# MACROBENTHOS COMPOSITION AT THE SHORELINE OF KISLO-SLADKOYE LAKE, SEPARATING FROM THE WHITE SEA

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## ABSTRACT

Kislo-Sladkoye Lake is a unique model reservoir separating from the White Sea, which requires careful comprehensive interdisciplinary study of all characteristics. The lake is a subject of systematic hydrological and hydrochemical surveys. An integral qualitative study of the macrozoobenthos at the shoreline of the lake has been conducted for the first time. Fourteen invertebrate macrozoobenthic taxa were found. Mass species distribution boundaries were determined. Such marine animals as *Mytilus edulis*, *Semibalanus balanoides, Littorina saxatilis*, are only found at the marine side beyond the lake rapid. Brackish species show three distribution patterns: *Gammarus duebeni*, chionomids, *Haliplus apicalis* are met around the lake; *Hydrobia ulvae, Chironomus salinarius, Enochrus halophilus* are absent near the lake rapid; diptera larvae *Setacera aurata* are only found on slightly sloping coast parts.

The collected data allowed us to map the lake zonation based on the species composition. Three zones are allocated: Marine fauna zone on the east near the rapid; brackish fauna around the lake and enriched muddy shallows in the northern part.

## INTRODUCTION

This work is a part of an interdisciplinary comprehensive research on separating sea bays and meromictic water reservoirs in the Kandalaksha Bay of the White Sea. The White Sea itself is in some aspects a separating water body, undergoing a process of coastal rise (1) and separation from the Barents Sea (2). Hydrological, hydrochemical, microbiological aspects have been a subject of long-term monitoring, while benthic communities have not been studied yet.

Kislo-Sladkoye Lake is a model reservoir separating from the sea, which requires careful comprehensive interdisciplinary studies of all characteristics. The lake has been a subject of systematic hydrological and hydrochemical surveys, the results of which were used to conduct a qualitative study of the macrozoobenthos at the shoreline (depth up to 0.5 m) of the lake for the first time.

The coastal (littoral) part of a lake is a very important zone for life in water reservoirs. This zone incurs influences from both deeper parts and the inland surroundings (3).

Not very many investigations were conducted on separating sea bays, and mostly marine communities from near oceanic salinity are studied (4,5,6,7). Naturally separated water bodies demonstrate similar evolutionary trends to those of artificially isolated bays, such as tidal power or fishery basins (8). Artificially isolated water bodies ecosystems have been well studied in the Russian Arctic. The less connection with the sea, the more benthic communities degrade (9):

1. Normal marine situation with high biodiversity including infauna, filtrator molluscs, polychaetes etc.
2. First state of degradation: lack of filtrators and less infauna.
3. Satisfactory condition: chironomids and oligochaetes dominate over other groups.
4. Bad environmental quality: only non-burying crustations are found.
5. Awful state: macrofauna is absent.

DOI: 10.12760/02-2015-1-09

Most of the investigated naturally and artificially separating water bodies belong to the first or second degradation stage: the well-studied Mogilnoye lake on Kildin island (10), Dolgaya Bay at Solovetsky Islands (11), Avachinskaya Bay on the Kamchatka Peninsula (12) and others. Kislo-Sladkoye Lake went further in separation, and its low depths along with strong stratification and high $H_2S$ content affect the benthic community.

Kislo-Sladkoye is a very young lake: less than fifty years ago it was a regular marine channel between the land and a small nameless island (13). Its fauna was previously studied only once: in 2010 M V Chertoprud conducted preliminary research on coastal invertebrates biodiversity (14).

For qualitative analysis, it was necessary to determine the composition of the macrobenthos, to determine, whether the fauna along the shoreline of the lake is homogeneous and if there is heterogeneity, and to determine the boundaries of marine, brackish and freshwater organism distribution.

## METHODS

In August 2014, we conducted a collection of benthic samples from five stations around the lake (Figure 1). Station 1 is a steep littoral part where boats are kept; station 2 is set at the threshold; station 3 is set at the muddy shallows; station 4, near the freshwater creek at the southern side of the lake; station 5, on the western part in willow thickets. Sample collection was done manually from different grounds and using a bottom net with 1 mm mesh size from the shore down to 0.5 m. Three ground samples were collected from each zone. Mass species were additionally observed around the whole coastline. All features of the lake were covered: a place of confluence in the creek, a marine threshold, a swamp (former threshold, which is currently not filled with seawater due to the elevation of land). Most organisms were identified up to the species level and up to larger taxa in difficult cases. Corresponding identification keys were used (15,16,17,18,19,20). For each taxon, a semiquantitative estimation of its occurrence was done for all five stations. A MBI-1 binocular and a Micmed-1 microscope were used to determine the species.

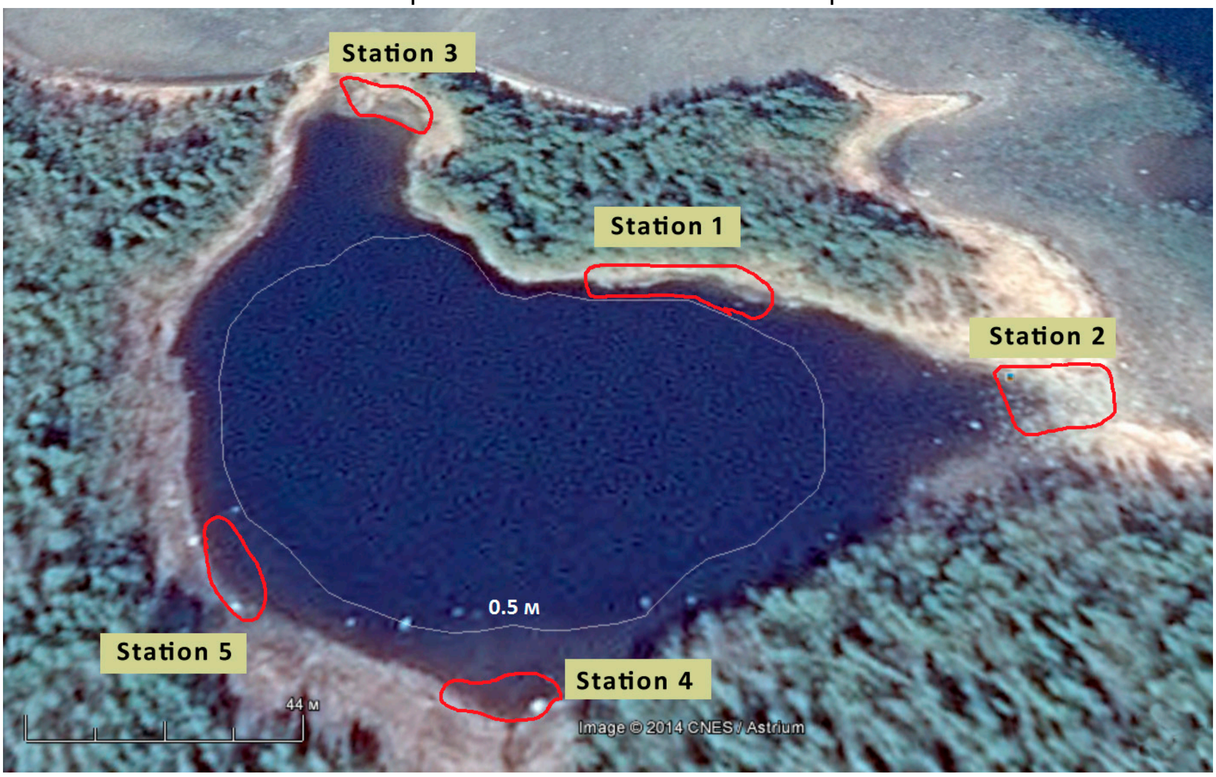


*Figure 1. Kislo-Sladkoye Lake satellite photograph with five stations of the benthic study mapped.*

**RESULTS**

Fifteen invertebrate macrozoobenthic taxa (Table 1) were found in shallow water of the shoreline: Insecta: Diptera - 4 taxa (larvae and adults), Coleoptera - 3 taxa (larvae and adults), Heteroptera - 2 taxa, Odonata - 1 taxon (larvae); Crustacea: Amphipoda - 1 taxon; Mollusca: Gastropoda - 2 taxon, Bivalvia - 1 taxon; Oligochaeta - 1 taxon, as well as tubes of *Pectinaria* sp.

*Table 1: Species list for the five sampling stations. Species are listed in marine to freshwater order; stations follow the threshold - muddy shallows direction.*

| | | Station number | | | | |
|---|---|---|---|---|---|---|
| **Species** | **Taxon** | **2** | **1** | **4** | **5** | **3** |
| *Mydius edulis* L., 1758 | Bivalvia, Mytilidae | Numerous | | | | |
| *Littorina saxatilis* Olivi, 1792 | Gastropoda, Littorinidae | Numerous | | | | |
| *Gammarus duebeni* Lilljeborg, 1852 | Amphipoda, Gammaridae | Numerous | Present | Rare | Numerous | |
| *Hydrobia ulvae* Pennant, 1777 | Gastropoda, Hydrobiidae | Rare | Numerous | Numerous | Numerous | Numerous |
| Chironomidae gen. sp. | Diptera, Chironomidae | Present | Numerous | Numerous | Numerous | Numerous |
| *Chironomus salinarius* Kieffer, 1915 | Diptera, Chironomidae | | Numerous | Numerous | Numerous | |
| *Haliplus apicalis* (Thompson, 1868) | Coleoptera, Haliplidae | Sporadic | Numerous | Rare | Numerous | Sporadic |
| *Haliplus apicalis* larvae | Coleoptera, Haliplidae | | Rare | | Numerous | |
| *Enochrus halophilus* Bedel, 1878 | Coleoptera, Hydrophylidae | | Present | | | Numerous |
| *Enochrus halophilus* larvae | Coleoptera, Hydrophylidae | | Numerous | Present | Numerous | Present |
| *Setacera aurata* (Stenhammar, 1844) | Diptera, Ephydridae | Rare | | | Numerous | Numerous |
| Oligochaeta | Oligochaeta | | | Numerous | Numerous | |
| *Aeschna juncea L., 1758* | Odonata, Aeschnidae | | Sporadic | | | |
| Dytiscidae gen. sp. | Coleoptera, Dytiscidae | | | | | Sporadic |
| Corixidae gen. sp. 1 | Heteroptera, Corixidae | | | | | Sporadic |
| Corixidae gen. sp. 2 | Heteroptera, Corixidae | | | | | Sporadic |
| *Aedes* sp. | Diptera, Culicidae | | | | | Sporadic |

Mass species distribution boundaries were determined. Such marine animals as *Mytilus edulis*, *Semibalanus balanoides, Littorina saxatilis* are only found at the marine side beyond the lake rapid (Figure 2). Brackish species show three distribution patterns (Figure 3): Some are met around the lake (*Gammarus duebeni*, chionomids, *Haliplus apicalis*); the second group is absent near the lake rapid (*Hydrobia ulvae, Chironomus salinarius, Enochrus halophilus*); the last group consists of insects larvae such as *Setacera aurata* only found on slighty sloping coast parts.


*Figure 2. Distribution boundaries of some mass species in the Kislo-Sladkoye lake. Marine species are numerous beyond the lake rapid; brackish ones live in the lake and do not pass the rapid.*

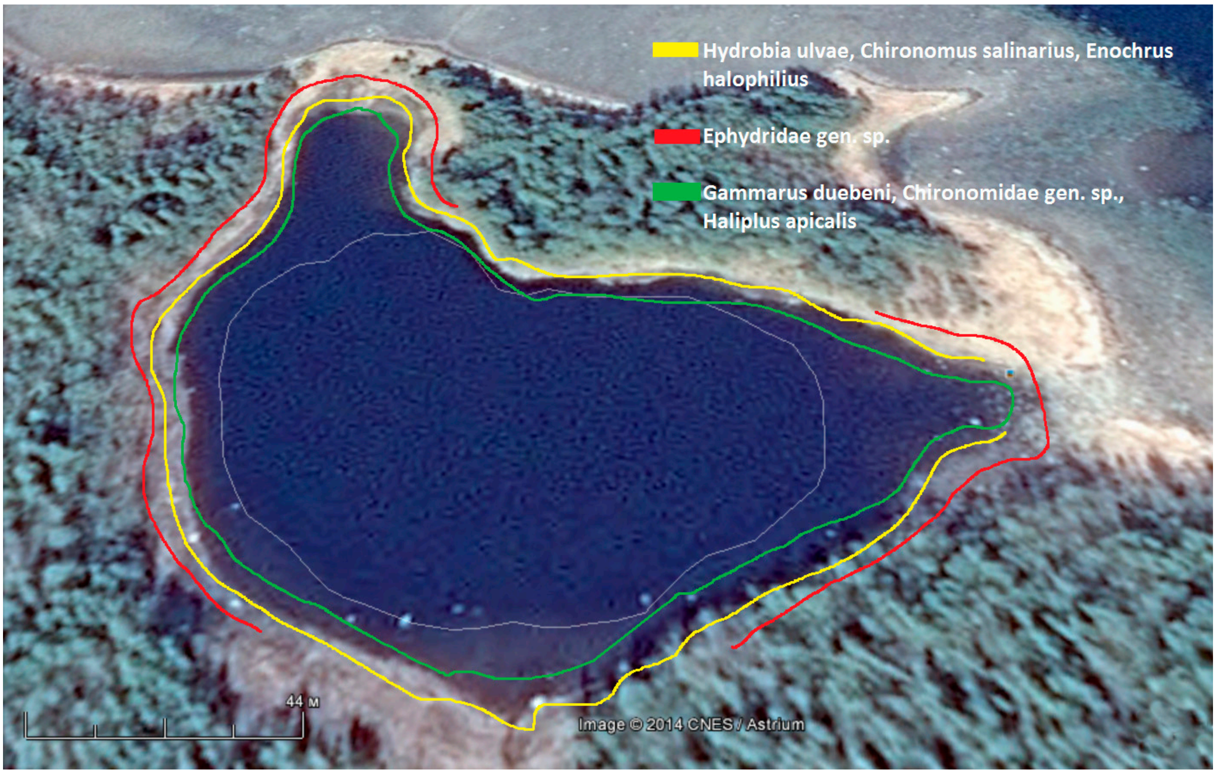


*Figure 3. Distribution boundaries of three brackish water species in the Kislo-Sladkoye Lake.*

**CONCLUSIONS**

Considering that the lake water salinity is 11 psu in the upper layer, brackish water organisms can live there, whereas sea organisms that live at the salinity of the White Sea (24 psu), cannot live in the lake. In some parts of the lake, such as southern creek area, the salinity in the upper water layer appears even lower, down to 1-2 psu. That area is rich on typical freshwater inhabitants, mostlly insects larva (14).

Considering marine animals, *Mytilus edulis, Littorina saxatilis, Semibalanus balanoides, Littorina saxatilis* are present in the lake. These species were not noted for the lake previously, because the threshold was not considered the lake part. We found that the mussels and periwinkles have become mass species in the middle of the sea threshold on the rocks. Apparently, it is the point, where the water comes up to during high tide. Barnacles and fucoids were found a little further out to sea, that is, about two thirds the length of the threshold starting from the lake. On the side of the threshold facing the lake and in the lake, numerous *Hydrobia ulvae* were found. These species live in a wide range of salinity (10-25 psu (17)). However, on the very threshold only empty shells were found, which is likely due to the strong current of water in the sea threshold. *Hydrobia ulvae* is one of the most popular species in the lake and similar marine habitats (14).

On the other side of the threshold, which faces the lake, no larvae of *Chironomus salinarius* were found, although they are predominant species in the benthic composition of the lake. This is due to the fact that they inhabit silty micropits and cannot live on the rocks or open areas (14). Amphipods were found on the threshold, both on the side facing the sea (bottom surface of the stones) and on the side facing the lake (thickets of conferva) and also in large numbers in the lake. *Gammarus duebeni* lives in an extremely wide range of life conditions and can inhabit different grounds (20). Larval and adult beetles *Enochrus halophilus* and *Haliplus apicalis* were massively found around the lake. *Setacera aurata* larvae were only found on slightly sloping coastal parts. This may be explained by the reproductive biology of the species, since flies lay their eggs at the water edge, where they find convenient plants protruding out of the water. These plants grow only on the flat littoral.

These data mostly agree with the previous investigations results. *Cladotanytarsus* gr. *mancus* (42% quantity) – *Hydrobia ulvae* (31%) – *Chironomus salinarius* (23%) community is described as the main one fro silty lake areas (14). In the current study we have not identified chironomids other than *Ch. salinarius*, but in latter samples *Cl. gr. mancus* were revealed in numbers up to 24% total quantity. *H. ulvae* and *Ch. salinarius* dominate the whole lake perimeter excluding the threshold.

A particularly diverse composition of the benthic species was found at station 3 (silty shallows). This is because there are quite favourable conditions for the development of larvae of insects at this point: nearly stagnant water, relatively warm temperature and a huge amount of organic residues. The representatives of such families as Culicidae, Corixidae, Dytiscidae were found only there. These groups found sporadically in both works have not much in common. *Haliplus apicalis* was found at the same places, but the others probably undergo too strong seasonal fluctuation in quantities. These sporadic groups are a subject for further year-round monitoring.

At the mouth of the creek, where we expected to find some freshwater species, such species were not found, because there is a rapid mixture of fresh and salt water at this point along the entire depth of the confluence of fresh water, which is evident from the results of the hydrological survey. This process does not allow the freshwater forms to live here. In previous works more attention was paid to the boggy area in the south-west of the lake with freshwater-originated benthal communities consisting mainly of dipterans. Such species as *Dixella obscura, Ptychoptera contaminata, Limnephilus nigriceps* and others along with chironomids live in that part of the lake (14).

The obtained data allowed us to map the lake zonation based on the species composition (Figure 4). Three zones are allocated: marine fauna zone on the east near the rapid; brackish fauna around the lake, and enriched muddy shallows in the northern part.

*Hydrobia+Chironomus* communities are considered depleted compared to regular marine ecosystems with high biodiversity and bivalves dominating the biomass (9). Most of the naturally separating sea bays are much closer to the original biodiversity than Kislo-Sladkoye lake. Lake Mogilnoye and Dolgaya bay have marine filtrator molluscs as well as ascidians, anthozoans (10) and relict arctic fauna, for example *Portlandia arctica* (11). These communities should be described as great environmental conditions, even though isolation lowered the biodiversity compared to marine ecosystem (9). Kislo-Sladkoye lacks bivalves, *Hydrobia ulvae* us the only mollusc in the lake. No marine fauna retained; only 3 brackish species, while others are originally freshwater organisms (14).

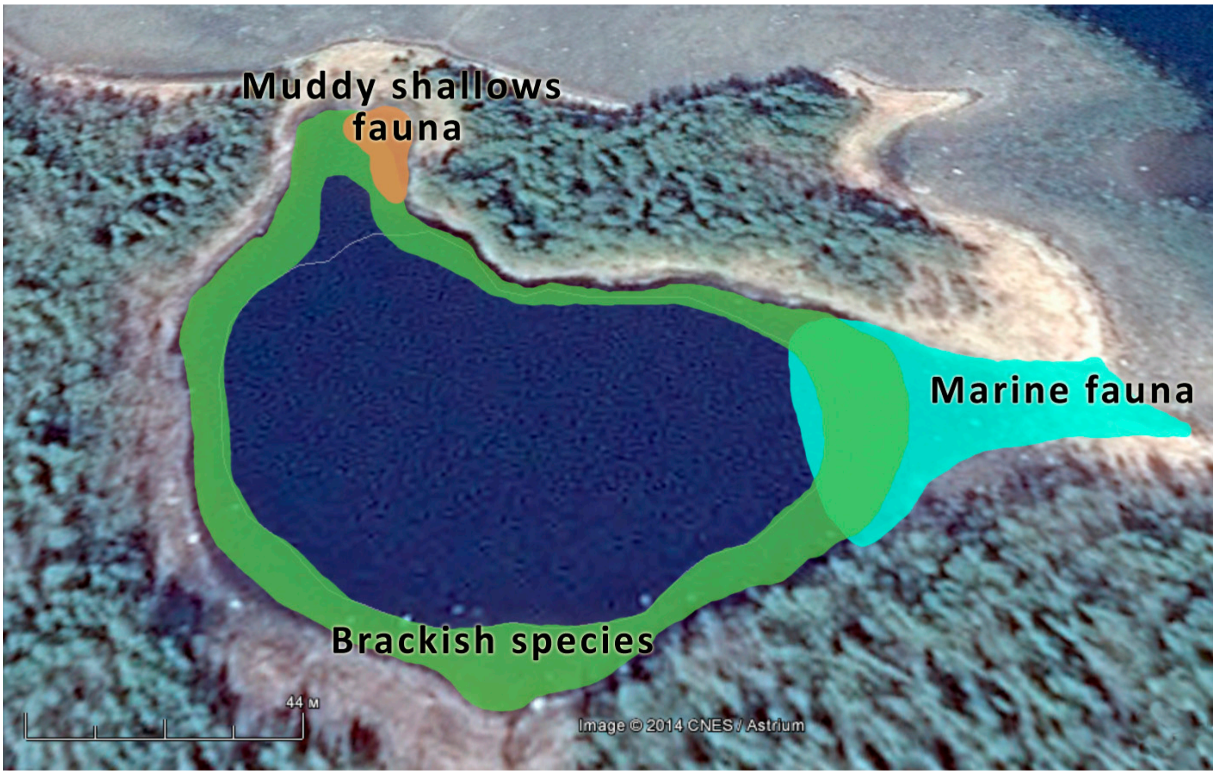


*Figure 4. Benthic zonation of Kislo-sladkoye Lake. Marine fauna influence zone is shown in light blue; brackish communities are shown in green; specific enriched muddy shallow fauna in shown in brown.*

Some river estuaries at the White Sea coast contain slightly similar communities of chironomids, oligochaetes and molluscs, but even those are richer in species number (21)

Somewhere similar scene appears in artificially separated fishery ponds in Onega bay of the White Sea (22): Chironomidae and somewhere Oligochaeta communities replace the original ones.

Kislo-Sladkoye lake, being a model object of naturally or artificially separating water bodies, should be monitored for a longer period, and benthic communities changes during the separation process are to be described yet.

## ACKNOWLEDGEMENTS

The authors are grateful to WSBS director A B Tzetlin and his staff, and to the biophysics students: N M Volovich, D S Vinogradov, S A Varlamov, S A Ilchenko, E V Malyshko, E S Nesmeyanova, A A Grigoryeva, V A Kuznetsov, A R Murtazina, I V Kruchinin, A V Kosenkov. We are grateful to F A Balabin, V V Karpychev, and to A D Voronova, M A Krylova, I V Izyurov, and A K Tabachnik for their help in collecting specimens, and to G Y Lyubarsky for identification guidance in Coleopterans.

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