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ICHTHYOFAUNISTIC DIVERSITY AND STRUCTURAL AND FUNCTIONAL STATE OF ICHTHIOCENOSIS OF THE KUCHURGAN RESERVOIR-COOLER UNDER MODERN ENVIRONMENTAL CONDITIONS

165.03. Ichthyology

Summary of the doctoral thesis in biological sciences

CHIȘINĂU, 2024

The thesis was developed on the basis of **the Laboratory of Ichthyology and Aquaculture, Institute of Zoology of the State University of Moldova**. The doctoral studies were completed at the **Doctoral School of Natural Sciences of the State University of Moldova.**

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The defense will take place on April 26, 2024 at 14:00 at the meeting of the specialized council on the basis of DSNS, Main Directorate – Doctoral School of Natural Sciences, State University of Moldova (http:// www.usm.md/), st. M. Kogalniceanu 65, building 3, room 332, MD-2009, Chisinau, Moldova.

The dissertation and the abstract can be found in the National Library of the Republic of Moldova, the "Andrei Lupan" Central Library (Institute), the Central Library of the Moldavian State University, the Library (st. A. Mateevich 60 A, Chişinău, MD 2009) and on the USM website (http://usm.md/), on the ANACEC website (http://www.cnaa.md/).

The summary was sent on March 19, 2024.

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CONCEPTUAL FRAMEWORK OF THE RESEARCH

The actuality of the subject. The water bodies of the Republic of Moldova are subject to numerous anthropogenic pressures: overregulation, hydraulic construction, wastewater pollution, etc., as well as climate change. Water bodies with a high level of anthropogenic pressure include the Kuchurgan reservoir, which serves as a cooling reservoir for a thermal power plant - the MSDPP. The influence of thermal power plants on the ecosystem of the reservoir is manifested in thermofication, pollution with heavy metals, and changes in hydrochemical parameters [14].

Due to the overregulation of the natural estuary, anadromous species (beluga, stellate sturgeon, sabrefish) and part of rheophilic fish species (sterlet, barbel, vimba) fell out of its ichthyofauna, while others (bream, carp, chub, European catfish) significantly reduced their populations. As a result of the thermalization of the cooling pond, the number of zender and pike significantly decreased. The thermofication of the reservoir had a positive effect on heat-loving species (common white bream, rudd, etc.), and the number of South European smelt, an invasive species, has recently increased significantly and tends to further increase.

Currently, the impact of the MSDPP on the reservoir has decreased, which is associated with a reduction in generated electricity volume. At the same time, due to climate change, there is an increase in average annual temperature in the Turunchuk where water is exchanged with the reservoir. The mineralization of water in the reservoir, due to the lack of flow, insufficient water exchange and the cumulative effect, is at a high level, exceeding the permissible norm by more than 2 times [15].

The Kuchurgan estuary (reservoir) was characterized by high fish productivity, which in certain periods reached 120 tons of fish [10]. Analysis of the fishery currently makes it possible to study its modern structure and make recommendations for preserving and improving the fish production potential of the reservoir.

In conditions of climate change, the Kuchurgan reservoir can serve as a model reservoir for studying the processes occurring in the ichthyocenosis of changes under conditions of rising environmental temperatures.

Purpose of research is to assess the current state of the ichthyocenosis of the Kuchurgan cooling reservoir, to establish its structural and functional state and successional changes under conditions of anthropogenic and bioinvasive influence.

To achieve this goal, the following **tasks** were set:

- to study the modern ichthyofauna of the Kuchurgan reservoir and its structural and functional state;
- establish successional changes in ichthyocenosis from a historical perspective;
- study the structure of ichthyofaunistic complexes;
- explore rare and invasive fish species in the reservoir;
- establish the bioecological characteristics of individual fish species;
- study the influence of environmental factors on the ichthyofauna of the reservoir;
- establish the potential fish productivity of the reservoir based on feed resources;
- explore the modern structure of the fishery on the Kuchurgan reservoir;
- develop recommendations to improve the ichthyological situation in the reservoir.

The methodological basis of the research was the works fundamental works by E. Zinoviev and S. Mandrits [5], G. Plotnikov et al. [12], as well as Moldovan ichthyologists Dm. Bulat [19], M. Usatîi [22], Dn. Bulat [20]. The works of F. Yegerman, F. Zambriborshch, V. Chepurnov, I. Kubrak [9], M. Vladimirov [2], V. Karlov [6], O. Krepis [8] made it possible to reveal successional changes in the ichthyofauna of the Kuchurgan reservoir in a historical aspect.

Scientific novelty: In a comparative aspect, biodiversity and successional changes in the ichthyofauna of the reservoir were studied in historical terms, depending on the degree of

anthropogenic impact.For the first time, a new invasive species, the Amur grouse, *Pseudorasbora parva*, has been recorded in the Kuchurgan reservoir. The faunistic characteristics of the ichthyocomplexes and the bioecological characteristics of the South European small smelt - *Atherina boyeri*, the sun perch - *Lepomis gibbosus* and the silver bream - *Blicca bjoerkna*, as well as the forecast of their abundance are given. The potential fish productivity of the reservoir was calculated in terms of food resources. Recommendations are given to improve the ichthyological state in the Kuchurgan reservoir.

The solved scientific problem in the dissertation is that new *scientifically based knowledge* has been obtained about the ichthyofauna of the Kuchurgan cooling reservoir of the MSDPP, *which led* to the establishment of patterns of its dynamics in the space-time aspect, depending on the degree of anthropogenic impact, revealed the reasons causing structural changes in the ichthyocenosis, which *allowed* to develop recommendations for the preservation and restoration of the fish production potential of the reservoir.

Fundamentally new results for science and practice: based on modern ecological methods and approaches integrated into classical ichthyological science, fundamentally new results for science and practice were obtained about the ichthyofauna of the Kuchurgan cooling reservoir of the MSDPP, which established the peculiarities of changes in the ichthyocenosis and its functioning in conditions of transformation of a water body under the influence of anthropogenic factors.

Theoretical significance: the results obtained make a significant contribution to the analysis and knowledge of the structural and functional state of ichthyocenoses of natural aquatic ecosystems subject to active processes of transformation, thermofication, chemical pollution and invasion by alien species.

The applicative value of the work: Scientific results on the current state and functioning of the ichthyocenosis of the Kuchurgan reservoir served as the basis for the development of measures in the field of restoration, conservation and sustainable use of fish resources of the MSDPP cooling pond. Recommendations are given on the organization of recreational fishing in the reservoir. The “Amateur Fisherman’s Handbook” was published, as well as the methodological guide “Practical Work on Ichthyology” for students of biological specialties at universities. The research results are an integral part of the scientific project no. 20.80009.7007.06 AQUABIO.

Basic provisions for thesis defense:

1. In the ichthyocenosis of the Kuchurgan reservoir, under the influence of anthropogenic factors, structural changes occurred as a result of its transformation into a cooling reservoir for the MSDPP.

2. In the Kuchurgan Reservoir there is an intrusion of alien fish species.

3. Creating favorable conditions for the natural reproduction of commercially valuable fish species in the reservoir will lead to the restoration of their populations and increase the fish productivity of the reservoir.

Implementation of scientific results: The research results are used by the “Environmental Center” of Tiraspol when organizing measures for the conservation, restoration and rational use of fish resources of the Kuchurgan reservoir; Moldavian State University and Transnistrian State University named after T.G. Shevchenko in the educational process when training specialists for the education system and the environmental industry; International Association of River Guardians "Eco-TIRAS" in the implementation of environmental projects, environmental education and upbringing.

Approval of scientific results: The dissertation materials are presented at the following International conferences and symposiums: Geoecological and bioecological problems of the Northern Black Sea region (Tiraspol, 2014); Lake ecosystems: biological processes, anthropogenic transformation, water quality (Minsk, 2016); Integrated Management of the

Transboundary Dniester Basin (Tiraspol, 2017); Hydropower impact on river ecosystem functioning (Tiraspol, 2019); European integration and management of the Dniester basin (Chisinau, 2020); Functional changes of aquatic ecosystems in the context of anthropogenic impact and climate change (Chisinau, 2020); Biological diversity of the Caucasus and southern Russia (Makhachkala, 2020; Magas, 2022); Modern problems of biology and ecology (Makhachkala, 2021); Transboundary Dniester River basin management and EU intergaration – step by step (Chisinau, 2022); The scientific symposium biology and sustainable development the 20th edition (Bacău, 2022).

Regional conferences, including ones with international participation: Contemporary trends in the development of science: visions of young researchers (Chisinau, 2020); Readings in memory of Candidate of Biological Sciences, Associate Professor L.L. Popa (Tiraspol, 2020); Academician L.S. Berg is 145 years old (Bendery, 2021); Republican scientific and practical seminar "Modern problems of industrial fish farming in Pridnestrovie" (Tiraspol, 2021); Biodiversity of Ecosystems of the Dniester Basin (Tiraspol, 2022); The national scientific conference of doctoral students dedicated to the 75th anniversary of USM (Chisinau, 2022); Life sciences in the dialogue of generations: connections between universities, academia, and the business community (Chisinau, 2022).

Author's contribution: The dissertation work is based on the research materials on the ichthyofauna of the Kuchurgan reservoir carried out by the author for the period 2012–2023. The author formulated the problem, set tasks, analyzed the results of research, and formulated generalizations, conclusions, and recommendations. The personal participation of the author in joint publications is proportional to the number of authors.

Publications on the topic of the thesis: 29 scientific papers were published on the topic of the dissertation (including 8 without co-authors): articles in foreign peer-reviewed journals - 1, articles in journals included in the National Register of specialized scientific journals - 4, publications in international conference proceedings - 4, in national collections - 16, abstracts in international collections – 2, reference book – 1, methodological works – 1.

The volume and structure of the thesis: The dissertation is presented on 112 pages of the main text, which includes: an introduction, 4 chapters, general conclusions and recommendations. The work contains 18 tables, 41 figures and a list of references, including 180 titles.

Keywords: ichthyofauna, ichthyocenosis, Kuchurgan reservoir, cooling pond, fish productivity, alien species, introducent, abundance, biomass, environmental indices.

THESIS CONTENT

INTRODUCTION highlights the relevance, scientific and practical significance of studying the fish of the Kuchurgan reservoir, indicates the purpose and objectives of the study, the methodological and scientific-theoretical basis of the work and its scientific novelty.

1. FORMATION OF THE ICHTHYOFAUNA OF THE KUCHURGAN RESERVOIR

The successional changes in the ichthyofauna of the Kuchurgan (liman) reservoir-cooler are considered according to the periods of heat load before carrying out our own research, as well as the influence of the MSDPPon the reservoir. The index of biotic integration of the ichthyocenosis of the Kuchurgan reservoir was calculated.

2. MATERIALS AND METHODS OF STUDY

The research material was the control catches carried out at the Kuchurgan reservoir from 2012 to 2023. The water area of the Kuchurgan reservoir occupies about 2730 hectares with an average depth of 3,5 m. The volume of water is 88 million m^3. Its configuration represents an irregular triangle with a maximum width of 3 km in its lower part. The Kuchurgan river flows into the upper part of the reservoir.

Collection and analysis of the collected material was carried out according to standard methods generally accepted in ichthyology [12, 19, 20, 22]. Separately, fish species with the most pronounced trends in population growth and range expansion were studied: Aterina boyeri, Blicca bjoerkna, Lepomis gibbosus. The volume of collected ichthyological material amounted to about 17 thousand individuals of various species, sexes, and ages. Linear dimensions, sex composition, and age were determined in 1030 fish individuals. An exponential function, a polynomial model of the 4th degree, and a logarithmic curve were used to approximate the abundance monitoring data. Potential fish productivity in terms of food resources was calculated in accordance with Instrucţiune… [21]. To establish the reliability of the data, methods of mathematical and statistical analysis were applied using the MS Excel 2019 software package.

3. THE STATE OF THE ICHTHIOCENOSIS OF THE KUCHURGAN RESERVOIR UNDER THE PRESENT CONDITIONS OF THE RESERVOIR-COOLER OF THE MOLDAVIAN STATE DISTRICT POWER PLANT

As a result of our research, it has been established that the modern composition of the ichthyofauna of the reservoir is formed by 44 species of fish belonging to 18 families from 11 orders. The most numerous order is Cypriniformes, which includes 7 families: Leuciscidae – 12 species, Xenocyprididae – 3, Cyprinidae – 2, Tincidae, Acheilognathidae, Gobionidae and Cobitidae in one species. The order Siluriformes is represented by two families: Siluridae and Ictaluridae, one species each. The order Gobiformes is represented by the family Gobiidae, which includes 9 species. Order Perciformes – Percidae – 3 species. The order Clupeiformes is represented by one family, Clupeidae, and three species. The orders Esociformes, Mugiliformes, Gasterosteoiformes, Sygnathiformes, Atheriniiformes, Centrarchiformes are represented by one family: Esocidae, Mugilidae, Gasterosteidae, Syngnathidae, Atherinidae, Centrarchidae, including one species each.

According to the frequency of occurrence in the control catches, all fish belong to five groups: absolute dominants, dominants, subdominants, minor and insignificant. The absolute dominants in the ichthyofauna of the Kuchurgan reservoir are: *Atherina boyeri* (38,62%), *Blicca*

bjoerkna (16,93%) and *Scardinius erythrophthalmus* (10.07%). The second group includes one dominant species – *Carassius gibelio* (7,54%). The group of subdominants includes four species: *Neogobius fluviatilis* (4,98%) of the total number of individuals caught, *Perca fluviatilis* (4,97%), *Rhodeus amarus* (3,04%) and *Rutilus rutilus heckeli* (2,74%). Minor species include: *Neogobius melanostomus* (1,7%) and *Hypophthalmichthys nobilis* (1,4%). The rest fall into the category of insignificant species. On June 7, 2023, during the control catches, one individual of the Black Sea-Azov anadromous herring, *Alosa immaculata*, was caught, which has not been recorded for many years. In 2019-2022 no sub-accumulation was noted in the control catches.

In terms of economic value, the fish of the reservoir are classified as: commercially valuable – 17 species, low-value – 4 species and short-cycle – 21 species. Commercially valuable species include: *Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Cyprinus carpio, Ctenopharyngodon idella, Carassius gibelio, Rutilus rutilus heckeli, Aspius aspius, Abramis brama, Tinca tinca, Sander lucioperca, Alosa tanaica, Rutilus frisii, Liza haematocheilus, Ictalurus punctatus, Esox lucius, Silurus glanis, Squalius cephalus, Alosa immaculata.* Together they occupy 15,7% by number and 87% by biomass. The proportion of introduced Far Eastern species is 2,6% in terms of abundance and 56,1% in terms of biomass.

Low-value species are represented by: *Lepomis gibbosus, Perca fluviatilis, Scardinius erythrophthalmus, Blicca bjoerkna*. They account for 32,66% in number and 12,33% in biomass.

Short cycle: *Neogobius fluviatilis, N. melanostomus, N. eurycephalus, Caspiosoma caspium, Knipowitshia longicaudata, Babka gymnotrachelus, Ponticola kessleri, Proterorhinus marmoratus, Benthophilus nudus, Pungitius platygaster, Leuciscus leuciscus, Pseudorasbora parva, Gymnocephalus cernuus, Leucaspius delineatus, Petroleuciscus boristenicus, Clupeonella cultriventris, Cobitis taenia, Syngnathus abaster, A. alburnus, Rhodeus amarus, Atherina boyeri.* Together they occupy 51,7% in terms of abundance and only 0,7% in terms of biomass (Fig.3.1).

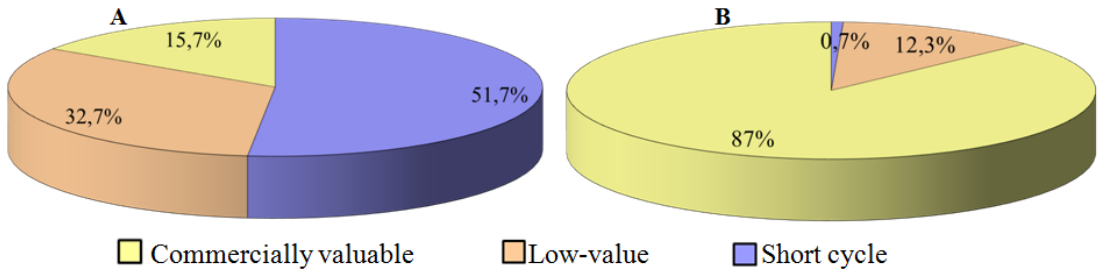

Fig. 3.1. The proportion of fish in the Kuchurgan reservoir by their economic value 2018-2022 (A - abundance, B - biomass).

According to the trophic structure, the fish of the reservoir are: predators – 7 species, including obligate predators – 5: *Esox lucius, Silurus glanis, Leuciscus aspius, Ictalurus punctatus* and *Sander lucioperca*, facultative predators – 2: *Squalius cephalus* and *Perca fluviatilis*. To peaceful – 35 species, including zoobenthosophages – 22: *Cyprinus carpio, Carassius gibelio, Abramis brama, Tinca tinca, Rutilus heckeli, Rutilus frisii, Blicca bjoerkna, Gymnocephalus cernua, Petroleuciscus boristenicus, Pseudorasbora parva, Leuciscus leuciscus, Lepomis gibbosus, Cobitis taenia*, gobies – *Neogobius fluviatilis, Proterorhinus semilunaris, Neogobius melanostomus, Knipowitshia longicaudata, Ponticola kessleri, Ponticola eurycephalus, Babka gymnotrachelus, Caspiosoma caspium* and *Benthophilus nudus*. 8 species belong to zooplanktonophages: *Hypophthalmichthys nobilis, Alosa tanaica, Clupeonella cultriventris, Atherina boyeri, Alburnus alburnus, Leucaspius delineatus, Syngnathus abaster* and *Pungitius platygaster*, 2 species belong to phytozoophages: *Scardinius erythrophthalmus* and *Rhodeus amarus*, to phytoplank tonophages – *Hypophthalmichthys molitrix*, to macrophytophages – *Ctenopharyngodon idella* and detritivores – *Liza haematocheilus*.

For the normal functioning of the ecosystem, the proportion of ichthyophages in the ichthyocenosis should be within 10-25%. In total, the share of predatory fish species in the cooling pond in the period 2019-2022. is 5,5% of the total number of fish caught in control fisheries (Fig. 3.2), which indicates the depressed state of their populations in the reservoir, which negatively affects the general condition of the ichthyofauna, due to a decrease in pressure on short-cycle and low-value fish in the reservoir.

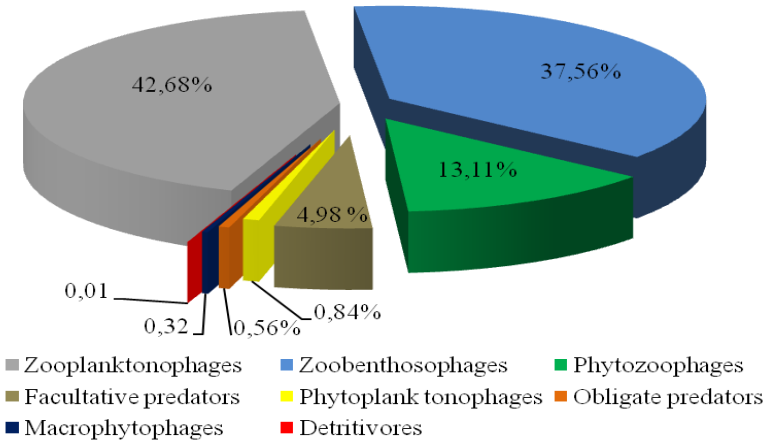

Fig. 3.2. Proportional composition of fish (abundance) by trophic structure in control catches of the Kuchurgan reservoir for the period 2019-2022.

For the normal functioning of the ecosystem, the proportion of predatory fish in the ichthyocenosis should not be lower than 10-25% [10]. In the control catches in the cooling pond, they occupy only 5,5%, which indicates the depressed state of their populations, which negatively affects the general state of the ichthyofauna, due to a decrease in the pressure on short-cycle and low-value fish in the reservoir. Pike before the construction of MSDPP in the ichthyocenosis dominated in terms of numbers and accounted for 20,0% [10], occupying a leading position in the fishery, and 10 years later – 9,6% (Fig. 3.3).

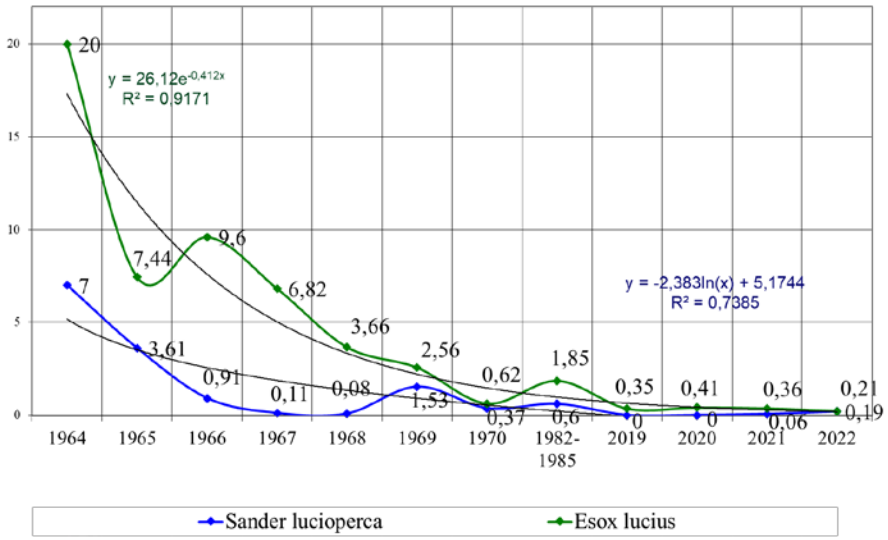

Fig. 3.3. Dynamics of the share (in %) of pikeperch and pike in the ichthyofauna Kuchurgan reservoir in 1964-2022

By 1985, the number of pike had declined significantly. The decrease in the number of pike is associated with a complex of unfavorable factors, primarily with a reduction in the area of natural spawning grounds and a change in the temperature regime of the reservoir, which led to

violations in the quality of gametes. As a result, the reproduction of pike and its fishing potential have decreased. A small herd of pike survived in the upper area overgrown with macrophytes, which was practically not subjected to heat stress. Today, the pike population is in a depressed state, its average share in the control catches in recent years is only 0,33% of the total ichthyofauna (Fig. 3.4).

Thermofication of the reservoir had a negative impact on the pike perch population, its maximum number was noted before the construction of MSDPP and amounted to 7%. Over the past four years, pikeperch was not caught in the control catches in 2019 and 2020, in 2021 its number was 0,06%, and in 2022 – 0,2%. The increase in the share of pikeperch in the control catches is associated with the stocking of the reservoir with fish by this active biological reclamator.

To determine the fish productivity of the reservoir, ichthyomass is important. In terms of ichthyomass in control catches in the reservoir, the dominant species are bighead carp (which is the main species in the catches of commercial fishermen and occupies 35,7% of the total ichthyomass), prussian carp (17,1%), silver carp (13,3%), and silver bream (7,5%) and carp (6,0%) (Fig. 3.4).

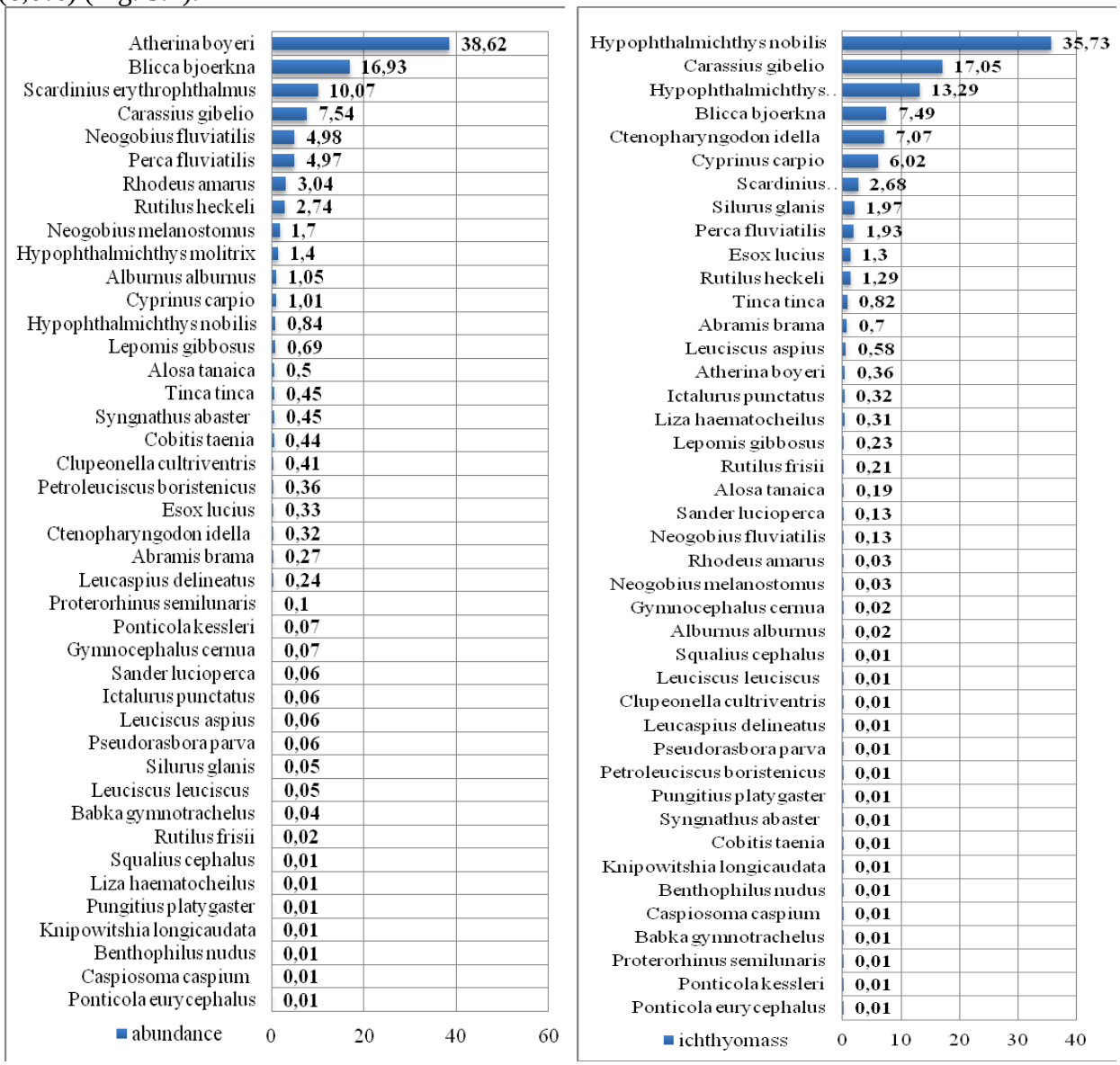

Fig. 3.4. The share composition of fish (%) by abundance and ichthyomass in the control catches of the Kuchurgan reservoir in 2019-2022

At the beginning of 2020, a species previously not noted in the literature for the ecosystem of the Kuchurgan reservoir was identified – the Amur chebak – *Pseudorasbora parva*. The Amur chebak is an invasive species of the Dniester basin, which entered the water bodies of Moldova along with fish seeding material from Far Eastern fish species. Its native habitat includes the waters of most East Asian countries from the Amur River to southern China. The penetration of the Amur chebak into the water bodies of Moldova took place in the early 1960s, but its first documentary mention was published in 1972 [18].

Moldovan ichthyofauna is characterized by 25 species of fish included in the Red Books. From the entire list of Red Book fish species in the reservoir, we noted five: beaver – *Petroleuciscus borysthenicus*, tench – *Tinca tinca*, carp – *Rutilus frisii*, caspiosome – Caspiosoma caspium and Knipovich's long-tailed goby – *Knipowitschia longecaudata*.

From the beginning of the 20th century to the present, more than 40 species of fish of alien origin and invaders have been identified on the territory of the Republic of Moldova, of which 4 species are considered allogeneic naturalized, 21 introducents and 12 invaders [1]. Since the transformation of the natural estuary into the Kuchurgan reservoir, 24 alien fish species have been noted in it. As a result of work on acclimatization and introduction of new fish species from faunal complexes of the Far East and North America, the reservoir was replenished with 8 new commercial fish species: white and bighead carp, white and black carp, channel catfish, sawfish, smallmouth and largemouth buffalo

Over the past 4 years, we have noted 20 alien scpecies: South European small sculpin, gobies (9 species), prussian carp, silver carp, bighead carp, sun perch, grass carp, Black Sea sprat, needlefish, channel catfish, stone moroco and so-iuy mullet. In total, they occupy 57,37% in the control catches.

One of the indicators characterizing the degree of fish bioinvasion is the Branch index [18], which is the ratio between the number of alien species and the total number of fish species recorded in a reservoir, and its modified form, which expresses the share ratio of caught individuals (Table 3.1).

Table 3.1. Analysis of invasion indicators and the degree of biocontamination alien species in the ichthyocenosis of the Kuchurgan reservoir

	Invasive Branch Index (Branch,1994)		Invasive index (according to the share ratio, %)	
Analysis of invasion indicators in ichthyocenosis	47,2%	3	55,47%	4
Degree of biocontamination with alien species	22,2%	3	39,6%	3

Note: *0 - no biocontamination; 1 – low biocontamination (>0 – <10%); 2 – moderate biocontamination (> 10–20%); 3 – high biocontamination (21–50%); 4 - strong biocontamination (> 50%).*

Without taking into account the Ponto-Caspian relics and those fish species that got into the reservoir before the construction of the MSDPP, the invasive Branch index is 3 on a 4-point scale, which corresponds to a high degree of biocontamination (Table 3.1).

The ichthyofauna of the Kuchurgan reservoir belongs to nine faunal complexes: boreal-plain (19 species), Ponto-Caspian marine (16 species), Ponto-Caspian freshwater (9 species), Chinese-plain (7 species), tertiary-plain (5 species), North American (4 species), Mediterranean (2 species), boreal-piedmont and West Asian complexes one species each (Fig. 3.5). Before the transformation of the natural estuary into a cooling pond, the Dniester endemic *Alburnus sarmaticus* was still found in it, and since 2010 another endemic, *Umbra krameri*, has ceased to be recorded.

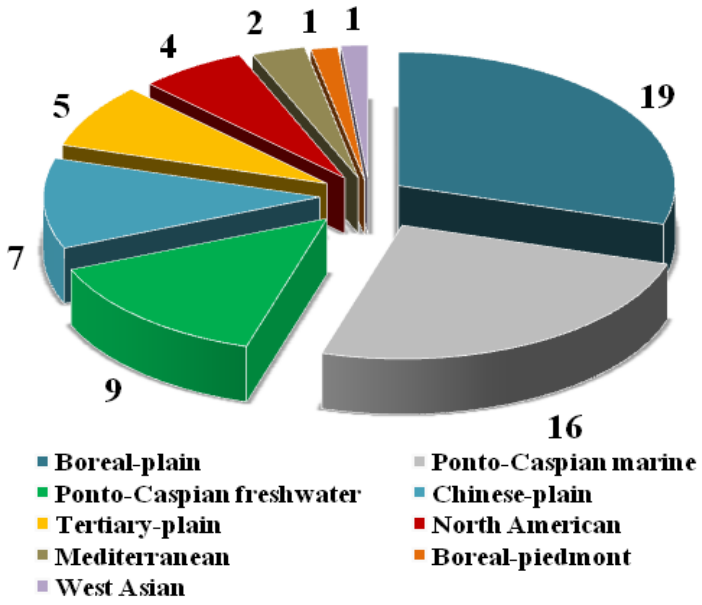

Fig. 3.5. The ratio of representatives of faunal complexes ichthyofauna of the Kuchurgan reservoir (estuary) over the past 100 years

Currently, only one endemic inhabits the reservoir – *Petroleuciscus boristenicus*, the number of which in the reservoir does not cause concern. According to the composition of ichthyofaunistic complexes, the reservoir is close to the Dniester, which, in turn, is close to the Danube [17].

Big-scale sand smelt – *Atherina boyeri (Risso, 1810*) In the Kuchurgan reservoir-cooler, *Atherina boyeri* began to be recorded in the early 1980s. According to our assumptions, it got into the reservoir during water exchange with the Turunchuk river. By origin, the atherina is an estuarine Mediterranean immigrant. Due to rapid puberty (in the first year of life), as well as eurybiontism, Aterina boyeri quickly took a dominant place in terms of abundance in the ichthyocenosis of the reservoir. In 2019-2022 Aterina boyeri is the absolute dominant in abundance in the ichthyocenosis of the cooling reservoir.

On average, over 4 years of control catches using a log it was established that the subdominant fish species of the reservoir include: *Neogobius melanostomus* (2,4%), *Carassius gibelio* (3,4%), *Perca fluviatilis* (3,9%) and *Rhodeus amarus* (4,9%). The group of dominant species includes *Blicca bjoerkna* (6,2%), *Neogobius fluviatilis* (7,1%) *and Scardinius erythrophthalmus* (9,4%). Superdominants include *Atherina boyeri*, the average percentage of which in terms of numbers is slightly more than 55% (Fig. 3.6).

Atherina boyeri has a high invasive potential, which according to the FISK protocol is 27 points [23]. Morphometric studies of Atherina of the Kuchurgan reservoir revealed the following biological characteristics: the average length of females is 7,04±0.048 cm, with a weight of 2,09±0,049 g with maximum values of 9,8 cm and 4,3 g. The average length of males is 6,55±0,041 cm, with a weight of 1,58±0,035 g, maximum – 9,4 cm and 3,9 g. Standard length of females – 6,09±0,041, males – 5,67±0,038. The age of the shale in the Kuchurgan reservoir does not exceed 2 years. Puberty of *Atherina boyeri* occurs in the first year of life. During this period, the gonads of mature two-year-old females are in stages IV-V of maturity. In early March, it massively approaches shallow water. Spawning occurs at a depth of 1 – 1,5 m, at a temperature of 12 °C.

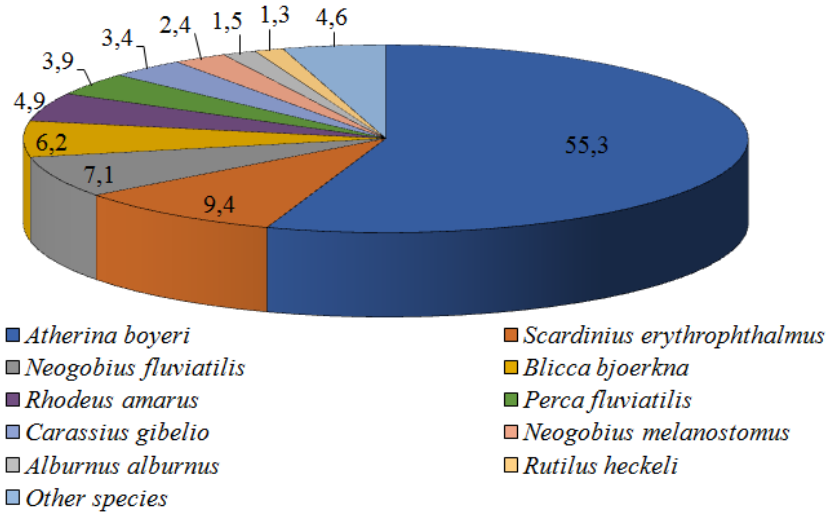

Fig. 3.6. Share ratio (in %) of the most abundant fish species in the reservoir based on the results of control catches in 2019-2022, using a log.

Atherina boyeri in the reservoir spawns in the coastal zone, where abundant vegetation serves as the spawning substrate. It has an extended batch spawning, which in the cooling pond begins in March and ends in August. The absolute fecundity of big-scale sand smelt ranges from 350-600 eggs. The eggs are large, 1,5-2,0 mm in diameter. The hatched larvae (5,0-6,0 mm) stay in the surface layers of water.

On average for the reservoir, South European atherina small in terms of dominance belongs to the category of absolute dominants with a dominance index D5 = 55,27%, including in the sections of the reservoir: D_{upper} = 17,65%, D_{middle} = 34,44%; D_{lower} = 74,39%. According to the constancy index, atherine belongs to the category of constant C3 = 53,89%. By sections of the reservoir: C_{upper} = 26,67%, C_{middle} = 53,34%, C_{lower} = 81,67%. According to the index of ecological significance, atherine is included in the category of characteristic W5 = 30,3%, including the water area of the reservoir: W_{upper} = 5,63%, W_{middle} = 22,44%, W_{lower} = 61,56%. The dynamics of index changes is shown in fig. 3.7.

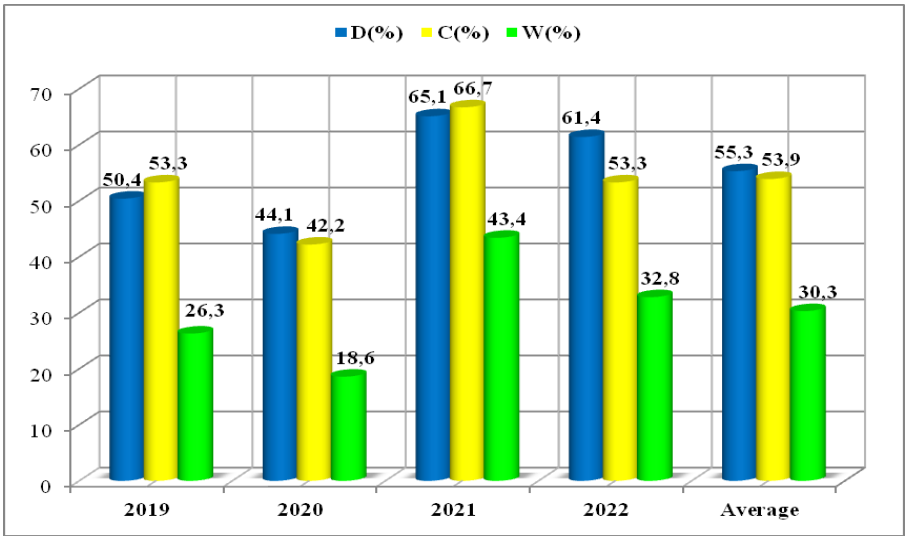

Fig. 3.7. Indexes of dominance (D), persistence (C) and ecological importance (W) *Atherina boyeri* of the Kuchurgan reservoir.

The obtained data on ecological indices confirm the fact that *Atherina boyeri* is a heat-loving species and due to this it is massively found in the warm discharge of the TPP channels, especially in the cold season. In the upper part of the reservoir, which is practically not subject to heat stress, *Atherina boyeri* occurs in smaller quantities. In the reservoir, accumulations of *Atherina boyeri* most often stay close to the surface of the water, in creeks, and only in winter go to the depths or to warm channels, where the temperature is 5 or more degrees higher than in the open water area. In summer period, the population is dispersed throughout the water area of the middle and lower sections of the reservoir and to a lesser extent in the upper section. In the Kuchurgan reservoir, *Atherina boyeri* massively migrates twice to the coastal part of the reservoir – in spring from early March to early April and in autumn from early October to early November.

Due to the high concentration of South European smelt in warm channels in the autumn-winter period, the number of predators increases here, in particular asp, which actively feeds on South European smelt. In addition to predators, crucian carp, bream, and ram feed on South European stern, and in 2022 it was noted in the intestines of the common bream.

Figure 3.8 shows the dynamics of the share of South European smelt in the ichthyocenosis of the reservoir from 2008 to 2022, demonstrating progressive growth. To approximate the monitoring data of its share, an exponential function was used, the approximation reliability coefficient was R2=0,9245, which indicates a high degree of compliance between the monitoring data and the calculated mathematical model (Fig. 3.8). Currently, the *Atherina boyeri* population of the reservoir is at the 1st stage of logistical development.

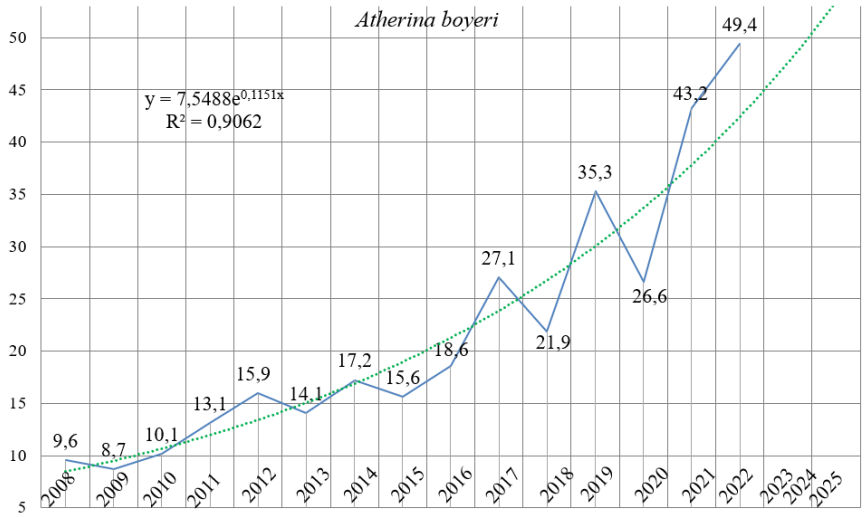

Fig. 3.8. Share (in%) *Atherina boyeri* in ichthyocenosis Kuchurgan reservoir, 2008-2022, 2023-2025 (forecast).

At the stage under consideration (2008-2022), there is an exponential growth in the population of smelt, which is likely to increase interspecific competition in the ichthyocenosis and lead to a reduction in the populations of native fish species in the near future.

***Sunfish – Lepomis gibbosus* (Linnaeus, 1758).** It is one of the common invasive species of the Dniester basin, which is found in the Kuchurgan reservoir, the Lower Dniester, the Turunchuk branch, and in 2020 it was also noted in the Dubossary reservoir. The sunfish has a high invasive potential, which is estimated at 34 points according to the FISK protocol [23].

In the period from 1920 to 2000, sunfish was noted in the ichthyofauna of the Kuchurgan reservoir in 1965 [9]. After the construction of the MSDPP, *Lepomis gibbosus* was not observed

in the reservoir until the 2000s. Since 2004, its single specimens have again been recorded in the control catches, which probably got into the reservoir along with the pumped water from the Turunchuk branch. The share of the number of sunfish in the control catches increased from 0,5% in 2008 to a maximum of 15,7% in 2017 and reduced to 0,13% in 2022 (Fig. 3.9).

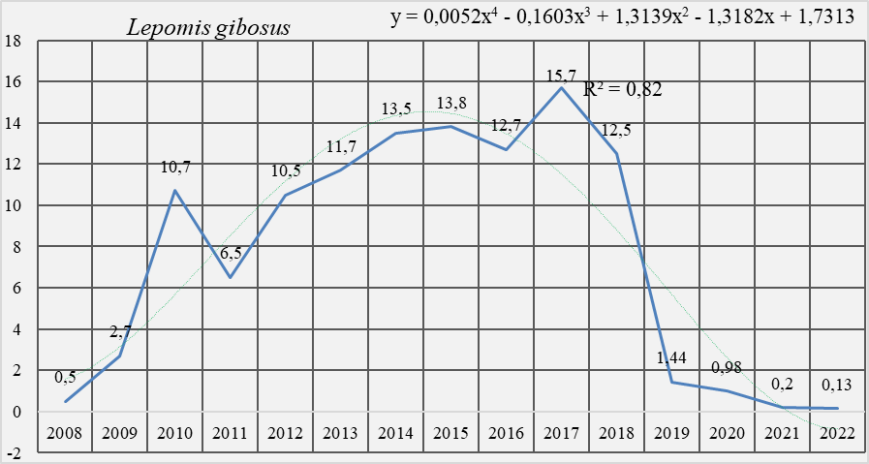

Fig. 3.9. Change in the proportion of *Lepomis gibbosus* (in %) in terms of abundance in the control catches in the Kuchurgan reservoir

In a short period of time, *Lepomis gibbosus* moved from a single species in 2004 to the superdominant category in 2010, where it remained for the next 8 years. The maximum share (15,7%) in control catches was noted in 2017.

The rapid growth in the number of sunfish over a short period in the Kuchurgan reservoir is due to the fact that, along with taking care of the offspring, this species has a portioned type of spawning, high fecundity (from 500 to 5000 eggs), and earlier onset of puberty (1-2 years) [18].

In 2016, a new invasive species, the Dutch crab *Rhithropanopeus harrisi* (Gould, 1841), was noted for the first time in the Kuchurgan reservoir, which has already formed a stable population here. The appearance and increase in the number of crab in the reservoir was accompanied, starting from 2018, by a sharp decrease in the share of sun perch in the control catches. Presumably, the reason for this was the increase in the number of crab in the reservoir, along with the breeding characteristics of the solar perch, which lays eggs in nests at the bottom of the reservoir, which, probably, becomes an easy prey for the crab. An interesting fact is that the Dutch crab entered the food chain and became the object of food for common perch and carp.

In order to quantitatively characterize the *Lepomis gibbosus* population of the Kuchurgan Reservoir, a polynomial model of the 4th degree was used to approximate the data on its abundance (reliability coefficient R2=0,8211). This model (y=0.0052x4 - 0.1603x3+1.3139x2 - 1.3182x+1.7313) demonstrates a rapid increase in abundance typical of invasive fish species, followed by a 4-year stage of population stabilization followed by a decrease in abundance (Fig. 3.9), which is caused by the appearance of the Dutch crab in the reservoir.

The maturation of sunfish in the reservoir occurs at the age of one or two years. Mature females of sun perch weighing from 7,2 g were caught in the reservoir, and with a weight of 13,4 g they were identified at the IV stage of egg maturation. In the lower Prut, many mature individuals with a body weight of 6,2-6,5 g were identified [18].

The spawning period of sunfish in the reservoir begins in the third decade of May, at a water temperature of about 20 ° C, and continues until the end of July. Larger, five-year-old females are the first to start laying eggs, while in four-year-old individuals, the ovaries during this period continue to remain at the IV completed and IV-V stages of maturity [18]. Our studies

of the sex structure of the sun perch showed that the sex ratio is biased in favor of females, amounting to 1,5:1 or 60,4% to 39,6%.

The behavior of males of the solar perch during the spawning period becomes very interesting. Before the breeding season, they occupy small territories in the coastal zone at a depth of about 50-100 cm, clear them of plants with the help of their mouth, tail and pectoral fins and build a round-shaped nest with a diameter of about 20 cm. During the nest building period, males become very aggressive, ready attack even larger individuals. If you catch a male from the nest, then another immediately appears in his place.

In the Lower Dniester and the Prut River, the maximum body length of sunfish rarely exceeds the standard length of 13 cm and weight of 60 g. For example, the standard length of the sunfish of the Zaporizhia Reservoir does not exceed 10 cm [13], while in the Kuchurgan Reservoir, the standard body length of the sunfish is more than 17 cm, and the maximum weight is 220 g.

The high morphometric parameters of the sunfish of the Kuchurgan reservoir are due to the fact that, being a heat-loving species, it found favorable conditions here, where the water temperature, due to the operation of the thermal power plant, becomes higher than in the natural reservoirs of the region. The sunfish is a facultative predator, euryphage. Dreissena was noted in the diet of the solar perch of the reservoir, which allows it to act as a bioreclamator.

The fatness of the sunfish of the cooling pond according to Fulton and Clark is 3,47±0,059 and 3,08±0,048 respectively. The absolute length of males ranged from 8,0 to 19,0 cm, females – from 10,0 to 21,3 cm. Juvenile individuals – underyearlings (0+) had a length of 3,5 to 7,1 cm. was 3,0–5,7 cm in immature individuals, 5,4–16,0 cm in males and 8,2–17,9 cm in females. The mass of juvenile representatives was in the range from 0,8 to 5,0 g; in males from 4,5 to 70,0 g and in females 20,0–160,0 g.

According to the literature data, the average body length of five-year-old female sunfish in natural water bodies of Moldova is 14,5±0,21 cm with a mass of 126,25±3,75 g [16]. According to the results of our year-round studies at the Kuchurgan reservoir, the average body length of Lepomis gibbosus females is 15,8±0,23. In the control catches, sun perch were represented by individuals from 0+ to 5 years old, with a predominance of five-year-old (29,8%), three-year-old (25,6%) and four-year-old (19,8%) individuals.

From fig. 3.10. it follows that individuals of older age groups predominate in the control catches, which does not correspond to the general pattern of development of populations of invasive fish species, when the number of older age groups decreases. The older age groups of sun perch appeared in 2017-2018 when the number of Dutch crab in the reservoir was minimal, and it did not affect the destruction of eggs laid by the sun perch as a result of strong predation.

In the future, we predict a further decline in the population of the sunfish up to its disappearance in the cooling pond.

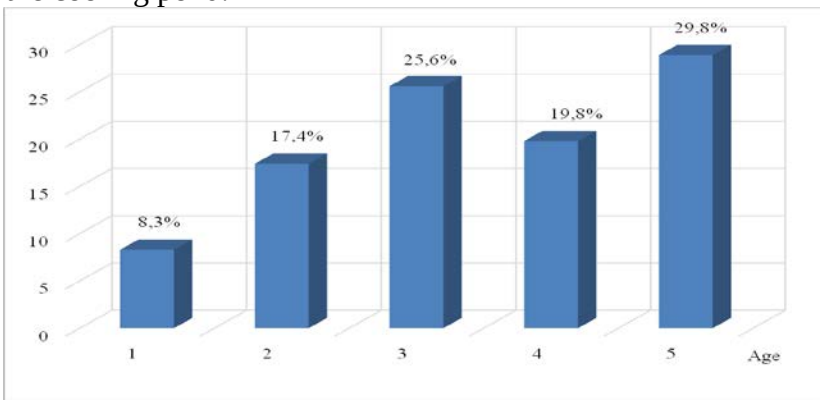

Fig. 3.10. Age structure of *Lepomis gibbosus* from the control catches of the Kuchurgan reservoir

For the period from 2019 to 2022 66 specimens of solar perch were caught in the control catches, including in the sections of the reservoir: in the upper section – 28, in the middle section – 17, in the lower section – 21 individuals. According to the average dominance index for the reservoir, sun perch moved from the category of superdominants (D5) to the category of insignificant species (D1) = 0,62%, including in the reservoir water area: D_{upper} = 2,1%, $D_{average}$ = 0,45%, D_{lower} = 0,4%. According to the index of constancy, on average for the reservoir, sunfish belongs to the category of random species (C1) = 13,89%; by sections of the reservoir: C_{top} = 20%, C_{middle} = 10%, C_{bottom} = 11,67%. According to the index of ecological significance, sun perch belongs to the category of additional species (W2) = 0,14%, W_{upper} = 0,54%, W_{middle} = 0,07% and W_{lower} = 0,13%. Sunfish is almost evenly distributed throughout the entire water area of the Kuchurgan reservoir.

When conducting control catches, 46 specimens of sunfish fell into fixed nets with meshes from 25 to 40 mm, including 26 individuals in the upper section, 16 in the middle section and 4 individuals in the lower section. According to the average dominance index for the reservoir, using nets with a mesh size of 25-40 mm, sunfish belongs to the category of minor species (D2) – 1,23%, D_{upper} = 2,82%, D_{middle} = 1,56%; D_{lower} = 0,23%. According to the constancy index, on average for the reservoir, it belongs to the category of random (C1) – 18,33%, C_{max} = 25%, C_{medium} = 20%, C_{bottom} = 10%. According to the index of environmental significance, on average for the reservoir, it belongs to the category of additional (W2) – 0,61%, W_{upper} = 1,62%, W_{middle} = 0,89%, W_{lower} = 0,1%.

***White bream – Blicca bjoerkna* (Linnaeus, 1758)**. Bream is one of the mass species of fish in the reservoir. The share of common bream in the control catches increased from 5,2% in 2008 to 12,3% in 2022, the maximum abundance was recorded in 2020 – 20,4% (Fig. 3.11). The data obtained indicate an increase in the population of the common bream in the Kuchurgan reservoir, which is associated with a good food supply and a favorable thermal regime.

At present (2008-2022), the abundance of *Blicca bjoerkna* continues to be at a fairly high level and makes up 10,4% of the total ichthyofauna of the cooling reservoir. In 2019-2022 its share in the control catches increased to 16%, exceeding the indicators of the previous periods of studies of the ichthyofauna of the reservoir.

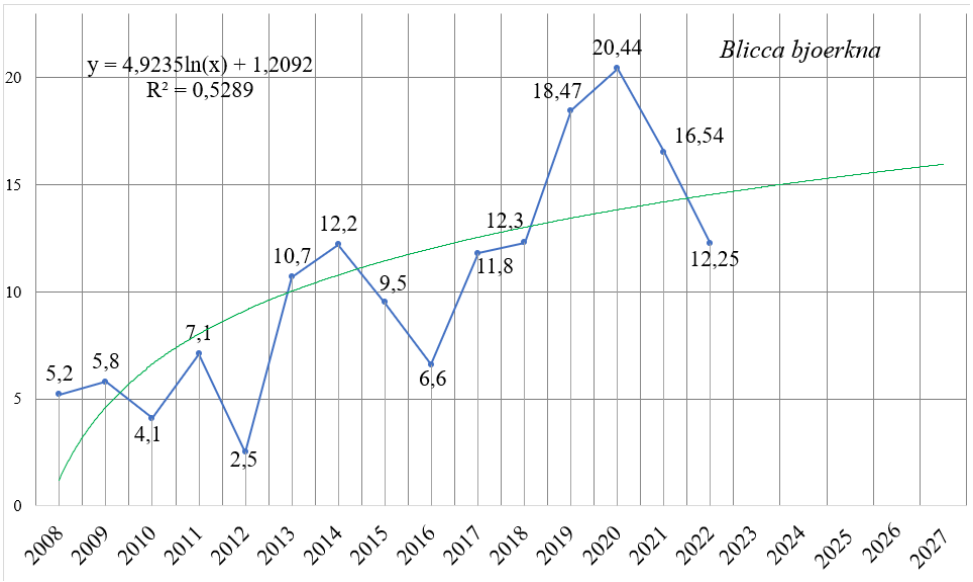

Fig. 3.11. The number of white bream - *Blicca bjoerkna* Kuchurgan reservoir (in %) and its linear forecast

The rate of increase in the number of white bream, observed since 2013, showed the maximum values in 2020, followed by a decrease and reaching a stable level. The obtained data were analyzed by means of a logarithmic curve with a confidence factor R2=0.5289. The analysis showed the stabilization of the number of white bream, which, according to our forecasts, will last for the next few years.

In the control catches carried out throughout the year, the silver bream is especially numerous in the period from mid-March to the end of May. In nets with a mesh size of 25x25 to 40x40 mm, the share of common bream is more than 75% of the total catch.

In the control catches, the silver bream is represented by individuals from 0+ to 7 years old, with a predominance of three-year-olds – 22,1%, four-year-olds – 26,1% and five-year-olds – 23,3%. The seven-year-old group is represented only by females. Long-term studies of the sexual structure of the black bream have shown that the sex ratio is shifted in favor of females in the ratio of 2:1 or 67,4% to 32,6%, which is even higher than the ratio of male and female white bream of the Dniester River (35,4% to 64,6 %) [7].

The dominance of females in populations is characteristic of fish with a short and conditionally short life cycle, and is characteristic of many fish species. This is explained by an adaptive mechanism that allows increasing population fertility and covers the decrease in the number of age groups. The females of the common bream are larger than the males, they mature at an earlier age and their life expectancy is shorter. In the Kuchurgan reservoir, the proportion of males in the population is significantly reduced, overcoming the age of 4. The proportion of females increases as their length increases, reaching 100% among large individuals (Fig. 3.12).

In the control catches *Blicca bjoerkna* comes in a standard length (l) from 3,8 to 24,5 cm and a total length of 4,8 to 31 cm. Three-year-old females have a standard length of 12,2 ± 0,12 cm, males 10,4 ± 0,2 cm; four-year-old females 14,9±0,1 cm, males 14,2±0,3 cm; five-year-old females 16,8 ± 0,15 cm, males 15,8 ± 0,1 cm. Starting from the age of four, the growth of the common bream slows down. The average size of males is in the range of 7,3-20,3 cm. Females are slightly larger – 9,2-22,1 cm. The data obtained showed that at the present stage the current size and weight indicators of the population of the Kuchurgan reservoir population are higher than in the period before the formation of the reservoir cooler. We believe that this is due to several factors, including the thermofication of the reservoir, which leads to an increase in the growing season and favorable conditions for the development of the main food objects of the common bream.

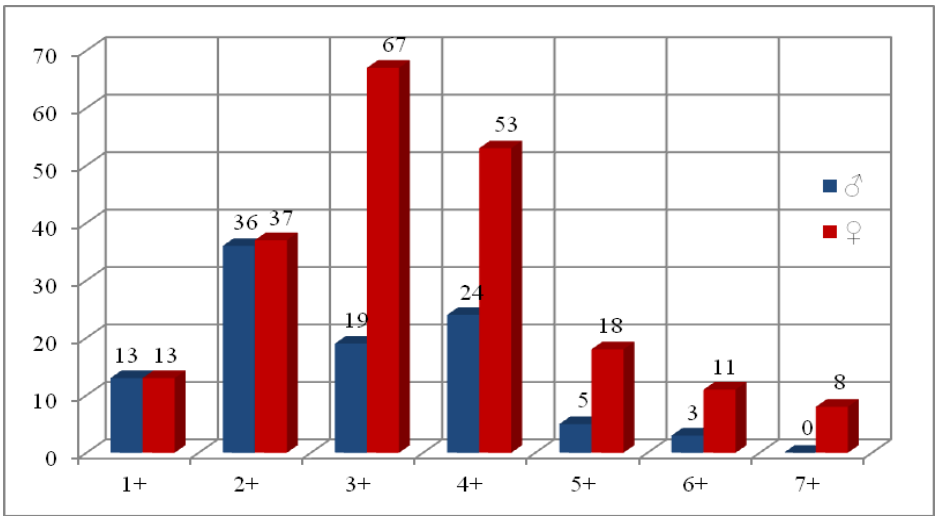

Fig. 3.12. The ratio of male and female *Blicca bjoerkna* by age

For the period from 2019 to 2022 in the control catches, *Blicca bjoerkna* was noted only in the log and nets with meshes from 25 to 60 mm. 712 specimens fell into the delirium, including 151 in the upper section of the reservoir, 251 in the middle section, and 310 individuals in the lower section. According to the dominance index on average for the reservoir, using a log in control catches, the white bream belongs to the category of dominant species with the dominance index (D4) = 6,18%, for the sections of the reservoir: D*upper* = 8,25%, D*middle* = 7,93%; D*lower* = 5,68%. According to the constancy index, on average for the reservoir, it belongs to the category of additional (C2) = 38,89%, for sections of the reservoir: C*upper* = 45%, C*middle* = 40%, C*lower* = 31,67%. According to the index of ecological significance, on average for the reservoir, the bream belongs to the category of additional (W3) = 2,42%, W*upper* = 4,85%, W*middle* = 4,27%, W*lower* = 1,4%.

2162 specimens of common white bream were found in the net with a mesh pitch of 25 to 40 mm, including 833 specimens in the upper section, 345 in the middle section, and 984 in the lower section. It belongs to the category of absolute dominants (D5) = 53,07%, D_{upper} = 41,13%, D_{middle} = 41,95%; D_{lower} = 64,87%. According to the index of constancy - to absolutely constant (C4) = 88,33%, C_{upper} = 80%, C_{middle} = 85%, C_{lower} = 100%. According to the index of environmental significance – to the category of characteristic (W5) = 49,18%, W_{upper} = 32,9%, W_{middle} = 36,95%, W_{lower} = 64,87%.

At present, the Fulton fatness coefficient of *Blicca bjoerkna* of the reservoir is 2,25 ± 0,017, which exceeds this coefficient (2,1) in the period before the formation of the cooling pond. In the Volga-Caspian region, the fatness according to Fulton in the spawning part of the population of white bream is 2,43±0,04 [11]. The fatness coefficient according to Clark is 1,96 ± 0,013 and varies from 0,95 to 2,63, which is almost the same as the fatness coefficient of the silver bream of the cooling pond of the Chernobyl NPP – 2,0 [4]. The high fatness coefficients of the common bream in the Kuchurgan reservoir indicate favorable conditions for growth and development in the cooling pond.

In the first period of life, the white bream feeds mainly on plant foods; as it grows, it switches to feeding on zoobenthos, including mollusks. A rather interesting fact of observations in 2022 is that in 5 out of 330 specimens of white bream gobies and atherins were found in the intestines, which indicates the possibility of feeding on small fish in the Kuchurgan reservoir.

Common bream in the Dniester River belongs to short-cycle species, with early puberty and high abundance [7]. In northern latitudes, the life expectancy of the silver bream increases. Thus, in the Rybinsk reservoir, formed on the Volga River and its tributaries, the Sheksna and Mologa, the life expectancy of the silver bream can reach up to 16 years [3]. In the Kuchurgan reservoir, we came across individuals up to 7 years old. The common bream belongs to the group of fish with batch type spawning and mainly breeds in the littoral zone of the reservoir. Lays eggs on last year's and vegetative vegetation. The sexually mature bream in the cooling pond becomes 1-2 years old when it reaches a body length of about 8-10 cm and a body weight of 15-20 g, which makes it possible to attribute it to the group of short-cycle fish.

Spawning of the common silver bream in the cooler reservoir of the MSDPP begins in early May and lasts until July at a water temperature of +19,5 ° C, spawning 2-3 portions of caviar. Due to the length of the spawning period, the descending part of the curve of the gonadosomatic index (GSI) is characterized by a decrease from May to July. The maximum value of GSI reaches in April, the minimum – in August. In autumn, the common bream again gathers in flocks and goes to winter in the pits or in the warm TPP channels, where amateur fishermen catch it in the autumn-winter-spring period.

4. PROTECTION AND RATIONAL USE OF FISH RESOURCES OF THE KUCHURGAN RESERVOIR

The Kuchurgan reservoir-cooler of the MSDPP is a highly productive reservoir, largely due to the rich food resources – phyto- and zooplankton, zoobenthos and higher aquatic vegetation. The diversity and quantitative development of food resources contributed to the formation of a rich ichthyocenosis of the reservoir, which currently includes 44 fish species. According to the type of food, the fish of the Kuchurgan reservoir form 9 groups.

Due to the feed resources of zoobenthos and zooplankton, the potential fish productivity of the Kuchurgan reservoir is 144.201 kg/ha, or in terms of the area of the reservoir 393.7 tons of fish, respectively.

The Kuchurgan reservoir is largely an overgrown reservoir. Higher aquatic vegetation is a food base for herbivorous fish, including grass carp, an obligate phytophage. Studies have established that grass carp consumes 50-55 kg of soft submerged aquatic plants (weeds, vallisneria, hornwort, etc.) for an increase of 1 kg of body weight. In the Kuchurgan reservoir, grass carp destroys 0.6-0.7 kg of plants per 1 kg of weight. As a result, during the growing season, grass carp consumes 140 kg of aquatic plants, adding up to 2 kg of ichthyomass. According to approximate calculations, in the Kuchurgan reservoir, the potential increase in grass carp production due to the utilization of only soft aquatic vegetation can be up to 120 kg/ha [14].

At the beginning of the 20th century, commercial catch at the Kuchurgan Estuary reached 120 tons. By the 1940s the estuary retained its fish production potential, giving up to 100 kg/ha of fish products, amounting to more than 150 tons of fish products. The stocking of the MSDPP cooling reservoir with species of the Far Eastern ichthyocomplex led to a significant increase in commercial catches - from more than 100 tons per year, starting from 1985 to 155.6 tons in 1987 [17].

Of the 44 species of fish in the reservoir, 18 commercially valuable species of fish were noted in our control catches, 11 are objects of fishing. Species of low value in the fishery are represented by the common silver bream and rudd, as well as the short-cycle South European small smelt. Most of the carp was caught in 2019 by Moldovan fishermen – 21,4 tons. Such a high figure is associated with the stocking of carp in 2016-2017 by Ukraine. The maximum volume of commercial catches was recorded in 2020– 45,4 tons.

The main share in the structure of the fishery is occupied by acclimatized Far Eastern species - silver carp and bighead carp and grass carp (Fig. 4.1). For the period 2018-2022 more than 57 tons were caught. Being limnorheophiles, these species often concentrate in large numbers in the warm TPP channels with a constant flow (a zone of permanent ban on fishing). In the control catches we carried out in the northern discharge channel of warm waters, more than 40 specimens of silver carps with a total weight of over 200 kg fell into the net with a mesh size of 90 mm and a length of 150 m per catch.

It is important to note that under the conditions of the Kuchurgan reservoir, where the elevated water temperature favorably affects the growth of phytoplankton and the overgrowing of the reservoir with macrophytes, Far Eastern cyprinids become important objects not only for fishing, but also for bioreclamation, preventing eutrophication of the reservoir.

For the period 2018-2022 the share of predatory fish (pike, catfish, pikeperch and perch) in the fishery in terms of numbers was only 1,7% and 0,9% in terms of ichthyomass of the total number of fish caught. Previously, the proportion of predators in the fishery ranged from 20% in the first half of the 20th century to 73% by the mid-1960s [10]. For 5 years, Pridnestrovian fishermen caught about 130 tons of fish in the reservoir, of which 125 tons fall on 5 main

commercially valuable species: white and bighead carp – 52 tons, silver carp – 35 tons, carp – 32 tons, grass carp – 6 tons.

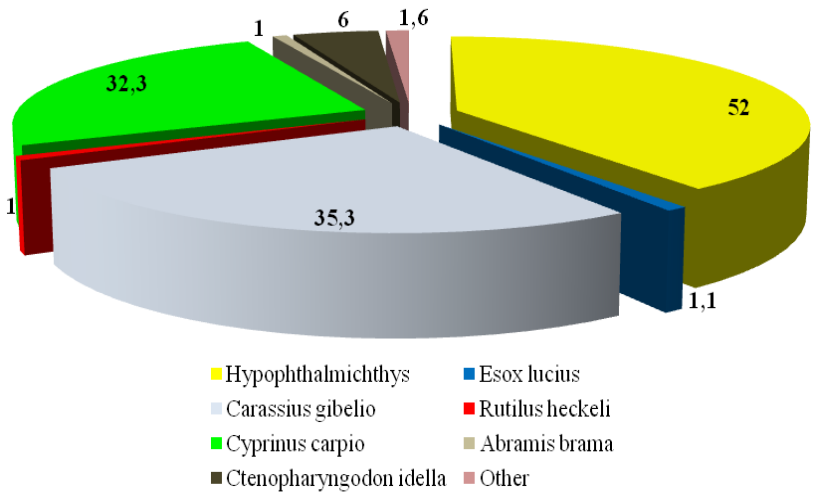

Fig. 4.1. Total catch (tonnes) of main commercial fish species in the Kuchurgan reservoir, 2018-2022.

For the first time, studies of recreational fishing for the fish stocks of the Lower Dniester were carried out by scientists from Moldova and Ukraine in 2019-2020. We carried out similar studies to determine the impact of recreational fishing on the Kuchurgan reservoir. At the cooling reservoir, the bulk of amateur fishermen concentrate near thermal discharge channels, which is due to the fact that such valuable fish species as prussian carp, grass carp and silver carp gather here in large numbers, and such a valuable species as channel catfish is found mainly in warm canals of MSDPP. Near the exit of thermal channels, we noted up to 40 fishermen per 1 km of the coastline in spring-summer periods. In hard-to-reach places, single fishermen were observed at a distance of 1-2 km. In the spring-winter period, amateur fishermen concentrate mainly on the warm channels of the MSDPP, where fishing is prohibited. The average catch of one amateur fisherman at the Kuchurgan reservoir in spring was– 3,2 kg, in summer – 3,1 kg, in autumn – 2,5 kg. (Table 4.1).

Table 4.1. Catches (kg) of amateur fishermen at the Kuchurgan reservoir in the period 2020-2022.

Total length of the accounted area, km	Number of fishermen/day in terms of total length Average catch per fisher per day (kg) (holidays, weekends and working days) Total catch, kg/day			Number of fishermen/day in terms of total length Average catch per fisher per day (kg) (holidays, weekends and working days) Total catch, kg/day			Number of fishermen/day in terms of total length Average catch per fisher per day (kg) (holidays, weekends and working days) Total catch, kg/day		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
17	86	75	59	3,2	3,1	2,5	275,2	232,5	147,5

Individual fishermen caught up to 7 or more kg of fish per day. In the Kuchurgan reservoir, the most frequently caught fish species are rudd (21,6% of the total number of caught individuals), crucian carp (17,9%), gobies (12,5%), perch (11,8%), carp (9,6%) and white bream (8,8%), other species – less than 5% (Fig. 4.2).

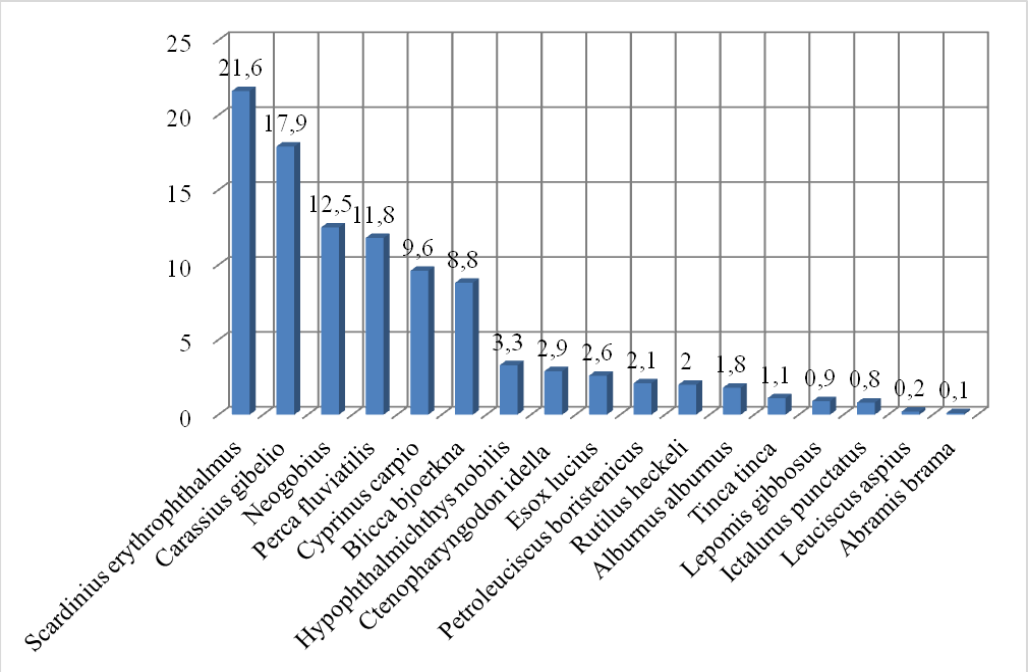

Fig. 4.2. The proportion of the fosh catches of amateur fishermen at the Kuchurgan reservoir

In the catches of amateur fishermen, there were specimens of silver carp weighing 10 kg or more, carp – 5 kg or more and grass carp – over 15 kg.

GENERAL CONCLUSIONS:

1. As a result of the transformation of the natural estuary into a cooling pond for the MSDPP and changes in environmental conditions, significant changes occurred in its ichthyocenosis. Migratory species (beluga, stellate sturgeon, sabrefish) and some rheophilic species (sterlet, barbel, fisherman) dropped out of the ichthyofauna, while others (bream, carp, chub, European catfish) significantly reduced the number of their populations. The number of pike perch and pike has decreased significantly.
2. The biotic integration index of the Kuchurgan reservoir is 26 points, which corresponds to the fourth quality class and satisfactory water quality, in accordance with the Water Framework Directive 2000/60 EC.
3. Currently, the ichthyocenosis of the Kuchurgan reservoir is formed by 44 species from 18 families. The ichthyofauna is dominated by species of the Ponto-Caspian (39%), boreal-plain (27%) and Chinese-plain (11%) faunal complexes.
4. The absolute dominants in the ichthyofauna of the reservoir are the southern European silverside (38,62% of the total number of caught individuals), the common bream (16,93%) and the rudd (10,07%). The dominant species are silver crucian carp (7,54%), sand goby (4,98%) and perch (4,97). The group of subdominants is formed by bitterling (3,04%) and ram (2,12%). The remaining types are classified as secondary and insignificant. In terms of ichthyomass, the dominant species are bighead carp (35,73%), prussian carp (17,05%), silver carp (13,29%), silver bream (7,49%), grass carp (7,07%) and carp (6,02%).
5. As a result of acclimatization, white and bighead carp, grass carp, American channel catfish and haarder appeared. Only the channel catfish has currently formed a stable self-reproducing population in the canals of the MSDPP. As a result of self-invasion, the following appeared: southern European silverside, sun perch, and Amur chebak. Without taking into account Ponto-Caspian relics, Branch's invasive index is 3 on a 4-point scale, which corresponds to a high degree of biocontamination.
6. In the Kuchurgan Reservoir, there is an exponential increase in the population of the small southern European silverside; a significant decline in sunfish numbers as a result of the introduction of the Dutch crab; stabilization of the number of silver bream, predicted for the next few years.
7. The potential fish productivity of the Kuchurgan reservoir due to food resources (zoobenthos and zooplankton) is 144,201 kg/ha, or in terms of the reservoir area 393,7 tons of fish.
8. The commercially valuable ichthyofauna is formed by 18 species of fish, 11 of which are objects of fishing with a predominance of white and bighead carp, silver crucian carp, carp and grass carp, the annual catch of which averages about 26 tons of fish according to Moldovan fishermen.
9. In the current conditions of the Kuchurgan reservoir, coupled with the trend of climate change, we predict an increase in the population of heat-loving, eurytopic, phytophilic species that are resistant to adverse factors: prussian carp, silver bream, big-scale sand smelt, common bleak and sunbleak.

PRACTICAL RECOMMENDATIONS

for the conservation and restoration of the ichthyofauna of the Kuchurgan reservoir:

1. The spawning ban should be moved to an earlier date to protect species with an early breeding season (pike, asp, etc.). To restore the populations of predatory fish: pike perch, asp, pike and European catfish, completely ban their fishing for a period of five years.
2. Completely ban for a period of five years the fishing of predatory fish species: pikeperch, asp, pike and European catfish. Limit pike fishing in the period from February to March, preceding the general ban.
3. Organize annual reclamation fishing for such numerous short-cycle and low-value fish species as big-scale sand smelt, silver bream, common rudd, etc.
4. Make more active use of Far Eastern herbivorous fish species (silver carp and grass carp) in biological reclamation and the fight against overgrowth and flowering of the reservoir.
5. To reduce the salinity and thermofication of the Kuchurgan reservoir, it is recommended to systematically carry out work to intensify its water exchange.
6. Organize the receipt of juveniles (larvae, fingerlings) of valuable aquatic species (bream, taran, common carp, tench, Black Sea roach etc.) with their further release into the reservoir. Annually stock 50 thousand pikeperch yearlings.

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4. **МУСТЯ, М.В.,** ИГНАТЬЕВ, И.И., БОЛГАРОВА, А.В., БЕШЛЯГА, Т.С. Густера (Blicca bjoerkna) Кучурганского водохранилища. Конференция памяти кандидата биологических наук, доцента Л.Л. Попа. Тирасполь, 25 июня 2020. С.133 – 136. ISBN 978-9975-3404-3-4.

3. Theses in collections of scientific conferences

3.1 in the proceedings of international scientific conferences (abroad)

1. **MUSTYA, M.,** BULAT, DM. Biology of the atherina (Atherina boyeri Risso, 1810) of the Kuchurgan reservoir-cooler - o.l. In: The scientific symposium biology and sustainable development the 20th edition. November 24-25. Bacău, 2022, Romania. P. 72.

3.2 in the proceedings of national scientific conferences with international participation

1. **MUSTYA, M.** Atherina (Atherina boyeri Risso, 1810) of Kuchurgan reservoir. In: Life sciences in the dialogue of generations: connections between universities, academia and business community September 29-30. Chisinau, 2022. P. 99. ISBN: 978-9975-159-80-7.

Methodological guidelines

1. ФИЛИПЕНКО, С., **МУСТЯ, М.,** ИГНАТЬЕВ, И. Справочник рыболова-любителя. Бендер: Полиграфист, 2023, 36 с. ISBN 978-9975-3538-7-8.

2. **МУСТЯ, М.,** ФИЛИПЕНКО, С. Практические работы по ихтиологии. (методические указания). Тирасполь: Изд-во Приднестр. Ун-та, 2018. 67 с.

ANNOTATION

Mustya Mikhail "Ichthyofaunistic diversity and structural and functional state of the ichthyocenosis of the Kuchurgan reservoir-cooler under modern environmental conditions", PhD thesis in biological sciences, Chisinau, 2024.

Thesis structure: introduction, four chapters, general conclusions and recommendations, bibliography of 180 titles, 6 annexes, 112 basic pages, 41 figures, 18 tables. The obtained results are published in 29 scientific papers on the thesis.

Keywords: ichthyofauna, ichthyocenosis, Kuchurgan reservoir, cooling pond, fish productivity, alien species, introduced, abundance, biomass, environmental indices.

Purpose: is to assess the current state of the ichthyocenosis of the Kuchurgan cooling reservoir, to establish its structural and functional state and successional changes under conditions of anthropogenic and bioinvasive influence.

Objectives: to study the modern ichthyofauna of the Kuchurgan reservoir and its structural and functional state; establish successional changes in ichthyocenosis from a historical perspective; study the structure of ichthyofaunistic complexes; explore rare and invasive fish species in the reservoir; establish the bioecological characteristics of individual fish species; study the influence of environmental factors on the ichthyofauna of the reservoir; establish the potential fish productivity of the reservoir based on feed resources; explore the modern structure of the fishery on the Kuchurgan reservoir; develop recommendations to improve the ichthyological situation in the reservoir.

Scientific novelty and originality: In a comparative aspect, biodiversity and successional changes in the ichthyofauna of the reservoir were studied in historical terms, depending on the degree of anthropogenic impact.For the first time, a new invasive species, the Amur grouse, *Pseudorasbora parva*, has been recorded in the Kuchurgan reservoir. The faunistic characteristics of the ichthyocomplexes and the bioecological characteristics of the South European small smelt – *Atherina boyeri*, the sun perch – *Lepomis gibbosus* and the silver bream – *Blicca bjoerkna*, as well as the forecast of their abundance are given. The potential fish productivity of the reservoir was calculated in terms of food resources. Recommendations are given to improve the ichthyological state in the Kuchurgan reservoir.

The solved scientific problem: is that new *scientifically based knowledge* has been obtained about the ichthyofauna of the Kuchurgan cooling reservoir of the MSDPP, *which led* to the establishment of patterns of its dynamics in the space-time aspect, depending on the degree of anthropogenic impact, revealed the reasons causing structural changes in the ichthyocenosis, which *allowed* to develop recommendations for the preservation and restoration of the fish production potential of the reservoir.

Main results: Based on modern ecological methods and approaches integrated into classical ichthyological science, fundamentally new results for science and practice were obtained about the ichthyofauna of the Kuchurgan cooling reservoir of the MSDPP, which established the peculiarities of changes in the ichthyocenosis and its functioning in conditions of transformation of a water body under the influence of anthropogenic factors.

Theoretical significance: The results obtained make a significant contribution to the analysis and knowledge of the structural and functional state of ichthyocenoses of natural aquatic ecosystems subject to active processes of transformation, thermofication, chemical pollution and invasion by alien species.

Applicative value: Scientific results on the current state and functioning of the ichthyocenosis of the Kuchurgan reservoir served as the basis for the development of measures in the field of restoration, conservation and sustainable use of fish resources of the MSDPP cooling pond. Recommendations are given on the organization of recreational fishing in the reservoir. The “Amateur Fisherman’s Handbook” was published, as well as the methodological guide “Practical Work on Ichthyology” for students of biological specialties at universities. The research results are an integral part of the scientific project no. 20.80009.7007.06 AQUABIO.

Implementation of scientific results: The research results are used by the “Environmental Center” of Tiraspol when organizing measures for the conservation, restoration and rational use of fish resources of the Kuchurgan reservoir; Moldavian State University and Transnistrian State University named after T.G. Shevchenko in the educational process when training specialists for the education system and the environmental industry; International Association of River Guardians "Eco-TIRAS" in the implementation of environmental projects, environmental education and upbringing.

ADNOTARE

Mustea Mihail «Diversitatea ihtiofaunistică și starea structural-funcțională a ihtiocenozei lacului refrigerent Cuciurgan în condițiile ecologice actuale», teză de doctor în științe biologice, Chișinău, 2024.

Structura tezei: introducere, patru capitole, concluzii generale și recomandări, bibliografia din 180 de titluri, 6 anexe, 112 pagini de bază, 41 figuri, 18 tabele. Rezultatele obținute sunt publicate în 29 lucrări ştiinţifice la tema tezei.

Cuvinte-cheie: ihtiofauna, ihtiocenoza, lacul de acumulare Cuciurgan, lac refrigerent, productivitate piscicolă, specie alogenă, introducent, efectiv numeric, biomasa, indice ecologic.

Scopul lucrării: Evaluarea stării actuale a ihtiocenozei lacului refrigerent Cuciurgan sub aspect structural și funcțional, inclusiv a modificărilor succesionale în condițiile termoficării și efectului bioinvaziv.

Obiectivele cercetării: Analiza ihtiofaunei lacului Cuciurgan și a stării structural-funcționale a ihtiocenozei; stabilirea modificărilor succesionale în ihtiocenoza lacului; analiza structurii complexelor ihtiofaunistice; investigarea speciilor rare și invazive de pești din ecosistemul lacului; elucidarea particularităților bio-ecologice la unele specii de pești din lac; investigarea influenței unor factori de mediu asupra ihtiofaune lacului; evaluarea productivității piscicole a lacului în funcție de baza trofică naturală; analiza structurii capturilor industriale a lacului refrigerent Cuciurgan; elaborarea recomandărilor științifico-practice de ameliorare a fondului piscicol din lac.

Noutatea şi originalitatea ştiinţifică: În aspect succesional a fost evaluată diversitatea ihtiofaunei și particularitățile populaționale a speciilor reprezentative de pești în funcție de gradul influențelor antropice asupra ecosistemului lacului refrigerent Cuciurgan. Pentru prima dată a fost semnalată în lac o specie invazivă – *Pseudorasbora parva*. Sunt relevate particularitățile complexelor ihtiofaunistice din lac și analizate caracteristicile bioecologice, inclusiv, se face pronosticul dinamicii populaționale la unele specii de pești, precum: *Atherina boyeri, Lepomis gibbosus* și *Blicca bjoerkna*. Este evaluată productivitatea piscicolă a lacului refrigerent Cuciurgan în funcție de starea bazei trofice naturale. Au fost elaborate recomandări științifico-practice pentru ameliorarea stării ihtiofaunei din ecosistemul lacului refrigerent Cuciurgan.

Problema științifică soluționată: Constă în obținerea de noi cunoștințe argumentate științific cu referire la ihtiofauna lacului de acumulare Cuciurgan, ceea ce a condus la stabilirea unor legități privind dinamica acesteia în aspect spațio-temporar în funcție de intensitatea factorului antropic, descifrarea cauzelor modificării structurii ihtiocenotice și elaborarea recomandărilor de protecție și ameliorarea a fondului piscicol din lac.

Rezultatele principale: S-au obținut cunoștințe principial noi privind ihtiofauna lacului refrigerent Cuciurgan, prin intermediul integrării metodelor ecologice în investigațiile ihtiologice clasice, în vederea relevării particularităților structural-funcționale a ihtiocenozei în condițiile transformării ecosistemului acvatic sub acțiunea factorului antropic.

Semnificația teoretică: Rezultatele științifice obținute în lucrare aduc un aport semnificativ la analiza și cunoașterea stării structural-funcționale a ihtiocenozelor ecosistemelor acvatice naturale supuse proceselor active de fragmentare biotopică, termoficare, poluare chimică și invazie cu specii alogene.

Valoarea aplicativă: Rezultatele științifice obținute privind starea actuală și funcționarea ihtiocenozei lacului de acumulare Cuciurgan au servit drept bază pentru elaborarea măsurilor în domeniul restabilirii, conservării și utilizării durabile a resurselor piscicole din ecosistem. Sunt înaintate recomandări privind organizarea pescuitului recreativ în lacul de acumulare Cuciurgan. A fost editat ”Ghidul pescarului amator” și un îndrumar metodic pentru studenții universităților cu profil biologic ”Lucrări practice la ihtiologie”. De menționat, de asemenea că, rezultatele obținute sunt parte componentă a Programului de Stat №. 20.80009.7007.06 AQUABIO.

Implementarea rezultatelor științifice: Rezultatele cercetării sunt utilizate în cadrul «Centrului ocrotirii naturii», or. Tiraspol, la organizarea activităților de conservare, restabilire și utilizare rațională a resurselor piscicole ale lacului de acumulare Cuciurgan; Universitatea de Stat din Moldova, Universitatea de Stat Nistreană” T.G. Shevchenko” în procesul didactic la formarea specialiștilor în domeniu; Asociația Internațională a Păstorilor Râului „Eco-TIRAS” în implementarea programelor educative pentru un mediu sănătos.

АННОТАЦИЯ

Мустя Михаил «Разнообразие ихтиофауны и структурно-функциональное состояние ихтиоценоза Кучурганского водохранилища-охладителя в современных экологических условиях», диссертация на соискание ученой степени доктора биологических наук, Кишинэу, 2024 г.

Структура диссертации: Диссертация представлена на 112 страницах основного текста, состоит из введения, 4 глав, общих выводов и рекомендаций, содержит 18 таблиц, 41 рисунок, список литературы из 180 наименований, 6 приложений. Полученные результаты были представлены в 29 научных работах.

Ключевые слова: ихтиофауна, ихтиоценоз, Кучурганское водохранилище, водоем-охладитель, рыбопродуктивность, чужеродный вид, инродуцент, численность, биомасса, экологический индекс.

Цель работы: состоит в оценке современного состояния ихтиоценоза Кучурганского водохранилища-охладителя, установлении его структурно-функционального состояния и сукцессионных изменений в условиях антропогенного и биоинвазивного воздействия.

Задачи исследования: Изучить современную ихтиофауну Кучурганского водохранилища – охладителя МГРЭС и ее структурно – функциональное состояние; установить сукцессионные изменения ихтиоценоза в историческом аспекте; изучить структуру ихтиофаунистических комплексов; исследовать редкие и чужеродные виды рыб водохранилища; установить биоэкологические особенности отдельных видов рыб; исследовать влияние экологических факторов на ихтиофауну; установить потенциальную рыбопродуктивность по кормовым ресурсам; исследовать современную структуру промысла; разработать рекомендации для улучшения состояния ихтиоценоза.

Научная новизна и оригинальность: В сравнительном аспекте исследованы разнообразие и сукцессионные изменения в ихтиофауне водохранилища в историческом плане в зависимости от степени антропогенного воздействия. Впервые для водоема-охладителя Молдавской ГРЭС отмечен инвазивный вид – амурский чебачок – *Pseudorasbora parva*. Дано фаунистическое описание ихтиокомплексов и биоэкологическая характеристика атерины южноевропейской малой – *Atherina boyeri*, солнечного окуня – *Lepomis gibbosus* и густеры обыкновенной – *Blicca bjoerkna*, а также прогноз их численности. Рассчитана потенциальная рыбопродуктивность водохранилища по кормовым ресурсам. Даны рекомендации по улучшению ихтиологического состояния в водохранилище.

Решенная научная проблема: состоит в получении новых *научно обоснованных* знаний о ихтиофауне Кучурганского водохранилища-охладителя Молдавской ГРЭС, *что привело к* установлению закономерностей ее динамики в пространственно-временном аспекте в зависимости от степени антропогенного воздействия, раскрыло причины, обуславливающие структурные изменения ихтиоценоза, что *позволило* разработать рекомендации по сохранению и восстановлению рыбопродукционного потенциала водохранилища.

Полученные принципиально новые результаты для науки и практики: на основе современных экологических методов и подходов, интегрированных в классическую ихтиологическую науку, получены принципиально новые результаты для науки и практики о ихтиофауне Кучурганского водохранилища, которые установили особенности изменений в ихтиоценозе и его функционировании в условиях трансформации водного объекта под воздействием антропогенных факторов.

Теоретическое значение: Полученные результаты вносят значительный вклад в анализ и познание структурно-функционального состояния ихтиоценозов естественных водных экосистем, подверженных активным процессам трансформации, термофикации, химическому загрязнению и инвазии чужеродными видами.

Прикладное значение: Научные результаты о современном состоянии и функционировании ихтиоценоза водохранилища послужили основой для разработки мер в области восстановления, сохранения и устойчивого использования рыбных ресурсов водоема-охладителя МГРЭС. Даны рекомендации по организации любительского рыболовства и ведению промысла на водохранилище. Издан «Справочник рыболова любителя», а также методическое пособие «Практические работы по ихтиологии» для студентов биологических специальностей университетов. Результаты исследований являются составной частью научного проекта №. 20.80009.7007.06 AQUABIO.

Внедрение научных результатов: Результаты исследований используются «Природоохранным центром» г. Тирасполь при организации мероприятий по сохранению, восстановлению и рациональному использованию рыбных ресурсов Кучурганского водохранилища; ГУМ и ПГУ им. Т.Г. Шевченко в учебном процессе при подготовке специалистов для системы образования и природоохранной отрасли; Международной ассоциацией хранителей реки «Эко-ТИРАС» в реализации экологических проектов, экологическом образовании и воспитании.

MUSTEA MIHAIL

ICHTHYOFAUNISTIC DIVERSITY AND STRUCTURAL AND FUNCTIONAL STATE OF ICHTHIOCENOSIS OF THE KUCHURGAN RESERVOIR-COOLER UNDER MODERN ENVIRONMENTAL CONDITIONS

165.03. ICHTHYOLOGY

Summary of the doctoral thesis in biological sciences

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