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Macrozoobenthos of Skurcha Lake (Republic Of Abkhazia) Under Changing Hydrochemical and Hydrological Conditions.

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ABSTRACT

The study of macrozoobenthos changes was performed for the salty lake Skurcha in the Republic of Abkhazia during the application of hydraulic activities to pass Cawdor river waters across the lake. During the partial freshening of the lake in 2012, the change of species composition of macrozoobenthos and the qualitative improvement of the water quality is revealed according to hydrobiological indicators: the species, demanding oxygen (from the order of mayflies and stoneflies) appeared in the pond, but the stability of the existing communities was a low one. The calculation of similarity ratios between the communities over the years showed that the performed hydraulic measures led to a significant change of the species composition in the macrozoobenthos of Skurcha lake. After the entry of the Black Sea salty waters the nature of water exchange changed, the salinity of bottom water layers increased, the terms for the living of euryhaline zoobenthos species appeared, which led to the ousting of freshwater fauna. Due to the stratification of water the conditions for biotope co-existence with different salinity indicators, which led to the coexistence aquatic organisms that live in different environments within the same ecosystem. In general, the biodiversity of the lake Skurcha after the application of hydraulic activities increased, the biomass of zoobenthos and the productivity of the ecosystem increased. The appearance of rheophilic and euryhaline species of zoobenthos and the species of benthic organisms rare for this region was noted.

Keywords: macrozoobenthos, the Republic of Abkhazia, water quality, brackish lake, Skurcha lake, hydraulic experiment, desalination.

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INTRODUCTION

Macrozoobenthos is an important indicator in hydrobiological monitoring, the bottom organisms are the bio-indicators of changes, including those related to water quality improvement after special measures. The ecosystems of brackish lakes are vulnerable, because they have a unique composition of species which is not resistant to pollution. Pollution occurs both in the water catchment area, and from the sea, resulting in water quality decrease, common biodiversity and bio-productivity of ponds [4]. The optimization of water body ecological state may be carried out in various ways (biological, hydraulic, mechanical ones, etc.). The hydraulic measures are the effective methods of water quality change, the effect of application of which may be detected in a short time.

The aim of our research was to study the changes of macrozoobenthos community indices in the brackish lake Skurcha, the Republic of Abkhazia after the application of hydraulic measures with the pass of Cawdor river waters across the lake; the activities were carried out during the period from 2012 to 2013. The monitoring of the lake ecological state was conducted during the period from 2009 to 2013.

MATERIALS AND METHODS

The studies were conducted in the Laboratory of aquatic ecosystem optimization and the Department of Environmental and Water Management and Territorial Development Institute of KFU, in collaboration with the Institute of Ecology, the Republic of Abkhazia AS and the Committee on Environment and Natural Resources of the Republic of Abkhazia.

The samples were collected during the summer period (August) 2011-2013., within the network of stations (10 samples in the littoral zone and 2 at the depth on the average). Zoobenthos was gathered in shallow littoral zone with a scraper (to capture an area of 20 x 20 cm), at a depth of 1-2 m with a rod bottom scraper and a box bottom scraper at great depths (with the area of capture 10 x 10 cm). More than 40 quantitative samples were processed. The quality analysis samples were taken additionally.

The water quality in terms of zoobenthos values was determined using the biotic indices of species diversity according to Shannon, Simpson, Pielou and Woodiwiss index [7,8]. The similarity of the communities was determined by calculating Jaccard-Sorensen ratio [8].

The obtained results were processed in the program Statistika 7.

RESULTS AND THEIR DISCUSSION

Hydrological and hydrochemical indicators

Abkhazia is located in the north-western part of Transcaucasia between Psou and Inguri rivers, and it is washed by the Black Sea at the south-west [6].

Skurcha Lake is located in the eastern part of Abkhazia, in Ochamchire district, southeast of the river Kodor mouth. This large shallow brackish pond is an artificial water body, formed within a pit. The water filling was due to amelioration channels, the entering of underground and marine waters. The sea waters flow into the lake by infiltration through the sea channel. Perhaps now the lake is developing towards coastal salt lake ecosystem. The lake Skurcha borders with agricultural areas, it is the place for recreation and fishing.

Currently, the lake area makes no less than 140 ha, the largest width of the lake makes 1000 m, the maximum length of the lake makes 2050 m, the maximum depth of the lake according to bathymetric surveys makes 27 m.

Until 2011, the lake waters were characterized by high salinity, low oxygen and high hydrogen sulphide content in the middle and bottom layers. This led to a low species diversity, fish kills, reduced biological productivity of the lake ecosystem [3].

During the period from 2011 to 2013 at the suggestion of the Committee on Environment and Natural Resources of the Republic of Abkhazia and the Laboratory of aquatic ecosystems KFU the hydraulic activities were carried out here with Cawdor river water passing through the lake. The purpose of the experiment is to improve the water quality by desalination of the reservoir in order to preserve the ecological balance in the river-lake-sea system and create a sustainable lake ecosystem.

In order to reduce the salinity of waters and saturate them with oxygen an artificial canal was built (Acuna canal) the length of which made 380 m and which directs the water of the river Cawdor along the old eastern Cawdor river bed to the western part of the lake. The consumption of supplied fresh water makes at least 8 m/s. Thus, there was a partial desalination of the reservoir, the water quality changed, its hydro-chemical parameters and the composition of aquatic organisms also changed. In 2013 the canal linking Skurcha lake in the eastern part of the Black Sea was greatly deepened and expanded. The length of the canal was 167 m in 2009 (according to the map data) with an average depth of 1.5-2 m [1]. In 2013, the canal length was 172 m, the depth of the canal was more than 3 m. The clearing of the canal connecting with the sea increased the inflow of sea waters into the lake, which also changed its species composition and water quality.

The impact of measures on the water quality according to hydrobiological indicators was studied in comparison with 2009 and 2010. The construction of a freshwater canal Acuna and the pass of Cawdor river waters to the lake reduced the conductivity, the oxygen saturation of bottom layers, the reduction of hydrogen sulphide content. The expansion of channel connecting the lake to the sea, led to the lake stratification, increased the salinity of bottom layers, refreshed the surface layer of the lake water (Table 1).

Table 1: Physical and chemical indicators of Skurcha lake in 2009-2013

Year	Transparency, m	Electroconductivity, mcS/cm ² surf./bottom (12 m)	Oxygen content in solution, % surf./bottom (12 m)		Water color (according to color scale)	Water quality (by RV ESC) surf./bottom
Prior to hydrotechnical experiment performance (2009-2011)						
2009	1,00	3375/ N/A	N/A	N/A	Greenish	N/A
2010	1,25	5450/11330	100	34	Greenish	9 / N/A
2011	0,70	13807/17358	100	25	Yellow-greenish	6 / 8
During the period of hydrotechnical experiment performance (2012-2013)						
2012	1,50	6664/15237	100	94	Greenish	9 / 4
2013	2,00	4371/15518	100	78	Yellow-greenish	3 / 6
Note: ESC - Environmental and sanitary classification of surface water quality: RV - ranking value: 1-4 - net, 5 - slightly polluted, 6 - polluted, 7-9 - dirty [4], N/A - Not available.						

Change of macrozoobenthos values

Species diversity

Over the entire study period 2009-2013 at the lake Skurcha 29 species of macrozoobenthos organisms, with a predominance of insect larvae - 13 species, of 9 species of crustaceans, 6 species of shellfish, 1 species of polychaete. Before the use of hydraulic measures (August 2009 - October 2011) zoobenthos organisms dominated in Skurcha lake: insects (10 species), crustaceans (6 species) and shellfish (3 species).

In 2009, among the organisms of zoobenthos 1 species of organisms was revealed from the class of insects, larvae of chironomids - *Syndiamesa c. nivosa* (Goetghebuer, 1928). In 2010 5 species of organisms from 3 classes and 3 orders were discovered: 2 species from shellfish class, 2 species of insects, 1 species of shellfish. In 2011, the selected samples showed 16 species of organisms from 3 classes, 6 orders: insects - 9 species (4 of them belong to the order Diptera, 3 species belong to dragonfly order, 2 species belong to Coleoptera order); shellfish - 3 (2 species of bivalves, 1 species of gastropods), crustaceans - 3 types (2 of them are from amphipod order, 1 species is decapods).

In 2012, after the construction of a freshwater canal supplying water from the river Kodor, zoobenthos species composition changed. There were mayflies peculiar to the river fauna (*Heptagenia sulphurea*, Müller, 1776) and stoneflies (*Chloroperla burmeisteri*, Pictet, 1841), polychaete typical of brackish water (*Hediste diversicolor*, OF Müller, 1776). The samples of 2012 revealed 13 species of 4 classes, 9 orders: Class of insects - 8 species (3 species of dragonfly order, 2 - of Hemiptera order, 1 - stoneflies order, 1 - mayflies, 1 species is presented by Diptera), polychaete - 1 species, shellfish - 1 species, crustaceans - 3 species (2 species are from amphipod order, 1 species is decapods).

Potamon tauricum Czerniavsky, 1884 crabs previously occurred only in the upper and the middle current of small mountain rivers and were recommended for the Red Book of the Republic of Adygea [5]. Due to the desalination of Skurcha lake, the habitat of this species was probably expanded. But in 2013, after the receipt of marine waters in the eastern section of the lake near the sea channel a lot of eliminated crabs of this species was observed. In 2012, the dragonflies *Aeschnophlebia longistigma* Selys, 1883 were discovered at the lake, the spread of which is typical of the Primorsky Territory and Japan.

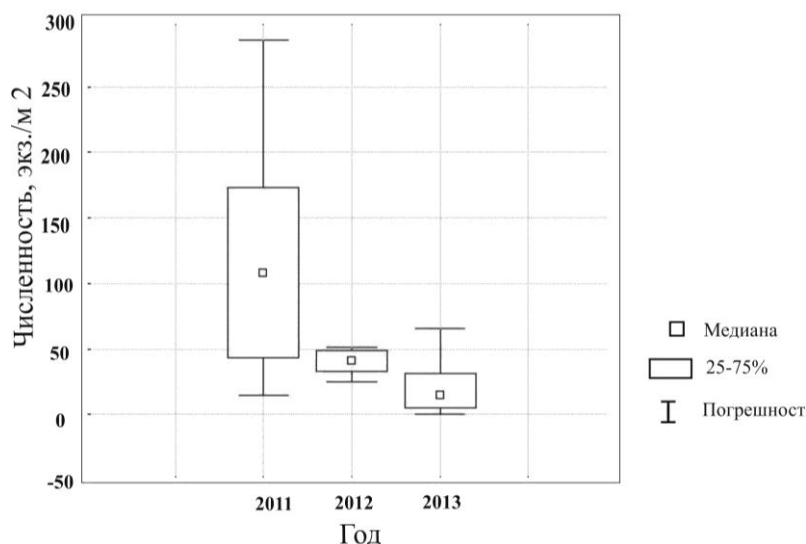
In 2013 (after the canal expansion connecting the lake Skurcha with the Black Sea) the number of zoobenthos species was reduced to 10 species of 5 classes: crustaceans - 3 species (2 of them are from amphipod order, 1 - decapods), shellfish - 3 species (1 order), insects - 3 species of 3 groups (1 - mayflies, 1 - Diptera, 1 - dragonflies), polychaete - 1 species. The species diversity of insects and lung clams reduced.

The calculation of the similarity between the communities over the years showed that the most similar were zoobenthos communities studied in 2012 and 2013. Minimum similarity was found with the community of zoobenthos prevailing before 2011 (Table 2). Consequently, during the period from 2011 to 2012 the most significant changes occurred in zoobenthos community associated with the freshening of the water body. The findings suggest that the use of hydraulic measures led to a significant change of the species composition in the macrozoobenthos of Skurcha lake.

Table 2: Similarity ratios of Skurcha lake zoobenthos communities in 2011-2013

Ratios/years	2011-2012	2011-2013	2012-2013	Maximum
Jaccard's coefficient	0,07	0,08	0,25	1
Serensen's coefficient	0,13	0,15	0,40	1

Quantitative values of zoobenthos



Численность, экз./м² - Amount, pieces/m²; Медиана – Median; Погрешность – Error;
 Год – Year

Figure 1: The average number of zoobenthos organisms in Skurcha lake (2011-2013).

In 2011, the number of macrozoobenthos organisms varied from 3 to 39 pieces/m² with the dominant species of *Paramoera udehe* (Derzhavin, 1930) (125 pieces/m²) crustaceans and *Palaemon serratus* (Pennant, 1777) (50 pieces/m²), chironomids *Glyptotendipes glaucus* (Meigen 1818) (62 pieces/m²), *Chironomus singulatus* Meigen (187 pieces/m²) and the clams *Lymnaea fulva* (Kuster, 1862) (125 pieces/m²). Biomass ranged from 0.05 g/m² among chironomids to 2.45 g/m² among the larvae of Diptera. The largest contribution to the biomass was performed by Diptera *Chrysops caecutiens* (47 g/m²), chironomids *Cricotopus silvestris* (36,2 g/m²) and the crustaceans *Palaemon serratus* (123 g/m²). The biomass of other species did not exceed 2.3 g/m². The average number of macrozoobenthos organisms for the lake in August 2011 made 119 pieces/m², biomass - 26.82 g/m² (Figure 1, 2).

In 2012, after the passage of Kodor river waters through the canal, the species composition of organisms changed and the overall number of organism indicators reduced. The values of macrozoobenthos numbers changed at the stations in the range of 8 - 51 pieces/m². There was the following domination: shrimp *Atyidae* sp. (51 pieces/m²). The number of other organisms in the samples did not exceed 37 pieces/m². The biomass of organisms changed from 0.008 g/m² to 7.39 g/m². The largest contribution to the biomass was brought by freshwater crabs *Potamon tauricum* (2,54 g/m²), the shrimps *Atyidae* (7,39 g/m²) and the large polychaete *Hediste diversicolor* (4,7 g/m²). The average number of macrozoobenthos organisms for the lake was 42 pieces/m², biomass - 2.28 g/m² in August 2012 (Fig. 1,2).

In 2013, the values of macrozoobenthos organisms number ranged from 5 - 58 pieces/m², with a maximum number of polychaete species *Hediste diversicolor*. *H. diversicolor* species is a euryhaline one, marked as the background species for the lower current reservoirs of the river Syrdarya, near the Small Aral Sea in conditions of high salinity - 12-14 ‰ [2]. Its dominance in the lake Skurcha indicates the increased salinity.

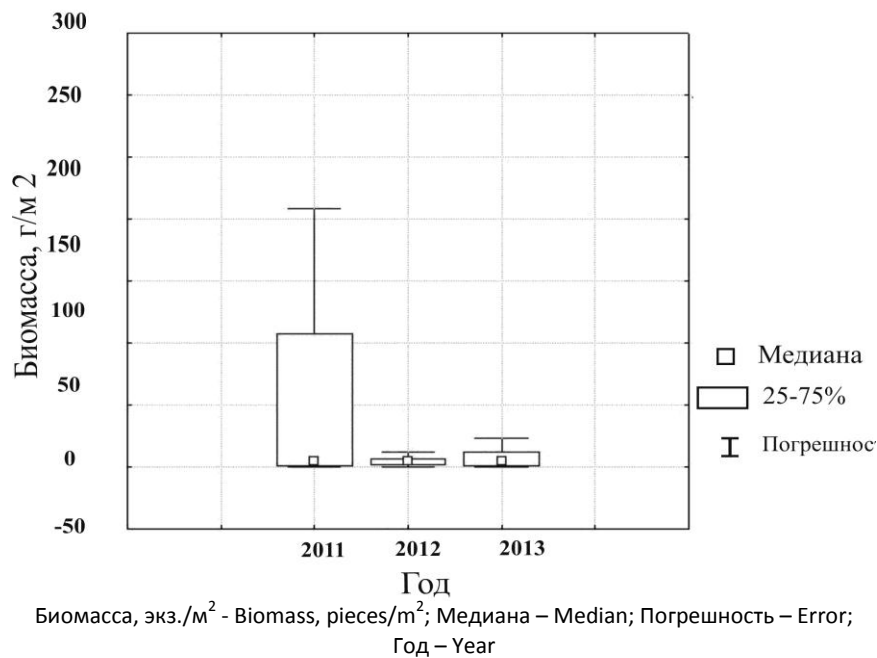


Figure 2: Biomass of Skurcha lake zoobenthos organisms (2011-2013).

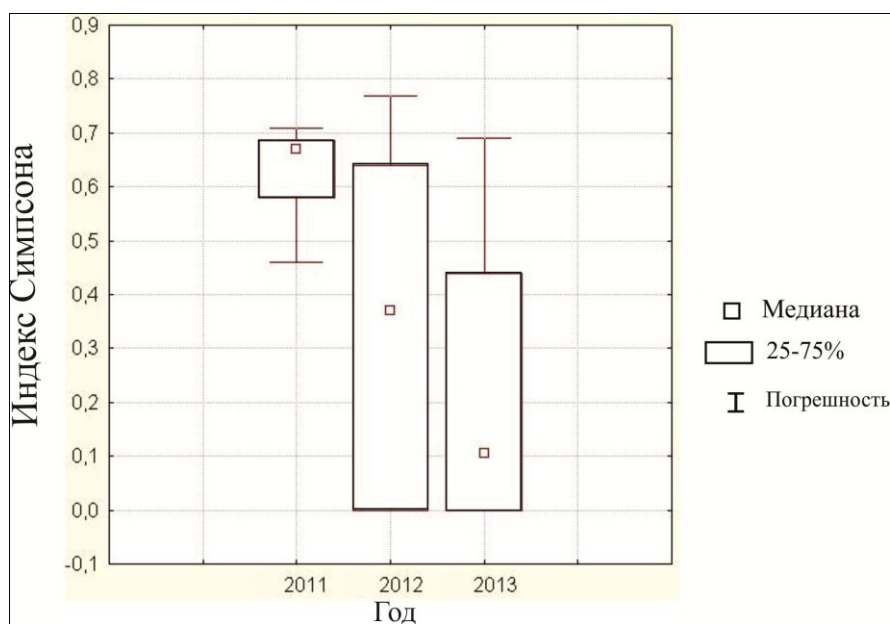
The number of remaining organisms in the samples did not exceed 31 species/m². The biomass of organisms changed through the stations from 0.01 g/m² to 68.75 g/m². The largest contribution to the biomass was made by the crustaceans *Potamon tauricum* (68,75 g/m²). The biomass of other species did not exceed 9.44 g/m². At the stations located close to the canal, numerous eliminated species of *Potamon tauricum* were found, which is probably due to the influence of sea waters. The average number of macrozoobenthos organisms for the lake made 21 species/m², biomass - 9.19 g/m² (Fig. 4.5) in August 2013.

Thus, after the application of hydraulic events the terms for the mutual living of freshwater and euryhaline species of zoobenthos organisms were developed in Skurcha lake. At the expansion of the channel connecting Skurcha lake with the sea, the overall values and biomass of zoobenthos organisms reduced.

Evaluation of water quality in terms of macrozoobenthos

In 2009-2010 the water quality was low according to all biological parameters, the waters were classified as "contaminated" ones. In 2011, the Woodiwiss index at all stations except one (there were oxygen demanding gammarus) made 1-2, which describes water as "very dirty". Shannon and Pielou indices characterizing the evenness of community in 2011 were the highest ones (from 1.01 to 1.58, and from 0 to 1.1, respectively). The Simpson index values ranging from 0.46 to 0.71, characterizing the community stability was also the highest one in 2011 (Figure 4). The Simpson index responsible for the stability of the community ranged from 0.46 to 0.71, indicating a sufficient stability of benthic community in the lake Skurcha.

In 2012, the Woodiwiss index values raised to 6 (which is associated with the influx of river waters and river fauna), its median values made 2 points, which corresponds to the "pure" and "moderately polluted" waters. Clean waters occurred in the western part of the lake, at the confluence of Cawdor river waters in lake Skurcha. Shannon index ranged from 0 to 1.58, which corresponds to "polluted" waters. Simpson index decreased (the median value made 0.4), which shows the community stability decline (Figure 3).



Индекс Симпсона, экз./м² – Simpson's index, pieces/m²; Медиана – Median; Погрешность – Error; Год - Year

Figure 3: Simpson's index values of Skurcha lake zoobenthos organisms (2011-2013).

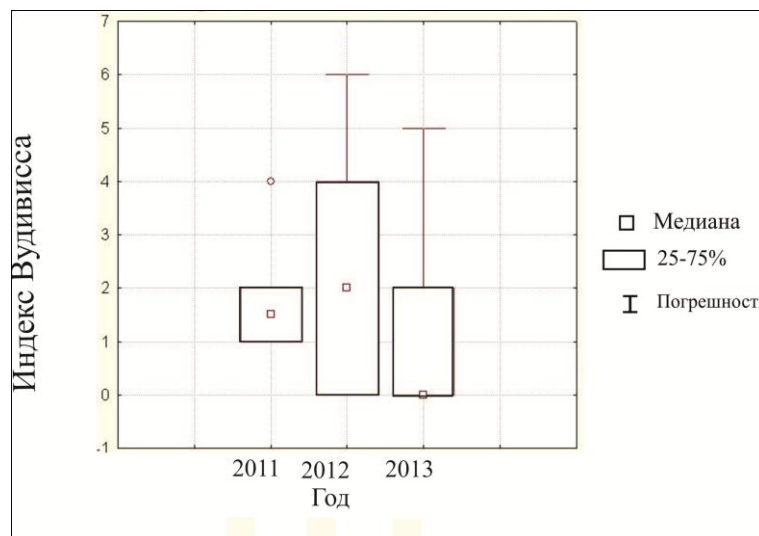


Figure 4: Index of Woodiwiss values for Skurcha lake zoobenthos organisms (2011-2013).

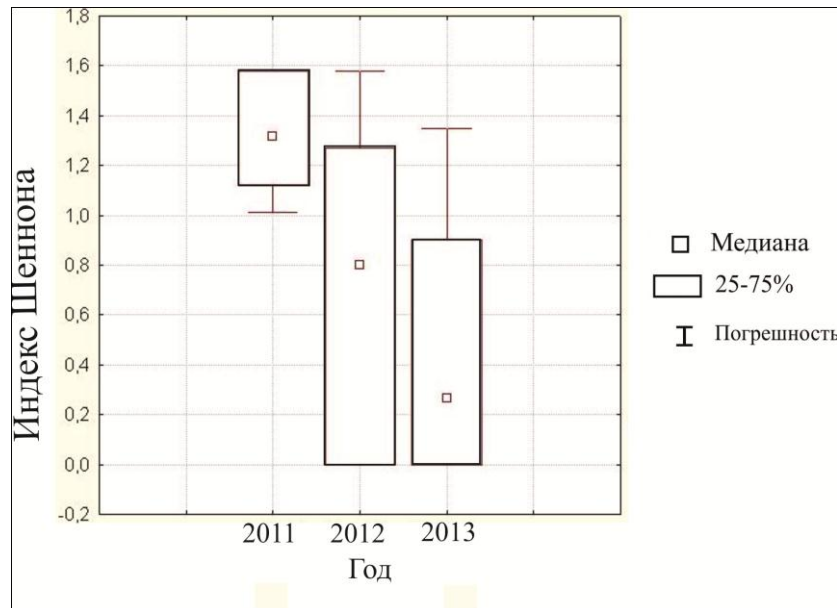


Figure 5: Shannon index values for Skurcha lake zoobenthos organisms (2011-2013).

In 2013, the index of Woodiviss varied from 0 to 6, in most of the stations it was equal to 0, which indicates the water quality decrease (Fig. 4). Simpson index varied from 0 to 0.66; the median value also decreased to 0.1. Shannon index values ranged from 0 to 1.35, with a median value of 0.2 by stations (Figure 5).

All biotic indices of 2013 characterized waters as "contaminated" and the community indicators as unstable.

SUMMARY

The study of Skurcha lake macrozoobenthos at the use of hydraulic measures with a pass of Kodor river waters through the lake, led to conclusions about the significant changes that occurred in the ecosystem of the lake. The result of the measures application was a partial desalination of the lake waters, the hydrogen sulfide content reduction in deep layers. The subsequent extension of the sea channel led to increased communication with the sea water, the stratification of waters and salinity increase.

Biological indicators of macrozoobenthos demonstrated the water quality improvement after the fresh water supply from the river Kodor: the species, demanding oxygen (from the order of mayflies and stoneflies) appeared in the pond, but the stability of the existing communities was a low one.

In 2012, the species of dragonflies not detected earlier - *Aeschnophlebia longistigma* Selys, 1883, revealed the spread of which is typical of the Primorsky Territory and Japan. The desalination of the lake Skurcha led to freshwater crabs *Potamon tauricum* Czerniavsky, 1884 emergence, previously mentioned only in the upper and middle currents of the mountain rivers, rare for the neighboring region (Republic of Adygea). Due to the desalination of Skurcha lake, the habitat of this species probably expanded.

The calculation of similarity ratios between the communities over the years showed the greatest similarity between the communities in 2012 and 2013. Minimum similarity is found with the zoobenthos community developed before 2011, prior to the measures application. The obtained data suggest that the used hydraulic measures led to a significant change of the species composition in Skurcha lake macrozoobenthos.

After the Black Sea salt waters supply the nature of water exchange changed, the salinity of bottom water layers increased, the habitats for euryhaline species of zoobenthos appeared, which led to the ousting of freshwater fauna. Due to the stratification of waters the conditions for the co-existence of biotope habitats with different salinity indicators appeared, which led to the coexistence in the same ecosystem of aquatic organisms that live in different environments.

In general, the biodiversity of the lake Skurcha after the application of hydraulic activities increased, zoobenthos biomass and the productivity of the ecosystem increased.

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