DYNAMICS OF WATER TURBIDITY IN THE AMUR LOWER REACHES AND THE AMUR LIMAN

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Combination of different natural conditions determines relatively moderate water turbidity in the rivers of the Amur Basin. However, sometimes constantly accumulating small-size debris on the mountain slopes, in the river valleys and at the river banks (in time of low floods) is washed out into the rivers, which in this time resemble mud streams, especially small mountain rivers. Although such sharp increase of sediment flow (once in 10-15 years) lasts for a short time (several days), it significantly effects river-bed transformations (Makhinov, 1988).

Economic activities in the basin, i.e. wood cutting, mining, road constructions along the rivers, tilling of wild land, etc., increase sediment flow. Construction on river dams and river runoff regulation decrease sediment flow (Berkovich, Chalov, 2004, Ljvovich, 1974). Access roads to timber harvesting sites and logger routes are other sources of suspended matter origin, especially in monsoon climate regions. Noticeable impact on sediment flow in the Amur Basin is caused by mining and placer mining in particular. Even though a special water treatment is provided in mining areas rivers there contain hundred times more suspended matter than other rivers. From 0.1 to more than 16% of total processed rock mass get into some rivers of the basin and is carried downstream (Voskresensky, Sokolsky, Belaya, 1981).

Since 1980-1990ies vast territories in the Basin, especially in the north-east of China are transformed in to agricultural lands. That is why erosion at small rivers and accumulation of suspended matter in big rivers has increased.

Annual average amount of sediments at Khabarovsk is 24 million tons (average suspended matter discharge is 760 kg/sec.). Maximal amounts (about 47 million tons) were registered in 1956 and 1960 and minimal amount (63 million tons) in 1979 (Multiyear…,1986).

The analysis of the dynamics of sediment discharge fluctuations shows that sediment discharge significantly changes in time. It happens because in time of floods water levels raise high and small-size particles from the floodplain are washed out into the rivers. High concentrations of suspended matter were registered in 1953, 1956, 1960 and 1983, when floods on the Amur and other rivers were very heavy (Fig.1). And vice versa, in years of low water content in the Amur suspended matter concentrations in river water are not high. It happens because water levels and velocity do not increase and floodplain materials are not washed out.

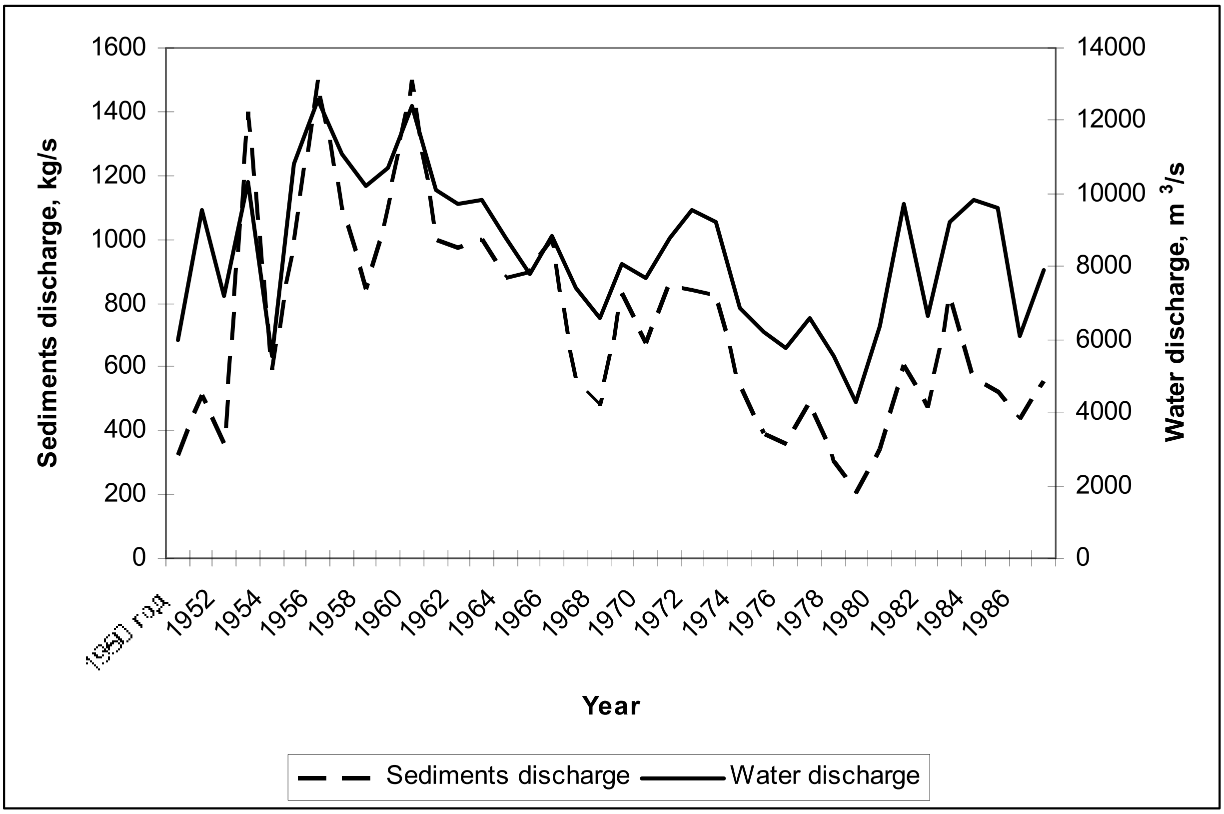

Fig. 1. Integrated Graph of Amur Water and Sediment Discharge Fluctuations near Khabarovsk.

Within a year sediment discharge is very uneven. Most sediment amounts (87% of the year total, even 91% in some years) are discharged in non-freezing time (April – September).

Changes of sediment dischargde in time at Khabarovsk (966 km from the river mouth), Komsomolsk-on-Amur (614 km from the river mouth) and Bogorodskoe (238 km from the river mouth) are synchronous, but the amplitude of fluctuations at Komsomolsk-on-Amur and Bogorodskoe is smaller due to the regulating role of the floodplain between these two points. When river water level is high huge areas of the floodplain are covered with water and lots of suspended matter sediment there and in the floodplain lakes. That is why much less sediment concentrations are registered at Komsomolsk-on-Amur and Bogorodskoe compared to Khabarovsk. And vice versa, when water level is low the floodplain of this river passage is not flooded and thus no sediment deposits are formed there. At the same time as water discharge during small floods increases compared to summer low water, the river banks are washed out, and thus fine-particle loamy material, which mostly composes the river floodplain, gets into the river water. That is why in 1974-1980 years of low water content sediment discharge at Komsomolsk-on-Amur prevailed over that at Khabarovsk.

Annual average sediment content in the Amur at Komsomolsk-on-Amur is 19 million tons, i.e. 5 million tons less than that at Khabarovsk. Maximal sediment content (19 million tons) was observed in 1964 and minimal one (9 million tons) was registered in 1979. We may conclude that sediment flow at Komsomolsk-on-Amur is more stable compared to that at Khabarovsk and less depends on water content fluctuation (Fig. 2).

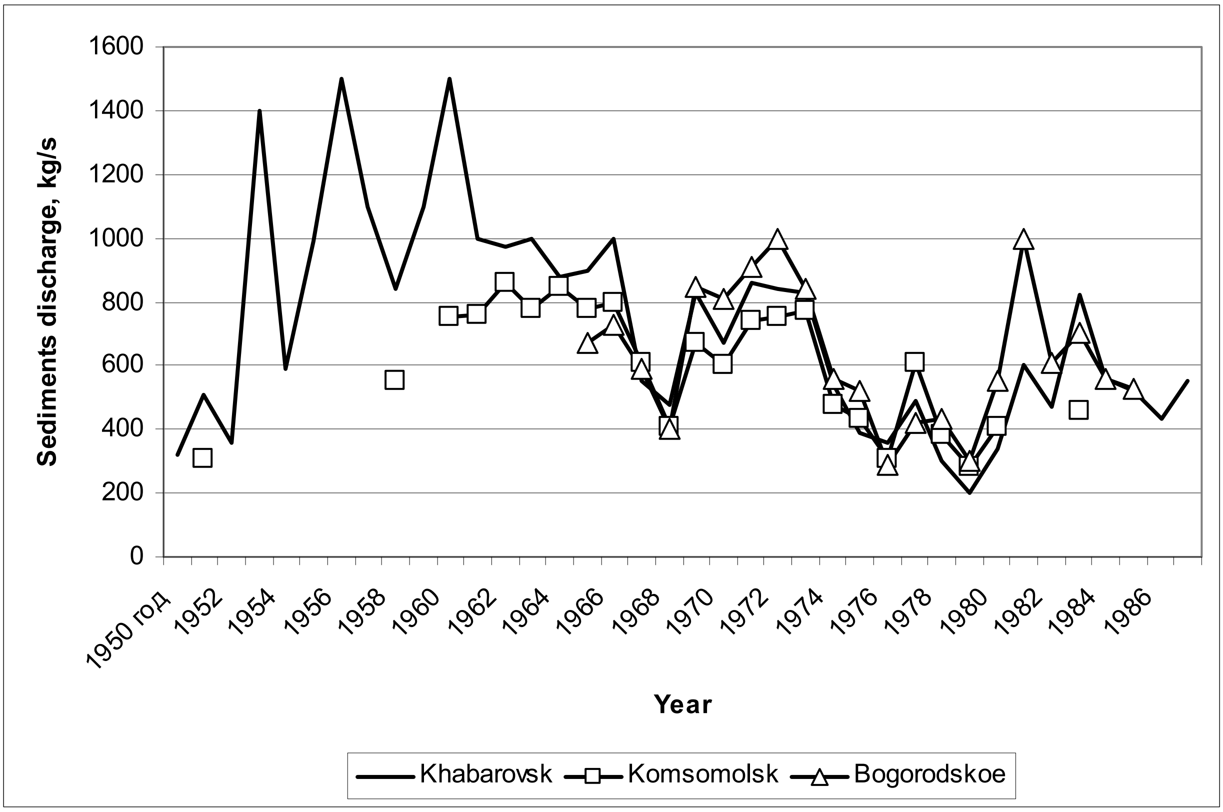

Fig. 2. Dynamics of Sediment Discharge Fluctuations in the Amur at Different Observation Stations.

Annual average sediment content at Bogorodskoe is 19.5 million tons and maximal values (32 million tons in 1972) exceed minimal values (9 million tons in 1976) 3.6 times.

A general trend of sediment decreasing from Khabarovsk towards the Amur mouth is observed because water velocity decreases due to the increase of the effective cross-section. Observation data obtained in different phases of water regime revealed general 30-35% decrease of water turbidity down the river (Kim, 2008).

Water turbidity in the Amur fluctuates in a wide range within a year. The first peak of turbidity (spring) occurs after the ice-breaking on the river. It is observed in May, when snow melting waters increase river runoff. Summer and autumn rains cause several flood waves and water turbidity fluctuations in a wide range. The turbidity peak is usually in August – September due to increased washing out of solid particles after heavy monsoon rains and in general coincides with the day of maximal daily total precipitation. Average turbidity of Amur water at Khabarovsk is 94 g/m^3, maximal reaches 400 g/m^{3,} and at Komsomolsk-on-Amur it is 66 g/m^3 and maximal reaches 220 g/m^3 (Kim, Shamov, 2000) (Fig. 3).

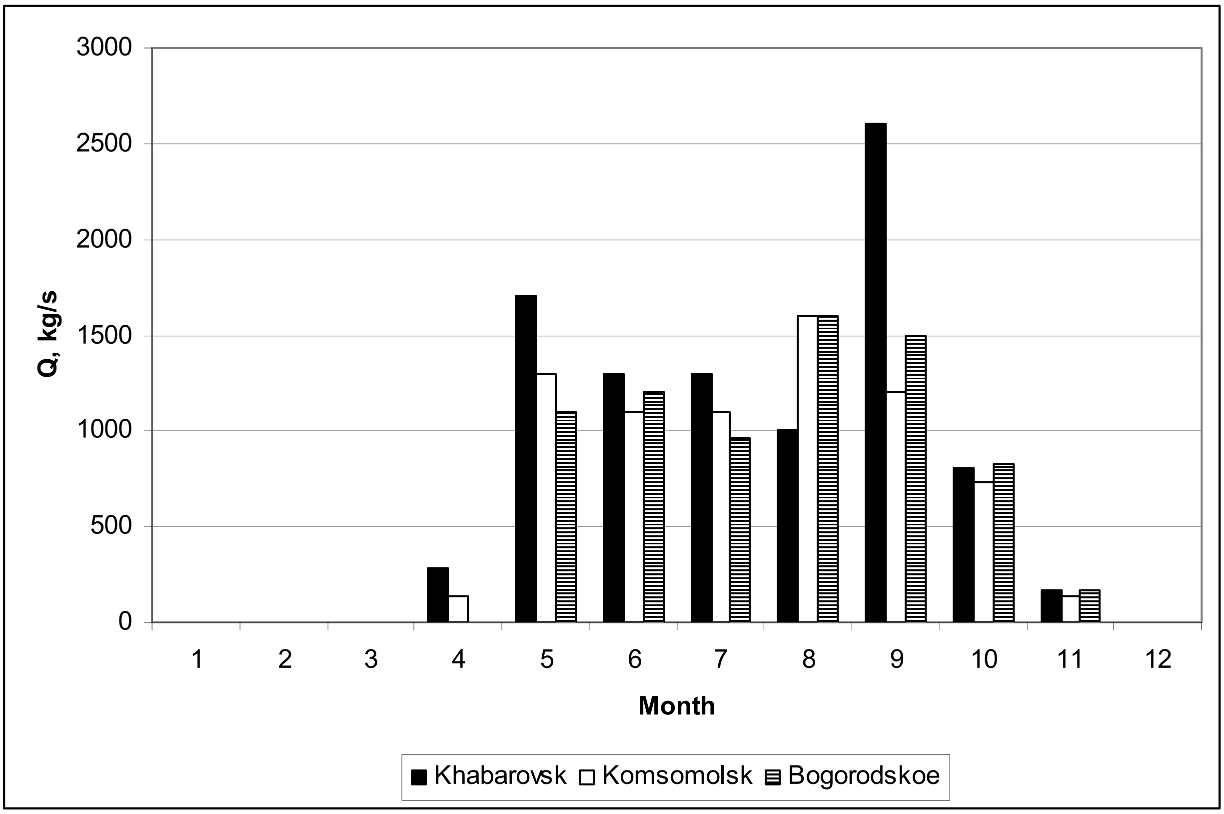

Fig. 3. Annual Distribution of Sediment Discharge in the Amur at Different Observation Stations.

In time of floods river-beds are changed and the water stream is redistributed between the rive sub-channels, river banks are washed out and water turbidity significantly rises.

In time of winter low water the water content in the river sharply decreases and is characterized with minimal water velocity. Besides no suspended matter comes from the surface of the river drainage area. That is why, water turbidity in winter is minimal and does not exceed 5-15 g/m^3.

Water turbidity in some Amur passages much depends on tributaries, which join the Amur there. For example, water turbidity in time of 1998 summer low water in the Middle Amur varied from 20 to 40 g/m^3. There was a flood on the Sungari River, the biggest Amur tributary, at that time. Water turbidity in the Amur lower the Sungari juncture reached 417 g/m^3 (Kim, 2008). In summer 2009 there were two overlapping floods in the Middle Amur: one was formed on the rivers of the Upper Amur and the other occurred in the Sungari basin. Water turbidity upper the Sungari juncture was 50 g/m^3 and lower the juncture it was up to 700-800 g/мm^3 and then it gradually decreased (Kim, 2009) (Fig. 4).

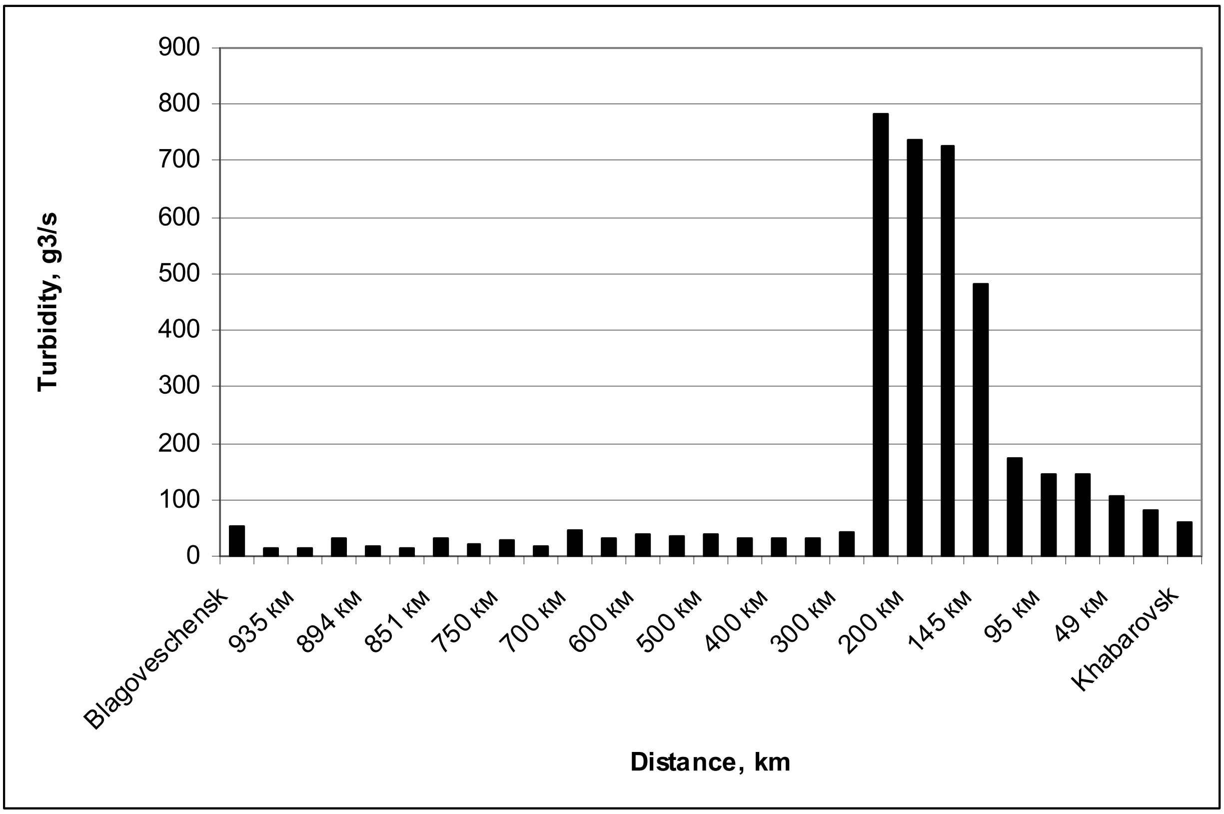

Fig.4. Distribution of Suspended Matter Concentrations in the Amur River in the Amur Passage from Blagoveshchensk to Khabarovsk.

Big tributaries also cause significant differences of water turbidity across the Amur. At Khabarovsk clean water masses that come from the Zeya and Bureya water reservoirs are quite evident at the left Amur bank, whereas in the middle of the river water turbidity is much higher because of the Sungari impact and at the right Amur bank there is a narrow stripe of clean water from the Ussuri River.

IWEP FEB RAS scientists with their Japanese colleagues undertook expedition studies of water turbidity in the Amur estuary, Amur liman and the Sakhalin Bay in 2006 and 2008 in the frame of the Amur-Okhotsk Project.

Water regimes in those years significantly differed (Fig. 5). In 2006 there was a flood with several peaks. It lasted for nearly three months. The maximal water level was 339 cm, registered August 17. Field studies in the Amur estuary and liman were carried out in time of water level rise. The highest concentrations of suspended matter (over 100 г/м^3) were found on the border between the estuary and liman.

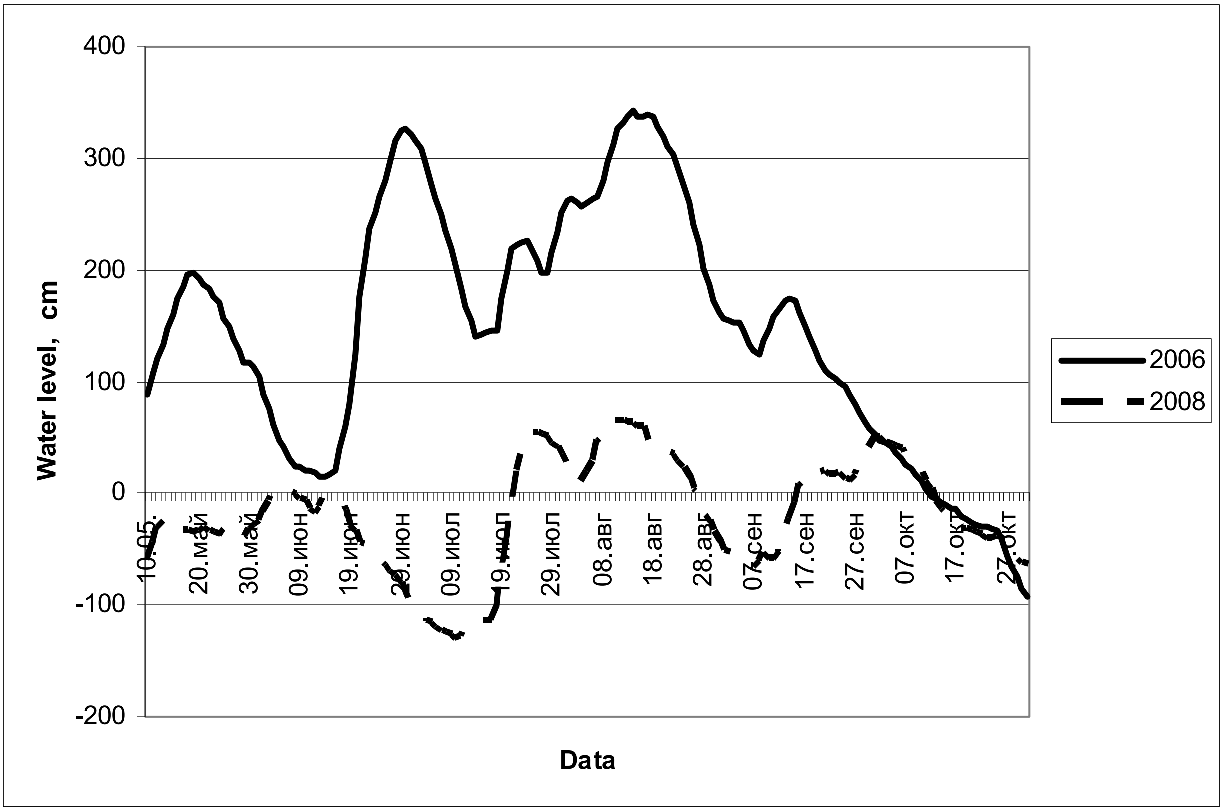

Fig. 5. Integrated Graph of Amur Water Level Fluctuations near Khabarovsk in 2006 and 2008 (an open water period).

That is why high water turbidity values were registered in the Amur estuary. In the Amur liman suspended matter sedimentation in rather intensive as water velocity decreases there. Increased concentrations of suspended matter were observed in those waterway passages, where water velocity was high. Towards the liman north water turbidity values decreased to minimal values (Table 1).

Table 1. Suspended Matter Concentrations (August 2006).

№	Date	Depth, m	Sampling site, Station	Suspended matter content, g/m^3	
				Surface	Bottom
1.	10.08	6.0	Estuary – lower Nickolaevsk-on-Amur, St. 1	76	89
2.	10.08	20.0	Estuary – Vospry Island, St. 2	83	90
3.	10.08	4.4	Estuary – opposite Pronge Cape, St. 3	114	127
4.	13.08	4.0	Amur Liman – St. 4	49	53
5.	14.08	16.6	Amur Liman - St. 5	84	38
6.	14.08	6.0	Amur Liman - St. 6	37	37
7.	15.08	7.3	Amur Liman - St. 7	13	23
8.	15.08	9.4	Amur Liman - St. 8	12	5
9.	15.08	25.2	Amur Liman - St. 9	5	2

The water regime in 2008 was characterized with unusually low water levels throughout the entire summer period. The maximal water level was 65 cm, registered August 11 at the Khabarovsk observation station. Nearly all summer water levels were below “0” and the minimal 130 cm-level was observed July 10. That is why Amur water velocity and discharge values at that period were very low, and thus river transporting capacity was weak. Suspended matter concentrations in the Amur lower reaches upper Nickolaevsk-on-Amur changed from 75 to 31 g/m^3 and gradually decreased down the river.

Due to low water content in the Amur suspended matter concentrations in the Amur estuary and liman were moderate and were much lower compared to those of 2006 (Table 2). The highest turbidity values were registered in the estuary and in the Amur waterway in the liman (Station 6). In the rest part of the Amur liman suspended matter concentrations were low. In the very north of the Amur liman and in the southern part of the Sakhalin Bay no suspended matter was observed in water samples.

Table 2. Suspended Matter Concentrations (August 2008).

№	Date	Depth, m	Sampling site, Station	Suspended matter content, g/m^3	
				Surface	Bottom
1.	4.08	9.2	Estuary – lower Nickolaevsk-on-Amur, St. 1	8.4	6.0
2.	4.08	15.1	Estuary – Vospry Island, St. 2	6.8	4.0
3.	4.08	18.3	Estuary – opposite Pronge Cape, St. 3	3.1	3.4
4.	5.08	7.7	Amur Liman – St. 4	5.0	1.6
5.	5.08	16.3	Amur Liman - St. 5	3.7	9.8
6.	5.08	10.3	Amur Liman - St. 6	5.8	11.3
7.	5.08	10.4	Amur Liman - St. 7	3.6	5.6
8.	5.08	21.1	Amur Liman - St. 8	0	0
9.	5.08	45.0	Amur Liman - St. 9	0	0

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