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16. Evaluation of the potential abundance and biomass of commercial benthic fish in the Yalpug and Kugurluy lakes (Ukraine)

ZAMOROV Veniamin[1], LEONCHYK Yevgen[1], ZAMOROVA Maria[1], DZHURTUBAEV Michael[1]

1 - Odessa I.I. Mechnikov National University: 2 Shampansky lane, Odessa 65058, UKRAINE

Address of author responsible for correspondence: **ZAMOROV Veniamin** - Odessa I.I. Mechnikov National University: 2 Shampansky lane, Odessa 65058, UKRAINE; email: hydrobiologia@mail.ru ; bio@onu.edu.ua

ABSTRACT. The paper deals with assessment of the potential abundance and biomass of commercial species of benthophagous fish from Yalpug-Kugurluy lake complex. The proposed method of calculation is based on analysis of feeding base, volume of catches of separate fish-species, sex, populations' size and age composition, feeding and breeding. The basis for calculation of potential fish production is the total production of macrozoobenthos during the growing season. Fluctuations of environmental factors are also considered. This algorithm takes into account biological and ecological parameters of the species and changes in environmental factors, providing higher estimation accuracy compared with methods used in aquaculture (based only on calculation of the total amount of feed rate). Significant feeding on macrozoobenthos by Gobiidae negatively affects the productivity of valuable commercial benthophagous fish. Drainage and irrigation works were proposed to increase the number of valuable predatory species – *Sander lucioperca* - for which gobies are important food-components. The method of potential fish production assessment is suggested for being used in management of fisheries in lake ecosystems. The calculated values indicate the potential capacity of feeding base of reservoirs, i.e. allowing the assessment of the maximum number of individuals and biomass at a certain ratio of fish species. To increase fish production of commercially valuable species in lakes Yalpug and Kugurluy, more intense stocking of *Cyprinus carpio* is proposed. This will facilitate the most effective use of feeding base by benthophage fish that will lead to a significant increase in catches valuable species of carps in these lakes.

Key words: benthic fish, productivity, feeding base, Danube Lakes, Ukraine

INTRODUCTION

There are quite a lot of publications concerning the feeding of fish in the water bodies, which are used in fisheries, for example ([***10***]; [***19***]). In order to assess fish production in artificial reservoirs, a feed rate is often used, which has a large range of value fluctuation, and that is why the features of individual species and the dynamics of environmental factors can be neglected. This approach provides a fairly objective assessment of the fish production in water bodies that are under human control. However, this method does not allow calculating the potential number of fish in natural waters, since it ignores the nutritional needs of all types of fish, their trophic relationships in the fish community and fluctuations in environmental factors.

In most works on the relationship between fish and their feeding base in natural waters the relationship between the dynamics of the species composition of fish fauna, abundance fluctuations of separate fish species and changes in qualitative and quantitative composition of feed organisms in the biocenosis have been shown. The results of some studies also provide rough estimates of the fishing stock of population at a time ([***6***]; [***3***]; [***17***]).

The Danube Lakes is the largest lake district in Ukraine, with the area of Kagul, Yalpug, Kugurluy, Kotlabuh and Kitaj of about 450 km^2 and their volume of more than 800 million m^3 [***7***]. These lakes have a great fishery potential, which is currently not fully used. As a result of construction of dams in the second half of the XX^{th} century, the relationship with the Danube Lakes has noticeably decreased. This led to a major rebuilding of lake ecosystems and their impact on fish productivity.

The investigations on the Yalpug and Kugurluy Lakes were reasonable due to their high productivity of commercial species of benthophagous fish: Common carp (*Cyprinus carpio* Linnaeus, 1758), Common bream (*Abramis brama* Linnaeus, 1758) and Prussian carp (*Carassius gibelio* Bloch, 1782) in comparison with other lakes. Over the past ten years the average catches of these three species per year equalled the following: Yalpug-Kugurluy - 330.2 tons, Cagul - 65.2 tons, Kotlabuh – 54.6 tons; Kitaj – 152,1 tons.

In this paper we propose an algorithm to calculate the potential number of fish in the Yalpug-Kugurluy lake-complex. This method can be effectively used to conduct rational fisheries in natural inland waters.

The aim of the study was to determine with sufficient accuracy the potential total abundance and biomass of all the representatives of commercial fish fauna, as well as certain benthophagous species of fish in the lakes.

MATERIALS AND METHODS

The material for the study was collected in 2011 – 2012 period. Macrozoobenthos was sampled all year round. The fish was caught in spring and autumn. For benthos sampling bottom-grab (with a gripping area 0.02 m^2) and a hydrobiological dredge net were used. Sampling and processing of the material was conducted by standard methods ([***28***]; [***29***]; [***31***]; [***33***]; [***34***]). Ichthyological material was collected by means of nets of different types. The commercial benthophage fish were studied: Common carp, Common bream, Prussian carp, Roache (*Rutilus rutilus* Linnaeus, 1758), Silver bream (*Blicca bjoerkna* Linnaeus, 1758), Common rudd (*Scardinius erythrophthalmus* Linnaeus, 1758). Statistics of commercial catches values for 2002 - 2012 period was provided by Western Black Sea department of protection, exploitation and reproduction of aquatic resources and fisheries regulation.

Demersal noncommercial species of fish from Gobiidae family were also studied: Round goby (*Neogobius melanostomus* Pallas, 1814), Monkey goby (*Neogobius fluviatilis* Pallas, 1814), Racer goby (*Neogobius gymnotrachelus* Kessler, 1857). These species are food competitors of commercial benthophagous fish. The bottom area that is favorable for gobies makes 134.2 km^2 in Yalpug-Kugurluy [***26***].

Biological analysis of fish and study of their feed was carried out according to ichthyological methods ([***4***]; [***16***]). During the study, standard length (cm) and body weight (g) of fish were measured; sex, maturing of gonads and their mass (g) were determined. The age of the carps was determined by scales; that of the gobies with the help of otoliths. Taxonomic affiliation of feed objects was determined using monograph [***32***]. Fish names were given according to V. Movchan [***13***].

To determine the productivity of macrozoobenthos of the lake, the biomass of organisms (kg/ha) of each major taxon during the growing season was used, which allows calculating bioproduction of organisms (J/ha) by the formula [**10**]:

$$P = 10 \cdot r \cdot B \cdot P/B \cdot C$$

where:

- ***r*** is the coefficient of utilization of production, utilization permissible degree of organic matter, in our case equals 50%;
- ***B*** *(*g/m^2*)* – density of organisms per unit area;
- ***P/B*** – relation coefficient of production during the growing season to the mean biomass over the same period;
- ***C*** (KJ/kg) – energy equivalent of food organisms per unit of biomass.

Constant factor 10 is applied in the formula due to the fact that the density of organisms of the reservoir is measured in g/m^2, and the productive biomass in kg/ha.

The values of the coefficients ***s***, ***r***, and ***C*** for a certain type of macrozoobenthos can be found in ichthyological literature, for example ([***1***]; [***2***]; [***20***]; [***25***]). Summing up the energy contribution of each group of organisms, we obtained the value of macrozoobenthic production per 1 ha of the reservoir during the growing season.

Nutritional requirements of fish are determined by the amount of energy required for primary and generative exchange and optimal growth. Thus, the method of ration`s calculation is based on the balance between the energy intake and the consumption for vital functions, weight gain and waste of undigested part.

To determine the daily ration ***K*** that is needed for mature adult fish, the following formula of energy balance was used [***12***]:

$$K = R + L + Q + F$$

where:

- **R** - consumption of energy metabolism;
- ***L*** - energy consumption of anabolism;
- ***Q*** - energy consumption of generative growth;
- ***F*** - undigested portion of the consumed food.

For juveniles the value can be considered to be zero. The unit of measurement of all the summands in this formula is: **J/(specimen day)**.

The values on the right side of the formula is calculated as follows:

1) Energy metabolism R is calculated using the formula:

$$R = \frac{731{,}88 \cdot a \cdot W^k}{q \cdot C_c},$$

where:

- ***W*** – is the average weight of fish in this age group (g);
- ***a*** and ***k*** – coefficients of the equation of velocity of oxygen consumption by this species of fish [***4***];
- ***q*** – the temperature correction data is equal to the ratio of metabolism velocity at temperature 20ºC, and given temperature, $q = 2.3^{2-0.1T}$
- C_c – energy equivalent of raw fish material (J/g). For adult fish of all species, this value is set to be equal to ***4184.0*** (J/g).

The constant value ***731.88*** is obtained as a product ***24 · 1.5 · 20.33***, where ***24*** is the number of hours in the day; ***1.5*** – taken ratio of average metabolism velocity in natural and artificial conditions; ***20.33*** – the energy equivalent of oxygen.

The weight gained by the fish was determined in a retrospective way – by deduction of the average weight of an individual of given age group out of the average weight of the individual from the older age group. At the same time the temperature correction ***q*** was calculated on the base of the average temperature at which the fish was fed, and the growth period, which is usually about ***6 - 8*** months, i.e. ***183 - 244***. Precise data on the growth period of certain species of fish can be found in the ichthyological literature.

2) Anabolism ***L*** is the energy consumption for the weight gained by the fish per day. It is calculated according to the formula:

$$L = C_W \cdot W$$

where:

W – average mass of fish;
C_W – is a specific growth rate. The value ***C_W*** can be calculated as follows:

$$C_w = \frac{1}{t} \cdot \ln \frac{W_2}{W_1},$$

where:
W_1 – weight of fish in the early studies;
W_2 – weight of fish at the end of studies;
t – duration of the growth period in days.

3) Generative exchange ***Q***. In order to calculate the diet of mature individuals, it is necessary to have data on the generative growth. Further, to determine the average daily growth of gonads on the same principle as the weight gain of the fish.

4) Undigested part of the diet ***F***. During the consumption of animal food its value has been taken equal to its value 20% [***12***]. If the value of the daily diet has not been determined, it is more convenient to introduce a factor **1.25**.

Later the average value of a diet $\bar{K}$ is calculated, based on the sex ratio, age structure and weighted average of the diet of all species of fish of the water body.

The potential general quantity of all species of the reservoir will make $N = \frac{\sum P}{\bar{K} \cdot t}$.

The considered value determines the maximum number of individuals in fish populations at a certain ratio of their species in the reservoir, which may subsist in the aquatic ecosystem.

On the basis of the relative composition of fish species of water body, potential abundance of individuals is determined.

The calculations of the potential abundance and biomass of fish are given using MS Excel spreadsheet application without an approximation that gives higher accuracy.

RESULTS AND DISCUSSION

Yalpug is the largest lake in Ukraine. Its area is about 149 km^2, length – 38 km, the average depth – 2.6 m, volume – about 387 million m^3 [***21***]. Yalpug connects Kugurluj Lake in the south with a wide canal in the sand-spit, which separates the two lakes. In fact they form a single lake system. The connection of Yalpug with the Danube is possible through Kugurluj Lake as well as directly over the canal Large Rapid. A thin layer of gray silt is the dominant soil, which occupies about 50% of the lake bottom area. There are areas of silty and sandy soils with admixture of shells; clay and rocky soils ([***11***]; [***15***]).

The area of Kugurluj Lake is about 82 km^2, length – 20 km, average depth – 1.0 m, volume – about 82 million m^3 [***11***]. Lake Kugurluj is connected with the Danube River by the channels Skunda and "105-km", and also the canal Large Rapid. Almost all of the Lake`s bottom is covered with silt [***15***]. Our studies revealed the presence of areas with silted sand both on the lake littoral zone and outside it.

As a result of our research in the Danube Lakes, 176 species of macrozoobenthos were found ([***8***]; [***9***]). The most abundant were oligochaetes – 32 species, chironomid larvae – 29, gastropods – 26. In the Yalpug-Kugurluy Lake complex practically all known species of macrozoobenthos have been met.

On average, the production of macrozoobenthos of the Yalpug Lake during the growing season outside the littoral zone made 45,281.1 tons, including oligochaeta – about 3,400 tons, chironomids – more than 5,000 tons, bivalves – 32,780 tons. Total production of macrozoobenthos, taking into account the littoral zone, was 46,300 m that is 3,107 kg/ha.

In the Kugurluy Lake the production of macrozoobenthos on average was 13,690 tons, or 1,670 kg/ha during the growing period. The production of oligochaetes was about 1,380 tons, chironomids – 1,968 tons. Both in the Yalpug and the Kugurluy Lake bivalves made high contribution (7,380 tons) to a total production of macrozoobenthos.

Species composition of ichthyofauna of the Lower Danube and its Delta is very diverse. It is home to 95 species of fish, of which 17 are listed in the Red Data Book of Ukraine, and 7 are in the European Red List. 25 - 28 species have commercial importance [***5***].

According to the results of our research and literature data ([***18***]; [***23***]; [***27***]; [***30***]), 63 species from 10 orders, 15 families and 51 genera are known for the Danube Lakes. 51 species of fish from 8 orders and 14 families, including Anguillidae, were found in Yalpug and Kugurluj Lakes: European eel (*Anguilla anguilla* Linnaeus, 1758); Clupeidae: Black Sea-Azov sprat (*Clupeonella cultriventris* Nordmann, 1840), Pontic-Azov shad (*Alosa pontica* Eichwald, 1838), Black Sea shad (*Alosa maeotica* Grimm, 1901); Cyprinidae: Roache (*Rutilus rutilus* Linnaeus, 1758), Ide (*Idus idus* Linnaeus, 1758), Common rudd (*Scardinius erythrophthalmus* Linnaeus,1758), Grass carp (*Ctenopharyngodon idella* Valenciennes, 1844), Stone morocco (*Pseudorasbora parva* Temminck et Schlegel, 1846), Sunbleak Belica (*Leucaspius delineatus* Heckel, 1843), Tench (*Tinca tinca* Linnaeus, 1758), Crucian carp (*Carassius carassius* Linnaeus, 1758), Prussian carp (*Carassius gibelio* Bloch, 1782), Bitterling (*Rhodeus amarus* Bloch, 1782), Ziege (*Pelecus cultratus* Linnaeus, 1758), Asp (*Aspius aspius* Linnaeus, 1758), Gudgeon (*Gobio gobio* Linnaeus, 1758), Pontian shemaya (*Alburnus sarmaticus* Freyhof et Kottelat, 2007), White-eye bream (*Ballerus sapa* Pallas, 1814), Blue bream (*Ballerus ballerus* Linnaeus, 1758), Vimba bream (*Vimba vimba* Linnaeus, 1758), Bleak (*Alburnus alburnus* Linnaeus, 1758), Common carp (*Cyprinus carpio* Linnaeus, 1758), Silver carp (*Hypophthalmichthys molitrix* Valenciennes, 1844), Bighead carp (*Aristichthys nobilis* Richardson, 1845), Common bream (*Abramis brama* Linnaeus, 1758), Silver bream (*Blicca bjoerkna* Linnaeus, 1758); Cobitidae: Spined loach (*Cobitis taenia* Linnaeus, 1758), Weatherfish loach (*Misgurnus fossilis* Linnaeus, 1758); Siluridae: European sheatfish

(*Silurus glanis* Linnaeus, 1758); Esocidae: Nothern pike (*Esox lucius* Linnaeus, 1758); Umbridae: European mudminnow (*Umbra krameri* Walbaum, 1792); Mugilidae: Flathead mulled (*Mugil cephalus* Linnaeus, 1758), So-iyu mullet (*Liza haematocheilus* Temminck et Schlegel, 1845); Atherinidae: Black Sea sand smelt (*Atherina pontica* Eichwald, 1831); Gasterosteidae: Southern ninespine stickleback (*Pungitius platygaster* Kessler, 1859), Three-spined stickleback (*Gasterosteus aculeatus* Linnaeus, 1758); Syngnathidae: Black-striped pipefish (*Syngnathus nigrolineatus* Eichwald, 1831); Centrarchidae: Pumkinseed (*Lepomis gibbosus* Linnaeus, 1758); Percidae: European perch (*Perca fluviatilis* Linnaeus,1758), Pikeperch (*Sander lucioperca* Linnaeus, 1758), Ruffe (*Gymnocephalus cernuus* Linnaeus, 1758), Schraetzer (*Gymnocephalus schraetser* Linnaeus, 1758), Zingel (*Zingel zingel* Linnaeus, 1766), Danube streber (*Zingel streber* Siebold, 1863); Gobiidae: Monkey goby (*Neogobius fluviatilis* Pallas, 1814), Round goby (*Neogobius melanostomus* Pallas, 1814), Bighead goby (*Neogobius kessleri* Gunther, 1861), Racer goby (*Neogobius gymnotrachelus* Kessler, 1857), Stellate tadpole-goby (*Benthophilus stellatus* Sauvage, 1874), Western tubenose goby (*Proterorhynus semilunaris* Heckel, 1837).

Six species of carps (Common carp, Common bream, Prussian carp, Roache, Silver bream, Common rudd) and three species of gobies (Round goby, Monkey goby, Racer goby) are related to the numerous benthophagous fishes from the investigated lakes.

Mass values of the major groups of benthic organisms from the diet composition varied considerably for different species of benthophage fish in the Yalpug-Kugurluj Lake complex (**Table 1**). In the stomach content of Common carp, Prussian carp, Roache and Round goby, Bivalvia dominated. Chironomidae were an important feeding source for the Common bream and Monkey goby. The silver bream fed mainly by Amphipoda. Oligochaeta and Gastropoda were met in diet composition of all the fishes.

In Ukrainian water bodies the Common rudd has a wide range of diet composition depending on habitat conditions and seasons. Plant foods can range from 8.5 to 92.5% (in average 53%) as part of the food category of adult individuals. Animal food diet consists essentially of Mollusca, Amphipoda, Oligochaeta, Chironomidae, Odonata larvae and Coleoptera [***14***]. Crustacea and Polychaeta constituted the basic of Racer goby`s food in the estuaries of the Odessa Region (Ukraine). Mollusca and juvenile fish were less represented [***24***].

Table 1

Relative values of the reduced mass (%) of food items in the diet of benthophage fish in the Yalpug-Kugurluj Lake complex

Food items	Common carp	Common bream	Prussian carp	Roache	Silver bream	Round goby	Monkey goby
Polychaeta	-	3.5	-	-	-	-	0.6
Oligochaeta	2.1	13.4	0.1	0.03	1.8	0.05	4.2
Gastropoda	0.2	9.6	1.5	5.7	8.9	10.3	0.5
Bivalvia	71.5	6.2	95.7	93.1	54.9	88.5	5.4
Amphipoda	0.2	14.4	1.1	0.04	28.5	0.08	3.9
Mysidacea	-	-	-	-	-	-	0.8
Isopoda	-	-	-	0.01	-	0.07	-
Odonata	10.8	17.4	0.2	-	0.2	-	3.7
Heteroptera	-	-	-	-	-	-	4.4
Coleoptera	-	10.7	1.2	1.0	2.6	-	0.2
Plecoptera	-	1.7	0.1	0.02	-	-	-
Chironomidae	15.2	23.1	0.1	0.01	3.1	0.3	9.4
Gobiidae	-	-	-	-	-	0.7	66.9

During the study of the potential productivity of the water body firstly it is necessary to estimate the value of bioproduction of its main groups of food organisms. The value for bioproduction for each group of macrozoobenthos per hectare is calculated (**Table 2**). For example, the values for oligochaetes are the following: $10 \cdot 0.5 \cdot 3.4 \cdot 5 \cdot 3910 = 332.4$ **MJ/kg**.

Table 2

Characteristics of feeding macrozoobenthos from Yalpug-Kugurluj Lake complex

Macrozoobenthos taxon	Biomass, g/m^2	P/B coefficient	Energy equivalent, kJ/kg	Bioproduction, MJ/ha
Oligochaeta	3.4	5	3910	332.4
Gastropoda	5.26	2	2260	118.9
Bivalvia	78.0	2	1990	1552.2
Amphipoda	1.36	5	2950	100.3
Mysidacea	0.92	10	4790	220.3
Chironomidae	2.54	21	4640	1051.9

The value of bioproduction of all studied groups of zoobenthos in the reservoir during the growing season makes **3376.0** MJ/ha.

For the final calculation of the bioproduction of macrozoobenthos of the lakes that can be consumed by benthophagous fish species, it is very important to assess the impact on the stock of zoobenthos by non-commercial, but numerous fish species, which also feed on benthic animals. In the Danube Lakes such fish are represented by three species of gobies: Monkey goby, Round goby, Racer goby.

Taking into account the catchability coefficient by net 0.5 and bycatch area (600 m^2), based on data from 2011 – 2012 period, the Monkey goby abundance per hectare was 4166 individuals, Round goby – 1550 individuals, Racer goby – 633 individuals.

These data indicate the significant use of feeding macrozoobenthos by goby fish, which may negatively affect the productivity of commercial benthophagous fish species. In future, for more efficient use of feeding source in the Danube Lakes, the amelioration should be carried out on these reservoirs. For example, the number of fishing predatory species Pikeperch should be significantly increased because gobies are a major component of its diet. To address this issue, a large number of artificial spawning beds of Pikeperch can be arranged. Such implementation will be especially important for the Yalpug-Kugurluj Lake complex where an abundance of valuable commercial species Common carp is not very high.

Taking into consideration the age and sex composition of fish populations, the value of the mean seasonal diet is calculated for each species of fish separately. To calculate the diet of each age group the formula of energy balance is proposed. On the basis of the relative number of species in commercial catches, the average value of the diet for all fish during the growing season is calculated.

To estimate the daily diet of separate age groups of fish, the size-mass characteristics of each species and its relative abundance in the catches are used (**Table 3** and **Table 4**). Besides the values of gonadal somatic index of fish is needed for calculations (**Table 5**). The ratio of males and females of Common carp, Common bream and Prussian carp was almost the same in the catches.

Table 3

Length, weight and abundance of individuals of different ages of Common carp, Common bream and Prussian carp

Age of fish, years	**Common carp**			**Common bream**			**Prussian carp**		
	Length (cm)	Mass (g)	Abundance (specimens)	Length (cm)	Mass (g)	Abundance (specimens)	Length (cm)	Mass (g)	Abundance (specimens)
2+	28.9±0.7	614±19	44	24.1±0.7	307±7	14	17.9±0.5	216±6	60
3+	41.0±0.7	1623±34	51	25.8±0.5	373±7	63	21.0±0.5	302±5	158
4+	48.5±1.0	2301±44	27	28.8±0.6	536±9	44	23.1±0.6	438±7	78
5+	56.9±1.2	4115±53	14	31.6±0.6	710±10	24	24.9±0.6	492±9	44
6+	60.4±1.3	4826±59	7	33.4±0.8	822±15	12	26.0±0.7	667±12	20
7+	64.0±1.5	5870±74	3	35.1±1.1	936±12	5	26.7±0.9	710±14	9

Table 4

Length, weight and abundance of individuals of different ages of non-commercial benthophagous fish species

Species of fish	**Age, years**	**Length, cm**	**Mass, g**	**Abundance, specimen**
Roache	1+	8.4±0.3	12.9±0.4	6
	2+	12.8±0.4	47.3±2.1	15
	3+	13.8±0.4	59.6±2.7	32
	4+	14.6±0.4	68.8±3.1	50
	5+	15.0±0.5	74.4±3.5	34
Silver bream	1+	5.2±0.1	2.1±0.1	4
	2+	7.2±0.2	8.1±0.3	22
	3+	12.3±0.3	46.1±1.2	41
	4+	13.5±0.3	62.0±1.1	73
	5+	14.6±0.4	75.3±1.5	57
	6+	15.4±0.6	89.3±2.1	30
Common rudd	2+	12.6±0.4	49.5±2.3	20
	3+	13.9±0.5	57.9±1.6	38
	4+	15.0±0.7	78.5±2.8	23
Racer goby	1+	4.9±0.2	1.2±0.1	10
	2+	6.0±0.1	2.4±0.1	38
	3+	6.8±0.2	3.3±0.1	14
Monkey goby	1+	5.1±0.3	1.8±0.2	12
	2+	6.0±0.2	2.3±0.1	48
	3+	6.4±0.2	2.5±0.1	26
	4+	6.6±0.4	2.6±0.3	7
Round goby	1+	8.2±0.2	15.7±0.4	155
	2+	10.8±0.1	32.2±0.8	603
	3+	12.7±0.3	53.8±1.3	76
	4+	14.3±0.5	85.0±2.2	13

Table 5

Average value of gonadal and somatic index (%) of benthophagous fish (n – number of specimens)

Species of fish	Males		Females	
	Beginning of the spawning	End of the spawning	Beginning of the spawning	End of the spawning
Common carp	5.1±0.3 n=5	0.7±0.04 n=6	11.2±0.6 n=7	2.7±0.10 n=7
Common bream	4.8±0.2 n=10	0.6±0.03 n=18	8.5±0.5 n=11	2.2±0.08 n=16
Prussian carp	5.3±0.2 n=21	0.8±0.05 n=25	11.7±0.4 n=16	2.9±0.08 n=22
Silver bream	6.0±0.1 n=14	0.6±0.02 n=8	10.5±0.3 n=20	1.4±0.06 n=12
Roache	9.0±0.5 n=11	0.7±0.03 n=8	19.4±0.8 n=14	1.8±0.07 n=7
Common rudd	7.0±0.4 n=6	0.6±0.04 n=5	12.3±0.7 n=8	1.6±0.05 n=6
Round goby	3.8±0.1 n=17	0.6±0.02 n=25	9.8±0.5 n=18	1.9±0.06 n=30
Racer goby	2.7±0.1 n=6	0.4±0.01 n=8	9.1±0.4 n=10	0.9±0.03 n=14
Monkey goby	3.1±0.1 n=19	0.5±0.02 n=26	9.3±0.4 n=18	1.1±0.04 n=32

Further, on the basis of the age composition of each species of fish, calculation of their daily diet was made. To do this, for each age group the value of diet on energy balance formula specified in the materials and methods, was calculated and the average temperature during the growth of fish in the lake complex (17.7ºC) was taken into account. The results of calculation are shown in **Table 6**.

Table 6

The average value of the diet of one individual of each species during the growing season and its relative abundance in commercial catches

Species of fish	Value of diet, MJ/spec.	Relatively abundance, %
Common carp	35.66	0.3
Common bream	11.40	8.7
Prussian carp	9.69	55.0
Silver bream	2.18	15.8
Roache	2.12	12.4
Common rudd	2.14	7.8

Thus, the weighted average value (taking into account the relatively abundance of species in the catch) of all commercial benthophagous fish diet for separate lake makes:

$$35.66 \cdot 0.003 + 11.40 \cdot 0.087 + 9.69 \cdot 0.550 + 2.18 \cdot 0.158 + 2.12 \cdot 0.124 + 0.5 \cdot 2.14 \cdot 0.078 = 7.12 \text{ MJ}$$

Before the summand, which is appropriate to diet of Common rudd, there is a factor **0.5**, as animal food in the diet of adult individuals makes 50% on average [***14***].

The given results allow us to calculate the energy equivalent of food that will meet all the body's energy expenditures during its life. This indicator is calculated with respect to **1** kg of fish using the average values of mass for commercial benthophage fish: Common carp –**1.4688** kg, Common bream – **0.4548** kg, Prussian carp – **0.3432** kg, Roache – **0.0623** kg, Silver bream – **0.0686** kg, Common rudd – **0.0642** kg.

Further, for example, the value of the diet during the growing season for Common carp is **35.66** MJ, and its average weight is **1.4688** kg, hence the energy equivalent is equal to:

$$\frac{35{,}66}{1{,}4688} = 24{,}28 \text{ MJ/kg}$$

Using described method of calculation, we obtain the value of the energy equivalent of food (MJ/kg), which is required to provide all the needs of life for commercial benthophage fish in the Danube Lakes: Common carp – **24.3**; Common bream – **25.1**; Prussian carp – **28.2**; Roache – **34.0**; Silver bream – **31.8**; Common rudd – **33.3**.

The smaller value of the energy equivalent of feeding rate indicates more efficient use of food by fish, which correlates with a maximum weight gain of the individual. According to the obtained values of feed energy equivalent for commercial benthophagous fish species, we can assume that Common carp remains the most promising species for stocking the Danube Lakes. This species has the highest weight gain while consuming macrozoobenthos of the reservoirs.

On the base of the energy equivalent of feeding base of the water body, the potential abundance of fish that can be provided with food is calculated. Finally, knowing the total number of fish of all species and their relative abundance in the catch, we establish the potential abundance of fish for each species separately. To calculate the potential biomass of each species, the abundance of fish of the same species is multiplied by the value of their average weight.

Using the results of our researches on nutrition of Round goby and Monkey goby and published data on diet composition of Racer goby [***24***], taking into account the average value of the energy equivalent of their daily diets [***22***] and the size-weight characteristics of fish, as well as the area of the lakes where gobies aggregate, we can estimate the macrozoobenthos, which could have been used by these three species. Thus, the energy equivalent of food that will be used to maintain the vital processes of the three species of gobies is **27445.3**GJ, which is 35.2% of the total value of all feeding base of macrozoobenthos in the Yalpug-Kugurluj Lake complex.

Let us show the sequence of calculations. Taking in mind the magnitude of bioproduction of total macrozoobenthos in the pond during the vegetation period, the weighted average value of the fish diet and part of bioproduction consumed by gobies (35,2%), the total number of specimens of all commercial fish per 1 ha is calculated:

$$\frac{3376{,}0 \cdot (1 - 0{,}352)}{7{,}12} = 307{,}3 \text{ spec}$$

Further, the potential density of each species of fish and their biomass per 1 hectare is established. For example, the average weight of bream makes **0.4548** kg, and relative abundance 8.4% (**Table 7**), hence:

$$307{,}3 \cdot 0{,}087 = 26{,}7 \text{ spec}$$
$$26{,}7 \cdot 0{,}4548 = 12{,}14 \text{ kg}$$

Table 7

Potential abundance and biomass of fish commercial species of fish in the Yalpug and Kugurluj Lakes

Species of fish	Potential abundance, spec./ha	Potential biomass, kg/ha
Common carp	0.9	1.32
Common bream	26.7	12.14
Prussian carp	169.0	58.00
Silver bream	48.6	3.33
Roache	38.1	2.37
Common rudd	24.0	1.54

It is important to remember that the calculated values do not show the actual number of fish living in these lakes. Primarily, these indicators show the possibility of the feeding base of the water bodies. In other words, they allow us to estimate the potential abundance of individuals and biomass at a certain ration of fish species that may subsist in investigated waters.

CONCLUSIONS

The data on the current state of macrozoobenthos of the lakes, the species composition of fish fauna, biology and ecology of benthophage fish have been presented.

Significant use of feeding macrozoobenthos by gobies, which may negatively affect the abundance of commercial fish species of carps, has been shown.

A method for calculation of potential abundance and biomass of commercial fish (carps) in accordance with their feeding base, nutrition and population structure has been proposed.

Stocking the Yalpug and Kugurluj Lakes with Common carp intensively will contribute to effective using of feeding base of water bodies to increase their fish production.

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