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Composition and Structure of the Mesopelagic Fish Communities in the Irminger Sea and Adjacent Waters

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Abstract—Species composition of ichthyofauna and the structure of the fish communities in the Irminger Sea and adjacent waters were studied in May–July 2003–2011. In total, 115 species/taxa have been registered in the catches; they belong to 47 families and 18 orders. The data on their abundance and biomass are presented. The vertical, spatial, and interannual variability of the species composition and the structure of ichthyocenosis have been described.

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INTRODUCTION

The large-scale complex Russian ichthyological studies in the Irminger Sea, including the northern Mid-Atlantic Ridge (MAR) were begun during the Soviet period, in 1981, after the registering of the commercial concentrations of deepwater redfish *Sebastes mentella* in this area (*Promyslovoe opisanie*..., 1988; Pavlov et al., 1989). However, presently, the only species composition and zoogeographic structure of the ichthyofauna of the Irminger Sea, both benthic (Kukuev, 2004) and pelagic (Gushchin and Kukuev, 1981; Kukuev et al., 2000; Kukuev and Trunov, 2002), are studied in detail. There is a number of publications on the structure of meso- and bathypelagic ichthyocenoses in the adjacent areas of the Atlantic Ocean (Fock et al., 2004; Sutton et al., 2008; Kobyliansky et al., 2010; Cook et al., 2013), although the quantitative data on the structure and distribution of the ichthyocenosis of the Irminger Sea are absent.

Since 2003, PINRO has been conducting research cruises within the international survey on the assessment of the stock of deepwater redfish in the pelagic of the Irminger Sea, and all the species in the bycatch are being determined and counted also. As a result, a significant dataset on the distribution and peculiarities of the biology of particular species, species composition, structure, and distribution of the fish communities was obtained for the study area.

The aims of this study are the analysis of the species composition and assessment of the structure of the fish communities in the Irminger Sea and adjacent waters.

MATERIALS AND METHODS

The analyzed dataset includes the results of the four cruises conducted by PINRO within the international survey on assessment of the stock of deepwater redfish in the pelagic of the Irminger Sea in May–July 2003, 2005, 2007, and 2011 on the area between 52° and 63° N (Fig. 1, Table 1). The area of the studies varied from year to year; it depended on several factors, including the partitioning of the area by three countries (Russia, Iceland, and Germany) taking part in the survey during a particular year, the number of the fishery vessels, and the number of the trawling days.

Table 1. The dates and the number of trawls conducted by the vessels of PINRO in the Irminger Sea in May–July of 2003–2011

Vessel, cruise no.	Trawling dates	Number of trawls		
		<500 m	>500 m	total
R/V *Smolensk* MG-0103, cruise no. 50	28.05–19.06.2003	26	50	76
R/V *Smolensk* MG-0103, cruise no. 57	19.06–07.07.2005	21	14	35
R/V *Smolensk* MG-0103, cruise no. 62	24.06–18.07.2007	16	31	47
R/V *Vilnius* M-0102, cruise no. 80	14.06–04.07.2011	46	46	92

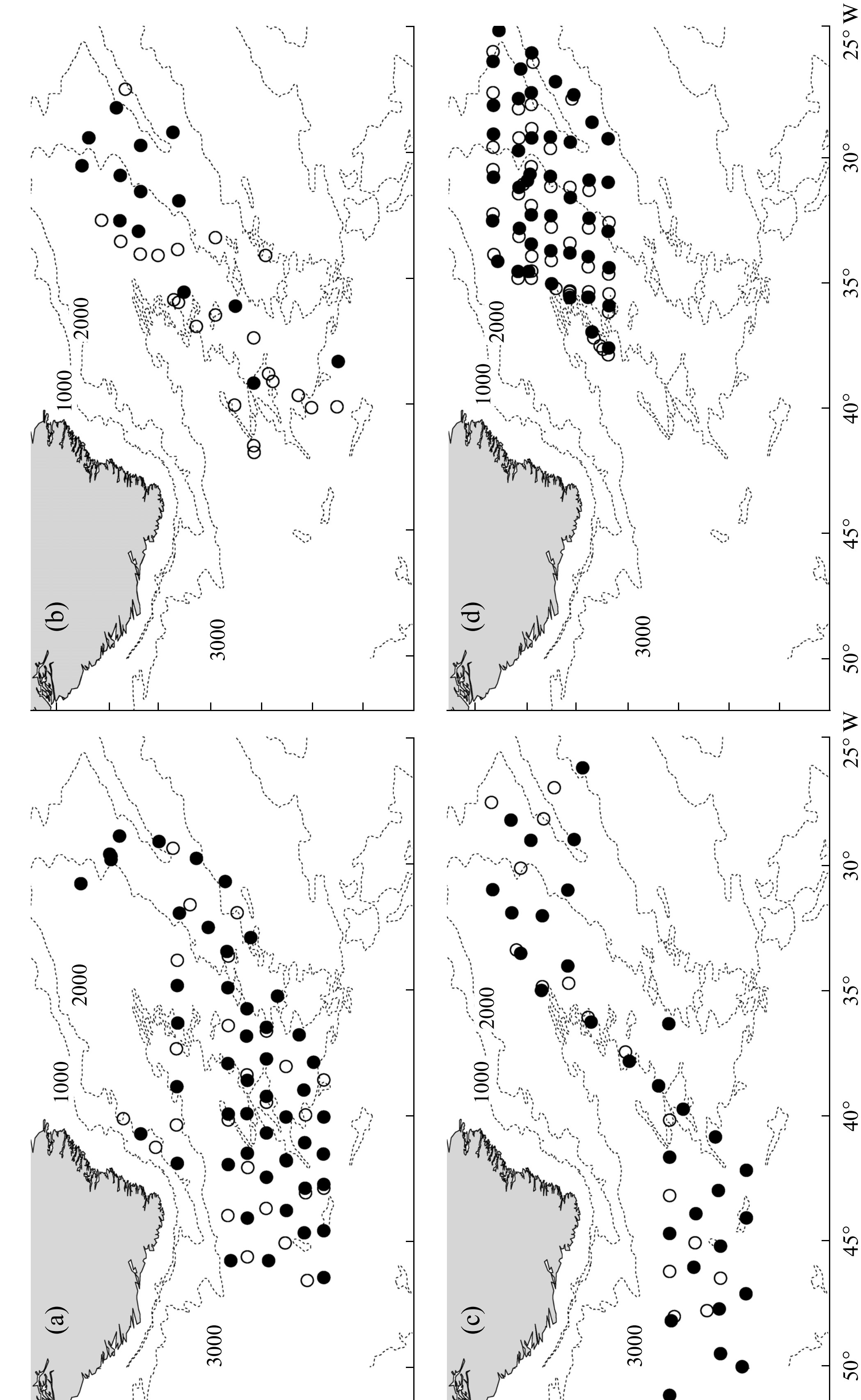

Fig. 1. Location of trawling stations, pelagic realm of the Irminger Sea, (○)—the depths of less than 500 m, (●)—the depths of more than 500 m. Years of studies: (a) 2003; (b) 2005; (c) 2007; (d) 2011. (···)—bathymetrical contours.

The sampling scheme refers to three trawling layers (Report…, 2002, 2003; *Metodicheskoe posobie*…, 2006): the first is above the deep scattering layer (DSL layer), which usually locates at a 500-m depth (Magnusson, 1996); the second is into the DSL layer at the depths of less than approximately 500 m; and the third locates into DSL layer and under it at the depths of 500–950 m. The trawling grid was even in the survey area. In the present study, the species composition and the structure of the fish communities were analyzed separately for the depth ranges of 200–499 m (above DSL layer) and 500–950 m (DSL layer and deeper); i.e., the data were combined by two layers: less than 500 m and more than 500 m (Table 1). The trawling stations performed in the areas of less than 2000-m depth were considered as referring to the region of the Mid-Atlantic Ridge.

The trawling was performed by using a standard scientific mid-water trawl (type 2492-00-000, mouth of 416 m × 78.7 m), mesh size of 16 mm. The trawling time at the first, second, and the third water layers was approximately 1, 2, and 3 hours, respectively. The trawling speed ranged from 3.0–4.1 knots, 3.5 ± 0.2 knots on average.

All the catches were separated by the species, abundance, biomass, and the size composition of each of the species were determinated. When the catch was large (more than 500 kg), a subsample was analyzed; then the data were recalculated by the total catch. The only exception was the deepwater redfish and the other large species; they were analyzed in the total catch. The fish species were identified onboard using the identification guides (*Instruktsiya*…, 1976; *Metodicheskie materialy*…, 1984, 1986, 1988; Whitehead et al., 1984, 1985, 1986). When the species definition was impossible, the identification was performed to the genus or family level. Some specimens were delivered to the Zoological Institute, Russian Academy of Sciences (St. Petersburg, Russia). The mean abundance (ind./hour of trawling) and biomass (kg/hour of trawling) were calculated for each species per each trawling.

The statistics were performed using Statistica software.

RESULTS

Species composition. In 2003–2011, 115 species/taxa belonging to 47 families and 18 orders were registered in the Irminger Sea and adjacent waters (Table 2).

The orders Perciformes (six families) and Osmeriformes, Aulopiformes, and Lophiiformes (five families each) were the most diverse by the number of families registered. The orders Anguilliformes, Gadiformes, Stomiiformes, and Scorpaeniformes were presented by three to four families each, and the other orders comprised one or two families. The maximal number of species belonged to the orders Stomiiformes (26) and Osmeriformes (22). The orders Myctophiformes, Lophiiformes, Perciformes, Aulopiformes, Anguilliformes, and Gadiformes were presented by 6–12 species, the other orders comprised only one to three species. Families Stomiidae and Myctophidae comprised 12 species each; the families Platytroctidae, Alepocephalidae, Sternoptychidae, Gonostomatidae, and Oneirodidae were represented by six to eight species, and the other families were represented by one or two species.

Only 45 species out of 111 registered were common for this area; these 45 species were found in the catches in the Irminger Sea throughout all surveys/years; the other species were registered only in one to three surveys/years. However, we cannot exclude the factor of complexity of their identification; thus, the absence of some of them in the particular years might be a result of nonidentification. This refers particularly to the species of Myctophidae, Gonostomatidae, and Stomiidae families.

Ichthyocenosis structure. The total catch biomass per 1 hour of trawling varied from 3.4 to 177.9 kg, on average 13.6 ± 12.38 kg (2003), 9.3 ± 6.64 kg (2005), 25.0 ± 16.40 kg (2007), and 24.3 ± 26.79 kg (2011). The number of species in the catch varied from one to 37, averaging 19.2 ± 6.4 (2003), 16.7 ± 7.0 (2005), 21.7 ± 11.1 (2007), and 16.9 ± 8.6 species (2011). Despite a significant number of the species in total list, only some of them constituted the majority of the catches both by abundance and by biomass (Table 2).

Fourteen fish species constituted approximately 90% of total abundance in the catches. Gonostomatidae was the most abundant group; their average catch was 709 ind./hour of trawling or 43.4% of total fish abundance in the catch. The subdominants were *Benthosema glaciale* and *Myctophum punctatum*, their maximal catches in different years reached 3742–7156 and 1560–2408 ind./hour of trawling, and the average catch was 421 and 110 ind./hour of trawling (25.8% and 6.7%), respectively. The mean catches of seven species (*Notoscopelus kroyeri, Bathylagus euryops, Chauliodus sloani, Lampanyctus macdonaldi, Serrivomer beanii, Maurolicus muelleri*, and *Lampanictus crocodilus*) were 23–81 ind./hour of trawling (1.5–4.9%). The mean catches of *Scopelogadus beanii, Stomias boa ferox, Arctozenus risso, Protomyctophum arcticum, Borostomias antarcticus*, and deepwater redfish ranged from 4–15 ind./hour of trawling (0.2–0.9%). The mean catches of the other species did not exceed 3 ind./hour of trawling; their total ratio in the total abundance of fish was 10%.

Generally, meso- and bathypelagic species dominated by abundance in the catches (approximately 90%). The ratio of wide-tropical species was 48% due to high abundance of small-size species of Gonostomatidae; boreal-subarctic species comprised 33% and boreal species comprised 11%.

Fifteen species dominated by biomass in the catches, they comprised approximately 93% of the total catch. The deepwater redfish was the absolute dominant; its maximal catches reached 89–173 kg/hour of trawl-

Table 2. Species composition of the catches and the mean abundance and biomass (per one hour of trawling) of different fish species in the Irminger Sea and adjacent waters in 2003–2011

Family	Species	2003		2005		2007		2011	
		n, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour
Petromyzontidae	*Petromyzon marinus*							0.01	+
Etmopteridae	*Etmopterus princeps*					0.01	+		
Somniosidae	*Centroscymnus crepidater*					0.01	+		
	Somniosus microcephalus					0.01	+		
Alepocephalidae	*Alepocephalus* sp.			0.03	+				
	Alepocephalus rostratus					0.01	+	+	+
	Bajacalifornia megalops	0.03	+			0.17	0.01	0.36	+
	Bathyprion danae	0.01	+						
	Bathytroctes microlepis	0.02	+						
	Photostylus pycnopterus	0.02	+			0.02	+	0.01	+
	Rouleina attrita							0.01	+
	Xenodermichthys copei	1.03	0.02	0.48	0.01	0.29	0.01	0.81	0.02
Platytroctidae	*Barbantus curvifrons*	0.01	+						
	Holtbyrnia anomala	3.14	0.06	0.03	0.00	2.21	0.08	0.12	+
	Holtbyrnia innesi					0.16	0.01		
	Holtbyrnia macrops	1.98	0.02	3.24	0.02	5.71	0.15	1.01	0.02
	Maulisia mauli	0.16	+	0.33	0.01	0.06	+	1.00	0.01
	Maulisia microlepis	2.08	0.02		0.13				
	Normichthys operosus	4.44	0.04	2.67	0.02	7.01	0.08	1.75	0.02
	Sagamichthys schnakenbecki	0.20	+	0.12	+	0.21	0.14	0.41	+
	Searsia koefoedi	1.26	0.02	0.08	+	0.02	+	0.04	+
Argentinidae	*Argentina silus*	0.05	+						
Microstomatidae	*Nansenia groenlandica*	0.80	0.01	0.83	0.01	0.06	+	0.12	+
	Nansenia oblita	0.06	+	0.13	+	0.11	+	0.02	+
	Microstomatidae spp.							0.01	+
Bathylagidae	*Bathylagus euryops*	54.10	0.95	34.45	0.78	72.27	2.28	25.61	0.64
	Melanolagus bericoides	1.62	+	1.16	+	2.95	0.04	0.02	+
Gonostomatidae	*Bonapartia pedaliota*							0.01	+
	Cyclothone microdon					+	+	1286.87	0.67
	Cyclothone pallida					+	+		
	Gonostoma elongatum			0.03	+			0.02	+
	Sigmops bathyphilus					28.59	0.02		
	Gonostomatidae sp.	12.12	0.02	61.54	0.03				
Sternoptychidae	*Argyropelecus gigas*	0.05	+	0.05	+	0.02	+	0.02	+
	Argyropelecus hemigymnus	2.37	+	0.90	+	0.02	+	0.09	+
	Argyropelecus olfersi	0.66	+	0.32	+	0.03	+	0.04	+
	Argyropelecus sladeni			0.02	+				
	Maurolicus muelleri	0.21	+	91.84		0.03	+	0.36	+

Table 2. (Contd.)

Family	Species	2003		2005		2007		2011	
		n, ind./hour	M, kg/hour	n, ind./hour	M, kg/hour	n, ind./hour	M, kg/hour	n, ind./hour	M, kg/hour
	Polyipnus polli	0.05	+						
	Sternoptyx diaphana	4.48	0.01	0.03	+	0.14	+	0.08	+
	Sternoptyx pseudobscura			0.26	+	0.22	+		
Stomiidae	*Borostomias antarcticus*	5.16	0.23	4.68	0.17	7.63	0.48	5.45	0.21
	Chauliodus danae	0.01	+						
	Chauliodus sloani	59.04	1.25	24.50	0.53	69.58	1.67	26.80	0.64
	Flagellostomias boureei	0.04	+			0.04	+		
	Idiacanthus fasciola	0.05	+						
	Leptostomias haplocaulus	0.02	+			+	+	+	+
	Malacosteus niger	5.11	0.18	0.65	0.03	3.10	0.13	1.59	0.06
	Melanostomias bartonbeani	0.17	0.01	0.02	0.00	2.11	0.06	0.12	0.01
	Neonesthes capensis	0.03	+	0.03	0.00	0.02	+	+	+
	Photonectes braueri	0.02	+			0.05	+	0.06	+
	Rhadinesthes decimus	0.02	+			0.05	+	0.04	+
	Stomias boa ferox	9.51	0.15	12.70	0.09	8.92	0.09	29.52	0.25
Notosudidae	*Ahliesaurus berryi*	0.03	+			0.05	+	0.02	+
	Scopelosaurus lepidus	0.03	+	0.03	+	0.03	+		
Evermarmellidae	*Evermannella balbo*	0.21	+	0.26	+	0.42	+	0.28	+
Alepisauridae	*Alepisaurus brevirostris*	0.01	0.02			0.04	0.02		
Paralepididae	*Arctozenus risso*	5.92	0.11	5.65	0.10	24.92	0.31	2.13	0.04
	Magnisudis atlantica					4.82	0.08	0.27	0.01
Anotopteridae	*Anotopterus pharao*	0.01	0.01	0.02	0.01	0.01	+	0.02	0.01
Myctophidae	*Benthosema glaciate*	816.80	1.82	537.34	1.15	120.50	0.40	209.22	0.71
	Diaphus sp.							+	+
	Electrona risso	0.03	+			0.02	+	0.02	+
	Lampadena luminosa	0.01	+						
	Lampadena sp.	0.02	+						
	Lampadena speculigera	2.17	0.03	0.73	0.01	0.89	0.02	0.39	0.01
	Lampanyctus crocodilus	0.17	+			59.14	0.93	1.44	0.03
	Lampanyctus intricarius	0.11	+					1.36	0.02
	Lampanyctus macdonaldi	52.25	0.89	35.29	0.51	13.07	0.26	69.46	1.01
	Lampanyctus sp.	0.16	0.20	0.09	+	4.54	0.08		
	Myctophum affine	0.01	+			0.16	+	0.19	+
	Myctophum punctatum	0.07	+	103.76	0.55	98.30	0.56	238.72	2.20
	Notoscopelus kroyeri	30.27	0.46	149.29	0.89	58.28	0.54	86.04	1.25
	Protomyctophum arcticum	3.90	+	14.14	0.01				
Rondeletiidae	*Rondeletia* sp.			0.01	+				
Eurypharyngidae	*Eurypharynx pelecanoides*	0.08	+	0.02	+	0.37	0.01	0.05	+
Derichtyidae	*Derichthys serpentinus*					+	+		
	Nessorhamphus ingolfianus					0.02	+	0.01	+

Table 2. (Contd.)

Family	Species	2003		2005		2007		2011	
		n, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour	*n*, ind./hour	*M*, kg/hour
Serrivomeridae	*Serrivomer beanii*	33.99	1.52	6.95	0.24	43.24	2.79	40.96	1.01
	Serrivomer brevidentatus	0.08	0.02	0.01	0.00	0.01	+	0.03	+
Nemichthyidae	*Nemichthys scolopaceus*	0.15	0.01	0.93	0.04	0.27t	0.01	0.50	0.03
Synaphobranchidae	*Synaphobranchus kaupii*			0.02	+			0.01	+
Syngnathidae	*Entelurus aequoreus*	0.05	+	0.87	+	0.08	+		
Macrouridae	*Coryphaenoides rupestris*	0.93	0.01	0.33	+	0.15	+	0.09	+
	Malacocephalus laevis					0.01	+		
Gadidae	*Micromesistius poutassou*	0.01	+			0.01	+	0.03	+
Lotidae	*Gaidropsarus argentatus*	0.02	+			0.02	+	0.01	+
	Molva molva							0.01	+
Moridae	*Lepidion eques*			0.06	+				
Trachipteridae	*Trachipterus arcticus*			0.02	0.09	0.42	0.76	2.64	7.23
Diretmidae	*Diretmus argenteus*	0.01	+						
Anoplogastridae	*Anoplogaster cornuta*	0.08	0.01	0.15	0.01	0.47	0.04	0.11	0.01
Melamphaidae	*Poromitra megalops*	0.73	+	0.18	+	0.03	+	0.15	+
	Scopelogadus beanii	19.06	0.28	6.16	0.07	24.23	0.30	14.31	0.19
Centrolophidae	*Schedophilus medusophagus*	0.01	0.01			+	+	0.14	0.06
Caristiidae	*Caristius fasciatus*	0.05	0.01	0.04	0.01	0.02	0.01	0.03	0.01
Chiasmodontidae	*Chiasmodon niger*	0.26	+	0.18	+	2.78	0.04	0.28	+
Anarhichadidae	*Anarhichas denticulatus*	0.01	+	0.01	+	0.16	0.17	0.04	0.04
Zoarcidae	*Melanostigma atlanticum*	0.05	+			0.02	+	0.31	+
Bythitidae	*Thalassobathia pelagica*	0.01	+						
Trichiuridae	*Aphanopus cargo*					0.03	+		
Sebastidae	*Sebastes mentella*	7.56	4.96	6.26	3.65	21.62	12.06	12.83	7.84
Cyclopteridae	*Cyclopterus lumpus*	0.09	0.12	0.03	0.02	0.05	0.16	+	0.01
Liparidae	*Psednos* sp.	0.05	+	0.01	+	+	+	0.03	+
Ceratoidea	*Ceratoidea* sp.			0.02	+				
Caulophrynidae	*Caulophryne jordani*	0.01	+			0.03	0.01	+	+
Oneirodidae	*Chaenophryne draco*	0.01	+	0.02	0.00	0.01	+		
	Chaenophryne longiceps	0.02	+			+	+	0.01	0.01
	Dolopichthys longicornis	0.07	+			0.08	0.01	0.03	+
	Lophodolos acanthognathus	0.01	+						
	Oneirodes eschrichtii	0.07	0.02			0.08	0.02	0.01	+
Ceratiidae	*Ceratias holboelli*	0.07	+	0.01	+	0.08	0.11	0.09	0.01
	Cryptopsaras couesii	0.13	0.02	0.05	0.02	0.04	+		
Linophrynidae	*Linophryne brevibarbata*	0.01	+						
Melanocetidae	*Melanocetus johnsonii*			0.01	+				

n—abundance ; *M*—biomass; "+"—less than 0.01 kg/hour of trawling.

ing, and the mean catch was 7.13 kg/hour of trawling or 36% of total biomass of the catch. The mean catches of five subdominating species (*Trachipterus arcticus, Serrivomer beanii, Bathylagus euryops, Chauliodus sloani*, and *Benthosema glaciale*) were 1.0–2.7 kg/hour of trawling or 5–13% (totally 37% of total biomass of the catch). *Myctophum punctatum, Notoscopelus kroyeri, Lampanyctus macdonaldi*, Gonostomatidae sp., *Borostomias antarcticus, Scopelogadus beanii, Stomias boa ferox, Arctozenus risso*, and *Malacosteus niger* formed the third group, their catches were 0.1–0.8 kg/hour of trawling or 0.5–4.0% (totally 20% of total biomass of the catch). The catches of the other species did not exceed 0.1 kg/hour of trawling or 0.4% of total biomass of the catch.

Generally, meso- and bathypelagic species dominated by the biomass in the catches, comprising approximately 93%. The ratio of boreal species reached 45% (mostly by the impact of high biomass of deepwater redfish); that of boreal-subarctic reached 29% and wide-tropical reached 15%.

Interannual dynamics of the catches of particular species. Significant variability of abundance and biomass of some species was observed from year to year (Table 2). The mean catches of *Bajacalifornia megalops, Sagamichthys schnakenbecki, Stomias boa ferox, Myctophum affine*, and *Melanostigma atlanticum* varied only by abundance; the mean catches of *Myctophum punctatum, Trachipterus arcticus*, and *Schedophilus medusophagus* varied both by abundance and by biomass. For example, the deep-sea ribbonfish *T. arcticus* was totally absent in 2003, but then its abundance and biomass increased rapidly from 0.09 ind./hour of trawling and 0.09 kg/hour of trawling in 2005 to 2.64 ind./hour of trawling and 7.23 kg/hour of trawling in 2011. Decrease of catches was registered for *Argyropelecus hemigymnus, A. olfersi*, and *Neonesthes capensis* (by abundance) and for *Searsia koefoedi, Nansenia groenlandica, Benthosema glaciale, Lampadena speculigera*, and *Coryphaenoides rupestris* both by abundance and by biomass. The catches of *Xenodermichthys copei* (by both abundance and biomass) and *Lampanictus macdonaldi* (by biomass only) decreased in 2005–2007 but increased in 2011. On the contrary, in some of the species (*Holtbyrnia macrops, Arctozenus risso, Anoplogaster cornuta, Chiasmodon niger*, and *Anarhichas denticulatus*), the increase of the catches by abundance and by biomass was observed in 2005–2007 followed by the decrease in 2011. Such dynamics was registered for *Nansenia oblita* (by abundance only) and for *Bathylagus euryops* (by biomass only).However, one has to take into consideration different reasons that cause the changes in the structure of the fish communities; these reasons are the different sampling areas, years, and even the expertise level of the ichthyologists performing the species identification onboard.

Peculiarities of the catches performed at different depths. The number of species in the trawls performed at the depth of less than 500 m and more than 500 m varied in the same ranges (1–32 and 2–37, respectively); however, the average number of species was lower at the water layer of 200–500 m (9.3–15.1) than at the depths of more than 500 m (21.4–28.1). Only 74 species out of 115 species found in total were registered at the depths of less than 500 m, and 109 species were registered below 500-m depth. Most of the species that have were found in the 200–500-m water layer were presented by single specimens in the catches; theoretically, these species might be found deeper than 500-m depth too. The species that were registered deeper than 500-m depth comprised both the rare species with low abundance and the species inhabiting the great depths (bathypelagic species); they were most of the species of Lophiiformes order. Generally, the number of the species in the catch increased accordingly with the depth increase (Pearson coefficient was 0.63–0.74).

The mean biomass of the catch per hour of trawling at the depths of 500 m and less was significantly lower (7.2–7.9 kg; min–max = 1.2–31.8 kg) in 2003 and 2005 compared to the greater depths (11.2–16.8 kg; min–max = 4.6–90.7 kg). The opposite pattern was observed in 2007 and 2011, when the mean catches at the depths of less than 500 m were higher than in the deep sea zone (26.5–32.5 kg versus 21.1–22.1 kg); this was preconditioned by the increase of the catches of the deepwater redfish and the deep-sea ribbonfish in the 200–500-m water layer.

In order to assess the depth-related distribution of the fish species, the ratio of the mean catches of particular species in upper and deep water layers was calculated. Three groups of species may be defined after such assessment (Table 3). Deepwater redfish, deep-sea ribbonfish, and *Myctophum punctatum* prefer the depths of less than 500 m; *Bathylagus euryops, Borostomias antarcticus, Chauliodus sloani, Chiasmodon niger, Lampadena speculigera, Lampanyctus macdonaldi, Malacosteus niger, Scopelogadus beanii*, and *Serrivomer beanii* inhabit the depths of more than 500 m. The third group comprises *Argyropelecus hemigymnus, Benthosema glaciale, Maurolicus muelleri, Notoscopelus kroyeri*, and *Stomias boa ferox*; they distribute evenly in all the studied water layers.

This analysis, however, does not consider the diel vertical migrations and ontogenetic migrations that are known for some of the registered species (Bekker, 1983; Fel'dman and Gushchin, 1985; Brooks and Saenger, 1991).

Spatio-temporal variability of the catches. The regularity of the spatial distribution of the number of the species in the catches was not found (Fig. 2). In 2003, the maximal number of the species was registered in the central part of the Irminger Sea; in 2005, it was registered in MAR area; in 2007, it was registered in MAR area and in the western Irminger Sea; and in 2011, it was registered in the southern part of the study area.

Table 3. Mean catches of the mosr abundant fish species at the depth of less than 500 m and more than 500 m in the Irminger Sea in 2003–2011

Species	Abundance, ind./hour of trawling			Biomass, kg/hour of trawling		
	<500 m	>500 m	<500/>500	<500 m	>500 m	<500/>500
Group 1						
Myctophum punctatum	168.96	79.24	2.13	1.303	0.506	2.57
Sebastes mentella	19.04	9.87	1.93	10.207	6.818	1.51
Trachipterus arcticus	1.66	0.43	3.83	4.387	1.063	4.13
Group 2						
Bathylagus euryops	17.05	102.46	0.17	0.413	2.507	0.16
Borostomias antarcticus	3.18	10.88	0.29	0.100	0.512	0.20
Chauliodus sloani	26.71	73.88	0.36	0.532	1.699	0.31
Chiasmodon niger	0.21	1.40	0.15	0.003	0.017	0.17
Lampadena speculigera	0.26	2.19	0.12	0.003	0.031	0.10
Lampanyctus macdonaldi	9.49	104.87	0.09	0.138	1.563	0.09
Malacosteus niger	0.05	4.58	0.11	0.018	0.189	0.09
Scopelogadus beanii	3.40	30.1	0.11	0.060	0.380	0.16
Serrivomer beanii	11.50	50.14	0.23	0.269	2.262	0.12
Group 3						
Argyropelecus hemigymnus	1.07	1.19	0.89	0.001	0.001	1.01
Benthosema glaciale	652.38	672.96	0.97	1.485	1.543	0.96
Maurolicus muelleri	31.97	49.52	0.65			
Notoscopelus kroyeri	116.28	126.73	0.92	1.063	1.025	1.04
Stomias boa ferox	14.50	20.38	0.71	0.110	0.223	0.49

In 2003, the total biomass of the catches was relatively low at the depths of less than 500 m (up to 12–17 kg/hour of trawling), the highest catches were observed in the deepest areas of the open sea (Fig. 3). At the depths exceeding 500 m, the catches reached 23–27 kg/hour of trawling and were similar in most of the areas, although some catches obtained in MAR area reached 64–98 kg/ hour of trawling. At the depths of less than 500 m, most of the catch was Myctophidae (88–92% by weight) followed by Stomiidae (20–29%). The deepwater redfish dominated in some catches (32–54%). This species comprised most of the catch obtained at the depths of more than 500 m (82–98%). When the ratio of the deepwater redfish was low, the dominant species in the catches were the representatives of two to three families: Myctophidae (39–51%), Serrivomeridae to a lesser extent (32–47%) and Stomiidae (30–37%).

In 2005, the total biomass of the catches was also relatively low—it did not exceed 22–31 kg/hour of trawling at the depths less than 500 m and 15–19 kg/hour of trawling at the depths of more than 500 m—and it distributed evenly over the study area (Fig. 4). At the depths of less than 500 m, the deepwater redfish (90–98% by weight), Myctophidae (72–88%) and, to a lesser extent, Stomiidae (27–39%) comprised the most of the biomass in the catches. Mueller's pearlside, *M. muelleri*, dominated in one trawl station (85%). The deepwater redfish (47–81%), Myctophidae (56–82%), and blacksmelt (33–42%) comprised the majority of the biomass in the catches at the depths exceeding 500 m. Mueller's pearlside was also found in a significant biomass in one trawl (25%). We did not find any regularity in the distribution of the biomass of the catch and domination of the particular species.

In 2007, the total biomass of the catch increased in comparison to 2003 and 2005 and varied from 1.9 to 89.1 kg/hour of trawling at the depths of less than 500 m and from 7.0 to 42.1 kg/hour of trawling in the depths exceeding 500 m (Fig. 5). Above 500-m depth, the maximal catches (34–89 kg/hour of trawling) were registered in the central and western parts of the Irminger Sea, and the deepwater redfish was the absolute dominant (79–100% by biomass). In the northeastern Irminger Sea (MAR area), the variability of the catches was less (1–20 kg/hour of trawling), and the majority of the biomass in the trawls was comprised of deep-sea ribbonfish (50–79%) and blacksmelts (50%). At the depths of more than 500 m, the biomass of the catch was nearly equal within the whole study area, and the dominating of any species in any

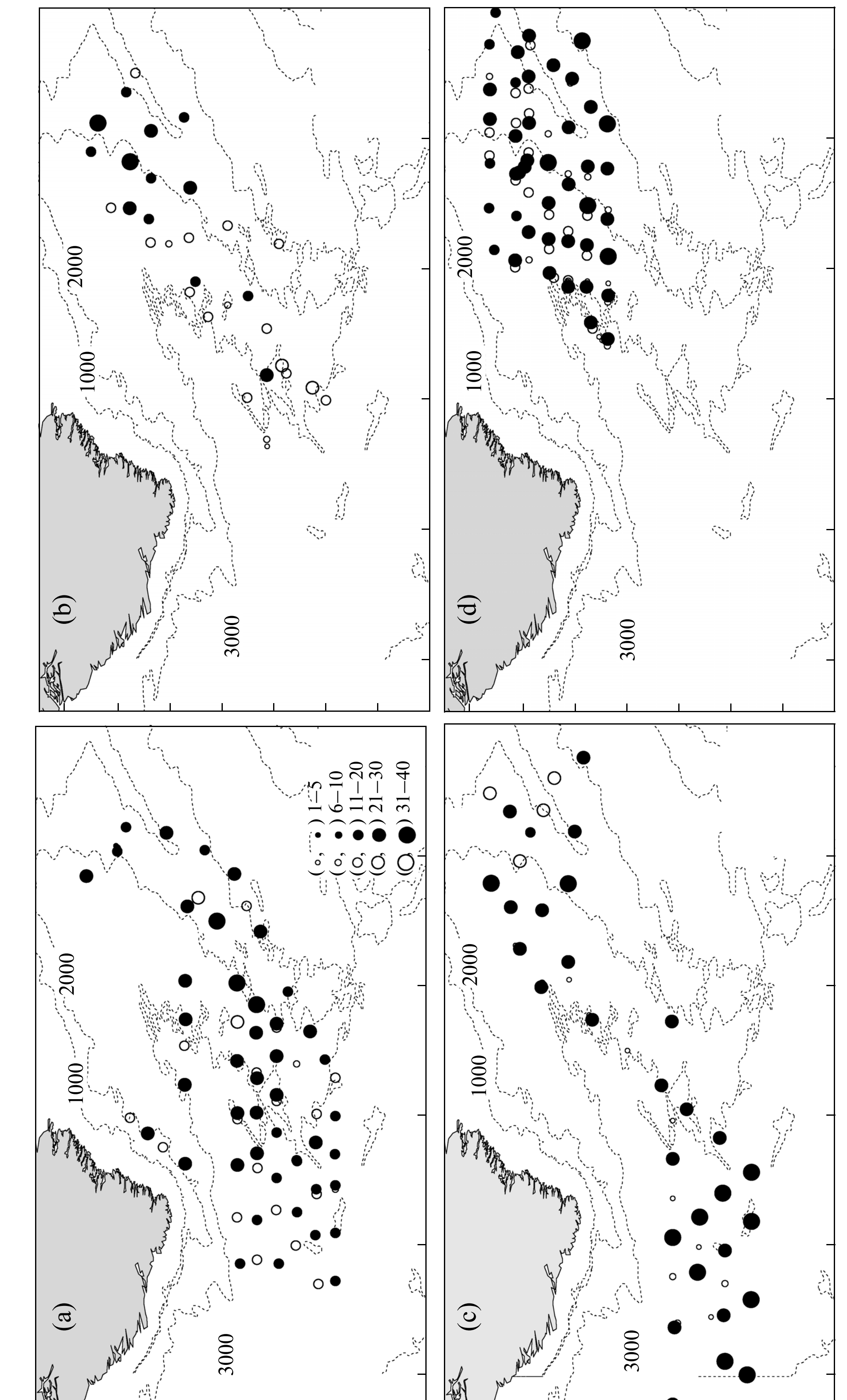

Fig. 2. The number of species in the catches obtained from the depths of less than 500 m in the pelagic realm of the Irminger Sea, in different years: of studies: a—2003; b—2005; c—2007; d—2011. For other disignations see Fig. 1.

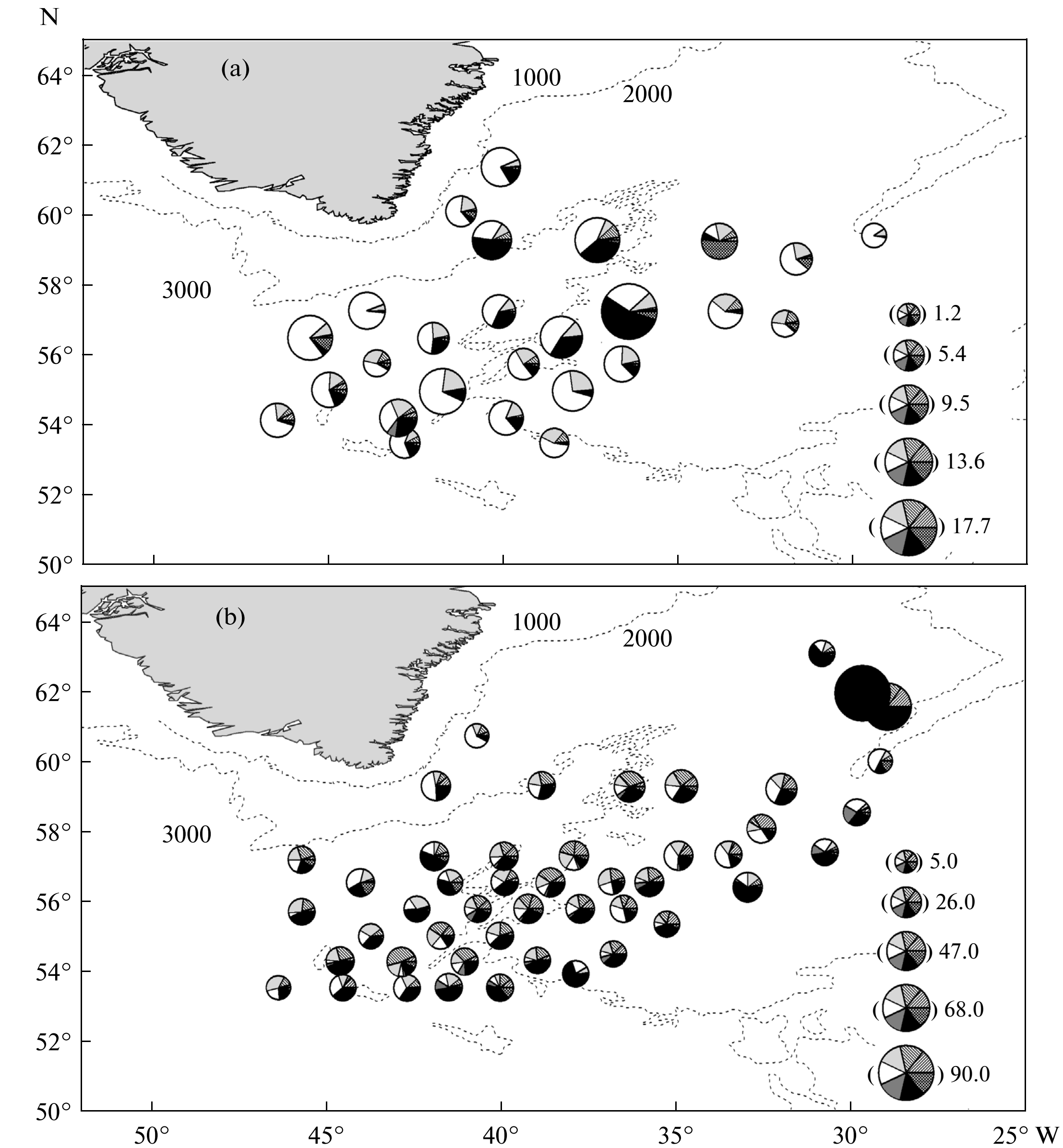

Fig. 3. The composition of catches (kg/hour of trawling) in the pelagic realm of the Irminger Sea in 2003: (a) the depths of less than 500 m, (b) the depths of more than 500 m. (▨) Bathylagidae, (▧) Serrivomeridae, (□) Stomiidae, (□) Myctophidae, (■) Melamphaidae, (■) Scorpaenidae, (▩) others.

particular areas was absent. Usually, the representatives of two to four families were presented in similar ratios in the catches; they were the deepwater redfish (up to 42–48%), Serrivomeridae (up to 31–38%), Myctophidae (up to 30–38%), rarely Stomiidae (up to 32–36%) and, in some trawls, deep-sea ribbonfish (31–65%).

In 2011, the total biomass of the catches was also high and even exceeded the level observed in 2007. At the depths of less than 500 m, the maximal catches (97–123 kg/hour of trawling) were registered in the southern part of the study area (MAR); meanwhile, the catches did not exceed 25–39 kg/hour of trawling in the other areas (Fig. 6). In the catches obtained in MAR area, the other fish species dominated, particularly, the deep-sea ribbonfish (85–95% by weight), in the deeper areas, they were Myctophidae (40–96%) and deepwater redfish (42–100%). At the depths of more than 500 m, the biomass of the catch was significantly lower; it rarely exceeded 28–31 kg/hour of trawling, except the cases when deepwater redfish dominated (70–177 kg/ hour of trawling). Here, the dominant species were the deepwater redfish (up to 84–97%), Myctophidae (up to 53–57%), and, rarely, deep-sea ribbonfish (up to 30–64%).

Composition of the catches obtained in MAR area and adjacent open waters. The mean number of species

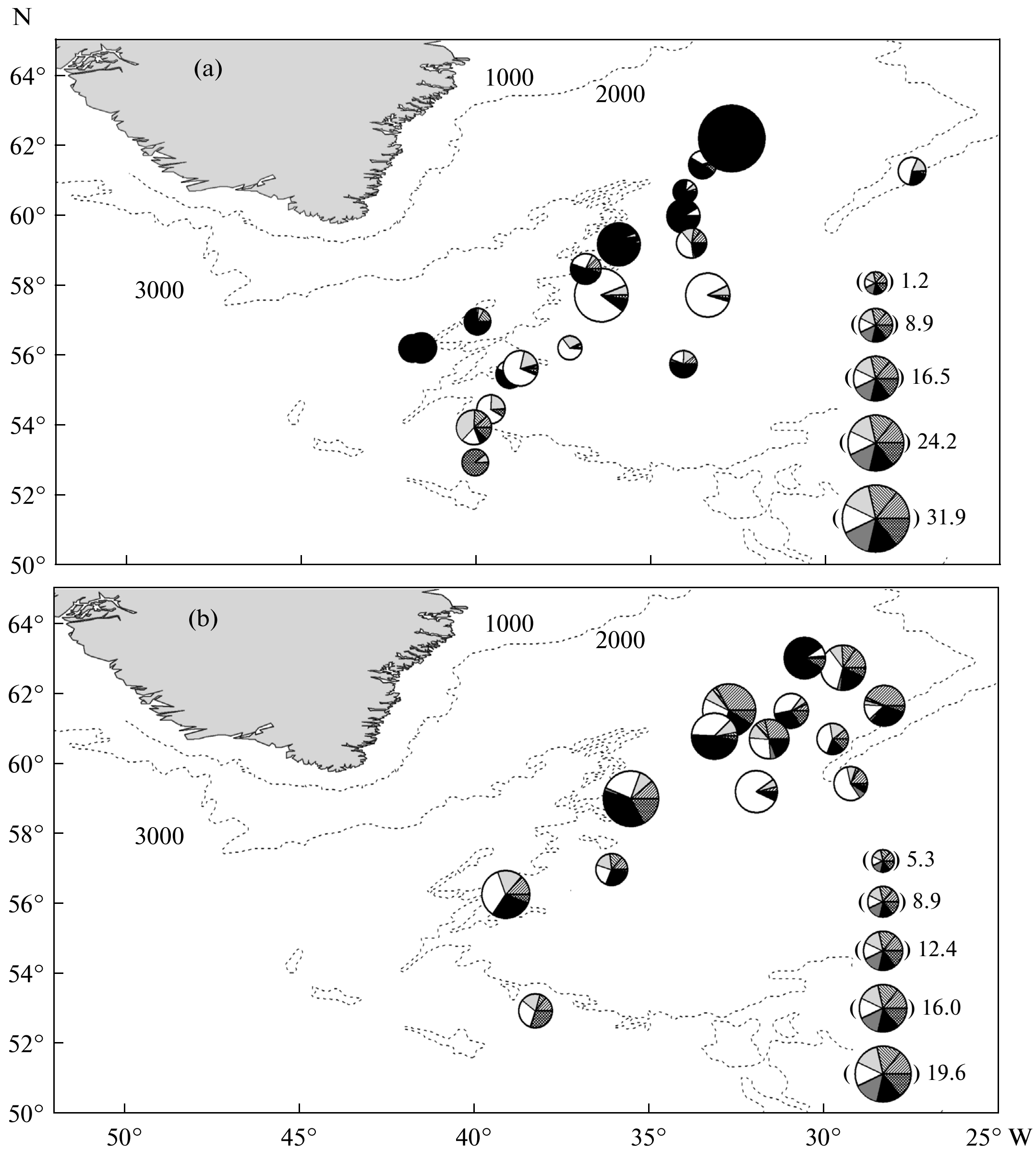

Fig. 4. The composition of catches (kg/hour of trawling) in the pelagic realm of the Irminger Sea in 2005: (a) the depths of less than 500 m, (b) the depths of more than 500 m. For the legend, please refer to Fig. 3.

in the catch in MAR area at the depths exceeding 500 m was similar to those observed in the adjacent waters (22.0 and 21.1, respectively), while this parameter was higher at the depths of less than 500 m: 19.6 vs. 13.7 species.

When comparing the catches at MAR area and in the open waters of the Irminger Sea, we may divide the species into three groups (Table 4). The first group combines 17 of 52 analyzed species whose abundance at MAR area was higher than in the adjacent waters in the whole range of the studied depths. The second group comprises nine species that are more abundant in the open waters of the Irminger Sea. The third group, in turn, comprises two subgroups: the catches of ten species in the layer 200–500 m were higher at MAR area and those in the depths exceeding 500 m were higher in the open water; for six other species, the pattern was the opposite. Although such peculiarities of the distribution of particular fish species were found, the cluster analysis did not reveal any isolated fish communities in MAR area and in the open waters of the Irminger Sea both in the layer of 200–500 m and 500–950 m.

Therefore, we have found a significant relationship between the trawling depth and number of the species, but no regularities were observed between the sea depth (MAR area or out of it) and the number of the species in the catch (of total biomass). When compar-

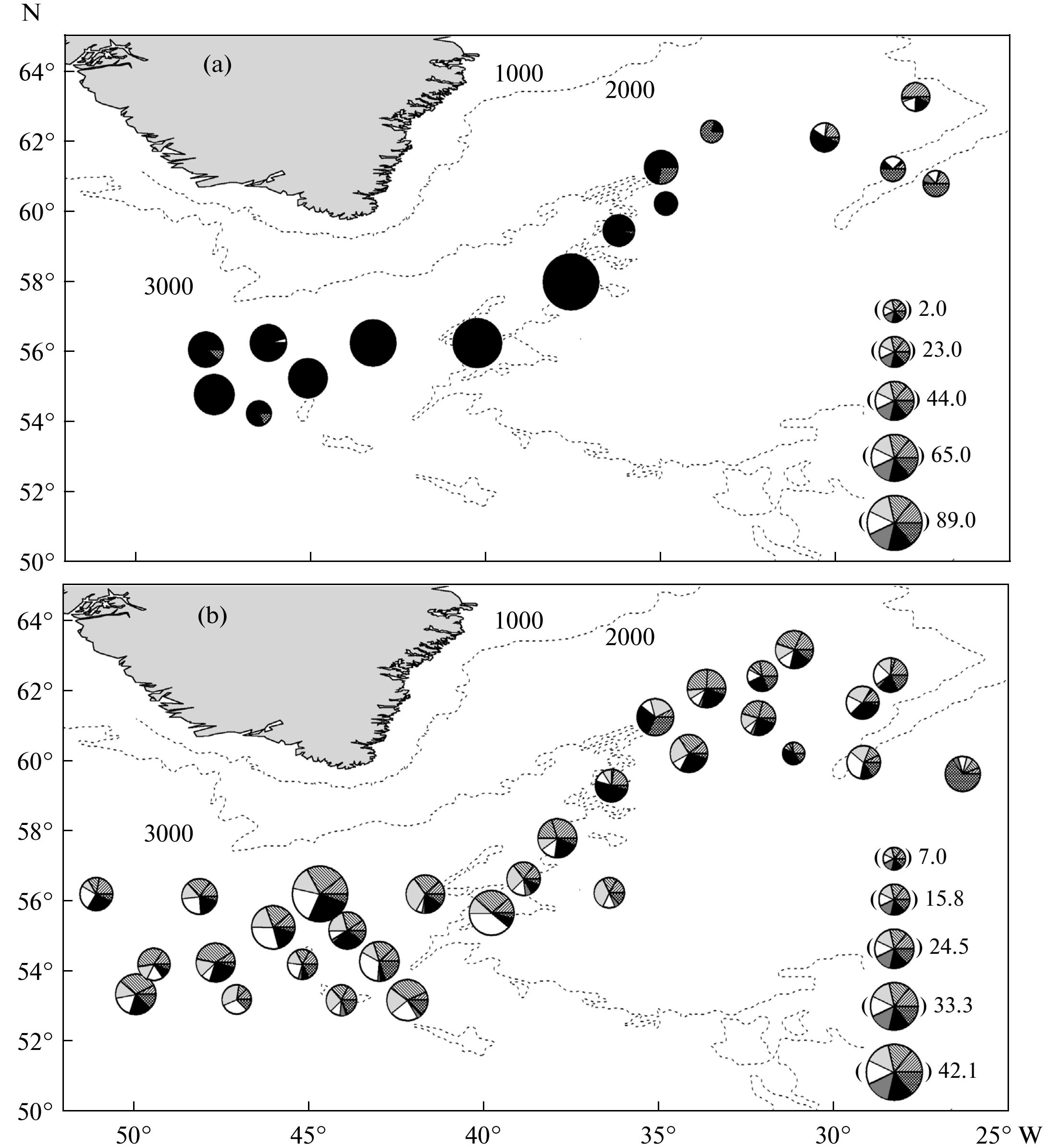

Fig. 5. The composition of catches (kg/hour of trawling) in the pelagic realm of the Irminger Sea in 2007: (a) the depths of less than 500 m, (b) the depths of more than 500 m. For the legend, please refer to Fig. 3.

ing the number of the species or total biomass of the catch with the sea depth, Pearson coefficients do not exceed 0.01–0.03. This dependence is even negative for the number of the species in the catch (i.e., fewer species are found at the areas of greater depths) but positive for the total biomass of the catch.

DISCUSSION

Generally, our data on the species composition of the fish communities of the northern MAR area and in the Irminger Sea fall into the results obtained earlier (*Promyslovoe opisanie*…, 1988; Kukuev et al., 2000; Kukuev and Trunov, 2002; Sigurdsson et al., 2002). However, some of the species found in this area previously, for example *Einara edentula, Ectreposebastes imus*, and some Myctophidae (Kukuev, 1991; Kukuev and Trunov, 2002), were absent in our catches.

In total, 68–143 species belonging to 35–67 families were registered in the northern MAR area (36°–60° N) by Soviet scientists (*Promyslovoe opisanie*…, 1988; Kukuev, 1991). Only approximately a hundred of them belong to meso- or bathypelagic. Iceland scientists found here 99 species in 1996–2001 (Sigurdsson et al., 2002).

We have also registered some species whose traditional geographical ranges lay out of the study area. Similar results were obtained in the late 1990s

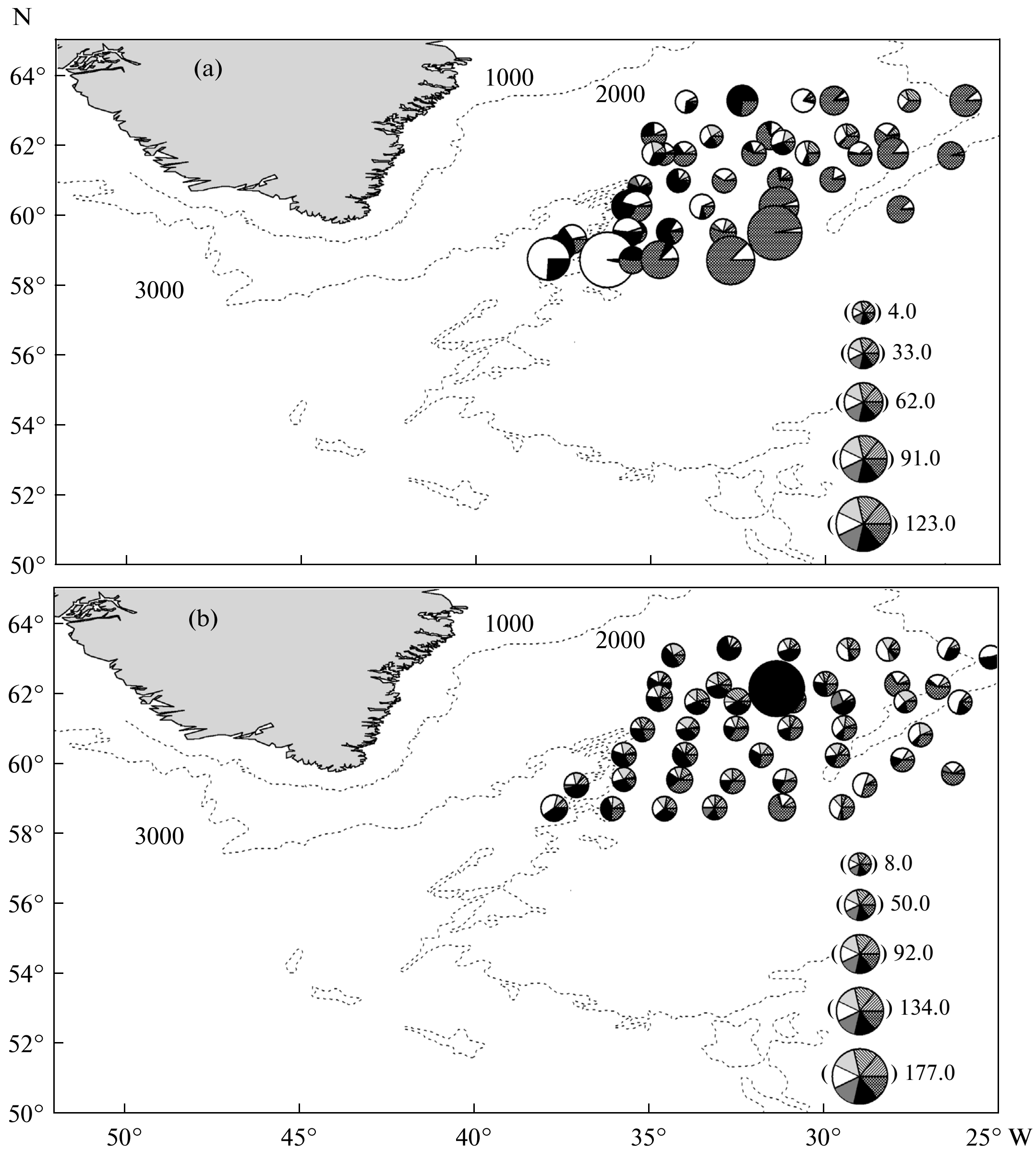

Fig. 6. The composition of catches (kg/hour of trawling) in the pelagic realm of the Irminger Sea in 2011: (a) the depths of less than 500 m, (b) the depths of more than 500 m. For the legend, please refer to Fig. 3.

(Kukuev and Trunov, 2002). *Argyropelecus sladeni, A. olfersi, Chauliodus danae, Leptostomias haplocaulus, Lampadena luminosa, Myctophum affine*, and *Serrivomer brevidentatus*, were found significantly northwards (present study) than before (Whitehead et al., 1984, 1985, 1986). This phenomenon may be linked to the global warming of the waters of the northern Atlantic Ocean in recent decades, including the area of the Irminger Sea, observed for the period 1997–2011 (Karsakov et al., 2011). Therefore, these species may be transported by the warm currents from the southern areas to the Irminger Sea. Regard must be paid to a number of similar findings of the warm-water fish species, including the mesopelagic ones, in the areas laying northwards off their traditional margin of the geographical range in many areas of the northeastern Atlantic Ocean (Post, 1988; Minchin and Isaev, 1989; Byrkjedal et al., 2004).

Our data on the structure of the fish communities in the Irminger Sea support the regularity found before, i.e., the decrease of the portion of the tropical-subtropical and boreal-subtropical species and increase of the portion of the boreal and boreal-subarctic species in the northern Atlantic Ocean northwards (Kukuev et al., 2000; Kukuev, 2002).

Generally, the representatives of only seven or eight families form the majority of the catches in the Irminger Sea. Myctophidae comprise approximately

Table 4. Mean catches of some of fish species in the region of Mid-Atlantic Ridge and in the open waters of the Irminger Sea at the depth of less than 500 m and more than 500 m in 2003–2011, ind./hour of trawling

Species	Mid-Atlantic Ridge (depth of less than 2000 m)		Open waters (depth of more than 2000 m)	
	<500 m	>500 m	<500 m	>500 m
Group 1				
Argyropelecus olfersi	1.99	1.14	0.36	0.14
Bathylagus euryops	25.22	86.57	10.64	68.02
Entelurus aequoreus	2.55	0.40	0.12	0.02
Evermannella balbo	0.19	0.92	0	0.08
Holtbyrnia macrops	0.73	3.93	0.42	2.93
Lampadena speculigera	1.11	5.38	0.10	1.49
Lampanyctus macdonaldi	17.41	86.98	6.78	71.89
Maulisia mauli	0.08	0.63	0.07	0.16
Myctophum punctatum	194.00	17.00	34.29	7.40
Nansenia groenlandica	2.15	1.96	0.57	0.16
N. oblita	0.08	0.15	0.01	0.13
Notoscopelus kroyeri	181.00	58.00	79.00	38.00
Caristius fasciatus	0	0.15	0	0.05
Polyipnus polli	0.06	0.08	0	0.03
Scopelogadus beanii	6.07	36.05	2.25	18.27
Searsia koefoedi	0.15	3.78	0.07	0.27
Xenodermichthys copei	1.00	2.15	0.14	0.85
Group 2				
Borostomias antarcticus	1.86	4.34	3.13	7.94
Ceratias holboelli	0	0.02	0.02	0.11
Cyclopterus lumpus	0	0	0.07	0.13
Maurolicus muelleri	1.96	0.50	53.58	25.18
Nemichthys scolopaceus	0.17	0.31	0.20	0.68
Arctozenus risso	5.27	2.44	7.14	6.49
Poromitra megalops	0.08	0.75	0.18	0.94
Psednos sp.	0	0	0.01	0.09
Sternoptyx diaphana	0.68	1.28	1.37	6.30
Group 3				
Sub-group 1				
Argyropelecus hemigymnus	3.09	1.91	1.61	1.98
Chauliodus sloani	67.47	44.23	33.64	59.83
Coryphaenoides rupestris	0.48	0.92	0.11	1.34
Eurypharynx pelecanoides	0.12	0	0.04	0.10
Holtbyrnia anomala	2.56	2.66	0.29	3.73
Malacosteus niger	0.82	4.94	0.74	6.65
Normichthys operosus	4.64	5.20	0.65	6.32
Sagamichthys schnackenbecki	0.12	0.17	0.06	0.31
Serrivomer beanii	24.14	27.83	8.55	41.76
Stomias boa ferox	15.97	9.19	8.64	12.07
Sub-group 2				
Benthosema glaciale	855.00	583.00	1040.00	444.00
Chiasmodon niger	0.11	0.38	0.23	0.18
Maulisia microlepis	0	5.06	0.08	1.09
Melanostomias bartonbeani	0	0.45	0.02	0.07
Protomyctophum arcticum	6.99	10.24	7.53	5.04
Sebastes mentella	0.83	11.51	5.36	7.84

70% of total fish abundance, and the species belonging to the families of Stomiidae, Stemoptychidae, Bathylagidae, Gonostomatidae, Serrivomeridae, Melamphaidae, and Platytroctidae comprise from 1% to 5%. Sebastidae (37%), Myctophidae (28%), and Stomiidae (11%) dominate by biomass; the ratio of Bathylagidae, Serrivomeridae, Melamphaidae and Platytroctidae is from 1% to 7%.

The species belonging to different biotope-related groups are found in the catches in the Irminger Sea pelagial. Most of the species belong to mesopelagic (families Myctophidae, Stomiidae, Gonostomatidae, Sternoptychidae, and Paralepididae) and bathypelagic (Caulophrynidae, Ceratiidae, Linophrynidae, Melanocetidae, and *Eurypharynx pelecanoides*) ichthyofauna. On the continental slope of Iceland and MAR, the bathypelagic species inhabiting the underwater mountains and the continental slope occur in the catches, particularly, sharks (*Centroscymnus crepidater, Etmopterus princeps*, and *Somniosus microcephalus*), macrourids (*Coryphaenoides rupestris* and *Malacocephalus laevis*), gadoids (*Gaidropsarus argentatus, Molva molva*, and *Lepidion eques*), trichiurids (*Aphanopus carbo*), synaphobranchids (*Synaphobranchus kaupii*), and the coastal neritic species usually inhabiting the coastal areas (*Entelurus aequoreus* and *Cyclopterus lumpus*).

In the Irminger Sea and in the northern MAR area, the highest abundance was obsered in fish species belonged to following zoogeographic groups: boreal-subarctic (*Benthosema glaciale, Notoscopelus kroyeri, Bathylagus euryops*, and *Protomyctophum arcticum*), boreal (*Myctophum punctatum* and *Lampanyctus macdonaldi*), boreal-subtropical (*Maurolicus muelleri, Scopelogadus beanii*, and *Stomias boa ferox*) and, to a lesser extent, wide-tropical (*Chauliodus sloani* and *Serrivomer beanii*).

Generally, the core of the pelagic ichthyocenosis of the Irminger Sea consists of the boreal and subarctic species as well as wide-tropical meso- and bathypelagic species. Such biotope-related and zoogeographical structure of the fish communities of the Irminger Sea fits nicely the previously obtained data for this area and adjacent waters of the northern Atlantic Ocean (Bekker, 1967; McKelvie, 1985; Filin, 1998; Kukuev et al., 2000; Kukuev and Trunov, 2002; Sigurdsson et al., 2002).

The analysis of the species composition and the biomass of myctophids in the catches obtained in 2003–2011 evidences that *Protomyctophum arcticum, Benthosema glaciale, Lampanyctus macdonaldi*, and *Notoscopelus kroyeri* are the most abundant species of this family in the northern Atlantic Ocean northwards 40° N (Bekker, 1967, 1983; Filin, 1989, 1998). Other authors, however, indicate *Benthosema glaciale* and *Maurolicus muelleri* as the most abundant and common species in the northeastern Atlantic Ocean and the Mediterranean Sea (Gjøsæter and Kawaguchi, 1980; Olivar et al., 2012) and *Notoscopelus kroyeri* as the most abundant and common species in the area off British Isles (Gjøsæter and Kawaguchi, 1980). In the Irminger Sea, the species composition of the fish communities differs in accordance to the depth; the number of the species increases together with the depth.

The distribution of some fish species differed for the areas of MAR and the open waters of the Irminger Sea; however, the cluster analysis did not reveal any significance of such difference. Similar results were also obtained for the mesopelagic fish communities in the areas of two other underwater mountains located in the southern areas of the northeastern Atlantic Ocean, when the authors noted the absence of specificity of the fish communities in such areas (Pusch et al., 2004).

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