LELP Batumi Shota Rustaveli State University

Faculty of natural sciences and health care
Department of biology

Paata Vadachkoria

Taxonomic Biodiversity and Bioecology of Invertebrate Hydrobionts in Paliastomi Lake

A thesis submitted in fulfilment of the requirements for the degree of Doctor in Biology

Field of expertise: Zoology-Hydrobiology

ANNOTATION

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Thesis presented to the faculty of natural sciences and health care, department of Biology. LEPL Batumi Shota Rustaveli State University.

Under the guidance of:

Temur Gogmachadze – Doctor of Biological sciences, BSU Emeritus, Professor.

Reviewers:

Bela Japoshvili - Academic Doctor of Biology, Biodiversity Research Center, Head of Hydrobiology and Ichthyology. Institute of Ecology, Ilia State University

Tariel Tserodze - Academic Doctor of Biology.

Thesis defence shall take place at __ __ p.m. on __ ______ 2021, at Batumi Shota Rustaveli State University, on dissertation board meeting of department of Biology of faculty of natural science and health care.

Address: Room ___, 35 Ninoshvili Street, Batumi.

Thesis is available in the library of Batumi Shota Rustaveli State University and on the website of the state university.

Dissertation council secretary,

Associate professor Nana Zarnadze

General description of the work

Actuality of the Topic. Paliastomi Lake is located on the Black sea coast, in the Kolkheti lowland, to south-east to the city of Poti. It is a flowing lake connected to the Black Sea through Maltakva channel. Three rivers flow into to the lake – Shavi-Ghele (Shavtskala) to the north-west, Pichori – to the north-east and Tkhorina (its tributary at the confluence – Gurinka) to the south. The river Kaparcha flows out of the lake.

Paliastomi Lake is a unique relict basin, which had been connected to the sea with the river Kaparcha until 1930s with a length of 9 km. In the 1930s, Paliastomi Lake was directly connected to the sea to prevent flooding of Poti with the lake waters during high water levels. This caused flowing of sea waters into the lake and over-salinizing, which resulted in transformation of fresh water basin to a salinized water basin and disbalance and change of ecosystem.

Paliastomi Lake is characterized by expressed fluctuation of hydro chemical condition, in particular, water salinity, caused by heavy rainfall and high waters, late spring and autumn winds. Low water levels of surrounding swamps causes water outflow from the lake for replenishing groundwater, which increases seawater inflow through a strait and consequently, salinizing of the lake. The most desalinated water is found in the Pichori River confluence, usually, salinity level gradually rises from the Pichori River confluence to the Maltakva channel, where it reaches its highest level. Average salinity is detected in the central part of the lake.

The lake water salinity, its vertical and horizontal distribution and monthly fluctuations have a huge influence specifically on structure and dynamics of the lake's biological environment.

In terms of fishery, Paliastomi Lake is one of the most significant internal basins. Traditionally, fishing is the most common and important activity of the nearby population. Currently, about 250 fishermen united in the small groups mainly follow net fishing, but most fishermen are using fishing rods, recreational fishing. This adds up to those coming from distant settled locations for fishing with the nets and rods. Along with a nutritional value, fish from Paliastomi Lake remains one of the most important and in some cases, the main income generating source for the locals. This explains increasing interest to the fish products in the recent years. Inadequate use of anthropogenic manipulations in the basin has led to the alarming condition of the lake ecosystem.

The Research Aim and Purpose. The research aim is to study current condition, number, dynamics and ecology of the biomass of the plankton and benthos taxonomic diversity, which are the important components of the natural feed base for the invertebrate animals – ichthyofauna; Also, revealing of new, dominant, predominant and rare forms.

The Research Object. The research objects are invertebrate hydrobionts free living in the pelagic and benthos in Paliastomi Lake.

Scientific Novelty. It is the first time in the latest years, when significant complex hydro biological studies have been conducted in terms of studying current condition of the Paliastomi Lake ecology, invertebrate hydrobionts. Conducted scientific study allows for assessment of the water ecosystem resistance towards fluctuating environment and development of the activities for preventing negative consequences ("blossoming" of blue-green algae, eutrophication followed by asphyxia from deficient supply of oxygen, in other words "choking").

Due to the topic actuality, conducted studies have an important **scientific and practical value.** In particular, a completed annotated list of zooplankton and benthos is of a high interest for using it in description of background environment condition of the lake; assessment of ecological monitoring and status; development of the basin ecological safety, system improvements and practical recommendations. The lake trophic classification was developed based on the materials revealed by the research on the number and habitat distribution of plankton and benthos in the lake. The data received enriches knowledge in biological diversity of the plankton and benthos main groups.

Additionally, the research results provide supporting knowledge for the persons interested in aquaculture (invertebrate animals and fish farming as well) in developing and proper planning of fish productivity in Paliastomi Lake and surrounding reservoirs.

Approbation

The dissertation materials have been presented and discussed:

At the meeting of the Natural Sciences under the Department of Biology of the Faculty of Natural Sciences and Health in the Batumi Shota Rustaveli State University (Seminar I and Seminar II); in the Fisheries, Aquaculture and Water Biodiversity Department of the National Environment Agency under the Ministry of Environment Protection and Agriculture of Georgia.

Paper Volume and Structure

The dissertation paper covers introduction, 7 chapters, 10 sub-chapters, 6 tables, 66 original photos, conclusions, recommendations and bibliography. The bibliography covers 147 national and foreign author works, including, 12 Georgian and 135 foreign. The dissertation paper covers 152 pages, annex – 12 papers.

Experimental Part

Research Materials and Methods.

The research has been carried in four phases from 2015 to 2021:

1. May – ecological spring, beginning of vegetation;
2. August – ecological summer, highest vegetation, the hottest month;
3. November – ecological autumns, end of vegetation;
4. February – ecological winter, species overwintering, the coldest month.

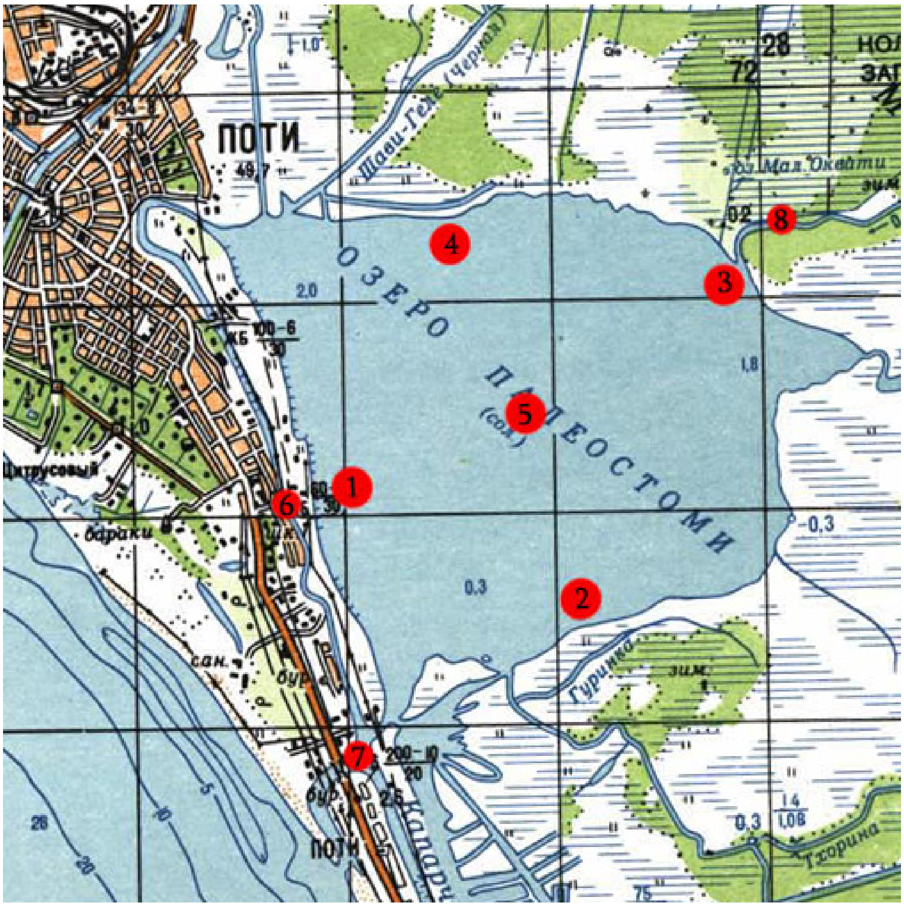
The Research Locations in Paliastomi Lake. Location distribution shall consider: relief of the ecosystem, ground in the research location for comprehensive study of the ecological conditions in shelf.

Considering different aspects (ecology, hydro morphology, and hydrobiology) of Paliastomi Lake and its basin, five locations (spots) have been identified. Locations were marked by "cross principle": center (5), north (4), east (3), south (2) and west (1). Additional three locations are marked according to their specificity: Pichori (8), Maltakva (7) and Kaparcha (6) – the most polluted locations.

The Methods and Tools Used during Research. Hydrobiological research was carried through the commonly recognized and used methods and guidelines. Also, through commonly established anamnesis (interview) method. For definition of current species nomenclature, we used: World Register of Marine Species (WoRMS): http://www.marinespecies.org; Marine Species Identification Portal: http://species-identification.org. FishBase: www.fishbase.org.

We were taking benthos samples with the Ponar or Ekman grabs with 0.025 m^2 grabbing area. Zooplankton samples were taken with Apstein net with filtering 100 L (5 buckets) water. The net canvas diameter was 32 cm, cylinder eye size – 150 μm, we did trailing with this net while taking qualitative samples. The material collected was fixed with 4% Formalin or 96% alcohol and labeled accordingly.

Fig. 1. Research Stations of Lake Paliastomi.



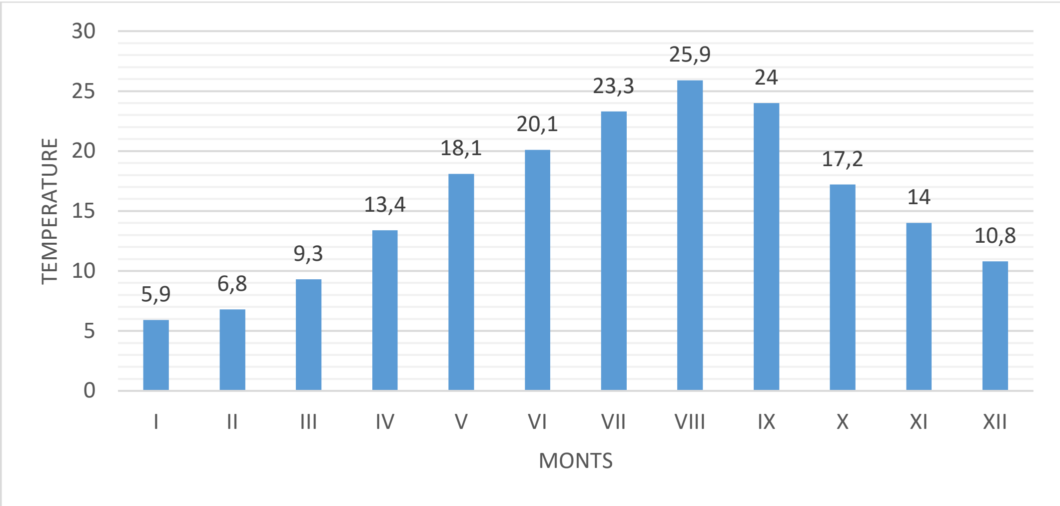
Thermal Regime and Hydrochemistry of the Lake

Water Thermal Regime. Water temperature, it's daily, monthly and seasonal fluctuations, vertical and horizontal distribution are of a high importance for any water basin, including Paliastomi Lake.

Temperature stratification in the lake is expressed weakly and found rarely due to shallowness and high wind aeration. The average monthly temperature of the lake water is shown in Figs. 2.

Salinity. Hydrochemical regime in Paliastomi Lake has been significantly changed after its direct linkage with the sea. The photo (#4) shows a salinity dynamics of Paliastomi water by years, detected by the researchers. Currently, Paliastomi Lake is distinguished by high water salinity fluctuation from 2,2‰ to 16‰, and average amounts to 7.2-8.1‰. The water desalination happens in spring and early summer through flooding and heavy rains. Later summer and autumn winds, low water levels in the surrounding swamps cause water outflow from the lake for filling the ground waters, which consequently increases flow of the sea water through the strait leading to increasing levels of the lake salinity.

Fig. 2. Average monthly temperature of the Paliastomi Lake waters

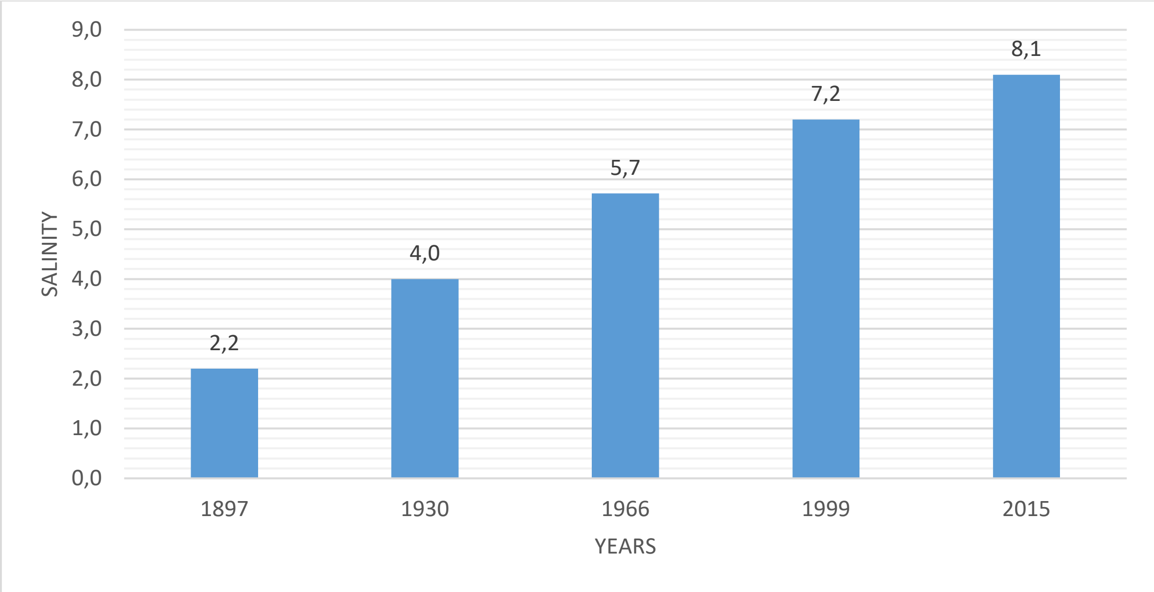


Aeration and Dissolved Oxygen. Paliastomi Lake is under strong wind aeration during the whole year, accordingly, storms are frequent at the lake leading to high concentration of oxygen.

Water Transparency. Paliastomi Lake is characterized by low water transparency, despite the shallowness, transparency does not reach the lake bottom. Water transparency is 0.15-1.2 meter due to shallowness, silty bottom, mixing of waters from winds and storms, and mass development of phytoplankton.

Water Active Reaction (pH). pH of the Paliastomi Lake water is 7.0-8.9.

Fig.3. An Average Annual Salinity (‰) of the Paliastomi Lake water



Certain groups of hydrobionts of Paliastom Lake Modern ecological-faunal analysis

Our research object, invertebrate hydrobionts in Paliastomi Lake, are strongly linked to the other lake hydro cenosis, like: lake flora, ichthyofauna and parasite fauna. As stated by Mollo (Молло и др. 2019) 100 kg zooplankton are fed with one tonne of phytoplankton, which generates 10 kg of larval fish and large crustaceans. Eating them increases common mass of 1

kg "feeding fish", which in turn ensures increase of predatory fish by 100 g. Thus, one kilogram of predatory fish requires ten tonnes of phytoplankton. They determine quantitative and qualitative data of one another.

Phytoplankton is a feed for planktonic invertebrate animals. Its excessive number leads to "blossoming" in the basin followed by oxygen deficiency negatively affecting hydrobionts, particularly, in the bottom community. This event is sometimes followed by massive death of community. Some of the species of phytoplankton are toxic. If those organisms are excessively reproduced in the basin and are massively taken, it may cause massive collapse of hydrobionts.

Microphytes represent nutritional base for invertebrate animals and fish as well. Small fish, also larval fish and especially invertebrate animals find good shelter there. Existence of multiple invertebrate animals in the basin is strongly linked to microphytes. We have detected a specie only found in the overgrown of microphytes, it was not found in the places without water plants.

Significant part of the invertebrate hydrobionts are intermediates between parasite and final hosts. The part of the parasites freely live in the basin, in benthos and plankton (facultative parasites) as well. Some of them go through free live stage in the short period of time.

Invertebrate hydrobionts represent the main nutritional base for ichthyofauna, thus their role is important in this regard. Due to the nutritional characteristics, fishes usually use planktons and benthos invertebrate animals as a feed. From planktonic animals, crustaceans (water fleas and copepods) and wheel animals are used as a feed. From benthos invertebrates – mollusk (Gastropods and Bivalvia), crustaceans (water fleas), different worms. Insect larval forms, particularly, Chironomidae and meroplanktons, are important part of fish nutrition. Adult fish forms are mainly planktonphages. Change of nutrition depends on biotic and abiotic factors: age, sex, maturity level, health condition, season, etc. Thus, ichthyofauna in the basin, its biodiversity, population composition and other determine diversity and number of invertebrate animals in the basin.

As mentioned, interlinkages between hydrocenosis is very high and interdependent, thus, we made a decision to briefly review this and other reasons based on literature review and our collected materials as well.

Phytoplankton

In terms of hydrobiology, Paliastomi Lake belongs to eutrophic group of basins according to its hypsometric marks, depth, thermal regime, biogenic composition, quantitative-qualitative indicators of benthos and plankton fractions and other characteristics.

There are 203 species and subspecies of phytoplankton water plants detected in Paliastomi Lake: 106 – diatoms; 49 – green; 21 blue-green, 15 – pyrophytics; 11 – euglenes; 1 – gold.

The species composition of water plants according to salinity are as follows: 51 species – polyhaline – euryhaline; 18 – mesohaline; 115 – oligohaline.

In 2015-2016, the number of phytoplanktons in Paliastomi Lake was between 6 560 cell/Mg to 43 799 cell/mg. The average number was 15 600 cell/Mg. Biomass fluctuated from 5 mg/l to 149 mg/l, average was 29 mg/l. Diatoms dominate phytoplankton with 79% of total number, 84% of biomass, blue-green take up to 11% of the total number and 7.9% of biomass.

Intensity of photosynthesis significantly increases from spring (on average 1.1 mgO_2/l in a day) to summer (on average 11.2 mgO_2/l in a day) and decreases in autumn (on average 2.0 mgO_2/l in a day). Thus, production of primary organic substances from phytoplankton is carried during summer and coincides with a maximum biomass of phytoplankton and vice-versa, minimal common production is detected in early spring – within minimal phytoplankton biomass conditions. Total primary production value on average amounts to 4.93 mgO_2/l in a day, while destruction is on average 0.042 mgO_2/l in a day, accordingly, average net primary production in a day amounts to 4.88 mgO_2/l.

Macrophytes.

Due to shallowness and frequent strong storms, the main part of Paliastomi Lake lacks macrophyte benthos. Small cenosis of macrophyte benthos are represented at the confluence of Pichori River, small Paliastomi, in some of the locations of dugs and coastline. Here the highest (Angiospermae) plants are detected: Eurasian watermilfoil – Myriophyllum spicatum L., tropical hornwort - Ceratophillum submersum L. and Colchis water caltrop – Trapa colchica Albov. In total, there are 23 species of macrophytes in the coastline and thin waters of the lake: semi aquatic plants, aquatic plants and floating leaf plants.

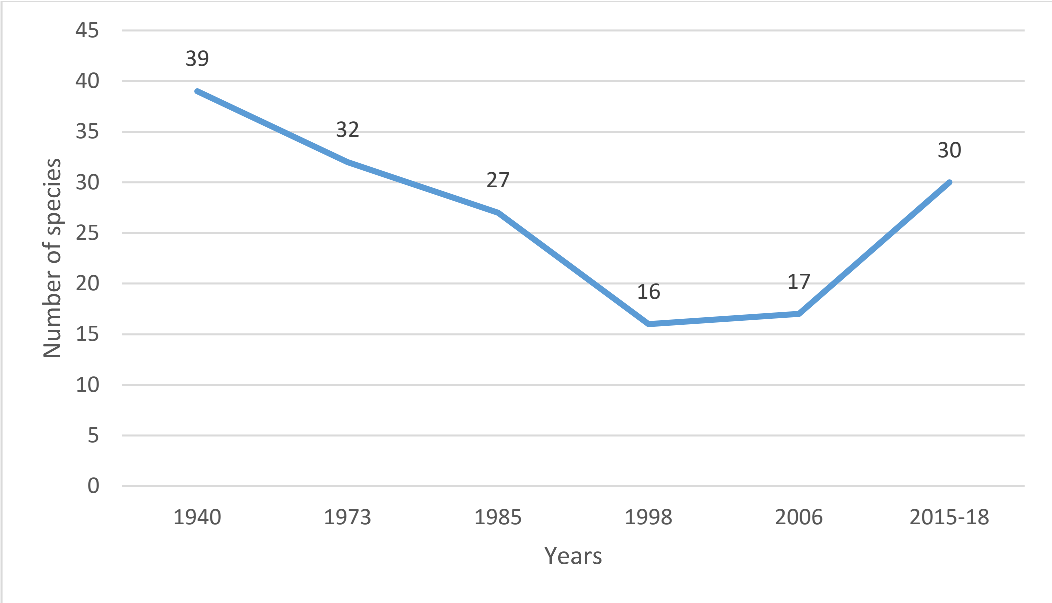
Ichthyofauna of Paliastomi Lake

Ichthyofauna is the only biodiversity component and its quantitative-qualitative indicators allow for observation of ongoing transformations in water environment and it's all biotic components (phytoplankton, zooplankton, neuston, benthos, epifauna, sea theriofauna and sea ornithofauna). Thus, a study of invertebrates in Paliastomi Lake without researching the diversity of their main consumers (ichthyofauna) would have provide incomplete study of the ecosystem.

Paliastomi Lake is among the most important internal fishery basins of Georgia. Despite a number of anthropogenic manipulations carried before, the lake is still distinguished with its productivity and richness. Biodiversity of ichthyofauna is also remarkable.

Since 1930s, a share of fresh-water fish has been significantly decreasing and diversity and number of sea form resistance to low salinity has been increasing. Until 1940, biodiversity of the Paliastomi ichthyofauna was represented by 39 species. Later, Chernova listed 32

Fig. 4. The Diversity Dynamics of the Paliastomi Lake Ichthyofauna by Years (1940-2015).



species, while Burchuladze 27. Recent studies show 16-17 species in the Paliastomi ichthyofauna. Based on the information we collected, the current biodiversity of the Paliastomi ichthyofauna is represented by 30 species.

It seems that mainly fresh water and partly salinized ecosystem of Paliastomi Lake has been transformed to the lagoon type salinized ecosystem during last 80 years.

Zooplankton of Paliastomi Lake

There are in total 88 zooplanktonic species identified in Paliastomi Lake during different periods of time. They are united in 6 types, 6 class, 19 orders, 40 families and 64 genera. The top three most diverse taxonomic living organisms: wheel animals (Rotifera), Copepoda (Hexanauplia) and Branchiopoda. The most represented are wheel animals (38), followed by Copepoda (29) and Branchiopoda (16). Ctenophora and Cnidaria are represented by three and two species accordingly, and Sagittoidea – by one. (Table 1,2)

Euryhaline-Polyhaline species dominate the zooplankton (Fig. 5). Zooplankton of spring and early autumn is represented by euryhaline forms of water fleas, wheel animals and Copecoda, water fleas are not present in late summer and autumn zooplankton. Meroplankton forms are detected during spring, summer and autumn, in particular: Larvae forms of polychaetes (Polychaeta), Bivalvia, snails (Gastropoda), decapods (Decapoda) and barnacle (Cirripedia) in the different larvae development stages.

A number of zooplankton in Paliastomi Lake is between 7 900 sample/m^3 to 424 600 sample/m^3, average is 86 500 sample/m^3. Biomass is between 85.5 mg/m^3 to 2 950 mg/m^3, average is 310.3 mg/m^3.

The Paliastomi Lake zooplankton is not distinguished by horizontal and vertical zoning. There is a small difference between the zooplankton localities, except from the Pichori river confluence and some other locations, and there is not practical difference between zooplanktons of the shore and open locations. This could be explained by the intensive mixture of the lake waters (winds, storms, flows). Also, intensive mixture of depth and water masses explained lack of the zooplankton vertical zoning.

It shall be noted that larvae forms of insects in the different development stages are not detected in the Paliastomi plankton.

Seven species were first found by us in samples from Lake Zooplankton. These are: Tropocyclops prasinus prasinus (Fischer, 1860); Alona costata G.O. Sars, 1862; Daphnia cucullata G.O. Sars, 1862; Pleurobrachia pileus (O. F. Müller, 1776); Mnemiopsis leidyi A. Agassiz, 1865; Beroe ovata Bruguière, 1789; Parasagitta setosa (J. Müller, 1847); All of these are saltwater (sea) organisms, And are widespread along the Black Sea coast. From whence they meet in a lake of strong turmoil.

Based on the analysis of literary and modern species diversity of Lake Paliastomi zooplankton, it can be said that we have a picture of the replacement of freshwater species with brackish and saline species (Fig. 5.).

Table 1. Taxonomic composition of zooplankton observed in Paliastom Lake

PHYLUM Rotifera			
CLASS Eurotatoria			
ORDER	FAMILY	GENUS	SPECIES
Ploima	Synchaetidae	Asplanchna	Asplanchna amphora Hudson, 1889
Flosculariaceae	Trochosphaeridae	Filinia	Filinia longiseta (Ehrenberg, 1834)
Flosculariaceae	Trochosphaeridae	Filinia	Filinia terminalis (Plate, 1886)
Ploima	Synchaetidae	Polyarthra	Polyarthra trigla Ehrenberg, 1834
Ploima	Synchaetidae	Synchaeta	Synchaeta stylata Wierzejski, 1893
Ploima	Synchaetidae	Synchaeta	Synchaeta sp.
Ploima	Trichocercidae	Diurella	
Ploima	Trichocercidae	Trichocerca	Trichocerca stylata (Gosse, 1851)
Ploima	Trichocercidae	Trichocerca	Trichocerca marina (Daday, 1890)
Ploima	Trichocercidae	Trichocerca	Trichocerca marina (Daday, 1890)
Ploima	Lecanidae	Lecane	Lecane sp.
Ploima	Euchlanidae	Euchlanis	Euchlanis dilatata Ehrenberg, 1832
Ploima	Lecanidae	Lecane	Lecane obtusa (Murray, 1913)
Ploima	Lecanidae	Lecane	Lecane bulla (Gosse, 1851)
Flosculariaceae	Testudinellidae	Testudinella	Brachionus patina Hermann, 1783
Ploima	Lepadellidae	Colurella	Colurella colurus compressa (Lucks, 1912)
Ploima	Brachionidae	Brachionus	Brachionus angularis Gosse, 1851
Ploima	Brachionidae	Plationus	Plationus patulus (Müller, 1786)
Ploima	Brachionidae	Brachionus	Brachionus falcatus Zacharias, 1898
Ploima	Brachionidae	Brachionus	Brachionus muelleri Ehrenberg, 1834
Ploima	Brachionidae	Brachionus	Brachionus budapestinensis var. punctatus Hempel, 1896
Ploima	Brachionidae	Brachionus	Brachionus bakeri O.F. Muller, 1786
Ploima	Brachionidae	Brachionus	Brachionus rubens Ehrenberg, 1838
Ploima	Brachionidae	Brachionus	Brachionus plicatilis Müller, 1786
Ploima	Brachionidae	Brachionus	Brachionus calyciflorus Pallas, 1766
Ploima	Brachionidae	Platyias	Platyias militaris (Ehrenberg) Carlin, 1944
Ploima	Brachionidae	Platyias	Platyias quadricornis (Ehrenberg, 1832)
Ploima	Brachionidae	Keratella	Keratella quadrata (Müller, 1786)
Ploima	Brachionidae	Keratella	Keratella cochlearis (Gosse, 1851)
Ploima	Brachionidae	Notholca	Notholca acuminata (Ehrenberg, 1832)
Ploima	Brachionidae	Notholca	Notholca striata (Müller, 1786)
Ploima	Gastropodidae	Gastropus	Gastropus sp.
Flosculariaceae	Hexarthridae	Hexarthra	Hexarthra mira (Hudson, 1871)
Flosculariaceae	Hexarthridae	Hexarthra	Hexarthra oxyure Sernov, 1903

FloscularIaceae	Testudinellidae	Testudinella	Brachionus patina Hermann, 1783
Flosculariaceae	Testudinellidae	Hexarthra	Hexarthra fennica (Levander, 1892)
Ploima	Synchaetidae	Synchaeta	Synchaeta monopus Plate, 1889
Bdelloidea			Bdelloidea sp.
PHYLUM Arthropoda			
CLASS Hexanauplia			
ORDER	**FAMILY**	**GENUS**	**SPECIES**
Cyclopoida	Cyclopidae	Mesocyclops	Mesocyclops leuckarti leuckarti (Claus, 1857)
Calanoida	Pseudodiaptomidae	Calanipeda	Calanipeda aquaedulcis Krichagin, 1873
Cyclopoida	Cyclopidae	Cyclops	Cyclops vicinus Uljanin, 1875
Calanoida	Centropagidae	Centropages	Centropages kroyeri Giesbrecht, 1893
Calanoida	Centropagidae	Centropages	Centropages ponticus Karavaev, 1895
Cyclopoida	Oithonidae	Oithona	Oithona nana Giesbrecht, 1893
Cyclopoida	Oithonidae	Oithona	Oithona similis Claus, 1866
Cyclopoida	Oithonidae	Oithona	Oithona minuta Scott T., 1894
Cyclopoida	Halicyclopidae	Halicyclops	Halicyclops neglectus neglectus Kiefer, 1935
Harpacticoida	Ectinosomatidae	Halectinosoma	Halectinosoma abrau (Krichagin, 1877)
Harpacticoida	Ameiridae	Nitokra	Nitokra lacustris lacustris (Schmankevitsch, 1875)
Calanoida	Acartiidae	Acartia	Acartia (Acartiura) clausi Giesbrecht, 1889
Calanoida	Temoridae	Eurytemora	Eurytemora velox (Lilljeborg, 1853)
Canuelloida	Canuellidae	Canuella	Canuella perplexa Scott T. & A., 1893
Harpacticoida	Harpacticidae	Harpacticus	Harpacticus flexus Brady & Robertson, 1873
Harpacticoida	Miraciidae	Schizopera	Schizopera jugurtha (Blanchard & Richard, 1891)
Harpacticoida	Miraciidae	Schizopera	Schizopera neglecta Akatova, 1935
Harpacticoida	Canthocamptidae	Mesochra	Mesochra aestuarii aestuarii Gurney, 1921
Harpacticoida	Laophontidae	Onychocamptus	Onychocamptus mohammed (Blanchard & Richard, 1891)
Harpacticoida	Cletodidae	Limnocletodes	Limnocletodes behningi Borutsky, 1926
Cyclopoida	Cyclopidae	Megacyclops	Megacyclops viridis viridis (Jurine, 1820)
Cyclopoida	Cyclopidae	Diacyclops	Diacyclops bicuspidatus bicuspidatus (Claus, 1857)
Cyclopoida	Cyclopidae	Mesocyclops	Mesocyclops leuckarti leuckarti (Claus, 1857)
Cyclopoida	Cyclopidae	Acanthocyclops	Acanthocyclops americanus americanus (Marsh, 1893)

Cyclopoida	Cyclopidae	Eucyclops	Eucyclops serrulatus serrulatus (Fischer, 1851)
Cyclopoida	Cyclopidae	Thermocyclops	Thermocyclops crassus crassus (Fischer, 1853)
Cyclopoida	Ergasilidae	Ergasilus	Ergasilus sp.
PHYLUM Arthropoda			
CLASS Branchiopoda			
ORDER	**FAMILY**	**GENUS**	**SPECIES**
Ctenopoda	Sididae	Diaphanosoma	Diaphanosoma brachyurum (Liévin, 1848)
Anomopoda	Macrothricidae	Lathonura	Lathonura rectirostris (O.F. Müller, 1785)
Anomopoda	Chydoridae	Chydorus	Chydorus sphaericus (O.F. Müller, 1776)
Anomopoda	Daphniidae	Ceriodaphnia	Ceriodaphnia setosa Matile, 1890
Anomopoda	Daphniidae	Ceriodaphnia	Ceriodaphnia pulchella G.O. Sars, 1862
Anomopoda	Daphniidae	Ceriodaphnia	Ceriodaphnia quadrangula (O.F. Müller, 1785)
Anomopoda	Daphniidae	Simocephalus	Simocephalus vetulus (O.F. Müller, 1776)
Anomopoda	Chydoridae	Coronatella	Coronatella rectangula (G.O. Sars, 1862)
Anomopoda	Daphniidae	Scapholeberis	Scapholeberis mucronata (O.F. Müller, 1776)
Onychopoda	Podonidae	Pleopis	Pleopis polyphemoides (Leuckart, 1859)
Onychopoda	Podonidae	Podon	Podon intermedius Lilljeborg, 1853
Ctenopoda	Sididae	Penilia	Penilia avirostris Dana, 1849
Anomopoda	Daphniidae	Daphnia	Daphnia (Daphnia) longispina (O.F. Müller, 1776)
Trombidiformes			Hydrachnidia sp.
PHYLUM Ctenophora			
CLASS Tentaculata			
ORDER	**FAMILY**	**GENUS**	**SPECIES**
Cydippida	Pleurobrachiidae	Pleurobrachia	Pleurobrachia pileus (O. F. Müller, 1776)
Lobata	Bolinopsidae	Mnemiopsis	Mnemiopsis leidyi A. Agassiz, 1865
Beroida	Beroidae	Beroe	Beroe ovata Bruguière, 1789
PHYLUM Cnidaria			
CLASS Sciphozoa			
ORDER	**FAMILY**	**GENUS**	**SPECIES**
Rhizostomeae	Rhizostomatidae	Rhizostoma	Rhizostoma pulmo (Macri, 1778)
Semaeostomeae	Ulmaridae	Aurelia	Aurelia aurita (Linnaeus, 1758)
PHYLUM Sagittoidea			
CLASS Aphragmorpha			
ORDER	**FAMILY**	**GENUS**	**SPECIES**

Aphragmophora	Sagittidae	Parasagitta	Parasagitta setosa (J. Müller, 1847)
19	40	66	88

Table 2. Species composition of zooplankton observed in Paliastom Lake in different years.

SPECIES	1940*	1974-81**	2015-21***
Asplanchna amphora Hudson, 1889	+	+	+
Filinia longiseta (Ehrenberg, 1834)	+	+	+
Filinia terminalis (Plate, 1886)	+		
Polyarthra trigla Ehrenberg, 1834	+	+	+
Synchaeta stylata Wierzejski, 1893	+	+	+
Synchaeta sp.	+		
Diurella	+		
Trichocerca stylata (Gosse, 1851)	+		
Trichocerca marina (Daday, 1890)	+		
Trichocerca marina (Daday, 1890)	+		
Lecane sp.	+		
Euchlanis dilatata Ehrenberg, 1832	+		
Lecane obtusa (Murray, 1913)	+		
Lecane bulla (Gosse, 1851)	+		
Brachionus patina Hermann, 1783	+		
Colurella colurus compressa (Lucks, 1912)	+		
Brachionus angularis Gosse, 1851	+		
Plationus patulus (Müller, 1786)	+		
Brachionus falcatus Zacharias, 1898	+		
Brachionus muelleri Ehrenberg, 1834	+		
Brachionus budapestinensis var. punctatus Hempel, 1896	+		
Brachionus bakeri O.F. Muller, 1786	+	+	+
Brachionus rubens Ehrenberg, 1838		+	
Brachionus plicatilis Müller, 1786		+	+
Brachionus calyciflorus Pallas, 1766		+	+
Platyias militaris (Ehrenberg) Carlin, 1944	+		
Platyias quadricornis (Ehrenberg, 1832)	+		
Keratella quadrata (Müller, 1786)	+	+	+
Keratella cochlearis (Gosse, 1851)	+	+	
Notholca acuminata (Ehrenberg, 1832)	+	+	+
Notholca striata (Müller, 1786)	+		

Gastropus sp.	+		
Hexarthra mira (Hudson, 1871)	+	+	+
Hexarthra oxyure Sernov, 1903	+	+	+
Brachionus patina Hermann, 1783		+	
Hexarthra fennica (Levander, 1892)		+	+
Synchaeta monopus Plate, 1889		+	+
Bdelloidea sp.		+	
Mesocyclops leuckarti leuckarti (Claus, 1857)	+		
Calanipeda aquaedulcis Krichagin, 1873	+	+	+
Cyclops vicinus Uljanin, 1875		+	
Centropages kroyeri Giesbrecht, 1893	+	+	
Centropages ponticus Karavaev, 1895	+	+	+
Oithona nana Giesbrecht, 1893	+	+	+
Oithona similis Claus, 1866		+	+
Oithona minuta Scott T., 1894	+		
Halicyclops neglectus neglectus Kiefer, 1935	+		
Halectinosoma abrau (Krichagin, 1877)	+	+	+
Nitokra lacustris lacustris (Schmankevitsch, 1875)		+	
Acartia (Acartiura) clausi Giesbrecht, 1889		+	
Eurytemora velox (Lilljeborg, 1853)		+	
Canuella perplexa Scott T. & A., 1893		+	
Harpacticus flexus Brady & Robertson, 1873		+	
Schizopera jugurtha (Blanchard & Richard, 1891)		+	
Schizopera neglecta Akatova, 1935		+	
Mesochra aestuarii aestuarii Gurney, 1921		+	
Onychocamptus mohammed (Blanchard & Richard, 1891)		+	
Limnocletodes behningi Borutsky, 1926		+	
Megacyclops viridis viridis (Jurine, 1820)		+	
Diacyclops bicuspidatus bicuspidatus (Claus, 1857)			
Mesocyclops leuckarti leuckarti (Claus, 1857)			
Acanthocyclops americanus americanus (Marsh, 1893)			
Eucyclops serrulatus serrulatus (Fischer, 1851)			
Thermocyclops crassus crassus (Fischer, 1853)			
Tropocyclops prasinus prasinus (Fischer, 1860)			+
Ergasilus sp.			
Diaphanosoma brachyurum (Liévin, 1848)	+	+	+
Lathonura rectirostris (O.F. Müller, 1785)	+	+	+
Bosmina (Bosmina) longirostris (O.F. Müller, 1785)	+	+	+

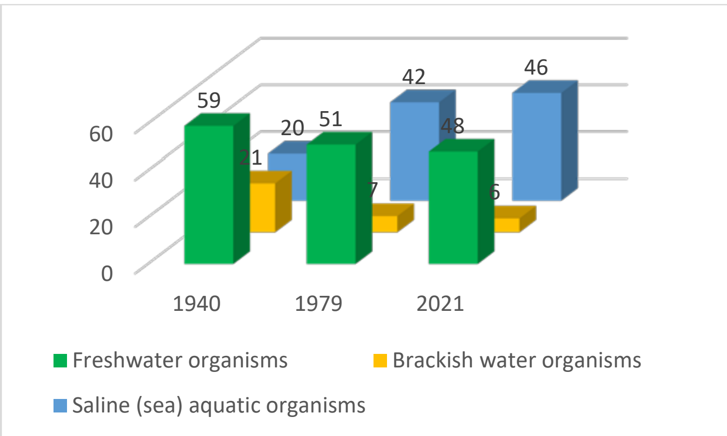
Alona costata G.O. Sars, 1862			+
Chydorus sphaericus (O.F. Müller, 1776)	+		+
Ceriodaphnia setosa Matile, 1890	+		
Ceriodaphnia pulchella G.O. Sars, 1862	+		
Ceriodaphnia quadrangula (O.F. Müller, 1785)		+	+
Simocephalus vetulus (O.F. Müller, 1776)	+		
Coronatella rectangula (G.O. Sars, 1862)	+		
Scapholeberis mucronata (O.F. Müller, 1776)	+		
Pleopis polyphemoides (Leuckart, 1859)	+	+	
Podon intermedius Lilljeborg, 1853		+	+
Penilia avirostris Dana, 1849		+	+
Daphnia (Daphnia) longispina (O.F. Müller, 1776)		+	+
Daphnia cucullata G.O. Sars, 1862			+
Hydrachnidia sp.			
Pleurobrachia pileus (O. F. Müller, 1776)			+
Mnemiopsis leidyi A. Agassiz, 1865			+
Beroe ovata Bruguière, 1789			+
Rhizostoma pulmo (Macri, 1778)			+
Aurelia aurita (Linnaeus, 1758)			+
Parasagitta setosa (J. Müller, 1847)			+
Total	49	43	35

1940* - Куделина, 1940.

1974-81** - Burchuladze et all. 1974; Mikashavidze, 1981.

2015-21*** - Our data.

Fig. 5. Percentage composition of fresh, brackish, and saline organisms in zooplankton of Lake Paliastomi.



Macrozoobenthos of Paliastomi Lake.

Benthos Animals Biodiversity.

Benthic fauna of Paliastomi Lake consists of 3 main components: Ponto-Caspian relicts ((Pontogammarus robustoides, Chaetogammarus ischnus), Black Sea forms (Nereis succinia, Merciella enigmatica, Balanus improvisus, Mesopodopsis slabberi, Hedrobia sp., Cardium sp.) and freshwater forms resistant to salinity.

Based on the evidence, species composition (in total 54 species) in the Paliastomi Lake zooplankton are united into 7 types, 12 classes, 28 orders, 36 families and 49 genera. The most diverse are anthropods united in 4 classes and 7 orders, in total 25 species, which represents 49% of the specie composition in benthic fauna. Anthropods are dominated by Malacostraca class, which unites 13 species. It is followed by Insecta class with 10 species. According to the species diversity in the benthic fauna, mollusks (in total 15 species) take the second place after anthropods, which unites 6 species of Bivalvia and 9 species of Gastropoda.

It was first observed by us in Lake Paliastomi: One species of foraminifera - Ammonia beccarii (Linnaeus, 1758). Four species of bivalve molluscs: Mytilus galloprovincialis Lamarck, 1819; Mytilaster lineatus (Gmelin, 1791); Mactra stultorum (Linnaeus, 1758); Cardium glaucum Bruguière, 1789. One species from decapoda - Xantho poressa (Olivi, 1792). One copy of the insect - Trichoptera sp.. Membranipora sp. from Bryozoa. Only from the listed Trichoptera belongs to the form of fresh water. The rest are (sea) saltwater organisms.

Oligochaetas dominate during spring, and polychaetes during summer and autumn. There is benthopelagic misidacea as well. Insects at larvae stage were not detected in the benthos samples, except for, chironomidaes related to lack of water plants (above and in water), water salinity and its fluctuations.

The benthos widely represents gastropods (Hydrobia acuta) and Bivalvia, without any consumers in the lake. Only Gobiidae family fishes feed on small size mollusks.

Table 3. Macrozoobenthos Species composition in the Lake Paliastomi

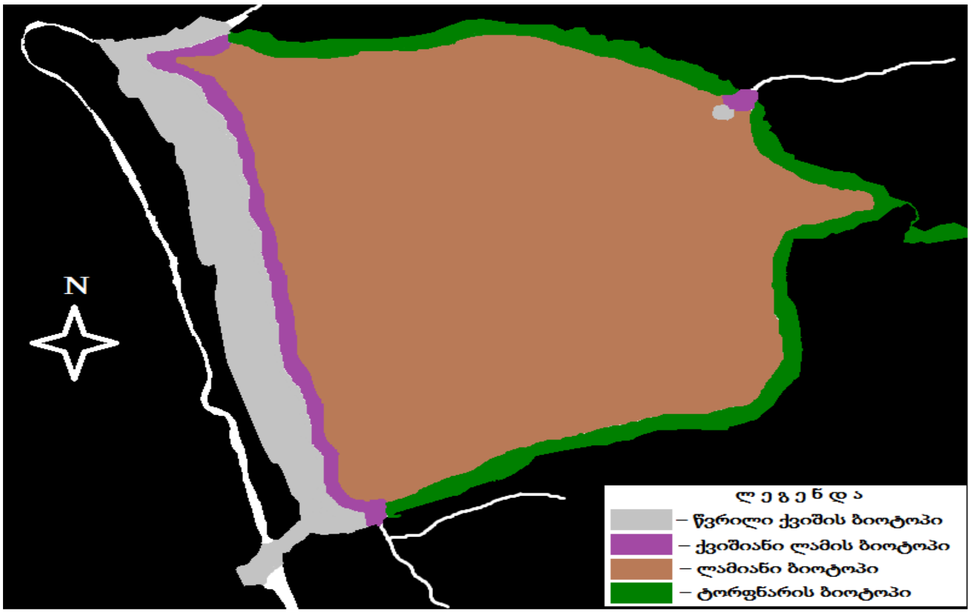
PHYLUM Foraminifera			
CLASS Globothalamea			
ORDER	FAMILY	GENUS	SPECIES
Rotaliida	Ammoniidae	Ammonia	Ammonia beccarii (Linnaeus, 1758)
PHYLUM Cnidaria			
CLASS Hydrozoa			
Anthoathecata	Cordylophoridae	Cordylophora	Cordylophora caspia (Pallas, 1771)
PHYLUM Nematoda			
CLASS Chromadorea			
Chromadorida	Chromadoridae	Prochromadora	Prochromadora megadonta Filipjev, 1922
Araeolaimida	Axonolaimidae	Axonolaimus	Axonolaimus typicus de Man, 1922
PHYLUM	Annelida		
CLASS	Clitellata		
Rhynchobdellida	Piscicolidae	Piscicola	Piscicola geometra (Linnaeus, 1761)
Haplotaxida	Naididae	Paranais	Paranais litoralis (Müller, 1784)
		Potamothrix	Potamothrix hammoniensis (Michaelsen, 1901)
		Nais	Nais pardalis Piguet, 1906
		Limnodrilus	Limnodrilus claparedianus Ratzel, 1869
		Tubifex	Tubifex tubifex (Müller, 1774)
CLASS Polychaeta			
Sabellida	Serpulidae	Ficopomatus	Ficopomatus enigmaticus (Fauvel, 1923)
Phyllodocida	Nereididae	Alitta	Alitta succinea (Leuckart, 1847)
PHYLUM Mollusca			
CLASS Bivalvia			
Cardiida	Cardiidae	Cerastoderma	Cerastoderma glaucum (Bruguière, 1789)
Mytilida	Mytilidae	Mytilus	Mytilus galloprovincialis Lamarck, 1819
		Mytilaster	Mytilaster lineatus (Gmelin, 1791)
Venerida	Mactridae	Mactra	Mactra stultorum (Linnaeus, 1758)
Cardiida	Cardiidae	Cerastoderma	Cardium glaucum Bruguière, 1789
Myida	Dreissenidae	Mytilopsis	Mytilopsis leucophaeata (Conrad, 1831)
CLASS	Gastropoda		
Cardiida	Tellinidae	Tellina	Tellina sp.
Littorinimorpha	Hydrobiidae	Hydrobia	Hydrobia acuta (Draparnaud, 1805)
Hygrophila	Physidae	Physella	Physella acuta (Draparnaud, 1805)
Caenogastropoda	Melanopsidae	Melanopsis	Melanopsis sp
Cycloneritida	Neritidae	Clithon	Clithon oualaniense (Lesson, 1831)
Hygrophila	Planorbidae	Planorbis	Planorbis planorbis (Linnaeus, 1758)
	Lymnaeidae	Stagnicola	Stagnicola palustris (O. F. Müller, 1774)
Architaenioglossa	Viviparidae	Viviparus	Viviparus contectus (Millet, 1813)
			Viviparus viviparus (Linnaeus, 1758)
PHYLUM Arthropoda			

CLASS Ostracoda			
			Ostracoda sp.
CLASS Hexanauplia			
Sessilia	Balanidae	Amphibalanus	Amphibalanus improvisus (Darwin, 1854)
CLASS Malacostraca			
Mysida	Mysidae	Mesopodopsis	Mesopodopsis slabberi (Van Beneden, 1861)
		Limnomysis	Limnomysis benedeni Czerniavsky, 1882
Amphipoda	Corophiidae	Chelicorophium	Chelicorophium curvispinum (G.O. Sars, 1895)
	Gammaridae	Echinogammarus	Echinogammarus ischnus (Stebbing, 1899)
		Pontogammarus	Pontogammarus robustoides (Sars, 1894)
		Gammarus	Gammarus locusta (Linnaeus, 1758)
			Gammarus crinicornis Stock, 1966
	Talitridae	Cryptorchestia	Cryptorchestia garbinii Ruffo, Tarocco & Latella, 2014
	Melitidae	Melita	Melita nitida S.I. Smith in Verrill, 1873
Decapoda	Palaemonidae	Palaemon	Palaemon elegans Rathke, 1837
	Xanthoidea	Xantho	Xantho poressa (Olivi, 1792)
	Panopeidae	Rhithropanopeus	Rhithropanopeus harrisii (Gould, 1841)
	Astacidae	Astacus	Astacus colchicus Kessler, 1876
CLASS Insecta			
Diptera	Chironomidae	Limnochironomus	Dicrotendipes nervosus (Staeger, 1839)
		Cryptochironomus	Cryptochironomus burganadzeae Tshernovskij
			Cryptochironomus defectus (Kieffer, 1921)
			Cryptochironomus conjugens (Kieffer,1921)
		Procladius	Procladius sp.
		Chironomus	Chironomus plumosus (Linnaeus, 1758)
			Chironomus sp.
		protentes	protentes sp.
		Tanypus	Tanypus sp.
Trichoptera			Trichoptera sp.
PHYLUM Bryozoa			
CLASS Gymnolaemata			
Ctenostomatida	Victorellidae	Victorella	Victorella sp.
	Membraniporidae	Membranipora	Membranipora de Blainville, 1830
28	36	49	54

The coastline in north, east and south-east of the lake is covered with peat soil, spread in 100-150 meters from the coastline, followed by silted sediments. Area in the south and south west from the confluence of the Tkhorina River to Kaparcha River is covered by sandy soil which is found in about 100 meters from the coastline to south-west, and more broadly in 400-500 meters in the west part. Thin line of sandy-silted soil lies between silted sediment and sandy soil, which is broadened in the confluence of the Tkhorina River and at the Kaparcha River source.

Based on the soil types of Paliastomi Lake and related environment, the following biotopes are differentiated: peatland biotope, sandy biotope, silty biotope, and also, interim – sandy silted transitional biotope (picture 5). Each of these biotopes are characterized by some of the features of benthos, which can be considered as bottom biocoenosis. Silty biotope is the largest taking more than 70% of the lake area.

Fig. 5. Bottom biotopes of Paliastomi



The legend: Thin sand biotope - , Sandy sludge biotope - ,

Sludge biotope - , Biotope of peat bog .

A form characterized to the Paliastomi benthos is N. succinea, which prevails all the biotopes, except for peatland. Thus, N. succinea is a eurytopic form in Paliastomi Lake and could not be used for characterizing a biotope. Peatland biotope biocoenosis is represented by Corophium + Chironomidae, sandy biotope biocoenosis - Gammarus + Corophium, and silty biotope biocoenosis by Oligohaeta + Ostracoda, sandy silted transitional biotope biocoenosis is formed by N. succinea + Corophium + Chironomidae.

Corophium curvispinum in the peatland biocoenosis takes on average 80-85% of total benthos number and on average 50-55% of the total benthos biomass. Chironomidae takes second place by the number (on average 8-8.5%) and biomass, mainly represented by Tanupus genera. The secondary components of this biocoenosis are: G. robustoides, N. succinea, Ostracoda და Oligohaeta (Limnodrilus claparedianus), this biocoenosis is the richest in Paliatomi, its biomass is from 0.8 to 31.06 gr/m^2, which 8.5 gr/m^2 on average.

N. succinea takes the highest number (70-77%) in the sandy biotope biocoenosis, G. robustoides is the second, and the secondary component of this biocoenosis is C. curvispinum. This biocoenosis is relatively poor according to its biomass and number, its biomass is from 0.47 to 1.190 gr/m^2, on average 1.06 gr/m^2, the average number is 263 sample/m^2.

Nereis succinea is the largest form of the silty biotope biocoenosis, which takes on average 68% of the total benthos biomass, and 50% of total number. Oligohaeta representatives take the second place: Hyodrilus hammoniensis and Limnodrilus claparedianus which cover 35% of the total benthos number and 26% of biomass in this biocoenosis. Ostracoda takes about 12% of the total number. A total benthos biomass in the biocoenosis is 2.218–10.210 gr/m^2, on average 4.690 gr/m^2. An average number is 573 sample/m^2.

Nereis succinea also prevails in the sandy silted biotope biocoenosis, Corophium curvispinum and Chironomidae are represented by a significant number, a total biomass of this biocoenosis is 3,733 gr/m^2, and the number is 1053 sample/m^2.

The biotopes mentioned above, except for sandy silted biotope, significantly differ from one another by bio-ecological conditions, topographically occupy relatively permanent areas over time and are functioning as a subsystems of common ecosystem. This is clearly evidenced by lack of Chironomidae and Oligohaeta in the sandy biotope, and of Corophium and Gammarus in the silty biotope. However, there are some common characteristics between the Paliastomi biotopes, for example, in all biotopes, except for peatland, N. Succinea prevails.

Table 4. Species composition of macrozoobenthos observed in Paliastom Lake in different years.

#	SPECIES	1940*	1979**	2015-21***
1	Ammonia beccarii (Linnaeus, 1758)			+
2	Cordylophora caspia (Pallas, 1771)	+		
3	Prochromadora megadonta Filipjev, 1922	+		
4	Axonolaimus typicus de Man, 1922	+		
5	Piscicola geometra (Linnaeus, 1761)	+		+
6	Paranais litoralis (Müller, 1784)	+	+	+
7	Potamothrix hammoniensis (Michaelsen, 1901)	+		+
8	Nais pardalis Piguet, 1906	+	+	+
9	Limnodrilus claparedianus Ratzel, 1869	+	+	+
10	Tubifex tubifex (Müller, 1774)	+	+	+
11	Ficopomatus enigmaticus (Fauvel, 1923)	+	+	+
12	Alitta succinea (Leuckart, 1847)	+	+	+
13	Cerastoderma glaucum (Bruguière, 1789)	+	+	+
14	Mytilus galloprovincialis Lamarck, 1819			+
15	Mytilaster lineatus (Gmelin, 1791)			+
16	Mactra stultorum (Linnaeus, 1758)			+
17	Cardium glaucum Bruguière, 1789		+	+
18	Mytilopsis leucophaeata (Conrad, 1831)			+
19	Tellina sp.		+	+
20	Hydrobia acuta (Draparnaud, 1805)		+	+
21	Physella acuta (Draparnaud, 1805)			+
22	Melanopsis sp			+
23	Clithon oualaniense (Lesson, 1831)			+
24	Planorbis planorbis (Linnaeus, 1758)	+		+
25	Stagnicola palustris (O. F. Müller, 1774)	+		
26	Viviparus contectus (Millet, 1813)	+		
27	Viviparus viviparus (Linnaeus, 1758)			+
28	Ostracoda sp.	+	+	+
29	Amphibalanus improvisus (Darwin, 1854)	+	+	+
30	Mesopodopsis slabberi (Van Beneden, 1861)	+		
31	Limnomysis benedeni Czerniavsky, 1882	+		+
32	Chelicorophium curvispinum (G.O. Sars, 1895)	+		+
33	Echinogammarus ischnus (Stebbing, 1899)		+	+
34	Pontogammarus robustoides (Sars, 1894)	+	+	+
35	Gammarus locusta (Linnaeus, 1758)	+		
36	Gammarus crinicornis Stock, 1966			+
37	Cryptorchestia garbinii Ruffo, Tarocco & Latella, 2014			+
38	Melita nitida S.I. Smith in Verrill, 1873			+
39	Palaemon elegans Rathke, 1837	+		+
40	Xantho poressa (Olivi, 1792)			+

41	Rhithropanopeus harrisii (Gould, 1841)			+
42	Astacus colchicus Kessler, 1876	+	+	+
43	Dicrotendipes nervosus (Staeger, 1839)		+	
44	Cryptochironomus burganadzeae Tshernovskij		+	
45	Cryptochironomus defectus (Kieffer, 1921)		+	
46	Cryptochironomus conjugens (Kieffer,1921)		+	
47	Procladius sp.		+	
48	Chironomus plumosus (Linnaeus, 1758)	+	+	+
49	Chironomus sp.	+		+
50	protentes sp.	+		
51	Tanypus sp.	+		+
52	Trichoptera sp.			+
53	Victorella sp.	+		
54	Membranipora de Blainville, 1830			+
	54	29	21	40

1940* - (Куделина, 1940). 1979**- (Сергеева, 1979). 2015-21***- Ours and others Authors (Mumladze et al. 2019; Copilas-Ciocianu et al. 2020; Japoshvili et al. 2020)მიხედვით

Conservative Status, Recommendations and Programmes for Protection, Restoration and Sustainable Management of the Species and Habitat.

There are several projects in talks to be implemented regarding Paliastomi Lake and we would like to offer our opinion.

Desalination of the Lake. In the 1930s, the Paliastomi Lake ecosystem was fundamentally transformed from fresh water and partly salinized type to the mainly salinized type, followed by negative events reflected in all biological conditions of the lake. This change was particularly harmful for qualitative and quantitative structure of ichthyocoenosis.

Nowadays, there are benthos, planktonic and nektonic systems formed in the lake. Currently, Paliastomi Lake properly functions as a Liman lagoon type ecosystem like other similar systems in the different Black Sea locations. We think that potential of such system is not fully revealed.

We think desalination of the lake and related manipulations are unjustified. The ecological immunity of the lake has been significantly weakened after multiple "experiments" carried in the recent century, it is possible that additional anthropogenic intervention may lead to total demolition of the lake bio-geo system. For example, arranging of culvert floodgate in the Maltakva channel linking the lake with the sea or permanent removal of the channel, with a purpose to recover previous hydrodynamic, hydrological and hydrobiological conditions, will lead to massive destruction of mullet family migrations distorting fishery in the lake. Desalination of the lake will have a negative influence of planktonic and benthos communities of the lake.

Deepening of the Lake and Organic Slime Removal. Currently, depth of Paliastomi Lake has been decreased from 6 to 2,6 meters. Removal of mass from the bottom considering unstable soil will cause increase angle of inclination in the territory. Due to slopping surface, there is a risk of slide for refilling a territory which is a threat for complete disappearance of the lake instead of deepening.

Artificial deepening will destroy detritus (dead cells) of plant and animal origin in the lake bottom, which is the main feed for fish there, and its formation requires hundreds of years. If during deepening process only above horizon of organic slime is removed, peat horizon surface will be opened, which contains a high number of poorly decomposed organic material. Decomposition of this material underwater will continue during dozen of years, which will provoke biological pollution of the lake.

The Lake Biological Melioration and Biological Conservation/Growth of Depths. Relatively high consistence of minerals and biogenic substances, thermal regime and some other characteristics, there is a massive development of planktonic organisms (mainly during spring-summer) followed by worsening of qualitative indicators and transparency, color change (green-yellowish), unpleasant smell, oxygen deficiency in water, dramatic activation of intensive organic sediment processes (accumulation of organic silt on the bottom) and formation of anaerobic and hypo aerobic layers within the bottom layer. All of the mentioned above, have a negative influence on sanitary-ecological and tourism-recreational potential of the basin.

Considering water plants development, which is one of the most important components of natural feed in Paliastomi Lake, belongs to the high productivity basins, however, only detritus and periphytons feed on water plants, phytoplankton is not fully engaged in the lake trophic flows and is not directly used as a feed by fishes. Considering excessive number of phytoplankton, most frequently revealed in water "blossoming" with follow up negative processes, it is important to ensure full occupation by this trophic flows for improvement ecological conditions in the lake.

The lake also lacks well-defined zooplanktonophages. Zooplankton with high biomass is mainly colonized by fish on larvae and fry stages, which does not really influence zooplankton biomass.

There are no consumers of large Bivalvia and Gastropadas the number and biomass is quite high in the lake. Historically, large benthophages, sturgeons, common carp, abramis and tench were feeding on this fraction, which are extremely poorly represented in the lake.

Along with colonization of planktonic fractions, sedimentation of dead planktonic mass, formation of detritus-silt on the lake bottom and consequently "thinning down" of the lake decreases significantly.

There are multiple methods adopted for the quality improvement and melioration of the water in basins, including, chemical, physical, mechanical and biological methods. In the recent years, developing countries widely use biological sanitation and melioration methods, for its efficiency, productivity and lack of side effects (ecological safety).

In the mesotrophic and eutrophic basins (such as, Paliastomi) of variable zone bio sanitation with Chinese model, often referred to as sanitary model, is used without a question. The Chinese model covers:

1. Bighead carp (Hypophthalmichthys nobilis (J. Richardson, 1845)) and silver carp (Hypophthalmichthys molitrix (Valenciennes, 1844)) – feed on planktonic fraction (bighead carp usually uses phytoplankton, and silver carp – zooplankton);

2. Grass carp (Ctenopharyngodon idella (Valenciennes in Cuvier & Valenciennes, 1844)) – feeds on macrophytes and the water highest plants;
3. Common carp (Cyprinus carpio Linnaeus, 1758) – feeds on benthos and detritus silt;
4. Sometimes, the Chinese model also includes black carp (Mylopharyngodon piceus (J. Richardson, 1846)) – which feeds on mollusks.

This model is the most effective in terms of bio-sanitation of the basins, as it transforms all organic and mineral flows in the ichthyomass.

One important thing to mention is that, except for common carp, the Chinese model requires specific conditions for reproduction, which permits it from independent reproduction outside its native Amur River basin, thus, there is a risk of its bioinvasion in the environment, which is important in terms of environment protection.

Reduction of Goldfish Negative Influence. One of the key reasons of decreasing indigenous species in Paliastomi Lake is the invasion of goldfish. It is an invasive specie widely spread in Georgia. It is distinguished by high reproduction, at the expense of multiple spawning, is able to reproduce sexually or asexually parthenogenetically according to the environmental conditions. It adapts to and inhabits any biotope conditions; is less demanding on oxygen, is able to bear lack of oxygen and water drying during one year. In case of intensive reproduction and lack of consumers (preventive catching), it is able to fully occupy the basin space and displace any predator fish, not even mentioning non-predatory fish. It has an ability to destroy common carps and other fishes for years.

The only possible solution for decreasing number of goldfish is annual restocking of fish with the identical nutritional form, in particular, common carp. It is also important to ensure balanced increase of predatory fish in the lake. The most effective in this regard is a predator – sander, which is not represented in Paliastomi, while its restoration is important to balance of the lake ecosystem. To decrease a number of goldfish it is important to organize its selective catching.

Restoration of Sturgeon in Paliastomi. Use of Paliastomi Lake for the restoration of sturgeons would be very effective as Paliastomi has a constant link with the sea, which limits free flowing out of young fish into the sea. The basin is characterized with a high gradation of salinity, from fresh water and less salinized location to 16% salinity location, which simplifies adaptation of fries with the Black Sea salinity. High biomass volume of benthos and benthic planktonic invertebrate forms, polychytes, demershal fish and small mollusks, creates precondition for high growth rate, additionally, the basin is distinguished by relative small number of predators.

Restoration of Common Carp and Pikeperches in Paliastomi. Common carp and Pikeperches were always one of the most spread and precious animals in fishery. In the recent decades, anthropogenic manipulations and excessive catching have led to the significant decrease of common carp and Pikeperches population in Paliastomi, collapse of the supply ad replacement of this ecological niche by non-commercial "weeds" species. Rehabilitation of common carp and Pikeperches would have allowed for use of the basin bio productivity, energy and substance flow for the practical purposes while transforming the basin's nutritional base to the actual feed.

Conclusion

The following conclusions were developed based on the scientific-research works conducted during 2015-2020 within a doctorate thesis:

1. Our research revealed increasing tendency of the average annual salinity in Paliastomi Lake. In particular, in 1897 the lake water salinity was 2,2 ‰, in 1930 - 4,0‰, in 1966 - 5,7 ‰, in 1999 - 7,2 ‰, while in 2015 salinity reached 8,1 2 ‰. Water salinity, its vertical and horizontal distribution, monthly fluctuations have a huge influence on, and practically define, consistence and dynamics of the biological environment.

2. Paliastomi Lake belongs to eutrophic group of basins according to its thermal regime, biogenic composition, quantitative-qualitative indicators of benthos and plankton fractions and other characteristics. Due to shallowness and frequent strong storms, the main part of Paliastomi Lake lacks macrophyte benthos. Its small cenosis of macrophyte benthos are represented at the confluence of Pichori River, small Paliastomi, Kaparcha River, in some of the locations of dugs and coastline. According to our research, these cenosis are settled with high water plants, such as Eurasian watermilfoil, tropical hornwort and Colchis water caltrop.

In total, there are 23 species of macrophytes in the coastline and thin watersof the lake: semi aquatic plants, aquatic plants and floating leaf plants.

3. There are 203 species and subspecies of phytoplankton water plants detected in Paliastomi Lake, where the most dominated are diatoms -106, green – 49, blue-green-21, pyrophytics – 15, euglenes – 11, gold - 1.

According to the 2015-2020 data, the Paliastomi Lake phytoplankton is not distinguished by horizontal and vertical zoning. There is a small difference between the phytoplankton localities, except for the Pichori river confluence and some other locations, and there is not a practical difference between phytoplanktons of the coastline and open locations. This could be explained by intensive mixture of the lake waters, caused by winds, storms, flows.

Considering the water plants development, which is one of the most important components of natural feed, Paliastomi Lake belongs to the high productivity basins. However, only detritus and periphytons partially feed on water plants. Also, phytoplankton is not fully engaged in the lake trophic flows and is not directly used as a feed by fishes. We think that it is important to ensure full occupation of the lake with phytophagous fish will improve ecological conditions in the lake.

4. To researcg the zooplankton biodiversity in Paliastomi Lake, we have collected and analysed up to 300 samples. According to the research, we have identified 31 forms of zooplankton in Paliastomi Lake, including 13 species of wheel animals, 5 – Copecoda, 8 – waterfleas, 1 – Coelenterata and 5 meroplanktonic forms. According to our data, zooplankton is dominated by euryhaline and polyhaline species.

According to our calculations, the number of zooplankton in Paliastomi Lake is between 7900 sample/m^3 to 424 600 sample/m^3, average is 86 500 sample/m^3. It shall be noted that we did not detected any larvae forms of insects in zooplankton.

5. Seven species were first found by us in samples from Lake Zooplankton. These are: Tropocyclops prasinus prasinus (Fischer, 1860); Alona costata G.O. Sars, 1862; Daphnia cucullata G.O. Sars, 1862; Pleurobrachia pileus (O. F. Müller, 1776); Mnemiopsis leidyi A. Agassiz, 1865; Beroe ovata Bruguière, 1789; Parasagitta setosa (J. Müller, 1847); All of these

are saltwater (sea) organisms, And are widespread along the Black Sea coast. From whence they meet in a lake of strong turmoil. Based on our research, we may conclude that zooplanktonic species of the sea are now spreading in Paliastomi Lake and fresh water forms are gradually decreasing.

6. In the bottom of Paliastomi Lake there are peatland biotope, sandy biotope, silty biotope, and also, interim – sandy silted transitional biotope. Each of these biotopes are characterized by some of the features of benthos, which can be considered as the bottom biocoenosis. Silty biotope is the largest taking more than 70% of the lake area. Nereis succinea is the largest form of the silty biotope biocoenosis, which takes on average 68% of the total benthos biomass, and 50% of total number. Oligohaeta representatives: Hyodrilus hammoniensis and Limnodrilus claparedianus take the second place which cover 35% of the total benthos number and 26% of biomass in this biocoenosis. Ostracoda takes about 12% of the total number. A total benthos biomass in the biocoenosis is 2.218–10.210 gr/m^2, on average 4.690 gr/m^2. An average number is 573 sample/m^2.

Corophium curvispinum in the peatland biocoenosis takes on average 80-85% of total benthos number and on average 50-55% of the total benthos biomass. Chironomidae takes second place by the number (on average 8-8.5%) and biomass, mainly represented by Tanupus genera representatives. The secondary components of this biocoenosis are: Gammarus robustoides, Nereis succinea.

Nereis succinea also dominates sandy biotope biocoenosis (70-77%), the second by the number is Gammarus robustoides.

Nereis succinea also prevails in the sandy silted biotope biocoenosis, Corophium curvispinum and Chironomidae are represented by a significant number, a total biomass of this biocoenosis is 3,733 gr/m^2, and the number is 1053 sample/m^2.

7. It was first observed by us in Lake Paliastomi: One species of foraminifera - Ammonia beccarii (Linnaeus, 1758). Four species of bivalve molluscs: Mytilus galloprovincialis

Lamarck, 1819; Mytilaster lineatus (Gmelin, 1791); Mactra stultorum (Linnaeus, 1758); Cardium glaucum Bruguière, 1789. One species from decapoda - Xantho poressa (Olivi, 1792). One copy of the insect - Trichoptera sp.. Membranipora sp. from Bryozoa. Only from the listed Trichoptera belongs to the form of fresh water. The rest are (sea) saltwater organisms. As in the zooplankton, spread of the sea forms and reducing fresh water forms are also visible in the benthofauna diversity.

8. We have specified the species composition and nomenclature of the Paliastomi Lake ichthyofauna. We have defined a conservative status of the ichthyofauna representatives. The conservation strategy and action plan have been developed accordingly.

9. Studies have shown that the migration of new forms from the sea to Lake Paliastomi continues. Including alien, invasive species for the Black Sea (rapana, beroe, mnemiopsis, etc.). This process will continue and the diversity of Lake Paliastomi hydrobionts will further increase with sea forms.

The published works within around the dissertation work:

1. Y. Kharytonova, M. Nabokin, M. Mgeladze, P.Vadachkoria, V. Dyadichko Current state and long-term changes in the mesozooplankton community of the Ukrainian and Georgian parts of the Black Sea as indicators of its ecological status Biosystems diversity. V.29 (1). 2021. DOI: https://doi.org/10.15421/012107

2. Paata Vadachkoria, Andrei Tregubov, Guranda Makharadze, Eteri Mikashavidze & Madona Varshanidze. Distribution and Quantitative Characteristics of Four Invasive Alien Species off the Black Sea Coast of Georgia. ACTA ZOOLOGICA BULGARICA, 72 (4), 539-544. 2020. http://www.acta-zoologica-bulgarica.eu/00SIO_1_08

3. Andrei Tregubov, Paata Vadachkoria, Ramaz Mikeladze Determination of Size-weight percentage of Invasive Bivalve Mollusk Anadara inaadival (Bruguière, 1789)in the Black Sea. International Journal of Environmental Sciences (ISSN: 2277-1948) (CIF: 3.654). Vol. 10. No.1. 2021. IJES – CRDEEP Journals

4. National Pilot Monitoring Studies and Joint Open Sea Surveys in Georgia, Russian Federation and Ukraine, 2016. Editors: J. Slobodnik, B. Alexandrov, V. Komorin, A. Mikaelyan, A. Guchmanidze, M. Arabidze, A. Korshenko, S. Moncheva. II.2. Zooplankton Completed by: Alexandrov B. Authors: Anokhina L.L., Dykyi E., Mgeladze M., Mikaelyan A.S., Mikeladze R., Shiganova T.A., Vadachkoria P., Zasko D.N. 2017. EMBLAS-II_NPMS_JOSS_2016_ScReport_Final3.pdf (emblasproject.org)

5. Mariculture (Marine Farming) Business Guide. Ed. R. Mikeladze. Group of researchers: Ts. Katamidze, I. Zakaria, K. Guchmanidze, P. Vadachkoria. 2018. (in Georgien)

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1. World Register of Marine Species (WoRMS): http://www.marinespecies.org.

2. European Register of Marine Species (ERMS): http://www.marbef.org/data/erms.php.

3. Marine Species Identification Portal: http://species-identification.org.

4. FishBase: www.fishbase.org.