On Behalf of Contractor
Director General

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Russian Federation – Support to National Action Plan for Protection of the Marine Environment in the Russian Federation

OAO Tiksi Sea Port

Summary Report

Services under Contract No.CS-NPA-Arctic-11/2009 dated 01 December 2009

Under Pilot Project

CLEANUP OF TIKSI BAY SEAFLOOR FROM SUNKEN LOGS AND WRECKS. PHASE 2

Client: Executive Directorate of the National Pollution Abatement Facility

Executing Agency: OAO Tiksi Sea Port

Tiksi, 2010

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Title: Cleanup of Tiksi Bay Seafloor from Sunken Logs And Wrecks. Phase 2.

Basis: Contract No.CS-NPA-Arctic-07/2008 dated 01 July 2008

Client

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1. Introduction

The whole area of the Laptev Sea, which lies east of the Lena River Delta, is subject to industrial pollution. In addition to the impacts of the two most powerful branches of the delta – the Trofimovsky Branch and Bykovsky Branch - it suffers from a significant burden of economic activities. It is the receptacle of untreated sewage from a number of settlements, while during the navigation period it sees massive vessel traffic. Noticeable amounts of contaminated water from the Lena River flow through the Bykovsky Branch, with frequently occurring major oily discharges.

Since Tiksi Bay is home to a sea port, the largest such facility in Yakutia, it is a source of contamination of the Laptev Sea. Multiple impacts such as export of contaminated water from the Lena River, navigation, discharge of industrial and domestic wastewater, timber rafting, which took place in the 1960-s – 1980-s led to the deterioration of water quality and living conditions of aquatic organisms.

Environmental monitoring of the Laptev Sea shelf has been conducted since 1978 by taking samples for hydrobiological and hydrochemical analysis at stations in the Tiksi Bay and the Gulf of Bulunkan and their subsequent processing.

Tiksi Bay is of great fishery importance and serves as nursery grounds. Kirillin F.N., the famous Yakut ichthyologist, wrote in his work "Fish of Tiksi Bay", (1951, published by Tomsk State University (p. 155 - 162)) that the marine waters of Tiksi Bay are home to 14 species of fish fauna such as sturgeon, herring, Siberian white salmon, whitefish, Arctic cisco, garganey, lake herring, Coregonus muksun, grayling, and smelt. There are also such fish as flounder, cod and Myoxocephalus quadricornis labradoricus. These included 6 species - sturgeon, Siberian white salmon, whitefish, garganey, lake herring, Coregonus muksun – that fall into the category of valuable whitefish species of fish.

Leftovers of the earlier round wood rafts, sunken logs, strapping steel wire and steel wire ropes and half-sunk skeletons of ships and wrecks that are still in the bay, decaying and rusting, emit harmful substances (organic, biogenic, etc.) and these lead to the loss of all forms of plankton (bacteriaplankton, phytoplankton, zooplankton) and zoobenthos, and hence, to the potential loss of the principal nursery grounds of valuable northern species of fish populations.

Entering the coastal waters, pollutants have a repelling impact on fish and change the conditions of fish feeding, wintering and spawning. They also contribute to high concentrations of fish shoals within a limited area, while keeping the fish from the fodder organisms making it difficult to use the feeding resources and reducing the biological productivity of the water body as a whole.

Direct poisoning of water with toxic pollutants and industrial waste, reduced aeration of the water body due to the freezing up or man-induced contamination with oxidizing organic pollutants, in particular caused by the accumulation of decaying vegetation, timber or development of toxic microorganisms may generate fish kill conditions or kill fish outright in shallow areas of the bay and in the Gulf of Bulunkan. Fish kill could occur in the summer (during algal blooms) and in the winter (during the period of ice cover), with the oxygen content reduced to its lowest values.

In accordance with the Terms of Reference (TOR) of the Project, the main purpose of this work was to protect the biosphere in the marine and coastal zone of Tiksi Bay and the Gulf of Bulunkan from man-induced pollution.

2. Work Stages

Stage 1

From June 15 to July 16, 2010, the seafloor of the Gulf of Bulunkan was dredged with a grappler installed on the floating crane to lift the sunken logs, load them onto a seaborne barge, and transport the logs to the onshore offloading point. The barges were towed by the VOLNA RBT harbor pusher tug. On the shore, the logs in an amount of 990 m3 were unloaded, graded and stacked.

As noted earlier, the progress report for Contract № CS-NPA-Arctic-07/2008 dated 01.07.2008 indicated that bottom dredging yields positive indicators of water quality after the cleanup works.

Stage 2

In August 01-31, 2010, works were carried out to lift and transport three sunken ships without violating the integrity of their hulls.

The ships were floated by cleaning their decks from accumulated soil and garbage. Diving operations were also carried out to cut out technological openings for the holds to be dried. As the ships were floated they were towed to the cutting and demolishing site.

In September 02-30, 2010, two ships, submerged near the shore, were pulled on shore with a pull winch, with their hulls cut in a step by step way. A ship was pulled out of water onto the shore, with the garbage removed. Holds were then dried up. Part of the ship was then cut out onshore to be then separated into smaller portions for disposal.

Stage 4

At stage 4, the Project entered into a contract with FGU "The State Nature Reserve Ust' - Lensky" for the works titled "Baseline Study of Physico-Chemical Contamination of the Seafloor Sediments and Seawater in Tiksi Bay".

The Contractor carried out the following scope of work:

1. Preliminary survey of the Gulf of Bulunkan and Tiksi Bay was carried out and monitoring stations were identified;
2. Hydrochemical samples were taken in Tiksi Bay and Gulf of Bulunkan;
3. Tests were carried out to determine the impact of the sunken timber on the water chemistry in Tiksi Bay;
4. Water chemistry was determined;
5. The samples were processed and the seafloor sediments were analyzed;

From the "Baseline Study of Physico-Chemical Contamination of the Seafloor Sediments and Seawater in Tiksi Bay" Report one may conclude that the cleanup operations (removal of sunken logs and ships) had positive effects on the environmental status of the water area.

3. Baseline Study of Physical and Chemical Contamination of the Seafloor Sediments and Seawater in Tiksi Bay

In order to establish long-term trends, the analysis used all available data and took specific hydrochemical samples in Tiksi Bay and the Gulf of Bulunkan.

<u>Dissolved oxygen</u>

In 2010, the mean volume concentration of 0_2 was 10.86 mg/l, which is similar to the concentration of this substance in 2009. Spatially, the highest oxygenation of the water mass was observed near the village of Tiksi. Seasonal variations of mean monthly concentrations of dissolved oxygen are minor, with a relative increase to 12.20 - 13.42 mg/l in winter. During the hydrological summer, the 0_2 mean monthly concentrations were not higher than 10.20-10.85 mg/liter. The lowest concentration of oxygen – 2.30 mg/l - was recorded on August 20 in the bottom horizon in the area east of Brusnev Island. This was caused by the wash-in of natural water from submarine depressions, which often occurs in the conditions leading to the mass fish mortality. In the areas where low oxygen concentrations are observed on a regular basis, there were frequent occurrences of relatively high concentrations of hydrogen sulfide (up to 11.0 ml/dm3).

Ammonia nitrogen

Mean annual concentration of ammonia nitrogen in Tiksi Bay was 0.064 mg/l, with the highest concentrations found in its western sector. In most cases, the concentration of ammonia nitrogen decreases with depth. But in some cases, this pattern is reversed. The spatial and depth distribution of ammonia nitrogen in Tiksi Bay depends to a great extent on inflow of water from the Gulf of Bulunkan and discharges of wastewater from some ships. All these factors and water circulation in Tiksi Bay jointly work to transform some zonal contaminations (caused by a direct source of contamination) into a local one. In the time scale, one could see a pronounced seasonal pattern of contamination. The highest concentrations occurred in winter, with the mean monthly concentration of ammonium nitrogen ranging from 0.050 to 0.090 mg/l. The lowest concentrations - ranging from 0.030-0.038 mg/l - were observed in the hydrological summer. This specific feature is caused by the seasonality of this pollutant contamination that triggers the intensity of the circulation processes. The highest concentration value - 0.176 mg/l - was recorded on March 12 in the bottom horizon in the west of the study area near Brusnev Island. The lowest concentration - 0.010 mg / l - was observed on August 20, also in the bottom horizon, and in the same area.

Total phosphorus

In 2010, the P_{tot} mean volume concentration in Tiksi Bay was 0.020 mg/l. The P_{tot} mean annual area value in the surface horizon was 0.016 mg/l, while at the bottom it was 0,025 mg/liter. At the 10-m horizon, concentration of total phosphorus was 0.029 mg/l – which is somewhat above this value due its specific spatial distribution. Spatially, the bay demonstrates a typical increase in the concentration of total phosphorus from west to east. The highest concentrations are observed in the extreme southeast of the study area. Seasonal variability of concentrations is characterized by a lower value of the monthly concentration in the winter period (0.010-0.014 mg/l) and a higher one in the summer period (0.0190 - 0.044 mg/l). The highest concentration - 0.071 mg/l - was recorded on September 10 in the bottom horizon of the extreme south-east of the study area. The lowest concentration - 0.0082 mg/l – was observed in - March 17-21, in the surface horizon east of Brusnev Island.

Petroleum hydrocarbons

In Tiksi Bay, mean annual concentration of petroleum hydrocarbons was 0.07 mg/l, which is slightly higher than MPC. Seasonal variations in the concentration levels demonstrate somewhat higher values in the mean area figures (0.09 - 0.011 mg/l) in relation to the summer period (0.03-0.05 mg/l). This was caused by intensive water exchange processes during the navigation period. The mean concentration of oil pollutants in Tiksi Bay is more than 0.1 mg/g, while in the Gulf of Bulunkan concentrations often exceed 1.0 mg/g.

4. Analysis of the Data Obtained from the Study of Physical and Chemical Contamination of the Seafloor Sediments and Seawater in Tiksi Bay

Analysis of the data showed that the aquatic ecosystem of Tiksi Bay was exposed to man-induced pollution from multiple sources. These include the inflow of the Lena River, navigation, domestic and industrial discharges generated by the village of Tiksi.

One indicator of contamination is low oxygen content in the sea water. At the bottom, it could be as low as 6.1mg/liter. Lack of oxygen affected aquatic organisms. Polychaetes, which do not require much oxygen, were found (more than 70% of the total of benthic organisms) in the structure of the seafloor biotic community. Oxygen-sensitive crustaceans, mysids, isopods and amphipods accounted to less than 5% of the total benthos. The water oxygen content in the Gulf of Bulunkan tends to decrease because of a number of processes. During winter, there is a gradual increase in ice thickness, which reaches 215 cm by June. Thicker ice cover decreases the amount of water in the bay contributing to the concentration of organic matter and pollutants in the bay. Reduced flow of the Lena River during low water periods in winter reduces the inflow of oxygen-rich river water into Tiksi Bay and the Gulf of Bulunkan.

Decomposition and decay of sunken timber intensifies export of pollutants and oxygen uptake. Sunken larch trees are a source of long-term accumulation of nutrients and organic matter in water. A five-year contact with water does not ensure total of leaching of biogenic matter from wood. Phenol content can be as high as 37 MPC (0.037 mg/l) in the bottom horizon.

The experimental studies showed that with the wood/water ratio of 1:200 considerable deterioration of gas conditions occurs as early as the second - fourth day. Accumulation of biogenic and organic matter also takes place within the same period of time.

Table 1. Mean Daily Buildup of CO_2 in the Experimental Studies with Larch Tree of Different Ages, g\m^2 "work area"

Date	CO_2 buildup when flooding larch tree aged		
	48 years	31 years	14 years
April			
23-25	3.5	2.6	1.9
25-28	1.6	1.9	1.4
26-30	6.7	5.6	5.0
April - May			
30 April – 5 May	0.7	0.6	0.3
23 April – 5 May	2.4	2.	1.6

Data on the daily uptake of oxygen, deposition of the carbon dioxide, concentration of biogenic and organic matter per 1 m2 of the surface of larch tree contacting water allows the assumption that flooded timber has a strong impact on gas conditions and leads to the increase of biogenic matter in the water body.

Flooded trees of older ages have a longer-term impact on gas conditions of the water body. With the younger sunk trees, the water body conditions will be established and normalized at a faster pace.

Table 2. Mean Daily Buildup of Biogenic Matter (g) with Larch Tree of Different Ages per 1 m^2 of "work area"

Substance	Buildup of biogenic matter when flooding larch tree of different ages		Substance	Buildup of biogenic matter when flooding larch tree aged	
	48 years	31 years		48 years	31 years
NH^+_4	0.58	1.59	Fe_{total}	0.16	0.35
NO^-_3	0.12	0.29	$Fe_{soluble}$	0.05	0.24
PO^{3-}_4	0.05	0.08	COD	1.18	1.78

In addition to phenol contamination, there is petrol contamination of water and sediments. Mean annual concentration of petroleum hydrocarbons in Tiksi Bay was 0.07 mg/l, which was slightly higher than MPC levels. Seasonal variations in the concentration levels demonstrated somewhat higher values in the mean area figures (0.09 - 0.011 mg/l) in relation to the summer period (0.03-0.05 mg/l).

Throughout the entire year, bottom horizons of water mass were rich in silicon. Massive density gradients impede mixing of water layers.

Table 3. Mean Concentrations of Soluble Silicon in the Lena Delta Water 2007-2010

Month	Water discharge, kmi	SiO_2 concentrations in the head of the delta, mg/dmi	Export of SiO_2 to the head of delta, 10i t	SiO_2 concentration in the estuary of delta branches mg/dmi	SiO_2 export to the sea, 10i t
01	7.1	6.4	45	7.3	52
02	4.8	6.6	32	7.7	37
03	4.0	7.1	28	8.4	34
04	3.2	7.3	23	8.8	28
05	15.1	5.8	88	6.2	94
06	191.0	3.6	688	2.2	416
07	107.6	3.9	420	2.8	301
08	73.4	4.1	301	3.0	220
09	64.5	4.3	277	3.4	219
10	38.0	4.9	186	4.5	171
11	8.7	6.0	52	6.4	56
12	7.6	6.2	47	6.9	52
yearly	525	4.2	2187	3.2	1680

The Tiksi Bay waters are characterized by low concentrations of phosphorous in winter. During the high water period, concentrations of phosphorous, both organic and mineral one, tend to be considerably lower in the direction from the head of the delta toward the estuaries of the delta branches due to the intensive consumption of this substance by phytoplankton.

Table 4. Mean Concentrations of Organic and Mineral Phosphorous in the Water of the Estuary Section of the Lena River (mean annual data)

Hydrological period	P mineral,		P organic,		P total,	
	mkg/dm^3	thos. t	mkg/dm^3	thos. t	mkg/dm^3	thos. t
Stolb Island						
Winter low water	4	0.14	4	0.14	8	0.28
High water	8	3.09	23	8.87	31	12.0
Summer low water	24	2.46	38	3.90	62	6.36
Yearly	11	5.69	25	12.9	36	18.6
Estuary of the Lena Delta Branch, Tiksi Bay						
Winter low water	4	0.14	5	0.18	9	0.32
High water	5	1.93	17	6.56	22	8.49
Summer low water	23	2.36	40	4.10	63	6.46
Yearly	8	4.43	21	10.8	29	15.2

In Tiksi Bay, nitrate nitrogen concentrations are lower during the high water period and higher during the low water summer season. After the high water period, water in the estuaries is characterized by similar concentrations of nitrate and ammonium nitrogen (30 - 40 mkg/dm2). Further intensive consumption of these substances by water organisms leads to a considerable reduction in the concentration of nitrate nitrogen (to 5-10 mkg/dm2). Throughout the year, bottom waters of the estuary seawater areas are rich in nitrate and poor ammonium nitrogen. This is due to the accumulation of plankton organisms residues in the bottom layers, their subsequent decay and nitrification.

Entering the coastal waters, pollutants have a repelling impact on fish and change the conditions of fish feeding, wintering and spawning. They also contribute to high concentrations of fish shoals within a limited area, while keeping the fish from the fodder organisms making it difficult to use the feeding resources and reducing the biological productivity of the water body as a whole.

Direct poisoning of water with toxic pollutants and industrial waste, reduced aeration of the water body due to the freezing up or man-induced contamination with oxidizing organic pollutants, in particular, caused by the accumulation of decaying vegetation, timber or development of toxic microorganisms may generate fish kill conditions or kill fish outright because of insufficient amount of oxygen in the water of the Gulf of Bulunkan. Water is especially oxygen-poor in winter and as ice cover grows thicker. The thicker the ice cap is the less the amount of water in the bay and this contributes to the concentration of organic, biogenic, and polluting substances in the bay. Also, the Lena River carries less fresh oxygen-rich water into Tiksi Bay and Gulf of Bulunkan. Decomposition and decaying of the sunken logs intensifies generation of pollutants and uptake of oxygen.

It is important to address the problem impacts that sunken timber has on the quality of natural waters. It is known that sunken timber could be a long-term source of both organic substances and decay products of biogenic matter getting into water environment.

The analysis found that following the cleanup of the bay seafloor, the amount of pollutants, in particular, phenols, was reduced due to the reduction in the amount of decaying wood, which is a major source of phenols.

The results of the physical and chemical studies yielded the following conclusions on the results of the cleanup operations:

- Concentrations of pollutants tend to decrease with a distance from the Lena river delta branches to the sea and with the increasing depth of the sea. In some periods, peak discharges of pollutants in the river flow at the mouth of the Lena River, including sulfides and chlorides, lead to fluctuations in the abundance and biomass of zooplankton and mobile benthos. These data indicate that contaminated river water may have an impact on the coastal shallow part of the Laptev Sea shelf;

- The cleanup operations demonstrated the need in cleaning the seafloor from decaying timber, even if such an operation was small in scale and carried out within a short period of time.

5. CONCLUSIONS

1. Intensive decaying of the sunken logs leads to dangerous and toxic chemical contamination of water. Sunken larch trees are a source of long-term accumulation of nutrients and organic matter in water. A five-year contact with water does not ensure total of leaching of biogenic matter from wood.

2. Chemical contamination of water has a negative impact on wintering, feeding and spawning of the most valuable commercial species of the Arctic fish. This requires not only the continuation of cleanup operations, but their intensification

3. Providing local (indigenous) people with firewood from the logs so lifted will help conserve forests since there will be no need for felling forests

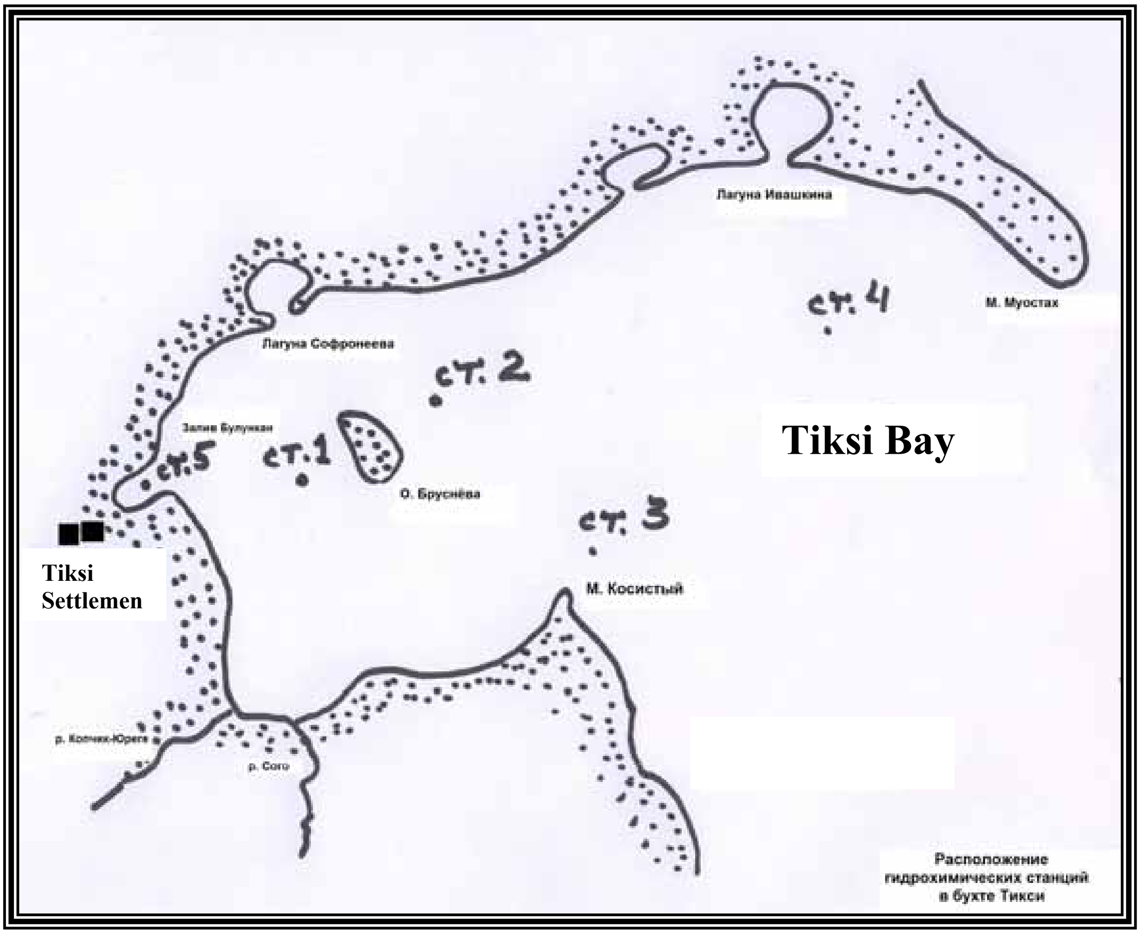
4. Sunken wrecks pose environmental threats and could be dangerous for the local population. The works with the wrecks were carried out in accordance with the Contract and basic technologies of ship lifting and transportation without violating the integrity of the ships. The ships were dragged onshore and cut out in a staged way by separating parts of their hulls.

5. From the environmental point of view, the wreck floating and lifting techniques were the right choice since they were not associated with sediment detachment and subsequent generation of vast areas of contaminated suspended matter. Suspended matter could increase concentrations of both suspended matter and pollutants accumulated in the sediments, in particular, petroleum products. This was not the case in the implementation of this contract, since the wrecks moved at a speed of smooth bottom deformation causing no breakup in the surrounding sediment mass.

6. Future cleanup operations will definitely lead to significant improvements in the environmental status of the Tiksi Bay and the Gulf of Bulunkan basin.

6. Annexes

Layout chart of hydrochemical stations in Tiksi Bay.



PHOTOS