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FEATURES OF FISH POPULATIONS FORMATION IN THE KREMENCHUK AND KAKHOVKA RESERVOIRS

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INTRODUCTION

Due to the peculiarities of their bottom, the Dnipro reservoirs were created in the form of a cascade[1]. Taking into account human impact on natural and artificial reservoirs, their hydroecological state is constantly changing, there are changes of hydrology, water quality, hydrobiological characteristics, among which special attention should be paid to the ichthyocenosis. Among the Dnipro river reservoirs, the Kremenchuk and Kakhovka ones are marked by the largest areas of the water surface (225 and 215,5 thousand hectares), the largest filling of the water level during the year (4–6; 2–4 m), the maximum of which falls on the winter period (January-March), and the lowest complete water exchange (2,5–4; 2–3 times a year)[2].

According to the location of the cascade of reservoirs from south to north, the Kakhovka reservoir is located in the lower flow of the Dnipro river in the steppe zone, lower than others which affects its hydrobiological features. The Kakhovka reservoir was filled with water in 1956, it has an open top that flows directly into the river and has the largest width at the top, which reaches almost 23 km. The area of shallow water with depths is 2 m and occupies 5%, where, mainly, vegetation grows and phytophilous fish spawn.

The Kremenchuk reservoir is located on the middle flow of the Dnipro river in the forest-steppe zone of Ukraine. Its top is supported by a barrier above the Dnipro reservoir. Shallow water in the Kremenchuk reservoir makes up 18% of the total area. Filling of the Kremenchuk reservoir with water to the planning level lasted for two years, during 1960–1961. The Kremenchuk reservoir is distinguished by the presence of three large tributaries of the Sula, Vilshanka, and Ros[3], a considerably larger area of shallow water with depths of up to 2 m, and a width of up to 30 km in the

[1] Шапар А.Г., Скрипник О.О., Сметана С.М. Еколого-економічні проблеми переводу екосистеми річки Дніпро до режиму сталого функціонування. *Екологія і природокористування*. 2011. Вип. 14. С. 26–48.

[2] Гідроекологічний стан Каховського водосховища / О.В. Федоненко, Н.Б. Єсіпова, Т.С. Шарамок, О.М. Маренков. *Питання біоіндикації та екології*. Запоріжжя : ЗНУ, 2010. № 15(2). С. 214–222. URL: http://sites.znu.edu.ua/bioindication/issues/2010-15-2/Fedonen.pdf.

Oxidative stress and antioxidant defenses in goldfish Carassius auratus during anoxia and reoxygenation / V.I. Lushchak, L.P. Lushchak, A.A. Mota, M. Hermes-Lima. *Regulatory, Integrative and Comparative Physiology: American Journal of Physiology*. 2001. Vol. 280. P. R100–R107. DOI: https://doi.org/10.1152/ajpregu.2001.280.1.R100.

[3] Ficke A.D., Myrick C.A., Hansen L.J. Potential impacts of global climate change on freshwater fisheries. *Reviews in Fish Biology and Fisheries*. 2007. Vol. 17(4). P. 583. DOI: https://doi.org/10.1007/s11160-007-9059-5.

lower part. It should be added that in the Kremenchuk reservoir there was observed a loss of water level by 0,5–1,0 m almost every year in July – August. That contributes to the development of dryland meadow vegetation on which phytophilous fish lay roe the following year.

The Kremenchuk and Kakhovka reservoirs are located in different parts of the Dnipro, in different landscape zones and differ significantly in hydrographic features. Despite this, most of the processes of ichthyofauna formation in both reservoirs were of similar nature[4].

For the present, there have been changes in hydrological and hydrobiological regimes of reservoirs, for which reason the terms, places and conditions of spawning and incubating of roe, their growth, fattening, fertility, spawning age and body size at which breeding age begins, as well as the nature and the size of spawning areas were changed[5]. Special attention should be paid to the level of water bodies pollution of various origins, migration routes of radionuclides, heavy metals, petrochemicals and synthetic surface active agents coming from outside[6].

Creating a cascade of reservoirs[7] led to a gradual change in the structure of reservoirs: from rheophilous with a significant flow rate to limnophilous with a reduced flow rate, which affected the species diversity and the number of all groups of aquatic organisms[8], and especially ichthyocenosis[9]. The qualitative and quantitative composition of vegetation in spawning areas and substrata on which fish roe are laid have undergone significant changes.

1. Vegetation of spawning areas of the Kremenchuk and Kakhovka reservoirs

During the study of spawning vegetation, a profile method was used, its necessity when working with shallow reservoirs is determined by ridged

[4] Morphological and biochemical indicators of blood of rats poisoned by carbon tetrachloride and subject to action of liposomal preparation / B. Gutyj, T. Martyshchuk, I. Bushueva, B. Semeniv, V. Parchenko, A. Kaplaushenko, N. Magrelo, A. Hirkovyy, L. Musiy, S. Murska. *Regulatory Mechanisms in Biosystems*. 2017. Vol. 8(2). P. 304. DOI: https://doi.org/10.15421/021748.

[5] Губанова Н.Л. Формування зообентосу на різних ділянках Дніпровського (Запорізького) водосховища. *Agrology*. 2019. Vol. 2(3). P. 156–160. DOI: https://doi.org/10.32819/019023.

[6] Martínez-Álvarez R.M., Morales A.E., Sanz A. Antioxidant defenses in fish: Biotic and abiotic factors. *Reviews in Fish Biology and Fisheries*. 2005. Vol. 15. P. 75–88.

Van der Oost R., Beyer J., Vermeulen N.P.E. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. *Environmental Toxicology and Pharmacology*. 2003. Vol. 13. P. 57–149. DOI: https://doi.org/10.1016/S1382-6689(02)00126-6.

[7] Вишневський В.І. Дніпровські водосховища та проблеми їх використання. *Гідроенергетика України*. 2018. № 3–4. С. 18–23.

[8] Максименко М.Л. Структура любительських уловів та їх частка в загальному вилові риби на Каховському водосховищі. *Рибогосподарська наука України*. 2015. № 3(33). С. 55–66. DOI: https://doi.org/10.15407/fsu2015.03.055.

[9] Видовий склад молоді риб Кременчуцького водосховища / С.П. Озінковська, Г.О. Котовська, Д.С. Христенко, В.І. Полторацька. *Рибогосподарська наука України*. 2009. № 4. С. 15–20.

Аборигенні види риб як тест-об’єкти для дослідження сучасного стану гідроекосистем / Н.М. Присяжнюк О.І. Слободенюк, Н.Є. Гриневич та ін. *Агроекологічний журнал*. 2019. № 1. С. 97–102. DOI: https://doi.org/10.33730/2077-4893.1.2019.163277.

mesorelief of the Dnipro floodplain and consequent shallow areas of reservoirs and by variable regime of the Dnipro reservoir levels, which in combination with the first factor gives significant variations in the area of flooded shallows. The floristic composition of spawning vegetation is quite diverse. In the Kremenchuk reservoir it includes about 80 species, in the Kakhovka about 60 species of plants.

Table 1

Floristic composition of spawning areas of the Kremenchuk and Kakhovka reservoirs

№	Ecological and biological groups of plants	Kremenchuk reservoir	Kakhovka reservoir
1	Meadow perennials:	45	25
	grasses	11	8
	sedges	5	3
	legumes	1	–
	herbs	28	14
2	Annual plants and weeds	10	–
3	Amphibious and marsh plants:	20	18
	grasses	4	3
	sedges	5	2
	herbs	11	13
4	Water plants	8	15

Thus, the flora of spawning areas of both reservoirs consists of two main ecological elements: meadow perennials, which to a certain extent have adapted to the conditions of variable hydrological regime of shallow water, also amphibious and water plants.

Creeping bentgrass (*Agrostis stolonifera L*) can constantly be found in the Kremenchuk and Kakhovka reservoirs, it is quite common spawning grass. From all grasses it is the most resistant to prolonged flooding. Creeping bentgrass is a plant with a wide ecological amplitude; it has a number of biological features associated with adaptation to variable level regimes.

White bentgrass, according to our observations, is also characterized by adaptation for existence in conditions of prolonged flooding. Thus, in the Kakhovka reservoir, during the highwater, the formation of long and very tender floating leaves, which sometimes spread the entire surface of the water, was noted (at a depth of 0,7–0,8 m). Such grasses as sloughgrass (*Beckmannia eruciformis L.)* and meadow foxtail (*Alopecurus pratensis)* much rarely but constantly are found in spawning areas of both reservoirs.

However, in addition to these common features in the composition of grasses in spawning areas of the Kremenchuk and Kakhovka reservoirs some differences have been established. Normal component among the vegetation of spawning areas in the Kakhovka reservoir is water mannagrass (*Glyceria fluitans L.*); this grass does not occur in the Kremenchuk reservoir. On the contrary, genus Poa (*Roa angustifolia L., R. palustris L., P. trivialis L.*), absent in the spawning areas of the Kakhovka reservoir, was often found in spawning areas of the Kremenchuk reservoir.

Plants from the group of sedges in spawning areas are represented by only a few species. First of all, it is a kind of spike sedge (*Eleocharis uniglumis*), widespread within the shallow areas of both the Kakhovka and Kremenchuk reservoirs. This species is quite polymorphic. It should be noted that in the Kremenchuk reservoir in low water years this plant created a relatively small arched shape with thin beams and fairly dense turf. When flooded in years with higher levels the plant elongated, the stem thickened, the turf became crumby.

The group of herbs is the richest among spawning species. Mayflower (*Cardamine pratensis L.*), a kind of rush (*Juncus atratus Krock*), creeping buttercup (*Ranunculus repens L.*), creeping jenny (*Lysimachia nummularis L.*), common hedgehyssop (*Gratiola officinalis L.*) and others are the most widespread meadow herbs species in spawning areas.

The group of amphibious and water plants in the floral composition of spawning vegetation of both reservoirs plays a secondary role. This is due to the fact that the beginning of the growing season of the large majority of these plants is delayed and they almost do not occur in spawning areas, at least in the first half of the spawning period.

From amphibious plants lakeshore bulrush (*Schoenoplectus lacustris*), common reed (*Phragmites australis*), great manna grass (*Glyceria maxima Holmb.*), fineleaf water dropwort (*Oenanthe aquatica*), common water-plantain (*Alisma plantago-aquatica*), yellow cresses (*Rorippa amphibia*)grow on spawning areas; from water plants there are some kinds of pondweed family (*Potamogeton aceae*), hornweed (*Ceratophýllum*). These plants are used mainly by fish that spawn later.

The composition and status of vegetation in spawning areas are not constant and change both in different years and during one growing season. All these changes are due to the peculiarities of the hydrological regime of reservoirs (height and timeline of filling, specifity of the water level decrease, etc.). Seasonal changes in vegetation also depend on the phenological characteristics of individual species which are components of phytocenoses of spawning areas.

According to the terms of the growing season beginning in spawning areas, several groups of plants can be distinguished. A very limited set of species (about 25) is observed in the spawning areas of the Kremenchuk reservoir until 1st May. All plants are in a vegetative state.

Among meadow grasses fowl bluegrass (*Poa palustris L.*), white bentgrass (*Agrostis alba*), sweet grass (*Hierochloa odorata L.*), annual bluegrass (*Poa annua L.*), creeping bentgrass (*Agrostis stolonifera*) can be found. It is interesting to point out the nature of the growth of these grasses: in the early stages they all (except sweet grass (*Hierochloë odorata (L.) P. Beauv.*)) form rosettes spread out on the ground, which are separated from each other by a considerable distance (1–3 m). Such rosettes by the structure are convenient for laying roe.

Meadow herbs on spawning areas in the first days of May were presented by small-flowered bitter (*Cardamine parviflora L.*), rupturewort (*Herniaria odorata*), common starwort (*Stellaria gramineae L.*), storksbill (*Erodium serotinum*), black medick (*Medicago lupilina L.*), creeping jenny (*Lysimachia nummularia*) and others.

Amphibious plants are still poorly developed during this period: yellow cresses (*Rorippa amphibia*) appears earlier than other plants; occasionally there are single samples of longroot smartweed (*Persicaria amphibia (L.) Delarbre*) and manna grass (*Glyceria aquatica (L.) Wahlb.*). Water plants are not developed.

By 10th May, the composition of grasses is replenished with about 20 species of plants: meadow grasses such as quitch grass (*Elymus repens (L.) Gould*), narrow-leaved bluegrass (*Poa angustifolia L.*) and smooth meadow-grass (*Poa pratensis*); meadow sedgrs such as spike sedge (*Eleocharis uniglumis*), spring sedge (*Carex praecox*) and fox sedge (*Carex vulpina*), jointleaf rush (*Juncus articulatus*); meadow herbs such as mayflower (*Cardamine pratensis*), forget-me-not (*Myosótis*), mint (*Mentha arvensis L.*) and others; amphibious plants such as lesser bulrush (*Týpha angustifólia*), lakeshore bulrush (*Schoenoplectus lacustris*), flowering rush (*Butomus umbellatus*) and others. Thus, on the 1st decade of May, most representatives of the spawning flora of meadows could be found in the grassland.

In the third five days, amphibious plants continued to appear, among them common water-plantain (*Alisma plantago-aquatica*), common reed (*Phragmites australis*), marsh spike-rush (*Eleocharis palustris*); and a group of water plants begins its growing, amoung them white water lily (*Nymphaea alba*), yellow water-lily (*Nuphar lutea*), shining pondweed (*Potamogeton lucens*), common duckweed (*Lemna minor L.*), frogbit (*Hydrocharis morsus-ranae*) and some others.

In the second half of May the composition of spawning flora is replenished by a group of species of mainly water plants: claspingleaf pondweed (*Potamogeton perfoliatus*) and pondweed grass (*Potamogeton heterophyllus Schreb.*), rigid hornwort (*Ceratophyllum demersum L.*), common water-crowfoot (*Ranunculus aquatilis*) and others. Lithophilous fish roe was found on many plants in the spawning areas of both reservoirs.

2. Status of fish populations in the Kremenchuk and Kakhovka reservoirs

Comparing of the results of ichthyological research allows to identify a number of common features in the formation of fish populations[10], dynamics of their breeding age, growth, fertility, conditions of reproduction and youth yield in the Kremenchuk and Kakhovka reservoirs[11].

The species composition of fish has changed relatively insignificant. Noticeable changes have occurred in the number of fish and the distribution of individual species in areas of reservoirs. The number of limnophilous fish has increased distinctly while rheophilous fish have decreased significantly, and such typical rheophilous species as *Barbus borysthenicus* and *Lota lota* have disappeared almost completely.

Chondrostoma nasus, Squalius cephalus, Ballerus sapa, Leuciscus leuciscus, Aspius aspius, Leuciscus idus are kept mainly in the upper parts of reservoirs, although the young of these species also occur in the middle and lower parts. *Abramis brama*, *Cyprinus carpio*, *Sander lucioperca*, *Pelecus cultratus*, *Ballerus ballerus*, *Blicca bjoerkna*, *Rutilus rutilus*, *Alburnus alburnus*, *Scardinius erythrophthalmus*, *Perca fluviatilis*, *Clupeonella cultriventris* are spread in reservoirs everywhere. However, during the feeding period high value species of fish (*Abramis brama*, *Cyprinus carpio*, *Sander lucioperca*, *Pelecus cultratus*) occur in the largest quantities in the lower and middle parts of reservoirs. *Esox lucius*, *Carassius gibelio*, *Tinca tinca* are spread mainly on the flooded floodplain of the upper areas, as well as in the bays of the middle and lower parts of reservoirs, and the number of these species in recent years has declined notably[12].

Assessing the diversity of fish by diet, it should be noted that the number of benthophagous fish is reduced due to a decrease in the amount of benthos[13],

[10] Динаміка якісних показників стану риби в каналі «Дніпро–Донбас» унаслідок сезонного прокачування / О.М. Васильєва, Р.О. Новіцький, Н.Л. Губанова, А.В. Горчанок, В.О. Сапронова. *Agrology*. 2019. Vol. 2(2). P. 106–111. DOI: https://doi.org/10.32819/019015.

[11] Видовий склад іхтіофауни верхньої ділянки Канівського водосховища та пригирлової акваторії р. Десна / Ю.М. Ситник, П.Г. Шевченко, Р.О. Новіцький, А.В. Подобайло, С.М. Салій. *Вісник Дніпропетровського університету. Серія «Біологія. Екологія»*. 2012. Вип. 20. Т. 2. С. 80–88. DOI: https://doi.org/10.15421/011232.

[12] Бондарєв Д.Л., Жуков О.В. Фенологія нересту плоскирки (*Blicca bjoerkna*) у біотопах природного заповідника «Дніпровсько-Орільський» залежно від сезонної зміни температур. *Biosystems Diversity*. 2017. Vol. 25(2). P. 67–73. DOI: https://doi.org/10.15421/011710.

The impact of temporal patterns of temperature and precipitation on silver Prussian carp (*Carassius gibelio*) spawning events / D.L. Bondarev, O.M. Kunah, M.P. Fedushko, N.L. Gubanova. *Biosystems Diversity*. 2019. Vol. 27(2). P. 106–117. DOI: https://doi.org/10.15421/011915.

Яковенко В.О., Білик В.В. Зоопланктон і зообентос Самарської затоки Запорізького водосховища. *Наукові записки Тернопільського національного педагогічного університету імені Володимира Гнатюка. Серія «Біологія»*. Тернопіль : ТНПУ, 2015. Вип. 3/4(64). Спецвипуск : Гідроекологія. С. 768–772.

[13] Аборигенні види риб як тест-об’єкти для дослідження сучасного стану гідроекосистем / Н.М. Присяжнюк О.І. Слободенюк, Н.Є. Гриневич та ін. *Агроекологічний журнал*. 2019. № 1. С. 97–102. DOI: https://doi.org/10.33730/2077-4893.1.2019.163277.

and the number of phytophilous species is increasing, especially in shallow waters and during their spawning.

Populations of secondary fish species in reservoirs formed faster than populations of high value fish species (except *Esox lucius*). That happened due to the fact that the first ones had a very high initial number, matured one or two years earlier, much less demanding of environmental conditions during reproduction. In addition, the majority of secondary fish species are marked by fractional spawning, while the majority of high value fish species lay roe only once in one season.

Formation of breeding herds of secondary fish species (*Clupeonella cultriventris*, *Alburnus alburnus*, *Blicca bjoerkna*, *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Perca fluviatilis*, *Gymnocephalus cernua* and others) lasts only two or three years, of *Cyprinus carpio*, *Sander lucioperca*, *Pelecus cultratus*, *Ballerus ballerus*, *Carassius gibelio* and *Tinca tinca* four years, of *Abramis brama* and *Leuciscus idus* five. Among the high value species of fish only *Esox lucius* forms breeding herd in two years[14]. It should be noted that single females of *Abramis brama* matured on the sixth year of life, and *Blicca bjoerkna*, *Rutilus rutilus* and *Scardinius erythrophthalmus* on the fourth. The period of formation of fish reserves is much longer. It can be considered completed only when the age structure of commercial catches of fish acquires the normal structure which is distinctive to species in the conditions of the river, and consists of the generations which were born in the conditions of a reservoir. It is approximately twice the period of breeding herd formation.

According to the time rate of breeding age of males and females, two types of fish population formation can be distinguished. The first type includes species which males mature a year earlier than females (most *Cyprinidae*); the second type includes species which males and females reach breeding age at the same age (*Esox lucius, Sander lucioperca*).

In reservoirs, compared to Dnipro river[15], the growth rate of fish accelerated significantly, so they reach maturity at larger body sizes and at a younger age (one or two years earlier).

The fertility of fish in the Kremenchuk reservoir has also increased significantly. In the Kakhovka reservoir conditions for reproduction of phytophilous fish became unfavorable therefore many species (*Esox lucius*, *Ballerus ballerus*, *Cyprinus carpio*, *Carassius gibelio*, *Tinca tinca*, частково

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[14] Бузевич І.Ю., Рудик-Леуська Н.Я., Максименко М.Л. Розмірно-вікова структура промислових уловів риб Каховського водосховища. *Наукові доповіді Національного університету біоресурсів і природокористування України*. 2012. № 2(31). С. 34–41.

Захарченко И.Л. Анализ факторов, влияющих на состояние и динамику промыслового стада судака Каховского водохранилища. *Рыбное хозяйство*. Москва, 2006. Вып. 2. С. 73–76.

[15] Marenkov O.N. Abundance and biomass estimation of this summer individuals of alien fish species in Zaporizke reservoir. *Ukrainian Journal of Ecology*. 2018. Vol. 8(1). P. 92–96. URL: https://www.ujecology.com/articles/abundance-and-biomass-estimation-of-this-summer-individuals-of-alien-fish-species-in-zaporizke-reservoir.pdf.

Abramis brama and *Blicca bjoerkna*) show a mass rebirth of unspawned roe every year. Therefore, the fertility of these species in the reservoir has significantly decreased compared to the river, despite a notable improvement in their growth; fertility of *Pelecus cultratus*, on the contrary, increased remarkably.

Growth rate of *Esox lucius*, *Sander lucioperca*, *Abramis brama*, *Pelecus cultratus*, *Ballerus ballerus*, *Blicca bjoerkna* in the Kakhovka and Kremenchuk reservoirs was almost the same. *Cyprinus carpio* and *Rutilus rutilus* grew better in the Kremenchuk reservoir, but *Leuciscus idus* and *Carassius gibelio* in the Kakhovka. Fertility of *Esox lucius*, *Ballerus ballerus*, *Abramis brama*, *Cyprinus carpio*, *Carassius gibelio* and *Tinca tinca* in the Kremenchuk reservoir was significantly higher than in Kakhovka. *Pelecus cultratus* and *Blicca bjoerkna*, on the contrary, showed slightly higher fertility in the Kakhovka reservoir. Fertility of *Sander lucioperca*, *Perca fluviatilis* and *Rutilus rutilus* in both reservoirs was similar. The coefficient of fractional spawning of *Cyprinus carpio*, *Carassius gibelio* and *Tinca tinca* was much larger in the Kremenchuk reservoir, of *Blicca bjoerkna* in the Kakhovka. All these facts indicate that the fertility of fish depends not only on the conditions of their feeding, but also on the conditions of reproduction[16].

In both reservoirs the fish matured at the same age and at almost the same body length. Units of the same age during the first two or three years of existence of reservoirs matured at a slightly larger body size than in following years when we observe a decrease in fish growth. Males of *Cyprinidae* matured a year earlier and at a smaller body size than females. Maturity of females and males of predatory fish (*Esox lucius*, *Sander lucioperca*) was reached at the same age, but the first ones matured at a slightly longer body length. Among male and female fish of the same generation, units with the best growth rate reached maturity a year earlier than those with a slower growth rate. *Cyprinus carpio* in the Kremenchuk reservoir reached maturity at a larger body size than *Cyprinus carpio* in the Kakhovka reservoir. *Carassius gibelio*, on the other hand, matured earlier in the Kakhovka reservoir at a larger body size.

Unfortunately, now the growth rate of fish in reservoirs has decreased and their fertility has declined accordingly. This is the most noticeable with benthic fish (*Abramis brama*, *Cyprinus carpio*, *Carassius gibelio*, *Blicca*

[16] Environmental Characteristics by Eco-Sanitary and Toxic Criteria of the Cooling Pond of Zaporizhzhya Nuclear Power Plant (Ukraine) / O. Fedonenko, T. Ananieva, T. Sharamok, O. Marenkov. *International Letters of Natural Sciences*. 2018. Vol. 70. P. 1–10. DOI: https://doi.org/10.18052/www.scipress.com/ILNS.70.1.

Accumulation of radionuclides in Dnipro reservoir fish / N. Hubanova, A. Horchanok, R. Novitskii, V. Sapronova, O. Kuzmenko, N. Grynevych, N. Prisjazhnjuk, M. Lieshchova, O. Slobodeniuk, O. Demyanyuk. *Ukrainian Journal of Ecology*. 2019. Vol. 9(2). P. 227–231.

Котовська Г.О., Христенко Д.С., Новіцький Р.О. Вплив потужного промислового навантаження на біологічні показники плітки звичайної (*Rutilus rutilus*). Biosystems Diversity. 2015. Vol. 23(2). P. 129–133. DOI: https://doi.org/10.15421/011519.

bjoerkna, *Rutilus rutilus*), which average linear-weight characteristics of different age groups decreased from year to year[17]. Predatory fish (pike, pike-perch) showed reducing of growth only with young units under age of four years old[18]. Therefore, the fertility of predatory fish (*Esox lucius, Sander lucioperca*) varied over the years less significantly than benthic fish[19].

Reducing in the growth of benthic fish was due to a decrease of the biological productivity of reservoirs and a significant reduction of forage zoobenthos[20].

Growth rate of *Ballerus ballerus* in the Kremenchuk reservoir remained almost unchanged, and in the Kakhovka decreases every year. Amount of zooplankton in the Kakhovka reservoir is significantly reduced due to mass consumption of planktonic invertebrates by *Clupeonella cultriventris*, the number of which is growing rapidly from year to year.

It is known that the best conditions for natural reproduction of fish in reservoirs were created in the first year of their filling, when a large area of the most valuable lands for spawning, especially meadows, was flooded for the first time with the presence of relatively small initial breeding herds. Further in the reservoirs breeding conditions for phytophilous fish changed for the worse noticeably due to the death of many areas of vegetation that cannot withstand great depths and prolonged flooding, and a significant reduction of the spawning areas in the lower and middle parts of reservoirs. First of all, dryland meadow, woody and bushy vegetation died, which process of dieback occurred mainly during the first growing season.

Deterioration of fish reproduction conditions, when the processes of overgrowing of new shallow areas were significantly slower than the processes of vegetation dieback in flooded deep water areas in the Kakhovka and Kremenchuk reservoirs, led to the situation when there were more often and in large number female fish which did not participate in spawning (there was resorption of their roe).

In reservoirs, the main substrate for spawning of phytophilous fish is waterlogged and semi-waterlogged aquatic vegetation. Only in the upper part of the Kremenchuk reservoir, while the areas with meadow vegetation are preserved, fish relatively rarely use for the spawning amphibious and

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especially water plants. In the Dnipro floodplain, before its regulation, phytophilous fish laid roe mainly on meadow vegetation.

In general, the fish breeding conditions in the Kremenchuk reservoir are better than in the Kakhovka. With almost the same area of the water surface, the first is shallower and differs from the second by an open top, the presence of a highwater in the upper part and much smaller daily fluctuations of water level during fish reproduction.

In the Kakhovka and Kremenchuk reservoirs, the most adapted for reproduction are fish species, which are characterized by average spawning time, its longer period and wide biological flexibility in relation to environmental factors (depth, water temperature, flow rate, substrate, etc.) during spawning. They are *Abramis brama*, *Sander lucioperca*, *Blicca bjoerkna*, *Rutilus rutilus*, *Alburnus alburnus*. This group of fish also includes *Pelecus cultratus* (bathypelagic roe) and *Clupeonella cultriventris* (pelagic roe). Species with early spawning terms and short spawning periods (*Esox lucius, Ballerus ballerus*), as well as species with late terms periods and the longest spawning period (*Cyprinus carpio, Carassius gibelio, Tinca tinca*) have much lower biological adaptation. These species lay roe in the shallowest riverside areas (mainly at depths up to 50 cm), where it often dies from drying out due to fluctuations of water levels.

In recent years, the number of fish of the first group in reservoirs has increased significantly, while the second group after its initial increase is notably reduced (*Esox lucius, Ballerus ballerus, Carassius gibelio, Tinca tinca*) or remained almost the same (*Cyprinus carpio*).

Thus, the Kakhovka and Kremenchuk reservoirs are characterized by high biological productivity and rich reserves of planktonic and benthic feed resources for fish. Therefore, we can assume that in these reservoirs fish are provided with a forage base which does not limit the number of fish. In both reservoirs the number of fish is limited mainly by breeding conditions, as well as fatigue and diseases. In addition, the number of fish is influenced to a curtain extent by predators (fish, invertebrates), which eat the roe and young fish in spawning areas. Fish breeding conditions depend on the level and thermal regimes and hydrographic features of reservoirs. The existing level regime of reservoirs does not meet the requirements of fisheries.

CONCLUSIONS

Thus, in the Kakhovka and Kremenchuk reservoirs, compared to the Dnipro river, the conditions of natural reproduction of fish deteriorated significantly as a result of reduced spawning areas and death of meadow vegetation, but fish feeding conditions, on the contrary, improved notably due to increased feed resources and feeding areas. In order to increase the number of high value fish species and enrich fish resources in both reservoirs, it is necessary to take the following steps:

1. Keep the level regime of reservoirs in accordance with the requirements of fisheries, filling reservoirs to the mark of normal water level after the winter empting should be carried out evenly during April – May. From the end of May to 15^{th}–20^{th} June keep the water level constantly and then start its empting. Summer empting should be carried out in such a way that during the second half of June – first half of July it decreases by 1,0 m, and during the second half of July by 0,5 m (and the level decrease per day should not exceed 5–8 cm). This will bring the regime of the riverside shallow zone of reservoirs to the natural regime of the river floodplain, as a result favorable conditions for the development of amphibious and dryland (including meadow) vegetation will be created in shallow waters, overgrowing areas will increase, and fish breeding conditions will improve. In winter period (January – March) the water level should be emptied smoothly so that during the day it decreases by no more than 5 cm.

2. Replenish reservoirs annually with fish resources of young high value species raised in spawning fish farms. To do this, it is important to organize mass breeding not only of *Cyprinus carpio*, *Abramis brama* and *Sander lucioperca*, but also such high value fish species as *Ballerus ballerus*, *Esox lucius* and *Silurus glanis*, because the conditions of their reproduction in reservoirs are unfavorable.

3. Create artificial spawning areas in the bays of the lower and middle parts of reservoirs with little vegetation (natural substrate).

4. Prevent from releasing of water wastes of industrial and household enterprises into the reservoir.

5. Follow strictly the fishing rules for catching high value fish species, especially young *Abramis brama* and *Sander lucioperca*.

6. Do not reduce the catch of secondary fish and increase the catch of sprat, which is not used enough.

SUMMARY

One of the most important aspects of the water resources rational use in the Dnipro reservoirs is their commercial fishing exploitation. The decrease of commercial fish catches has necessitated to analyse the state and dynamics of fish populations, to estimate the impact of various forms of anthropogenic load on ichthyocenosis, to determine the effectiveness of natural reproduction of fish resources and to analyse sufficiently the main factors that lead to breaking crises in the Kremenchuk and Kakhovka reservoirs.

The Kremenchuk and Kakhovka reservoirs, which provided an annual catch of fish at the level of 20–25 thousand tons and 9–10 thousand tons respectively over the recent past, began to lose their economic value. Species

and quantitative composition of fish populations in the Kremenchuk and Kakhovka reservoirs are determined by both the original fauna complexes from which a certain ichthyofauna was formed, and the history of the Dnipro basin, as well as current environment, human influence, etc.

Unfortunately, current tendencies in the development of ecosystems of the Dnipro reservoirs are characterized by noticeable changes in hydrological and hydrochemical factors, which are crucial for the formation conditions of quantitative and qualitative indicators of fish populations. The amount of abundance and biomass of fish population in reservoirs are affected by abiotic and biotic elements of the environment, activating regulatory mechanisms which control changes in abundance and biomass of population, these changes for the most part function due to changes in the supplying of fish feed and causing restructuring of intraspecific interactions.

Therefore, an important issue is to develop a system of rational use of bioresources of the Dnipro reservoirs not only by means of their direct exploitation (fishing), but also through the rational use of their combined bioproductive potential capacity.

In order to optimize the conditions of fish existence and reproduction, as well as to preserve the existing biodiversity of the Kremenchuk and Kakhovka reservoirs and the status of valuable species populations, works on renewal of the hydrological mode of reservoirs, which are aimed to clean wellhead sections and separate flows from the sand deposits and the excessive aero-aquatic vegetation, need to be carried out.

The analysis of changes in the dynamic and functional indices of fish populations can serve for the macro performance of aquatic ecosystems, the assessment of the main factors for the fish populations formation and exploitation is the basis for forecasts and regulatory activity of fishery management.

Species and quantitative composition of fish populations in the Kremenchuk and Kakhovka reservoirs is determined both by the original faunal complexes from which a certain ichthyofauna was formed, and by the history of the Dnipro basin, as well as modern living conditions, human influence etc. The values of number and biomass of the fish population of reservoirs are affected by abiotic and biotic elements of the environment, activating regulatory mechanisms that control changes in values of number and biomass, which almost always act through changes in fish feed providing and cause restructuring of intraspecific relationships.

The aim of the work is to analyse the formation of fish populations in the Kremenchuk and Kakhovka reservoirs.

Despite the fact that the reservoirs are located in different parts of the Dnipro in different landscape zones and differ significantly in hydrographic features, most of the processes of ichthyofauna formation in both reservoirs are the same.

Analysing the results of ichthyological research a number of general features of fish population formation, dynamics of their breeding age, growth, fertility, reproductive conditions and level of young yield in the Kremenchuk and Kakhovka reservoirs were found.

To this date, changes have occurred in hydrological and hydrobiological regimes of reservoirs, for which reason the terms, places and conditions of spawning and incubating of roe, their growth, fattening, fertility, spawning age and body size at which breeding age begins, as well as the nature and the size of spawning areas were changed.

The species composition of fish has changed comparatively slightly. Significant changes have occurred in the number of fish and the distribution of certain species in areas of reservoirs. The number of limnophilous fish has risen exponentially, while rheophilous fish have decreased significantly and such typical rheophilous species as *Barbus borysthenicus* and *Lota lota* have disappeared almost completely. *Chondrostoma nasus*, *Squalius cephalus*, *Ballerus sapa*, *Aspius aspius*, *Leuciscus idus* inhabit mainly the upper parts of reservoirs, although the young of these species can be encountered in the middle and lower parts. *Abramis brama*, *Cyprinus carpio*, *Sander lucioperca*, *Pelecus cultratus*, *Ballerus ballerus*, *Blicca bjoerkna*, *Rutilus rutilus*, *Alburnus alburnus*, *Scardinius erythrophthalmus*, *Perca fluviatilis*, *Clupeonella cultriventris* are spread in reservoirs everywhere. However, during the feeding period, high value fish species (*Abramis brama, Cyprinus carpio, Sander lucioperca, Pelecus cultratus*) occur numerously in the lower and middle parts of reservoirs. *Esox lucius, Carassius gibelio, Tinca tinca* are spread mainly in the floodplain of the upper areas, as well as in the bays of the middle and lower parts of reservoirs, moreover, the number of these species has declined significantly in recent years.

Assessing the fish diversity by diet it should be noted that the number of benthic fish is reduced due to decrease in the number of benthos, and the number of phytophilous species increases, especially in shallow waters and during their spawning.

The growth rate of fish in reservoirs has significantly accelerated so they reach breeding age with larger body sizes and at a younger age (one or two years earlier), compared to the Dnipro areas. The fertility of fish in the Kremenchuk reservoir has also increased significantly. In the Kakhovka reservoir conditions for phytophilous fish breeding became unfavourable, consequently many species (*Esox lucius, Ballerus ballerus, Cyprinus carpio, Carassius gibelio, Tinca tinca*, partly *Abramis brama* and *Blicca bjoerkna*) showed annually mass degeneration of unspawned roe. Therefore, the fertility of these species in the reservoir compared to the river has decreased significantly, despite a considerable improvement in their growth; on the other hand, the fertility of *Sabre carp* increased notably. The growth rate of *Esox lucius, Sander lucioperca, Abramis brama, Pelecus cultratus, Ballerus ballerus, Blicca bjoerkna* in the Kakhovka and Kremenchuk reservoirs was almost the same. *Cyprinus carpio* and *Rutilus rutilus* grew better in the Kremenchuk reservoir, but *Leuciscus idus* and *Carassius gibelio* in the Kakhovka.

Fertility of *Esox lucius*, *Ballerus ballerus*, *Abramis brama*, *Cyprinus carpio*, *Carassius gibelio* and *Tinca tinca* was significantly higher in the Kremenchuk reservoir than in the Kakhovka. On the other hand, *Pelecus cultratus* and *Blicca bjoerkna* had slightly higher fertility in the Kakhovka reservoir. Fertility of *Sander lucioperca*, *Perca fluviatilis* and *Rutilus rutilus* in both reservoirs was similar. The coefficient of spawning of *Cyprinus carpio, Carassius gibelio* and *Tinca tinca* was much higher in the Kremenchuk reservoir, and of *Blicca bjoerkna* in the Kakhovka. All these facts indicate that the fertility of fish depends not only on the conditions of their feeding, but also on the conditions of breeding. In both reservoirs the fish reached breeding age at the same age and at almost the same body length.

Unfortunately, today the growth rate of fish in reservoirs has decreased and their fertility has been declined accordingly. This is most noticeable with benthic fish (*Abramis brama*, *Cyprinus carpio, Carassius gibelio, Blicca bjoerkna*, *Rutilus rutilus*), which average linear-weight characteristics of different age groups decreased from year to year. Predatory fish (*Esox lucius, Sander lucioperca*) showed a decrease in growth of only young units aged under four years old. Therefore, the fertility of predatory fish changed over the years less distinctly than benthophagous.

The decrease of benthic fish growth was due to decrease biological productivity of reservoirs and a significant decrease of the resources of feed zoobenthos.

Thus, in the Kakhovka and Kremenchuk reservoirs, compared to the Dnipro areas, the conditions of fish natural breeding significantly worsened due to reducing of spawning areas and death of meadow vegetation; fish feeding conditions, on the contrary, improved significantly due to increasing of feed resources and feeding areas. To optimize the conditions of fish existence and breeding, as well as to preserve the existing biodiversity of reservoirs and populations of high value species, it is necessary to carry out restoring of the hydrological regime of reservoirs, which is aimed for cleaning wellhead sections and particular streams from sandy accretion and overgrown aero-aquatic vegetation.

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