Universitatea „Dunărea de Jos” din Galaţi

Școala doctorală de Inginerie Industrială

TEZĂ DE DOCTORAT

Analiza ecosistemelor acvatice ale principalelor lacuri din Delta Dunării în vederea exploatării pescărești

Doctorand,

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Conducător științific,

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Introduction

Keywords:

Aquatic ecosystems, Danube Delta, benthic macroinvertebrates communities, fish productivity, fishies,

The PHD thesis with the title ***Analysis of aquatic ecosystems of the main lakes of the Danube Delta*** **for fishery *exploitation purposes*** focuses on a subject that is in trend with the modern scientific topics concerning the integrated assessment of quality of aquatic ecosystems and their productivity. I focused my research on the Danube Delta, as one of the most complex freshwater ecosystem of Romania, which provide a wide spectrum of ecosystem services, of which we mention here only three: huge reservoir of biodiversity; natural biofilter and buffer area; natural goods provider due to its high biological production and productivity.

The monitoring and quality assessment of freshwater ecosystems are based on the analysis of physical, chemical and biological parameters of waters and sediments as well as of within biological components, which form the biocoenosis. The methodologies used for the monitoring and quality assessment should be permanently harmonized and optimized and for management reasons, scientific methods and communication of good practices should be employed, which to adapt to the stakeholders' needs.

In case of complex, broad aquatic ecosystems this task is even more difficult since a lot of natural and/or anthropogenic factors are involved in evolution of their ecological quality. The Danube has a huge hydrographic basin (almost 1 million km^2), covering nineteen countries, about 1/3 of its surface being on the territory of Romania. Since 2008, Romania implemented the Water Framework Directive (WFD) (2000/60/EC), which defined the monitoring strategy for the assessment of quality of aquatic ecosystem (surface and groundwater) and in accordance The Danube River Basinal Management Plan (last version for the period 2016 - 2021) has been elaborated. These documents comprises the qualitative and quantitative physical and chemical parameters, hydromorphological and biological elements that stand at the base of chemical and ecological assessment of quality status of waters. The main objective of Water Framework Directive is the maintaining/improving the chemical/ecological status of aquatic ecosystems, through progressive reducing of dangerous substances input, which directly influence the population health, since the freshwater is the main source of potable water of human agglomerations. The synergic aspects which contribute at deterioration of quality of aquatic systems cannot be ignored, an important role having the land pollutants drained into the water courses following natural physical laws or anthropic intervention. The surface waters in

Romania have undergo severe pressures, which have led to deterioration of aquatic ecosystems, the Danube Delta being one of them.

Based on these reasons, the present study is focused on the lakes of the main aquatic complexes of the Danube Delta. The aims of the study were to monitor and evaluate the quality of its water taking into account the changes suffered by the macroinvertebrates communities caused by pollution or by hydrophysical alteration of their biotopes. Another important objective was to estimate the natural fish productivity of the lakes, necessary for taking the correct management decisions and measures for rationale and sustainable exploitation of the resources.

The macroinvertebrates communities were proved a reliable tool to study the relationship between the environmental variables and the biological ones, in other words the reaction of benthic fauna to factors such as organic pollution, eutrophication that could be reflected in changes of its diversity, abundance, and distribution in a manner that mirror the quality status of respective waters. The benthic macroinvertebrates, most of them having a reduce mobility, “deposit” environmental information during their life span, witnessing the ecosystem evolution in a certain period of time. Therefore, the benthic organisms are considered good biological indicators for assessment of quality of aquatic ecosystems and for early identification of the changes occurred within as long as the functional connections between the disturbing factors and organisms’ response are well studied and understood.

It is for the first time when such a complex study is performed in the Danube Delta’s lakes system.

At this moment, the lack of systematic biological studies translated into global biotic and abiotic indices hinders the adoption of a harmonized and unanimous accepted quality classification system of the deltaic waters. Besides, the spatial and temporal information gaps prevent us from getting a complete picture of the evolution of quality of waters of Danube or Danube Delta. Under the influence of so many pressures, the monitoring is essential for filling these gaps and for quantification of anthropic effects on one of the most important hydrographic basins in Europe.

The study occasioned by the present Ph.D. thesis was performed in the period 2011-2017 within 44 lakes from 6 aquatic ecosystems complexes. Overall, there were monitored 23 physic- chemical parameters, 4 sedimentological indicators in hundreds of stations, while the biological parameters concerning the benthic macroinvertebrates were analyzed in more than 200 stations/samples. In order to achieve the thesis objectives, the following steps were followed during the research performed: selection of monitoring locations; establishes the frequency of samples collecting; sampling and preserving of water, sediments and benthic fauna for in situ and in the laboratory analysis of physic-chemical parameters and determination of benthic species; data analysis and calculation of ecological indices; estimation of biogenic capacity and of natural fish productivity of the lakes.

Through a global approach to the elements defining the study area, based on some documentation and individual research done for the thesis, i considered the following objectives**:** Integrated approach of a little assessed hydrographical area – Danube Delta, Chemical and biological monitoring over a significant period of time and areal subject to agriculture, industrial and human impact, Assessment of ecological quality based on biotic indices, including the diversity of aquatic ecosystems, Analysis of similarities and biological correlations, Estimation of natural fish productivity.

The physical, chemical and biological parameters were assessed after a detailed analysis of the natural spatial variability and characteristics of the lakes, in order to better explain the heterogeneity and variation observed in the structure, diversity and seasonality of the benthic fauna and to gather information for the future in-depth taxonomic and ecological researches and comparison with the actual situation.

Based on the results obtained, the author of the thesis suggests that a good strategy for the monitoring and assessing the quality of the aquatic lakes within the Danube Delta should be based on methodologies that integrate the water bodies with similar geomorphological and hydrological characteristics, which would help on better predict the evolution of a unit system in terms of its quality under natural and anthropic pressures. This approach was tested within the present thesis, by analysis all lakes within an aquatic complex in a similar way by looking after the physical-chemical and biological connections between them. It represents the main original element of the thesis along with the vast range of physic-chemical, geomorphological, and biological indicators measured and statistical correlations of the data obtained used to establish the interdependence between those indicators. There were 9 biological and diversity indicators and in addition 23 physic-chemical parameters and 4 sedimentological used to calculate the correlations.

The thesis is structured in **6 chapters**.

In the **first** chapter, an overview of general characteristics of the Danube Delta (genesis, evolution and its role) was performed.

In the **second** chapter, there are presented the methods and the material used in the research for collecting and data analysis of biotic and abiotic parameters measured. The statistical analysis and calculation of indicators were carried out with the help of different statistical and spatial analysis programmes PRIMER VII, Past 3, Global Mapper, and Google Earth.

In the **third** chapter the research results of the physic-chemical and sedimentological analysis of **44** lakes of the Danube Delta are presented. These were obtained thanks to collaboration with the specialists from the NIRD GeoEcoMar within the project: *Geoecological researches for the assessment of the natural and anthropogenic factors* influencing *the distribution of sediments, water quality and greenhouse emissions in the Danube Delta and Razelm-Sinoie Lagoon complex,* performed in the framework of the national program NUCLEU.

In the **fourth** chapter the results based on my own researches on the benthic communities carried out in **14 lakes** of the Danube Delta as well as the statistical analysis applied to determine their structure and distribution are presented.

The chapter **five** comprises the calculations performed in order to determine the biogenic capacity and natural fish productivity of the lakes taking into account the physic-chemical and hydrobiological parameters.

The chapter **six** is dedicated to final conclusions concerning the biological diversity indices and the significant correlations between them used for the determination of natural fish productivity for fishery exploitation purpose.

EXPERIMENTAL DATA

CHAPTER II - MATERIALS AND METHODS

Water sampling was the first and most important step in the analysis of the physico-chemical and biological properties of water. [95].

In practice, there are several types of samples for physicochemical analysis [96]. The sample type used was the instantaneous (momentum) sample representing a random sample randomly harvested from a given place and at a time.

1. Determination of chemical properties of water

The determination of the physicochemical parameters of the water was carried out using the portable spectrophotometer "HACH DR 2000", the portable multi-line set "P4 (WTW-Weilheim)" and the "WTW Oxy 320" oximeter. Surface water samples were analyzed for the following parameters: temperature (T^oC), oxygen (O_2), oxygen saturation (O_2%), conductivity (CND), total dissolved solids (TDS), ph, suspended solids (NO_2^-), nitrate (NO_3^-), phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), and sometimes sulfur (S_2^-) and detergents.

Parameters were determined immediately after sampling in the laboratory on the Istros ship. Samples for subsequent analyzes (TOC, ammonium, chlorophyll) were preserved to be made in the laboratory in Constanta.

Water samples for the determination of nutrients and chlorophyll were collected in a 5 liter of Niskin bottle at different depths, selected on the basis of vertical temperature profiles, sigma T, dissolved oxygen and fluorescence.

Fig. 43 Niskin bottle

For nutrients, approximately 0.5 l of water was transferred from the Niskin bottle into plastic bottles and frozen at about -20°C (but no more than three months) for further analysis in the laboratory according to analytical methods.

Analytical methods used in the laboratory are in accordance with standard water analysis methods. SR ISO 5667-2 / 1998 [97].

2. **Sample preparation for chemical analysis**

For chemical analyzes, samples collected on the field are processed to bring the appearance and quantity required for analysis. Typically, the samples have an initial weight greater than that required and a granulation not suitable for analysis. It was therefore necessary to grind and reduce them to the limits required by STAS.

3. Magnetic susceptibility of lake sediments

Measurement of magnetic susceptibility of bottom sediments and analysis of data through a novel calibration scale, based on the determined magnetic parameter and with a lithological support.

The sampling of the magneto - recorder environment is a mandatory, decisive step in the process of detecting, identifying and deciphering the rock - magnetic signals.

In this case, the magnetic recording medium was constituted by bottom sediments.

The identification of some magneto - environmental characteristics in the main ecosystems was based on the use of the magneto susceptibility method, more precisely on the measurement of the magnetic susceptibility signal detected in the bottom sediment samples taken with the Van Veen grab.

For the study of magnetic susceptibility sub-samples were taken especially from the layer "a" and when it was extremely thin, or the sediments had a massive texture, the first 5 cm from the upper part of the sample with the Van Veen grab, representative for characterization of the average sediment type in that station. In this way, the aim was to obtain in-depth magneto-susceptibilimetric information, independent of the superficial layer of the bottom sediments, almost always constituted of a fluid slurry suspended in the stormy periods and redeployed in calm periods. In case of "a", "b" and sometimes "c" different layers, well represented as thicknesses, sub - samples were collected from each litologic level.

Individual MS determinations were performed for each "coat", averaging the sample.

Magnetic susceptibility measurements were performed with a laboratory "Kappabridge KLY-2" and the susceptibility bridge has a sensitivity of 4x10-8 u.SI.

The technique of MS measurements on the bottom sediment consisted mainly of the following phases: introduction of the unconsolidated sediment into a plastic cylindrical vessel supplied by the building company of the apparatus; placing the sediment cylindrical vessel in the susceptibility bridge transducer module; applying the usual procedure for obtaining primary observation data with the "Kappabridge KLY-2" [100].

Most of the sediment samples collected from the sampling stations established in the investigated lakes were completed with two cylindrical plastic vessels, finally obtaining a mean value k associated with the sediment at that point

The magnetic susceptibility scale

Previous research, based on the measurement of the magnetic susceptibility of thousands of bottom sediment samples from deltaic, deltaic - fluvial, fluvial, lagoon and marine aquatic environments belonging to the Danube - Danube Delta - Black Sea geosystem, demonstrated that the determined SM values reflect variations lithological of sedimentary deposits. The results obtained indicate that the k values can sometimes be highlighted in the case of finer sediments and metallic contamination levels, the highest being clearly noted by high susceptibilities.

Taking into account the connections detected between the SM values measured in the laboratory and the lithological descriptions of the bottom sediment samples carried out at the stage of their exposure to the Van Veen grab at the sampling station and then confirmed by laboratory analysis (granulometric, mineralogical), it was possible to systemize the data through "susceptibility classes".

Low MS (grades I to II) indicate fine sediments, usually richer in organic matter and / or carbonates. Average values (Class III) are characteristic of fine clayey to silty sediments, and very high (grades IV - V) are generally common to coarse and sandy sediments. On the other hand, for the same lithological composition, sediments affected by pollution (especially heavy metals) have much higher values of magnetic susceptibility. The SM values can be influenced by other parameters, but the two main trends remain valid: the magnetic susceptibility of the sediments was granulometry and the degree of pollution.

4. Benthic analysis

From a trophic point of view, benthos is divided into vegetal benthos or phytoobenthos, bentos animal or zoobenthos and bacterial or bacterial benthos.

Conventionally, organisms that are retained on the 0.5 mm mesh screen form macrozoobenthos. The organisms passing through the sieve with the meshes of 0.5 mm, but retained on the sieve with the meshes of 62 μm, constitute the meiobenthos. Organisms passing through the mesh of 62 μm compose the microbe.

Thus, 18 quantitative and qualitative zoobenthos samples were collected with a Van Veen bodengreifer and the limnological cricket from Babadag Lake, 5 samples from Lake Ciorticut, 14 samples from Lake Băclăneşti, 22 samples from Lake Iacub, 19 samples from Bogdaproste lake, 21 samples from the Lake of the Pole, 17 samples from Lake Polideanca, 10 samples from the Istrian lake, 20 samples from Fortuna Lake, 31 samples from the Razelm - Sinoe lagoon complex in two consecutive years.

4.1. The study of aquatic macrophytes (macrophitobenthos)

Macrophitobenthos was made up of all aquatic vascular plants (cormophytes), muscles (bryophytes) and macroscopic algae (talofites), which can easily be observed with the naked eye.

Macrophitobenthos was spread only in the seaside area where it can perform the photosynthesis process. [102]

The qualitative analysis of aquatic macrophytes consists of the taxonomic identification of submerged vegetation from different sectors of the aquatic basin or from different basins (presence / absence data).

Collecting aquatic macroflora by various means (manually or by means of rakes and creepers); sorting plants by systematic groups and identifying them to species level.

The qualitative harvesting of benthic macroflora in shallow waters was manual collection, as it allows the plants to be detached together with their basal fastening. In the case of vascular aquatic plants, manual collection was done by removing rhizomes and roots from the sediment by means of a de-planter or knife.

Harvesting macroscopic algae from small depths was done by removing the talc from the substrate by means of a knife. In the deep waters a creeping drag can be used, which plucks some plants from the substrate while it was slashed from the boat. [103]

Aquatic cormorants or macroscopic algae collected were placed in plastic bags with a little water. Inside, a slip paper label was also marked on a black pen or pen with water proof ink sample code as well as date, place, depth of collection, and substrate type.

The conservation of aquatic macrophytes was done with a solution of 5% (v / v) formaldehyde or with ethyl alcohol.

In the macrophages laboratory they were washed very well by impurities in plastic buckets or glass crystallizers. The material was washed in plastic trays with clean water, sorted into systematic groups and determined to species level. It was recommended to make a reference collection of plants pressed or preserved in alcohol for subsequent identification or for comparing data. [104]

4.2. Zoobenthos study

Zoobenthos is the ecological group made up of all animal organisms that lead their lives, in whole or in part, in close connection with the substrate of aquatic basins. They can live either at the surface of the sediment, forming the so-called epiphauna, or in the sediment thickness, forming endophauna.

Depending on the size, the zoobenthos can be classified as macrozoobenthos (macrofauna), which comprises animals that are retained on the mesh sieve of 0.5 mm and meiobenthos (meiofauna), which consists of the animal organisms passing through the sieve with the mesh of 0, 5 mm but retained on the sieve with 0.062 mm mesh. Meiobentic animals occupying the spaces between adjacent sediment particles or living attached to individual sand seals form so-called interstitial fauna. This includes micro-metazores, macrophage larval stages and ciliated protozoa.

The study of benthic biocenoses could be achieved by both qualitative analysis methods (based on simple lists of presence / absence of species) and by quantitative analysis methods (based on numerical data of abundance and species biomass). In turn, the quantitative analysis can be of two types: quantitative proportion, when no reference to a given substrate surface (relative relative dominance or relative biomass) and quantitative density, which necessarily implies the reference to a certain bottom surface (density and biomass). [105]

The study of the invertebrate community in aquatic ecosystems involves the following steps: sampling, preservation / fixing, sample preparation (taxonomic grouping and sorting), analysis (taxonomic identification, counting), presentation of the results.

Qualitative analysis consists of identifying species from a particular aquatic ecosystem and drawing up a faunistic view, as well as comparing lists of species between different acoustic ecosystems (presence / abundance data).

Sampling of zoobenthos by limnology, sorting of invertebrates under the optics by systematic groups, and identification of animal organisms from each systematic group to species level. [106] (Figure 44)

For sampling, the method was chosen according to the nature of the substrate and the type of sample (qualitative and semi-quantitative samples). In order to obtain conclusive evidence for the studied ecosystem it is necessary to take the samples in consideration of heterogeneity of the substrate. For this, a multi-habitat harvesting technique (which is a modified version of the AQEM Method, used in monitoring the ecological status of bodies of surface water in Romania) will be applied to it.

The sampling action, according to this technique, began with the determination of the types of microhabit and the proportion between them. All microhabitats having a coverage> 5% of the surface of the station have been noted. Finally, complete the microhabit estimation sheet. For qualitative analysis, samples from all the habitats found in that lake were sampled, following the diversity of taxa and emphasizing the diversity of endangered and vulnerable species. For the semi-quantitative analysis samples were taken (according to the multihabitat sampling technique) taking into account the harvesting surface necessary to study the abundance and density of identified individuals.

Fig.44 Collecting zoobenthos samples with the limnological net

For the qualitative sampling of zoobenthos samples various methods and equipment were used depending on the purpose of the research, the type of the aquatic ecosystem, the nature of the bottom (hard substrate or mobile sediments), the depth of water, the speed of the water stream, the size of the collected organisms and the sample type (qualitative or quantitative). [107];

The simplest and most common instrument for qualitative and semi-quantitative collection of aquatic organisms was the limnological net. It has been used to pick macro-invertebrates from the muddy, sandy substrate or among the aquatic plants in the case of shallow waters (up to 1.5 m), stagnant.

For limnological logging, the specimen was drawn through the handle on the bottom of the water or among the aquatic plants. The organisms encountered are led by the water stream to the bottom of the bag. After a sufficient amount of material has been collected in the bag, the corkscrew was taken out of the water with the mouth upward, shaken gently by holding the sack in water to remove the particles of mud or sand and emptied into a plastic tray, a wide-necked jar containing water, and the sample identification code was engraved with a watermark marker. As a precautionary measure, it is recommended to include sample identification data in the sample container and a label of paper that has been marked with a pencil or pen with waterproof ink.

For each sample, a landfill has been completed with the name of the river basin, the station number and sample code, the location of the sampling station (geographic position), the date and time of the sampling, the sample type (qualitative or quantitative), the collection mode the nature of the sediment (granulometry and the amount of organic carbon), the sampling depth, the flow rate of the water, the main physico-chemical characteristics of the water at the time of sampling (water temperature, pH, conductivity, dissolved oxygen concentration, water hardness, nutrient regime, etc.), as well as special observations (floods, accidental pollution, shoreline, shore-side exploitation, etc.). [108]

Conservation of zoobenthos samples was done with concentrated formol (formaldehyde aldehyde ~ 37%), which was added to the sample until a final concentration of 10% (formaldehyde 3-4%) was achieved. The fixative used, however, may vary according to the systematic group. Since formol dissolves limestone formations and penetrates hard in chitin, the conservation of molluscs and arthropods was recommended to be made in 70-80% ethyl alcohol.

Alternatively, formalin may be previously neutralized with borax (100 g of $Na_2B_4O_7 \cdot 10H_2O$ per liter of formaldehyde 37-40%). Sample storage was done in small 70-80% glass tubes in which there were also pencils with Chinese pencil or ink.

The quantitative analysis of zoobenthos consists in assessing the number of organisms and their biomass on a known surface unit. In general, the zoobenthos density was reported per square meter of benthic surface.

Moist weight is the weight of individuals living or fixed in formol, which are not previously dehydrated. [102]

Sampling a certain bottom surface with quantitative sampling equipment; separation of organisms from sediment particles; counting and weighing zoobentonic organisms identified; determining zoobenthos density and biomass by extrapolating data to square meter.

The sampling points were chosen in such a way that they are as representative as possible for the aquatic ecosystem studied. For a more accurate estimation of population variability in each station, at least three samples were randomly drawn (randomized). [109]

While most species and individuals populate the first 2-10 cm sediment, a significant number of animals can bury in the substrate up to 50 cm deep [110].

The Van Veen Bodengreifer features a scissor-type locking system, consisting of two long arms attached to each jaw. These arms increase the force exerted on the jaws, allowing a better closure, and prevent the tangle from the bottom. The work surface can be 200-2500 cm^2 depending on the model. It has been used for deep and high-velocity water and whose substrate has been consisted of solid sediments or covered with dense vegetation. (Figures 45, 46) [106]


Fig.45, 46 Van Veen grab

After the sampling, a concentration of the fauna was first recovered, in whole or in part, by reducing the volume of the sample taken. In the case of specimens taken with the help of bodengreifers, this operation was almost always done by washing samples in special sites. The meshes of the site must be sized according to the studied fauna, the purpose of the research and the sediment granulometry. Thus, for the study of biological cycles or population dynamics, fine sites (eg 0.25 mm or even 0.1 mm mesh) will be used, while for general water quality monitoring studies, sites with larger meshes (0.5 mm or even 1.0 mm). In the case of fine sands and sands, the mesh size is 0.5 mm, but in the case of coarse sands and gravel, a 1.0 mm or 1.4 mm mesh is required. Typically, however, a set of overlapping webs, which have a mesh size decreasing from the top to the lower sieve, have been used. In this way, even very small organisms can be retained, while avoiding the clogging of sites too quickly. By scrubbing the samples in the site the dimensional separation of the organisms (macrobenthos / meiobenthos) was made (Fig.47, 48) [105]


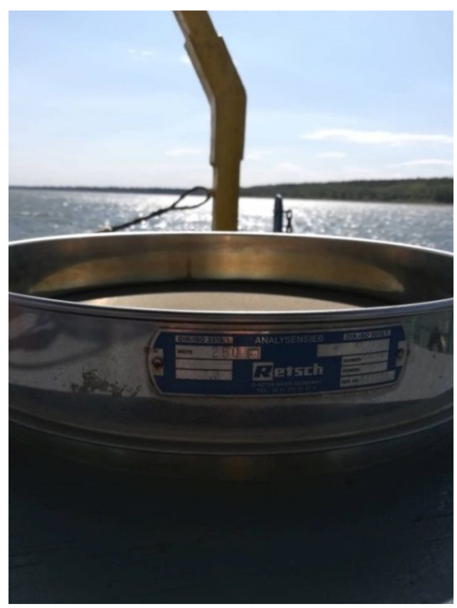

Fig. 47, 48 Washing macrozoobenthos samples

After washing the coarser inert materials retained on the site (stones, pieces of wood, leaves, hollow shells), before being removed from the sample, carefully inspect to see if they are not living organisms caught by them.

The material resulting after washing is transferred to glass receptacles with a plunger stopper or plastic with screw plug. The plug or walls of the sample containers were numbered with a water resistant marker. As a precautionary measure, it was recommended to insert an additional label of dyed paper duly annotated with a pencil or pen with waterproof ink and fixative inside the container. The container code together with all sample identification data (sampled date, collection site, depth, nature of the substrate, temperature, water hardness, dissolved oxygen concentration, etc.) was recorded on site in the field book or in a analysis of typified zoobenthos. [108]

Immediately after sampling, zoobenthos samples were fixed with concentrated formol (37-40% formaldehyde) added to the sample and then diluted with water to achieve the desired concentration. In general, for the fixation of organisms, a solution of 10% formaldehyde (3-4% formaldehyde) was used, but for keeping the samples the concentration of formalin can be reduced to 2.5 or 5% provided that the volume of the preservative liquid is much greater than that of organisms. In the case of bulky samples containing a high proportion of sediment, care must be taken, in addition to adding a sufficient amount of preservative, that the mixture of formol and sample is complete.

Since formalin over time becomes acidic and can dissolve calcareous formations of molluscs and crustaceans or modify biomass values by solubilizing lipids or other fatty tissues, it is buffered with borax (40 g of sodium tetraborate per 1 liter of concentrated formol). [112]

In the laboratory, a second strain of sediment mass was used to obtain an even greater concentration of samples. For the complete separation of benthic fauna from sediment particles or organic debris, the manual sorting method was used most frequently.

The sample was screened under a stereomicroscope, operation after which the organisms separated from the sediment particles and sorted into taxonomic categories. If the number of organisms was very high, we used the fractionation of the sample and the complete sorting of the organisms from the subprobe. At the same time, it was intended that rare forms should not be omitted. [113]

The zoobenthonic organisms, separated by systematic groups, were counted concurrently with their sorting and identification. Summarizing the numerical abundance values of each taxon and taking into account the surface of the substrate from which the sample was taken, the total zoobentonic density per 1 m^2 was established.

CHAPTER III - STUDY OF AQUATIC COMPLEXES IN THE DANUBE DELTA

The Danube Delta is a unit with a special position within the Danube - Danube Delta - Black Sea geosystem, as a natural interface between the vast Danube drainage area and the Black Sea basin, a basin with an inner sea character.

This position gives the Delta a role as a buffer or filter between the Danube intakes, loaded solid matter and more or less contaminants (present in the solution or associated with the particular phase) and the Northwest Black Sea area. Sedimentary processes occurring in the delta area as well as the action of filtering sediments and contaminants exerted by delta ecosystems are both physical and biochemical mechanisms whose intensity and sense of manifestation are controlled by the activity of some natural factors, a variable measure of anthropogenic interventions and, in the long run, global changes.

Natural processes, anthropogenic interventions and global change interact and interrelate each other, with medium and long-term effects on the environment and the socio-economic conditions of the afflicted areas.

The Danube Delta is one of the largest delta in Europe (the second after the Volga River), covering an area of over 4150 km^2 (without the Razelm-Sinoe Lagoon Complex). The Danube Delta Aquatic System comprises over 3500 km of natural and artificial lakes and canals, and over 450 lakes and yachts, interconnected in a very complex hydrographic network, which is a huge complex of flowing and stagnant aquatic ecosystems interact and interact closely with terrestrial ecosystems in areas not covered by water. [59]. Under these circumstances, an exhaustive approach to such a system is practically impossible, so that in order to achieve the proposed objectives, the research was focused on a few representative sectors of the deltaic area.

The choice of perimeters has taken into account a number of factors that make them somewhat similar, as well as the more important elements that distinguish them.

The resemblance refers to the fact that in each researched sector the lakes are arranged one after the other on the main drainage path, so that the upstream lake has the role of buffer for the downstream lake in terms of sediment and pollutant inflows. The differences lie in the location of the sectors within the deltaic edifice: the fluvial delta or the Marine Delta and the position they occupy over the Danube's water inflow points: lakes directly affected by the Danubian inlets and lakes located in the distal position protected from inflows direct river flows. L. L. Trei Ozere Lakes through Lake Trei Ozere, L. Bogdaproste have particular situations, they are fed directly through two channels perpendicular to the old Danube, and the L. Puiuleţ, L. Iacub, L. Lumina lakes are supplied mainly by an almost rectilinear artificial channel , Crişan - Caraorman, which facilitates the achievement of important water and sediment flows (fig.49)

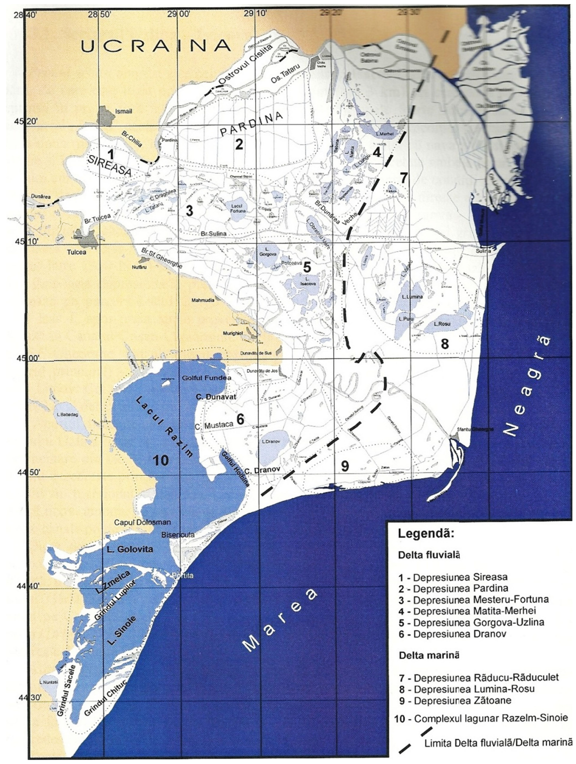

Fig. 49 Map of the Danube Delta and the Razelm-Sinoe Lagoon Complex. [59]

The study covered by this PhD thesis was conducted during 2011-2017 in 44 lakes of 6 aquatic ecosystems. Altogether, 23 physico-chemical parameters, 4 sedimentological indicators in hundreds of stations were monitored. (Table 10)

Table 10 Classification of Depression in the Danube Delta

Nr.crt.	Classification of Depressions in the Danube Delta	Danube Delta lakes
1.	Sireasa Depression	Cutețchi, Trofîlca
2.	Lumina – Roșu Depression	Iacub, Lumina, Vătafu, Puiuleț, Roșu, Roșulet, Puiu, Potcoava Nord și Sud, Frasin, Macovei, Lungu, Porcu, Rotund
3.	Matița Merhei Depression	Trei Ozere, Bogdaproste, Covaliova (Rădăcinos), Căzănel, Japșa Polideanca (Miazăzi), Ciorticuț, (Rădăcinoasele), Corciovata, Babina, Merhei, Matița, Sfiștofca
4.	Gorgova – Uzlina Depression	Obretinciuc, Isăcel, Uzlina, Isacova, Gorgova, Gorgovăț, Cuibeda, Obretinul Mic
5.	Meșteru – Fortuna Depression	Tătaru, Lungu, Canalul Crânjală, Băclănești, Belâi, Durnoi, Japșa Lungu Meșteru, Fortuna, Meșteru, Lideanca, Văcaru
6.	Razelm – Sinoe lagoon complex	Babadag, Istria, Zmeica, Golovița, Sinoe, Razelm, Ceamurlia, Leahova Mare și Mică, Erenciuc, Belciug, Gorgoștel, Meleaua Sacalin,

The first four sectors mentioned above belong to the river delta, and the latter two are included in the Danube Delta Marine Delta (namely, fluvial-marine) area. Fortuna, Sireasa and Matiţa - Merhei Depression are situated in the northern wing of the Danube Delta (between the

Chilia and Sulina arms), and the depressions of Gorgova - Uzlina and Lumina - Roşu belong to the southern wings (between Sulina and St. Gheorghe). From the point of view of the distance of the sectors from the inflow points of the Danube water and sediment inlets, Lungu, Meşteru, Gorgova and Uzlina lakes are under the direct influence of the river inlets, Belāi, Tătaru, Isacova, Fortuna and Puiu occupy an intermediate position , and Roşu, Rosuleţ, Babina, Matiţa and Merhei are located far away from the Danube's arms. The effects of the Danube inflows (clogging, pollution) are reduced as the transport distance increases (the Rosu, Matiţa, Merhei lakes), but also by preliminary decantation in a upstream buffer lake (Uzlina Lake, or Tataru Lake , protected by Lungu.) [115]

Most lakes have been monitored each year, except for special situations when extremely low waters have not allowed entry with craft funded under the core geoecological research program to assess the influence of natural and anthropogenic factors on sediment distribution, water quality and emissions greenhouse gases in the Danube Delta and the Razim - Sinoie Lagoon Complex. "The analysis of the physicochemical, chemical chemical parameters of the water and the biological analyzes were carried out in each campaign and the sediment analyzes were made in complex networks only once during the period 2011-2017, as the lithological changes occur more slowly, their results were performed and interpreted with colleagues from INCD Geoecomar and used in the kernel program reports called Geoecomar Archives Reports.

Evaluation of chemical ecosystems and sedimentological ecosystems for the Lumina - Rosu Depression:

The chemical parameters recorded normal values in the studied lakes, being in good chemical status, except for phosphates that exceeded punctually (in some stations) the maximum admitted values (according to Order 161/2006),

For Lake Macuhova, there was a concentration of siliciclastic mineral material in the north-western branch of the lake, where the channel of connection with the Vătafu Canal is located, through which the waters of Danubian origin loaded with suspensions reach to the great waters.

Evaluation of chemical ecosystems and sedimentological ecosystems for Matiţa - Merhei Depression:

Similarly, the chemical parameters did not exceed the admissible values except for phosphates (Annex 2)

In L. Matiţa and L. Babina, the phytocoenosis represented by a great diversity of macrophyte species, forming extraordinary biomass, is the dominant element in the detriment of the planktonic algal component.

Evaluation of chemical and sedimentological aquatic ecosystems for the Gorgova - Uzlina Depression:

As in the case of the lakes in the previous depressions, the physico-chemical and chemical parameters were within the normal limits (Order 161/2006) (Annex 2), their values being generally lower than in the other depressions due to the fact that Cn. The node is made of the half-banded Mahmudia and not directly from the active Danube.

Evaluation of chemical and sedimentological aquatic ecosystems for the Meşteru - Fortuna Depression:

Maximum values, but within the limits of the good chemical status of the physicochemical and chemical parameters of the waters, were recorded in the lakes Lungu, Meşteru, Tătaru, in the samples collected during the hot season, when important developments of macrophytic fields were observed.

Evaluation of chemical and sedimentological aquatic ecosystems for the Razelm - Sinoe lagoon complex:

Within the complex, only in Babadag Lake were found higher sulphate values (SO_4^{2-}) in some of the stations analyzed during the cold season, probably due to the resuspension of organically loaded sediments, given that the lake is a fishing enclosure

The sediment quality (organic load) is influenced by more or less direct intakes of water loaded with solid suspensions in the Danube, which gives the sediment the characteristic appearance (greasy, grayish or blackish, greasy, strongly bioturbated, usually fluid, grayish gray (oxidized) at the top - lakes directly influenced by the Danube; loose, porous, grayish-brown or yellowish, non-cohesive, sometimes saprogenic or hydrogen sulphide-rich calcium carbonate autigen, coprogenic and vegetal organic material - lakes protected by direct Danube intakes)

In general, from the point of view of the quality of the investigated aquatic environments, there were no exceedances of the allowed limits, except exceptionally, at the levels of phosphates, which exceeded the maximum values in some stations, especially in autumn- (> 2 mg / l).

In the case of deltaic lakes, because of the greater distance from the direct Danubian inflows and their "cascade" position, the sedimentary material of mineral origin is decanted along the way so that the major component of the sediments in these lacustrine areas is the organic substance in mostly indigenous origin.

In this respect, the differences between the sediment of the lakes (Lungu, Meşteru, Fortuna from the Meşteru Depression - Fortuna) are influenced by fluvial intakes through close channels, where the organic component is net dominant, and those from Belâi lakes (Meşteru Depression - Fortuna), Trofilca (Sireasa Depression), Covaliova, Căzănel and Polideanca (Matiţa - Merhei Depression), Cuibeda, Isăcel (Depression Gorgova - Uzlina) and Lumina (Rosu - Lumina Depression), protected by the Danube intake, .

The lithological and magneto-susceptibilimetric study of the sediment in the cores revealed significant vertical variations, reflecting changes in time of the hydrodynamic conditions caused by the hydromorphological evolution of these areas in historical times. From the macroscopic examination, the collected cores show major changes in the dynamics of the delta environment; from this point of view, we can consider important carotiers in the lakes Cuibeda, Polideanca and Lumina, where the boundary between the marine and lake deposits was intercepted.

CHAPTER IV - EVALUATION OF BIOLOGICAL AQUATIC ECOSYSTEMS

The Danube Delta is a unit with a special position within the Danube - Danube Delta - Black Sea geosystem, as a natural interface between the vast Danube drainage area and the Black Sea basin, an indoor sea basin.

The choice of areas has taken into account a number of factors that make them somewhat similar, as well as the more important elements that distinguish them.

The research on the evaluation of biological aquatic ecosystems carried out within the PhD thesis in the Danube Delta focused on four representative sectors of the deltaic area in which 14 lakes, considered standard perimeters, were studied. (Table 30)

Table 30 Classification of lakes analyzed in the Danube Delta

Nr. crt.	Classification of Depressions in the Danube Delta	Danube Delta lakes
1.	Matița Merhei Depression	Trei Ozere, Bogdaproste, Japșa Polideanca (Miazăzi), Ciorticuț,
2.	Meșteru – Fortuna Depression	Băclănești, Fortuna,
3.	Lumina – Roșu Depression	Iacub, Puiuleț,
4.	Razelm – Sinoe lagoon complex	Babadag, Istria, Zmeica, Golovița, Sinoe, Razelm,

The first four sectors mentioned above belong to the river delta, and the latter two are included in the Danube Delta Marine Delta (namely, fluvial-marine) area. Fortuna, Sireasa and Matiţa - Merhei Depression are situated in the northern wing of the Danube Delta (between the Chilia and Sulina arms), and the depressions of Gorgova - Uzlina and Lumina - Roşu belong to the southern wings (between Sulina and Sf. Gheorghe). From the point of view of the distance of the sectors from the inflow points of the Danube water and sediment inlets, Lungu, Meşteru, Gorgova and Uzlina lakes are under the direct influence of the river inlets, Belāi, Tătaru, Isacova, Fortuna and Puiu occupy an intermediate position , and Roşu, Rosuleţ, Babina, Matiţa and Merhei are located far away from the Danube's arms. The effects of the Danube inflows (clogging, pollution) are reduced as the transport distance increases (the Red, Matiţa, Merhei lakes), but also by preliminary decantation in a upstream buffer lake (Uzlina Lake, or Tataru Lake , protected by Lungu). [115]

Most lakes have been monitored every year, except for special situations when extremely low waters have not allowed entry with the boats.

Physical, chemical, chemical water parameters analysis and biological analysis were conducted in each campaign, and sediment analyzes were performed on complex networks once during 2011-2017, as lithological changes occurred more slowly.

We analyzed macrozoobenthos samples from the depressions studied (Matiţa Merhei Depression, Fortuna Depression, Lumina - Rosu Depression, Razelm - Sinoe Lagoon Complex).

1. Evaluation of biological ecosystems analyzed in the Matiţa-Merhei Depression

It includes the lakes L. Three Ozere, L. Bogdaproste, L. Covaliova, L. Căzănel, Japşa Polideanca.

The Matiţa - Merhei depression is situated in the northern wing of the Danube Delta (Sulina - Chilia), being bordered by the Cernovca arm (sub - arm of Chilia) to the north, the Old Mouth (Great M) to the south, the Chillia - the Letea ridges - Răducu to the east. To the west of Chilia Field is the Pardina Depression.

The depression includes 108 lakes (more than 1 hectare), of which the most important are Merhei - 1057 ha, Matiţa - 652 ha, Three Ozere - 437 ha, Bogdaproste - 435 ha, Babina - 432 ha, Rosca - 222 ha., Radacinosu, Lungu and others. Lake Poludionca is an "annex" of Lake Matiţa, where it is separated by a narrow and discontinuous cordon. In the current configuration, the depression is supplied mainly from the Tulcea Arm along the channels Mila 36 - Şontea - Dunarea Veche - Eracle - Lopatna with the variant Dunărea Veche - Căzănel and temporarily (large water) in the Chilia Arm, through the Pardina - The Radacinoasele and Bahrova, and the evacuation is ensured by Bogdaproste and Dovnica to the south (to the Danube Veche - Sulina) and Sulimanca to the north (towards Chilia). In small waters, the Radacinoasele and Bahrova channels can change their meaning, becoming discharge channels, which can influence sedimentary processes in their respective sectors. Basically, all lakes have poorly marked shores, with dry limits varying depending on the water level and concealed by surrounding reeds.

Even if the depression of the Mila 36 basin channel originates, the very long route of the main access road (that of the Tulcea Arm) makes most of the lakes in the Matita - Merhei Depression to be sheltered by the direct Danubian inflows, the water circulation is slow, and in periods of low water in certain sectors, stagnant conditions and reversal of the flow direction on some channels occur. After the closure of the Periteaşca Canal a few years ago, the direct inputs of the sedimentary material from the Danube through the Mila 36 Channel diminished, the connection with the Sontea being now made through a segment of the Sireasa Canal that extends the route and decreases the water drainage slope . Most of the sludge sediments are deposited in the upstream section of the feed and most of the contaminants are retained by the ecosystems traversed along the way, so that, except for periods of high fl ood, sedimentation is predominantly organic and sometimes carbonic, sedimentation rates are very low, and system pollution (including heavy metals) is low. The only factor of stress is the nutrient influx, algal blooms, and their most dangerous consequence for aquatic life - eutrophication. (Fig.173)

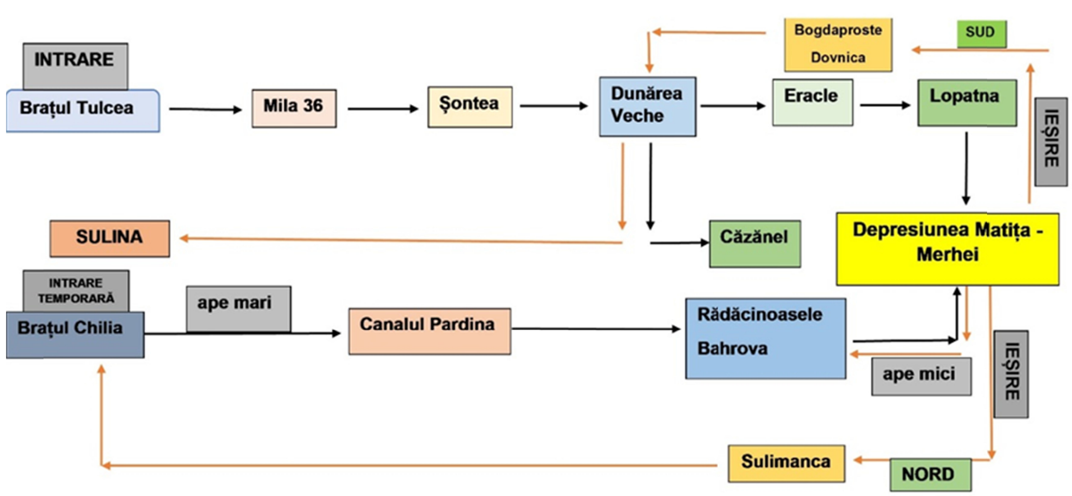

Fig. 173 Water and Sediment Supply from the Matiţa - Merhei Depression [115]

The characteristics of the aquatic environment and the sedimentary environment in the main lakes studied are relatively similar.

In 2013, the Three Ozere, Bogdaproste and Ciorticut lakes were studied, and Polideanca Lake was studied in 2014.

The Three Ozere and Bogdaproste lakes

The Three Ozere and Bogdaproste lakes are located to the south of the Babina-Matiţa perimeter and to the east by Garla Şontea, in a position well protected from Danubian direct inlets, which is a factor favorable to the accumulation of organic deposits.

The Three Ozere Lake is characterized by dark gray to dark brown mosses, loose, poorly cohesive, dominated by organic medium-to-thick organic material (mostly at the bottom), sometimes containing reed fragments strong saprogenic odor; often mud contains whole specimens and / or fragments of Viviparus, Dreissena and Anodonta, usually depigmented partially or totally and friable.

In Bogdaproste Lake, located in the east, in a more protected position than L. Three Ozere, the sediments are similar, the color can go to brown-gray gray, the non-cohesive character and the saprogenic odor persist, and the tanatocenosis is made up of the same type molluscs

32 taxa belonging to 16 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Amphipoda, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera) were identified in Lake Three Ozere. (Table 31)

Observations on benthic fauna come to complete the ecological research undertaken in recent years to characterize the state of the ecosystem in the lakes of the Danube Delta. Being the compartment directly connected to sediment debris, benthos is the main link that transfers the energy stored in sediment as organic debris to superior trophic levels (bentophagous fish), thus indirectly contributing to the valorisation of the energy accumulated by primary producers in aquatic ecosystems [117, 118].

The highest occurrence frequency in samples is adjudicated by 5 typical taxons for wetlands with muddy sedimentary substrates such as Oligochaeta, Chironomida, Nematoda, Trichopters represented by the Oxyethira genus and *Cypria ophthalmica* ostracodes. Crustaceans are almost exclusively represented by ostracodes. (Figure 174)

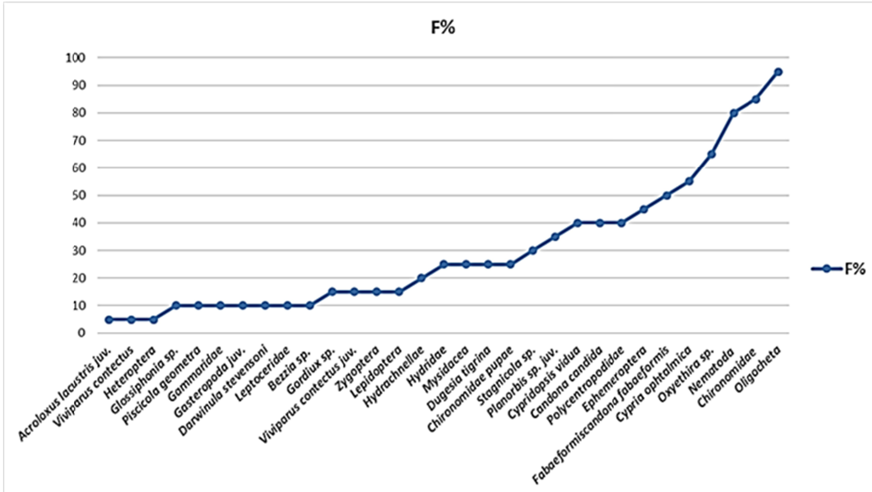

Fig. 174 Frequency of zoobenthal taxa in Lake Trei Ozere

Within the investigated area, the density of the nematode is 10610,81 ind / m^2, the *Fabaeformiscandona fabaeformis* with 8359,37 ind / m^2, Chironomidae larvae with 4260,93 ind / m^2 and the oligochets with 2896,48 ind / m^2 . (Table 32)

The large abundance of chironomide larvaes suggests a large organic load and the existence of an oxygen deficiency in the substrate.

The overall average density of the biennial populations in Lake Three Ozere 2013 was 32982.41 ind / m^2, consisting of 45% worms, 30% crustaceans, 20% insect larvae and 5% varying.

The presence of a large number of species of insects and larvae is due to the permanent character of the ponds, which ensures the permanent reproduction of species with aquatic larvae, a situation not encountered in temporary ponds, where the number of insect larvae species is much small [119]

The large number of species of Odonate larvae (Zygoptera suborder) illustrates that these predators have a rich and permanent trophic base, providing their trophic needs throughout their larval development period, which may take up to several years in the case of species.

Among the molluscs, juvenile gastropods of the species *Planorbis sp., Viviparus contectus, Acroloxus lacustris, Stagnicola sp*.

Also, insect larvae such as Chironomide larvae that predominate in all samples collected as a density, Zygoptera subordinate larvae, and trichoppera larvae family. Leptoceridae Fam, Hydroptilidae Fam. and Polycentropodidae Fam., Ephemeroptera larvae, and Lepidoptera larvae.

Of the total of 32 taxa identified in Lake Three Ozere, only 9 species are more abundant, making up almost 98% of the density: Nematoda, *Fabaeformiscandona fabaeformis*, Larvae of Chironomidae, Oligocheta, *Cypria ophthalmica, Cypridopsis vidua*, Oxyethira sp., Ephemeroptera. (Figures 176, 177)

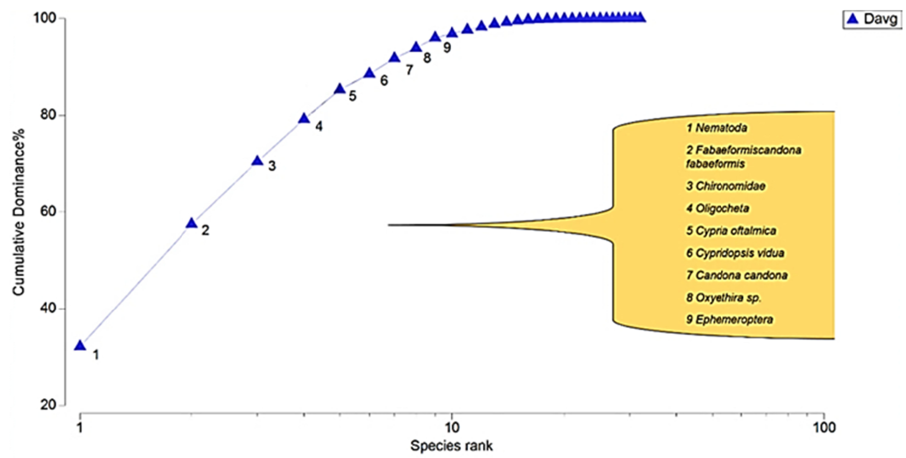

Fig. 176 Cumulative curve of the average density of benthic populations in Lake Three Ozere

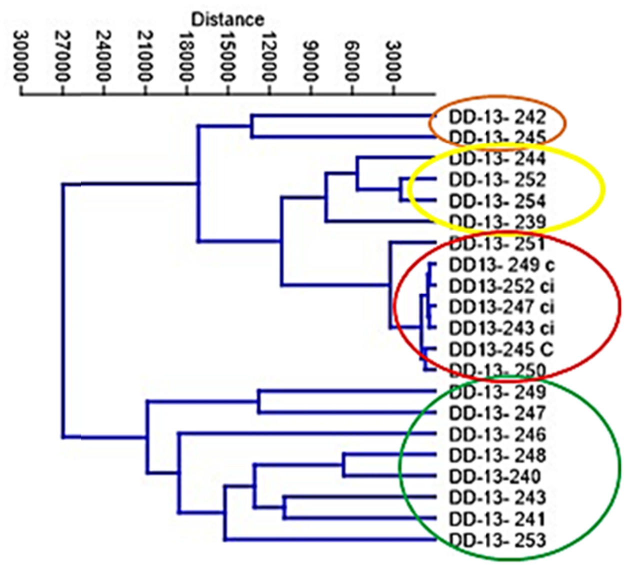

Fig. 177 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be noticed that on the basis of the data transformed by the Euclidean distance, the stations DD-13-242 and DD-13-245 show the highest specific diversity compared to the other stations in the Lake Three Ozere, followed by the stations DD-13-249, DD -13-247, DD-13-246, DD-13-248, DD-13-240, DD-13-243, DD-13-241, DD-13-253, the rest of the stations are low in abundance.

The main taxa of submerged vegetation were 2 species of Ceratophyllum - *Ceratophyllum submersum, Ceratophyllum demersum*.

Lake Bogdaproste

26 taxa belonging to 15 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Efemeroptera, Odonata,

Trichoptera, Lepidoptera, Chironomida, fish) were identified in this lake. (Table 33), the specific diversity being lower than Lake Trei Ozere. The highest occurrence frequency in samples is adjudicated by 5 typical taxa for wetlands with muddy sedimentary substrate such as chironomides (larvae and pupae), and oligochetes, nematodes, ostracoda *Fabaeformiscandona fabaeformis* and ephemeroptera larvae. Crustaceans are almost exclusively represented by ostracodes. (Fig.178)

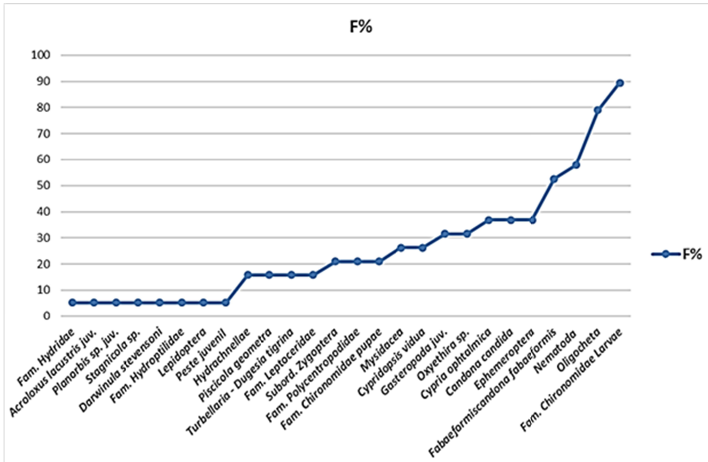

Fig. 178 Frequency of zoobenthal taxa in Bogdaproste lake

Within the investigated area, the density of the nematodes is 3692,907 ind./m^2, the chironomide larvae 2536,934 ind./m^2, and the *Fabaeformiscandona fabaeformis* ostracoda 1162,381 ind./m^2.

The overall average density of the benthic populations in Bogdaproste Lake in 2013 was 8887,552 ind / m^2, consisting of 51% worms, 31% insect larvae, 16% crustaceans and 2% varying.

Of the 26 taxons identified in the Bogdaproste lake, only 4 species are more abundant, making up almost 95% of the density: Nematoda, Larvae of Chironomidae, *Fabaeformiscandona fabaeformis*, Oligocheta. (Fig. 180, 181)

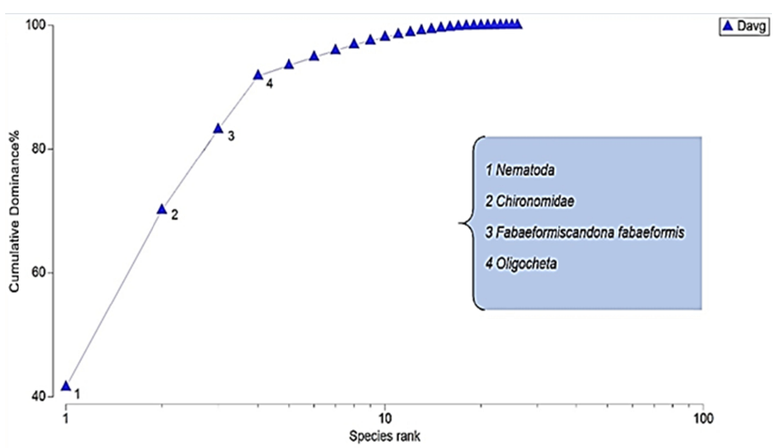

Fig. 180 Cumulative curve of the average density of benthic populations in Bogdaproste Lake

Fig. 181 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be seen that on the basis of data converted to Euclidean distance, in DD-13-226, DD-13-237, DD-13-235, DD-13-236, DD-13-231 shows the highest comparative specific diversity with the other stations in Bogdaproste Lake.

The main taxa of the submerged vegetation were represented by 2 species of Ceratophyllum - *Ceratophyllum submersum, Ceratophyllim demersum*.

Lake Ciorticut

The Corciovata-Ciorticut Lakes are located in the north of Babina Lake, belonging to the Matiţa-Merhei Depression.

After the analysis of the samples in this lake, 28 taxa belonging to 17 systematic groups (Acarieni, Hydridae, Hirudinee, Bivalve, Miside, Isopoda, Gammaride, Nematoda, Oligocheta, Gastropoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera).

The highest occurrence frequency in samples is adjudicated by 5 characteristic taxons for humid wetlands such as oligochets, chironomides (larvae and pupae), Hydrachnellae (Hydra), Misidele and Trichopters of Fam. Leptoceridae (Fig.182)

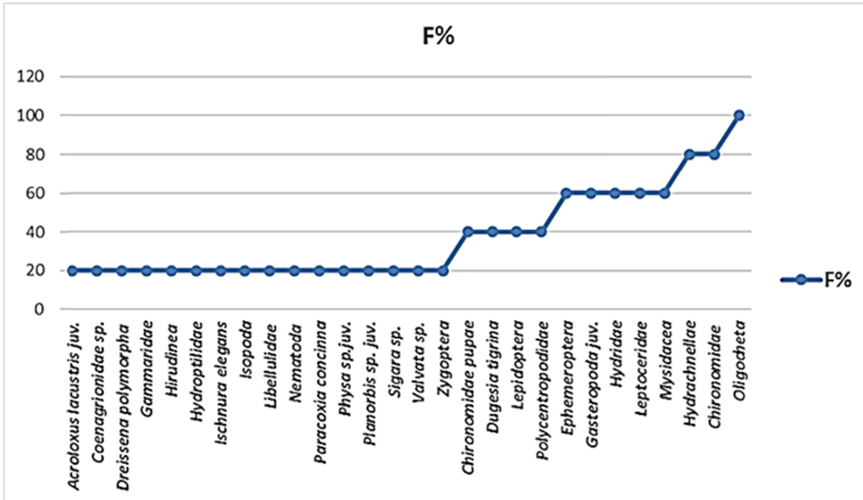

Fig. 182 Frequency of benthic taxa from Ciorticut lake

Within the investigated area, the 7250 ind./m^2 oligochets, the chironomide larvae 5687.5 ind./m^2, followed by the *Dugesia tigrina* and the juv gastropods, each with 1906.25 ind./m^2, are dominant.

The overall average density of the benthic populations in Lake Ciorticut in 2013 was 23156.25 ind / m^2, being made up of 40% of insect larvae, 39% of worms 11% of molluscs and 10% of them.

Thus, the fundamental functional compartiments are occupied by a small number of eurioid species, of which numerical dominance are oligochetes, chironomide larvae and molluscs.

Of the total of 28 taxa identified in the Ciorticut lake, only 10 species are abundant, making up almost 95% of the density: Oligocheta, Larva de Chironomidae, Gastropoda juv., Dugesia tigrina, Polycentropodidae, Hydroptilidae, Hydridae, Ephemeroptera, Leptoceridae, Mysidacea. (Figures 184, 185)

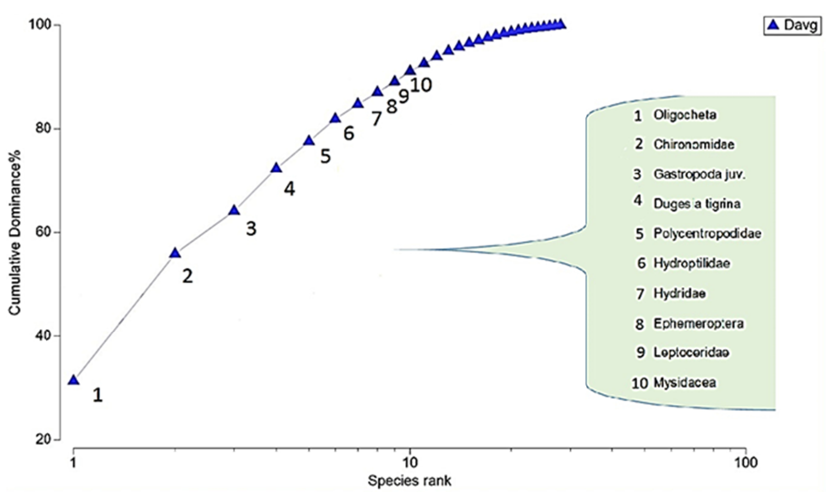

Fig. 184 Cumulative curve of the average density of benthic populations from Ciorticut lake

Fig. 185 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be seen that on the basis of the Euclidean distance converted after the station presents the greatest diversity D13-220 compared with other cell-specific Ciorticuţ lake.

Lake Polideanca

Polideanca lake sediments consist for the most part from the banks of gray-brown, blackish film, loose, non-cohesive odor of H_2S containing plant fibers frequencies; they may become coarser at the bottom, where sometimes reed fragments and centimeter elements run by fine peat appear. Lake fauna consists of fragments of Anodonta, *Lymnaea stagnalis*, Viviparus etc., usually depigmented and friable. To the west, the channel that connects the mouth with the mixture appears Lopatna Gârla and marine life (Cardiide, Abra) newly composed of the substrate in the excavations for deepening the channel.

After analyzing samples in 2014 in this lake were identified 34 taxa belonging to 18 groups systematic (mites, Spongia, Hydridae, Hirudinee, mysis shrimp, Isopoda, Gammaride, Corofidae, nematode, oligochaeta, Gastropoda, ostracods, Turbelaria, mayfly, Odonata , Trichoptera, Lepidoptera, Chironomida,).

The highest frequency of occurrence in the 6 samples is awarded taxa substrate characteristics for wet areas such as nematodes muddy sediment, *Cypridopsis vidua* Leptoceridae, Turbelaria indet., Chironomidele (larvae and pupae), and oligochaetes. (Fig.186)

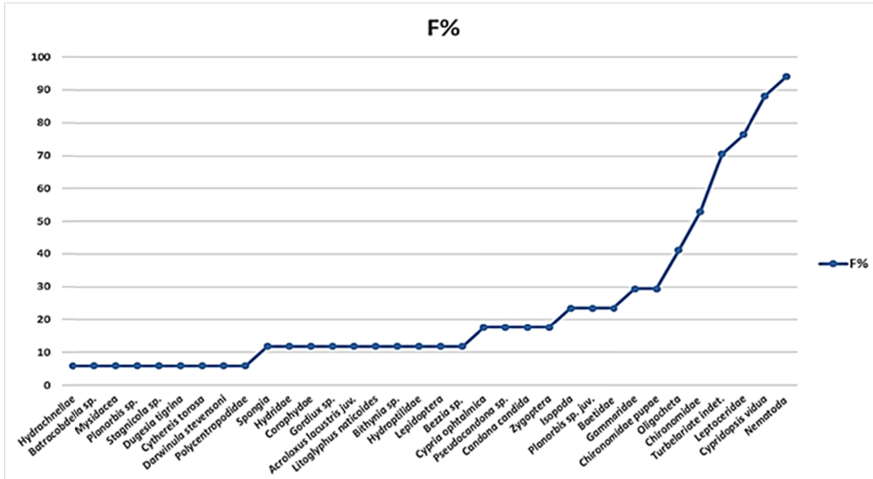

Fig. 186 Frequency of benthic taxa from Lake Polideanca

Within the investigated area, the densities are the oligochets with 33097,426 ind./m^2, the chironomide larvae 32536,764 ind./m^2, and the *Cypra ophthalmica* ostracods 23648,89706 ind./m^2 and *Candona candida* 16406,25 ind./m^2. (Table 38)

The overall average density of the benthic populations in Lake Polideanca in 2014 was 127363.97 ind / m^2, being made up of 41% of crustaceans, 29% of worms, 28% of insect larvae and 2% of them.

Of the total of 34 taxa identified in Lake Polideanca, only 10 species are more abundant, making up almost 98% of the density: *Cypria ophthalmica, Candona candida*, Oligocheta, Larvele de Chironomidae, *Darwinula stevensoni*, *Cythereis torosa*, *Pseudocandona sp.*, Hydroptilidae, *Stagnicola sp* , Polycentropodidae (Figure 188)

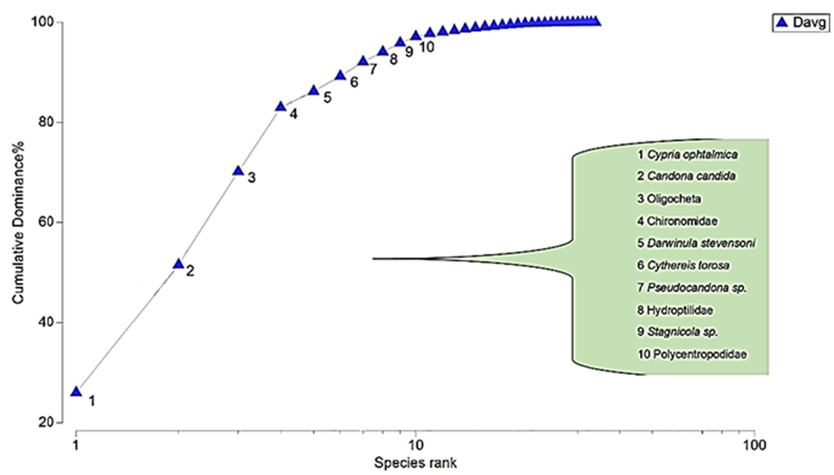

Fig. 188 The cumulative curve of the average density of the benthic populations of Lake Polideanca

The Ichtiofauna in the Matiţa - Merhei Depression is made up of a representative number of species that characterize delta formations: most are sweet, common with the Danube, ((*Esox lucius* Linnaeus, 1758 , *Cyprinus carpio* Linnaeus, 1758, *Carassius auratus* Linnaeus , 1758, *Rutilus rutilus* Linnaeus , 1758, *Leuciscus cephalus* Linnaeus , 1758 , *Tinca*

tinca Linnaeus, 1758, *Scardinius erythrophthalmus* Linnaeus , 1758, *Aspius aspius* Linnaeus, 1758, *Abramis brama* Linnaeus , 1758, *Hypophthalmichthys molitrix* Valenciennes, 1844, *Hypophthalmichthys nobilis* Richardson, 1844, *Silurus glanis* Linnaeus, 1758, *Perca fluviatilis* Linnaeus, 1758, *Sander lucioperca* Linnaeus , 1758). (see Chapter V)

2. Evaluation of biological ecosystems analyzed in the Meşteru - Fortuna Depression

The supply of lakes in the research sector in the Danube is currently quite slow, through peripheral plains, or by stronger inflows during floods, when Danube waters overtake river banks. This gives the lake system a fairly protected regime, in contrast to the situation prior to the closure of the Periteasca Canal, when the direct Danube intakes from the Mila 36 Channel produced significant clogging processes in Lungu and Meşteru lakes. The situation has changed again four years ago, by digging channels between Periteaşca Canal and Lungu and Meşteru lakes; but the dam remains functional, small water flow is indirect and remains diminished. In the hydrological conditions at the end of April (when the samples from these lakes were collected), there were a lot of high water inflows from the Danube. On the Periteaşca Canal, cloudy water flows in the direction of Cn. Mila 36 - G. Şontea, bypassing the built dam and entering almost entirely into Lungu and Meşteru lakes through the interconnecting channels with Periteaşca dug in 2012, contributing to the integration of the process of clogging these lakes. From the entrance to L. Meşteru to the east the water is clear, up to 500 m from the intersection with G. Şontea, whose influence is felt very little. The clear water area is actually controlled by the surrounding water intake from the surrounding swamps, which have already undergone a decanting and filtration process.

In the perimeter of the lakes, the water flows in the sense of L. Lungu - L. Meşteru - Cn. Draghilea - Cn. Şontea, or L. Lungu - Cn. Draghilea - L. Tataru - Cn. Draghilea - Cn. Şontea. It is interesting that under the high water conditions, the slightly more turbid flow from L. Lungu does not cross Cn. To the east; Instead, L. Tătaru directs the relatively clear water flowing on Cn. Drag the west. This phenomenon explains why Lake Tataru occupies the most protected position in the system, even in the high levels of the Danube. [115]

Fortuna Lake

Lake Fortuna currently has a relatively protected position, the main source of input (water and sediment) being represented by Garla Şontea (north), at a point far from the Danube. Currently, the direct connection from the south through the Cranial Channel with the Sulina Arm is interrupted for many years, so that the massive clogging process, which mostly dominated the southern half of the lake for a long time, was stopped, causing a shift towards a weaker sedimentation, rich in organic native material.

The sediments of L. Fortuna are predominantly represented by coarse, sometimes finely sandy, mica silicified mosses with oxidation film at the top.

Among the molluscs were identified gastropods of the species *Viviparus sp.*, *Acroloxus lacustris, Planorbis sp.*, Organisms commonly found in submerged vegetation and *Anodonta woodiana* bivalves, and *Unio pictorum*, species that were accidentally encountered.

Also, insect larvae such as chironomide larvae that predominate in all samples collected as a density, the Zygoptera subordinate larvae, and trichoptera larvae family, Leptoceridae Fam, Hydropteridae Fam. and Polycentropodidae Fam.

Frequency of occurrence - was used as a structural index on the basis of which - groups of constant organisms (F ≥ 50%), accessories (25% ≤ F <50%) and accidental (F <25%) from the phytopathic communities analyzed in all the IMB scale investigated ecosystems [120].

The group with the highest frequency and constant was the chironomide larvae, followed by oligochetes, hirudinas, gastropodes, gammarides, ephemerides, odonates, trichopters, turbellars, nematodes, hydrozoa and misids, while isopods, lepidopters, mites accessory groups. The lower frequency, classified as accidental groups, was: cumal and bivalve. Sporadically, copepods and cladoce were also found (Fig.189).

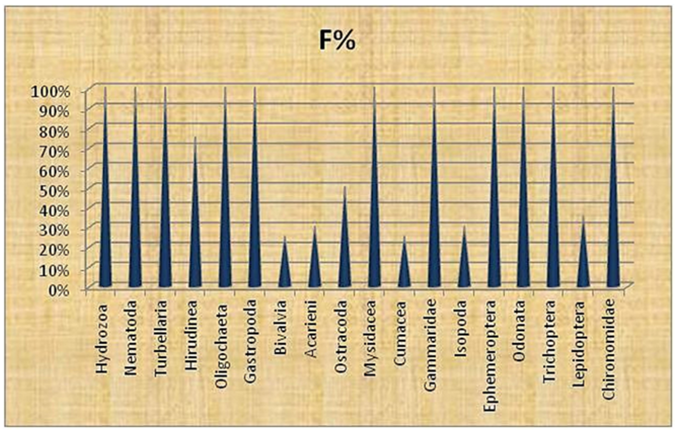

Fig. 189 The average annual frequency of occurrence of the main benthic taxonomic groups identified in samples at the scale of all communities analyzed in September 2011

Evaluating these results, we can say that they are comparable to the results of numerous literature studies.

However, in some cases, the dominant dominating status of the group is taken up by other groups of organisms, Oligochaete as numerical abundance and Gastropods as abundant biomass. These are considered invertebrate groups commonly found in phytophyte fauna [121], which are particularly abundant in aquatic systems where rich feed sources, such as shallow lakes, or adjacent canals are available, where organic matter is present in high concentrations and the biomass of epiphyton is high [122, 123, 124].

As regards the co-dominance aspects encountered in the phytophilic communities analyzed, they are also recognized in the literature; the main taxa are: Hydrozoa, Oligochaeta, Gastropoda, Chironomidae, Gammaridae, Nematoda, Trichoptera, Ephemeroptera, Odonata, Hirudinea, Mysidae, Turbellaria, etc. [121, 122, 123, 124, 125, 126, 127, 128].

From a numerical point of view, the dominance is very high and is largely given by larons of chironomides, accompanied by oligochetes, gastropods, gammarides, ephemeras, odonata, trichoptera, and turbelariates that make up the phytophyl fauna.

From the point of view of the large number of taxons met, Fortuna Lake is included in the category of lakes with the highest diversity in the Danube Delta.

The presence of juvenile mollusks and crustaceans (myside, copepode) in numerous evidence suggests that some of these populations are still prosperous.

Lake Baclanesti

In October 2013 the superficial marshes (the first 5-8 cm below the sediment water interface) in Lake Băclăneşti are represented by loose, non-cohesive sediments, dark gray-brown, rich in finely triturated vegetable material, sometimes coarser to the base with saprogenic odor, often including shell fragments and rarely whole specimens of Viviparus, Planorbis or Anodonta, generally depigmented and friable, due to the acidic environment within the sediment. Considering the share of the main lithological components, the sediments of L. Băclăneşti fall within the organic sediment class, with an average composition of 85.6% organic matter, 12.1% mineral material (predominantly detritic, siliciclastic) and 2.3% carbonates. The variation range of the organic substance content (77.4-91.2%) places all the samples in the category of organic mud.

19 taxons of 11 systematic groups (Acarieni, Hydridae, Hirudinee, Nematoda, Oligocheta, Gastropoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Chironomida) were identified in this lake.

The highest occurrence frequency in samples is adjudicated by 4 typical taxa for humid areas with muddy sedimentary substrates such as oligochets, chironomides (larvae and pupae), juv gastropods. and nematodes. (Fig.190)

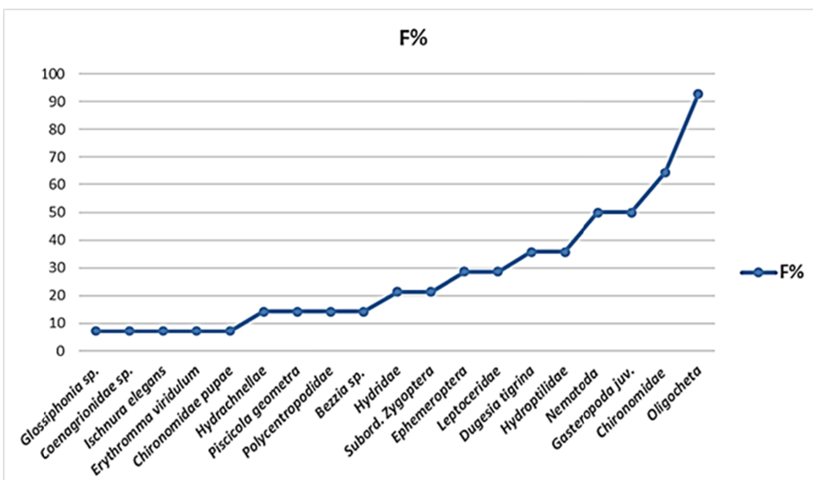

Fig. 190 The frequency of benthic taxa in Băclăneşti Lake

Within the investigated area, dominant density is Chironomide larvae 4062.5 ind./m^2, oligochete 2321,429 ind./m^2 and *Dugesia tigrina* 2299,107 ind./m^2.

The overall average density of the benthic populations in Băclăneşti Lake in 2013 was 13459.82 ind / m^2, being made up of 46% insect larvae, 38% of worms 11% molluscs, and 5% varying.

Of the total of 19 taxa identified in Băclăneşti Lake, only 9 species are abundant, making up almost 98% of the density and 99% of the average average biomass: Larvae of

Chironomidae, Oligocheta, *Dugesia tigrina*, Gastropoda, Hydroptilidae, Nematoda, Ephemeroptera, Zygoptera, mites. (Figure 192, 193)

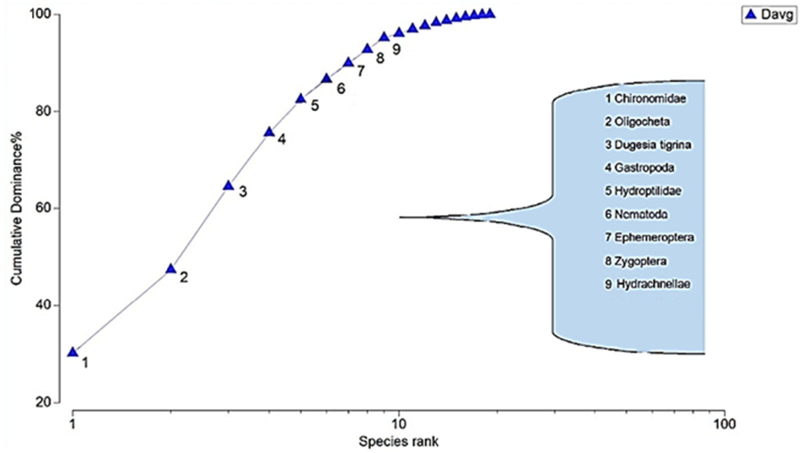

Fig. 192 The cumulative curve of the average density of the benthic populations in Băclăneşti Lake

Fig. 193 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be noticed that on the basis of the data transformed by the Euclidean distance, in the D13-330 and DD-13-325 stations the highest specific diversity compared to the other stations in Lake Băclăneşti.

The Ichtiofauna in the Mesteru - Fortuna Depression is made up of a representative number of species that characterize delta formations: most are sweet, common with the Danube, (*Esox lucius* Linnaeus, 1758 , *Cyprinus carpio* Linnaeus, 1758, *Carassius auratus* Linnaeus , 1758, *Rutilus rutilus* Linnaeus , 1758, *Leuciscus cephalus* Linnaeus , 1758 , *Tinca tinca* Linnaeus, 1758, *Scardinius erythrophthalmus* Linnaeus , 1758, *Aspius aspius* Linnaeus, 1758, *Abramis brama* Linnaeus , 1758, *Hypophthalmichthys molitrix* Valenciennes, 1844, *Hypophthalmichthys nobilis* Richardson, 1844, *Silurus glanis* Linnaeus, 1758, *Perca fluviatilis* Linnaeus, 1758, *Sander lucioperca* Linnaeus , 1758). (see Chapter V)

3. Assessment of aquatic ecosystems analyzed from the biological point of view in the Lumina - Rosu Depression

The Lumina - Rosu Depression is located in the southern part of the Danube Delta (Sulina - St. Gheorghe), but in the Delta Delta Marine sector. The depression is very extensive, being struck between the Caraorman grind to the west, Br. Sulina to the north, line of the Black Sea coast to the east and Br. St. Gheorghe in the south. The depression includes three very large lakes – Rosu (1445 ha.) Lumina (1367 ha) and Puiu (865 ha) and many smaller lakes, of which Iacub, Roşuleţ - Satellite of Red Lake, Puiuleţ, Vătafu, Lungu, Porcu, Rotund, Macuhova, Potcoava, Erenciuc and others. The major axis of water circulation in the depression consists of the main channel Crisan - Caraorman - Lake Puiu - Rosu Lake. Prior to the branch to Caraorman, the main canal receives as a tributary the Litcov Canal and redistributes the waters in the northern sector of the depression through the channels Iacub and Vătafu - Imputţita. The discharging from the terminal lakes - Roşu and Roşuleţ is made through the Busurca Canal to the Sulina branch and the Tătaru Canal (digging between Sulina and Sf. Gheorghe), a part flowing northwards towards Sulina and another south towards Sf. Gheorghe. [115 116]

Initially, the Crişan - Caraorman Channel had a positive role in the transfer of water through the depression, especially until 1991 until the Litcov Channel, the old depression channel was closed. Subsequently, the large amount of suspended solids, as well as the intake of remnant material from the channel eroded substrate, contributed to the integration of downstream lagging processes (Iacub, Puiu, Roşu). Thus, the display cone formed in Puiu Lake, at the mouth of the Crisan - Caraorman Canal, was largely fed by the eroded sand and transported from the Caraorman Grind, and the one located in the Rosu Lake, at the mouth of the Puiu - Roşu Canal, contains sedimentary (sandy) originated primarily from the erosion of the cord separating the two lakes. Another major change in water circulation in the region was the construction of the Sulina - St. Gheorghe seashore, the road and the accompanying canal (Tătaru Canal), started in 1988, which blocked the direct flow of water from the delta to the sea. Besides discharges through the aforementioned canals, there is also the possibility of a direct transit between the Lumina - Rosu and Sea depressions, over the pier and the highway, through a spillway provided by the station Channel, which is too high to allow a rapid and efficient passage of large spring waters. For this reason, the delta space between Caraorman and the sea is severely affected by saltwater processes, and blocking the water volume in the complex to a higher level than the natural one reduces water retention, promotes nutrient storage and H_2S under the plains and leads to the eutrophication 16,300 ha. [115 116]. In order to allow a quicker evacuation of large waters in July 2005, the dam was broken in the area of the spillway, allowing direct flow to the sea, but interrupting the traffic on the road connecting Sulina to St. Gheorghe.

Lake Iacub is situated in the western extremity of the Lumina - Rosu Depression, it has an elongated shape NNE-SSW, parallel to the Caraorman sandstones, which also forms the substrate of the lake. The lake is connected by a short channel (several hundred meters) from the Crisan Channel, so the influence of the river inlets from the Sulina branch is very strong. At the mouth of the canal there was a true delta, with arms and islets covered with reeds and shrubs, which clearly highlight the process of gradual clogging of the lake from the south to the north.

Given the special hydromorphological conditions in Lake Lacub, its sediments are much more varied. The southern area of the lake is dominated by dark gray to dark brown marshes, usually with yellowish oxidation films at the top, thick siliceous to fine sandy or even fine sandy sands, usually softer at the top and more compact at the side inferior, cohesive, sometimes with biotubes stuffed with yellowish, oxidized material.

The screech is represented by the rare shells of *Viviparus, Dreissena, Radix, Corbicula.*

In the central and northern parts, dark gray, silky, increasingly fine north, cohesive, sometimes even naughty, with many biotubes, prevail. Scratch is richer, along with numerous Viviparus and Dreissena shells, less Planorbis and Anodonta, live specimens of Unio, Viviparus and larvae of chironomidae.

The lithological composition covers a wider spectrum of sediments, from minerals and mineral-organic mills to the south, to organo-mineral and organic mud in the north.

Following the analysis of the samples in this lake, 25 taxa belonging to 17 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Isopoda, Gammaride, Nematoda, Oligocheta, Polychaeta, Gastropoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera). (Table 41).

The highest occurrence frequency in samples is adjudicated by 4 characteristic taxons for humid sedimentary wetlands such as oligochets, chironomides (larvae and pupae), ephemeropter larvae and juv gastropods. (Figure 194.)

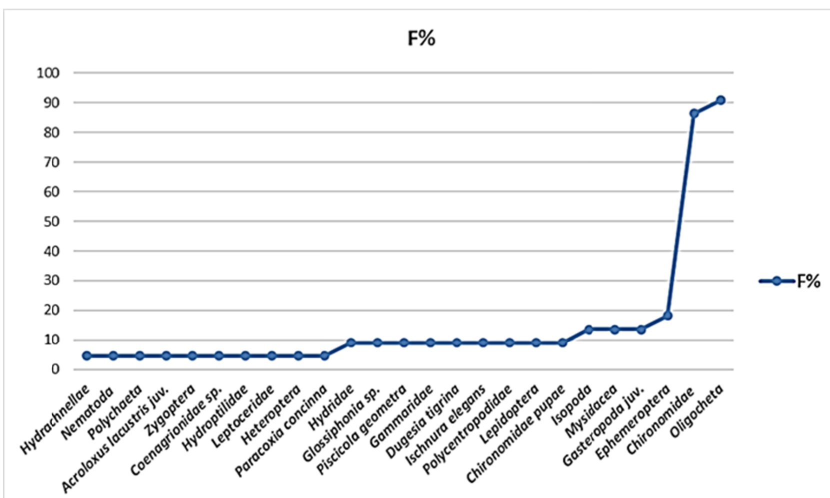

Fig. 194 Frequency of benthic taxa from Lake Iacub

Within the investigated area, the density of oligochets with 13302,56 ind./m^2, the chironomide larvae 7372,159 ind./m^2.

The overall average density of the Iacub Lake benthic populations in 2013 was 22833.80 ind / m^2, consisting of 58% worms, 35% insect larvae, and the rest vary.

Out of the total of 25 taxa identified in Iacub Lake, only 5 species are more abundant, making up nearly 98% of the density and 99% of the overall average biomass: Oligocheta, Larvae of Chironomidae, Ephemeroptera, Hydridae, Heteroptera. (Figures 196, 197)

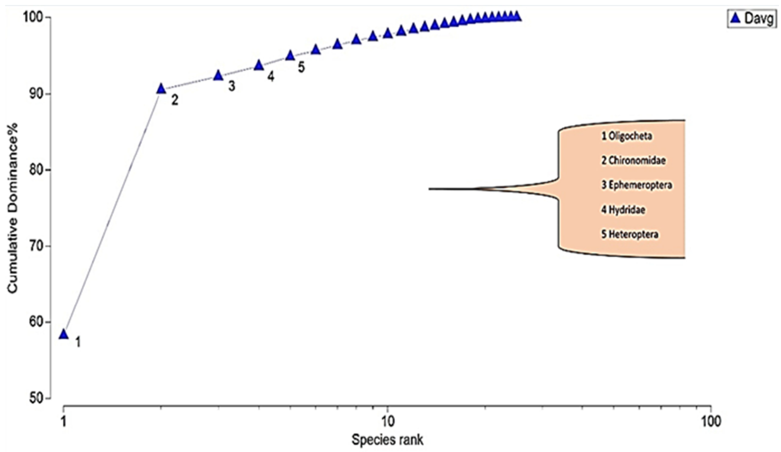

Fig. 196 Cumulative curve of the average density of the benthic populations in Lake Iacub

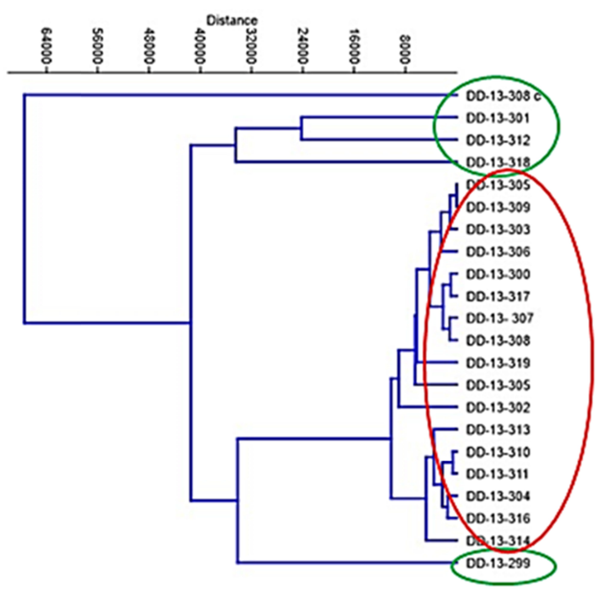

Fig. 197 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be seen that on the basis of data transformed by the Euclidian distance, in D13-308 struts, DD-13-301, DD-13-312, DD-13-318 and DD-13-299 show the highest specific diversity compared to the other stations in Lake Iacub.

Lake Puiuleţ

The sediments of Lake Puiuleţ are characteristic of lakes relatively protected by direct river intakes. Except for sample DD14-151 from the mouth of the western channel that connects to Cn. Crişan-Caraorman, where a dark gray mist appears to blackish, finely sandy, micaceous, soft, with a yellowish oxidized film at the top, the other sediments tested are dark gray organic mud, dark brown, soft, sometimes cohesive, sometimes (H_2S or saprogenic smell), rich in fine plant material, sometimes coarser.

The moths often contain fragments and shells of *Anodonta, Viviparus, Dreissena, Lymnaea stagnalis* etc., sometimes more or less depigmented and friable.

Following the analysis of the samples in this lake, 32 taxa belonging to 16 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Gammaride, Corofidae, Nematoda, Oligocheta, Gastropoda, Turbelaria, Ostracoda, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida).

The highest occurrence frequency in samples is adjudicated by 5 characteristic taxons for humid sedimentary humus substrates such as chironomides (larvae and pupae), *Candona candida, Cypria ophthalmica,* oligocheta, nematoda. Crustaceans are almost exclusively represented by ostracodes. (Fig.198)

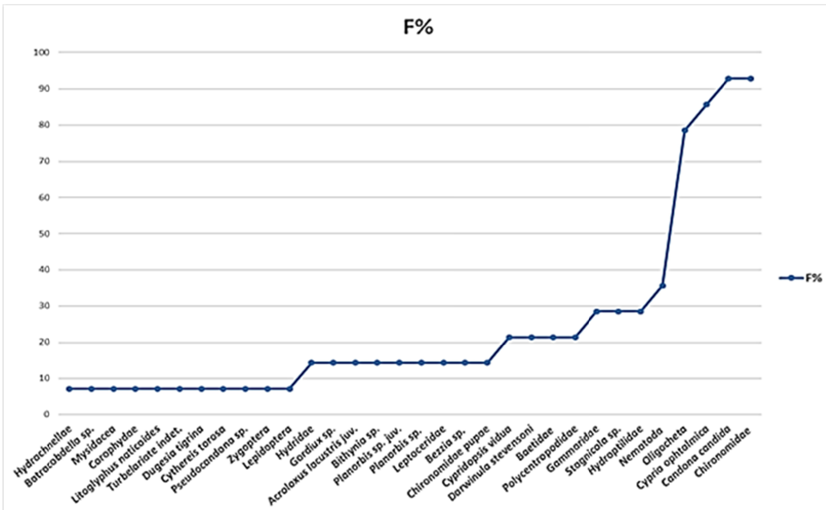

Fig. 198 Frequency of benthic taxa in Puiuleţ Lake

In the investigated area, the dominant species are the chironomide larvae 32366,071 ind./m^2, the oligochets 25904,01 ind./m^2, and the *Cypra ophthalmica* ostracoda 21573,66 ind./m^2.

The overall average density of Benthos populations in Lake Puiuleţ in 2014 was 115,100.44 ind / m^2, being made up of 40% of crustaceans, 30% of insect larvae, 23% of worms, and the rest vary.

Of the total of 32 taxa identified in Iacub Lake, only 7 species are more abundant, making up almost 95% of the density: Larvae of Chironomidae, Oligocheta, *Cypria ophthalmica, Candona candida,* Nematoda*, Pseudocandona sp., Cypridopsis vidua*. (Figures 200, 201)

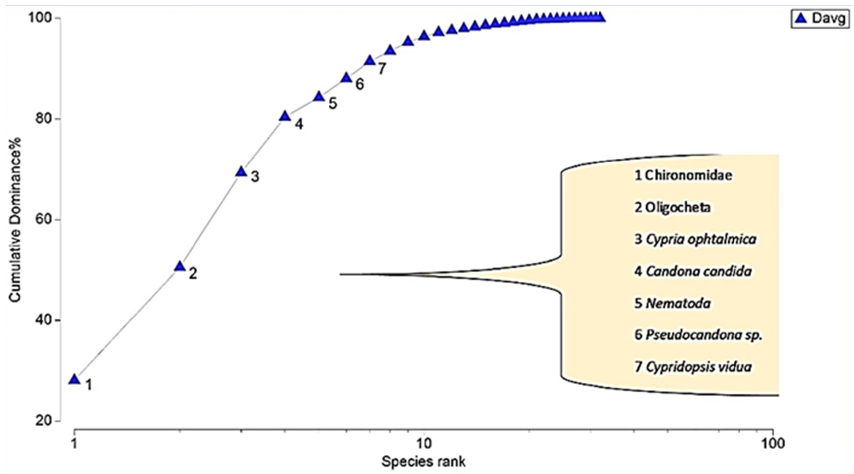

Fig. 200 The cumulative curve of the average density of the benthic populations of Puiuleţ Lake

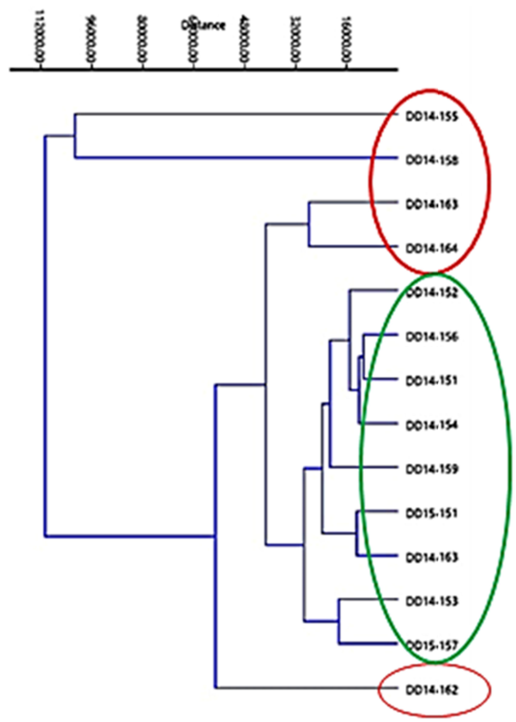

Fig. 201 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be seen that on the basis of data transformed by the Euclidean distance, in DD-14-155 stations, DD-14-158, DD-14-163, DD-14-164 and DD-14-162 show the highest specific comparative diversity with the other stations in Lake Puiuleţ.

The Ichtiofauna in the Lumina - Rosu Depression is made up of a representative number of species that characterize delta formations: most are sweet, common with the Danube, (*Esox lucius* Linnaeus, 1758 , *Cyprinus carpio* Linnaeus, 1758, *Carassius auratus* Linnaeus , 1758, *Rutilus rutilus* Linnaeus , 1758, *Leuciscus cephalus* Linnaeus , 1758 , *Tinca tinca* Linnaeus, 1758, *Scardinius erythrophthalmus* Linnaeus , 1758, *Aspius aspius* Linnaeus, 1758, *Abramis brama* Linnaeus , 1758, *Hypophthalmichthys molitrix* Valenciennes, 1844, *Hypophthalmichthys nobilis* Richardson, 1844, *Silurus glanis* Linnaeus, 1758, *Perca fluviatilis* Linnaeus, 1758, *Sander lucioperca* Linnaeus , 1758). (see Chapter V)

4. Evaluation of biologically analyzed aquatic ecosystems in the Razelm - Sinoe Lagoon Complex

Lake Babadag (October-November 2014) is the largest of the lakes marginal lagoon complex was included in the Danube Delta Biosphere Reserve, designated as the first Ramsar site in Romania in 1991. The lake is also included in the Natura 2000 network the special avifauna protection area. - ROSPA 0031 - The Danube Delta Razelm - Sinoe Complex and the site of community importance ROSCI 0065 - Danube Delta.

From a genetic point of view, Lake Babadag is a fluvial-lake limestone, grafted on Lake Razelm in the Lagunar Complex, a complex that arose from the barrage of the old Halmyris Golf in historical times. The lake also has some secondary limestones (Sărătura, Cotului Zebil, Tăuc and Topraichioi, the last two being converted into fish ponds). The lake is fed by two rivers northwest of important Central Dobrogea - noodles, which flows into the lake Topraichioi and Teliţa, through a channel bypassing artificial lake Tăuc flowing directly into Lake Babadag. To the southeast, Lake Babadag is linked to Razelm Lake via the Enisala artificial canal (4.5 km), blocked by a dike by DJ 222. The channal crosses a vast reed area, grown on the alluviums that make up the natural dam of the pawls on which the liman was formed. Babadag Lake has a length of about 9 km, a maximum width of about 3.5 km and depths reaching 3m. The total area of the lake (including the Sărătura and Cotul) is 2370 ha, of which 2080 ha represents the surface of the spawning. The lake is oriented to the NW-SE, it has vertical slopes up to 8-10 m on the south-western slope and 2-3 m to the north-east, dug into loessoid deposits, under which can be seen sometimes the Cenomanian limestone Babadag Basin (SW). [115, 116,]

In the case of Lake Babadag, bottom sediments formed in conditions different from those of delta. Until the bay closure and its transformation into the valley, the sediments were probably very similar to those in Razelm Lake.

By switching to closed seas or semi-cisterns, the circulation of sediments between the two lakes could not be made, so that Babadag Lake remained strictly subject to the continental inlets, manifested through the two main streams in the northwest - Taita and Telita, (Tabana and Suhata Valley), the waters of the surrounding hills and the loess cliffs.

The macroscopic examination of sediment samples taken at the time of sampling revealed the presence of marshes largely different from those of the Delta lakes and the Lagunar Complex. The sediments in the central area of the lake are generally more similar to those in Lake Razelm, being represented by fine silty mosses, dark gray to dark brown, rather loose, but cohesive, with rare biotubes, passing to the top to a liquid sludge with a yellowish-yellow oxidation film. The sediment at the periphery of the lake is represented by coarse, dark brown or blackish gray silt, gray-yellow oxide oxidation film, compact at the bottom and more lying at the top, sometimes with visible active biotubes (generated especially by larvae Chironomidae). More rarely, close to the shores, thick silt coats, fine sands or black-and-white sands with oxidation films and shells of shells are emerging.

Following the analysis of the samples in this lake were identified 9 taxa belonging to 5 systematic groups (Nematoda, Oligocheta, Ostracoda, Corofidae, Chironomida,).

The highest occurrence frequency in samples is adjudicated by 4 characteristic taxons for humid sedimentary wetlands such as oligochetes, chironomides (larvae and pupae), *Darwinula stevensoni and Cyprideis torosa*. Crustaceans are almost exclusively represented by ostracodes. (Figure 202)

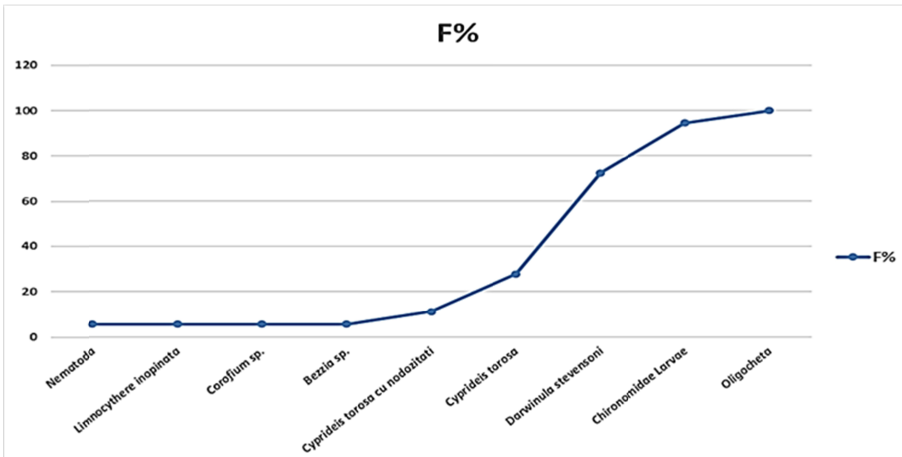

Fig. 202 Frequency of benthic taxa in Babadag lake

Within the investigated area, the densities are the oligochetes 11627,78 ind./m^2, the chironomide larvae 5320 ind./m^2, and the nematode 4511,11 ind./m^2.

The general average density of Babadag Lake benthic populations in 2014 was 22407.78 ind / m^2, with 72% of worms, 24% insect larvae and the rest varying.

Of the total of 9 taxa identified in the Babadag lake, only 4 species are more abundant, making up almost 98% of the density: Oligocheta, Chironomidae Larvae, Nematoda, *Darwinula stevensoni* (Figures 204, 205)

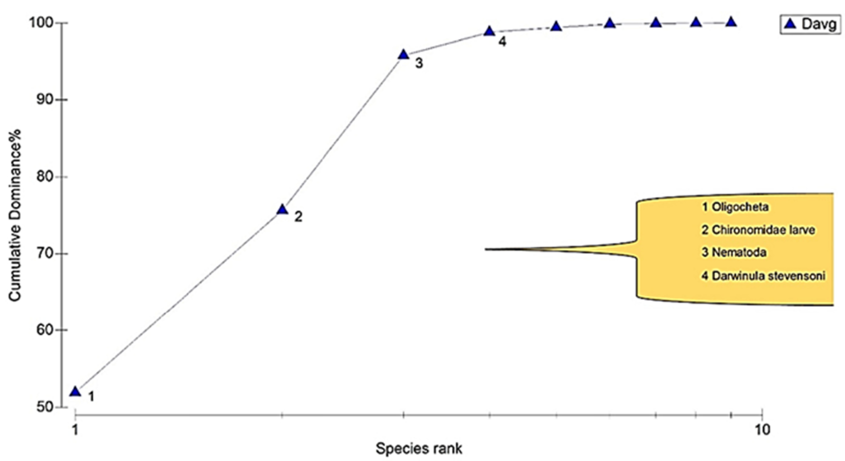

Fig. 204 The cumulative curve of the average density of benthic populations in Babadag Lake

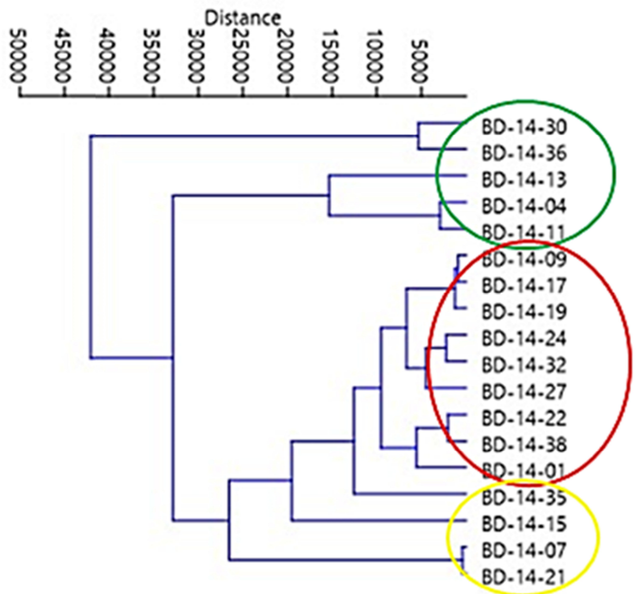

Fig. 205 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be noticed that based on data transformed by the Euclidean distance, BD14-30, BD14-36 and BD14-04, BD14-13, BD14-11, BD14-11 show the highest specific diversity compared to other stations in Babadag lake.

Istria lake

The marginal lakes of Lagunar Complex are former Hallmyris bays, separated by natural dams. Istria Lake lies to the west of Histria Citadel and Lake Sinoe, to which it is bounded by a channal in the north. To the south, the lake communicates through a channel, now inoperative, with the Nuntasi Lake.

The sediments of Istria Lake are predominantly made of dark gray, sometimes darker mud, covered by a yellowish oxidation film, often biotubed, with a soft, top-to-bottom, compact coat, sometimes with saprogenic smell. commonly shells and fragments of Cardiide, Corbula, Spisula, Sphaerium, associated with Balanus. On the south-east frame of the lake (samples H15-13 and H15-18) there are sandy sediments.

Following the analysis of the samples in this lake, 11 taxa belonging to 9 systematic groups (Acarieni, Nematoda, Oligocheta, Corofidae, Ostracoda, Odonata, Trichoptera, Chironomida, Heteroptera) were identified. (Table 47).

The highest occurrence frequency in samples is adjudicated by 3 taxons characteristic of wetlands with muddy sedimentary substrate such as Bezzia species, chironomides (larvae and pupae), and oligochetes (Fig. 206)

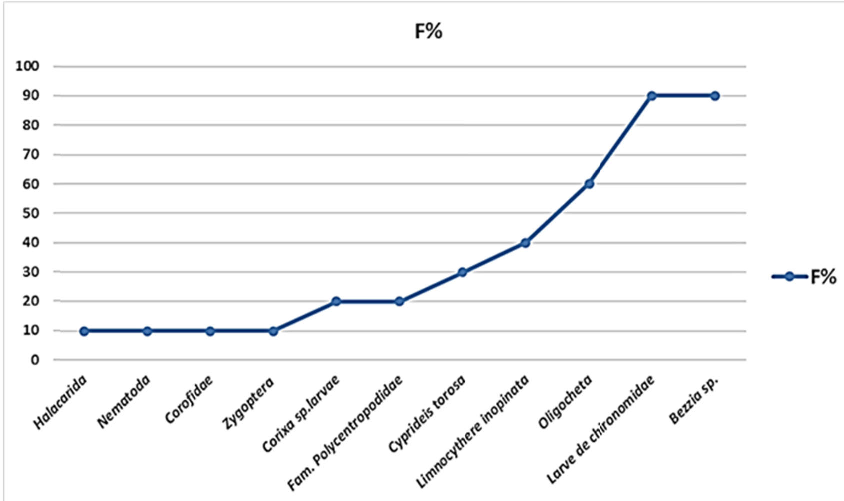

Fig. 206 Frequency of benthic taxa in Istria

Within the investigated area, the oligochets with 3390,625 ind./m^2, chironomide larvae 2562,5 ind./m^2, Limnocythere unopposed with 2375 ind./m^2 and nematodes 1734,375 ind./m^2 are dominant.

The overall average density of the benthic populations in Istria Lake in 2015 was 11593.75 ind / m^2, being made up of 44% of worms, 26% of insect larvae, 26% of crustaceans, and the rest vary.

Of the total of 11 taxa identified in the Istria lake, only 4 species are more abundant, making up almost 98% of the density and 99% of the overall average biomass: Oligocheta, Larvae de Chironomidae, *Limnocythere inopinata*, Nematoda, *Cyprideis torosa*. (Figure 208, 209)

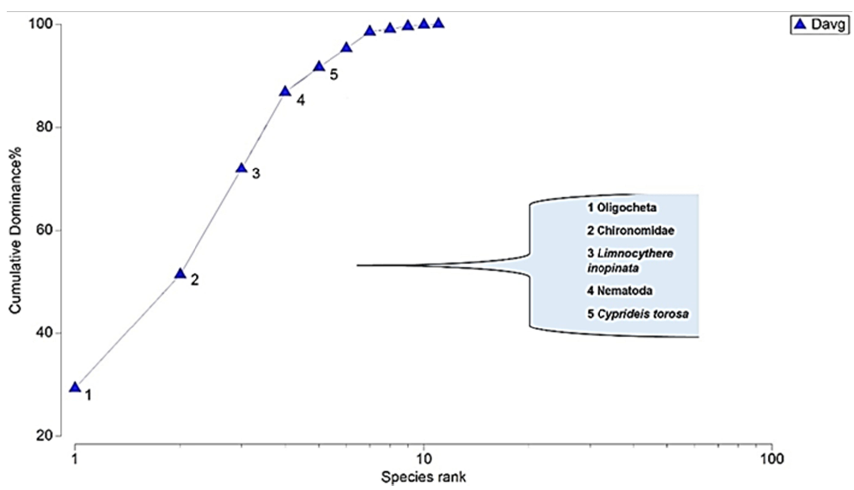

Fig. 208 The cumulative curve of the average density of the benthic populations in the Istria lake

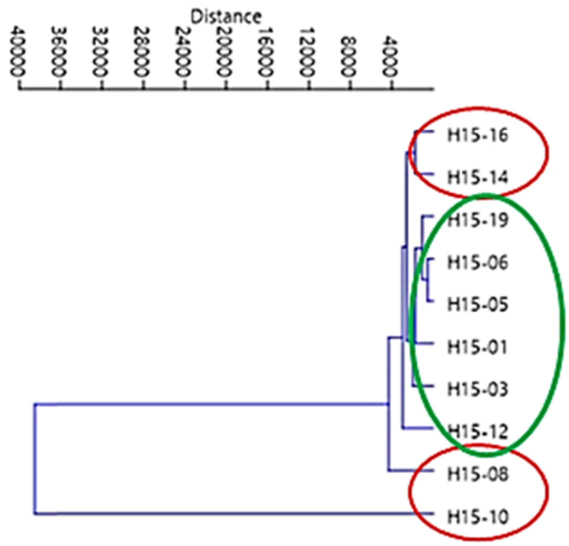

Fig. 209 The similarity between the analyzed stations calculated by the Euclidean distance method

It can be seen that on the basis of data transformed by the Euclidean distance, stations H15-16, H15-14 and H15-10 and H15-08 show the greatest specific diversity compared to the other stations in the Istria lake.

Razelm - Sinoe

In the Lagunar Complex, the sediments are relatively similar to those in the delta lakes influenced by the Danube intakes, in the sense that the superficial part of the bottom sediments (up to 5-10 cm) is made of dark gray mud, with a moderate content of organic matter, and with common sweet fauna (Anodonta, Unio, Viviparus). Under this recent sediment blanket, however, there is a strong, dark-shell, sometimes light-colored shell, rich in the predominant shells (Cardiide, Dreissena), which in turn covers a greasy, greasy gray grease.

The direct observations made on sediments in the Lagunar Complex indicate a fairly uniform lithology in Razelm and Golovita lakes and a slightly larger variation in the other two: Sinoe and Zmeica. In the first two lakes, at the top of the bottom sediments there is a dark gray mud layer - dark gray (described in the descriptions as "a" layer), which always has a film of 0.1-1.0 cm yellowish and usually very fluid in color and may contain mollusks shells and live specimens, especially Anodonda, rarely Unio, subdivided by Dreissena and Viviparus and accidentally limnocardiide). Under the "a" layer, there is a constant level of 2-7 cm thick (marked with "b"), very rich in Cardiide shells, with the subordinate or sporadic appearance and Dreissena shells (often depigmented) Abra, gasteropodes, etc. The composition of the sediment ranges from a blackish moth, very rich in organic matter, and usually quite fluid, non-cohesive, to a spruce with a muddy matrix, or even a clean, almost matrix-free cleft. When it is muddy, the cochlea passes to the bottom gradually to a gray-gray, light, compact, greasy, very cohesive mist, sometimes full of unoxidized fine biotubes, whose thickness intercepted in the specimen specimen can reach 4-5 cm denoted as "c"). More sandy sediments are frequent in the areas of the main Dunavăţ and Dranovul intake channels and along the eastern bank of the lake, south of the Dunavat Canal, also in the area of influence of the Danube inlets. [101]

In Sinoe Lake, the central area is occupied by gray-black, bioturbated mud, with a rather low oxidized film, with rare shells or shells to the base, which is the equivalent of the "a" layer in the northern lakes.

Below it, sometimes an equivalent of "b + c" strata in Razelm Lake is also intercepted, represented here by a lighter gray clay, very cochiliferous (especially Cardiide, subordinate to Dreissena). In the peripheral areas the situation changes, the proximity of the sandy cords being marked by the abundance of a coarse component, so the sediments pass to silt mills, sandy sands and finally sands, usually rich in shell debris.

The sediments of Lake Zmeica are similar in the more central areas of the lake, and at the periphery they pass to sandy mills (rarely sands), sometimes very cochilifers, reaching to true screeches. Unlike L. Sinoe, among the Cardiide, Dreissena or Abra shells, there are also freshwater molluscs (Anodonta).

It has been noticed that in Razelm Lake the siliciclastic detrimental material is supplied primarily by the three main channels - Dunavat, Mustaca and Dranov (from north to south), which protrude into the lake from the east. All three have well-marked display areas of siliciclastic sediments, the detritic material being then transported along the eastern shore by north-south currents. The siliciclastic sedimentary band joins south with the coarser sedimentation area adjacent to the Coşna grind. Small concentrations of siliciclastic mud also appear around the Popina Island and near the Agighiol and Babadag lakes (both of which are limestone). Organic and mineral sediments rich in organic matter appear in deeper areas and in protected areas (Fundea and Holbina bays) in L. Golovita Organo-mineral moths predominate in most of the lake, with the exception of the eastern area adjacent to the cords sandy beaches from the Island of Bisericuta and Portiţa, which can provide the basin with a significant siliciclastic detrimental component, but limited to the nearby areas.

From the analysis of the samples collected from the Sinoe, Zmeica and Golovita lakes, 31 taxa were identified in the quantitative and qualitative samples (Table 48) belonging to 16 zoobenthic groups (Halacarida, Hydridae, Nematoda, Oligocheta, Hirudinea, Gasteropoda, Bivalva, Larvae of Chironomide, Ostracoda, Corofida, Gammaridae, Cumacea, Heteroptera, Trichoptera, Lepidoptera, Efemeroptera).

The qualitative structure of the benthic fauna is characterized by eudominant and econstant species (chirnomida larvae, Oligocheta, amphipods with Gammarus and Corofium generes and policeman species with invalid Hypania species), species with a frequency between 50-75% are constant species and species with frequency less than 50% are incidental or accidental species (Figure 210)

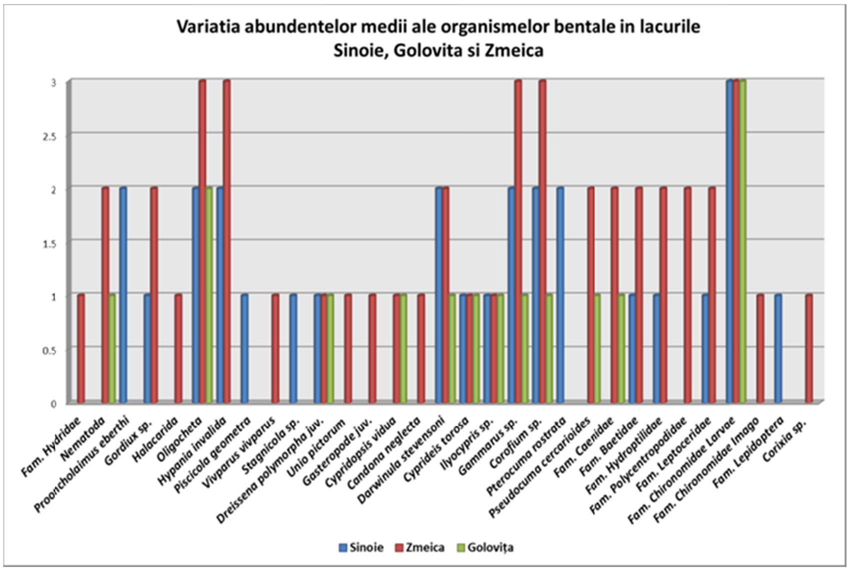

Fig. Variation of average abundances of benthic organisms in lakes Sinoie, Golovita and Zmeica

Among the nematodes was the species *Prooncholaimus eberthi*, Filipjev, 1918, a marine species with a great abundance in Lake Sinoe.

Of the cumaceae two species of *Pterocuma rostrata* Sars, 1894 and *Pseudocuma cercarioides* Sars, 1894 were identified.

Pear-shaped Sars, 1894, lives on sandy, muddy, muddy banks at 2-8 m deep, in relicts, Ponto-Caspian (Dreissena, Hypania, etc.). The night comes to the surface without being phototropic. It was found in Lake Sinoe.

The *Pseudocuma cercarioides* Sars, 1894 prefers the muddy but covered with plants, but washed by a light current (1-5 m). At night he leaves the substrate to swim freely in the water; on this occasion, at dawn, it can also cling to the floating leaves remaining in place. This explains why it can sometimes be caught in the daylight among the water lilies. It is, therefore, one of the few known cumacea known planticles; because of the sedentary life and the favorite biotope, its skin often attracts algae and various particles that can make it black. They increase camouflage, (homochromy). It was found in the samples collected from the lakes Zmeica and Sinoe.

As underwater vegetation have been identified the species *Myriophyllum spicatum, Azolla filiculoides, Elodea nutalii, Potamogeton perfoliatus*

Due to anthropogenic interventions over the last decades on the whole system Razelm - Sinoe to transform it into a reservoir of freshwater for agriculture, with some marginal sectors for intensive fish farming, have led to significant changes associated ecosystem.

Temporal variation regime saline, translated by the increasing trend of sweetener in recent years, due, on the one hand, the gradual reduction of the influence of marine (closing by human intervention of natural links with the sea) and, on the other hand, higher input of the Danube's fresh waters, has put its mark on the qualitative and quantitative structure of the benthic populations.

If before 1956 more than 70% of zoobenthos was formed by Ponto-Caspian relicts and only 30% by freshwater. and brackish [129], at the beginning of the 21st century the ratio between them changed completely. Today, the dominant forms are freshwater.

The most important changes in the qualitative structure of the lagoon fauna were felt by the benthic molluscs and a part of the crustaceans, especially the ostracodes. The comparative analysis of the 2016 biological material with the data obtained in the 1970s (Teodorescu-Leonte, 1977) shows that a series of eurihaline species (Cardiidae, Syndesmia (Abra), Hydrobia, Briozora, Balanus sp., Marine ostracodes) as well as the more sensitive sweetheads (Theodoxus). These have been gradually replaced by newly emerged, more resistant, stenobiotic forms such as *Anodonta cygnaea, Corbicula fluminaea* and *Unio pictorum*, etc. Therefore, the ecological succession of the lagoon complex, through the gradual passage from the marine environment to the lake, allowed the evolution of an ecosystem formed mostly of sweet species.

In 2017, faunistic researches in the lakes studied revealed the presence of 51 taxa belonging to 20 major taxonomic groups of invertebrates (halacarid, nematodes, tulbarians, oligochetes, polychetes, hirudines, gastropods, bivalves, ostracodes, amphipods, isopodes, decapods, ephemeropters, trichopters, odonates, chironomides, lepidoptera, heteroptere) in the lagoon complex Razelm - Sinoe.

Among the worms, the oligochets have the numerical weight (mean abundance of 986 ind./m^2), not determined to the species. The molluscs were represented by a limited number of species in the study area, *Bithynia leachi, Lithoglyphus naticoides, Theodoxus danubialis, Esperiana esperi, Viviparus viviparus and Radix sp.* Were identified among the gastropods and *Anadonata cygnea juv, Dreissena polymorpha , Sphaerium corneum, Limnocardiidae juveniles.*

Of the crustaceans, the number of identified gammarides and corophilides is limited, but all forms are Ponto-Caspian relicts, which have adapted to existing conditions, where they form true agglomerations. The dominant form throughout the studied region is *Corophium curvispinum*, constituting 72% of the total amphipod. Next to it are smaller *Corophium robustum, Dikerogammarus haemobaphes fluviatilis, Dikerogammarus villosus, Chaetogammarus tenellus behningi, Uroniphargoides spinicaudatus, Pontogammarus obesus, Chelicorophium curvispinum, Euxinia sarsi, Stenogammarus kereuschi and S. compresso similis.* Among the misids were identified two species *Paramysis bacuensis* and *Paramysis ullscyi* and among the cumaceae were identified the species *Pseudocuma cercarioides, Pterocuma pectinatum, Schizorhamphus scabriusculus.*

The crustaceans are also the *Jaera Sarsi* isopod, which is very common in the Danube and in the lakes of the Danube Delta and is the only isopod quoted for all sectors [130]. In 2017, this isopod species was rarely found in evidence.

Ostracods are rarely found in the study area and are poorly represented quantitatively. Present were the species *Darwinula stevensoni, Ilyocypris sp., Pseudocandona albicans.*

Of the insects, the most important groups are the larvae of chironomides, trichopters and ephemeropters, and a rare presence of Zygoptera and Anisoptera, and Lepidoptera.

Trichopters are represented by species of Hydropsychidae Fam, Polycentropodidae Fam., Leptoceridae Fam, Hydroptilidae Fam., Ephemeroptera larvae are represented by

Caenidae, Baetidae, Leptophlebriidae. Also present in the samples were insects belonging to the Heteroptera group with representatives of the species C*orixa dentipes and Paracoxia concinna*. Of the marine fish, the *Syngnathus acus* of the Syngnathidae family with a unique biological feature is identified as a species with a wide ecological plasticity, populating both salty and sweet waters.

This avoids fresh flowing waters because it can not swim against the current. During the day it is hidden in the aquatic vegetation. It feeds on lower crustaceans, rotifers, insect larvae.

Quantitative composition of benthic populations in the lagoon complex Razelm - Sinoe

Observations on benthic fauna come to complete the environmental research undertaken in recent years to characterize the status of ecosystems in the studied areas. Being the compartiment directly connected to sediment debris, benthos is the main link that transfers the energy stored in sediment as organic debris to superior trophic levels (bentophagous fish), thus indirectly contributing to the valorisation of the energy accumulated by primary producers in aquatic ecosystems [117, 118]. The overall average density of benthic populations in the Razelm - Sinoe lagoon complex in June 2017 was 24,403 ind./m^2.

Thus, the fundamental functional compartiments are occupied by a small number of eurioid species. The highest occurrence frequency in samples is adjudicated by 5 typical taxa for wetlands with muddy sedimentary sedimentary substrate such as corophidae and gammaridae crustaceans, chironomidae larvae and trichopters, and *Piscicola geometra* hirudine species. (Figures 211, 212)

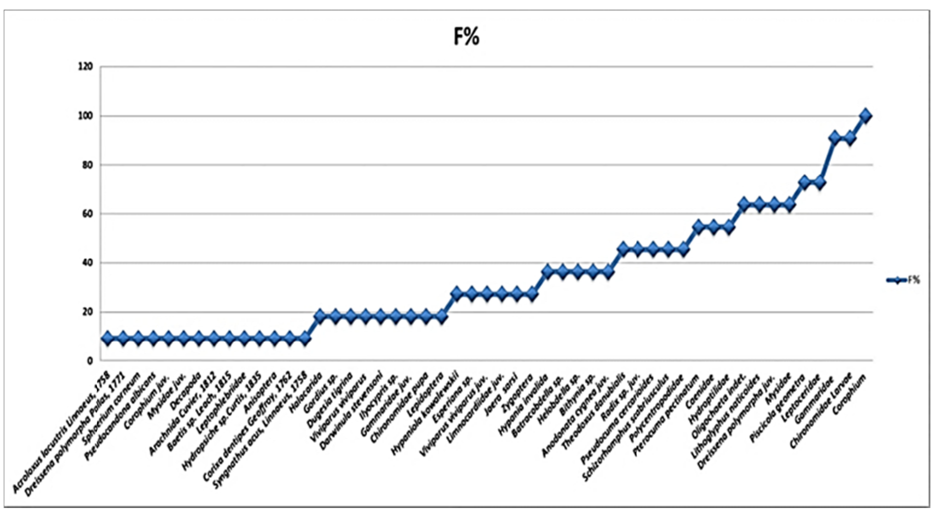

Fig. 211 Frequency of benthic taxa in the Razelm - Sinoe lagoon complex area in June 2017

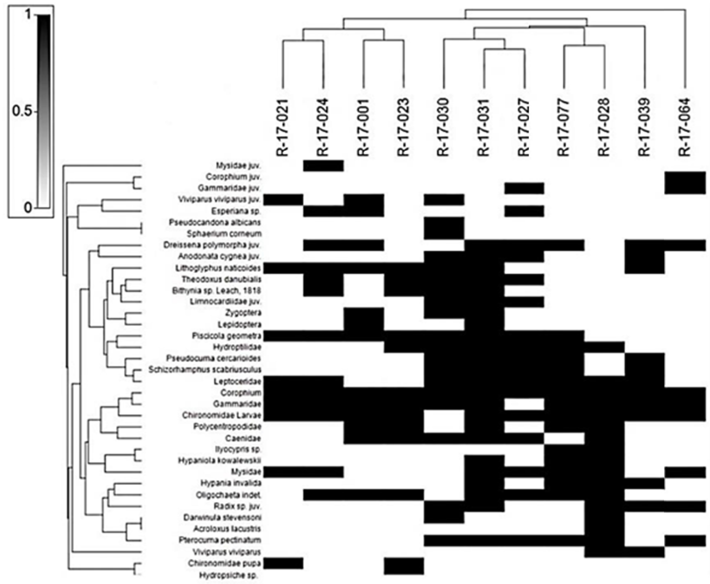

Fig. 212 Index of association between macrobental species (vertical) and stations based on the Bray-Curtis similarity (presence / absence transformation) (horizontally)

Of the total of 51 taxons identified, only 6 taxons are more abundant (*Corophium, Gammaridae, Darwinula stevensoni, Pterocuma pectinatum, Pseudocuma cercarioides, oligocheta*), making almost 75% of the density. (Fig.213)

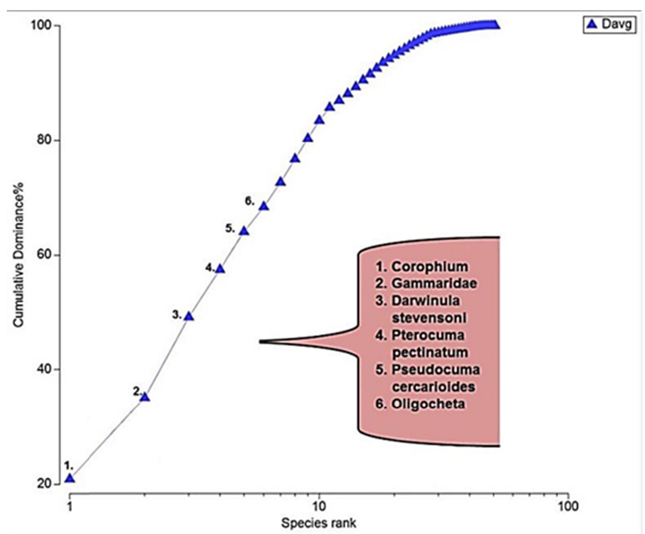

Fig. 213 The cumulative curve of the average density of benthic populations in the investigated area

It can be seen that on the basis of data converted to the Euclidean distance, in stations R-17-028 and R-17-077, R-17-064 shows the highest abundance. (Figures 214, 215)

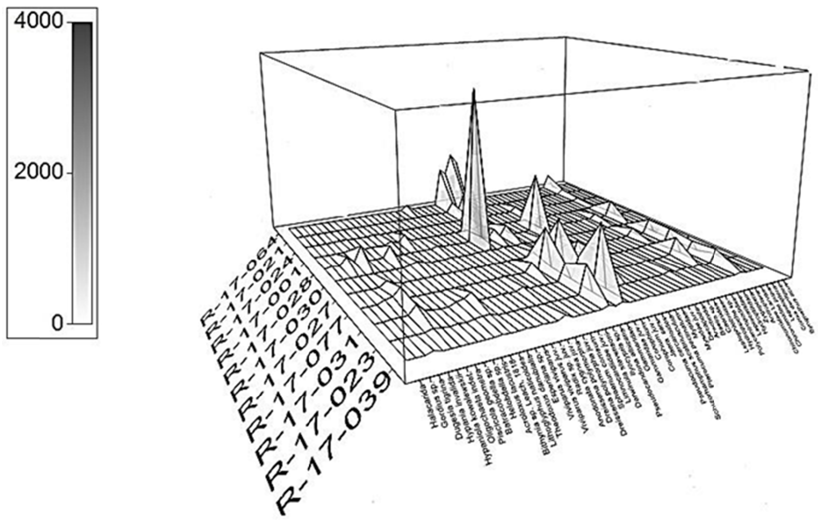

Fig. 214 Abundance at stations in the lagoon complex Razelm – Sinoe

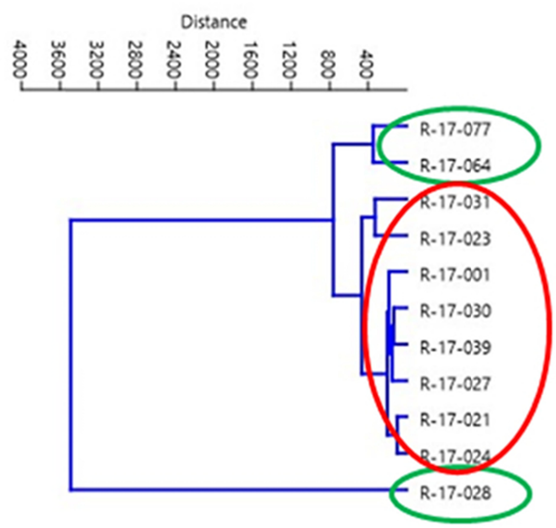

Fig. 215 The similarity between the analyzed stations calculated by the Euclidean distance method

Ihtiofauna in Razelm - Sinoe Lagoon Complex is made up of a representative number of species that characterize delta formations: most of them are sweet, common with the Danube (*Esox lucius* Linnaeus, 1758 , *Cyprinus carpio* Linnaeus, 1758, *Carassius auratus* Linnaeus , 1758, *Rutilus rutilus* Linnaeus , 1758, *Leuciscus cephalus* Linnaeus , 1758 , *Tinca tinca* Linnaeus, 1758, *Scardinius erythrophthalmus* Linnaeus , 1758, *Aspius aspius* Linnaeus, 1758, *Abramis brama* Linnaeus , 1758, *Hypophthalmichthys molitrix* Valenciennes, 1844, *Hypophthalmichthys nobilis* Richardson, 1844, *Silurus glanis* Linnaeus, 1758, *Perca fluviatilis* Linnaeus, 1758, *Sander lucioperca* Linnaeus , 1758). their juveniles penetrating into the complex looking for food, plus the marine species that enter the complex for lunch or attracted by the richness of food. (see Chapter V).

The abundance of representatives of the Gobiidae family (Ponto-Caspian relicts) (*Gobius fluviatilis, G. gymnotrachellus, Benthophylus stellatus*), perfectly adapted to the oligohalin environment of the complex, must be emphasized. The fishery production in the complex is based on four limestone species: salami (the first place in the country), carp, plaice, caraway and roe. (see Chapter V)

From the point of view of the general average density for benthic fauna, the depression with the highest weight is Matiţa - Merhei with 48%, followed by Lumina - Rosu with 34%, Razelm - Sinoe lagoon complex with 15%, Meşteru - Fortuna Depression 3% (Figure 216)

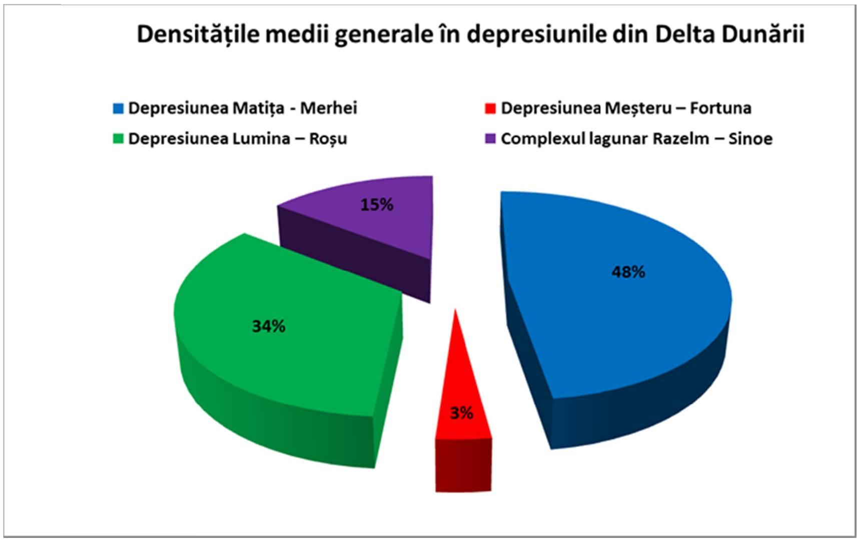

Fig. 216 Share of average general densities in the Danube Delta depressions

The overall average density of benthic fauna in the four depressions analyzed is 402188,77 ind / m^2.

CHAPTER V - ANALYSIS OF THE DATA OBTAINED FROM THE RESEARCH OF THE MAIN LAKES IN THE DANUBE DELTA AND THEIR IMPORTANCE IN FISHING EXPLOITATION

The Danube Delta presents an impressive diversity of habitats and wetland species in a limited space, which led to its declaration in 1990 as the Danube Delta Biosphere Reserve.

Among the economic activities carried out, fishing is the main traditional economic activity taking place on the territory of the Danube Delta Biosphere Reserve, thus, the objectives of the PhD thesis have been aimed at making a contribution to the creation of a database for a scientifically based strategy based on the knowledge of ecological conditions, species biology and the requirements of sustainable management of natural resources.

Fish catches in the natural basins of the Danube Delta Biosphere Reserve are in a continuous decline and, at the same time, in a broad modification of the structure of the dominant populations by replacing economically valuable fish species with other less important or exotic species, phenomena caused by deterioration of environmental conditions or anthropogenic influences, and the improvement of the qualitative and quantitative composition of the fishery resource is achieved through a permanent knowledge of the histopathology, past and present, but also through the sustainable management of biological resources. [131]

In Romania, the Danube Delta represents the place of transition from freshwater to marine waters, which results in a combination of freshwater fish and marine water species.

In marine waters fish species have completely different adaptations starting from the shore to the sea.

The taxonomic and ecological knowledge of fish species in the Danube Delta Biosphere Reserve is a basic component of the scientific substantiation process.

The fish species identified in the Danube Delta Biosphere Reserve are 133 and are classified in 3 Classes, 20 Orders, 45 Families, ie 47 species are freshwater, 12 eurihaline species, 9 marine-migratory species, 56 marine species, and 9 introduced species , alohtones [130, 131, 132], but this number is not fixed, but one variable due to the continuous dynamics of fish species, since new species are regularly appearing in the Danube-Danube Delta-Black Sea system.

Most of the freshwater species are from the Ciprinidae family followed by marine species, especially the marine migratory species potamotocean (on the river and in the ponds only accidentally) or eurihaline marine species.

Of the only marine species found only in the salty waters of the sea, only 56 species were captured in the Marine Area of the Danube Delta Biosphere Reserve until it is 20 m deep, but the number can be improved at any time as a result of fish mobility.

And migratory species are species that move long distances from the marine environment to the wild or vice versa for reproduction. These are 9 species: on the one hand, most of them are anthropos (potamotoceae) such as *Huso huso* (morun), *Acipenser gueldenstaedtii* (sturgeon), *Acipenser stellatus*, *Alosa immaculata, Alosa tanaica* and endemic species the *Salmo labrax* Pontian basin, the only sea trout in the Pontic basin, and catadromes such as *Anguilla anguilla* (eagle), the species with the longest migration in the world, 6,000 km to the Sargassa Sea, where adults put up their sexual elements and die out. The extinct are *Acipenser sturio* (sip) and *Acipenser nudiventris* (visa).

Among the eurihaline species are those with a wide range of salinity to live. 9 species have been described, such as Gobiidae (guvizi), *Atherina boyeri* (aterine). [132]

And among the dulce species there are species such as *Carassius gibelio* (caras), *Cyprinus carpio* (carp), long considered exotic, which are totally 51 species.

These species usually occur in the freshwaters of the Delta, but many of them can also reach the sweetened areas of the Black Sea, especially at the mouths of the Danube. Most freshwater species can undertake feeding, reproduction or wintering migrations on short lengths between the river and adjacent lakes. Such species have been called potamodrome semimigrams and include *Silurus glanis* (catfish), *Cyprinus carpio* (carp), *Abramis brama* (platica), *Aspius aspius* (avat).

Exotic species (alohtone) describe 8 species artificially introduced by man (for fish farming) or accidentally from other regions, which currently populate the aquatic environments of the Danube Delta Biosphere Reserve. They may be marine like *Liza haematocheila*, eurihalins such as *Percarina demidoffi*, which currently have the world's most stable population in the Razelm-Sinoe complex, or exotic suckling species such as *Lepomis gibbosus* (queen) and Chinese carp species. A new exotic species *Perccottus glenii* [132] has recently been reported and probably other alotonic species will appear in the near future, being signs of their existence upstream of the Danube Delta Biosphere Reserve.

In the Danube Delta, there are species, the vast majority of which are semi-migratory between the two streams of water (euritope), but there are also limnophile species (species that prefer stagnant waters, but can also reach quiet areas of running waters) such as *Esox lucius, Tinca tinca, Carassius carassius, Scardinius erythrophthalmus, Misgurnus fossilis, Umbra krameri, Pungtius platygaster*. [132]

Typical reophilic species living in the rivers and rivers stream are endemic species of the Danube basin, such as *Zingel zingel, Zingel streber, Gymnocephalus schraetser and Gymnocephalus baloni.* Others, such as *Barbus barbus, Chondrostoma nasus, Roman spp., Vimba vimba, Leuciscus idus, Lota lota, Abramis sapa*), they only arrive accidentally in the lake complexes.

The dominant and most common species in the Danube Delta Biosphere Reserve are *Alburnus alburnus, Rutilus rutilus, Perca fluviatilis, Scardinius erythrophthalmus, Blicca bjoerkna (batca), Carassius gibelio (caras).* [132]

Thus, for the Danube waters and its arms dominates the ring, but important are also the avatele, the Danube scrub in the migration season, the carp, the carass, the species of Abramidae, species of Gobiidae. For the dominant lacustrine complexes are the swan, red, perch, bat, carass, and significant values also have sleep, lance and pike, as well as small-sized species such as ankle, dove, mermaid (*Rhodeus amarus*) indicator of the presence of shellfish in the aquatic environment. The Razelm-Sinoe lagoon complex is dominated by the Gobiidae, *Alosa tanaica*, the swamp, and the chalky species (though its values are constantly decreasing every year), *Percarina demidoffii, Pelecus cultratus* (sword). [132]

List of dominant fish species identified within the Danube Delta Biosphere Reserve [131]:

Species of migratory fish

Clupeidae Family

1. Alosa Gen
Alosa immaculata Eichwald, 1838

Alosa tanaica Eichwald, 1838

Freshwater species

Esocidae Family

2. Esox Gen
Esox lucius Linnaeus, 1758

Cyprinidae Family

3. Cyprinus Gen
Cyprinus carpio Linnaeus, 1758

Carassius Gen

Carassius auratus Linnaeus, 1758

(ssp. *C. a. gibelio* Bloch, 1783)

Carassius carassius, Linnaeus, 1758

4. Rutilus Gen
Rutilus rutilus Linnaeus, 1758

5. Leuciscus Gen
Leuciscus cephalus Linnaeus, 1758

Leuciscus idus Linnaeus, 1758

6. Tinca Gen
Tinca tinca Linnaeus, 1758

7. Scardinius Gen
Scardinius erythrophthalmus Linnaeus, 1758

8. Aspius Gen
Aspius aspius Linnaeus, 1758

The main fish resource of the Danube Delta Biosphere Reserve is the lake complex, followed by the Danube water resource and its arms (mainly based on the migration of the Danube Scrub), following the Black Sea fishery resource (based on small species: sprat, anchovies, gobiidae species,)

From the available data on official catch statistics from the Danube Delta Biosphere Reserve [132,133] it can be seen that fish catches are continually decreasing from 14,000 tons of fish per year to a minimum of 1,800 tons of fish per year, where some commercial fish species had a drastic drop in catches that in the last 10 years they were almost no longer found in catches (caracuda), while other species had a steady evolution in catches (caras exploded numerically after the great flood of 1970 and later after the stabilization of the population had a relatively constant evolution of catches).

Thus, we can list the factors that negatively influenced the evolution of catches of all fish species, especially species with vulnerable populations, are:

• biological factors (the development of opportunistic, competing species, with high ecological plasticity, such as the roach, the bat, the carass, against the native species such as caracuda;

multiplication of ihtiofage birds consuming a calculated amount of Năvodaru et al, at over 7500 tons of fish per year; [134]

• abiotic factors (climate change by increasing the multi-year temperature by 1-2ºC);

• the anthropic influences (poaching, especially electric, over-fishing, industrialization and agricultural development through the use of insecticides) have facilitated the spread of eutrophication with serious effects on aquatic fauna, especially since the 1980s;

• water pollution - the amount of water suspension has increased with negative impact on benthic fauna;

• interruption of the longitudinal and lateral aquatic links - have affected fish migrations;

• drastic climate change;

• damming over 100,000 ha, dismantling large water areas, ballast water of vessels - all of which have led to the spread of competing species to food.

At present, the main fish resource of the Danube Delta Biosphere Reserve is made up of commercial species such as caraway, more than 50%, followed by the roach (swarms) and the plaque (battleship), but significant species are also species catfish, carp, scomber of the Danube. [132,133]

The concepts of fishing are those that complete a full scientific study of the fishery resource of the Danube Delta Biosphere Reserve, a resource that although renewable is continually declining over the last 50 years, and its recovery can be achieved through a thorough scientific substantiation to encompass biological, ecological and fishery knowledge in a favorable environment for the sustainable exploitation of the resource.

That is why the research on the analysis of the data obtained from the study of the main lakes in the Danube Delta and their importance in the fishing exploitation carried out within the PhD thesis in the Danube Delta are to complete this framework.

The analyzes made in the PhD thesis focused on five representative sectors of the deltaic area, considered standard perimeter.

In order to calculate the natural fish productivity in the Danube Delta depressions, 17 most representative lakes were chosen from all points of view (chemical, sedimentological, biological, large anthropic impact): Matiţa, Babina, Fortuna, Merhei, Uzlina, Isacova, Rosuleţ, Razelm, Sinoe, Golovita, Istria, Gorgoştel, Baia Sacalin, Erenciuc, Babadag, Gorgova. (Table 50). The most important physico-chemical and chemical parameters (temperature, transparency, pH, oxygen, carbon dioxide, organic matter in suspension, ammonia content, nitrites, phosphates, chlorides, sulfates, hydrogen sulfide, metals iron, zinc, copper), detergents, pesticides, cyanides, phenols) are within normal limits, and heavy metal concentrations in sediments do not exceed the admissible values. Changing the parameters within the normal range may result in the accelerated development of some fungi or bacteria that can damage the growth and development of fish.

Table 50 Classification of lakes analyzed in the Danube Delta

Nr. crt.	Classification of Depressions in the Danube Delta	Lakes
1.	Lumina – Roșu Depression	Roșu, Roșulet,
2.	Matița Merhei Depression	Babina, Merhei, Matița,
3.	Gorgova – Uzlina Depression	Uzlina, Isacova, Gorgova,
4.	Meșteru – Fortuna Depression	Fortuna

5.	Razelm – Sinoe lagoon complex	Babadag, Istria, Golovița, Sinoe, Razelm, Erenciuc, Gorgoștel, Meleaua Sacalin,

The productivity of a biological ecosystem is given by its primary and secondary production, is primary, chemotrophic and autotrophic producers, respectively decaying bacterioplankton and bacteriobenthos and the micro and macrophytic elements of the aquatic ecosystem, as well as by primary and secondary consumers of different orders herbivorous and predatory organisms).

The quantity of fish produced by an aquatic pool over a natural time period is natural fish productivity.

Fishery productivity is the possibility of an aquatic ecosystem - running water, lake, pond, etc. - producing fish biomass at certain known biotic and abiotic components.

The capacity of an aquatic ecosystem to produce fish is dependent on biogenic capacity; index that includes: the value of environmental factors that affect productivity, fish species, and age class

Total fish productivity is the sum of natural fish productivity, productivity induced by fertilizer (organic and mineral) and productivity attributed to feed.

The biogenic capacity of an aquatic basin is appreciated by a complex examination of the physiographic, physical, chemical and biological characteristics followed by a correlational analysis of the results

Based on the method proposed by O. Gheracopol, D. Bogatu, M. Selin, G. Munteanu, 1977 we appreciated the biogenic capacity of the water in several lakes.

Regarding the qualitative structure of the ichthyofauna, the dominance of the non-aggressive freshwater fish species (70%), the rapeseed species (13.26%), migratory fish species (14.59%) and marine species (2.16 %).

From the category of fresh water species dominate the nonagresive species, and the largest share in them is (*Carassius auratus* Linnaeus, 1758) - 66,26%, (*Cyprinus carpio* Linnaeus, 1758) - 8,67%, (*Rutilus rutilus* Linnaeus, 1758) - 8,39%, urmate de cele răpitoare: (*Silurus glanis* Linnaeus, 1758) - 39,15%, (*Esox lucius* Linnaeus, 1758) - 25,96% (*Sander lucioperca* Linnaeus, 1758) - 23,45%. In the case of marine fish species, small marine fish dominate, and migratory species dominate the Danube - Alosa immaculata Eichwald, 1838. [133]

Results and Discussions on the Assessment of Aquatic Ecosystems for Fishing in the Danube Delta Biosphere Reserve

A more complex analysis of the quantities of recorded fish and natural fish productivity will be depicted as follows:

1. Evaluation of aquatic ecosystems for the exploitation of fisheries in the Light-Red Depression

The average value of catches made / recorded in the Lumina - Rosu Depression in the last 3 years was **266248,66 kg**.

Natural fish productivity (kg / ha) was analyzed in two lakes in the Lumina - Rosu (Rosu and Rosulet) depressions.

For Rosu Lake, natural fish productivity was 450 kg / ha and for Rosuleţ Lake it was 438 kg / ha.

Depending on the biogenic capacity, the water from Rosu Lake and from Rosuleţ Lake falls within the category of medium waters with biogenic capacity between IV and VI.

2. Evaluation of aquatic ecosystems for fishing exploitation Matiţa - Merhei Depression

The average value of catches made / recorded in the Matiţa - Merhei Depression in the last 3 years was 401608,33 kg.

Natural fish productivity (kg / ha) was analyzed in three lakes of the Matiţa - Merhei Depression (Babina, Matiţa, Merhei).

For Matiţa Lake, natural fish productivity (kg / ha) was 735 kg / ha, and for the Merhei and Babina lakes it was 450 kg / ha each.

Depending on the biogenic capacity, the water in the Babina Lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in Lake Matiţa falls within the category of rich waters with a biogenic capacity between VII-X.

Depending on the biogenic capacity, the water in the Merhei lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

3. Evaluation of aquatic ecosystems for the exploitation of fisheries Gorgova - Uzlina Depression

The average catches achieved / recorded in the Gorgova - Uzlina Depression in recent years was 339637.66 kg.

Natural fish productivity (kg / ha) was analyzed in three lakes in the Gorgova - Uzlina Depression (Uzlina, Isacova, Gorgova).

For all three lakes (Uzlina, Isacova, Gorgova) the same value of the Natural Fishery Productivity (kg / ha) of 450 kg / ha / lake was obtained.

Depending on the biogenetic capacity, the water in the Uzlina Lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in Lake Isacova falls within the category of medium waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in Gorgova Lake falls within the category of medium-sized waters with biogenic capacity between IV and VI.

4. Evaluation of aquatic ecosystems for fisheries exploitation Meşteru Depression – Fortuna

The average value of catches made / recorded in Fortuna's Meşteru Depression in the last 3 years was 247082.66 kg.

Natural fish productivity (kg / ha) was analyzed in a single lake in Fortuna, Fortuna, Fortuna Lake.

For Fortuna Lake, Natural Fish Productivity (kg / ha) was 630 kg / ha.

Depending on the biogenic capacity, the water in the Fortuna Lake falls into the category of rich waters with a biogenic capacity between VII-X.

5. Assessment of aquatic ecosystems for fisheries exploitation Razelm - Sinoe Lagoon Complex

The average value of catches made / recorded in the Razelm - Sinoe lagoon complex during the last 3 years was 509679,33 kg.

The natural fish productivity (kg / ha) was analyzed in eight lakes in Razelm - Sinoe Lagoon Complex (Babadag Lake, Istria Lake, Golovita Lake, Sinoe Lake, Razelm Lake, Lake Erenciuc, Gorgoştel Lake, Meleaua Sacalin Lake).

For Razelm Lake, natural fish productivity (kg / ha) was 540 kg / ha, for Lake Sinoe 450 kg / ha, Golovita Lake was 450 kg / ha, Babadag lake was 240 kg / ha for Istrian Lake was 300 kg / ha, for Lake Gorgoştel was 450 kg / ha, for Lake Erenciuc was 24 kg / ha and for Lake Meleaua Sacalin was 270 kg / ha.

Depending on the biogenic capacity, the water in Razelm Lake falls into the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in Sinoe Lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenetic capacity, the water in the Golovita lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in the Babadag Lake falls within the category of medium-sized waters with biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in the Istria lake falls into the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in the Gorgoştel lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in the Meleaua Sacalin lake falls within the category of medium-sized waters with a biogenic capacity between IV and VI.

Depending on the biogenic capacity, the water in Lake Erenciuc falls within the category of poor water with a biogenic capacity between I and III.

The highest natural fish productivity was encountered in Lake Matiţa with a value of 735 kg / ha, followed by Fortuna Lake with 630 kg / ha, and the lowest in the Sacalin Meadow with a value of 24 kg / ha.

Meleaua St. Gheorghe or Baia Sacalin, as it is known the bay behind the island of the same name, occupies a particular position in the Danube Delta, being formed by joining the Sacalin Island to the deltaic land through migration under the influence of overwashing processes - washing the sands on the island by the shores of the sea and their throwing in the bay during the storms. At the same time, the bay receives a significant flow of water and sediments in the northeast, through Gârla Turcului, directly from the St. Gheorghe branch.The lithological variations are due to the double control exercised by fluctuating Danube inflows and sandy marine inputs brought by waves during storms through the overwashing process.

Due to the significant intake of marine water, Sacalin Meleaua becomes a particular lake vis-à-vis the rest of the delta lakes, which is why natural fish productivity can not reach high values. (Figure 217)

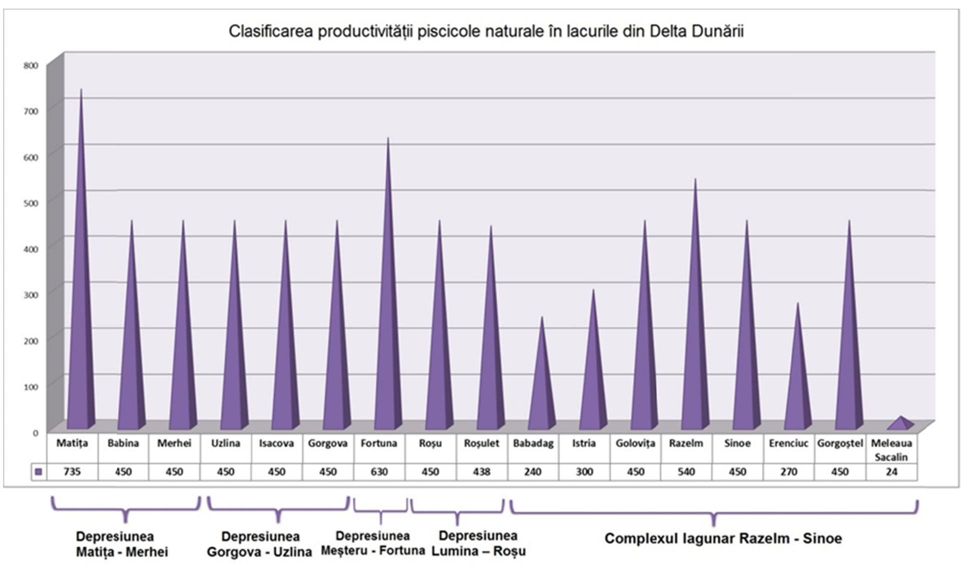

Fig. 217 Classification of natural fish productivity in the lakes of the Danube Delta

Based on the calculations made on the fish catches made / recorded within the aquatic complexes within the Danube Delta Biosphere Reservation, the highest value was recorded in the Razelm - Sinoe Lagoon Complex by 29%, followed by the Matita - Merhei Depression with 23 %, Gorgova - Uzlina depression by 19%, Light Depression - Red by 15% and Meşteru Depression - Fortuna by 14%. [141] (Fig.218)

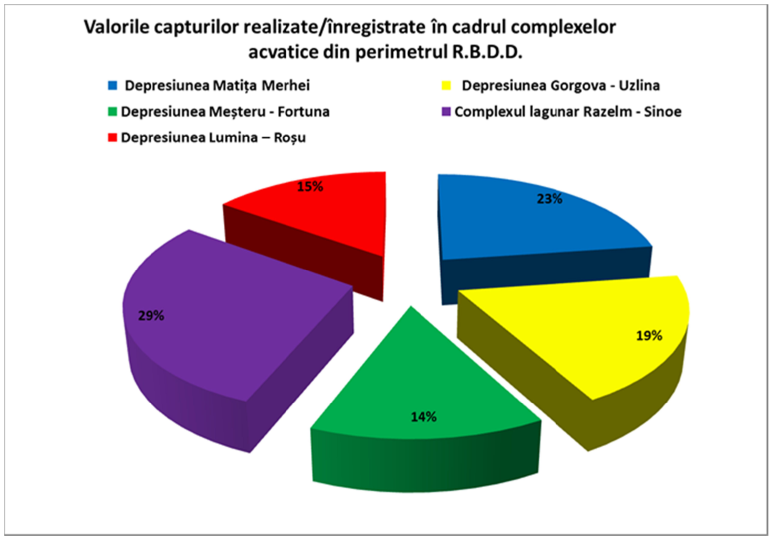

Fig. 218 Fish catches made / recorded in the aquatic complexes within the Danube Delta Biosphere Reservation

The total average amount of catches from commercial fisheries reported over the last 3 years at the Danube Delta Biosphere Reserve was 1764256,64 kg for the analyzed perimeters. [141]

Analyzing the reported catch data, we presented the results of the unreported catches over the past 3 years. Considering the correction coefficient and the data presented above, we estimate unreported catches at 763460.5 kg / year. [141]

Estimating the unreported quantity of the Danube Delta Biosphere Reserve has been established on the basis of the reports of the institutions in charge of control and finding, interviews with ecological agencies with guard duties and inspection from the reserve and professional fishermen. [141]

After analyzing the scientific data analyzed, it appears that in recent years, in various points of the Reserve, the unreported catch has an average of 50% of the total catches recorded; common freshwater species are 30% and freshwater 70%. For marine species, unreported catches are 20% of the total catches, of which 70% are valuable species and 30% are the usual species. [141]

At the Danube (Danube, Black Sea) the unrecorded catch has an average share of 40%, being included in the category of valuable species.

The phenomenon of unreported and illegal fishing, established as a mean value between common and valuable species, lake complexes and aquatic basins is higher in the Danube, as well as in the Somova Parcheş, Rosu Puiu and Gorgova Uzlina complexes.

CHAPTER VI - GENERAL CONCLUSIONS, ORIGINAL CONTRIBUTIONS AND PERSPECTIVES

6.1 GENERAL CONCLUSIONS

The Danube Delta is one of the main components of the Danube river system and is the natural interface between a vast area of drainage and the Black Sea basin, a basin of inner sea character. This position gives Delta a role as a buffer or filter between the Danube intakes, loaded with suspended solids and more or less contaminants (present in the solution or associated with the particle phase) and the Northwest Black Sea area.

Sedimentary processes occurring in the delta area as well as the action of filtering sediments and contaminants exerted by delta ecosystems are both physical and biochemical mechanisms whose intensity and sense of manifestation are controlled by the activity of natural factors influenced in a variable measure of anthropogenic interventions, and in the long run by global change.

The main aspects of sedimentary morpho-dynamics, the evolution of water quality and the biological diversity of lactic acid benthic ecosystems have been highlighted in this thesis by the analysis of 44 lakes of 6 aquatic ecosystem complexes during 2011-2017, during which they were monitored 23 of 4 parameters of the total of 44. A separate chapter was devoted to the calculation of the fish productivity of 17 representative lakes from the point of view of the ecological significance, view of economic importance as a exploitable fish resource (Matiţa, Babina, Fortuna, Merhei, Uzlina, Isacova, Roşu, Rosuleţ, Razelm, Sinoe, Golovita, Istria, Gorgoştel, Baia Sacalin, Erenciuc, Babadag, Gorgova) 5 depressions.

Conclusions on chemical and sedimentological assessment of aquatic ecosystems

Lumina - Rosu Depression:

• The chemical parameters recorded normal values in the studied lakes, being in good chemical status, with the exception of phosphates that exceeded punctually (in some stations) the maximum admissible values (according to Order 161/2006),

• For Lake Macuhova, there was a concentration of siliciclastic mineral material in the north-western branch of the lake, where the channel of connection with the Vătafu Canal is connected, through which the waters of Danube origin loaded with suspensions reach to the great waters.

Matiţa - Merhei Depression:

• Similarly, the chemical parameters have not exceeded the admissible values except for phosphates (Annex 2)

• In L. Matiţa and L. Babina, the phytocoenosis represented by a great diversity of macrophyte species, forming extraordinary biomass, is the dominant element at the expense of the planktonic algal component.

Gorgova - Uzlina Depression:

• As with lakes in the previous depressions, the physico-chemical and chemical parameters were within normal limits (Order 161/2006) (Annex 2), their values being generally lower than in the other depressions due to the fact that Cn. The node is made of the half-banded Mahmudia and not directly from the active Danube.

Mesteru - Fortuna Depression

• Maximum values, but within the limits of the good chemical status of the physicochemical and chemical parameters of the waters, were recorded in the Lungu, Meşteru, Tătaru lakes in the samples collected during the hot season, when important developments of the macrophytes .

Razelm - Sinoe Lagoon Complex:

• Within the complex, only in Babadag Lake were found higher sulphate values (SO_4^{2-}) in some of the stations analyzed in the cold season, probably due to the resuspension of organically loaded sediments, given that the lake is a fishing enclosure

• Sediment quality (organic load) is influenced by more or less direct intakes of water loaded with solid suspensions in the Danube, which gives the sediment the characteristic appearance (mineral, gray or blackish, greasy, strongly bioturbed appearance, usually presenting a fluid, grayish (oxidized) layer at the top - lakes directly influenced by the Danube; loose, porous, grayish-brown or yellowish, non-cohesive, sometimes saprogenic or hydrogen sulphide, Autiogen calcium, Coprogenic and vegetal organic material - Lakes protected by direct Danube intakes)

In general:

• From the point of view of the quality of the investigated aquatic environments, there were no exceedances of the allowed limits, except exceptionally, at the levels of phosphates, which exceeded the maximum admissible values in some stations, especially during autumn- > 2 mg / l).

• In the case of deltaic lakes, because of the greater distance from the direct Danube inflows and their "cascade" position, the sedimentary material of mineral origin is decanted along the way so that the major component of the sediments in these lacustrine areas is the organic substance, mostly indigenous.

• In this respect, the differences between the sediment of the lakes (Lungu, Meşteru, Fortuna from the Meşteru - Fortuna Depression) are influenced by the fluvial intakes through nearby channels, where the organic component is net dominant, and those from the Belâi lakes (Depression Meşteru - Fortuna), Trofilca (Sireasa Depression), Covaliova, Căzănel and Polideanca (Matiţa - Merhei Depression), Cuibeda, Isăcel (Depression Gorgova - Uzlina) and Lumina (Rosu - Lumina Depression) siliciclastic.

The lithological and magneto-susceptibilimetric study of the sediment in the cores revealed significant vertical variations, reflecting changes in time of the hydrodynamic conditions caused by the hydromorphological evolution of these areas in historical times. From the macroscopic examination, the collected cores show major changes in the dynamics of the delta environment; from this point of view, we can consider important carotiers in the lakes Cuibeda, Polideanca and Lumina, where the boundary between the marine and lake deposits was intercepted.

Conclusions on the evaluation of aquatic ecosystems from a biological point of view

The evaluation was based on the analysis of the structural parameters (component taxa) and quantitative (abundance / density, biomass) and the univariate statistical indicators (frequency, dominance, ecological significance) of the benthic fauna from the 14 lakes of the Danube Delta, as follows: Three Ozere, Ciorticut, Băclăneşti, Iacub, Bogdaproste, Puiuleţ, Babadag, Polideanca, Istria, Razelm, Sinoe, Golovita, Zmeica, Fortuna.

Matiţa - Merhei Depression:

• 46 taxa of 18 systematic groups (Spongia, Acarieni, Hydridae, Hirudinee, Miside, Amphipoda, Isopoda, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Ephemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera) .

• The most frequent taxa belonged to Chironomida (larvae) and oligolate, dominating in 80% of the abundance.

• The general average density of benthic populations in the Matiţa - Merhei Depression was 192390,18 ind./m^2.

a. Three Ozere Lake

• A total of 32 taxa belonging to 16 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Amphipoda, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera) were identified.

• The highest occurrence frequency in samples is adjudicated by 5 taxa (Oligochaeta, Chironomida, Nematoda, Trichopters of the Oxyethira genus and Cypria ophthalmica ostracode species).

• Dominant by density were: Nematoda - 10610,81 ind / m^2, ostracodes of the species Fabaeformiscandona fabaeformis - 8359,37 ind / m2, larvae of chironomidae with 4260,93 ind / m^2 and oligochets with 2896,48 ind / m^2

• The highest average biomass values were reached by chironomide larvae with 109.93 g / m^2, followed by the gastropod Stagnicola sp. with 18.38 g / m^2, Oxyethira sp. 18.23 g / m^2, and 17.89 g / m^2 ephemeropter larvae

• The overall average density of the biennial populations in Lake Three Ozeren 2013 was 32982,41 ind / m^2, consisting of 45% worms, 30% crustaceans, 20% insect larvae and 5% vary.

• Average recorded biomass was approximately 195.01 g / m^2, formed in 85% of insect larvae, followed by gastropods and variations.

b. Bogdaproste Lake

• 26 taxa belonging to 15 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, fish) were identified.

• The highest occurrence frequency in samples is adjudicated by 5 characteristic taxons for wetlands with muddy sedimentary substrate such as chironomides (larvae and pupae), and oligochetes, nematodes, ostracoda *Fabaeformiscandona fabaeformis* and ephemeropter larvae.

• Within the investigated area, the prevailing density is the nematodes with 3692.90 ind./m^2, the chironomide larvae 2536.93 ind./m^2, and the *Fabaeformiscandona fabaeformis* ostracoda 1162.38 ind./m^2.

• The highest average biomass values are the chironomidae larvae with 65.45 g / m^2

• The overall average density of the Bogdaproste benthic populations in 2013 was 8887.55 ind / m^2, being made up of 51% worms, 31% insect larvae, 16% crustaceans and 2% varying.

• Average recorded biomass was approximately 76.27 g / m^2, formed over 95% of insect larvae, and the rest vary.

c. Ciorticut Lake

• 28 taxa of 17 systematic groups (Acarieni, Hydridae, Hirudinee, Bivalve, Miside, Isopoda, Gammaride, Nematoda, Oligocheta, Gastropoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida, Heteroptera).

• The highest occurrence frequency in samples is adjudicated by 5 typical taxa for humid wetlands such as oligochets, chironomides (larvae and pupae), Hydrachnellae (Hydra), Misidele and Trichopters of Fam. Leptoceridae.

• In the investigated area, the 7250 ind./m^2 oligochets, the chironomide larvae 5687.5 ind./m^2, followed by the *Dugesia tigrin*a and the juv gastropods, each with 1906.25 ind./m^2, are dominant.

• The highest average biomass values are 146.73 g / m^2 larvae of chironomidae, followed by 97.96 g / m^2 of *Dreissena polymorpha* bivalves

• The overall average density of the benthic populations in Lake Ciorticut in 2013 was 23156,25 ind / m^2, being made up of 40% of insect larvae, 39% of worms 11% of molluscs and 10% of them.

• Average recorded biomass was approximately 450.29 g / m^2, formed over 55% of insect larvae, 22% molluscs, 13% worms and the rest varying.

d. Polideanca Lake

• 34 taxa from 18 systematic groups (Acarieni, Spongia, Hydridae, Hirudinee, Miside, Isopoda, Gammaride, Corofidae, Nematoda, Oligocheta, Gastropoda, Ostracoda, Turbelaria, Ephemeroptera, Odonata, Trichoptera, Lepidoptera, Chironomida).

• The highest sampling frequency was awarded by six taxa: nematodes, *Cypridopsis vidua,* Leptoceridae, Turbelaria indet. Chironomides (larvae and pupae), and oligochetes.

• Dominant by density were oligochets with 33097,42 ind./m^2, chironomide larvae 32536,76 ind./m^2, and *Cypria ophthalmica* ostracodes 23648,89 ind./m^2 and *Candona candida* 16406,25 ind./m^2.

• Larvae of chironomidae have reached the highest average biomass (839.44 g / m^2)

• The average general density of the benthic populations was 127363.97 ind / m^2, being made up of 41% of crustaceans, 29% of worms and 28% of insect larvae.

• Average recorded biomass was approximately 2054.50 g / m^2, formed over 45% of insect larvae and 44% by mollusc.

- Taking into account the high diversity, with 46 taxons and the high density of the invertebrate benthic species of 192390,18 ind./m2, in which the larvae of chironomides and oligochets were dominant, representing a valuable trophic resource for the fauna fish, we can say that the Matiţa - Merhei depression is in good ecological status.

Mesteru - Fortuna Depression

• In total, 20 taxa belonging to 13 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Amphipoda, Nematoda, Oligocheta, Gastropoda, Turbelaria, Efemeroptera, Odonata, Trichoptera, Chironomida)

• The most common species were Chironomide larvae and oligohelites, dominating at 75% in abundance.

• The general average density of the benthic populations in Fortuna's - Meşteru Depression is 13459,82 ind / m^2

a. Fortuna Lake

• 19 taxa belonging to 10 systematic groups were identified

• Among the molluscs were identified ghastropods of the species *Viviparus sp., Acroloxus lacustris, Planorbis sp*., Organisms commonly found in submerged vegetation and *Anodonta woodiana* bivalves, and *Unio pictorum*, species that were accidentally encountered.

• The highest frequency (over 75%) recorded the Chironomide larvae, the odyssey belonging to the Zygoptera Subordinate and the Trichopters from Fam. Leptoceridae, Fam. Hydropteridae and Fam. Polycentropidae, while the highest densities were found in the taxa of chironomides, oligochets and hirudinins.

b. Lake Baclanesti

• 19 taxa belonging to 11 systematic groups (Acarieni, Hydridae, Hirudinee, Nematoda, Oligocheta, Gastropoda, Turbelaria, Ephemeroptera, Odonata, Trichoptera, Chironomida) were identified.

• The highest occurrence frequency in samples was adjudicated by 4 taxa (oligohetes, chironomides (larvae and pupae), gastropods and nematodes).

• The highest average biomass values are 104.81 g / m^2 larvae of chironomidae.

• The overall average density of the benthonic populations was 13459.82 ind / m^2, consisting of 46% of insect larvae, 38% of 11% mollusc worms.

• Dominant by density were the chironomide larvae of 4062.5 ind./m^2, the oligochets 2321.42 ind./m^2 and the *Dugesia tigrina* 2299.10 ind./m^2.

• Average recorded biomass was about 234.93 g / m^2, formed over 68% of insect larvae, 30% of worms.

- In comparison to the previously analyzed lakes, whose average diversity was 30 taxons compared to 20 in the Meşteru - Fortuna depression, and the average density of the benthic fauna about 4 times smaller, we can state that it is in an ecological state weak. However, chironomides and oligochets represent an important energy contribution to benthic fish species.

Lumina - Rosu Depression

• 32 taxa from 16 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Gammaride, Corofidae, Nematoda, Oligocheta, Gastropoda, Turbelaria, Ostracoda, Ephemeroptera, Odonata, Trichoptera, Lepidoptera, and Chironomida).

• The highest frequency was 5 taxons: chironomides (larvae and pupae), *Candona candida, Cypria ophthalmic*a, oligocheta, nematoda.

• Within the investigated area, the dominant species were the chironomide larvae 32366.07 ind./m^2, the oligochets 25904.017 ind./m^2, and the *Cypra ophthalmica* ostracoda 21573.66 ind./m^2.

• The highest average biomass values are the larvae of chironomidae with 835.04 g / m^2 followed by *Stagnicola sp.* with 750 g / m^2

• The general average density of the benthic populations was 115,100.44 ind / m^2, being made up of 40% of crustaceans, 30% of insect larvae and 23% of worms.

• Average recorded biomass was approximately 2221.62 g / m^2, formed over 58% mollusc, 40% insect larvae.

- Due to the high diversity (41 taxons) and the extraordinary productive potential of chironomides, oligochaetes, and milliobentan and vagillous fauna (gammaridae, corophiidae), expressed in their high densities (137934,24 ind./m^2), the lakes in the depression The Lumina - Rosu, can ensure from a trophic point of view a good support of the fish fauna in optimal parameters, which is why we can say that the Depression, as a whole, is in a good ecological state.

Razelm - Sinoe Lagoon Complex:

• In total, 56 taxa belonging to 23 systematic groups (Acarieni, Hydridae, Hirudinee, Miside, Amphipoda, Isopoda, Cumacea, Misida, Decapoda, Nematoda, Oligocheta, Polycheta, Gastropoda, Bivalvia, Ostracoda, Turbelaria, Efemeroptera, Odonata , Trichoptera, Lepidoptera, Chironomida, Heteroptera, Syngnathidae).

• The most common species are larvae of chironomides and oligochetes

• The general average density of the benthic populations in Razelm - Sinoe Lagoon Complex was 58,404.53 ind./m^2

a. Babadag Lake

• 9 taxa belonging to 5 systematic groups (Nematoda, Oligocheta, Ostracoda, Corofidae, Chironomida, etc.) were identified

• The highest frequency was adjudicated by 4 taxa: oligochetes, chironomides (larvae and pupae), *Darwinula stevensoni and Cyprideis torosa*. Crustaceans were almost exclusively represented by ostracodes

• Density dominated were the 11627,78 ind./m^2 oligochetes, the chironomide larvae 5320 ind./m^2, and the nematodes 4511,11 ind./m^2.

• The highest average biomass values were reached by larvae of chironomidae by 19.10 g / m^2

• The overall average density of the benthic populations was 22407.78 ind / m^2, consisting of 72% of worms and over 24% of insect larvae.

• Average recorded biomass was about 21.50 g / m^2, formed over 89% of insect larvae.

b. Istria Lake

• 11 taxa belonging to 9 systematic groups (Acarieni, Nematoda, Oligocheta, Corofidae, Ostracoda, Odonata, Trichoptera, Chironomida, Heteroptera) were identified.

• The highest frequency was recorded by 3 taxa: Bezzia, chironomides (larvae and pups), and oligochetes

• Dominant by density were oligochets with 3390,625 ind./m^2, chironomide larvae 2562.5 ind./m^2, *Limnocythere inopinata* with 2375 ind./m^2 and nematodes 1734,375 ind./m^2.

• The highest average biomass values were Chironomidae larvae with 66,112 g / m^2.

• The overall average density of the benthic populations in Istria Lake in 2015 was 11593.75 ind / m^2, consisting of 44% worms, 26% insect larvae, 26% crustaceans

• Average recorded biomass was approximately 89.58 g / m^2, formed over 86% of insect larvae

• Of the total of 11 taxa found in the Istria lake, only 4 species were more abundant, accounting for almost 98% of the density and 99% of the overall average biomass: Oligochaeta, larvae Chironomidae, *Limnocythere inopinata*, Nematoda, *Cyprideis torosa*

c. The lagoon complex Razelm - Sinoe

• There were identified 41 taxa belonging to 16 zoobenthos groups (Halacarida, Hydridae, Nematoda, Oligocheta, Hirudinea, Gasteropoda, Bivalva, Larvae of Chironomide, Ostracoda, Corofida, Gammaridae, Cumacea, Heteroptera, Trichoptera, Lepidoptera, Efemeroptera)

• The general average density of benthic populations in June 2017 was 24403 ind./m^2

• The highest frequencies were obtained from 5 taxa (coropidae and gammaridae crustaceans, Chironomidae and Trichoptera larvae, and Piscicola geometra hirudine species)

- Of the 41 taxa identified in lakes of the lagoon complex, most of them are trophically accessible to both the juveniles and the adults of the exploitable species of fish, especially native species of carp, caraway, plaice and chalice, but also to those destinations of intensive culture, high densities of invertebrate benthic species (24403 ind./m^2), constituting a permanent trophic source in their diet. The Razelm-Sinoe lagoon complex is therefore in good ecological status, although the anthropic pressure and illegal fish exploits have dramatically decreased the fishing potential of the complex over the last decade.

Conclusions on Natural Productivity, Biogenic Capacity and Catches in Danube Delta Lakes

An important chapter of this doctoral thesis was dedicated to the analysis of the fish productivity of 17 lakes in the Danube Delta, considered as representative from this point of view: Matiţa, Babina, Fortuna, Merhei, Uzlina, Isacova, Roşu, Rosuleţ, Razelm, Sinoe, Goloviţa, Istria, Gorgoştel, Baia Sacalin, Erenciuc, Babadag, Gorgova.

Lumina - Rosu Depression

• The natural fish productivity (Pn) of the Rosu Lake was estimated at 450 kg / ha, and that of Rosulet Lake at 438 kg / ha.

• The biogenic capacity of the Rosu and Rosulets lakes ranges between IV and VI and falls within the category of medium-sized waters;

• The average catches recorded in the Lumina - Rosu Depression in the last 3 years was 266248.66 kg.

Matiţa - Merhei Depression

• Pn L. L. Matita was estimated at 735 kg / ha, and L. Merhei and Babina at 450 kg / ha, each.

• The biogenic capacity, comprised between VII and X, includes L. Matiţa in the category of rich waters, L. Babina and Merhei, whose biogenic capacity was IV-VI, in the category of medium waters.

• The average catches recorded in the Matiţa - Merhei Depression during the last 3 years was 401608,33 kg.

Depression of Gorgova - Uzlina

• For Uzlina, Isacova, Gorgova lakes was calculated at 450 kg / ha / lake.

• The biogenic capacity of L. Uzlina, Isacova and Gorgova was IV-VI, corresponding to the category of medium-sized waters

• The average value of catches recorded in the Depression over the last 3 years was 339637,66 kg.

Meşteru Depression - Fortuna

• L. Fortuna, PN was valued at 630 kg / ha.

• The biogenic capacity of L. Fortuna, ranging from VII to X, falls into the category of rich waters.

• The average value of the catches recorded in Fortuna's Meşteru Depression in the last 3 years was 247082.66 kg.

The lagoon complex Razelm - Sinoe

- L.n. Sinoe, L. Golovita and L. Gorgoştel at 450 kg / ha each, L. Istria at 300 kg / ha, L. (kg / ha) of L. Razelm was estimated at 540 kg / L. Babadag at 240 kg / ha, L. Erenciuc at 270 kg / ha and L. Sacalin at only 24 kg / ha.

• According to the calculations regarding the biogenic capacity of L. Razelm, L. Sinoe, L. Golovita, L. Istria, L. Gorgoştel, L. Sacalin, L. Babadag a value was obtained between IV and VI, indicating a framing of their waters in the category of medium waters

• The only exception within the complex was L Erenciuc, classified as poor water, with a biogenic capacity between I and III

- The average value of catches made / recorded in the Razelm - Sinoe Lagoon Complex in the last 3 years was 509679,33 kg

The following general conclusions are drawn:

➢ The general average density of the benthic fauna in the four depressions analyzed was estimated at 402188,77 ind / m2, the highest share being Matita - Merhei by 48%, followed by the Lumina - Rosu Depression by 34%, Razelm Lagoon Complex - Sinoe with 15% and Meşteru Depression - Fortuna 3%. (Fig.216)

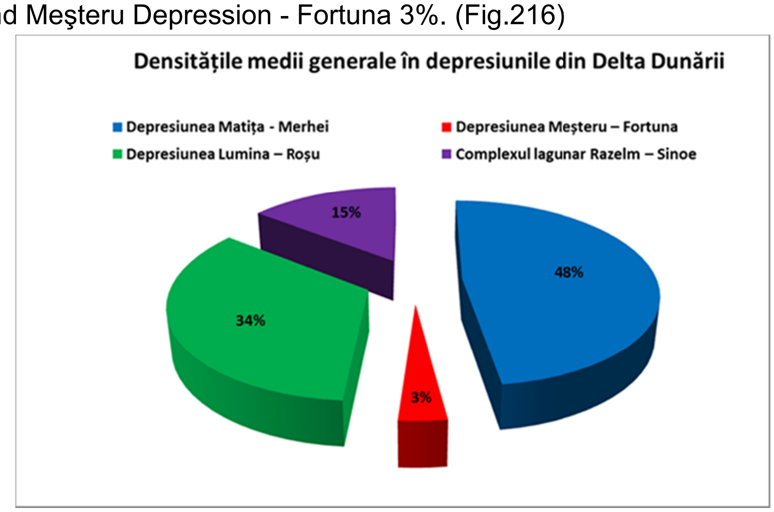

Fig. 216 Share of average general densities in the Danube Delta depressions

➢ The highest natural fishery productivity was recorded in Lake Matiţa, 735 kg / ha, followed by L. Fortuna - 630 kg / ha. At the opposite end, there was the Sacalin Meleaua, with the lowest estimated productivity of 24 kg / ha.

- The estimated annual inventory value for the Danube Delta Biosphere Reserve is 12265.7 tons of fish.
- The average total amount of catches from commercial fishing, reported in the last 3 years at the level of the Danube Delta Biosphere Reserve, was 1764256,64 kg and the average unrecorded catch of 763460,5 kg. Part of the stock is consumed by ihtiofage birds, estimated at 7500 tons of fish per year. Overall, annual catches at the Danube Delta Biosphere Reserve were assessed at 10027.72 tonnes.
- The anthropogenic activities that led to the modification of the flood-free regime of the Danube River and the intensive commercial fishing led to a continuous decline of fish stocks in the natural fish habitats in the Danube Delta Biosphere Reserve and changes in the qualitative and quantitative structure of the ichthyofauna by replacing economically valuable species with other less important species. It is the case of Razelm-Sinoe, Gorgova-Uzlina, Matiţa-Merhei, Lumina-Roşu, currently populated by common species

Recommendations

- From our own data on natural productivity and biogenic capacity of the analyzed lake complexes and the literature information on catches, we can conclude that at present the latter (the catches) exert a major pressure on estimated annual fish stocks. In spite of productivity listed as high in some of the lacustrian complexes (L. Matiţa, L. Fortuna), they are largely based on fish species with no great economic value, which is not a positive signal regarding the evolution of fish populations, which are artificially selected for exploitation.
- We recommend, in this regard, taking into account the important trophic resources made up of very productive benthic populations represented by species belonging to more than 40 major invertebrate groups, the establishment, where the abiotic and biotic conditions meet the optimal quality standards, popular / repopulation of deltaic lake complexes with biologically and economically valuable fish species in order to maintain a balance between resource and exploitation, preservation of genetic diversity and sustainable use of all biological resources in aquatic ecosystems within the reserve. We consider valuable species such as carp, somnolence, shawl to provide an average productivity of 120 kg / ha in all aquatic complexes (in their large lakes), species that can harness benthic biomass, to species such as caraway, which is currently dominating pelagic ecosystems, due to the growth of phyto- and zooplankton biomass. The shale is one of the reproductive breeding species recognized in the northern part of the Razelm Sinoe complex, whose stocks have diminished dramatically in recent years and which through sustainable protection and exploitation efforts can reach sustainable stocks under the conditions of insurance trophic resources, mainly from the benthic level.
- The results of this PhD thesis have highlighted, based on sedimentological analyzes, the dominance of Organogenic Organic Manganese, rich in organic substance, which promotes the development of benthic organisms, such as chironomide larvae and oligochets, important for the development and growth of fish fauna, especially cyprinid.
- Therefore, the continuation of such complex studies must be a priority of national research programs that will help to implement strategies for sustainable management and development of the entire territory of the Danube Delta Biosphere Reserve.

6.2 ORIGINAL CONTRIBUTIONS

- Although many studies have approached various aspects of Danube Delta ecosystems (Gâtestescu and Ştiucă [114], Rîşnoveanu [117] - the study of oligochetes, Zinevici and Parpale [91]) - Zooplankton and secondary productivity study, Cupşa, Telcean, Covaciu-Marcov, Ciubuc , Ciolpan [118,120] - studies on benthic fauna, Botnariuc, Vădineanu [116,119] - ecology of lakes), very few integrated the essential aspects of the lacustrian ecosystems of the Danube Delta, morphology, spatial dynamics and temporal physical, physicochemical, biological parameters and their fishery productivity.
  By the elements analyzed, within 6 years:
    - Physical-chemical and sedimentological parameters from 44 lakes in the Danube Delta,
    - The Structure of Macroforest Communities in 14 lakes in the Danube Delta,
    - Biogenic capacity and natural fish productivity in 17 lakes in the Danube Delta,
- This paper brings a series of new information, which adds to the valuable existing data thesaurus, which can at any time be integrated into national and international databases and exploited to deepen knowledge about biological diversity, the dynamics of abiotic and biological processes and transformations at the level of the Danube Delta, the elaboration of fishery management measures and the medium and long term evolution of the Reserve under natural, anthropogenic or climatic conditions.

PERSPECTIVES

The research directions on the continuation of the thesis will focus on the following aspects:

- Continue to optimize ecological observations and correlations between abiotic and biotic factors to improve monitoring programs, in line with the requirements of European directives, such as the Water Framework Directive (2000/60 / EC).
- development of assessment methodologies and indicators, including significant parameters for the creation of viable tools for assessing the quality and evolution of surface water ecosystems;
- extending the monitoring area to the basins of river basins;
- validation of scientific methodologies for evaluation and creation of databases accessible to decision-makers, resulting in conservation and mitigation measures on the quality of surface water in urbanized areas and with active industry or agriculture.
- there will be a continuous exchange of best practices at international level to extend the analogies and indicators in the surface aquatic ecosystems to the complexity of those studied in the doctoral thesis.

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