NONPROFIT ORGANIZATION
ECOLOGICAL FOUNDATION «GARMONICHNOE RAZVITIE»

UNEP/GEF PROJECT
«RUSSIAN FEDERATION – SUPPORT TO THE NATIONAL PROGRAMME OF ACTION FOR THE PROTECTION OF THE ARCTIC MARINE ENVIRONMENT»

ESTIMATION OF THE DEGREE OF IMPURITY OF BOTTOM WATERS AND BOTTOM SEDIMENT OF THE SOUTHERN KNEE OF KOLA BAY AS A RESULT OF ANTHROPOGENOUS INFLUENCE

Murmansk 2008

ESTIMATION OF THE DEGREE OF IMPURITY OF BOTTOM WATERS AND BOTTOM SEDIMENT OF THE SOUTHERN KNEE OF KOLA BAY AS A RESULT OF ANTHROPOGENOUS INFLUENCE

(on the basis of works executed under the contract "Purification of bottom sediment of Kola bay from dangerous substances. Phase 1. Monitoring of dangerous substances in bottom sediment of Kola bay ").

Bottom waters

Hydrochemical compound of bottom waters of Kola bay is under the influence of river flow of the rivers Kola and Tuloma, tidal effect and communication with the high sea, and also industrial and municipal drains of Murmansk and other settlements situated along the coast of the bay.

Table 1 Statistical data about the content of heavy metals, mineral oil and phenols in bottom water of Kola bay 2005-2007

Component	Period of information fusion	Number of measurements	Average item value mg/l	Concentration level min-max	V %	Exceed of maximum concentration level n				
						<1	1-5	5-10	10-30	>30
1	2	3	4	5	6	7	8	9	10	11
Cd	2005	11	0,91	0-8,16	266,56	10		1		
	2006	12	0	0-0		12				
	2007	18	0	0-0		18				
Pb	2005	11	55,893	21,61-109,11	48,656		6	4	1	
	2006	12	19,63	3,64-74,39	95,91	3	8	1		
	2007	18	2,22	0-5,19	85,37	18				
Zn	2005	11	86,826	0-253,7	85,462	1	4	2	4	
	2006	12	47,35	0-253,88	145,34	3	5	3	1	
	2007	18	2,88	0-15,64	175,71	16	2			
Cu	2005	11	15,957	2,73-38,37	76,159	2	7	2		
	2006	12	13,93	0-72,21	145,56	7	3	1	1	
	2007	18	1,701	0-5,46	88,497	17	1			
Oil products	2005	11	0,03	0,019-0,05	30,086	10	1			
	2006	5	0,0618	0,042-0,083	26,623	1	4			
	2007	18	0,0168	0,005-0,063	93,94	17	1			
Phenol	2005	11	0,002	0,001-0,005	45,90		11			
	2006	5	0,00334	0,0024-0,0048	28,37		5			
	2007									
	2006	5	0,00334	0,0024-0,0048	28,37		5			

Statistical data about the content of heavy metals, mineral oil and phenols in bottom water of Kola bay for 2005-2007 are given in Table 1.

The table shows, that in 2007 there were registered stations with increased content of several heavy metals, but generally we can see a tendency towards decrease of these parameters during 2005-2007. (Fig. 1).

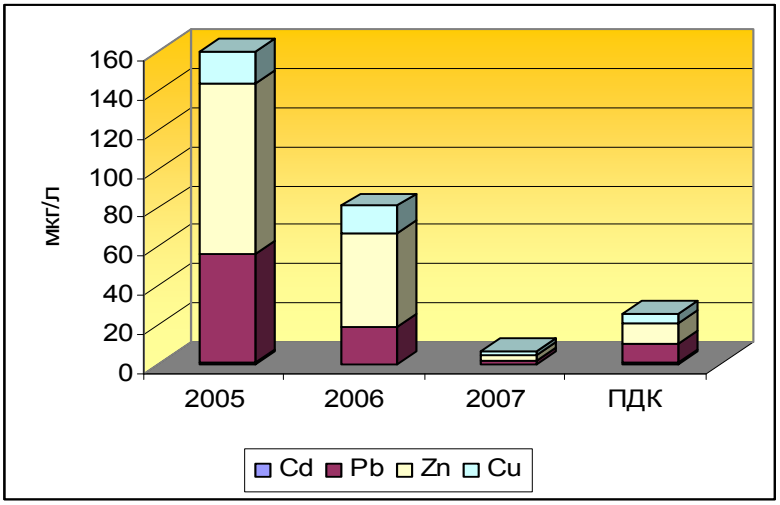

Fig. 1 Average content of heavy metals in bottom water of Kola bay, 2005-2007

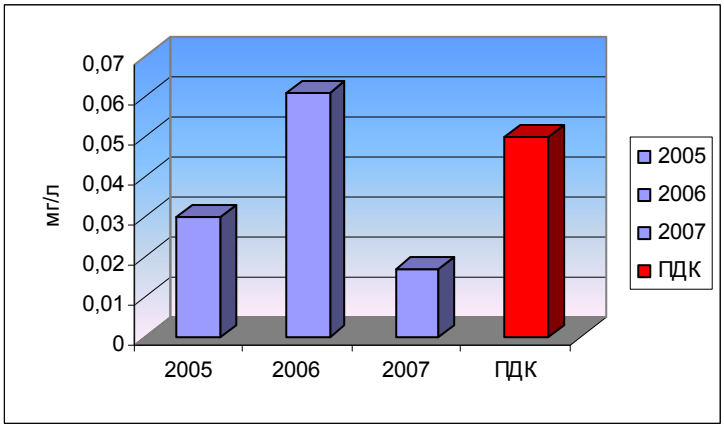

Fig. 2 Average content of oil products in bottom water, 2005-2007

The content of oil products in bottom water during 2005-2007 was low, and the maximum pollution has been registered in 2006 (fig. 2).

Absolute "record" of oil products content made 0,083 mg/l (maximum concentration level- 0.05 mg/l) at the station in the area of Mishukovo settlement (2006).

In 2007 the concentration of oil products did not exceed maximum concentration level at all stations, except for one station in the area of Murmansk port. Thus the highest concentrations are connected with the bottom of water area of Sea and Fish ports.

The hydrochemical map of Kola bay southern knee bottom waters is given on fig. 3 (Sevmorgeo).

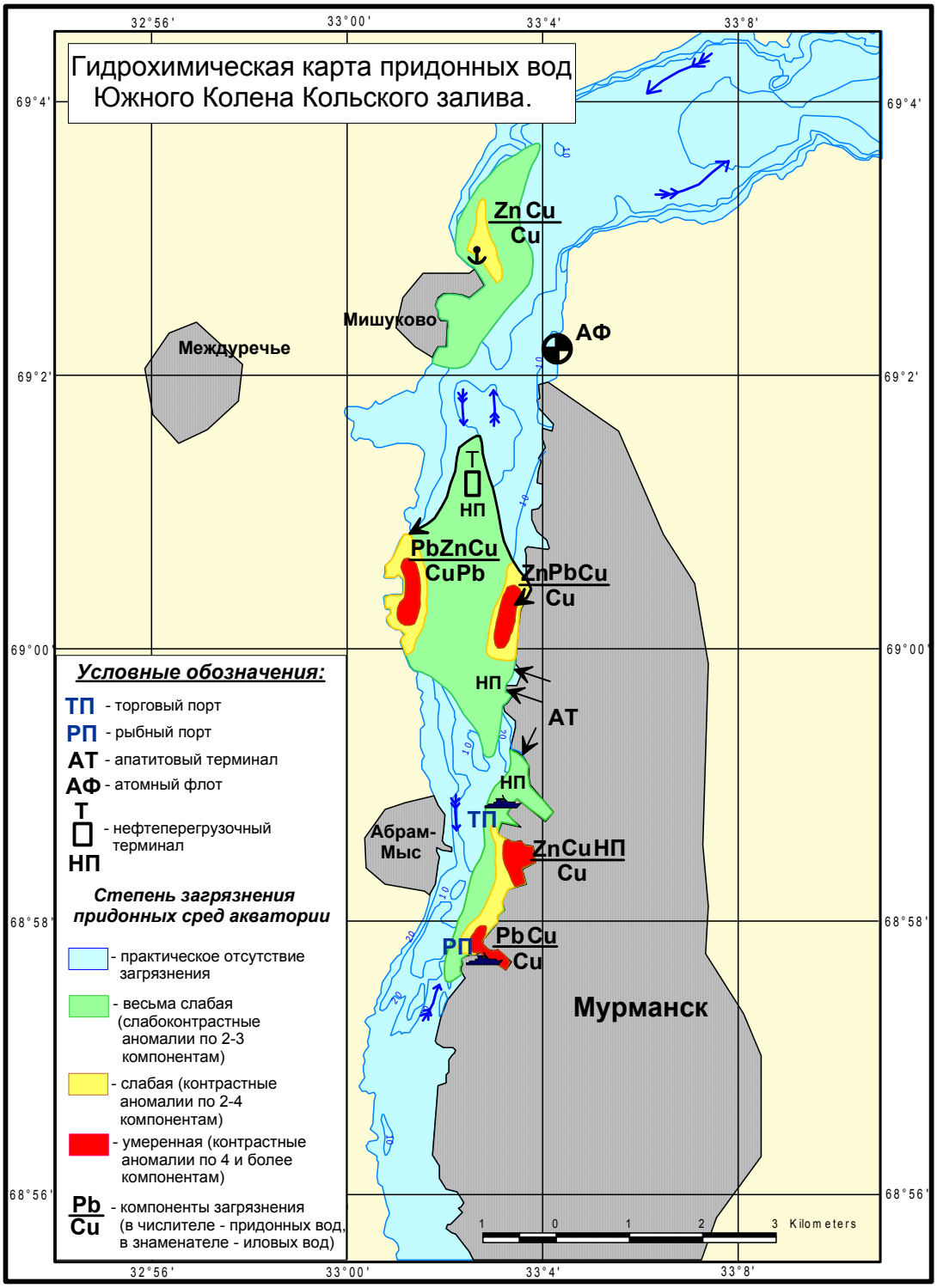

Fig. 3 Hydrochemical map of Kola bay southern knee bottom waters.

Bottom sediment

Table 2 shows that the content of polluting substances in bottom sediment of the southern knee of Kola bay has reached very high levels. The areas of dumps of vessels outstand especially. Figure 4 (geochemical map of bottom sediment) shows that pollution of bottom sediment, as well as in hydrochemistry, is mainly concentrated in areas of ports and ship-repair yards. However, its level is higher, than that for bottom waters.

As well as for bottom waters, 4 classes of pollution are marked on the map: from practical absence up to strong.

Table 2 **Table of bottom sediment pollution level in the southern knee of Kola bay**

	Min	Max	Dumps of vessels		Background /**/	
			Min	Max	Min	Max
Hydrocarbons (general analysis)	0,016	48	0,54	18,6	-	-
n-paraffins (ppm)	16,2	127	-	-	1,0	52.5
***Σ multiring hydrocarbon** (nanogram/gram)	467	9593	3406	14496	1,8	97,0
Σ hexachlorocyclohexane (nanogram/gram)	0,81	3,58	0,66	4,78	0,1	0,33
***hexachlorobenzene** (nanogram/gram)	0,271	3,72	0,41	5,55	0,01	0,08
***Σ** organochlorine pesticides (nanogram/gram)	4,48	47,8	60,5	118	0,42	1,53
***PCB** (nanogram/gram)	11,0	80,5	108	329	0,24	1,33
***benzpyrene** (nanogram/gram)	37,3	871	73,7	1111	0,01	10,0
Heavy metals	ppm					
***Copper**	87	359	304	458	5,42	21,3
***Zink**	51	544	670,6	2179,1	14,8	107
***Plumbum**	10	114	297,4	1347,3	10,2	32,5
Iron	2,68	5,03	39852	118973	19620	23740
Strontium	427	2397	-	-	-	-
Rubidium	42	122	-	-	-	-
Arsenic	13	36	-	-	0,5	79,8
Gallium	10	17	-		-	-
***Nickel**	51	328	34,6	77,8	13,6	53,7
Cobalt	13	46	-	-	2,8	11,6
***Chrome**	113	244	50,4	87,9	64,8	147,0
Vanadium	42	493	-	-	-	-
Titanium	0,38	0,72	-	-	-	-
Manganese	0,023	0,35	244,1	964,9	29,6	171,0
***Cadmium**	-	-	0,42	1,4	0,06	0,76
***Mercury**	-	-	0,199	2,98	0,005	0,064

Note:

* Bottom sediment pollution level according to the classification of Norwegian pollution control agency (SFT) /4/:

I - Background; - medium po II n;

III - Prominent pollution; IV ong pollution;

V - Very strong pollution.

** Estimation of pollution levels of marine waters and bottom sediments in the most important fishing areas and intensive economic activity zones of Barents Sea: The report of scientific research work of Polar Research Institute of Marine Fisheries and Oceanography; Chief N.F. Plotitsina – Murmansk, 2007. – 130 p. /3/

Bottom sediments of the major part of the southern knee can be characterized as medium polluted. They are marked by 1-2 or more pollutants, which concentration is higher the level of strong pollution, general presence of oil products with concentration exceeding 1 mg/g.

Finally, the area of apatite transfer terminal refers to the strongly polluted areas. The concentration of strontium here 5 times exceeds the level of strong pollution and

concentration of oil products, copper and zinc is very high. The areas of Trade and Fish ports also refer to such polluted areas. (5 different pollutants making anomalies higher than the high pollution level).

In all measurement points in 2007 there were recorded "prominent pollution" of multiring hydrocarbon, organochlorine pesticides content and predominantly "prominent pollution" of PCB content. There was recorded significant pollution due to content of aliphatic hydrocarbons and HCH

On the basis of measurements results there was plotted a map of complex estimation of geological environment of the southern knee of Kola bay (fig. 14).

The map is plotted with singling out of 4 classes: intensively destroyed, destroyed, slightly destroyed and unbroken state of geological environment.

The worst conditions connected with high content of pollutants, their variety and high reserve in entrapped waters are first of all characteristic of port harbors and areas of dumps of vessels.

The whole waterarea bottom of the southern knee in the area of Trade and Fish ports is situated in the zone of destroyed state of geological environment due to abnormally high content of oil products and related to them wide range of heavy metals and hard organics.

Besides, on the map there marked "hot spots" – the places, where it is necessary to organize regular control during various levels of monitoring, including municipal.

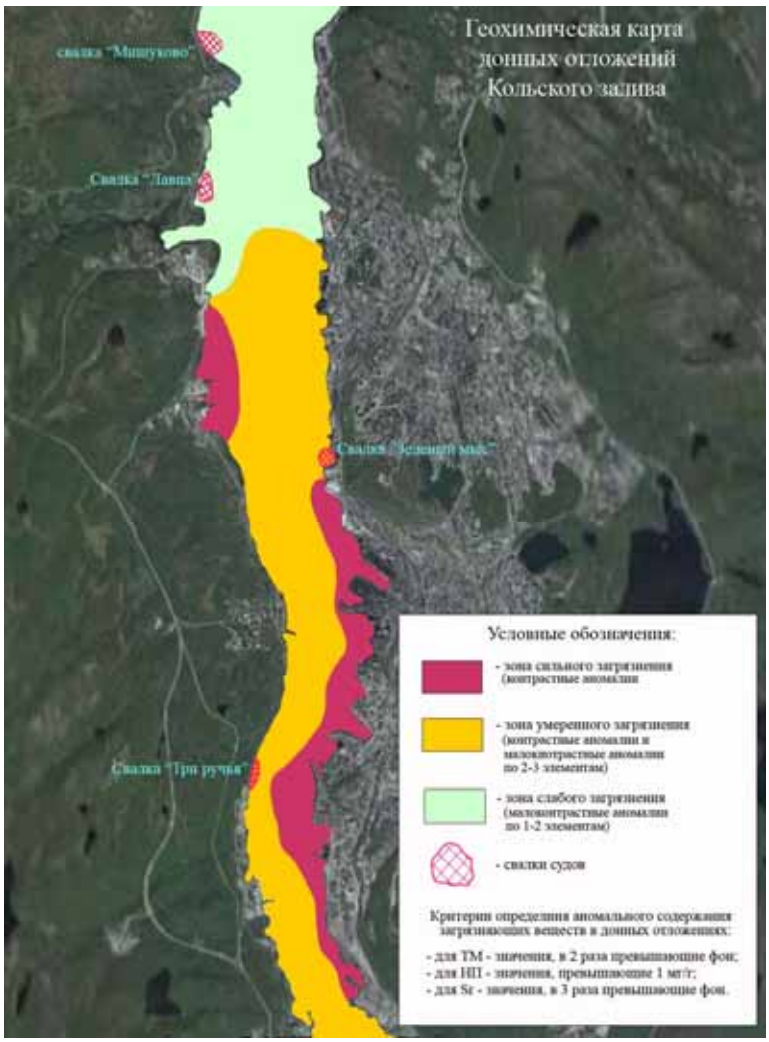

Fig. 4 Geochemical map of Kola bay bottom sediment

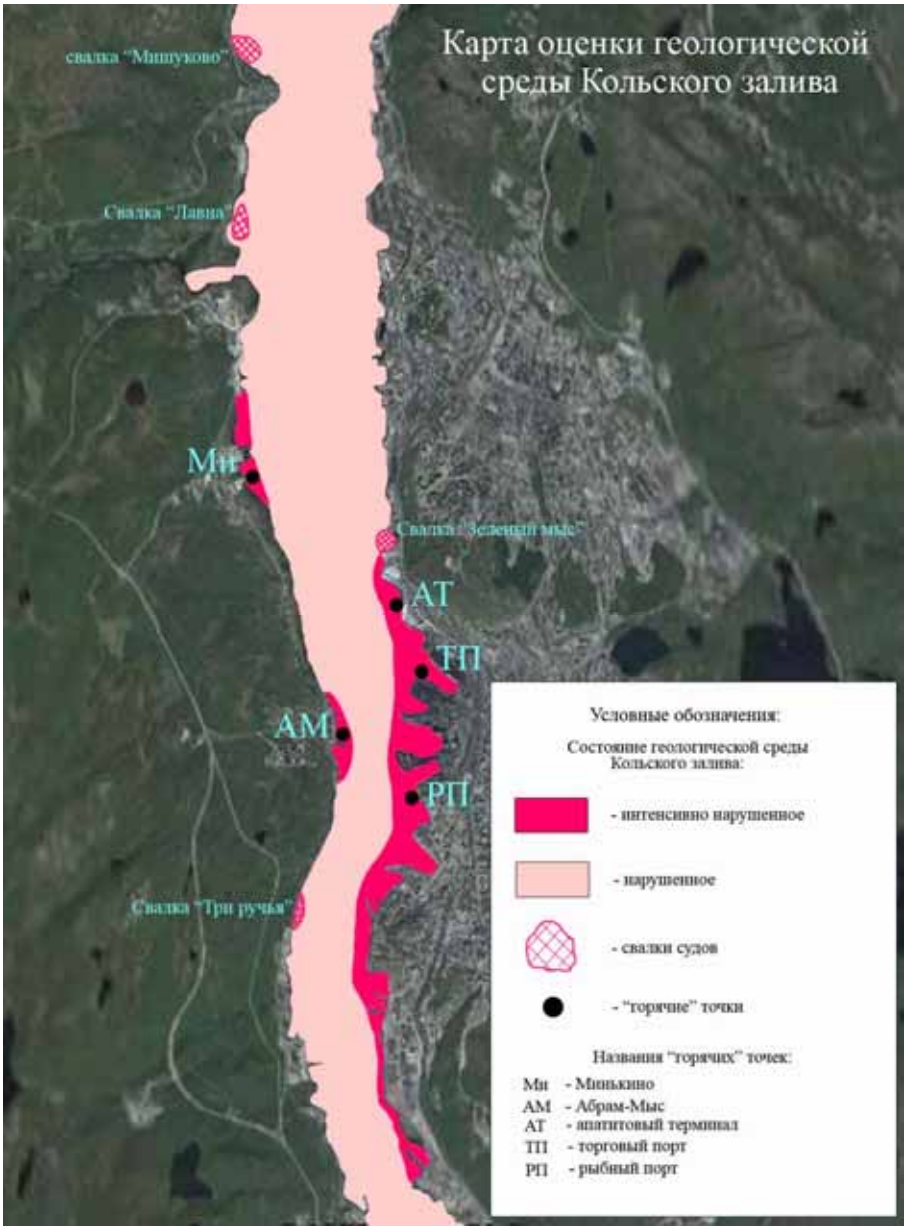

Fig. 5 The map of Kola bay geological environment estimation

Conclusions

1. According to the aggregate of anthropogenic influence on the marine environment the Kola bay remains one of the most loaded in the Arctic region. At the same time it is still a fishery water body of the 1st category.

2. The main sources of Kola bay pollution, especially of its southern and middle parts, are industrial enterprises, sewage waters of settlements and cities, the activity of civil fleet and Navy. 78% of waters are wasted untreated /1/. The question of Murmansk city treatment facilities commissioning demands urgent solution.

3. According to the monitoring investigations made by Murmansk Hydrometeorological Administration the quality of water in the bay during last years is characterized as medium polluted – polluted – in the southern knee, medium polluted – in the middle knee and pure – medium polluted – in the northern knee.

4. In some areas of the bay in the seawater there constantly found heightened concentrations of biogeneous elements, suspended and organic substances (for example tide house in the area of Trade port).

5. Oil pollution of water permanently occurs on the waterarea of the bay (oil slick, dissolved oil products). Unauthorized bilge and oily discharge from ships and vessels continues. The cleaning of bay from oil pollution has not been executed during last years. Characteristic pollution indicator is the wide oil streak at the cliffed coasts, seen during the low tide. The question of renewal of regular oil spill gathering from the surface of the bay and organization of measures preventing unauthorized discharge of oil products into the waters of the bay demands urgent solution.

Oil products are accumulated in the bottom sediment. The threat of further increase of water and bottom sediment pollution with oil products is connected with the forecasted increase of volumes of oil transportation and transshipment in Kola bay.

6. Unauthorized dumps of vessels are the result of wasteful attitude towards nature. The dumps are the sources of environmental threat, water and bottom sediment pollution with oil products, heavy metals, and hard organics, and sometimes represent a serious navigation danger. Dumps of vessels restrict the possibility of economic usage of coastal areas (development of coastal fishery, reappearance of coastal settlements, culture of mariculture and etc.)

7. High concentrations of pollutants in bottom sediment are the sources of secondary pollution of water and the reason of the bay ecosystem existence decline.

8. The analysis of pollutants content in bottom sediment of the southern knee of Kola bay and pollutant reserve in entrapped waters let us make quite a definite forecast – negative trends will continue or even increase.

9. The pollution of some coastal areas of Kola bay bottom (waterarea of ports, shipyards, navy bases, dump sites and etc.) have reached such concentrations when it is necessary to raise a question regarding the development of a special project aimed at their cleaning. At the same time the question of purification plants commissioning in Murmansk should be solved.

10. The results of monitoring investigations in 2007 has shown that not only silts refer to very polluted bottom sediments, which demand cleaning by means of ground excavation, but also sandy bottom (at the planning stage it was supposed that the major part of pollutants will be washed out of the sandy ground with sea currents and the significant part of pollutants will be found in silt ground only).

During monitoring investigation in 2008 it is necessary to make additional sampling and analysis of pollutants content in the bottom sediment of the areas of intensive exploitation of natural resources, where sandy grounds prevail in bottom sediment.

11. The ecological state of Kola bay is stretched to the limit of natural ability of self-purification (currents, high tides, river runoff). Exceed of this ability under continuous increase of load may lead to appearance of the areas of environmental threat. In this connection the development of "The integrated program of coastal zones management", which covers environmental management and environmental protection, becomes especially important.

12. Kola bay is a "hot spot" for the whole Barents region, herewith geological conditions, viz situation in a real seismogenic area, increase the risk of dangerous technogenic processes.

RECOMMENDATIONS ON EXCAVATION OF POLLUTED BOTTOM SEDIMENT IN THE SOUTHERN KNEE OF KOLA BAY

Integrated pollution of bottom sediment with macro-components (duff dust, slag, household garbage), chemical substances, which are mainly oil products, heavy metals (copper, nickel, partially zink), organoclorine pesticide and PCB is characteristic of Kola bay. At the same time the pollution is traced not only in the coastal part of the bay, but also the central part, where there are mainly sandy-aleurite sediment, rarely alternating with sandshale silt.

The main pollutant of the bay is oil products. They are representing a danger to ecosystems not only as such, but they are also strong sorbents, which promote accumulation of other pollutants.

It should be mentioned that the data of surface shooting do not always objectively show the level of pollution of the whole ground column. At the same time in silt ground the major part of pollutants is accumulated in the upper layer and decreases at the lower level. In the sandy sediment the picture is rather different, the level of pollution increases down the section.

The pollution, especially in sandy sediment, is of non-point character. Together with oil products penetration along the section there also exist lateral concentration leveling effect, when pollutants migrate sidewise the reducing gradient.

During the development of bottom sediment cleaning project it is recommended to consider the whole line along the eastern (city) coast of Kola bay up to Zeleny Mys, which separates northern and main parts of Murmansk city.

Researches show that practically all harbors of eastern coast are characterized by non-point pollution with oil products, which according to "Lenmorniiproekt" classification can be classified as "intensive" or "very intensive" (more than 5 mg/g) up to "catastrophically".

Heavy toxic metals, organochlorine pesticides, PCBs are also one of the main pollutants, which level in bottom sediment influences the inhabitants of sea bottom and negatively influence the health of a human being through the trophic chain. The research results show that the main pollutants referring to heavy metals in Kola bay are strontium, copper and zinc.

Fig. 6 shows the scheme of proposed bottom cleaning works.

In the area of Trade port the silt zone is marked in its outer part at the depth of 15-20 m, and also doubles Zeleny Mys, up to the dump of vessels. According to the data of acoustic profiling the thickness of sandshale silt makes 3-4m, and content of oil products in them makes 2.0-6.5 mg/g. In the depth their concentrations remain at the same level or increase. The core width reaches 30 sm. Besides, in those points the content of strontium and copper are very high, of nickel and zink – high.

In the boot basin itself there are very thick grounds, which are marked at the seismic profiles as a thin line. The test run finished with no result. The square of the proposed area of bottom cleaning makes 12 000 m2. The volume of cleaning is nearly 480000m3.

In the area of passenger port the square of bottom cleaning covers almost the whole boot basin, the thickness of sandy aleuritic silt, which probably alters into aleuritic sands at the depth of 1 m, makes 2-3 m. The pollution corresponds to oil products (5-9 mg/g) and heavy metals (Cu, Ni, Cr). The content of the latter usually exceeds the minimum level and seldom exceeds the levels of medium and strong pollution. The samples are polluted with cinder and household wastes.

The square of the proposed area of bottom cleaning makes 110000m2. The volume of cleaning is nearly 330000 м^3.

In the area of Fish port, viz in its boot basin, the most intensive pollution is connected with oil and high with copper, arsenic and nickel. The thickness of sediments cannot be determined by seismic-acoustic data because the ground consists of sand mainly, and absence of underlying border testifies their significant thickness, sufficient for immersion of acoustic signal, exceeding 1 m.

The square of the proposed area of bottom cleaning makes 75000 м^2.

Summary list of the first stage of bottom cleaning works is given in table 3.

Table 3 Summary list of the first stage of bottom cleaning works

№	Area	S, м^2	Design power, м	V, м^3
1	Trade port area	120000	4	480000
2	Passenger port area	110000	3	330000
3	Fish port area	75000	1	75000
4	Totally	305000		885000

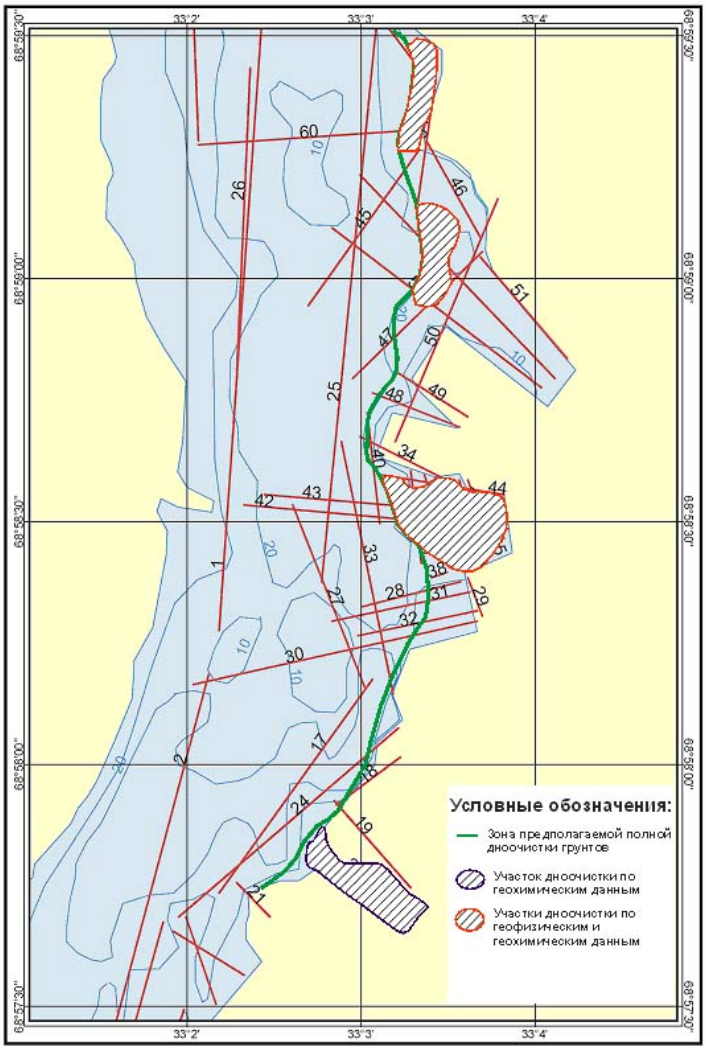

Fig. 6 The scheme of high priority areas proposed for bottom cleaning.

THE CONCEPT OF TECHNICAL PROJECT (FEASIBILITY STUDY STAGE) AIMED AT ENHANCEMENT OF ENVIRONMENTAL STATE OF KOLA BAY AND CLENING OF KOLA BAY FROM STRONGLY POLLUTED BOTTOM SEDIMENT

The development of project on cleaning of the southern knee of Kola bay from strongly polluted bottom sediment should be aimed at decrease of secondary pollution of the bay waters and decrease of polluted substances carried out into Arctic regions by currents.

The project development should include not only organizational and technical measures aimed at ground evacuation, but also a complex of measures aimed at utilization of evacuated ground.

During the development of the project the following points should be taken into account:

- Estimation of danger class of the grounds, which are supposed to be evacuated;
- Dewatering of evacuated grounds in temporary storages;
- Ways of utilization or disposal of evacuated grounds according to the content of most dangerous pollutants in them.

The bottom cleaning of Kola bay is supposed to carry out by means of hydraulic earth-moving method with help of dredge pump or multi-bucket dredger, transporting the slurry at lighters or though slurry pipeline to the place of temporary storage for ground dewatering and waste water clarification.

Taking into account the volumes of polluted bottom ground, which is supposed to be evacuated, the cleaning works should be divided into successions. Technical and economic performance of each turn may be determined according to the conditions of nominal capacity of pond, border of works and dredge operation hours agreed with the owner.

As temporary slurry dumps it is supposed to use coastal areas situated directly near the Kola bay. It is necessary to provide a territory for slurry wash taking into account the volume of works, the length of waterarea, restrictions connected with navigation and other factors. The optimal variant is that when the territories are situated at the same distances one form another, which correspond to the nominal distance of slurry transportation to the outflow point of a specified dredge. Otherwise it will be necessary to take into account additional expenses in order to organize the work of booster station, lighters, movement of hopper dredge and etc.

The project should include diving or instrumental (for example underwater echo sounding) inspection of the bottom in order to find out underwater obstructions and determine the volume of sunken objects. The cleaning of the bottom from large-dimensioned objects (more than 1m) should be carried out directly before the start of bottom cleaning works.

A separate paragraph of the project should be devoted to the technology of bottom sediment evacuation in the areas of dumps of vessels. The technology of cleaning of Kola bay from abandoned and sunken vessels should be worked through and suggested. The technology of cleaning from vessels should be determined taking into account the conditions in each concrete case:

- location of the vessel (distance from the coast, depth);

- availability of sites for organization of technological process of primary utilization of vessels; - ways of shipraising and utilization.

It is necessary to observe in the project contemporary methods of underwater cutting of vessels into large sections and methods allowing decreasing of water pollution during organization of shipraising operations.