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Spatial and temporal dynamics of the demersal fish community in the Barents Sea

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Abstract

The species composition and structure of the Barents Sea fish community is considered. Based on data from the Russian research surveys during 1998-2006 some types of the fish communities were revealed related to different environmental parameters (geographical position, water temperature, habitat depth). The northern Barents Sea fish community consists mainly of arctic species though mainly boreal species dominate in the southern Barents Sea. Deepwater community locates on the continental shelf slope (Greenland halibut, onion-eye grenadier, deepwater redfish, Arctic skate). Other species (like Atlantic spiny lumpsucker, shorthorn sculpin, Arctic staghorn sculpin) were more common only in shallow water communities. Some inter-annual changes related to water temperature were observed in the Barents Sea fish community. Due to water temperature increasing the portion of arctic species decreased and the portion of mainly boreal species increased.

Introduction

Despite investigations of single fish species both commercially important and non-target were started in the Barents Sea since the beginning of XX^{th} century, researches of whole fish community conducted only some years ago. Until now the number of published papers on this area are rather small (Burgos, 1989; Dolgov, 2000, Smirnov et al., 2000; Dolgov, 2004ab; Karamushko and Aleksandrov, 2003; Dolgov et al., 2005; Fossheim et al., 2006). So, main peculiarities of structure and spatial and temporal dynamics of the Barents Sea fish community are poorly studied.

The main objectives of this paper are consideration of structure of the Barents Sea fish community and its spatial and temporal dynamics, as well as the factor that determine these parameters.

Material and methods

Data on the fish species composition of the catches, collected during the Russian bottom survey in October-December 1998-2006, were used (Figure 1). The mean abundance of each fish species per 1-hour tow was used for analysis. Data on the depth of the trawl stations as well as data on the bottom temperature and salinity collected on the trawl stations by STD-units were used as parameters of habitat conditions for fish.

Results and discussion

Totally 103 species from 31 families were occurred in the catches.

Groups related to the habitat conditions

The cluster analysis shows the existence of some species groups related to the various habitat characteristics.

Three groups of fish species were separated relating to depths – shallow-water (depth less 50 m), mid-water (depths 100-500 m) and deep-water (depths more than 500 m) communities (Figure 2). It was caused by the differences in preferred depth for various fish species (Figure 3). Shallow-water species (e.g., shorthorn sculpin, dab and plaice) occurred mainly on the small depths (up to 100-150 m). Deep-water species (e.g., arctic rockling, roughhead grenadier, greater eelpout) dwell the depths more than 400-450 m. A number of species like cod, thorny skate and sea tadpole, were observed in wide temperature range.

Arctic staghorn sculpin and shorthorn sculpin (together with cod which occurred in wider depth range) were dominant species on the shallow-water community (Table 1). Additionally some other fish species were observed in this community and absent in deeper water. The traditional commercially important species (cod, haddock, long rough dab, deepwater redfish) dominated in the mid-water community. In addition, Atlantic hookear sculpin and moustache sculpin were occurred in this community. Greenland halibut was dominant species in the deepwater community (the depth more than 500 m). Besides, abundance of deepwater redfish and species with wide depth range (cod, haddock and long rough dab) was relatively high in this community as well as the species that occurred only in this community (roughhead grenadier, Arctic skate).

Six groups were separated relating to water temperature (Figure 4). It was caused by the differences in preferred water temperature for various fish species (Figure 5). Coldwater species (e.g., Arctic skate, Arctic eelpout and shorthorn sculpin) occurred mainly at the temperature below 2,5-3^{0}C, and its maximal catches – at the temperature below 1^{0}C. Warmwater species (e.g., greater argentine, Norway pout and Norway haddock) observed in the catches at the temperature above 4-5^{0}C. A number of species like cod, thorny skate and Vahl's eelpout, occurred in the wide temperature range.

The coldwater species (capelin, polar cod) and species with wide temperature range (cod, long rough dab) were dominant in the groups related to negative water temperature (Table.2). In addition some non-target coldwater species (shorthorn sculpin, gelatinous snailfish) were presented in these groups and absented in other groups. The maximal catches of coldwater species (polar cod) and species with the wide temperature range (cod, long rough dab) were observed in the group with the temperature 0-2^{0}C. The portion of the warmwater species (haddock, blue whiting, Norway pout) increased in the group with temperature 2-5,5^{0}C while the cod abundance remained to be high. The warmwater species (haddock, blue whiting, Norway pout) dominated in the catches in the group with temperature above 5^{0}C.

Three groups were separated relating to water salinity (Figure 6). Considerable lower species number was related to the water salinity. Most of species occurred in the wide salinity range (cod, long rough dab, thorny skate) or at high salinity (Arctic rockling, Norway pout). Only few species number (shorthorn sculpin) preferred waters with low salinity (Figure 7).

The species preferred low salinity (shorthorn sculpin and Arctic staghorn sculpin) and the species with wide salinity range (cod, saithe, long rough dab) dominated in the first group (below 33,6 $^0/_{00}$) (Table 3). The portion of the species with the wide salinity range increased in the second group (salinity 33.7-33.8 $^0/_{00}$). The species preferred the high salinity (cod, polar cod etc.) were dominant in the third group (salinity above 35$^0/_{00}$).

Spatial groups

Some differences in the species composition and structure of fish communities in various areas of the Barents Sea were revealed (Figure 8).

Haddock, polar cod, Atlantic herring, long rough dab and cod were the most abundant species in the southern Barents Sea (ICES area I). Blue whiting, Greenland halibut, deepwater redfish, haddock and Norway pout dominated in the Norwegian coast area (ICES area IIa). Blue whiting, cod, haddock, long rough dab, capelin, polar cod and Greenland halibut were the dominant species in the Bear Island-Spitsbergen area (ICES area IIb). Simultaneously the portion of other fish species (mainly non-target species) was rather high in all three areas, but the abundance of each separate species was considerably lower than the catches of dominated species.

Most of dominant species occurred in all three areas of the Barents Sea. But the distribution of some other species was restricted. So, the maximal catches of Atlantic spiny lumpsucker were observed only in the Bear Island-Spitsbergen area (6.5 ind. per 1 hour tow vs. 0.2-0.3 ind. per 1 hour tow in other areas).

Mainly boreal fish species were the most abundant in all three areas (Figure 9). The portion of warm water fish species (boreal and wide distributed species) was considerably higher in the Norwegian coast area while portion of coldwater fish species (arctic and mainly arctic species) was higher in the southern Barents Sea and in the Bear Island-Spitsbergen area.

Year-to year dynamics of the Barents Sea fish community

During 1998-2005 annual variations of the species from the different zoogeographic groups were observed (Figure 10). The abundance of coldwater arctic and mainly arctic species decreased to 2004-2005 after the maximum in 2000-2001. At the same time the catches of warmwater boreal, southern boreal and wide distributed species increased. It was related to increasing of heat content of the Barents Sea waters during 2004-2005, when temperature anomalies on the Kola section increased and reached 0,87-0,93^{0}C.

Conclusions

1. The distinct differentiation of fish species in the Barents Sea related to the habitat parameters (depth, temperature, salinity) and the species groups was revealed.
2. The species composition and structure in various areas of the Barents Sea us considerably was varied. Despite the total dominance of mainly boreal species, the portion of arctic and mainly arctic species was high in the northern and eastern Barents Sea, while the portion of southern boreal and wide distributed species was high in the southwestern areas.

3. The ratio of coldwater and warmwater species varies depend on the heat content of the waters in the Barents Sea. Increasing of the water temperature result the increasing of the portion of warmwater species and vice versa.

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Table 1. The species composition and structure of fish communities on the different depths.

Depth range, m					
0-50 m		51-500 m		501-800 m	
Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow
Gymnacantus tricuspis	53.3	Melanogrammus aeglefinus	141.9	Reinhardtius hippoglossoides	393.2
Gadus morhua	45.8	Gadus morhua	83.9	Sebastes mentella	49.3
Myoxocephalus scorpius	29.6	Hippoglossoides platessoides	82.7	Hippoglossoides platessoides	5.3
Ammodytes sp.	7.9	Sebastes mentella	42.5	Macrourus berglax	4.9
Hippoglossoides platessoides	3.3	Trisopterus esmarkii	10.5	Gadus morhua	3.9
Eumicrotremus spinosus	2.0	Reinhardtius hippoglossoides	9.3	Melanogrammus aeglefinus	2.7
Liparis gibbus	1.6	Amblyraja radiata	4.4	Lycodes esmarki	1.5
Liparis tunicatus	1.1	Pleuronectes platessa	4.1	Amblyraja radiata	1.3
Ulcina olrikii	1.0	Sebastes marinus	3.0	Amblyraja hyperborea	1.2
		Eumicrotremus spinosus	2.8		
		Anarhichas lupus	2.6		
		Artediellus atlanticus	1.9		
		Cyclopterus lumpus	1.6		
		Triglops murrayi	1.1		
		Limanda limanda	1.1		
		Sebastes viviparus	1.0		
Mean species number 6.2		Mean species number 10.6		Mean species number 7.6	

Table 2. The species composition and structure of fish communities at the different bottom temperature

Temperature range, m					
<-1.5 and -1.0 - 0^{0}C		-1.5- -1.01^{0}C		0-2^{0}C	
Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow
Boreogadus saida	548.8	Boreogadus saida	618.2	Boreogadus saida	147.5
Mallotus villosus	202.2	Mallotus villosus	174.2	Hippoglossoides platessoides	140.3
Hippoglossoides platessoides	70.7	Gadus morhua	117.6	Gadus morhua	118.4
Gadus morhua	61.5	Hippoglossoides platessoides	116.5	Mallotus villosus	67.1
Liparis fabricii	8.0	Melanogrammus aeglefinus	7.7	Micromesistius poutassou	57.1
		Reinhardtius hippoglossoides	7.6	Reinhardtius hippoglossoides	20.1
		Micromesistius poutassou	6.8	Melanogrammus aeglefinus	19.2
		Clupea harengus	5.7	Clupea harengus	13.0
		Myoxocephalus scorpius	5.6	Sebastes mentella	7.3
Mean species number 11.0		Mean species number 11.6		Mean species number 11.4	
2-5.5^{0}C		5.5-7.0 and 7.5-8.0^{0}C		7.0-7.5^{0}C	
Melanogrammus aeglefinus	219.2	Melanogrammus aeglefinus	290.0	Trisopterus esmarki	763.7
Micromesistius poutassou	181.8	Micromesistius poutassou	253.4	Micromesistius poutassou	290.8
Clupea harengus	113.3	Trisopterus esmarki	121.7	Melanogrammus aeglefinus	264.6
Gadus morhua	84.9	Sebastes mentella	40.9	Sebastes viviparus	45.3
Hippoglossoides platessoides	69.4	Gadus morhua	35.6	Pollachius virens	30.4
Mallotus villosus	34.9	Окунь вивипарус	31.4	Argentina silus	28.2
Sebastes mentella	33.6	Pollachius virens	13.4	Gadus morhua	25.0
Boreogadus saida	31.5	Hippoglossoides platessoides	10.6	Sebastes marinus	12.4
Trisopterus esmarki	20.2	Clupea harengus	9.3	Artediellus atlanticus	7.4
Reinhardtius hippoglossoides	15.4	Sebastes marinus	6.1	Hippoglossoides platessoides	6.9
Pleuronectes platessa	5.5	Argentina silus	5.8		
Mean species number 10.5		Mean species number 11.4		Mean species number 12.7	

Table 3. The species composition and structure of fish communities at the different salinity

Salinity range, m					
<33.6 $^{0}/_{00}$		33.7-33.8 $^{0}/_{00}$		>33.8 $^{0}/_{00}$	
Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow	Species	Mean catch, ind. per 1 hour tow
Myoxocephalus scorpius	93.8	Gadus morhua	33.0	Melanogrammus aeglefinus	215.0
Gadus morhua	83.1	Hippoglossoides platessoides	19.0	Boreogadus saida	107.2
Pollachius virens	51.0	Eumicrotremus spinosus	11.0	Gadus morhua	89.1
Boreogadus saida	45.0	Myoxocephalus scorpius	7.0	Clupea harengus	81.0
Gymnacantus tricuspis	25.7	Boreogadus saida	6.3	Hippoglossoides platessoides	67.7
Eumicrotremus spinosus	13.4			Micromesistius poutassou	66.6
Hippoglossoides platessoides	11.7			Mallotus villosus	42.1
Mallotus villosus	9.8			Trisopterus esmarki	23.9
Amblyraja radiata	6.1			Pleuronectes platessa	19.9
				Sebastes mentella	12.6
Mean species number 11.2		Mean species number 6.7		Mean species number 9.6	

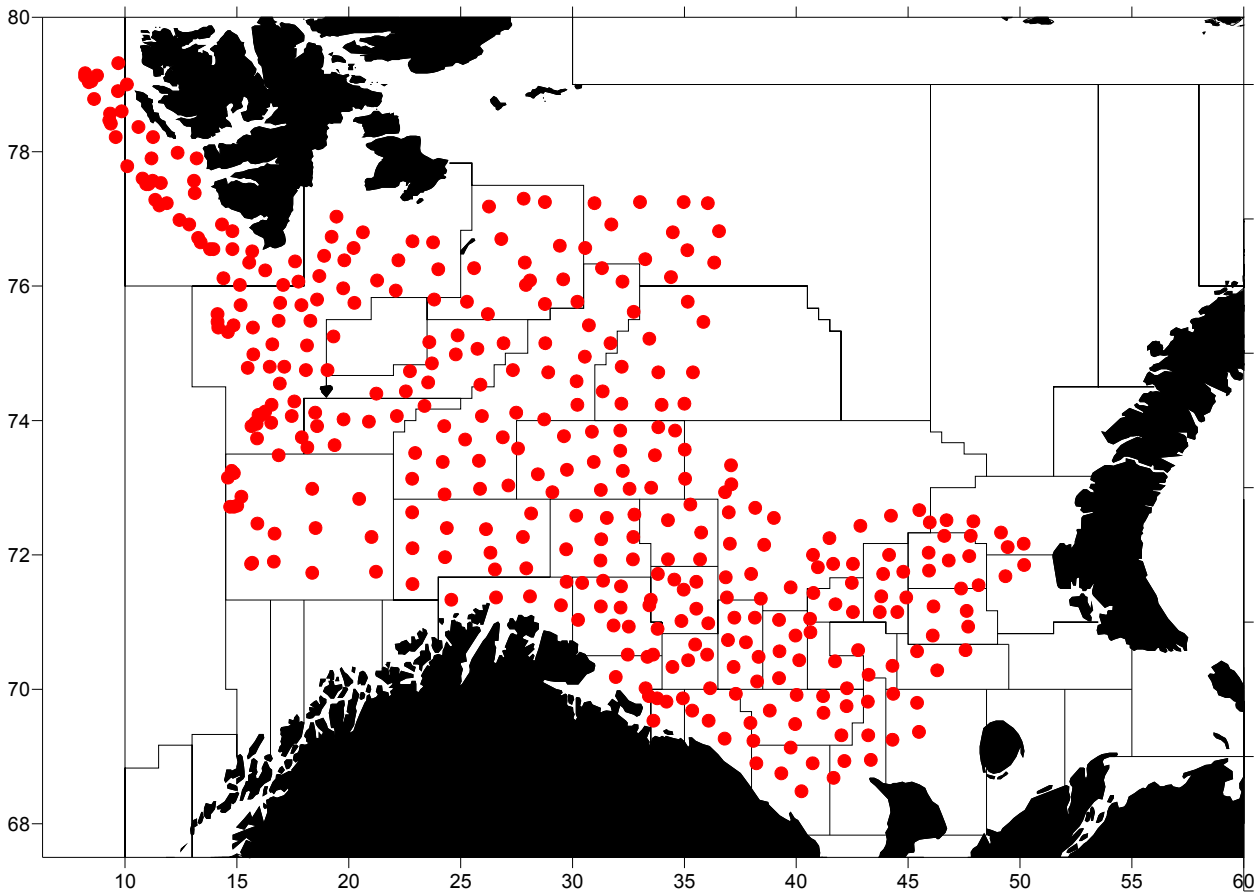


Figure 1. Locations of the trawl stations conducted during the Russian research survey in October-December 2005

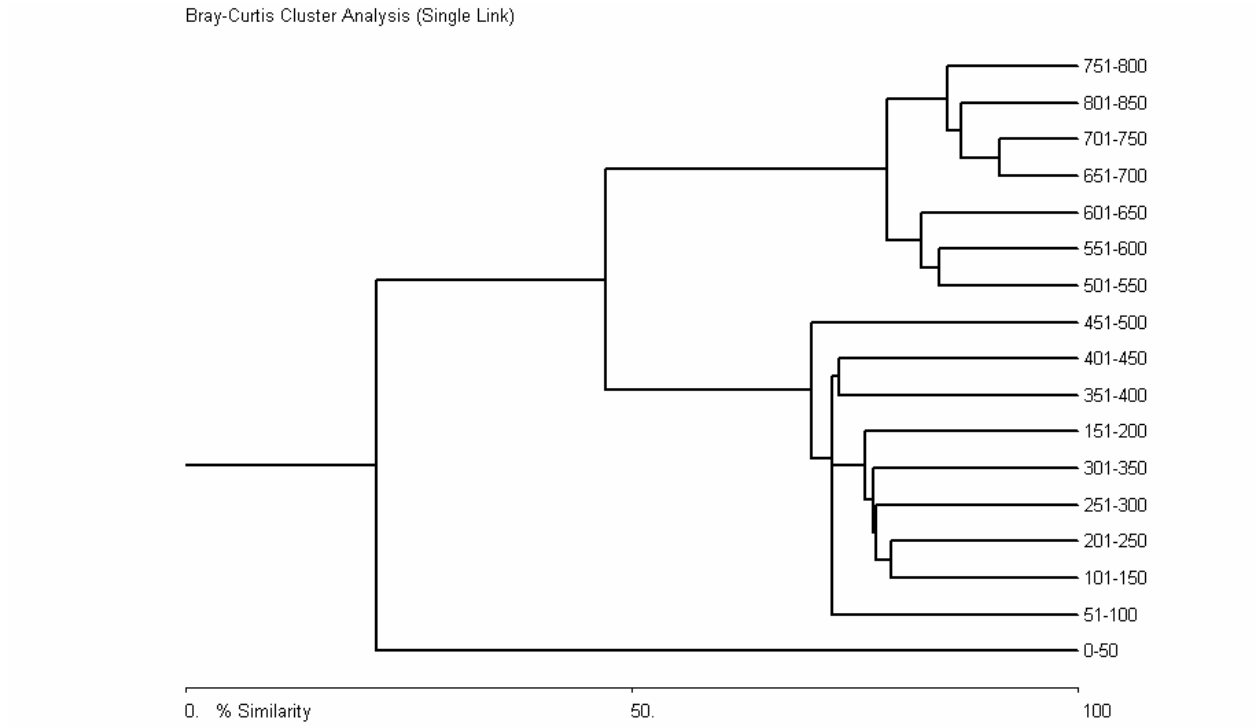
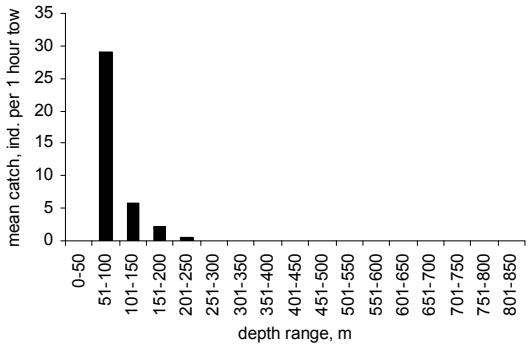
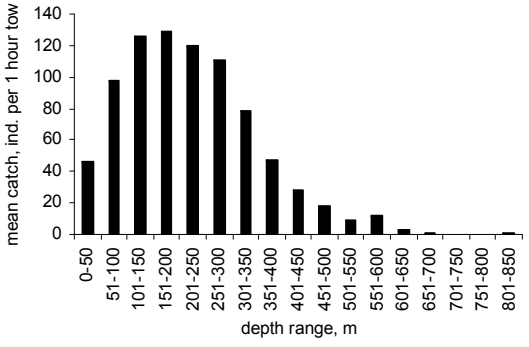


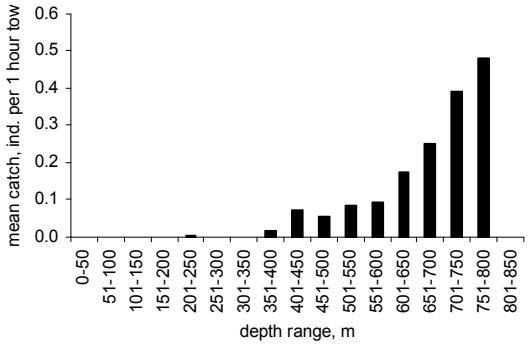
Figure 2. Hierarchical cluster analysis of the mean species composition from the trawl catches on different depth (data from 1998-2006).



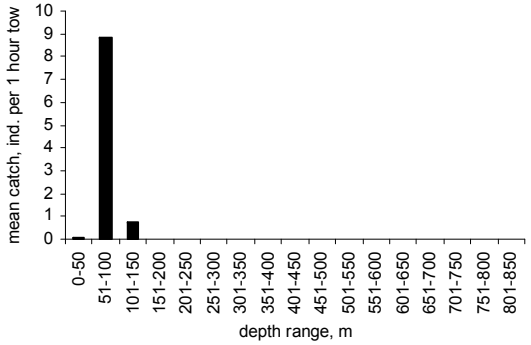
Pleuronectes platessa



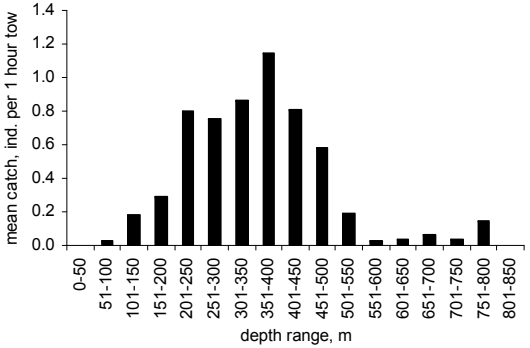
Gadus morhua



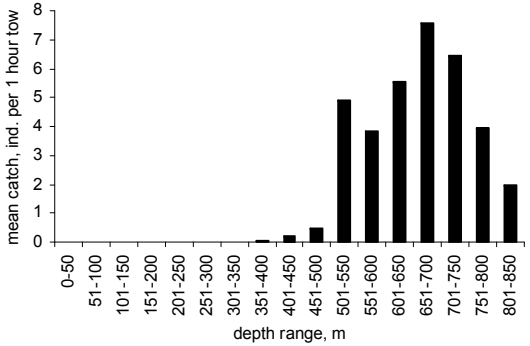
Gaidropsarus argentatus



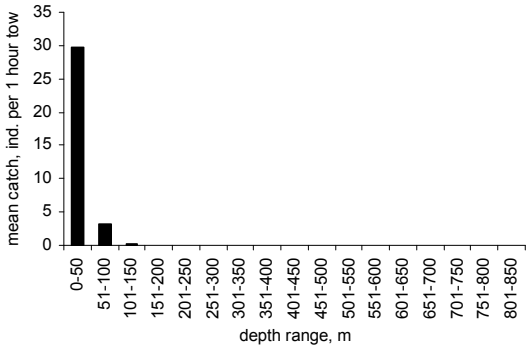
Limanda limanda



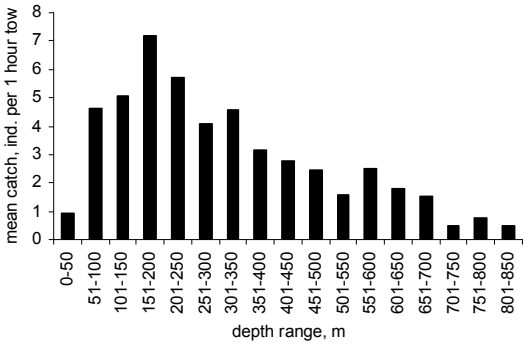
Careproctus reinhardti



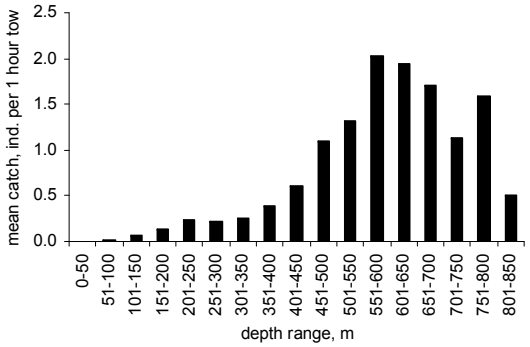
Macrourus berglax



Myoxocephalus scorpius



Amblyraja radiata



Lycodes esmarki

Figure 3. Different depth distribution patterns in some fish species in the Barents Sea

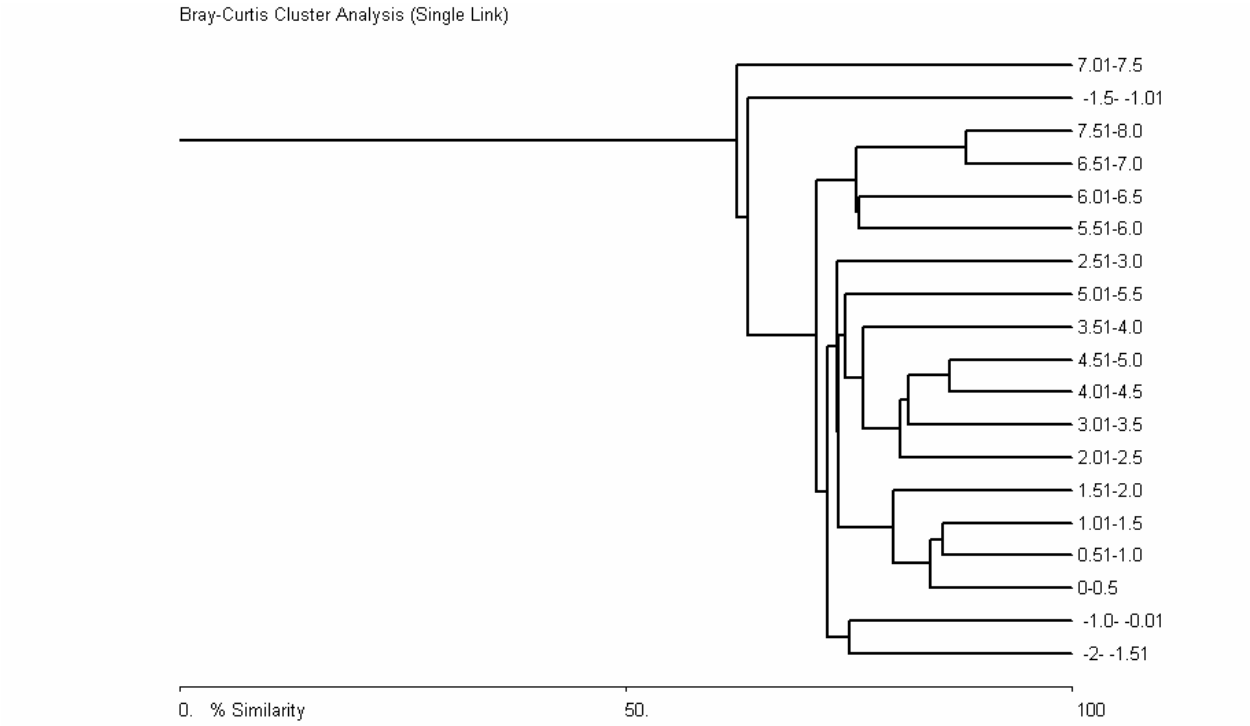
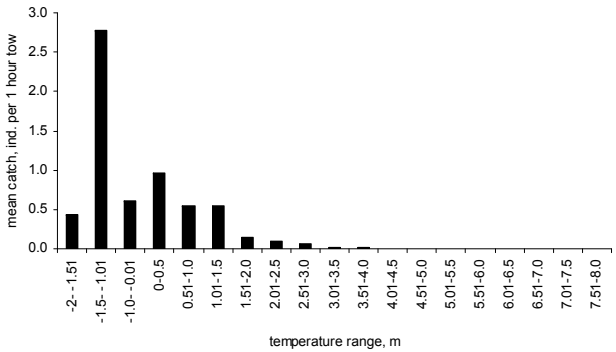
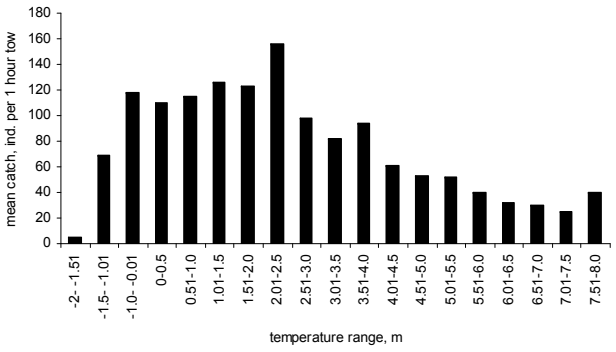


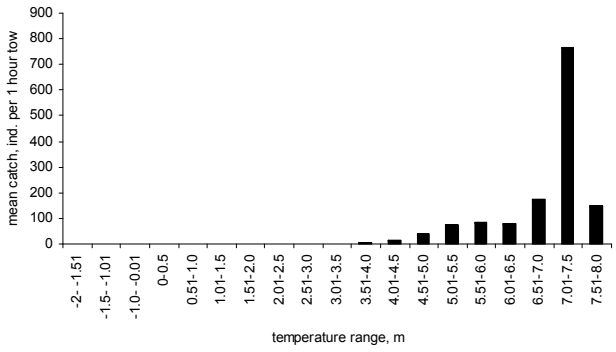
Figure 4. Hierarchical cluster analysis of the mean species composition from the trawl catches on different bottom temperature (data from 1998-2006).



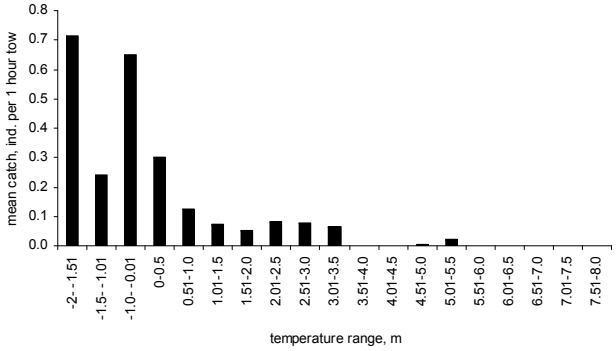
Lycodes reticulatus



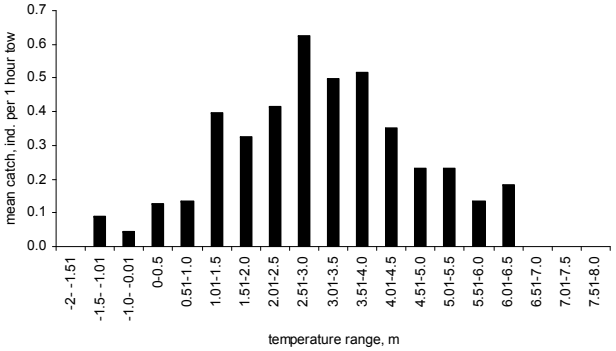
Gadus morhua



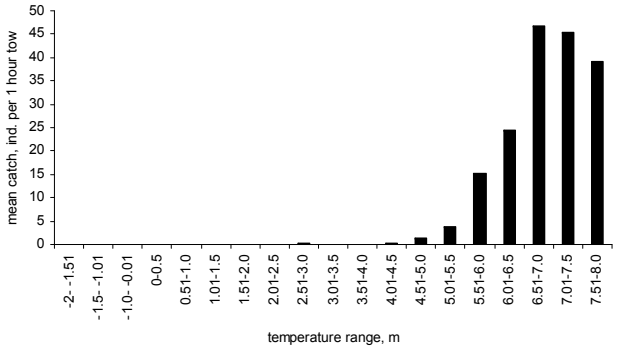
Trisopterus esmarki



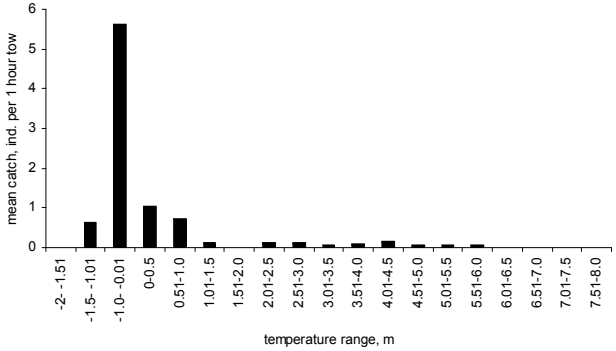
Amblyraja hyperborea



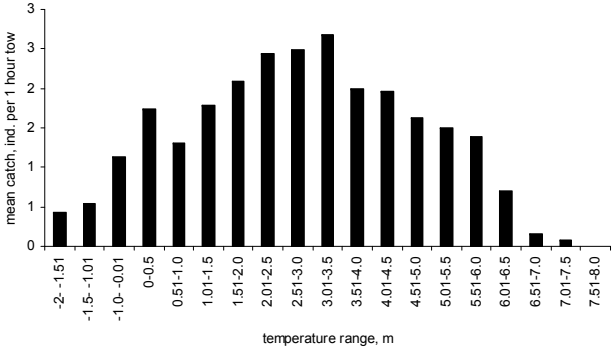
Lycodes vahli gracilis



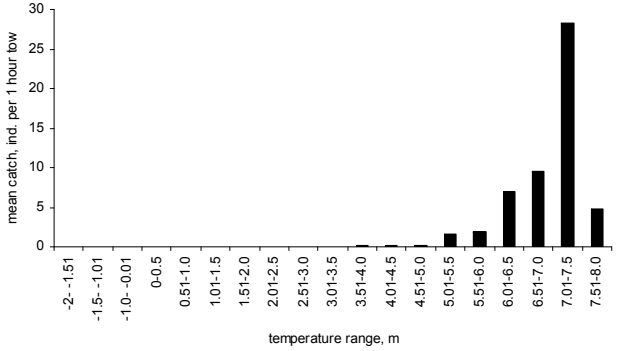
Sebastes viviparus



Myoxocephalus scorpius



Amblyraja radiata



Argentina silus

Figure 5. Different bottom temperature distribution patterns in some fish species in the Barents Sea

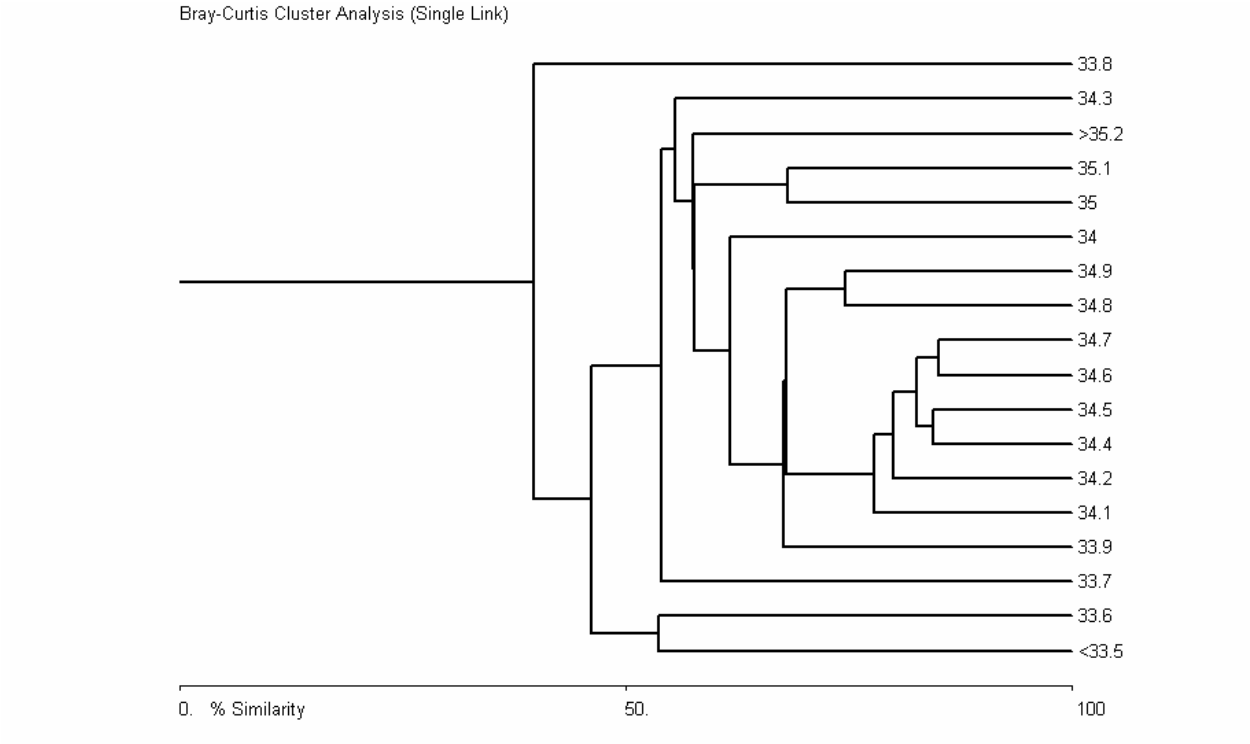
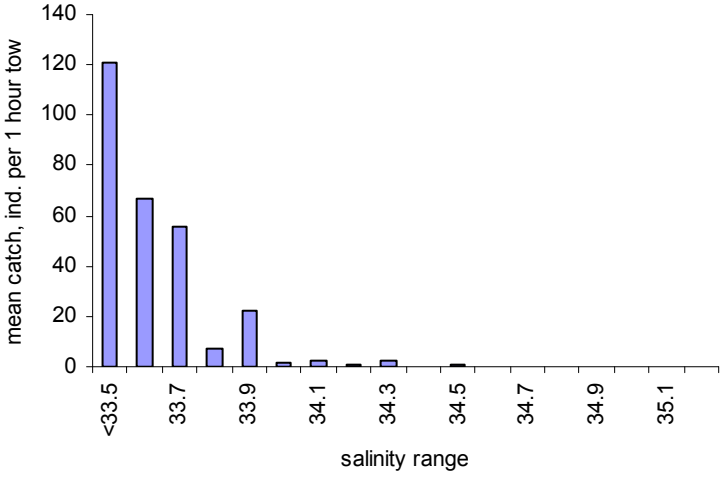
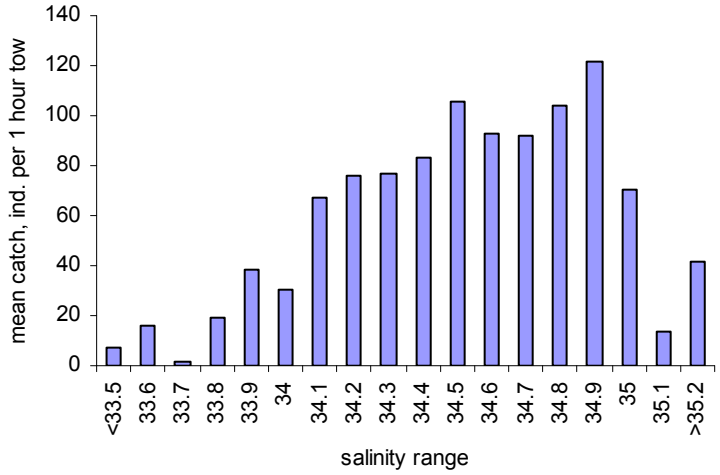


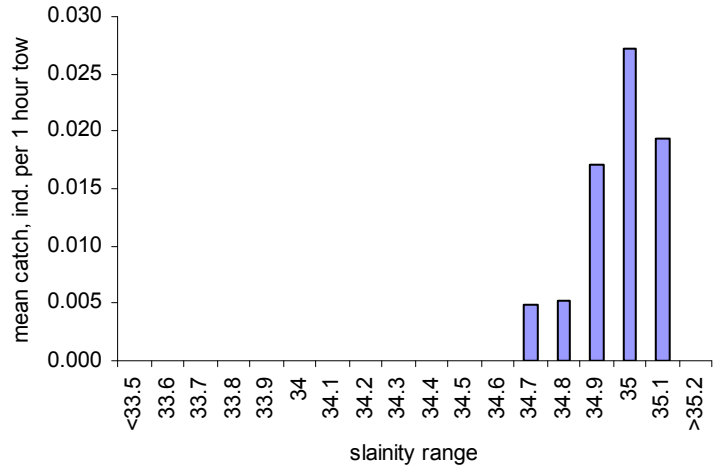
Figure 6. Hierarchical cluster analysis of the mean species composition from the trawl catches on different bottom salinity (data from 1998-2006).



Myoxocephalus scorpius

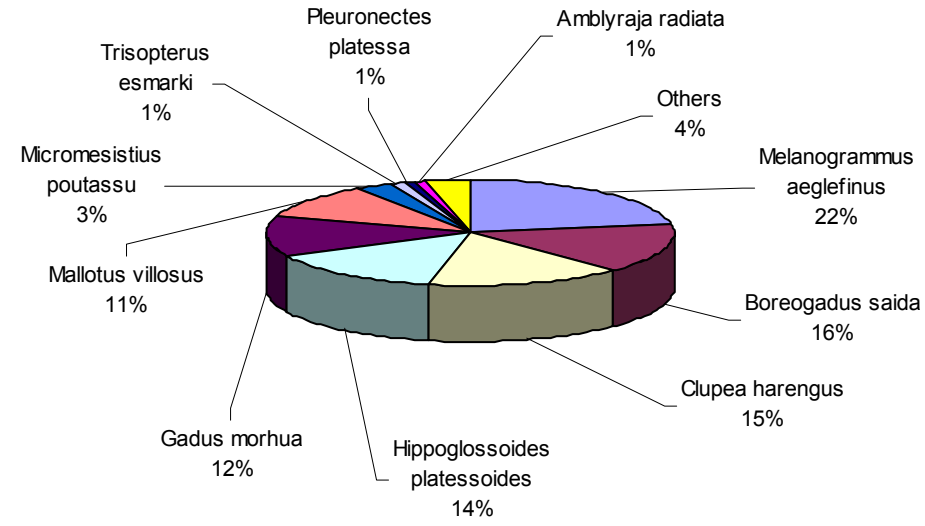


Hippoglossoides platessoides

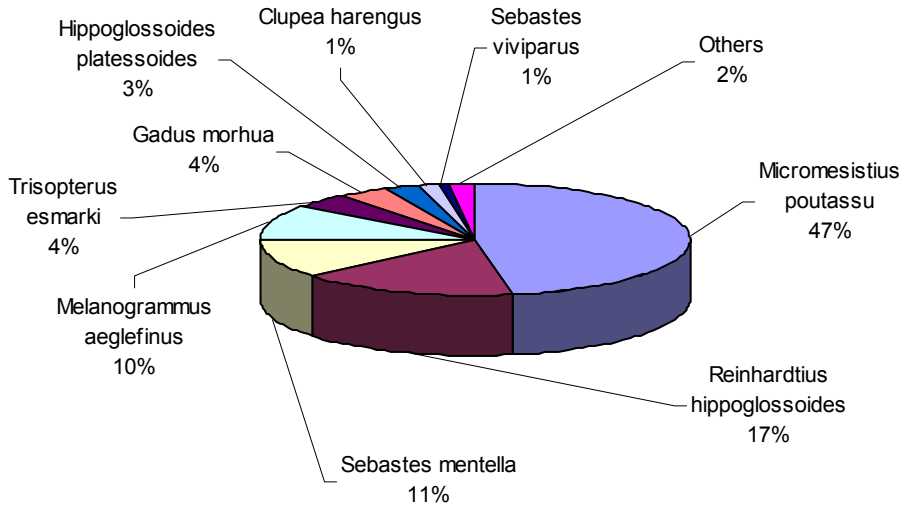


Gaidropsarus argentatus

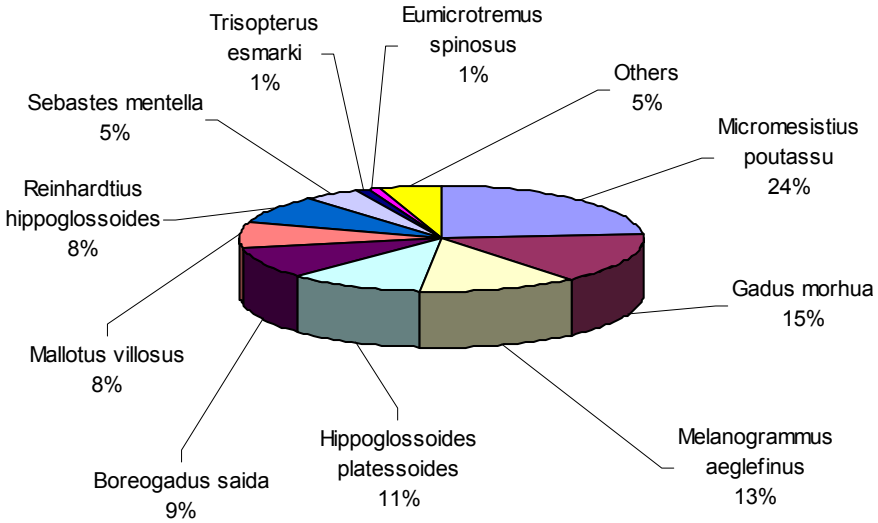
Figure 7. Different bottom salinity distribution patterns in some fish species in the Barents Sea



Area I ICES (the southern Barents Sea)



Area II A ICES (Coast of Norway)



Area II B ICES (the Bear Island-Spitsbergen area)

Figure 8. The species composition of the catches (by abundance) in the different ICES area in the Barents Sea

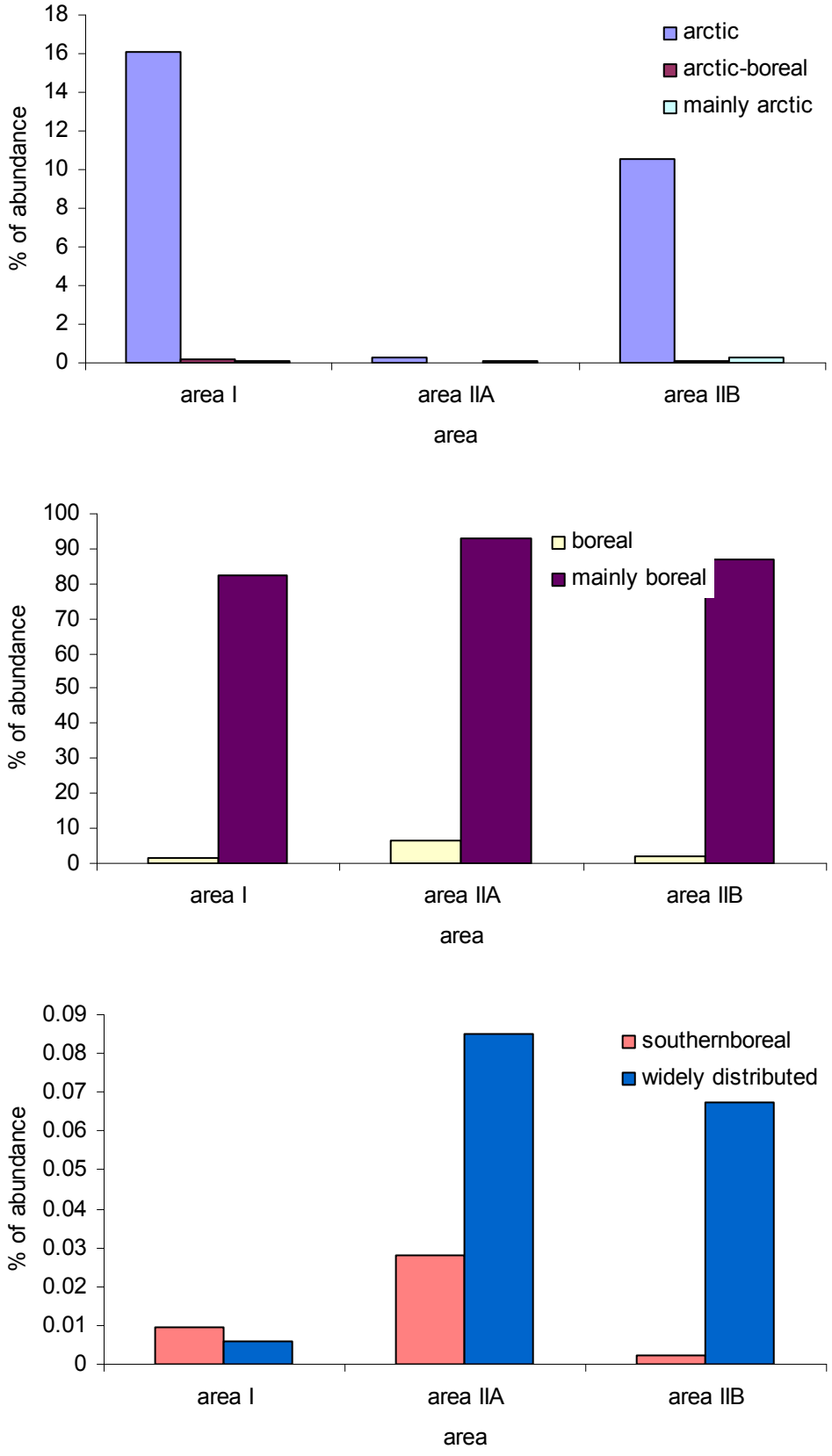


Figure 9. Ratio of species from various zoogeographical groups in the different areas of the Barents Sea

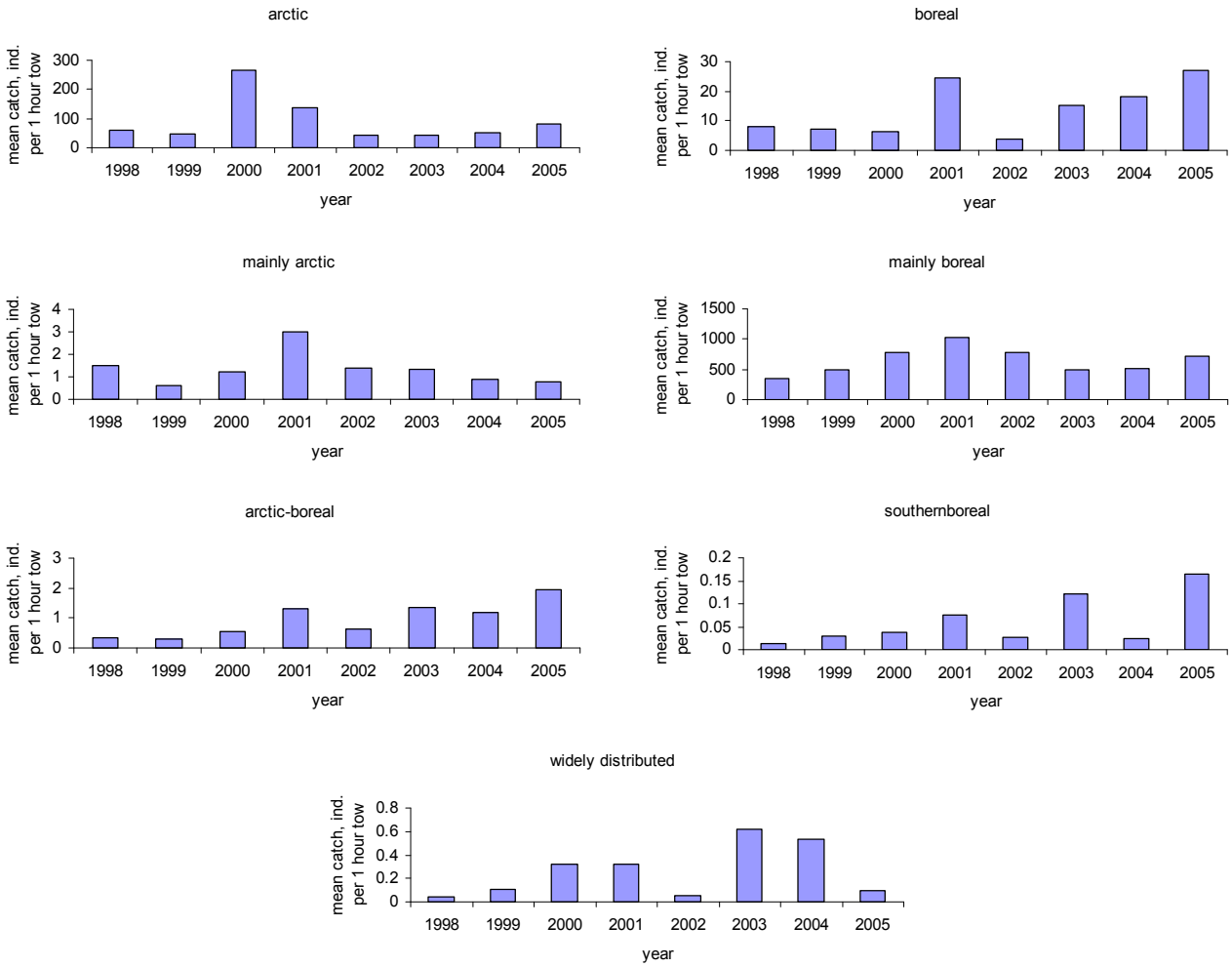


Figure 10. Mean catches of species from the different zoogeographical groups