Radioactivity levels in Barents, Petshora, Kara, Laptev and White Sea

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Since 1993 the Finnish Centre for Radiation and Nuclear Safety (STUK) has had the opportunity to participate in Russian scientific expeditions on Barents, Petshora, Kara and White Sea. The aim of this ongoing joint work between STUK and the Murmansk Marine Biological Institute (MMBI) has been to obtain reliable data on the levels of transuranics and other antropogenic radionuclides in the Russian Arctic Sea areas and ecosystems. Information about the amounts of dumped radioactive waste, of the number of scrapped submarines, still carrying nuclear fuel in their reactors, laying in the North Russian harbors or military bases, of the storage tanks for fuel assemblies on land and of the possible runoff from reprocessing plants on Ob- and Jenisei-rivers have caused great concern among the population in the North.

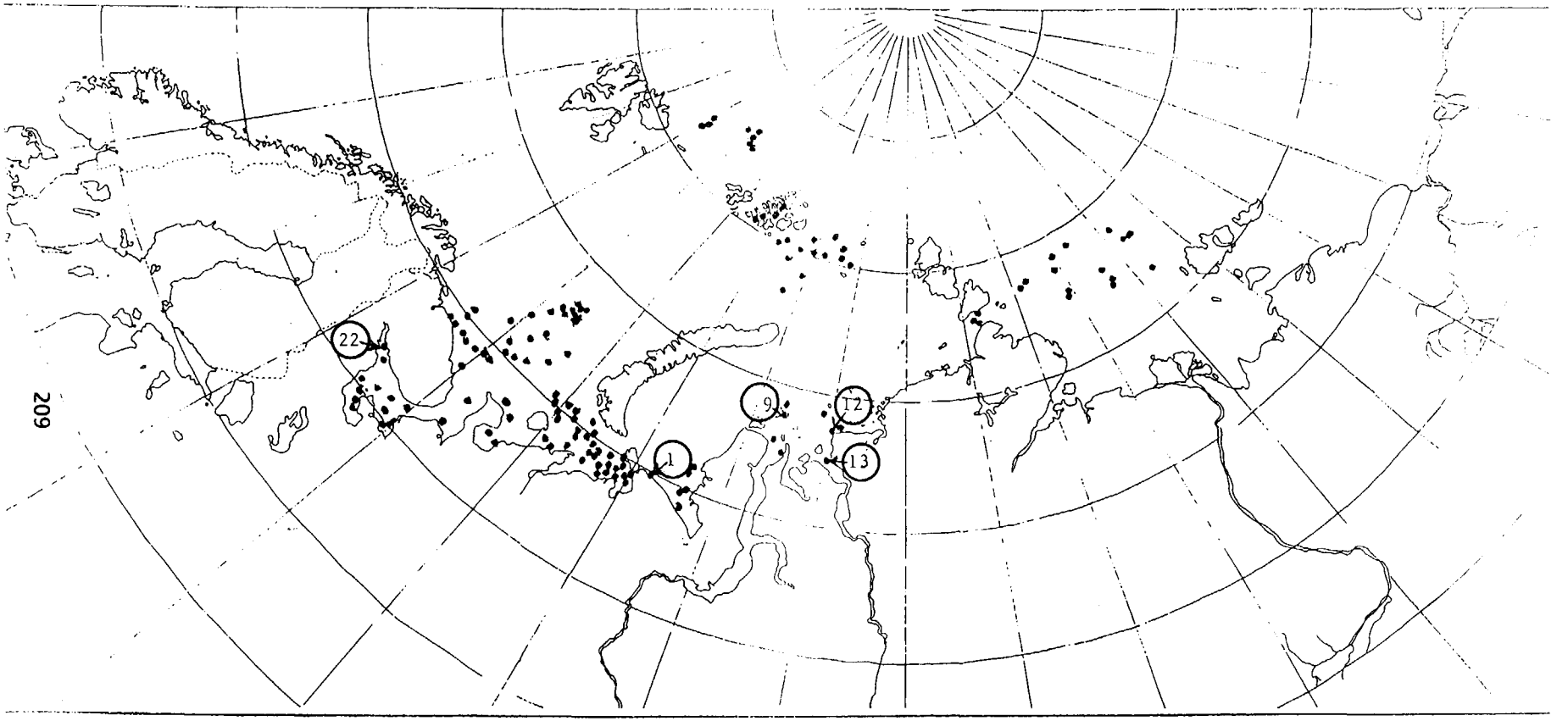
Marine and terrestrial samples were collected during scientific expeditions organized by MMBI in 1993 to Barents, Petshora and Kara Sea and in 1994 to Barents, Petshora and White Sea. MMBI was responsible for the organization of the expeditions and all necessary permission and for the heavy work on sample collection. STUK took care of the sample handling when the material was on the ship's deck. Experts of MMBI helped in identification of the marine biota. STUK was responsible for the terrestrial sampling and all radioactivity determinations.

SAMPLING

Sediment samples were collected from 137 locations marked on **Map 1**, STUK took part in collection on 74 locations. Additional 63 top layer sediment samples were collected by scientists of MMBI during expeditions to the Stohkmanovskaya gas field and to the northern part of Barents Sea near Franz Josefs Land and St.Anna Trough. Top layer sediment samples were also obtained from the Laptev Sea expedition of the icebreaker "Polarstern" of Alfred Wegener Institute.

The sediment samples represent usually the 0 - 2 cm top layer collected by a spoon or a spatula from a van Veen grab or Russian ocean grab. More quantitative samples were collected with a box corer. These samples were sliced with a large spatula. During the Barents, Petshora and White Sea expedition in 1994 a Niemistö gravity corer was also used. A Gemini corer was lost in the Barents Sea at the beginning of this expedition.

Several macrobenthic fauna samples were collected with a drag or grab from Petshora Sea, but some specimens also from Barents, Kara and White Sea. Red and brown algae samples were collected at the shoreline or by diving at nine locations in Barents, Petshora and White Sea. Fish samples from the most common fishing areas in Barents Sea were collected by trawling during three expeditions in 1993 and also during a special fishing expedition in 1994.



Map 1. Collection of sediment samples from the Russian arctic seas, STUK and MMBI 1993 and 1994. Small amount of ^{60}Co isotope noticed in sediments marked with a number.

Sampling of lichen, vascular plants and soil was carried out to reveal the contribution of atmospheric fallout from nuclear weapons tests and from the Chernobyl accident.

RADIOACTIVITY DETERMINATION

Radioactivity analyses were performed by STUKs Regional Laboratory at Rovaniemi. Before the analyses sediment, algea, plant and soil samples were dried at 105°C and homogenized. The preliminary treatment of marcobenthic samples depended on the type of organism. E.g. shells were separated from larger bivalvia and gastropoda before drying and homogenization. Flesh, bones, liver and other tissues were separated from the fish. All samples were dried before the gammaspectrometric measurement except the flesh of larger fish which were measured fresh.

All the samples were measured gammaspectrometrically with a high purity germanium semiconductor and a multichannel pulse-high analyser. The results were analysed using computer programs of STUK. Radiochemical analyses for ^{90}Sr and Pu-isotopes were carried out to selected sediment, algae and fish samples. ^{90}Sr analyses were made with the classical nitric acid precipitation method using ^{85}Sr isotope as a tracer. The method to analyse $^{239,240}Pu$ and ^{238}Pu and the results are presented in an other paper of this conference (Ikäheimonen *et al*, 1995).

RADIOACTIVITY LEVELS ON THE SHORE

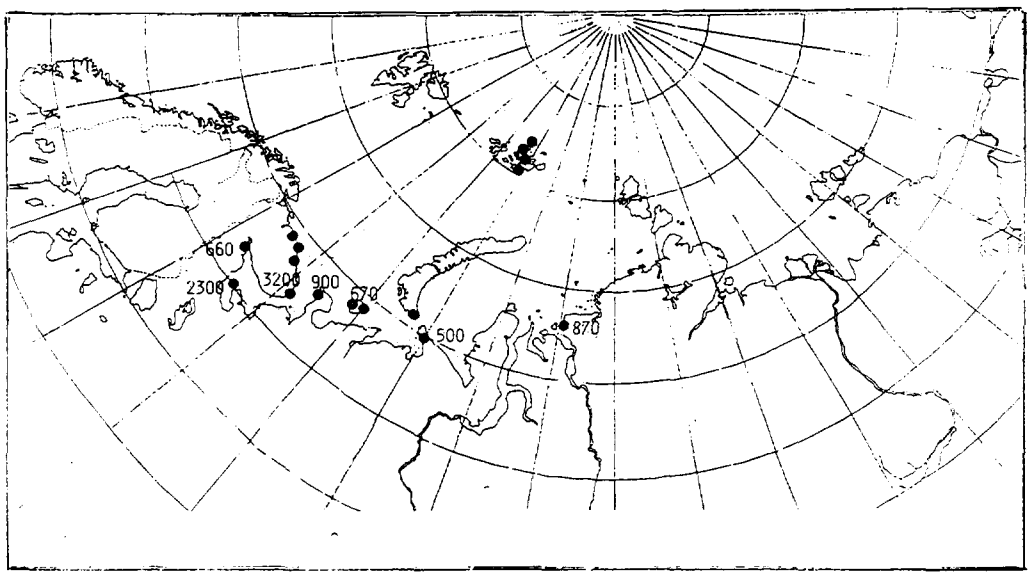
The atmospheric nuclear weapons tests on Novaya Zemlya in the 50's and 60's have not caused any particular fallout of long-lived radionuclides on the nearby islands or coastal areas. ^{137}Cs concentrations in lichen samples collected on south-shore of Novaya Zemlya, in two locations on Waigatsh island, on Jenisey outlet and on Kanin peninsula were exceptionally low, on average only 30 Bq/kg d.w. Higher ^{137}Cs concentrations 100 - 400 Bq/kg were measured in lichen collected on the Kola peninsula or White Sea area, where most of the samples contained also small amounts of ^{134}Cs isotope originated from the fallout of the Chernobyl accident.

Areal surface vegetation and soil samples (**Map 2**) from Waigatsh, Kolguev, Kanin peninsula and Jenisey showed a ^{137}Cs level of 500 - 900 Bq/m^2. Samples from Kola peninsula and White Sea area showed higher cesium levels, from 700 to 3200 Bq/m^2. These concentrations are similar to those measured in Northern Finland (Rissanen and Rahola, 1990).

RADIOACTIVITY LEVELS IN RUSSIAN ARCTIC SEAS

Cesium-137 was measured in all marine samples. Surface sediments from Barents, Petshora and Laptev Sea contained from 2 to 15 Bq/kg, sand samples below 1 Bq/kg d.w.

Higher ^{137}Cs concentrations were measured in the White Sea. Sediments from Kandalaksh bay contained 45 Bq/kg in the surface layer. The concentration decreased with the depth and after 15 cm no cesium was noticed in the Niemistö corer samples. Two sampling locations in the middle of White Sea showed 38 and 46 Bq/kg concentrations and 40 - 60 Bq/kg was measured in the mixed layers of a 20 cm long corer sample collected near the outlet of Dvina river. Other gammanuclide noticed in White Sea samples were small amounts of ^{134}Cs isotope in some samples from Dvina and Onega bay and 1.6 Bq/kg ^{60}Co in Kandalaksh bay (site 22 in Map 1.).



Map 2. Collection sites of terrestrial samples. ^{137}Cs concentration Bq/m^2 in areal surface soil samples with the vegatation, mainly lichen species. Size of the sample 50 cm x 50 cm, depth 5 - 7 cm.

Kara Sea sampling was carried out in the Baydaratskaya bay and at the outlets of rivers Ob and Jenisey. The highest ^{137}Cs concentration, 81 Bq/kg was measured in a box corer sediment profile collected at the Jenisey river outlet (site 13 in map 1) . This sample contained also ^{60}Co isotope and minor amounts of ^{125}Sb and ^{134}Cs isotopes (**Table 1**). Over 20 Bq/kg cesium-137 concentration was also measured in another Jenisey sample (site 12 in Map 1), in one sample outside Ob-river (site 9 in Map 1) and in a sample collected near the Kara gate (site 1 in Map 1). Minor amounts of ^{60}Co was measured in all of these samples as well as ^{134}Cs isotope, which was also noticed in all sediments collected outside Ob and Jenisey outlets.

Table 1. Radionuclide concentrations, Bq/kg d.w. in a box corer sediment collected at sampling site 13 at Jenisey outlet 1993.

sample depth cm	^{137}Cs	^{60}Co	^{90}Sr	$^{239,240}Pu$	^{238}Pu
0 - 2 cm	81	5.8	0.21	0.74	0.026
2 - 5 cm	75	5.1	0.64	0.65	0.029
5 - 8 cm	76	4.0	0.34	1.1	0.042
8 - 11 cm	70	2.3	0.39	1.1	0.040
11 - 14 cm	67	1.8	0.26	1.2	0.041
14 - 17 cm	75	1.8		0.72	0.032

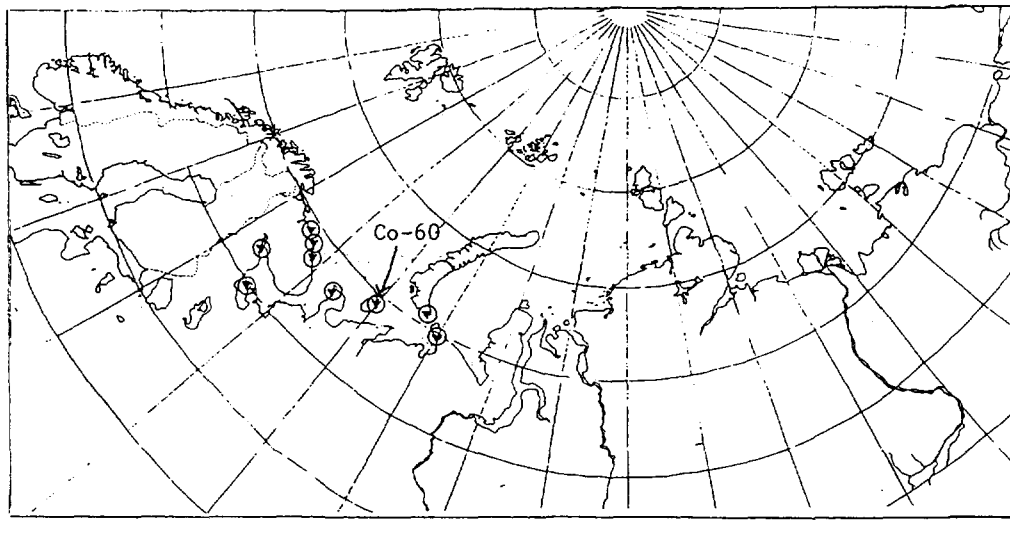
The average ^{137}Cs concentrations of the upper 0-2 cm layer of the sediment collected in Petshora and Barents Sea was about 100 Bq/m^2 , in Kara Sea 130 Bq/m^2 if the Jenisey outlet level 580 Bq/m^2 is excluded and in White Sea about 200 Bq/m^2 (Table 2)

Table 2. ^{137}Cs concentrations, Bq/m^2 in the upper layer (0-2 cm) of the sediments collected 1993 in Petshora and Kara sea and in 1994 in Barents and White sea. x = number of sampling sites

Sea	x	mean	min	max
Petshora Sea	13	100	60	170
Kara Sea	9	130	45	270 (580)
Barents Sea	4	110	40	160
White Sea	6	200	120	300

^{90}Sr analyses have been so far performed only to some sediment samples collected from Barents, Petshora and Kara Sea. All the concentrations have been below 1 Bq/kg d.w. and at about the same level as on the Jenisey outlet (Table 1). The plutonium concentrations of the sediment samples will be presented in another paper (Ikäheimonen *et al*, 1995) of this conference. All the gammanuclide, strontium and plutonium results for sediment samples obtained in this research are in good agreement with other monitoring results in the same areas (Strand et all, 1994) (Hamilton *et al*, 1994)

44 samples of red and brown algae were collected from 11 locations in Barents, Petshora and White Sea (**Map 3**). All the ^{137}Cs concentrations were very low but slightly higher concentrations were noticed in the few samples collected in the "mediterranean" White Sea (**Table 3**). Ptilota plumosa and Psycodrys rossica found drifting on the north-east shore of Kolguev island contained 4.4 and 1.7 Bq/kg d.w ^{60}Co isotope. Also slightly higher $^{239,240}Pu$ concentrations were measured in the same Ptilota sample (Ikäheimonen *et al*, 1995).



Map. 3. Locations of algae sample collection. Small amounts of ^{60}Co noticed in the species collected on the north-east coast of Kolguev island.

Table 3. Average ^{137}Cs concentrations, Bq/kg d.w. in algae samples collected 1993 - 1994 in Barents, Petshora and White Sea. (n) number of samples

	Barents Sea		Petshora Sea		White Sea	
	n	Bq/kg	n	Bq/kg	n	Bq/kg
Fucus sp	10	0.8	6	1.5	2	3.9
Ascophyllum nodosum	4	0.6				
Laminaria sp	5	2.2	2	1.5	1	3.4
Palmaria palmata	2	1.7				
Odonthalia dentata	2	2.2				
Chorda filum	2	<0.5				
micellaneus algae	8	<0.5-2.2				

All the samples of makrobenthic fauna showed also very low ^{137}Cs concentrations, usually below the detection level 0.1 Bq/kg d. w. Higher concentrations up to 20 Bq/kg d.w. were measured in the sediment constructed tubes of Polychaetes while the concentrations of the annelids living in the tubes were below detection level. However small amounts of ^{60}Co isotope was measured in the shells of bivalvia Modiolus modiolus (0.05 Bq/kg d.w.), in some polypes living on the shells (3.3 Bq/kg) and also in the shells of Mytilus edulis (0.1 Bq/kg) obtained by dredging from the sea area north east from Kolguev island. More results on benthic fauna are presented in another paper (Matishov *et al*, 1995) of this conference which contain also the results of the fish sampling.

DISCUSSION

The samples collected and analysed during this joint work between the Finnish Centre for Radiation and Nuclear Safety and the Murmansk Marine Biological Institute covers a rather large area of the arctic in north west Russia. All the analysed sediment, algae, benthic and fish samples have shown surprisingly low radionuclide concentrations and indicate that the open sea areas are almost uncontaminated. But the most interesting locations with potential risk sources are closed areas.

^{134}Cs isotope originating from the fallout of Chernobyl accident was measured only in terrestrial samples collected on the Kola peninsula and around the White Sea. Small amounts of this isotope with only 2 years half-life was also noticed in some sediment samples from White Sea. ^{134}Cs isotope was not noticed in any terrestrial sample collected from the coastal area between the Kanin peninsula and the Jenisey river. The very low concentrations of ^{134}Cs isotope measured in Kara Sea sediment samples were usually in association with an outlet of a river and were obviously transported by river water from the central parts of Russia.

The measured low concentrations of the antropogenic radionuclides in the Barents and Petshora Sea originate obviously from the the global fallout. The higher White Sea concentrations contain also additional fallout from the Chernobyl accident and probably also some terrestrial runoff. Low concentrations of ^{60}Co isotope in some sediment, algae and benthic fauna samples reveal however slight fresh contamination as were concentrations also at the outlet of Jenisey river.

The results on well documented sampling locations (GPS) represent also a background data for possible leakage or other accidents.

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