LONG-TERM RETENTION OF POLLUTANTS IN THE BOTTOM SEDIMENTS AND THEIR INFLUENCE ON BENTHIC VEGETATION

Chuyan, G.N. and O.N. Selivanova, Kamchatka Institute of Ecology, Far Eastern Division, Russian Academy of Sciences, 683000, Petropavlovsk-Kamchatsky, Russia

This work was based on long-term geomorphologic and lithologic studies and observations on marine benthic communities carried out in the Avacha Bay (Eastern Kamchatka). It is one of the largest and most beautiful enclosed bays in the world connected with the Pacific Ocean by a narrow strait. The city of Petropavlovsk with several sea ports, shipyards and numerous fishery enterprises is located on the eastern coast of the Bay.

The Avacha Bay is almost totally isolated from the oceanic waves, and waves in the Bay itself are produced only due to winds. Surface water temperature is maximum in August and minimum in January-February and ranges between -1 ^{0} C and +13 ^{0} C. The coastline of the Bay is very winding, with many small inlets. Two big rivers: Avacha and Paratunka, and plenty of small ones fall into the Bay. They bring large quantities of tractional material (sands and aleuro-pelites) and suspended load, including anthropogenic pollutants, from terrestrial environments.

Upper bottom sediments in the Avacha Bay are represented by silts, sands, gravel and pebbles, stones and sometimes also by bedrock. Pure sediments, without polluting substances, are represented by sands in the places influenced by coastal current (mostly in the south-eastern part of the Bay, near its neck) (Fig. 1). Silts containing high concentrations of pollutants (oil-products and detergents) are accumulated in the places unexposed to waves. Detergents are concentrated and accumulated both in the sediments and in the water and worsen the oxygen regime of the Avacha Bay. Oil-products are retained mostly in the bottom sediments. Numerous oil-spilt accidents and discharge of waters from the ships containing oil-products aggravate unfavourable ecologic conditions in the Bay. Black silts cover up to 45 % of the bottom and are observed mostly in the central part of the Bay and central parts of small inlets.

The process of decomposition of polluting substances is slow in cold water regions and most toxicants are sedimented and retained at the bottom. Only small part of them are carried out by the coastal current. Conservation and retention of pollutants is also favoured by the ice conditions in the Avacha Bay because small inlets, especially those located in its north-eastern part, are covered by ice for 4-5 months in a year. Intensive modern settling of the Bay's floor increases the process of deposition of loose rock material. The data of drilling in several small inlets within the Bay reveal intensive accumulation of silt sediments at the bottom, their layers sometimes reach 7 m. Usually silt sediments are underlaid by sandy ones. In the case of the presence of sandy loam which plays the role of aquiclude, the lower parts of silt and sand layers contain large quantities of oil products.

Accumulating for many years in the bottom layers which are unexposed to wave current, pollutants produce harmful effects on benthic organisms, including macrophytes. Twelve-year long observations on benthic vegetation of the Avacha Bay and comparison of our data to the data from the literature (Savich, 1914; Voronikhin, 1914; Sinova, 1933, 1954; Spasski, 1961; Klochkova, 1977) show an abrupt loss of species diversity, especially of red algae (up to 60 %). The reduction of the species number in brown algae reaches 50 %, and in green algae - 25 %. Nevertheless there are some relatively undamaged ecotops in the Bay where the loss of biodiversity is not so obvious.

We suppose the sterilizing effect of pollution to be the principal cause of red algae loss in the Bay. Most Rhodophyta growing in unfavourable ecologic conditions were sterile in the period which is normally reproductive for these species. Brown and green algae are probably less sensitive to pollution. Some of them are able to withstand harmful factors without evident morphologic and physiologic changes. We observed rare morphologic anomalies only in some laminariaceous algae (Alaria marginata, Agarum clathratum) with lamina spirally twisted around the midribs. But these anomalies were unlikely to be caused by pollution because teratic specimens were sometimes found in pure zones as well. Moreover, field experiments on marked specimens of Laminaria carried out in one of the pure bays revealed that such anomalies may be produced by artificial damage of the meristematic zone of the alga. In natural conditions physical damage may be produced by stormy waves and grazing animals (e.g. sea urchins).

We did not find any pathologic changes in vegetative cells and tissues of brown algae growing in polluted places. This is probably due to their high ability to repair damage that helps them to survive even in extremely unfavourable ecologic conditions.

We distinguished three ecologic groups of algae based on their resistence to harmful factors. Algae resistant to high, middle and low degrees of pollution were called accordingly poly-, meso- and oligotoxobic. We used the term 'toxobic' instead of 'saprobic' currently accepted in Russian ecologic literature because the latter corresponds only to organic pollutants while we took into account also inorganic ones. Our data show that most Chlorophyta belong to the polytoxobic group, Phaeophyta are mainly mesotoxobic and Rhodophyta represent the oligotoxobic group of species. Naturally these ecologic groups are conventional.

The differing degrees of algae resistence to pollution lead to serious changes in the structure of phytocenoses: in the character of dominance, in the number and correlation of the co-dominant species and abrupt growth of epiphytism. These changes in their turn influence the structure and functioning of marine benthic communities.

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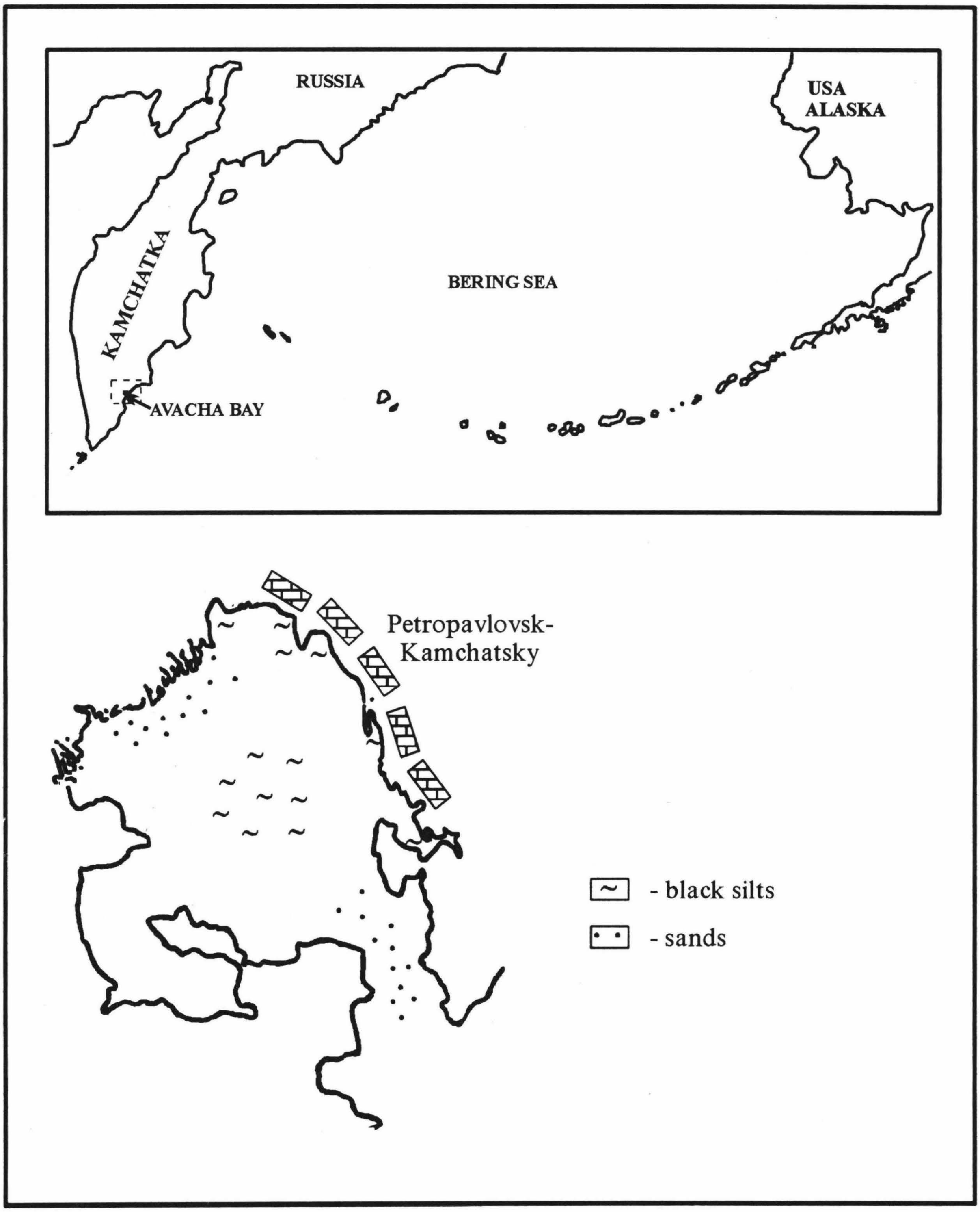

Figure 1. Bottom sediments of the Avacha Bay. Inset shows the position of the studied area on the Pacific coast of Kamchatka.