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IMPORTANCE OF SHALLOW AREAS OF THE UPPER PART OF THE KANIV RESERVOIR IN THE MAINTENANCE OF ITS ICHTHYOFAUNA

O. Gurbyk, ribak911@mail.ru, Institute of Fisheries NAAS, Kyiv

Purpose. *Determination of the relative number of fish juveniles on biotopes of the upper part of the Kanev reservoir in the aspect of evaluation of these areas in general propagation of ichthyofauna.*

Methodology*. The work is based on data of fish juvenile surveys conducted in the Kaniv reservoir during 2011—2013. Data collection and processing were performed according to generally accepted methods. Fish juveniles were caught using a beach seine made of mill gauze № 7, length 10 m, height 1 m. Relative number of fish juveniles on different sites has been calculated based on the areas of fish nursing biotopes under assumption of the constancy of catchability coefficients. Shannon-Weaver diversity index was used for comparing species diversity of the commercial ichthyofauna of different sites.*

Findings*. The majority of the studied littoral sites of the upper part of the Kaniv reservoir were characterized by sufficiently high indices of biodiversity — Shannon index values varied within 2,07—3,24 bit./ind. Twenty six species were recorded in the composition of the fish juvenile communities that was 80% of total number of species in the reservoir. It was found that despite a decrease of the relative number of the juveniles of valuable commercial species compared to previous years, the upper part of the reservoir remains the major site for recruitment of commercial fish stock — 70% of bream, tench, pike, roach, and wels of the Kaniv reservoir are reproduced here. Taking into account the especial value of the upper part in formation of the spawning fund of the reservoir, any hydroenhancement works here should be limited exclusively by navigable channel.*

Originality*. For the first time we quantitatively evaluated (in spatial aspect) the number of fish fauna recruitment in the Kanev reservoir under current state of spawning areas.*

Practical value*. Results of the work will be used during development of a program of enhancement works on spawning grounds of the Kaniv reservoir and development of nature conservation measures when planning hydroenhancement works in littoral zone of the reservoir.*

Keywords*: Kaniv reservoir, ichthyofauna, natural propagation, spawning efficiency.*

PROBLEM STATEMENT AND ANALYSIS OF LAST ACHIEVEMENTS AND PUBLICATIONS

Fisheries exploitation, which is an important aspect of human activity on the Kaniv reservoir, belongs to the factors of direct effect on qualitative and quantitative parameters of ichthyofauna. Taking into account that the reservoir is a complex system with high level of anthropogenic load and background effect of the regulated water flow, the problem of the conservation of biodiversity and stocks of valuable fish species is of vital importance.

One of important aspects of the realization of the mentioned problem is assurance of normal conditions for fish propagation, in particular in regard to the spawning stock available from the point of view of effective reproduction. Previous studies showed that spawning conditions for phytophilous fish, which compose the majority of both river

and lake commercial ichthyocomplex, significantly worsen due to overgrowing and silting of spawning grounds, unfavorable water level regime, and takeover of shallow areas of the reservoir for various business activities [1—3]. At the same time, there is a need for assessing these factors, in particular concerning the effect on quantitative parameters of the development of the spawning stock. Taking into account that the majority of the commercial stock in the Dnieper reservoirs is based on natural reproduction of ichthyofauna [4], investigation of these problems is of great scientific and commercial interest. Moreover, an important component of such studies is maintenance of the balanced structure of the ichthyocenosis – currently 11.0% of the total commercial ichthyomass of the Kaniv reservoir are predatory fish, while this value reached 19.0% during the period of sustainable fisheries exploitation in 1985—1989 [5]. A tendency for the decrease of the relative number of predatory fish in the Kaniv reservoir was also observed in fish juvenile surveys that is a negative phenomenon from the ecological point of view. It is necessary to take into account that all predatory fishes of the Kaniv reservoir (expect perch, which can be considered as an opportunistic predator [6]) belong to stenobiont species, in particular in regard to reproduction conditions.

HIGHLIGHT OF THE EARLIER UNRESOLVED PARTS OF THE GENERAL PROBLEM. AIM OF THE STUDY

The upper part and mouth of the Desna River have been traditionally the most productive zones of ichthyofauna reproduction in the Kaniv reservoir [7]. However, this pattern has not been observed last years. It can be possibly related to intensive building on the littoral zone and large-scale hydrotechnical works. In particular, a narrowing the Dnieper channel and reduction of spawning grounds near Konche-Zaspa and Kozinka River are considered to have significant effect on the reproduction of phytophilous fish [8].

The studies of fish juvenile communities carried out within the framework of the Kaniv reservoir monitoring, show that the upper part of the reservoir is traditionally an important zone for ichthyofauna reproduction and is characterized by its highest biodiversity [7]. However, except qualitative indices, quantitative ones of fish juveniles are of great interest, in particular in regard to the role of individual sites in the total production of ichthyopopulation recruitment. In particular, it has crucial importance for determining the most valuable sites (from the nature conservation point of view) and for assessing the possibilities of hydrotechnical works in the littoral zone of the reservoir.

The goal of this work is to determine the relative number of fish juveniles on biotopes of the upper part of the Kaniv reservoir in the aspect of the assessment of the role of these sites in total ichthyofauna maintenance.

MATERIALS AND METHODS

The material was collected in the second half of July 2011—2013 according to generally accepted ichthyological methods based on standard network of stations on the Kaniv reservoir [9, 10]. Five sites of total area of 4738 ha with typical biotopes and compositions of fish juvenile communities were defined in the zone of intensive hydrotechnical works in the upper part of the reservoir (I — “Vodnikov island – Zhukiv island”; II — “Bortnychi”; III — “Kozynka”; IV —

"Vyshen'ky-Protsiv", V — "Stugna-Ukrainka"). Fish juveniles were caught using a beach seine made of mill gauze № 7, length 10 m, height 1 m. In total, 12850 m^2 of the littoral zone was covered by seining, 15.4 thousand young-of-the-years of different species were analyzed. Analysis, measurements, and species identification were done directly on the sampling sites. Shannon-Weaver diversity index (H) [11] was used for comparing species diversity of the commercial ichthyofauna of different sites. Taking into account the same technique of fish juvenile collection on all stations of the reservoir, the catchability coefficient was taken as a constant that allows correct comparing absolute (calculated for the total area) indices of fish juvenile numbers. Areas of shallow waters were determined with the aid of the GSP-receiver Garmin Dakota 10, and MapSource and Google Earth software.

STUDY RESULTS AND THEIR DISCUSSION

The area of shallow waters in the Kaniv reservoir fluctuates within the range from 20 to 25% of the total area depending on the water level. The majority of shallow waters are covered with aquatic vegetation, which is a spawning substrate for phytophilous fishes and hiding zone for the majority of fish juveniles. The spawning substrate is formed of emersed, submerged, and floating macroflora. Following phytocommunities can be defined: littoral emersed rigid vegetation (reed, cattails, bulrush), meadow vegetation (sedge, bent, yellowcress, fowl bluegrass, rushes), plant with floating leaves (water smartweed, water cultrop, water lily, yellow pond lily), emersed soft vegetation (arrowhead, water-plantain, grass rush, manngrass), soft submerged vegetation (pondweeds, hornwort, watermilfoil) as well as roots of trees and bushes. Sandy shallows adjacent to vegetated zones are also a spawning substrate for many fish species [2, 12].

The majority of shallow waters are now the best spawning and nursery grounds, however some of them became overgrown, silted, covered with bottom sediments from dredgers and in such a way lose their importance. Intensive development of rigid aquatic vegetation and blue-green algae as well as sharp decrease of oxygen content deteriorated the sanitary-hydrobiological regime of some shallow sites that they not only lost their importance as spawning and nursery grounds but also became the sources of water pollution [1]. The value of a certain site for fish reproduction is determined by several components: availability and accessibility of the spawning substrate, remoteness from wintering grounds, availability of biotopes for fish juveniles, development of food base, etc. Accordingly, even potentially ideal shallow sites for spawning can have no importance for fish stock recruitment and vice versa. Therefore, an integral index – the number of young-of-the-years (based on the data of summer fish juvenile surveys) has been used for the assessment of the role of these reproductive grounds. Taking into account significant variability of qualitative and quantitative indices of fish juvenile yield in an inter-annual aspect, average values for a three-year period were used to characterize the spawning sites. During last five year, 34 fish species were recorded in beach seine catches in the Kaniv reservoir, the majority of littoral fish communities was composed of phytophilous representatives of cyprinids (up to 90% of total number of fish in catches). The relative number of species, which are considered as commercial, has a tendency for an increase during last years (mainly due to roach) – their part was 34.3% in 2011—2013 versus 20.9% in 2000—2002 [12]. Among species, which significantly increased their number, is Prussian carp, the relative number of young-of-the-year of which increased from 0.9 fish/100 m^2 in 2002 to 35.4 fish/100 m^2 in 2012.

Representatives of 26 fish species were recorded on the stations of the upper part of the reservoir, 50% of which were secondary commercial species – bleak and rudd. The part of non-commercial species on the majority of stations was low enough; the exception was the section Stugna-Ukrainka where this value exceeded the average value for the reservoir due to bitterling and gobies (Table 1).

Table 1. **Structure of fish juveniles on stations of the Kaniv reservoir (average for 2011—2013), %**

Fisheries category	Stations*					Average for the reservoir
	I	II	III	IV	V	
Valuable commercial	27.9	31.6	9.7	18.2	19.9	16.3
Secondary commercial	69.2	60.9	77.0	79.1	58.4	68.3
Non-commercial	2.4	3.3	11.4	2.4	20.4	14.9
Listed in the Red Book	0.5	4.2	1.9	0.3	1.3	0.5
Number of species	16	15	19	17	23	34

* — see the section "Materials and Methods"

An important characteristic of the role of reproductive sites is a possibility for reproduction of fish of different ecological groups. As a qualitative criterion for the assessment of this characteristic, we used information indices, which sufficiently correctly reflect the complexity of the systematic structure of biological communities.

The highest Shannon-Weaver index value was recorded on the sites "Bortnichi" and "Stugna-Ukrainka": 3.06 anf 3.24 bits/ind., respectively; the lowest – on the site "Vyshen'ki-Protsiv" – 1.62 bits/ind. Thus, a conclusion can be made that the obtained Shannon-Weaver indices for all analyzed sites (excluding "Vyshen'ki-Protsiv") were characterized by high enough values indicating on the developed species structure of these ichthyocenoses (at least from the point of view of the availability of nursery grounds). The low value in Vyshen'ky – Koncha-Zaspa can be explained by the effect of intensive building activities in the littoral zone that resulted in significant deterioration of qualitative and quantitative characteristics of the spawning fund in this zone. Somewhat higher values of this index (1.74—2.12 bits/ind.) in the upstream zones of the reservoir, which are also located in an urbanized area, in our opinion are due to the presence of developed spawning and nursery biotopes formed on littoral zones of Dnieper islands and an effect of migration processes from tributary systems [4], in particular from the Desna River. As mentioned above, the upper part of the reservoir was the main fish reproductive zone – juveniles of 77% representatives of the reservoir ichthyofauna was recorded here and the relative number of valuable commercial fish species exceeded similar values for middle and lower parts of the reservoir by 2.5—3.0 times (in particular, they were 46.4 fish/100 m^2, 18.9 and 16.4 fish/100 m^2, respectively, for 2002 [8]). Based on the results of our studies, the relative number of the indicated fish juveniles on different parts of the reservoir was 44.9 fish/100 m^2, 13.2 and 7.2 fish/100 m^2, respectively, i.e., no significant inter-annual changes of the localization of main reproductive areas observed in the spatial aspect. At the same time, the total number of fish juveniles (as an integral index of reproductive component for maintaining quantitative characteristics of ichthyocenosis) is characterized by a certain decrease – e.g., it was 197.3 fish/100 m^2 for the upper part in 2011—2013 versus 254.0 fish/100 m^2 in 2000 [8].It is necessary to note that the index of juvenile number on littoral biotopes is a dynamic characteristic, which is under a combined effect of two main factors – the area of spawning grounds and number of brood fish. Thus, a reduction of nursery grounds with the same number of brood fish results to an increase

in the number of juveniles just due their concentration on limited areas. Accordingly, for more correct assessment of the reproductive ability of littoral biotopes (at least in a comparative aspect), it is necessary to use the values of the actual areas of these sites. To do this, we calculated absolute (per area) numbers of fish juveniles with consequent determination of the part in the total reproduction of a certain fish species in the Kaniv reservoir. The results are presented in the Table 2.

Table 2. **Number of fish juveniles on the stations of the Kaniv reservoir (average for 2011—2013), million fish**

Fish species	Stations					Total	
	I	II	II	IV	V	Studies part	Reservoir
Bream	0.06	0.26	0.00	0.01	1.13	1.47	2.47
Pike	0.01	0.00	0.00	0.00	0.03	0.04	0.07
Aps	0.19	0.21	0.00	0.21	0.47	1.08	1.91
Ide	0.17	0.24	0.02	0.54	0.56	1.53	2.42
Pikeperch	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Roach	1.55	0.56	0.08	17.04	6.89	26.13	41.49
Silver bream	0.03	0.12	0.00	0.09	0.68	0.92	1.74
Prussian carp	0.02	0.01	0.00	0.00	0.53	0.56	3.88
Perch	0.03	0.22	0.01	0.43	0.03	0.72	1.15
Rudd	0.23	0.21	0.31	15.94	4.79	21.48	38.18
Zope	0.00	0.58	0.00	0.00	0.10	0.68	1.23
White-eye bream	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Tench	0.00	0.00	0.00	0.03	0.00	0.03	0.08
Vimba	0.00	0.00	0.00	0.09	0.00	0.09	0.14
Chub	0.14	0.02	0.04	0.66	0.60	1.45	2.73
Nase	0.00	0.07	0.00	0.19	0.28	0.53	1.05
Dace	0.04	0.18	0.03	0.29	0.65	1.19	1.97

An analysis of the Table 2 shows that 70% of vimba, 60—65% of bream, ide, roach, perch, and dace of the Kaniv reservoir are reproduced in the studied part of the Kaniv reservoir, which contains no more than 40% of nursery grounds. It gives grounds for designation of these sites as especially valuable in the nature-conservation aspect. At the same time, the upper part of the Kaniv reservoir is located in the zone of intensive hydrotechnical and sand extraction works. In the majority of cases, these activities are related with the changes of shoreline and have direct effects on the state of shallow water sites. Taking into account that a significant part of spawning grounds on the right bank of the upper part of the reservoir is very degraded (up to complete destruction) [12], the problem of the conservation of remaining spawning fund is of great importance. Due to this fact, it is necessary to prohibit any hydrotechnical works on littoral zones in the upper part of the Kaniv reservoir (up to the isobath of 2 m).

CONCLUSION AND PERSPECTIVES OF FURTHER DEVELOPMENT

Today, the upper part of the Kaniv reservoir remains the main fish reproduction zone of the Kaniv reservoir (fish juveniles of 77% of the local ichthyofauna are recorded here), which ensures more than a half of the recruitment of valuable commercial species. It dictates the necessity for the imposition of a special protection regime, the important component of which is limitation of activities related to the destruction of littoral biotopes. The perspective trend of further studies is a detailed classification of spawning grounds and development of a plan for reclamation measures

for improving the conditions of natural restoration of ichthyofauna in the Kaniv reservoir.

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ЗНАЧЕННЯ МІЛКОВОДНИХ ДІЛЯНОК ВЕРХНЬОЇ ЧАСТИНИ КАНІВСЬКОГО ВОДОСХОВИЩА У ВІДТВОРЕННІ ЙОГО ІХТІОФАУНИ

О. Б. Гурбик, ribak911@mail.ru, Інститут рибного господарства НААН, м. Київ

Мета. *Визначити відносну чисельність молоді риб на біотопах верхньої частини Канівського водосховища в аспекті оцінки ролі цих ділянок у загальному відтворенні іхтіофауни.*

Методика. *Робота базується на даних облікових малькових зйомок, проведених у Канівському водосховищі протягом 2011—2013 рр. Збір та опрацювання даних здійснювали за загальноприйнятими методиками. Виходячи з площ біотопів нагулу, за умови постійності коефіцієнтів уловистості, розраховувалась абсолютна чисельність молоді за окремими ділянками.*

Результати. *Більшість досліджених прибережних ділянок верхньої частини Канівського водосховища характеризуються достатньо високими показниками біорізноманіття — значення індексу Шенона-Уівера коливались в межах від 2,07 до 3,24 біт/екз. У складі угруповань молоді риб відмічено 26 видів, що складає 80% від загальної кількості видів у водосховищі. Встановлено, що, незважаючи на зниження, у порівнянні з минулими роками, відносної чисельності молоді цінних у господарському відношенні видів риб, верхня частина залишається основною ділянкою для поповнення промислового запасу іхтіофауни — тут відтворюється 60—70% ляща, лина, щуки, плітки та рибця Канівського водосховища.*

Враховуючи особливу цінність верхньої частини у формуванні нерестового фонду водосховища, проведення будь-яких гідромеліоративних робіт на ній слід обмежити виключно судновим ходом.

Наукова новизна. *Вперше кількісно оцінено питому (у просторовому аспекті) чисельність поповнення іхтіопопуляцій Канівського водосховища за сучасним станом нерестових ділянок.*

Практична значимість. *Результати роботи будуть використані при підготовці програми меліоративних робіт на нерестовищах Канівського водосховища та розробленні природоохоронних заходів при плануванні гідромеліоративних робіт в прибережній зоні водосховища.*

Ключові слова*: Канівське водосховище, іхтіофауна, природне відтворення риб, ефективність нересту.*

ЗНАЧЕНИЕ МЕЛКОВОДНЫХ УЧАСТКОВ ВЕРХНЕЙ ЧАСТИ КАНЕВСКОГО ВОДОХРАНИЛИЩА В ВОСПРОИЗВОДСТВЕ ЕГО ИХТИОФАУНЫ

А. Б. Гурбик, ribak911@mail.ru, Институт рыбного хозяйства НААН, г. Киев

Цель. *Определить относительную численность молоди рыб на биотопах верхней части Каневского водохранилища в аспекте оценки роли этих участков в общем воспроизводстве ихтиофауны.*

Методика. *Работа базируется на данных учетных мальковых съемок, проведенных в Каневском водохранилище в течение 2011—2013 гг. Сбор и обработку данных осуществляли по общепринятым методикам. Исходя из площадей биотопов нагула, при условии постоянства коэффициентов уловистости, рассчитывалась удельная численность молоди по отдельным участкам.*

Результаты. *Большинство исследованных прибрежных участков верхней части Каневского водохранилища характеризуются достаточно высокими показателями биоразнообразия — значения индекса Шенона-Уивера колебались в пределах 2,07—3,24 бит/экз. В составе группировок молоди рыб отмечены 26 видов, что составляет 80% от общего количества видов в водохранилище. Установлено, что, невзирая на снижение, в сравнении с прошлыми годами, относительной численности молоди ценных в хозяйственном отношении видов рыб, верхняя часть остается основным участком для пополнения промыслового запаса ихтиофауны — здесь воспроизводится 70% леща, линя, щуки, плотвы и сома Каневского водохранилища. Учитывая особую ценность верхней части в формировании нерестового фонда водохранилища, проведение любых гидромелиоративных работ на ней следует ограничить исключительно судовым ходом.*

Научная новизна. *Впервые количественно оценена удельная (в пространственном аспекте) численность пополнения ихтиопопуляций Каневского водохранилища при современном состоянии нерестовых участков.*

Практическая значимость. *Результаты работы будут использованы при подготовке программы мелиоративных работ на нерестилищах Каневского водохранилища и разработке природоохранных мероприятий при планировании гидромелиоративных работ в прибрежной зоне водохранилища.*

Ключевые слова*: Каневское водохранилище, ихтиофауна, естественное воспроизводство рыб, эффективность нереста.*