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Selected anthropogenic and natural radioisotopes in the Barents Sea and off the western coast of Svalbard

Ari-Pekka Leppänen [a,*], Nadezhda Kasatkina [b], Kaisa Vaaramaa [c], Gennady G. Matishov [b], Dina Solatie [a]

[a] Radiation and Nuclear Safety Authority – STUK, Lähteentie 2, 96400 Rovaniemi, Finland
[b] Murmansk Marine Biological Institute, 17 Vladimirskaya Street, Murmansk 183010, Russia
[c] Radiation and Nuclear Safety Authority – STUK, Laippatie 4, 00881 Helsinki, Finland

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ABSTRACT

The Murmansk Marine Biological Institute (MMBI) performed high-latitude expeditions to the Barents Sea during 2007–2009 where a scientist from the Radiation and Nuclear Safety Authority (STUK) participated. The aim of the expeditions was to study and map the current radiological situation throughout the Barents Sea. In the expeditions, samples of seawater, sediment and biota were collected for radioactivity studies. The ^{90}Sr and ^{137}Cs isotopes were analysed from the seawater samples and no spatial distribution in the concentrations of ^{90}Sr and ^{137}Cs was found. The sediment samples were analysed for γ-emitting isotopes. In the statistical analysis performed only the ^{90}Sr was found to have no spatial distribution. In the ^{137}Cs concentrations two areas containing higher concentrations were observed: one in the western part of Svalbard and another in Franz Victoria Trough near the Franz Josef Land archipelago. The increase in the western coast of Svalbard suggests an Atlantic influence while in the Franz Victoria Trough source regions are possibly more complex. Since ^{137}Cs in marine sediments mainly originates from terrestrial sources, finding higher concentrations in the northern part of the Barents Sea may also suggest a contribution of ^{137}Cs carried by the ocean currents and by sea ice from the outside Barents Sea. In addition to γ spectrometric measurements, the sediment samples were radiochemically analysed for ^{210}Pb. It was found that the unsupported fraction of ^{210}Pb showed significant spatial variation. The fraction of unsupported ^{210}Pb was reduced to 40–70% near Bear Island, Edge Island and in the Franz Josef Land archipelago. In these regions the sea is typically covered with sea ice during winter. The relatively low fraction of unsupported ^{210}Pb is possibly caused by blocking of wet and dry deposition of ^{210}Pb onto the sea by winter sea ice. In biota samples, only small traces, at the level of 0.2 Bq/kg w.w. of ^{137}Cs, were found. When the ^{137}Cs concentrations found in cod and in haddock were compared with studies done in the early 1990's an effective half-life of ^{137}Cs in cod and in haddock was deduced. For cod the estimated effective half-life of ^{137}Cs was between 5.8 and 7.5 years and for haddock between 5.3 and 9.5 years. Similarly, the concentrations of naturally occurring ^{210}Po and ^{210}Pb were from 0.1 to 0.3 Bq/kg w.w. The ^{210}Po/^{210}Pb ratio varied from 1.8 to 30 indicating a more efficient bioaccumulation of ^{210}Po than its precursor ^{210}Pb. The dose to humans eating Barents Sea fish was estimated. Even for people consuming large quantities of Barents Sea fish the annual dose was found to be below 20 μSv. The effective dose from anthropogenic ^{137}Cs was found to be less than 1% compared to the dose caused naturally occurring ^{210}Po and ^{210}Pb.

1. Introduction

The Barents Sea is a shallow-water ecosystem with high biological production of fish and mammals. The Barents Sea area is one of the richest oceanic areas in the world and among the most productive of the Arctic marginal seas (Sakshaug et al., 1994). Radioactive contamination of the Arctic environment has received much attention over the last decades. Since the beginning of the 1980s, decreasing concentrations of artificial radionuclides has been the trend for northern seas when considering both physical and ecological pathways of radionuclide transport. The present content of radioactive pollutants in the polar seas is caused by the global fallout from nuclear weapons tests, the Chernobyl accident, and radioactive wastes carried by sea currents from Siberian rivers and European nuclear processing facilities (Matishov and Matishov, 2004). The total amount of ^{137}Cs that entered the Kara and Barents Seas during 1961–1990 is estimated to be 14 PBq (Kryshev and

* Corresponding author. Tel.: +358 9 75988371.
E-mail addresses: ari.leppanen@stuk.fi, aapee73@gmail.com (A.-P. Leppänen).

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Sazykina, 1995 and references therein). Some 11 PBq of $^{239,240}Pu$ were distributed globally as a result of nuclear weapons testing (UNSCEAR, 2000). Based on the studies of shallow ice cores taken from Svalbard, the ^{137}Cs deposition from thermonuclear weapons tests in the region varied between 200 and 540 Bq/m^2 at the deposition date while the deposition from Chernobyl was 20 Bq/m^2 per annum. The annual ^{210}Pb deposition in the same region ranged from 12 to 21 Bq/m^2 (Pinglot et al., 1994 and references therein). In addition to past fallout and releases, there are several known potential sources for anthropogenic radioactive release in the Barents Sea or on land surrounding the Barents Sea where releases into the sea are possible (AMAP, 2009).

The Barents Sea has several inputs of radionuclides via oceanic circulation, riverine input and terrestrial runoff. Among the existing inputs there are numerous potential sources that can have an effect if released into the fragile marine environment. There are dumped wastes, sunken nuclear submarines and land-based nuclear storages. It is important to monitor the marine environment to detect increases in the radio nuclide concentrations and to identify their possible sources.

Since 1991, the Murmansk Marine Biological Institute of the Kola Science Centre of the Russian Academy of Sciences (MMBI KSC RAS) carried out comprehensive investigations of radioactivity of Arctic and Subarctic marine ecosystems that were based on extensive documentary, geographic, and taxonomic materials. Interest in this region stemmed from the availability of potential regional and local sources of radionuclide emissions: atomic fleet bases, nuclear test sites on the Novaya Zemlya archipelago, and radioactive waste burial sites on the shelf. In case of an accident or a release these potential sources can have a large affect on fragile Arctic ecosystems and also to local human health and economy. MMBI implements annual scientific expeditions to the Barents Sea where scientists from different disciplines are involved. In 2007, and 2009, MMBI and the Radiation and Nuclear Safety Authority, Finland (STUK) carried out joint expeditions and research activities in the Barents Sea. The objective of the collaboration was to study the contemporary distribution of radioactive contaminants and anthropogenic and natural radionuclides in the Barents Sea ecosystem.

2. Material and methods

2.1. Expedition routes during 2007–2009

In order to determine the current level of radioactivity and the status of the anthropogenic contamination in the Barents Sea samples of seawater, sediment and fish were collected. The sample collection presented in this study took place during three separate multi-disciplinary high-latitude expeditions to the Barents Sea

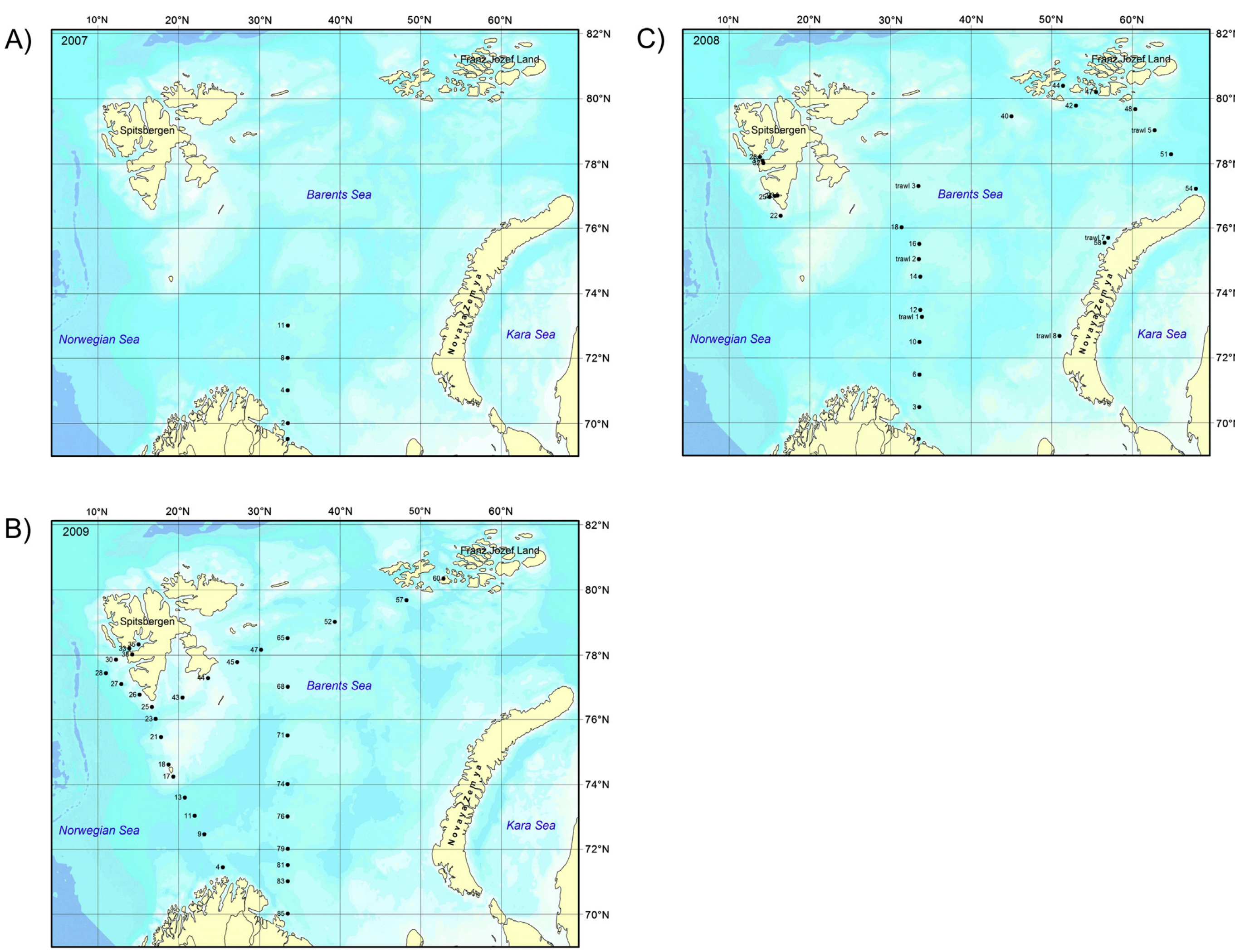

Fig. 1. The routes and locations of sampling stations of three high-latitude expeditions during 2007–2009: 2007 (panel A) 2009 (panel B), 2008 (panel C).