Journal of the Marine Biological Association of the United Kingdom, 2013, 93(5), 1143–1150.
doi:10.1017/S0025315412001890

Megafauna of the Charlie–Gibbs Fracture Zone (northern Mid-Atlantic Ridge) based on video observations

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Megafauna from the Charlie–Gibbs Fracture Zone (northern Mid-Atlantic Ridge) based on video observations from submersibles was analysed. Species composition was examined, frequency of species occurrence on the fracture wall and its base (depth range from 1740 m to 3100 m) and density of megafauna in the depression at the fracture zone bottom (4200–4500 m depth) were evaluated. At depths between 1700 and 2500 m hexactinellid sponges were most common and diverse. Deeper parts of the wall and its base were dominated by anthozoans (especially gorgonian corals) and echinoderms. A set of dominant species in the lower bathyal in the study area was different from that on the lower continental slope in the north-east Atlantic (Porcupine Seabight). An important contribution to local species richness of 'rare' species was demonstrated. The elpidiid holothurian, Kolga nana, *occurred at high density in the abyssal depression.*

Keywords: Mid-Atlantic Ridge, Charlie–Gibbs Fracture Zone, megafauna, video observations

Submitted 8 November 2012; accepted 29 November 2012; first published online 26 February 2013

INTRODUCTION

The Mid-Atlantic Ridge (MAR) separates the eastern and the western basins of the North Atlantic along the majority of its length, but there is flow of deep water between the basins through the Charlie–Gibbs Fracture Zone (CGFZ) (Lackschewitz *et al*., 1996). This major transform fault, where the ridge is offset 5° (east–west), lies at approximately 52°N. The average depth of the CGFZ is 3000 m, but it reaches ~4500 m in its deepest part (Felley *et al*., 2008). This fracture is the deepest connection between the north-east and north-west Atlantic basins, it is also the only deep-sea connection between faunas of the two basins. It was already shown that the CGFZ is important in biogeographical schemes of the North Atlantic since there is a pronounced change in benthic fauna in the bathyal on the MAR just south of the CGFZ (Mironov & Gebruk, 2006; Gebruk *et al*., 2010). The CGFZ fauna is also essential for understanding of ecology of mid-ocean ecosystems.

Samples of benthic fauna from fracture zone areas cannot be obtained using conventional tools such as trawls, dredges or corers. The present study is based on direct observations and video records made on three dives of the submersibles 'Mir-1' and 'Mir-2' in July 2003 during the 49th cruise of the RV 'Akademik Mstislav Keldysh'. These dives were the first in the CGFZ.

This study was a part of the 'Census of Marine Life' project MAR-ECO: Patterns and process of the ecosystems of the northern Mid-Atlantic (www.mar-eco.no). The major goal of MAR-ECO (spanning from 2001 to 2010) was 'to understand the biodiversity, distribution patterns, abundance and trophic relationships of pelagic, benthopelagic and epibenthic macrofauna inhabiting the mid-oceanic North Atlantic, from Iceland to the Azores' (Bergstad & Godø, 2003; Bergstad *et al*., 2008).

Based on video records and observations from the same *Mir* dives in the CGFZ, Vinogradov (2005) presented data on vertical distribution of macroplankton, and Felley *et al.* (2008) described small-scale distribution of demersal nekton and selected species of megafauna. In the present study we analysed epibenthic megafauna from two contrasting habitats—rocky outcrops and steep slopes on the northern wall and soft sediments in the abyssal depression at the bottom of the CGFZ. We examine the species composition, describe frequency of species occurrence on the fracture wall and its base and evaluate density of megafauna in the depression at the fracture zone bottom.

MATERIALS AND METHODS

Dives of the submersibles 'Mir-1' and 'Mir-2' were conducted in the north-western part of the CGFZ in June 2003 during the 49th cruise of the RV 'Akademik Mstislav Keldysh' of the Russian Academy of Sciences. Two double dives (using both submersibles) were performed. In the present study we use data from three dives (1/326, 1/339 and 2/340) (details in Table 1).

Both submersibles were equipped with high-resolution (720 lines) pan-and-tilt video cameras, mounted in frontal area in the upper part of submersible at the height of approximately 2.1 m. During video transects on the even seafloor cameras were looking almost vertically down.

Video transects were performed at a speed of approximately 0.3 m s^{-1}. The altitude was 1 m (controlled by

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Table 1. Dive details.

Submersible	Dive number	Date	Launch position	Description of dive	Depth, m	Time at seabed, hours
'Mir-1'	1/326	11.06.2003	52°58′N35°01′W	Up the northern slope of the fracture zone	3120–1740	8
'Mir-2'	1/339	11.06.2003	52°58′N35°01′W	Along the 3000 m isobath at the base of the northern slope of the fracture zone	3000	8
'Mir-2'	2/340	13.06.2003	52°47′N34°45′W	Deep depression close to the axis of the fracture zone, from bottom up a gentle slope	4500–4200	7

Table 2. Number and duration of transects and number of morphospecies for different depth ranges.

Dive	1/326				1/339	2/340
Depth, m	1740–2006	2022–2493	2500–2797	3000–3123	3000	4200–4500
No. of transects	2	3	2	3	3	8
Duration of transects, minutes: seconds (min:sec)	05:00	17:30	06:00	10:00	06:30	*
	22:30	24:30	17:00	14:30	09:00	
		29:00		47:00	44:30	
Total time, min:sec	27:30	71:00	23:00	71:30	60:00	>180
No. of morphospecies	13	24	9	21	22	11

*On dive 2/340 the length of transects was used (Table 4).

submersible echosounder) on the dive 2/340, but it could not be kept constant on the dives 1/326 and 1/339 due to extremely rough topography. The number of transects selected for the analysis from each dive depended on quality of the video records. The quality in turn was sensitive to conditions of the dive (speed and altitude) that were influenced by seafloor topography, currents and technical aspects. The speed and the altitude of submersible were slightly different between transects but constant within each transect.

For dives 1/326 and 1/339 we estimated frequency of occurrence (FO) of megafauna species (or morphospecies) over transect time. In all 13 transects from these dives were used for the analysis, varying in duration from 5 minutes to 47 minutes. For comparative analysis, occurrences from each transect were standardized to 5 minute units.

For dive 1/326 (up the slope of the fracture zone) we analysed occurrences of megafauna separately for the following depth horizons: <2000 m, 2000–2500 m, 2500–3000 m and >3000 m. The exact depth ranges of transects that fell into these horizons were 1740–2006 m, 2022–2493 m, 2500–2797 m and 3123–3000 m. The number of transects per depth zone was 2–3 (Table 2). Total duration of transects for each depth zone varied from 23 minutes (for 2500–2797 m depths) to 71 minutes 30 seconds (for 3000–3123 m) (Table 2).

For dive 2/340 (bottom of 4500 m deep depression) we estimated abundance of megafauna (number of individuals per m^2) separately for eight transects varying in length from 105 m to 879 m. The area of the bottom surveyed was estimated based on the transect length and the width of the field of view. The width of the field of view of the pan-and-tilt 'Mir' camera at a given altitude is a standard (~2 m at 1 m altitude) and can be taken from 'Mir' protocols. Benthic megafauna (animals large enough to be recognized on video records, usually of a size >1 cm) were identified and counted. Also we estimated approximately (visually) areal coverage in percentage of phytodetritus.

Calculations and analyses were carried out with SYSTAT 11 (2006).

RESULTS

The upslope dive ('Mir-1' dive 1/326)

On this dive along the northern wall of the fracture the submersible 'Mir-1' rose up the slope from 3100 m to almost 1700 m, traversing a variety of topographic features such as flattened areas of soft sediment, sediment clad slope with rocky outcropps and talus, rocky slopes and steep rocky cliffs.

At the base of the slope (3000–3123 m) prevailing substrates were soft sediments, talus and rocky outcrops. In total 21 morphospecies were observed in this depth zone at three transects with the total observation time of 71 minutes 30 seconds (Table 2). Highest frequencies of occurrence (FO) per 5 minutes at this depth were shown by two forms of gorgonian corals: whip-like (family Isididae) (mean FO 15.5) and fan-like (14.5), and the stalked crinoid *Anachalypsicrinus nefertiti* Clark, 1973 (5.6). All of these forms were attached to hard substrate. Also common were unstalked comatulid crinoids (3.65) usually associated with gorgonian corals and recorded up to five per gorgonian. Soft sediment fauna showed lower frequencies: the highest FO was in pourtalesiid echinoid (2.35), partly buried into sediment and leaving characteristic winding trails. Though, the pourtalesiid was observed only at one transect among three at this depth. FO >1 on soft sediment were shown by *Acanthephyra*-type shrimp and the elasipodid holothurian *Peniagone longipapillata* Gebruk, 2008 also recorded at only one of the transects.

In the depth layer between 2500 m and 3000 m the variety of substrates was the same as in the previous zone. At this depth we recorded only nine morphospecies of megafauna at two transects over a vertical range of 297 m (total time of observation 23 minutes). One characteristic feature of this depth zone was a high frequency of the holothurian *P. longipapillata*: mean FO 22.63, with the maximum 44.4 per 5 minutes at one of the two transects. All other forms at this depth showed FO < 1 and were seen only at one of the

https://doi.org/10.1017/S0025315412001890 Published online by Cambridge University Press

transects. Not a single attached form was observed at this depth, and the only form occurring on hard substrate was a brisingid sea star.

At depths between 2500 m and 2000 m prevailing substrates were rocky outcrops, vertical cliffs and steep partly sedimented slope with talus. In total 24 morphospecies of megafauna were observed in this depth zone at three transects over a vertical range of 471 m with the total time of observation 71 minutes. Most frequent at this depth were different species of sponges, primarily Hexactinellida but also Demospongiae. Beside sponges, mean frequencies of >1 appeared among the crinoid *A. nefertiti* (1.2) and the whip-like gorgonian corals (1.12), both recorded at all three transects. At one of the transects frequency 1.4 was shown by comatulid crinoids associated with gorgonians. Soft sediment forms at this depth supported holothurians, a pourtalesiid echinoid, asteroids, a sea pen and an enteropneust, all with FO <1.

In the shallowest depth zone, between 2000 m and 1500 m, prevailing substrates included rocky cliffs and outcrops with rare sedimented terraces and rare sedimented slope with talus. We recorded at this depth 13 morphospecies at two transects over a vertical range of 266 m, total time of observation 27 minutes 30 seconds. The prevalence of sponges in this depth zone was even more pronounced: 11 morphospecies out of 13 recorded were sponges, 10 among them Hexactinellida. Highest mean frequencies were shown by ?*Regadrella* sp. (36.6), one species of *Asconema* (9.45) and the demospongian *Geodia* sp. (4.4). Two other morphospecies apart from sponges included a sea pen and an ophiuroid each with FO 1.

The dive along 3000 m isobath ('Mir-2' dive 1/339)

On this dive the submersible 'Mir-2' travelled along the 3000 m isobath at the base of the fracture zone slope. The topography along the dive track was very rugged, substrates included rocky outcrops and cliffs mixed with sediment pockets and terrains. The variety of megafauna in this environment included 20 morphospecies, total time of observation 60 minutes. Majority of species (13; 65%) were associated with hard substrates (Table 3). On hard substrates whip gorgonian corals (family Isididae) were the most common: mean FO 22.67 based on three transects. Associated with whip gorgonians, comatulid crinoids also were observed frequently (mean FO 13.93). Common forms included the stalked crinoid *Anachalypsicrinus nefertiti*, *Acanella*-type gorgonians and brisingid sea stars. On soft sediments most frequently observed was the synallactid holothurian *Benthothuria funebris* Perrier R, 1898 (8.75). Frequencies of >1 were recorded for the holothurians *Peniagone longipapillata* and *Benthodytes* sp., and also a species of ophiuroid.

Compared to observations made on the vertical transect on dive 1/326 in the depth zone 3000–3123 m, on the dive along the 3000 m isobath we recorded more morphospecies of hard substrate fauna: ascidians (two species) and brisingid sea stars (three species) were observed only on the horizontal transect (dive 1/339). At the same time soft sediment echinoids were observed only on the vertical transect (dive 1/326). Overall nine morphospecies were common between these two transects, representing 43% and 45% of morphospecies observed on dive 1/326 and dive 1/339, respectively. One of the most frequent forms at the base of the wall on the vertical transect, a fan-like gorgonian (mean FO 14.50), was not recorded on the horizontal dive pointing at patchiness in distribution of common forms in the rocky environment on the ridge.

The abyssal dive ('Mir-2' dive 2/340)

On this dive the submersible 'Mir-2' travelled at 4200–4500 m. The total list of megafauna revealed over three hours of records included 11 morphospecipes. Nine of them were soft sediment dwellers and two attached to the hard substrate (glass sponges and a gorgonian coral) (Table 4).

Bioturbation of the sediment was very pronounced. Common tracks included spirals left by Enteropneusta and star-shaped prints left by echiurans. Mounds and holes of various size of unknown origin were also numerous.

Table 4 shows the density of megafauna (number of individuals per m^2) at eight video transects on this dive. A prominent feature in the depression was a phytodetrital material distinguished as a green–brown fluff on the seafloor. Estimated visually, the phytodetritus formed patches covering from 15 to 25% of the seafloor. At this density it was present over 20 minutes of the transect time (transects 4, 5 and 6 in Table 4, Figure 1).

The megafauna was different in areas with and without the phytodetritus on the sediment. At the bottom of a depression with no phytodetritus we recorded a very high density of the small elpidiid holothurian, *Kolga nana* (Théel, 1879): 76 individuals per m^2 (ind. m^2) (Figure 1). The density declined, first to 53 ind. m^2 and then to 23 ind. m^2. *Kalga nana* disappeared suddenly when patches of phytodetritus appeared. In the area with abundant phytodetritus occurred a sharp rise in density of monotholamus foraminiferans of the family Syringamminidae: from 0.33 ind. m^2 to 3.7 ind. m^2. The density of polychaete tubes and anemones also significantly increased (from 0.03 ind. m^2 to 1.21 ind. m^2 and from 0.2 ind. m^2 to 0.96 ind. m^2, respectively).

The phytodetritus disappeared at the base of depression slope and this was followed by a sharp decline in density of Syringamminidae from 3.7 ind. m^2 to 0.11 ind. m^2 and some increase in density of polychaete tubes: from 0.48 ind. m^2 to 0.69 ind. m^2 (Figure 1).

DISCUSSION

First data on megafauna of the Charlie–Gibbs Fracture Zone on the Mid-Atlantic Ridge has been received using manned submersibles. On three 'Mir-1' and 'Mir-2' dives, a total of 47 morphospecies were recorded. Although this number is not high, it should be noted that a number of species seen on video records of the seafloor usually is less than that revealed by trawling in the same area (Galkin & Moskalev, 1990). There is no trawl data from the CGFZ area available for comparison. Gebruk *et al.* (2010) reported 102 epibenthos species from the nearby area—the southern tip of the Reykjanes Ridge, based on four otter-trawl catches in this region at depths from 1600 to 3060 m by the 'G.O. Sars' MAR-ECO expedition in 2004.

Among the 47 recorded morphospecies, only six were identified to the species level: the hexactinellid sponge *Pheronema carpenteri* (Thomson, 1869), the holothurians

Table 3. Frequency of occurrence (FO) of megafauna on video transects. For morphospecies recorded at more than one transect, means with standard deviation in parentheses are given. Underlined values are based on records at three transects.

'Mir-1', 1/326					'Mir-2', 1/339	Substrate	Code
Depth, m	1740–2006	2022–2493	2500–2797	3000–3123	3000		
Porifera							
Hexactinellida							
Gen. sp 1				0.35		R	1
Gen. sp. 2		0.9				R	1
?*Asconema* sp.	3.05 (0.071)	1.35 (1.344)		0.7		R	2
Asconema sp. 1	4.45	6.4				R	3
Asconema sp. 2	4.7	4.85 (6.081)				R	2
Asconema sp. 3	9.45 (4.879)	4.14				R	3
Farrea sp.		0.63 (0.318)				R	1
?*Regadrella* sp.	36.6 (20.648)	18.3 (22.627)				R	4
Rosellidae, gen. sp.	3.4 (0.566)	2.25 (2.404)				R	2
Pheronema carpenteri	1.8 (0.283)	10.15			1.20 (1.556)	R	4
Euplectellidae, gen. sp.	0.45	0.7				R	1
Caulophacus sp.					0.55	R	1
Hexactinellida, indeterminate	45.1 (21.355)	27.525			4.6		
Demospongiae							
Gen. sp. 1		5.7		0.35		R	3
Geodia sp.	4.4 (4.808)					R	2
Anthozoa							
Hexacorallia							
?*Actinoscyphia* sp. (fly-trap)				0.5		R	1
Actiniaria, gen. sp. (long tentacle)		0.34				R	1
Octocorallia, Gorgonaria							
Isididae, gen. sp. (whip like)		*1.12* (0.831)		15.5 (8.485)	*22.67* (15.016)	R	4
Gen. sp (fan)				14.5 (4.950)		R	4
Gen. sp. ('small tree')				1.5		R	2
Gen. sp. ('small white tree')				0.35		R	1
Gen. sp. (bush)					3.90 (4.667)	R	2
Pennatularia, gen. sp.	1	0.15				S	2
Pycnogonida, gen. sp.			0.6	0.1		S	1
Decapoda							
Munidopsis sp.				0.1		R/S	1
Gen. sp. (red shrimp)			0.3	1.65	0.45	R/S	2
Asteroidea							
Brisingidae, gen. sp.1		*0.50* (0.563)	0.85		0.75	R	1
Brisingidae, gen. sp.2					3.85	R	2
Freyella sp.					0.35	R	1
Gen. sp.1		0.4				S	1
Gen. sp. 2 (short arms)		0.3				S	1
Gen. sp. 3 (long arms)		0.15				S	1
Ophiuroidea							
Gen. sp. 1	1		0.85	0.5	0.2	S	2
Gen. sp.2 (red, long arms)					1.20 (1.556)	S	2
Echinoidea							
Echinothuroida, gen. sp.				0.1		S	1
Pourtalesia sp.		0.2		2.35		S	2
Holothuroidea							
Peniagone longipapillata		22.63 (30.795)	1.5	1.63 (0.106)		S	4
Benthodytes sp. 1			0.6	0.8 (0.990)	1.55	S	2
Benthodytes gosarsi		0.2	0.85	0.3		S	1
Benthothuria funebris			0.3	0.6 (0.354)	8.75	S	3
Paelopatides sp.	0.4					S	1
Synallactidae, gen. sp.					0.55	S	1
Crinoidea							
Anachalypsicrinus nefertiti		*1.20* (0.954)		5.6 (0.566)	*4.60* (3.777)	R	3
Democrinus parfaiti		0.55		1.28 (0.318)	0.1	R	2
Comatulidae, gen. sp.		1.4		3.65 (1.202)	*13.93* (12.625)	R	4
Enteropneusta, gen. sp.		0.2	0.85		0.2	S	1
Ascidiacea							
Gen. sp. 1					0.1	R	1
Gen. sp. 2 (stalked)					1.18 (0.106)	R	2
Indeterminate Objects		*1.73* (1.397)			*6.30* (3.388)		

Substrate: R, rocks; S, soft sediment. Code: 1, FO <1; 2, FO 1–5; 3, FO 5–10; 4, FO >10 (see also Figure 3).

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Table 4. Abundance of megafauna (ind. m^2) in the abyssal depression (dive 2/340). + indicates presence/single occurrences; % for phytodetritus – area coverage.

Transect	1	2	3	4	5	6	7	8	Mean (standard deviation)
Transect length, m	879	405	675	150	450	300	105	292	
Phytodetritus		+	+	15–25%	15–25%	15–25%			
Kolga nana	76	53	23				0.01		19.00 (29.82)
Syringamminidae gen. sp.	0.08	0.1	0.33	3.75	3.7	3.7	0.11	0.12	1.49 (1.85)
Hexactinellida Euplectellidae gen. sp.						+			
Porifera varia							0.03	0.04	
Actiniaria gen. sp.			0.2	0.96	0.37	0.6	0.25	0.22	0.33 (0.32)
Ceriantharia gen. sp.	0.03	0.04				0.16	0.12	0.06	0.05 (0.06)
Polychaeta tubicolous	0.01	+	0.03	1.21	0.48	0.69	0.6	0.63	0.46 (0.43)
Paelopatides sp.		+			+				
Munidopsis sp.						+			
Decapoda gen. sp. (red shrimp)		+		0.01					
Gorgonaria gen. sp. (whip like)								+	
Indeterminate	0.01	0.05	0.01	0.08		0.01	0.04	0.04	0.03 (0.03)

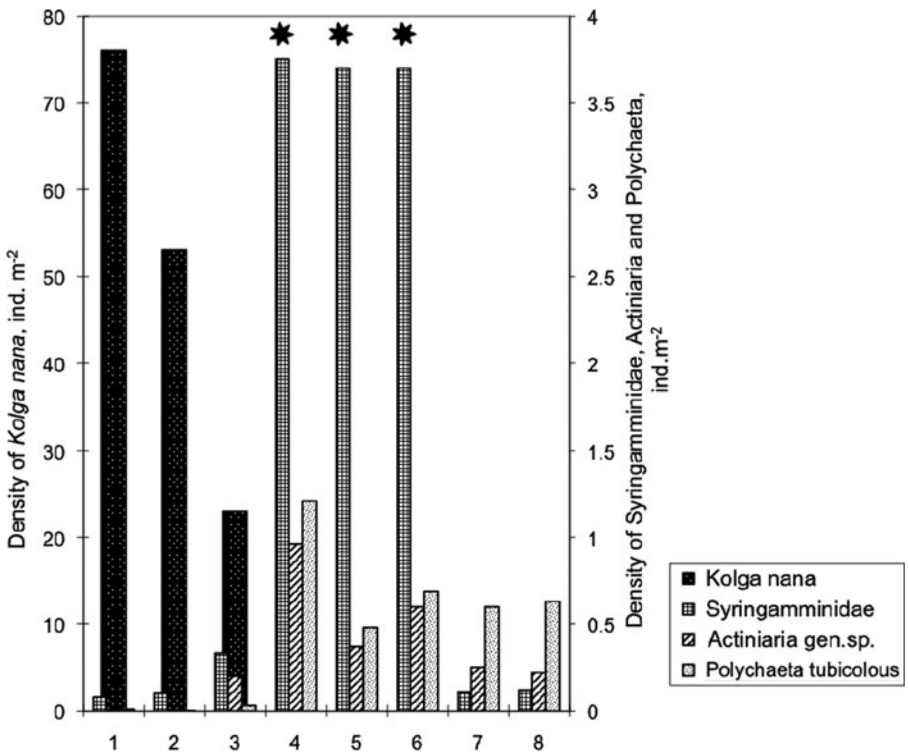

Fig. 1. Abundance of selected taxa on transects on the dive 2/340. Stars designate transects with areal coverage of phytodetritus 15–25%.

Benthothuria funebris, Benthodytes gosarsi Gebruk, 2008 and *Peniagone longipapillata*, and the crionoids *Anachalypsicrinus nefertiti* and *Democrinus parfaiti* Perrier, 1883. Most of these species are common in the North Atlantic. The two species of holothurians, *B. gosarsi* and *P. longipaillata*, have been described from the MAR and were thought to be endemic to the ridge (Gebruk, 2008), but recently they were found on the European continental margin in the Whittard Canyon (Masson, 2009).

Holothurians are known among most abundant forms at lower continental slope and abyssal plains. The synallactid, *B. funebris*, one of the most frequently observed in our records around 3000 m depth, is also rather abundant at slightly greater depths (~3500 m) at the slope base in the Porcupine Abyssal Plain in the north-east Atlantic (Billett, 1991). At the same time the species *P. longipapillata*, most frequently observed in our data between 2500 m and 2800 m, is not common outside the MAR. In the Porcupine Seabight and Abyssal Plain areas, species of *Peniagone* were not reported at all (Billett, 1991). In the Whittard Canyon area *P. longipaillata* was regularly seen but it was not among the most common forms (Masson, 2009). Thus, our results indicate that the lower slope fauna on the MAR has some differences from the continental slope.

At depths between 1700 and 2500 m hexactinellid sponges were the most diverse and common. In deeper parts of the slope and its base, anthozoans (especially gorgonian corals) and echinoderms were more diverse and abundant. These results in general are consistent with data based on trawl catches for the MAR-ECO area north-west of CGFZ

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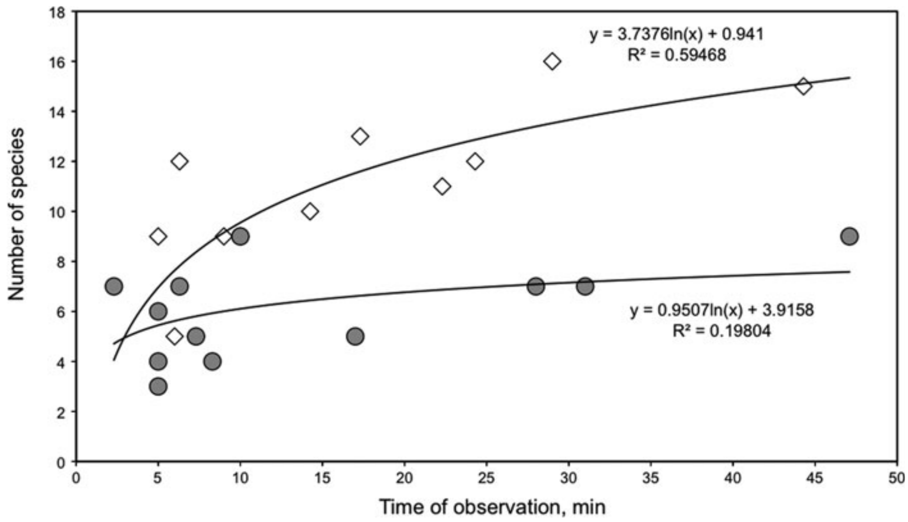

Fig. 2. Number of species per observation time on rocks (diamonds) and soft sediment (circles).

(Gebruk *et al.,* 2010). A similar pattern of megafauna distribution also was reported based on trawl catches for the Goban Spur slope between 49°N and 50°N (north-east Atlantic) (Lavaleye *et al.*, 2002).

Among 47 morphospecies in our data, 29 forms were associated with hard substrates, 16 with soft sediments and two were mobile crustaceans with no certain affiliation to the substrate. The ratio of rock and soft sediment megafauna varied between depth zones (Table 3) depending on availability of these two types of substrate. The ratio of soft sediment fauna was lower between 1700 m and 2500 m compared to deeper parts of the slope and its base.

Hard substrates apparently provide more heterogeneous habitat compared to the soft sediment, hence the species diversity appeared higher on rocks. This also follows from data of Felley *et al.* (2008). Our results also showed that the number of species per set observation time period was higher on rocks than on soft sediments, and the trend of growth of this number was steeper on hard rocks (Figure 2).

One of the reasons for higher species diversity on rocks is the fact that some species are associated with others that provide them with a substrate: e.g. comatulid crinoids or ophiuroids living on gorgonian corals.

In terms of depth-related distribution, the highest number of species in our observations occurred at the horizon 2000–2500 m (24 morphospecies) and at the base of slope, between 3000 and 3100 m (Table 2). However, both total observation time and the number of transects were higher at these depths, so we cannot make here any firm conclusions. Also at depths between 2000 and 2500 m a large part of the slope was covered with sediment adding soft sediment species to the diverse fauna of hard rocks.

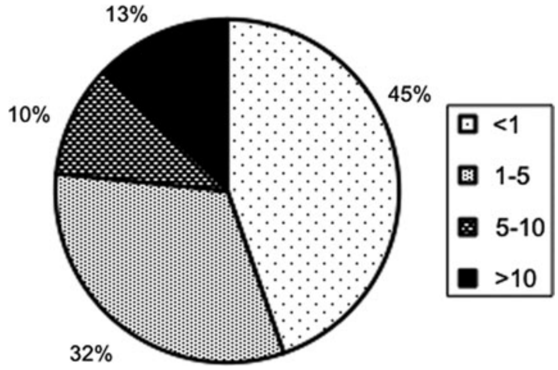

Fig. 3. Percentage of species with different frequencies of occurrence per 5 minute intervals.

We have categorized observed morphospecies of megafauna into four groups by frequency of occurrence on a relative scale from <1 per 5 minutes, 1–5, 5–10, and >10. Our results show that almost half of the observed 47 species (44%) can be considered as 'rare' (with frequency <1) (Figure 3). In ecological studies, rare species may have a minor role in terms of abundance and biomass, but they may constitute the largest component of species richness (Cao *et al.*, 1998; McGill, 2003; Cunningham *et al.*, 2005). Frequencies from 1–5 were shown by 15 morphospecies (32%) and from 5–10 by 5 (11%). Most frequently (>10) occurring were six forms (13%): sponges ?*Regadrella* sp. (Hexactinellida) and *P. carpenteri* (Demospongiae), whip-like (family Isididae) and fan-like gorgonian corals, the holothurian *P. longipapillata* and comatulid crinoids.

Aggregation of holothurians *Kolga* at the bottom of the abyssal depression is an important feature of the CGFZ. Billet & Hansen (1982) observed in the Porcupine Seabight in the North Atlantic an abyssal aggregation of a species of *Kolga* identified as *K. hyalina* Danielssen & Koren, 1881. Re-examination of this species showed that it belongs to *K. nana* (Rogacheva, 2012), the same species that we recorded in the CGFZ. The abundance of *K. nana* at 4480 m depth in the CGFZ reached 76 ind. m^2 and remained very high (from 23 to 76 ind. m^2) over more than 43 minutes of a video transect, indicating large and very dense aggregation of this holothurian at the bottom of the depression.

In the data of Billet & Hansen (1982), the maximum mean density of *Kolga* was 50 ind. m^2 at 3700 m (with the peak density found in small patches 716 ind. m^2), and 34 ind. m^2 around 4000 m depth. These high densities were associated with the Gollum Channel System. This fact and our new data suggest that a high abundance of small elpidiid holothurians in the abyssal can be related to the seafloor depressions, even inside fracture zones in open mid-ocean areas. Rowe (1971) regarded aggregations of elpidiid holothurians as a typical feature of canyons.

https://doi.org/10.1017/S0025315412001890 Published online by Cambridge University Press

Billett & Hansen (1982) discussed two possible interpretations of holothurian aggregations: a synchronous reproductive strategy and a response to periodic accumulation of organic matter. Our data are not appropriate to test a reproductive hypothesis. At the same time, the 'trophic' interpretation of aggregations seems likely since depressions at the seafloor (especially canyons and trenches) are known to trap organic matter attracting deposit-feeding holothurians (review in Gebruk, 1990; Billett, 1991; Bluhm & Gebruk, 1999).

However, according to our data, *K. nana* was avoiding patches of phytodetritus in the CGFZ abyssal depression. The size of food items used by holothurians depends on the size of holothurians (Roberts *et al.*, 2000). *Kalga nana* is a small-sized holothurian (<15 mm in length) that apparently feeds on detrital particles of a size smaller than clumps of fresh phytodetritus. In the abyssal of the North Atlantic the latter is often consumed by larger holothurians, such as *Oneirophanta mutabilis* Thiel, 1879 (Roberts *et al.*, 2000) and *Amperima rosea* (R. Perrier, 1896) (Billett *et al.*, 2001).

In our data a clear positive correlation was found between the amount of phytodetritus on the seafloor and densities of the monotholamus foraminiferans of the family Syringamminidae. The type of Syringamminidae we observed resembles *Galatheammina* sp. reported from 4300 m depth in the Nazaré Canyon, off the coast of Portugal (Tyler *et al.*, 2009). This single-celled protozoan grows to considerable size, often exceeding 10 cm in diameter. In the Nazaré Canyon it occurred in very high densities on the canyon floor enriched in organic matter.

High densities of Syringamminidae in our data apparently were related to seasonal flux of phytodetritus to the seafloor. Our observations were conducted in early June, a period of the year when in the North Atlantic phytodetritus appears on the seafloor in the abyssal as a result of a spring bloom (Bett *et al.*, 2001; Lampitt *et al.*, 2001). Seasonal fluxes of organic matter have a strong effect on deep-sea benthic biota, manifested in increase of activity, reproduction, population size, etc. In the abyssal ocean areas this effect is most evident among smaller organisms, particularly bacteria and protozoans (Gooday, 2002). Our new data show that the effect of seasonal fluxes of phytodetritus on benthic biota is also pronounced in the abyssal mid-ocean ridge ecosystems.

This study was one of the first investigations of the CGFZ megafauna. It has revealed a unique set of dominant species in the lower bathyal in this area. We also demonstrated an important contribution to local species richness of species that can be considered as rare. We discovered high density of holothurians in the abyssal depression and found evidence of the effect of seasonal fluxes of phytodetritus on benthic biota at abyssal depths on the MAR. These observations may help in better understanding of the mid-ocean ridge ecosystems.

ACKNOWLEDGEMENTS

The authors are grateful to the pilots and team of the 'Mir' submersibles and to the crew of 'Akademik Mstislav Keldysh' on the 49th cruise for their dedication and help. The following experts (IORAN, Moscow, Russia) helped us with identification of megafauna on video records: O.E. Kamenskaya (Syringamminidae), A.N. Mironov (Crionoidea), T.N. Molodtsova (Anthozoa) and K.R. Tabachnik (Porifera). We are grateful to Bruce Marshall (Te Papa Museum, Wellington, New Zealand) for editing the style of English and to two anonymous referees for improving the manuscript. This work was an element of MAR-ECO, a field project of the Census of Marine Life programme. Partial support received from Minobrnauki of the Russian Federation, contract number 8664.

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