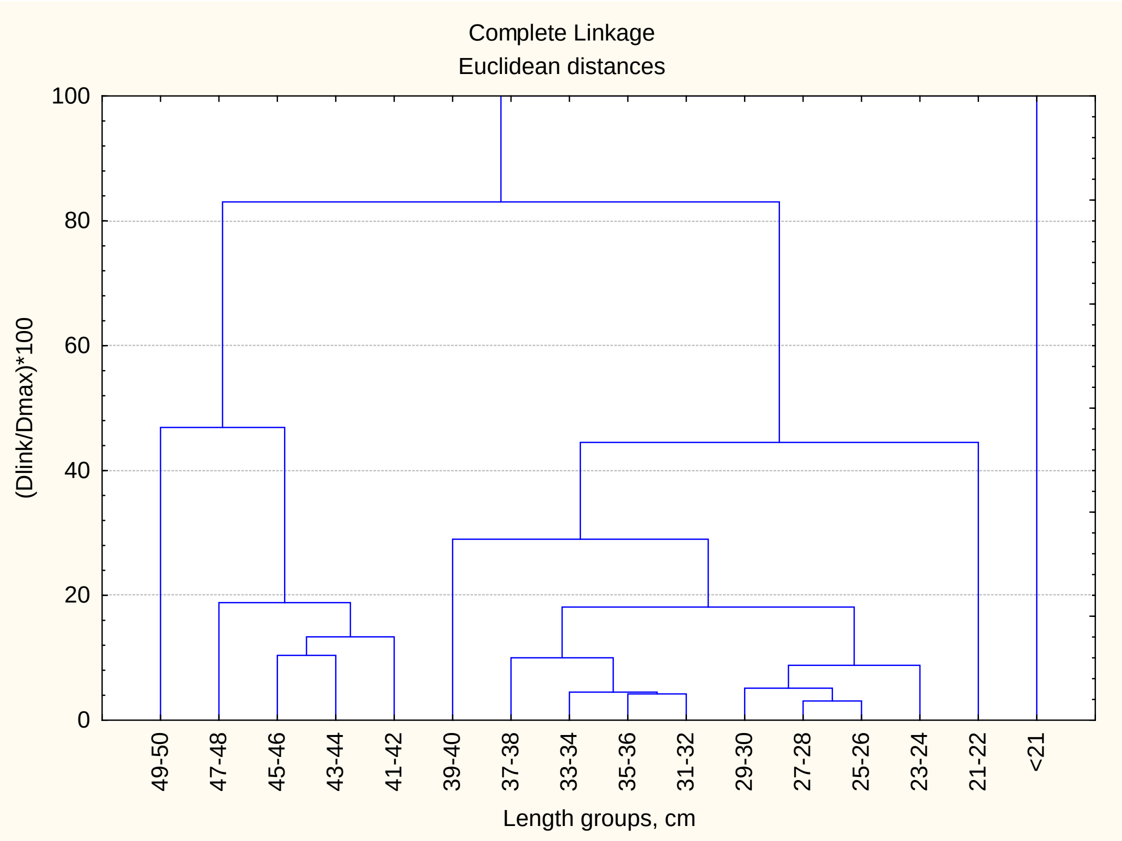

Figure 10. Claster analysis of qualitative data on diet of various length groups of pelagic redfish in 1980-2010

Vertical variability

As can be seen from the qualitative analysis of *S. mentella* food composition at different depths, in the layer up to 450 m, the diet of *S. mentella* is composed mainly of plankton (Copepoda, Euphausiidae, Hyperiidea, Pteropoda). Cephalopods, jellyfish and chaetognatha occur in the diet of *S. mentella* in a wider range of depths. Shrimps and mesopelagic fishes prevailed in the diet of *S. mentella* at the depth over 200 m. Juvenile *S. mentella* occured in the stomachs of adult specimens mainly in the layer up to 150 m (Figure 11).

Based on data from Soviet/Russian research surveys in the Irminger Sea two deep scattering layers (DSL) were observed during cold years (1980-1994) in the summer. Upper layer (depths 50-150 m) mainly consisted of small plankton organisms and juvenile squids, while lower layer (depths 300-550 m) was distribution area for mesopelagic fishes and adult squids. Dense concentrations of redfish located in the same layers (50-150 m and 300-450 m) (Figure 12).

During cold years redfish feed in the layer 0-500 m. Plankton (hyperiids, pteropods, jellyfish and juvenile squids) occurred in redfish diet mainly in the upper layer, while shrimps, mesopelagic fishes and adult squids dominated in the diet in the lower layer (Figure 11).

During warm years (1991-2010) deep scattering layer shifted downwards to depths 250-750 m. It resulted to migrations of redfish on deeper layer too, their commercial concentrations located on depths 250-400 m and 650-800 m. In this period redfish diet in the upper part of DSL (250-400 m) was similar to diet on the upper DSL (50-150 m) during cold years,. In contrast, importance of jellyfish, shrimps and cephalopods has increased on the lower part of DSL.

Quantitative data also show a similar tendency (Figure 13). The weight percent of plankton (Copepoda and Hyperiidae) in the upper layer is several times higher than in deeper layers whereas shrimps, cephalopods and fishes occur in the diet of *S. mentella* mainly at depth over 450 m.

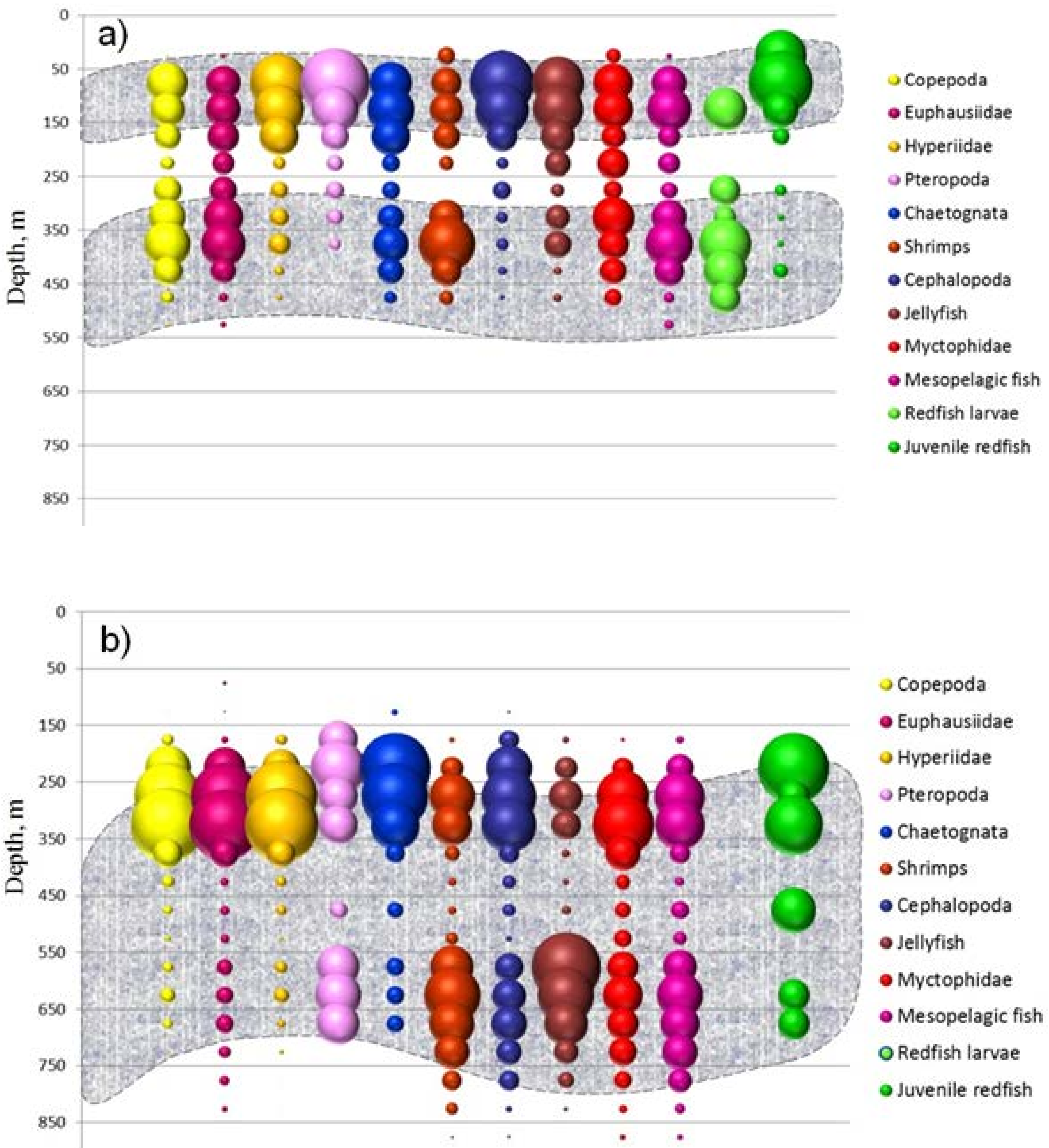

Figure_11. Proportion of different food items in the diet of *S. mentella* at different depths in cold (1980-1994) and warm (1995-2010) years (frequency of occurence, % of the number of feeding fish) Shadowed zone shows location of deep scattering layer (DSL)

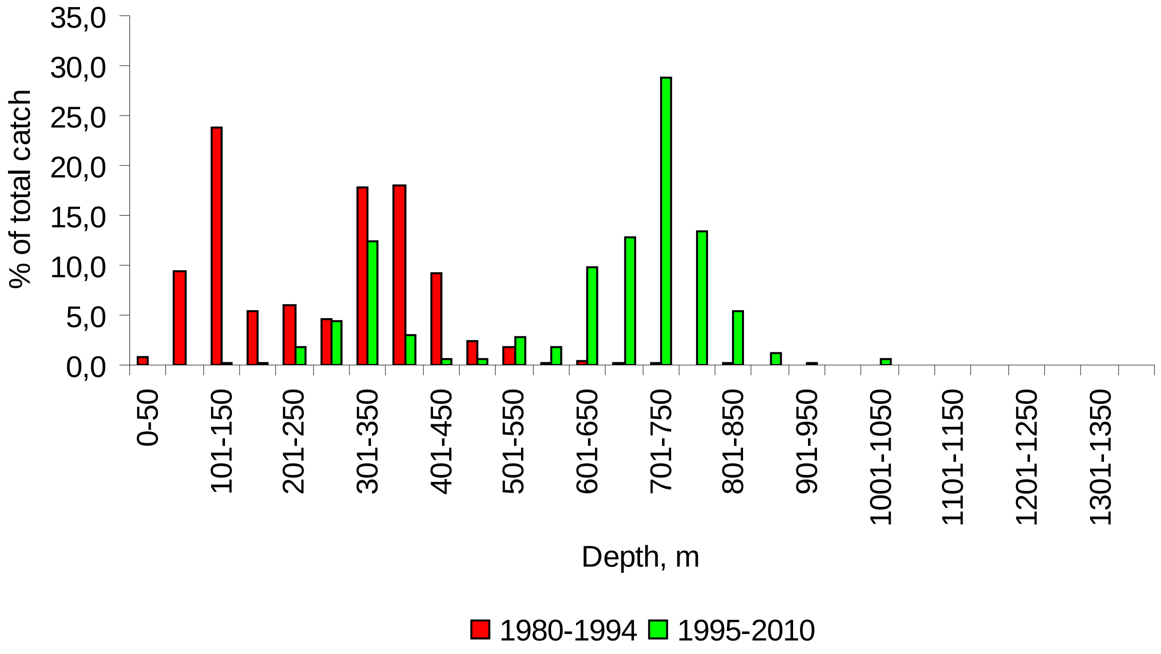

Figure 12. Ratio of Russian commercial catches of redfish on different depths during cold (1980-1994) and warm (1995-2010) years, % by total catch

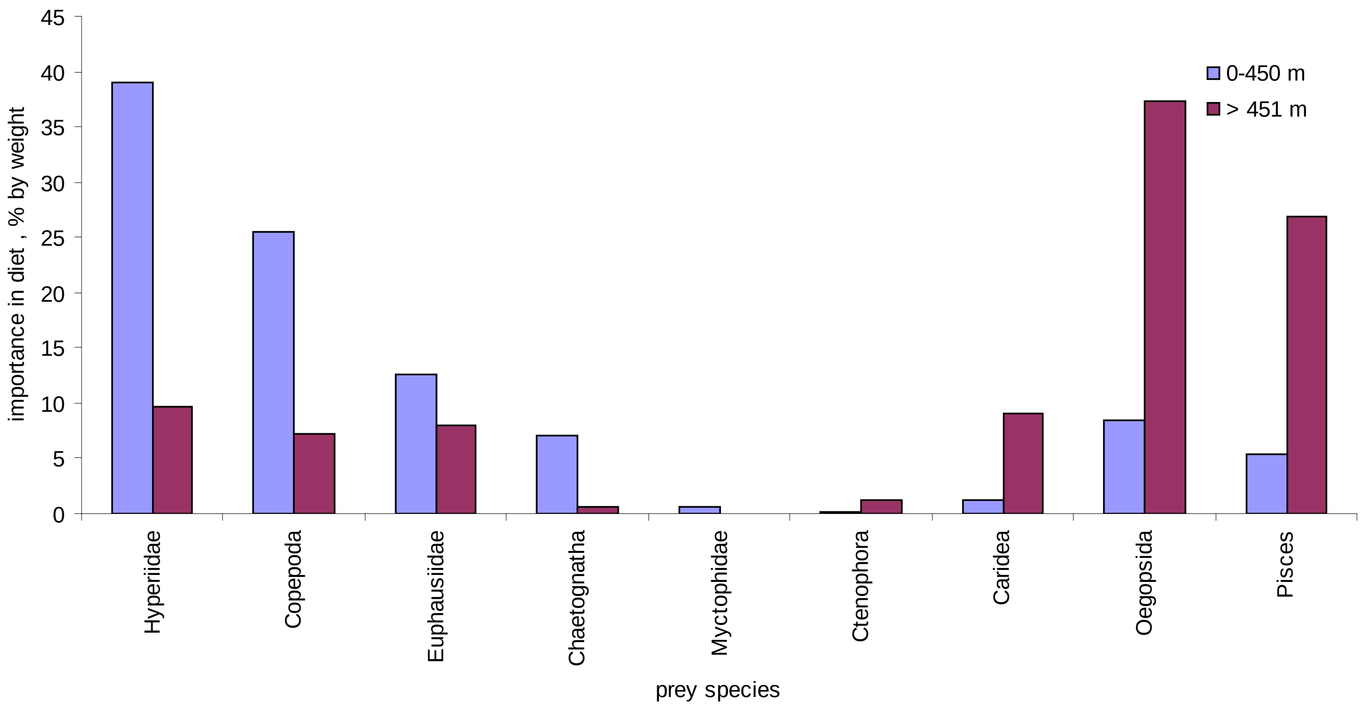

Figure 13. Food composition of *S. mentella* at different depths based on the quantitative data, %m

But differences in diet composition in layer 0-500 m and > 500 m were statistically insignificant both for quantitative data (Mann-Whitney U-test – 70 (crucial values 31 ($p \le 0.01$) и 42 ($p \le 0.05$)) and Wilcoxon T-test – 41 (crucial values 9 ($p \le 0.01$) и 17 ($p \le 0.05$))) and for qualitative data (Mann-Whitney U-test – 1635 (crucial values 1356 ($p \le 0.01$) и 1486 ($p \le 0.05$)) and Wilcoxon T-test – 461 (crucial values 362 ($p \le 0.01$) и 426 ($p \le 0.05$))).

Discussion

Our data on the food composition of *S. mentella* mostly correspond to the results of the previous Soviet/Russian researches (Pavlov, 1992; Bakay and Melnikov, 1992; Melnikov, 2006; Melnikov et al., 2007) (particularly because our results include the data used in the previouspapers), and by the foreign authors (Magnusson and Magnusson, 1995). At the same time, our data considerably differ from the data of González et al. (2000), collected onboard fishing vessels according to which in 1996 fishing waste dominated in the diet of *S. mentella*.

At the same time, according to the results of field and quantitative analyses, the significance of particular species was not equal. For example, Copepoda and Euphausiidae which are often found in the stomachs of *S. mentella* (2th and 3rd most frequently occurred) are only the 5th and 6th by weight. Minor significance of Copepoda in the diet of *S. mentella* in the Irminger Sea is confirmed by the data of the isotope analysis (Petursdottir et al, 2008). At the same time, the representatives of larger taxons (fishes, squids and shrimps) occurring relatively rarely (the 4th-6th most often occurred) dominate by weight in the diet of *S. mentella* (1st, 3rd and 4th correspondingly).

The ontogenetic changes in the diet reflect morphological changes occurring during the growth of fish (change of mouth size which enables catching larger organisms, change of stomach capacity etc.), on the one hand, and are caused by changes in the food supply in the areas (depths) where *S. mentella* migrates while growing, on the other hand. Obvious tendency of diet composition shift (from small-size to large prey items) with redfish growth and changes in depth habitat conditions was observed throughout all investigated period. Similar food selectivity in diet of different size fishes is know also for other Sebastes species, e.g. in northern Pacific (Snytko, 2001 and reference therein)

Well defined interannual changes in the diet of *S. mentella* indicate changes in the food supply in the Irminger Sea. During the temperature increase in the Irminger Sea and when the large aggregations of small mesopelagic fishes are transported to this area by streams its significance in the diet of *S. mentella* increases.

Thus, in our opinion, the information about the diet of *S. mentella* indicates that different changes in the food composition of *S. mentella* (including ontogenetic, spatial (at different depths), seasonal and interannual changes) to a greater degree can be caused by the changes in the food supply of *S. mentella* during the changes of its feeding biotopes while the fish grow. At the same time, it is impossible to explain the observed changes in feeding patterns by the existence of isolated groups (populations, sub-populations, etc.).

It is necessary to note that obtained results are preliminary. Further analysis should include consideration of additional information on oceanography conditions, spatial and vertical distribution of redfish as well as vertical distribution of prey organisms from research surveys.

References

Bakay Yu.I., Melnikov S.P. 2002. Vertical structure of Sebastes mentella concentrations in the pelagic part of the Irminger Sea. NAFO SCR Doc. 02/10. Ser. No. N4611. – 21 pp.

Dolgov A.V., Drevetnyak K.V. Some peculiarities of feeding and feeding interrelations of deepwater redfish (Sebastes mentella) in the Barents and Norwegian seas // ICES C.M. 1993/G:60. - 14 pp.

Dolgov A.V., Drevetnyak K.V. Feeding of young Sebastes mentella Travin in the Barents and Norwegian seas.// Precision and relevance of pre-recruit studies for fishery management related to fish stocks in the Barents sea and adjacents waters / Proceedings of the sixth IMR-PINRO Symposium, Bergen, 14-17 June 1994.(Ed. A.Hylen) - IMR, Norway, 1995. - P.129-134.

Dushchenko, V. V. 1986. Polymorphism of NADP-dependent malatedehydrogenase in Sebastes mentella (Scorpaenidae) from the Irminger Sea. Journal of Ichthyology, 27: 129-131.

González C., Bruno I. and Paz X. 2000. Food and Feeding of Deep-sea Redfish (Sebastes mentella Travin) in the North Atlantic. NAFO Sci. Coun. Studies, 33: 89–101

Gorelova, T. A. & Borodulina, O. D. 1997. Feeding spectra of young deepwater redfish Sebastes mentella and redfish S. marinus in the Greenland shelf area. Journal of Ichthyology 37, 779–785.

Jones D.H. 1970. Food, parasites and the reproductive cycle of pelagic redfish (Sebastes mentella Travin) from weather station Alfa in the North Atlantic // Bull. Mar. Ecology. V. 6. № 9. P. 347–370.

Konchina Yu.V. Main trophic relationships of redfish in the Northwest Atlantic// NAFO SCR. Doc. 1983 83/IX/75 24 pp.

Magnusson, J. 1977. Pelagic redfish in the Irminger Sea. Distribution and abundance. ICES Doc. CM /H: 43, 10 pp.

Magnusson, J., Magnusson, J.V., 1995. Oceanic redfish (Sebastes mentella) in the Irminger Sea and adjacent waters. Scientia Marina 59, 241–254.

Melnikov, S.P. 2006. Oceanic redfish of the NorthAtlantic: biology and fishery.:PINRO, Murmansk, 127 pp. (in Russian)

Melnikov S.P., Shibanov V.N., Stroganov A.N., and G.G. Novikov. On the issue of biological and genetic studies of S. mentella in the open areas of the North East Atlantic. ICES CM 2007/L:02. – 25 pp

Noskov, A., Romanchenko, A., and Pavlov, A. 1984. Abundance of larvae and assesment of the spawninf redfish (Sebastes mentella Travin) stock of the Irminger Sea for 1982. ICES Doc. CM/G: 24, 16 pp.

Palsson, O.K. 1983. The feeding habits of demersal fish species in Icelandic waters. Rit Fiskideildar, 7: 1-60.

Pavlov, A.I. 1992. Feeding and peculiarities of distribution of the redfish (S. mentella Travin) in the Irminger Sea. Collected Scientific Papers, PINRO Press. Murmansk. P.96-116. (in Russian)

Pedersen, S. A., and F. Riget. MS 1991. Feeding habits of redfish, Sebastes spp., in West Greenland waters with special emphasis on predation on shrimp. NAFO SCR Doc., No. 48, Serial No. N1931, 9 p.

Pedersen, S. A., and F. Riget. 1993. Feeding habits of redfish (Sebastes spp.) and Greeland halibut (Reinhardtius hippoglossoides) in West Greenland waters. ICES J. Mar. Sci., 50: 445–459.

Petursdottir H., Gislason A., Falk-Petersen S., Hop H., Svavarsson J. 2008. Trophic interactions of the pelagic ecosystem over the Reykjanes Ridge as evaluated by fatty acid and stable isotope analyses. Deep-Sea Research II 55 83–93.

Rikhter V.A. 1961. Are there aggregations of redfish in the pelagial? // Scientific and Technical Information Bulletin of the Baltic Research Institute of Marine Fisheries and Oceanography, 12:19-20 (in Russian).

Saborido-Rey F., Garabana D., Stransky C., Melnikov S. & V. Shibanov. 2004. Review of the population structure and ecology of S. mentella in the Irminger sea and adjacent waters. Reviews in Fish Biology and Fisheries 14: 455–479

Shibanov, V., Gorelov, A., and Oganin, I. 1984. Some results of researches into the biology of redfish (Sebastes mentella) in the Irminger Sea. ICES Doc. CM/G:79, 16 pp.

Snytko V.A. 2001. Redfish of northern part of the Pacific Ocean Vladivostok, TINRO-center, 468 pp. (in Russian).

Templeman, W. 1959. Redfish distribution in the North Atlantic. Journ. Fish. Res. Board Can. № 120: 167.

Yanulov K.P. Feeding habits of ”beaked” redfish (Sebastes mentella Travin) in the Newfoundland-Labrador area// ICNAF Annual Meeting 1962. Ser. № 1005. Doc. № 62. 19 pp.

Zakharov, G. 1964. Redfish above the ocean depths. ICNAF Res. Bull. № 1: 39-42.