HERRING KILL IN PILTUN BAY

Results of survey of Piltun Bay

Since 1996, in accordance with plan of operations, SakhNIRO have been conducting regular survey of the coastal zone of northeastern Sakhalin including lagoon-type bays. In July 1999, SakhNIRO in cooperation with Sakhalin Environmental Watch conducted the survey in Niysky, Nabil, Chaivo, and Piltun bays. At present, some materials still undergo analytical and office processing, but Piltun Bay may serve as the base case to represent some of the major results of the surveys. Among other reasons, the mass herring kill governed the choice of this bay as the first object of the study because severe man-induced impact was possible in that case.

The surveys included the studies of hydrological, hydrochemical, hydrobiological and ichthyological properties, measurement of the level of pollution of sub-bottom sediments, plant and animal tissues by metals, hydrocarbons and pesticides. Complex approach to the analysis of ecosystem parameters of Piltun Bay made it possible to reveal main relationships between its components.

Piltun Bay (Fig. 1) is a shallow water area with high summer temperatures. It is characterized by brackish water environment caused by 6 rivers falling into it and a narrow channel to the sea in the southern part of the Bay. Concentrations of biogenic elements are representative of the area with mixed river and sea waters. Sabo-River is the largest supplier of phosphate and silicon content (max P_{TOTAL} – up to 215 µg/l, $P\text{-}PO_4^{-2}$ – up to 107.5 µg/l; Si – up to 7700 µg/l). The values of permanganate oxidation (7.62-14.4 mgO/l) and biochemical oxygen demand (2.26-5.89 ml/l), as well as their ratio (0.22-0.82) show that the bay is a high-oxidation area with domination of stable (low-assimilation) organic matter represented by water-soluble humus. Single locations with high concentration of poor-oxidized forms of nitrogen (nitrites) indicate the presence of active production and destruction processes and low water oxygen content. The above-mentioned facts as well as high concentration of organic matters and sanitary-representative microorganisms revealed by the results of microbial indication make Piltun Bay an eutrophic water body.

The main source of metals in the bay is suspension slick in terrigenous river waters. Higher concentrations of almost all elements noted in the central area (accumulation zone) are caused by slick sedimentation due to weaker flow and mixing of fresh and sea waters. The only exception is distribution of mercury and vanadium with high concentrations in the river-mouths (the latter can also be considered the tracer of oil pollution). Concentrations of bulk and mobile forms of all metals in sub-bottom sediments are low and can be treated as background values for the area. Metals content in eel-grass was normal with the exception of lead which had high local background concentration. It should be noted that *Japanese Zostera* displays cobalt, nickel and mercury, while *Zostera marina* displays higher cadmium accumulation. Metal accumulation in fish revealed some interesting peculiarities, although general metal content was normal. E.g., flat-head goby had most elements concentrated in liver, while female gobies had them concentrated in muscle tissues. Similar situation was observed with striped

flounder. Only microbial indication of water in the bay revealed up to 3-fold excess of MPC of zinc, copper, barium, iron, nickel and lead.

* Concentrations of oil hydrocarbons in soils of Piltun Bay varied from trace quantities to 1.7 mg/g of dry weight with average quantity of 0.35 mg/g which is representative of the areas with notable oil pollution. Spatial distribution in the bay was nonuniform with higher concentrations near river-mouths on southeastern coast (maximum concentration was recorded in Mukhto-River mouth, p.32, Fig.1). Concentration range of organochlorine pesticides (OCP) in sub-bottom sediments in Piltun Bay was 0 – 0.47 ng/g and corresponded to the range for non-contaminated areas. Pesticide content in fish tissues was within normative ranges. Only two types of OCP (out of 8 analyzed types) were found: DDT and DDD. As with oil hydrocarbons distribution, higher concentrations of OCP were noted near river-mouths. ** (*…* - preliminary data not included in 1999 report, because official materials from analytical laboratory of State Oceanographic University have not been received yet – author's note).*

Based on the content of pollutants, it may be concluded that bay waters are relatively clean with the exception of oil pollution on southeastern coast, with onshore oil fields probably being the source of it.

Piltun Bay plankton is represented by more than 280 species and intraspecific forms of phytoplankton. The highest diversity and density indexes (up to 560,000 calories/l, 480 mg/m^3) were recorded in the northern part of the bay and in Piltun and Sabo river-mouths. Representatives of four divisions dominated: diatom, cyan, green and cryptophyte microalgae. This fact is another indication of eutrophication of the bay. Zooplankton in the bay is represented by 30 species and forms with domination of brackish-water copepodes. Maximum biomass value recorded in the northern part of the bay is a higher-order value as compared with average values. Marine species dominated in one of the defined communities. Abiotic environmental factors that provide the most pronounced influence on pankton are salinity and phosphor and silicon concentrations.

Phytobenthos is represented by 17 species of seabed plants. Biomass is mainly formed by the following species: Zostera – in southern part of the bay; pondweeds – in the northern part; filamentous algae – near the western coast. Average biomass value in the bay is 135 g/m^2, with maximum vvalues in filamentous algae clusters amounting to 1200 g/m^2. Zoobenthos is represented by more than 130 species of seabed invertebrates with the dominance of bivalve mollusks, sand hoppers, midges larvae, and Oligochaeta class. Average biomass value in profound areas of the bay was 100 g/m^2, in shallow areas – 10 g/m^2. Maximum values were recorded in southern part of the bay (up to 1000 g/m^2). Brackish-water communities had a zonal distribution based on salinity gradient. Freshwater communities had a mosaic distribution. The most important parameters for benthos distribution were water depth and granulometric composition of soil.

Fish fauna in Piltun Bay is represented by 33 species with the dominance of smelt, flat-head goby, redfin, stickleback, flounder, and char. The area is characterized by high values of quantitative parameters: aggregate density of 24 specimens per m^2, and average biomass of 100 g/m^2. The presence of the following freshwater

species was noted in the bay fish fauna composition for the first time: bitterling, Sakhalin minnow and goldfish.

Results of biological survey have not revealed any serious anomalies or changes in structural and functional characteristics of communities as compared with the previous data and analogous parameters in other bays.

Results of analysis of physicochemical and biological parameters characterize Piltun Bay as a high-yield water body with high pollution assimilative capacity. The greatest hazard for the ecosystem of the bay is an oil pollution introduced by the rivers.

Herring

May-June spawning-herring accumulations in northeastern Sakhalin bays are formed by native slow-growing specimens and “visitors” characterized by high growth rate. Native herring of northeastern Sakhalin has a slow growth rate as opposed to visitors. Native herring does not have long migration routes, their spawning grounds are located in the bays, wintering and feeding grounds offshore northeastern Sakhalin. Tagging performed in Niysky Bay in 1963 indicated that visiting specimens undertake long migration trips. The most probable sources of migrants are Okhotsk and Sakhalin-Hokkaido populations. However, it is not possible to make any positive assumptions based on the current level of scientific knowledge. Therefore, after an appropriate analysis all specimens with high growth rate are treated as migrants.

Native-visiting herring ratio in the yields changes annually. In 1987-1999, migrants share in the yields varied from 3.7% (1988) to 49.8% (1993). Last five-year period is characterized by steady decrease in the share of migrants with average value of 24.3%. In 1987, migrants share was especially high and amounted to 81.1% with domination of abundant brood of 1983. That brood dominated in other far-eastern populations as well, e.g. in Sakhalin-Hokkaido and Okhotsk populations. In recent years, Okhotsk herring population is at the peak, however, migrants share during spawning periods decreases. In summer and autumn period (according to trawl survey conducted by TINRO-Center), Okhotsk herring fattens on a very large water area including shelf area offshore northeastern Sakhalin.

According to seabed trawl survey conducted in 1998-1999 by research vessel “D. Peskov”, herring distribution area offshore northeastern Sakhalin matches average perennial data (Fig. 2). However, it should be noted that seabed trawl survey data is not the fundament for accurate assumptions regarding distribution areas or stock of aggregating pelagic fish species.

Herring spawning takes place in shallow bays of northeastern Sakhalin (the largest are Piltun, Chaivo, Niysky, Nabilsky, and Lunsky). Zostera marina serves as a medium for roe. Zostera marina is concentrated in the southern part of Piltun bay, mostly near the western coast.

Pre-spawning accumulations of herring are formed in water areas adjacent to the bays in April-May. Herring spawning run to the bays starts in mid-late May and usually lasts till mid-July. Judjing by the state of maturity of herring gonads, spawning herring probably stays in the bays for 10-15 days. Incubation interval lasts for 11-20 days depending on temperature. Herring larvae are flown to the sea. In July-August, juvenile fish with the length of 5-15 cm can be encountered in the bays. After the spawning, native herring stays on nursery grounds and hibernates in shelf waters offshore northeastern Sakhalin. In autumn and winter periods it can sporadically be noted in the bays.

Assessment of biological parameters and calculation of the stock of herring offshore northeastern coast are based on the materials collected during the spawning period (in May-June). Brood size of native herring and possible yields are assessed based on length and age composition of shoals, breeding power and other biological parameters. All materials used for the calculation of herring

population are taken from Niysky Bay because it has the longest and most stable history of surveys and it has the facilities to organize monitoring of the whole spawning period. Fishing and surveys in Piltun, Chaivo, Nabil and Lunsky bays are not regular, therefore materials from these water areas are not used for the calculation of total allowable catches. According to the results of 1999 surveys, herring population spawning in Niysky Bay stayed practically the same as in 1998.

Last five-year period is characterized by stable length and age composition of spawning stock of native herring. Specimens 2-10 years old have been noted n the yields with domination of 7-9 years old specimens. Only 1998 and 1999 were characterized by small increase in the number of young school members caused by 1995 generation. Generally, spawning shoals have low percentage of young members, and it indicates low size of stock-forming broods of native herring.

In the 80's and the 90's, the highest fishing stock was recorded in 80's. In the 90's, broods were low and it led to decrease in yields. Average annual herring yield for the last ten years amounted to 380 tons, with just about 30 tons in Piltun Bay. Fishing in Piltun was organized only in 1990-1993. Aggregate biomass of spawning herring in the bay was assessed at approximately 75-100 tons. Since 1995, aggregate taking varied from 0 to 28.6% with average value of 6.4% and was unlikely to affect the herring stock in the bays of northeastern Sakhalin.

Herring kill that occurred in Piltun Bay in June 1999 will definitively affect herring stock. However, we believe that calculated amount of dead herring based on three values without biological analysis is not representative and is significantly overstated. Total allowable catches for 2001 will be adjusted based on the results of 2000 surveys.

Review of documents, research methods and results

Beside our own research results, we used the following documents submitted by Sakhalin Environmental Watch in the development of our conclusion. Numbering of Attachments was preserved to facilitate further presentation of materials.

1. **Investigation Materials** on pacific herring mass kill in Piltun Bay in June 1999 by Sakhalin Environmental Watch, dated January 19, 2000, signed by D.V. Lisitsin, Chairman.
2. **Sampling Report,** dated July 03, 1999. Prepared by Greanpeace specialists O.D. Targulyan, S.V. Alexeenko, E.M. Surovikina.
3. **Laboratory Report on analysis of fish samples** for organic pollutants, performed on July 21 – August 04, 1999, by analytical ecotoxicology laboratory of Moscow Severtsov Institute of Ecology and Evolution Problems (Russian Academy of Sciences), signed (attested) by N.A. Kluev, director of laboratory.
4. **Laboratory Report on analysis of fish tissue sample** for DDT content, performed on July 21 – August 04, 1999, by analytical ecotoxicology laboratory of Moscow Severtsov Institute of Ecology and Evolution Problems (Russian Academy of Sciences), signed (attested) by N.A. Kluev, director of laboratory.

5. **Testing Report No. 15,** for analysis on metal content in fish tissues, performed on July 15-20, 1999, by Test Laboratory of soils, nutriment, agrochemicals, agricultural and food products at OOO "Tovecotest-M", signed by R.S. Svanidze, Director of OOO "Tovecotest-M".
6. **Results of chemical analytical analysis of herring samples** (analysis for possible causes of fish kill on western coast of Piltun Bay, Sakhalin), prepared by Division of international organization "Greanpeace Council", signed by N.L. Olefirenko, Coordinator Assistant of Toxic Pollution Campaign (*undated, original orthography preserved – author's note).*
7. **Analysis for possible causes of herring kill in Piltun Bay**, dated October 08, 1999, performed by G.V. Moiseichenko, specialist from laboratory on applied ecology and toxicology (TINRO-Center) (*without organization stamp and manager's signature – author's note*).
8. Copy of newspaper article by G. Martov titled **"There was herring … and now what?"**, dated July 02, 1999.
9. Copy of article by O. Ksyushin titled **"Herring has actually fed on something wrong…"**, from "Sakhalin Oil-Industry Worker", dated July 06, 1999.
10. **Letter** No. 4026, dated August 26, 1999, from Sakhalin State Environmental Committee, signed by N.I. Onischenko, Chairwoman.
11. **Letter** No. 482, dated August 10, 1999, from Okha State Sanitary and Epidemiological Supervision Center, signed by E.I. Fisher, Chief Sanitary Inspector of Okha District.
12. **Letter** No. 22/863, dated August 13, 1999, from "SakhalinNIPImorneft", signed by V.N. Astafiev, Director of Institute.
13. **Letter** No. 20/1584, dated August 23, 1999, from Sakhalin Region State Sanitary and Epidemiological Supervision Center, signed by E.V. Papirenko, Chief Sanitary Inspector in Sakhalin Region.
14. **Letter** No. 08-2209, dated September 08, 1999, from "Sakhalinrybvod", signed by A.V. Zatulyakin, Director.

Unnumbered – Act of Inspection of Piltun Bay coast and calculation of dead fish, dated June 12, 1999, executed by M.V. Kharitonov, State Inspector, Okha Fisheries Inspection; O.O. Grizhebovsky, fishery biologist, Okha Monitoring and Observing Station; V.V. Kiselyov, General Director, OOO "Stanitsa".

Unnumbered – Prints from video materials shot by Okha Fisheries Inspection on June 12, 1999, in herring kill area (location unspecified).

Calculated values of 907 tons and 11,167 tons were delivered by SakhNIRO based on the formal data collected on June 12, by the commission with participation of Inspector of Okha Fisheries Inspection and specialist of Okha Monitoring and Observing Station (Unnumbered Attachment, Act…). However, the manner of calculation of dead fish density does not make it possible to assess the total amount of herring. It is evident from the video materials and submitted printed video frames (Unnumbered Attachment, Prints…). Since it is obvious, that dead fish does not form a continuous cover, the size of the area should not be estimated as 12-km long and 1-6 meters wide. Not less than 120 sampling locations should have been used to make the accurate assessment possible for this area. Although recorded maximum concentration of dead fish amounted to 3328 pieces per 1 m^2, it could only be actually recorded in surface folds. Areas with lesser concentrations have not been accounted for in the calculations while their length surely was much

larger. Therefore, SakhkNIRO believes that submitted values of density are significantly overstated and can not be used for damage calculation.

On June 26, SakhNIRO specialists surveyed the areas of herring casting ashore near Sabo-River mouth. The average fish density (with body size of 19-27 cm, average size = 22.72 ± 2.49 cm) on open areas of seaside foreland coast was 14 pieces per m^2 (three samples in each of three locations; calculation of average value for a square meter; random distribution of sampling locations within the area under consideration). Fish concentration in grass clusters was much bigger, however estimation of density was impossible due to poor state of fish bodies. Besides, gulls had pecked large amount of fish, and bears actively fed on semi-decomposed fish. Therefore, even in that location no absolute quantitative assessment was made. In any case, herring density was far less than 1200 pieces per m^2. (Unnumbered Attachment, Act …). On July 3, when Greanpeace specialists took samples, herring density in sampling location (Sabo-River mouth) according to their visual assessment, was 100-200 pieces per m^2. Taking into account the average perennial dynamics of herring yields and quantitative assessment of spawning shoals in Piltun Bay, the *most accurate assessment would be several dozens of tons*. This assessment would also be similar to the preliminary visual assessment (Attachment 10, referring to Letter No. 141 from "Sakhalin Environmental Watch", dated August 04, 1999).

Re. volume of oil spill that would be able to cause this scale of fish kill.
Regretfully, it is practically impossible to produce even an approximate figure because it is necessary to have certain initial data: properties of oil, wind, current, water and air temperature, fish density etc. Various combinations of these parameters are not subject to approximation analysis. According to summary review issued by S.A. Patin (1999), minimum concentration of hydrocarbons that produces practically no biological impact is 10^{-3} – 10^{-2} mg/l in the water, or 10-100 mg/kg in the ground. Reasonably large oil spill would be required to reach even these values. Large-scale accidents in the open sea, such as, 30-500 thousand tons of crude oil lead to water hydrocarbons content of 1 mg/l, and ground hydrocarbons content does not exceed several mg/kg (Kormak, 1989). Lethal doses for fish are 1-15-g/l, i.e. very large oil spill in a confined water area would be required to reach concentrations of hydrocarbons in the water that are lethal for fish, as it is also noted in Greanpeace conclusions (Attachment 6). Environmental conditions and fish types, as well as their physiological state can increase or decrease lethal doses. More detailed information can be found in special literature where all aspects of oil impact on water ecological systems are reviewed (Nelson-Smith, 1977; Gerlah, 1985; Patin, 1997).

Materials of Investigation by "Sakhalin Environmental Watch" (Attachment 1).
During the collection of first samples on June 12-16, specific decomposition smell was registered (Unnumbered Attachment, Act…), therefore, fish could not be analyzed for epizooty (Attachment 11). Results of analysis showed 20-fold excess of MPC in DDT content. Metals concentrations were normal (Attachments 11, 13). Development of pesticide poisoning version stopped because pesticide analyses conducted on June 29-30 did not show any pesticide content in Piltun Bay or in other fish species. Second analysis of the herring for DDT content was not

conducted due to its obvious decomposition (Attachments 11, 13). However, the question on the cause of the kill remained unresolved. No oil pollution was registered in the Bay or river-mouths. No fish samples were collected for petroleum analysis (Attachments 11. 12).

Let us review the "sampling technique" used to conduct analysis for metals, organic pollutants and DDT in Moscow based on the samples collected by "Greanpeace" and "Sakhalin Environmental Watch". We should note at this point that no pesticide content was revealed in fish samples, and metals concentrations were normal. Samples were collected on July 3. Sampling Report (Attachment 2) reads: "… Altogether, the remains of approximately 9 fish specimens were collected in 3 bags…". So what exactly is meant by analysis of "internal muscle tissues", "gastric tissues with roe" or other internals (Attachment 5)? If anything, it was most likely the averaged analysis of semi-decomposed herring. Regretfully, Test Report produced by OOO "Tovecotest-M" does not contain the sample-preparation procedure, so it is impossible to assess the obtained degree of separation of internals.

Although the analysis techniques comply with GOST and proper documents certify the competence of the laboratories, the results of analysis should not be taken as impeccable because sample collection and storage requirements had not been complied with. Certain requirements should be observed while taking tissue samples of marine species for metals and hydrocarbons analyses: specimen should be fresh-caught, special ware should be used, and samples should be frozen until the analysis.
The sample-preparation procedure for organic pollutant analysis (Attachment 3) reads that entire fish sample had been homogenized, without separation of internals. Thus, produced concentrations of petroleum products as well as assumptions on the way of their entrance to the fish (Attachments 6, 7) are dubious.

Finally, according to the data produced by Severtsov Institute of Ecology and Evolution Problems, concentration of petroleum products in herring samples amounted to 191 µg/g (unspecified whether it means dry or wet weight). According to our data, bay flounders had the following average concentrations of hydrocarbons: in muscle tissues – 14 µg/g, in liver – 149 µg/g (wet weight). Maximum concentrations of hydrocarbons in liver reached 280 µg/g and it did not have any visual effect on fish behavior or condition. We did not manage to catch fresh herring during operations at the Bay, therefore, we were not able to take samples and measure hydrocarbon concentrations in herring tissues.

Attachment 7 reads "…According to official information, oil spill took place on May 30, 1999…", and it further states toxic combination of oil and Synthetic Surfactants as the cause of the herring kill. It does not provide any information on the size of the spill or official source of information. According to "Sakhalin Energy Investment Company", the volume of the spill was 16 grams. Meanwhile, representatives of supervising agencies (Sakhalin Territorial Office on Hydrometeorology and Environmental Monitoring) participate in production monitoring on Molikpaq. According to Sakhalin State Environmental Committee, no other accidental oil spills were registered in the coastal waters; therefore, there was no need in the use of

detergents. It should be noted that above-mentioned Attachment No. 7 is not the formal conclusion of TINRO-Center.

Regretfully, we did not take samples to be analyzed for Synthetic Surfactants (detergents) content. However, it is known that their main source is production and domestic waste and they could be brought to the Bay by rivers. Since no other analyses revealed presence of pollutants (including pesticides) in the water or sub-bottom sediments, except for high hydrocarbons content in the river-mouths on the southeastern coast of Piltun Bay, presence of Synthetic Surfactants and hydrocarbons in 9 pieces of decomposed herring collected in one location (even if we accept the results of analysis) could be caused by cross contamination.

Therefore, version implying that man-made factors had caused herring kill based on the results of analysis of decomposed tissues and assumptions on improper environmental management and actions of supervising agencies is not valid.

Conclusion

Why was herring the only fish species that was killed and why did it only happen in Piltun Bay?

Since herrings do not form well-defined pre-spawning shoals we believe that the herring kill was caused by specific conditions in the bay and not in the coastal waters. According to the data produced by satellite system "TeraScan" (SakhNIRO), Piltun Bay was covered with ice till the end of May. The dead fish was initially discovered in early June as the Bay started to clear from the ice, but it had probably been killed much earlier (specific decomposition smell on June 12, Unnumbered Attachment, Act…). Besides, according to the results of dissection of dead herring (June 26), gonads had IV degree of maturity (slightly immature); i.e. the herring probably entered the Bay in early or mid-May. The following two assumptions look quite valid.

Firstly, the amount of herring entering the Bay was larger than usual. It led to higher density of herring and, therefore, higher oxygen consumption. Secondly, the opening of the Bay was blocked with ice (ice-thickness reached 1.5 m according to Attachment 14). Thus, fish was temporarily confined within the limited water area. Moreover, herrings being marine fish species can not enter most of the bay where water is fresh. Therefore, insufficient water circulation between the sea and the Bay and low water oxygen content probably caused the mass fish kill.

Smelt, redfin and salmon trout also enter the Bay for spawning during the period under consideration. However, these species are well adapted for fresh water and they head for river-mouths without forming high-density shoals in the Bay. Other fish species: stickleback, flounder and goby, are well adapted for oxygen deficit in winter and spring periods and practice low-moving habits.

We believe that there are no well-grounded reasons to connect death of marine mammals in the coastal area with the fish kill in the Bay.

In 1999, some more similar accidents occurred which are far less publicized and can not be explained due to lack of initial data: anchovy, shrimp and hornbill kill at the South Kurils and on Hokkaido, spawning herring kill (sic!) on West Kamchatka. Since no qualified sampling had been conducted in either of the cases, various

versions are being considered, such as, intoxication caused by blooming of toxic micro-algae, various diseases.
Thus, although we obviously do not have sufficient factual data to produce accurate conclusion and come to a single explanation of the accident, we believe that the natural causes of herring kill in Piltun Bay are the most credible.

[signed]
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