Chemical and Radiological Characterization of bottom sediment samples from Admiralty Bay, King George Island, Antarctic

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INTRODUCTION

The Antarctic region is known as an area that provides remote data, since it shows basal concentration of elements and compounds, without anthropogenic influence. Therefore, it is important to assess the natural levels of environmental components as well as the anthropogenic contributions due to human activities in the region[1]. The Brazilian activities in Antarctic are based at the "Comandante Ferraz" Antarctic Station (EACF), on Bransfield strait and King George Island (62°05'S and 58°25'W). The purpose of the present work is to determine total mercury, trace elements (As, Ba, Br, Co, Cr, Cs, Hf, Rb, Sb, Sc, Ta, Tb, Th, U, Zn), rare earth elements (Ce, Eu, La, Lu, Nd, Sm, Tb and Yb) and major elements (Fe, K and Na), phosphorus (organic and total), total nitrogen, organic carbon, sulphur, natural and artificial radionuclides in sediment samples from Admiralty Bay.

MATERIAL AND METHODS

Sediment samples (Figure 1) were collected during the sampling trip in January/February 2003 by using a steel Van Veen-type dredge. Trace elements (As, Ba, Br, Co, Cr, Cs, Hf, Rb, Sb, Sc, Ta, Tb, Th, U, Zn), rare earth elements (Ce, Eu, La, Lu, Nd, Sm, Tb and Yb) and major elements (Fe, K and Na) were determined in 15 samples by using instrumental neutron activation analysis (Silva et al., 2005). For total mercury determination FIA-CV-AAS technique was employed (Fávaro et al., 2004). ^{226}Ra, ^{228}Ra and ^{210}Pb were measured by gamma spectrometry using a hyper pure Ge detector (Silva et al., 2005). Sr and Pu determination was based on the selective separation of these elements by extraction chromatography, source preparation and measurement by beta scintillation counting and alpha spectrometry, respectively. The particulate total and organic phosphorus were analysed following the Aspila method and the phosphate obtained was determined according to Grasshoff. Organic P was determined by subtracting inorganic phosphorus from total phosphorus. For the grain size analysis, 30 g of dry sediment were treated with HCl and H_2O_2 (10% each) to eliminate $CaCO_3$ and organic matter, respectively, and weighed. For the determination of organic carbon, nitrogen and sulphur concentrations, samples were previously treated with HCl (10%) to eliminate $CaCO_3$ and determined in an Elemental Analyzer 2400 – CHN, Perkin-Elmer (Fávaro et al., 2004).

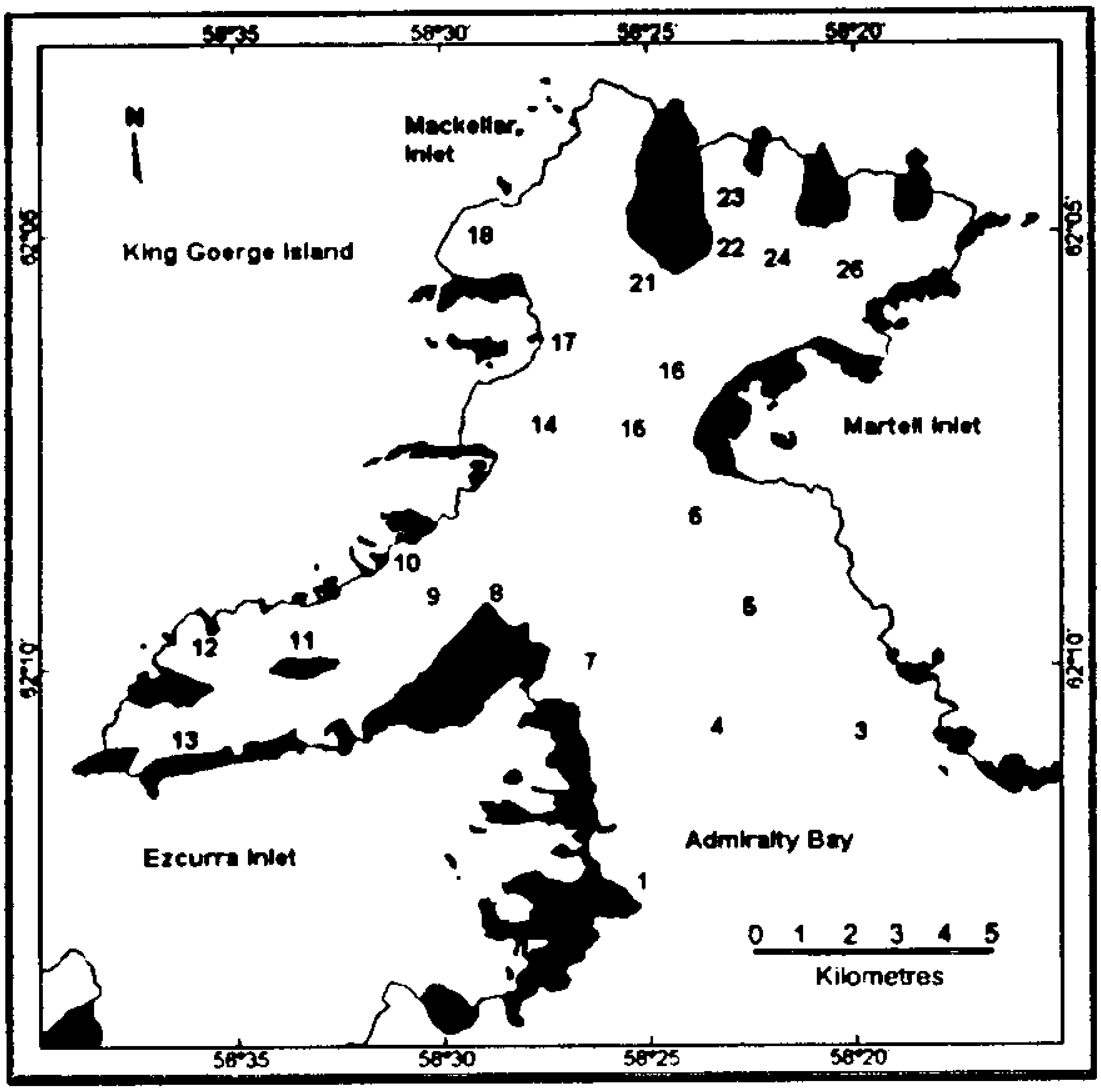

Figure 1: Sampling location

RESULTS AND CONCLUSION

The concentrations of the analyzed elements are presented in Table 1. The concentration of total mercury in the sediment samples varied from 53 to 210 µg kg^{-1} in all but one (sample 18, located at Mackellar Inlet), which presented concentration of 1789 µg kg^{-1}, value considered high for this region. Sample 18 also presented 75% of inorganic P, indicating terrestrial input of inorganic matter in this location with low contribution of organic matter. Most of phosphorus in the sediment was represented by the inorganic fraction (65-93%).

Grain size analysis showed predominance of silt mixed with clay (10 points in a total of 15), occurring mainly in the inner portions of the Bay, while sand was found mainly in the central part. The organic matter content is related to the presence of silt and clay, since high values were observed in station 21 and lower values in station 11, where the sediment is composed mainly by sand. The organic carbon concentrations were highest in the central part of the Bay and lowest near the Brazilian base. Nitrogen content in the sediment was higher also near the EACF and lower in the outer portion of the bay. Sulphur content in the sediment was higher at station 13 and lower in the eastern part of the Martel inlet.

Table 1: Concentration (range, mean values and standard deviation) of the analyzed sediment samples

	Hg	P-org	P-inorg.	P-total	C-org	N-org	S-org	OM
minimum	52	44	495	639	0.18	0.02	0.64	1.12
maximum	1789	265	631	839	0.61	0.34	1.13	3.81
mean	218	209	546	754	0.34	0.13	0.84	2.56
SD	438	64	43	53	0.13	0.12	0.16	1.02
	As	**Ba**	**Br**	**Ce**	**Co**	**Cr**	**Cs**	**Eu**
minimum	6	269	44	35	16	19	2	1.2
maximum	18	537	145	57	22	145	6	1.5
mean	9	364	90	44	19	47	3	1.4
SD	3	77	28	5	2	37	1	0.1
	Fe (%)	**Hf**	**K(%)**	**La**	**Lu**	**Na (%)**	**Nd**	**Rb**
minimum	4.4	3.3	1.0	14	0.3	2.4	25	38
maximum	5.9	5.7	2.9	23	0.5	4.3	47	77
mean	5.2	4.2	1.7	18	0.3	3.2	36	56
SD	0.4	0.6	0.5	2	0.0	0.6	6	12
	Sb	**Sc**	**Sm**	**Tb**	**Th**	**U**	**Yb**	**Zn**
minimum	0.2	21	4.5	0.4	3.5	0.8	1.8	71
maximum	1.0	27	6.7	0.9	6.0	2.6	2.5	201
mean	0.6	24	5.5	0.6	4.5	1.8	2.1	119
SD	0.2	1	0.5	0.1	0.7	0.6	0.2	32
	Pb-210	**Ra-226**	**Ra-228**	**K-40**	**Pu-238**	**Pu-239**	**Sr-90**	
minimum	<15	13	<11	356	<0.1	<0.1	<2.6	
maximum	176	40	27	1066	0.5	0.29	111	
mean	105	21	17	612	0.3	0.19	31	
SD	44	8	5	222	0.1	0.07	40	

A cluster analyses in R-mode was applied for these samples and the result is shown in figure 2. It can be seen that the set of samples was divided in two main groups. The first one (group 1) contains mainly samples located in the inner parts of the Bay, whereas group 2 comprises samples located in the entrance of the Bay under influence of the water of the Bransfield strait and located in deeper waters.

Statistical data analysis applied to the results of the samples chemical composition showed good correlation between RRE, Th, Rb, Hf, Ba, K, Cs, Sb, As, Hg, Sr-90, K-40 and silt content. These elements are more concentrated in the samples that belong to the inner part of the Bay. Silt content is also well correlated with organic matter and nutrients (organic S, N, C, P and inorganic P). The elements Fe, Zn, Cr, Co, Sc, U and Nd presented relatively higher concentration in the samples located at the entrance of the Bay and good correlation with sand, clay content and nutrients. The same pattern was also found for radionuclides Pu-238, Pu-239, Ra-226, Ra-228 and Pb-210 that present an inverse correlation with nutrients. However, for the artificial elements these results must be treated carefully since in many samples the concentrations stands bellow the detection limits. Ra-226, Ra-228 and K-40 concentrations were of the same order of magnitude than the results obtained by Godoy et al (1998) for sediment samples collected in the same region.

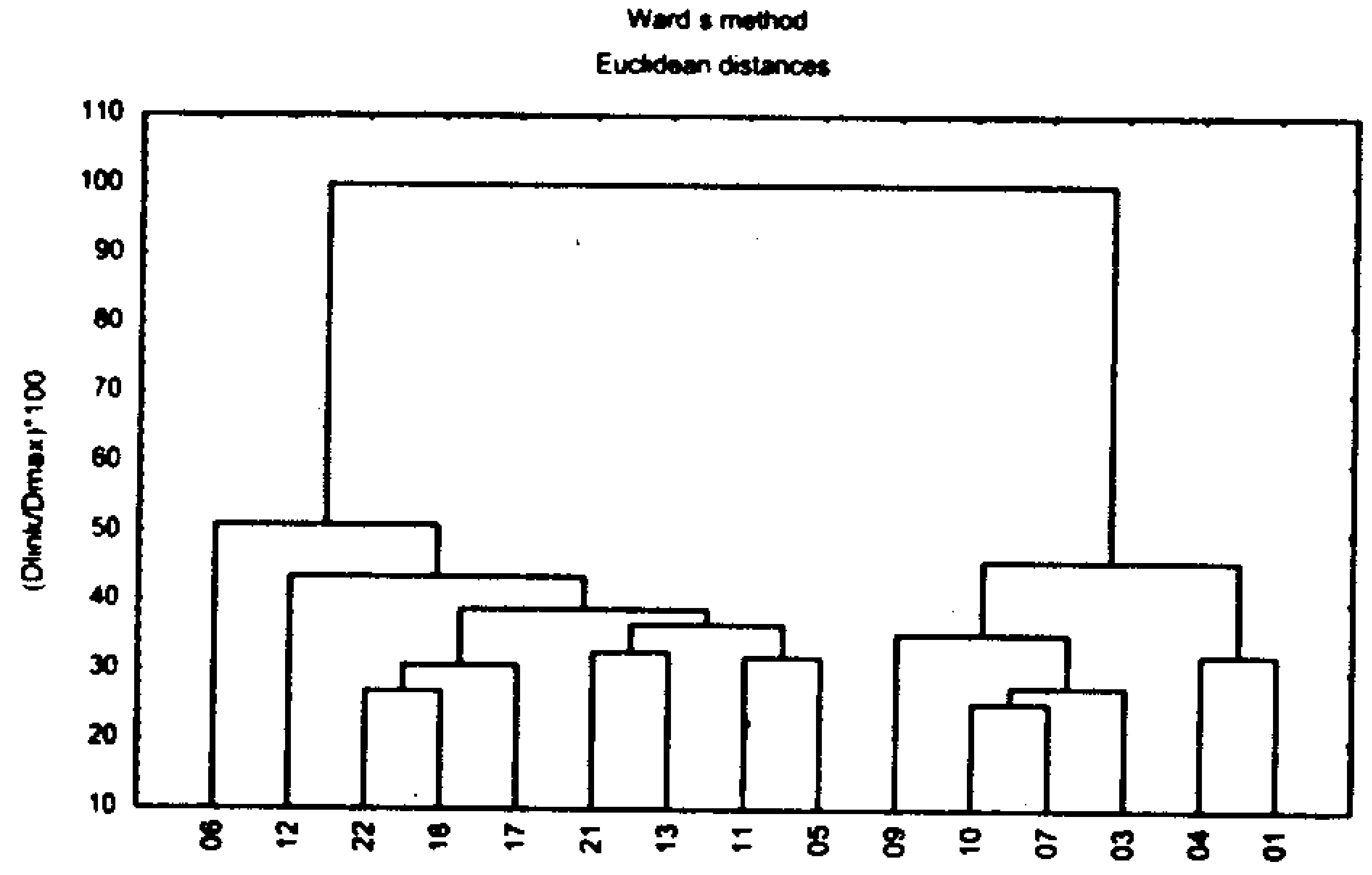

Figure 2: Cluster analysis applied to the sediment samples.

The results obtained for the elemental concentration in the sediment samples are quite uniform and correspond to the natural levels of the region. One exception is sample collected at point 18, which presented Hg and As concentrations above the natural levels, and deserves further investigation. Two main groups were observed, one formed by samples collected inside the Bay and the second one formed by samples gathered around the mouth. In the first group prevails processes of intense terrestrial input, while in the second group the differences can be explained by sediment accumulation.

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Environmental sensitivity analysis methodology for assessment of effects from contaminant releases into the arctic marine environment from Siberian Rivers

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INTRODUCTION

A methodology is presented for determining the sensitivity of biological systems to the consequences of contamination by radionuclides and heavy metals discharged into the marine environment. In this procedure, a box model, modified for use in ice-covered waters of the Kara Sea (Iosjpe et al., 2002; Iosjpe et al., 2003), is used to simulate discharges and define disturbance areas of both heavy metals (Co, Cd, Pb, Cu, Zn) and radionuclides (^{60}C) from the Ob and Yenisey Rivers. The determined disturbance areas, when overlain with information on the distribution of biological resources and types of physical habitats in the region, are then used to determine species' vulnerability to contaminant discharges. Species vulnerability is assessed using a modified version of the Adaptive Environmental Assessment and Management (AEAM) approach primarily used by the petroleum industry in environmental risk and impact assessments. In this procedure, valued ecosystem components (VECs) are identified and used in an environmental risk analysis framework to assess the probability of damage to biological resources from environmental disturbances at the individual, population or ecosystem level. Negative effects are identified when there is an overlap between the disturbance factor (i.e. presence of contaminants) and a biological resource in time and space. Potential organism- population level effects are subsequently assessed and a determination is made of species vulnerability. The application of this methodology to the arctic marine environment indicates that accidental contaminant releases from Siberian Rivers will impact fish eggs and larvae, resulting in reduced recruitment and leading to a reduction in year class strength.

MATERIALS AND METHODS

Levels assessment

Simulated contaminant concentration data for discharges from the Ob and Yenisey estuaries was produced for a 10 year period for water and sediments. Model results were calculated for five 'open sea' boxes and the estuary of the river from which the discharge occurred. Water concentrations were then converted to biotic contaminant concentrations using concentration factors (CF) presented by the IAEA (IAEA 2004). These results are assessed in combination with Norwegian standards (Molvær *et al.* 1997) for acceptable levels of contaminants in sea water and blue mussel and toxicity values for biota. No standards were available for Co. Simulation results for accidental discharges were compared to the present-day levels detected in the Ob and Yenisey estuaries. Model concentrations are a minimum of 1 order of magnitude greater than observations indicating that model simulations are a reasonable approximation of a situation involving the accidental discharge of heavy metals in these estuaries.