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# Benthic communities of Russian Arctic Seas under radioactive pollution condition

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**Abstract.** One of the primary goals was to estimate the impact of the concentration of radioactive caesium on meio- and macrobenthic organisms in Barents and Kara Seas. It is determine that macrobenthos is more inert component, less subjected to the influence of this factor. Meiobenthos reacts to the radioactive pollution by the change of the taxonomic diversity and quantitative characteristics faster then.

## 1. INTRODUCTION

Radioactive pollution of marine ecosystems is one of the most dangerous anthropogenic impacts on the biota. The objects of this study were bottom ecosystems of Barents and Kara Sea. Different areas of Russian Arctic seas were exposed to significant emission of radioactive nuclides. The main aim of our study was to evaluate the impact of a radioactive contamination on macro- and meiobenthic communities. The special attention was given to the meiobenthic organisms – the small bottom animals inhabiting a small space between grains of the sediment.

## 2. MATERIALS AND METHODS

The study was based on the material collected by expeditions of Zoological Institute RAS, VNIIOkeangeologia, Murmansk Marine Biological Institute around the Murmanskoe shoal. Samples of meiobenthos were collected on cruises of research vessel “Geologist Fersman” in August–September, 1993 around Novaya Zemlya, and hydrographic ship “Captain Smirnitsky” in August–October 1995 on the international expedition “Seas and estuary of the Russian Arctic-95” [1–7] (Fig. 1).

The collection and the treatment of samples were carried out by using standard methods. To obtain the quantity of information about taxonomic diversity, the Shannon-Weawer index [8] showing the degree of habitat saturation by various taxonomic groups was calculated:

$$H = -\sum_{i=1}^{n} P_i \log_2 P_i.$$

$P_i = \mathrm{Ni/N}$ – part of «i» taxonomic group in total density.

## 3. RESULTS AND DISCUSSIONS

The radioactive pollution is the result of various reasons: a waste discharge of industrial waters, radioactive waste disposal and breakdowns on atomic submarines.

The area of the Murmansk shoal where the nuclear submarine “Kursk” has sunk on the ridge of the Murmansk bank (69°37′08″ n. lat., 37°33′03″ e. long., 115–116 m. depth) was chosen as the object

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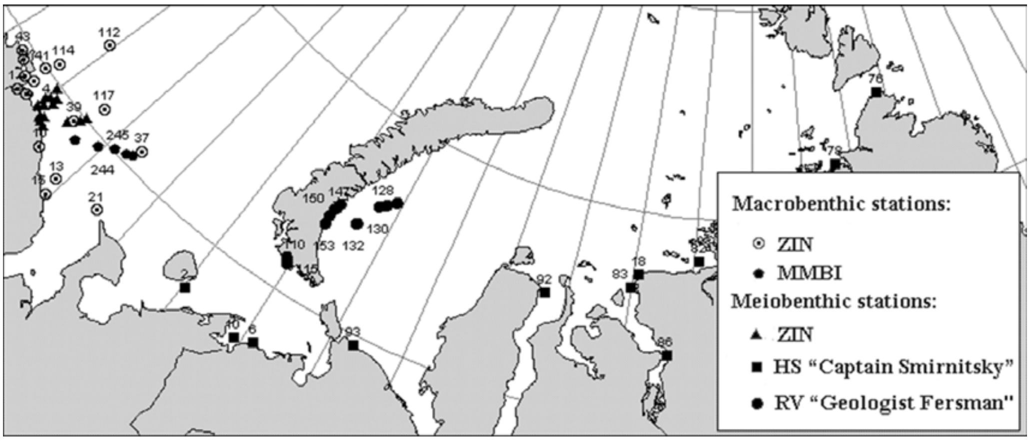


**Figure 1.** The location of macro- and meiobenthic stations on the Murmanskoe shoal, Novaya Zemlya and the shelf zone of Barents and Kara Seas.

of the study of macro- and meiobenthic communities structure. The species diversity of macrobenthos sites under study was rather high. The taxonomic list of macrobenthos of Murmansk shoal includes 192 species of animals. The difference on the quantitative characteristics (on the biomass) in various macrobenthic communities composed several orders of magnitudes. On an average, the biomass equals tens to hundreds grams on 1 $m^2$. The values of the Shannon-Weawer index varied from 0,87 to 2,32.

In the structure of macrobenthos of the coast slope (by species diversity) the first place belonged to *Cirripedia* and *Echinodermata* (sea-urchins and basket stars). The banks population was characterised by *Echinodermata* domination (sea-urchins, holothurians and starfishes on the Murmanskaya bank) and by a considerable quantity of *Bivalvia*. The taxonomic structure of invertebrates of depressions and troughs showed a considerable quantity of *Echinodermata* (starfishes in the Kaninsky trench and the North-Djupet trench) and *Bivalvia*. The trophic structure of the biocenoses of macrobenthos was composed of fixed sestonophages, mobile sestonophages, gathering detritophages, deposit-feeders and carnivorous. In the biogeographical structure boreal-arctic species predominated, then were arctic and boreal organisms. The spatial distribution of the macrobenthos in the shelf zone of the Murmanskoe shoal had a mosaic structure.

One of the tasks of this work was to study a possible local influence of sources of radioactive pollution on bottom communities. Relative to macrobenthos, on the basis of the analysis of references [9, 10] it is possible to assume the following. Macrobenthic communities are the most inert component of marine bottom ecosystems. The lifetime of the primary macrobenthic organisms is measured by several years. Therefore, this category of benthos cannot instantly react to an increase of the radioactivity level of environment by a change in its structure, including species diversity. It is possible to expect with the big share of probability, the substantial growth of radionuclide concentration in bottom organisms, especially in mobile and fixed sestonophages, detritophages and deposit-feeders.

Relative to meiobenthos, at the present moment there are few studies, concerning the influence of the radioactive pollution on meiofauna. To resolve this problem, the additional material collected during the cruise of research vessel "Geologist Fersman" around Novaya Zemlya in a Chernaya Inlet (31–87 m. depth), in Stepovogo and Abrosimova Inlets (44–74 m. depth) and around the Novozemelskaya Depression (333–403 m. depth), and also – during the cruise of hydrographic ship "Captain Smirnitsky" in 1995 in the shelf zone of Barents and Kara Seas, including Obskaya Inlet and Yeniseiskiy Gulf was used.

Meiobenthos includes the forms which remain in dimensional category 0.1–3.0 mm during entire life cycle, and also immature individuals of macrobenthos. According to this in the limits meiobenthos is divided in permanent (eumeiobenthos) and temporary (pseudomeiobenthos) components. The following groups of eumeiobenthos were found in Barents and Kara seas: *Foraminifera, Turbellaria, Gnathostomulida, Nematoda, Kinorhyncha, Cnidaria, Priapulida, Ostracoda, Harpacticoida, Entoprocta, Tardigrada*; and pseudomeiobenthos: *Nemertini, Oligochaeta, Polychaeta, Tanaidacea, Amphipoda, Gastropoda, Bivalvia, Asteroidea, Isopoda.* The values of the Shannon – Weaver index varied from 0.40 to 2.41, the average value was 1.50 (Fig. 2).

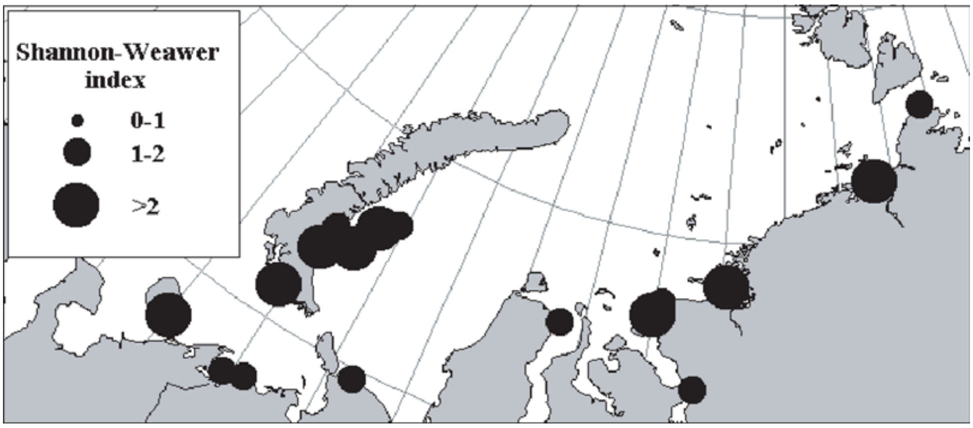


**Figure 2.** Spatial distribution of the meiobenthos diversity in various areas of Barents and Kara Seas.

The quantitative characteristics (the density and the biomass) of meiobenthos, its subdivisions and separate groups changed in the limits of 2–3 orders of magnitudes. The minimum density of meiobenthic animals was 15 thousand ind/m$^2$, the maximum density – 5426 thousand ind/m$^2$ (Fig. 3). The highest value of the biomass of meiobenthos was 47327 mg/m$^2$, the smallest one – 833 mg/m$^2$. The eumeiobenthos density varied from 40 to 100%, averaging 89.5% of the density of the total meiobenthos. Nematodes usually were the dominant group, harpacticoids and foraminifers – subdominant.

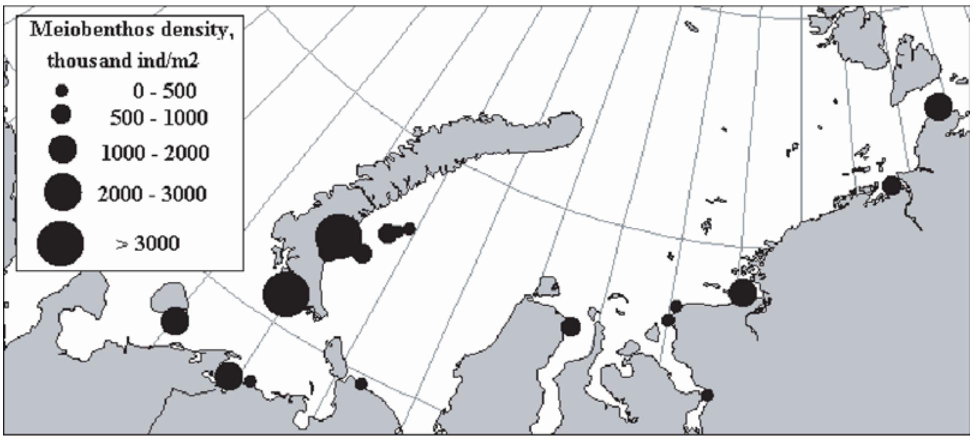


**Figure 3.** Spatial distribution of the meiobenthos density in various areas of Barents and Kara Seas.

The Chernaya Inlet is the place of the first underwater, atmospheric and underground tests of the nuclear weapon. The Abrosimova and Stepovogo Inlets on the east coast of archipelago became a place of underwater storage of barges, ships and containers with radioactive waste. The Obskaya Inlet and the Yeniseiskiy Gulf were exposed by radioactive nuclides with river flows for a long time. This kind of influence resulted in a high radiocaesium concentration in bottom sediment (more than 100 Bq/kg, at averages of value of 0–10 Bq/kg) (Fig. 4).

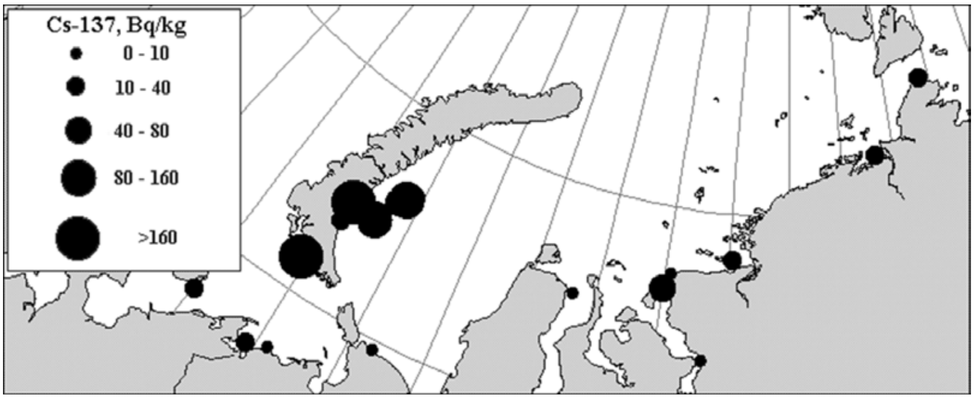


**Figure 4.** Concentration of radiocaesium in bottom sediments in various areas of Barents and Kara Seas (Bq/kg).

Comparison of the Chernaya Inlet meiobenthic communities with those of neighboring areas off the Novaya Zemlya Souther Island showed the communities of the open sea turned out to be more abundant. In other words, averaged characteristic of the open see differed from those of the inlet [11]: 1) meiobenthos density here was three times lower and biomass – five times lower then Chernaya Inlet; 2) community structure was quite different; 3) communities variability turned out to be smaller.

One of the primary goals was to estimate the impact of the concentration of radioactive caesium on meiobenthic organisms. To establish dependences, the Pearson correlation coefficient was calculated between the radiocaesium concentration, the meiobenthic density and the Shannon-Weawer index. The value of the correlation coefficient shows significant relationship between these parameters (Table 1).

**Table 1.** Value of the Pearson correlation coefficient, showing relationship between the radiocaesium concentration, the meiobenthic density and the Shannon-Weawer index in Barents and Kara sea.

| Taxon | Correlation coefficient | | Student's test | | Number of degrees of freedom | Reliability of estimate |
|---|---|---|---|---|---|---|
| | r | $\sigma_r$ | t | $t_{st}$ | v | |
| Novaya Zemlya, 1993 year | | | | | | |
| Shannon-Weawer index | 0,41 | 0,21 | 1,92 | 1,75 | 15 | Reliable positive |
| Meiobenthos | −0, 43 | 0,21 | 2,08 | 1,75 | 15 | Reliable negative |
| Shelf zone of Barents and Kara seas, 1995 year | | | | | | |
| Shannon-Weawer index | 0,54 | 0,18 | 2,99 | 1,81 | 10 | Reliable positive |
| Meiobenthos | 0,63 | 0,16 | 4,02 | 1,81 | 10 | Reliable positive |

The increase of radiocaesium concentration results in increase of the taxonomic diversity (Fig. 5). However, the influence of the content of caesium-137 on quantitative characteristics is not univocal (Fig. 6). Most likely, the small concentrations of $^{137}$Cs have no influence, or can even lead to insignificant increase of the density of small bottom fauna. However, reaching some threshold concentration (20 Bk/kg) changes in meiobenthic communities start to have an irreversible character that leads to the reduction of their density.

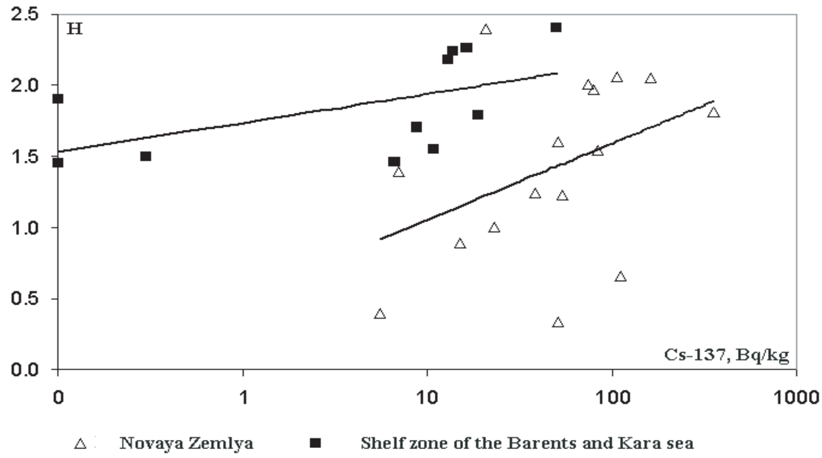


**Figure 5.** The correlation between diversity of meiobenthos and concentration of radiocaesium in hydrobiological station in Barents and Kara Seas.

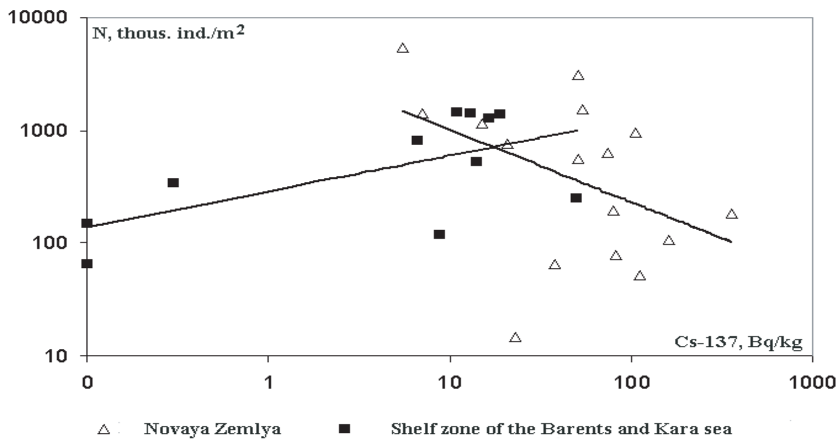


**Figure 6.** The correlation between density of meiobenthos and concentration of radiocaesium in hydrobiological station in Barents and Kara Seas.

## 4. CONCLUSION

It is possible to conclude that meiobenthos reacts to the radioactive pollution by the change of the taxonomic diversity and quantitative characteristics faster then macrobenthos, which is more inert component, less subjected to the influence of this factor. Large bottom organisms accumulate radioactive nuclides in cells and tissues for long period of time.

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