

ORIGINAL ARTICLE

Ecological and biological aspects of zander and Volga zander reproduction under conditions of the Zaporizhzhia reservoir (Ukraine)

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Through the example of zander and Volga zander it was researched the current state of the populations of predatory species of fish, and their biological and ecological characteristics of reproduction under conditions of the Zaporizhzhia reservoir. It is determined that populations of experimental species of fish are in a depressed state. In zander, the index of individual absolute fertility is twice higher than such of Volga zander. The zander and Volga zander belong to a group of fish with synchronous growth of oocytes, a one-time and short-term type of spawning. By the features of oogenesis, females of these species of fish belong to a group of fish that hibernate with ovaries at IV stage of maturity. The artificial spawning nests were designed and complex of ecological measures for their installation and maintenance with the purpose of restoration of natural spawning grounds of experimental species of fish were developed. The results of research can be applied at realization of a number of measures on rational use and restoration of natural populations of zander and Volga zander in regulated and anthropogenically transformed reservoirs.

Key words: zander; Volga zander; Zaporizhzhia reservoir; spawning; fertility; artificial spawning ground

Introduction

In the reservoirs of Europe, Asia and North America, the genus *Sander* (Zander) is represented by 5 species; the following species inhabit Ukraine: *Sander lucioperca* (Linnaeus, 1758), zander; *Sander volgense* (Gmelin, 1789), Volga zander; *Sander marinus* (Cuvier, 1828), sea zander. In the internal freshwater reservoirs of Ukraine, the genus *Sander* is represented by two species, the zander, *S. lucioperca* (Linnaeus, 1758) and the Volga zander, *S. volgensis* (Gmelin, 1789). These fish species are one of the most valuable in the industrial aspect of the representatives of the ichthyofauna of fresh water in our country, characterized by a high rate of linear and weight growth, with a high reproductive capacity, excellent consumer qualities. In addition, adult individuals play a significant reclamation role, consuming predominantly small, low-value fish (Lind, 1977; Lappalainen, 2003; Bulakhov et al., 2008; Fedonenko et al., 2012).

In the last 10–15 years, there is a significant drop in catches of zander and Volga zander in all Dnipro reservoirs. In the cascade of Dnipro reservoirs, the Kakhovka reservoir was traditionally the most productive for catches of zander, but today its catch here is only 1.6–3.1 % of the total annual catch. Today, the share of zander in the general catches in the Zaporozhye reservoir is only 2 % and its catch is kept at 9 tons.

The analysis of literature data shows that the majority of both biotic and abiotic regulatory factors that provide and modulate the basic life processes of zander and Volga zander in the Zaporizhzhia reservoir remained relatively stable for the entire period of its existence (Bulakhov et al., 2008; Fedonenko et al., 2012). Exception is only abiotic conditions of reproduction, such as availability of spawning grounds and level regime. In addition, a significant role is played by various forms of anthropogenic impact such as water intakes, pollutant emissions, poaching, amateur and sports fishing, irrational fishing. The role of the last factor in the indicator of industrial mortality is not fully reflected. If the main industrial load falls on the individuals of the younger and middle age, then the filling of the right wing of the variation series is much weaker. Accordingly, even with a relatively low overall mortality rate, the age limit for catches will be significantly lower than expected for this magnitude of replenishment (Shykhshabekov et al., 2014).

The reaction of zander and Volga zander populations on the influence of external biotic factors can be estimated by biological parameters such as linear and weight growth, fattening and fertility. In connection with this, it was necessary to conduct a comprehensive study of biology, ecology, features of reproduction and development of recommendations for improving the conditions for the natural regeneration of predatory fish species. Therefore, the purpose of scientific work was to study the

current state of the populations of predatory fish species and their biological and ecological characteristics of reproduction under conditions of the Zaporizhzhia reservoir through the example of zander and Volga zander.

The solution of these tasks has an important fundamental and applied value for implementation of a number of measures for the rational use and restoration of natural populations of zander and Volga zander.

Materials and methods

The objects of research were zander and Volga zander. Material for the work was sexually mature individuals caught during research and provided by users of aquatic bioresources and, in the case of the red-book Volga zander species, providing access to materials by the fish protection authorities during the seizure of poaching and inspection of industrial or amateur (sports) catches.

Research fishing was carried out on the basis of permits issued by the State Agency of Fisheries of Ukraine, Department of Protection, Use and Reproduction of Water Bioresources and regulation of fishing in the Dnipropetrovsk region (№ 0001, № 0002 – 2015, № 000037, № 000038 – 2016, 2017) within the limits of allocated quotas and approved work programs of scientific research works. Fish were caught with a standard set of stack nets in accordance with classical ichthyological techniques in accordance with the current legislation (Ozinkovska et al, 1998; Arsan et al., 2006).

The fish were caught with a standard set of stacked nets with a mesh size of 30, 36, 40, 50, 60, 70, 75, 80, 90, 100, 110, 120 mm. At each observation point for the entire period of work it was analyzed at least 25 netting days of each mesh size (Ozinkovska et al, 1998). In the catches the species composition and mass fraction of each species was determined.

The biological analysis of fish was carried out in accordance with the classical methods of the ichthyology (Pravdin, 1966; Ozinkovska et al, 1998; Arsan et al., 2006) according to the following indices: standard and absolute body length, individual weight, sex, fattening factor, maturity stage, mass of sexual products, maturity factor (gonadosomatic index), weight of individuals (both with and without entrails). Age of fish was determined according to standard ichthyological methods of V. L. Bruzgin (1969) and I. I. Chugunova (1959).

To determine the age of the fish, the scales were taken from at least 10 individuals (5 females and 5 males) from each class interval of the size series. In order to determine the size and age structure of populations Morozov-Mayorova method was used (Tyurin, 1973). To prepare the preparation, several pieces of scales from the middle part of the body between the base of the first dorsal fin and the lateral line were taken and washed in a weak solution of ammonia (1–10 %). Then they were dusted with a soft cloth and placed between the two glass panes. The specified age was recorded in a biological journal or entered into a database of biological indicators of fish.

The physiological state of fish was estimated by the coefficients of fattening. Fatality of fish was calculated by Fulton (1) using the formulas:

$$K_f = m / l^3 \times 100\%, \quad (1)$$

where K_f is Fulton fattening factor;

m is fish body weight, g;

l is standart fish length, cm.

To study the fertility of fish, ovaries were taken from females at IV stage of maturity. The stage of maturity of the gonads was determined visually (Ozinkovska et al, 1998; Arsan et al., 2006). Individual absolute fertility was determined by the weight method; for this, samples of eggs weighing 1 g were taken in the middle section of the gonads and fixed with ethyl alcohol with a 2 % solution of formalin in a ratio of 1:1. The number of eggs in the sample was counted and multiplied by the total weight of the ovary.

To determine the individual relative fertility, the values of individual absolute fertility were divided by the weight of the body of fish without internal organs.

The gonadosomatic index was calculated as the ratio of the mass of the gonads to the weight of the body of fish in percentages (2) (Arsan et al., 2006; Ghanbahadur, Ghanbahadur, 2012):

$$GSI = (P_g \times 100) / P \quad (2)$$

where GSI is gonadosomatic index;

P_g is the weight of gonads, g;

P is weight of the body of fish, g.

During research bioethical norms were not violated.

Statistical processing of the material was carried out using software packages for personal computers Microsoft Excel 2010 and STATISTICA.

Results and Discussion

Researches were conducted in Zaporozhian Reservoir – the multi-purpose reservoir during 2014–2016. The reservoir is located in the South-west of Ukraine, in the territory of the agro-industrial zones and been under strong anthropogenic influence (Fedonenko et al., 2012).

In the current ichthyofauna of Zaporozhye reservoir there are 52 species of fish. But among them only 18 species are of industrial importance (Fedonenko et al., 2012). At the same time, the last 20 years there is a crisis of predatory species of fish, a negative decreasing tendency in catches of the predators such as pike, zander. Anthropogenic load on the ecosystem of the reservoir caused not only the reduction of industrial catches of some species of predators, but also led to a significant reduction in their populations, which created the conditions for the inclusion of some of them into the Red Data Book of Ukraine, for example, the Volga zander and ruffe fell into the list of endangered species (Bulakhov et al., 2008).

Today, the proportion of zander in general catches in the Zaporizhzhia reservoir is no higher than 2 %; annual average catches are kept at the level of 9.25 tonnes (Fig. 1), and the commercial exploitation of the Volga zander in 2010 is generally prohibited by law.

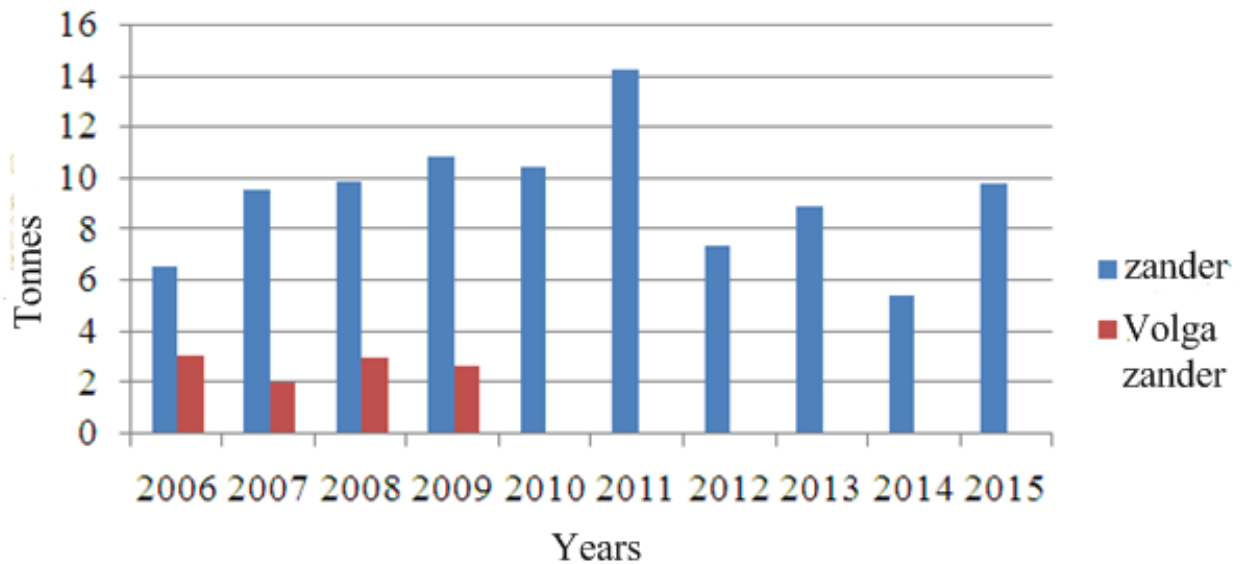


Figure 1. The actual catch of zander and Volga zander in Zaporizhzhia reservoir.

Volga zander.

In the Dnipro reservoirs of the Dnipropetrovsk region, the Volga zander has a limited distribution. This is a not numerous species, since it meets mosaically throughout the water area of Kakhovka, Zaporizhzhia and Dneprodzerzhinsk reservoirs, in large tributaries (Samara Bay, Samara Dniprovskia River, the entry of Mokra Sura and Kilchen). In the Zaporizhzhia reservoir the Volga zander forms local populations, the morphotype of which differs from the morphotypes of the Don and Volga representatives of the species. The species is protected in accordance with the provisions of Annex 3 of the Berne Convention, entered in the International Red Data Book of IUCN, in the Red Data Book of Ukraine (Bulakhov et al., 2008).

In the Zaporizhzhia reservoir, the main places of existence of the Volga zander are located on plots with sufficient flow, rich oxygen regime, and rocky, sandy and sandy-rocky bottom, depth fluctuations, adjacent to the shallow, flooded riverbeds of the river. The most numerous populations of the Volga zander are such from the middle (from the Dnipro to the Petrov-Svistunovo village) and the lower (from the village Petrov-Svistunov to the dam Dneprges) deep-water sections of the Zaporizhzhia reservoir.

The Volga zander population in the Zaporizhzhia reservoir is in critical state, the species is classified as vulnerable and endangered, and its number is limited and is characterized by localization.

The length of the individuals of the Volga zander was: 35 cm in females, 32 cm in males; the weight of females varied in the range from 180 g to 2.4 kg, an average of 620 g, males – from 170.0 g to 1.2 kg, an average of 510 g.

The Volga zander population shows an increase in the proportion of 2-year-olds and 3-year-olds, indicating its rejuvenation. Rejuvenation of the population is a negative consequence, which indicates excessive catching of the individuals of the population, first of all, poaching fishing, catching inferior individuals and the catch of this species by fishermen.

The average weighed Fulton fattening coefficient of the Volga zander was at the level of fattening of the zander and was 1.4 units. The feeding conditions of the Volga zander in the Zaporizhzhia reservoir can be considered as good, and its forage base is formed by many numerical representatives of small short-cycle species (bleak, kilka, gobies, and aterina), which, according to the fishery classification, are low-value and non-industrial. The tempo of the linear and weight growth of the Volga zander in this reservoir is stable high, that is, the conditions of feeding is not a limiting factor in the formation of its ichthyomass.

The length of the individuals of the Volga zander was: 35 cm in females, 32 cm in males; the weight of females varied in the range from 180 g to 2.4 kg, an average of 620 g, males – from 170.0 g to 1.2 kg, an average of 510 g.

The age range of the Volga zander has 8 classes (2–9 years). The population core consisted of 3–5-year-old individuals (78 %). The share of elderly fish in the main was represented by 7–9-year-olds and amounted to 7 % (Table 1).

Table 1. Biological indicators of the Volga zander

Indicators		max	min	M±m
Length L, cm	♀	61.00	23.00	39.10±1.74
	♂	62.00	21.00	35.29±1.45
Length l, cm	♀	52.00	19.00	34.14±1.55
	♂	51.00	17.00	31.18±1.23
Weight, g	♀	2400.0	180.00	620.15±108.10
	♂	1200.0	170.00	510.23±56.16
FC (by Fult.)	♀	2.13	1.16	1.46±0.05
	♂	2.40	1.10	1.35±0.04
Age, years	♀	8.00	2.00	4.36±0.25
	%	1.5	3.3	-
	♂	9.00	2.00	4.54±0.37
	%	2.5	1.5	-
Fertility, thous. eggs.		138.75	31.3	91.72±32.84

Note: max is maximum value, min is minimum value, M±m is arithmetic mean and error, σ is mean square deviation, V is quadratic coefficient of variation, ♀ – females, ♂ – males.

Zander.

The industrial length of the zander from the control nettings was: 38 cm (28–63 cm) in females, 33 cm (29–42 cm) in males ; the weight of females ranged from 280.0 to 4.2 kg, an average of 1200.0±103.2 g, males – from 190.0 g to 1.1 kg, an average of 560 g (Table 2).

Table 2. Biological indicators of the zander

Indicators		max	min	M±m
Length L, cm	♀	72.00	31.50	43.72±5.65
	♂	50.00	34.00	39.00±2.61
Length l, cm	♀	63.00	28.00	38.05±4.26
	♂	42.00	29.00	33.19±2.15
Weight, g	♀	4200.0	280.00	1200.0±103.2
	♂	1100.0	190.00	560.15± 106.58
FC (by Fult.)	♀	1.67	1.24	1.5±0.18
	♂	1.58	1.25	1.35±0.28
Age, years	♀	8.00	2.00	4.55±0.59
	%	5.1	13.3	-
	♂	9.00	2.00	4.37± 0.47
	%	4.1	1.5	-
Fertility, thous. eggs.		668.36	53.3	225.21±76.32

Note: max is maximum value, min is minimum value, M±m is arithmetic mean and error, σ is mean square deviation, V is quadratic coefficient of variation, ♀ – females, ♂ – males.

The natural range of the zander covers all the large river and lake basins of the Baltic (Elba, Oder, Vistula, Neman, West Dvina, Neva, the rivers of the Bothnichna and the Finnish bays) and the Black Sea (Maritsa, Danube, Dniester, Dnipro, Don, Kuban). After the construction of numerous channels and reservoirs and acclimatization works, the area of zander has considerably expanded. In Europe, it was acclimatized in England (Thames River), France (Rhône), Germany (Rhine River), Southern Sweden (Lake Venern), in the White Sea basin, Crimea (Bulakhov et al., 2008).

In the reservoirs of the Dnipropetrovsk region, the zander is widespread, not numerous species. It is found everywhere in all reservoirs of the region, in some lakes and ponds, in river tributaries it is less common. It is valuable object of fishing.

In recent years, the population of zander in Zaporizhzhia reservoir had such tendency as low rates of replenishment, reduced reproductive indicators and "rejuvenation" of the spawning stock, and a decrease in the linear and weighted indices of the industrial population. The age of a zander in control catches was fairly poor and comprised only 8 classes (2–9 years). The core of the industrial population consisted of 3–5-year-old individuals (from 22 to 31 % of each age group). The share of older fish was mostly represented by 8–9 year-olds and accounted for 6.5 %.

The state of the fodder base of the zander as one of the factors of the formation of industrial ichthyomiasis in the Zaporizhzhia reservoir is characterized by very high rates; the total stock of small short-cycle species is 5.8 times higher than their actual consumption of predatory species. This is confirmed by the data on linear and weight growth of zander, and its tendency to decrease in recent years is not marked. The Fulton fattening factor was at the level of previous years and reached 1.40, indicating satisfying conditions of its fattening.

Comparative analysis of indicators of fertility of Volga zander and zander.

Indicators of absolute fertility of the Volga zander ranged from 31.26 thousand eggs in two years old individuals to 138.75 thousand eggs in 9-year-old individuals. The average fertility of the spawning population was 91.72 thousand eggs. In the spawning herd the ratio of males and females was 43 % and 57 % respectively. The coefficient of industrial return from eggs was 0.0015 %.

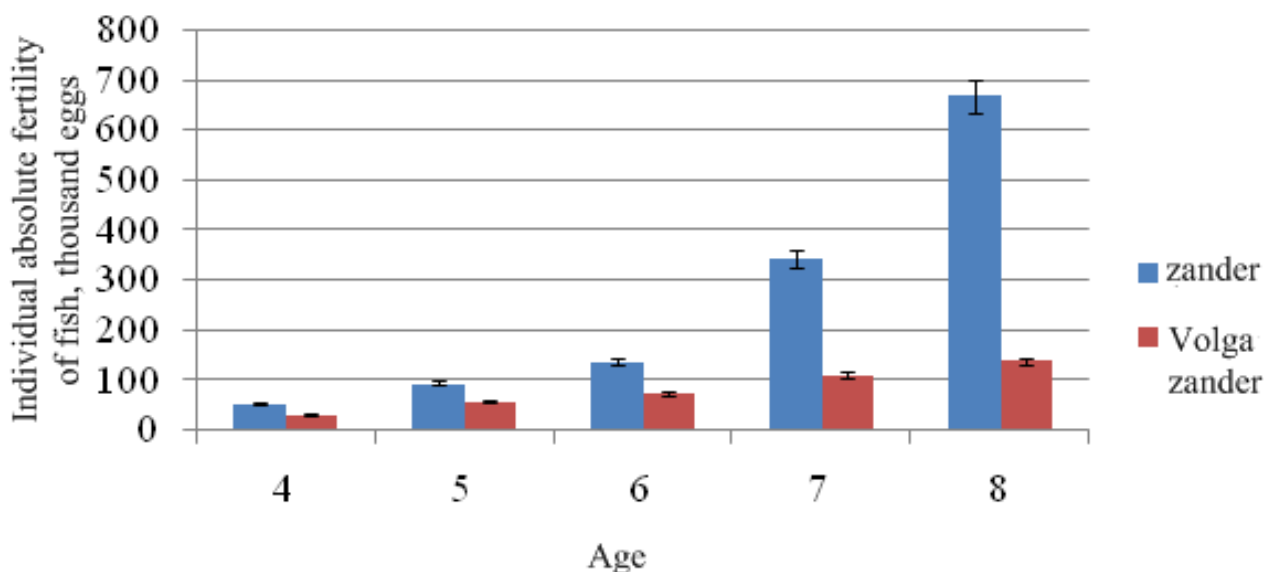


Figure 2. The dynamics of fertility of individuals of different age of zander and Volga zander under conditions of the Zaporizhzhia reservoir.

In the spawning population of zander, the proportion of younger age groups has increased. Thus, females of 3 and 4 years of age (each group is approximately 30 %) dominated in the control catches. Females of older age groups (6 years old) accounted for only 11 %. Indicators of absolute fertility of females of zander varied from 53.25 thousand eggs in four-year-old individuals to 668.4 thousand eggs in 8-year-old individuals. The average fertility of the population amounted to 225 thousand eggs, which is almost twice higher than in the Volga zander (Fig. 2).

The phenomenon of increasing the absolute fertility index can serve as a signal of the deterioration of the conditions of the existence of a zander in the Zaporizhzhia reservoir, since the increase in the number of eggs is an adaptive reaction of the species for survival in anthropogenic press (the body operates on the quantity; the greater the fertility, the greater the descendants, but with the increase of the number eggs, decreases the size of eggs, decreases the amount of nutrients and the percentage of the output of larvae from eggs significantly decreases). The confirmation of this phenomenon is low indicators of the relative size of young zanders in the coastal areas of the reservoir.

Features of the spawning and scale of maturity of sex products.

Research of the spawning features, the development of the phases of sexual products and the development of the maturity scale of the gonads of fish has an important applied ecological and fishery significance. We have conducted year-round studies on the development of gonads of zander and Volga zander with the monthly selection of gonads in males and females of these species of fish. According to the results of the research, the gonadosomatic gonadal indexes were determined for each stage of development of the gonads and the annual gonadal maturity scale was developed.

The development of the maturity scale of the sexual products of these species of fish allows adjusting the timing of the prohibition of their industrial catch. Also, the terms of the transition of the gonads into the pre-spawning period can optimize the process of setting artificial spawning nests with a view to their timely installation in the reservoir.

The scale of maturity of zander`s sex products.

The zander and Volga zander belong to a group of fish with synchronous growth of oocytes, a one-time and short-term type of spawning. By the features of oogenesis, females of these species of fish belong to a group of fish that hibernate with ovaries at IV stage of maturity.

Maturation of the gonads takes place in the second decade of April, females of zander in the IV stage of maturity have a fairly high gonadosomatic index (GSI), which, on average, is $14.1 \pm 2.85\%$ (Fig. 3). It is worth noting that in recent days, it is observed an increase in GSI from 14.1 % to a maximum value of 15.5 % in females before spawning, after which their mass spawning takes place. The spawning period of the zander ends at the end of April, in the first decade of May.

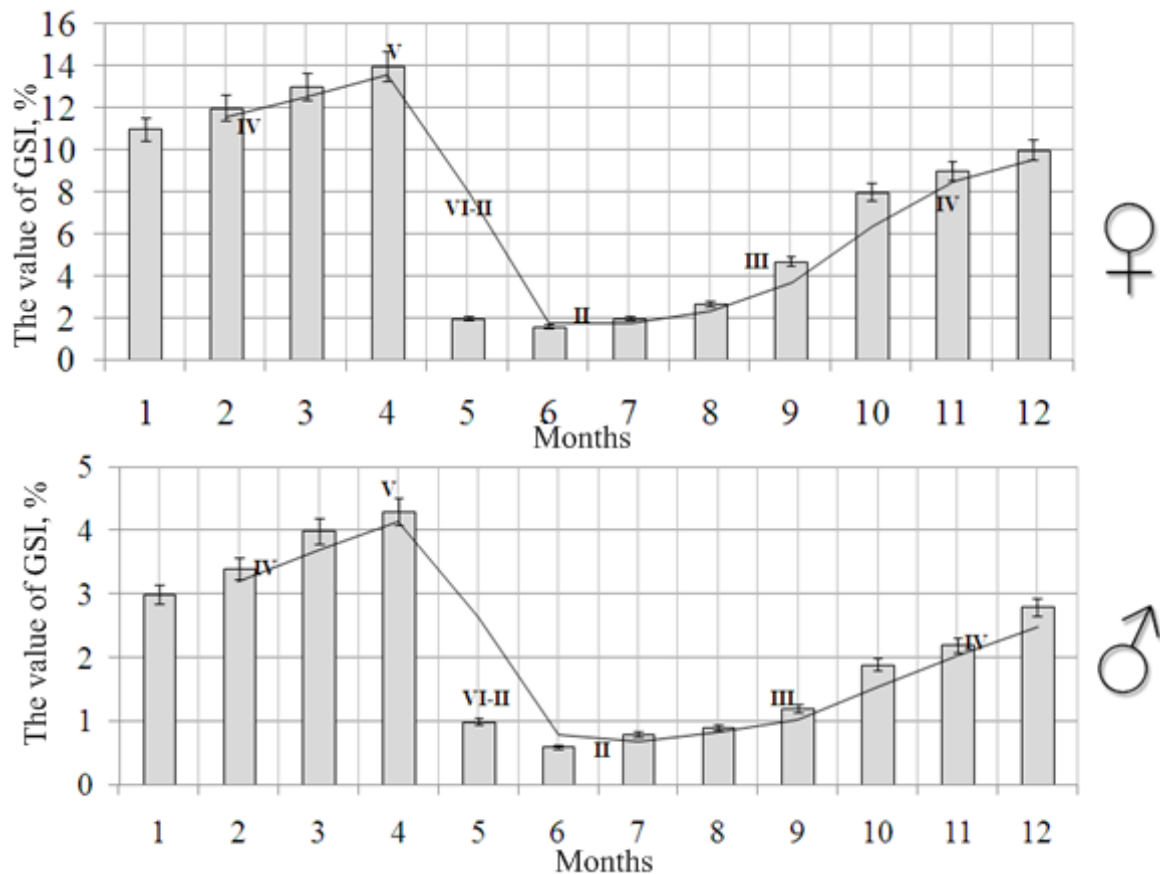


Figure 3. Indices of gonadosomatic index of the zander in different months of the year: ♀ – females, ♂ – males.

The largest index of GSI in zander males is in mid-April and reaches 4.3 %, when the zander finds a place for the nest in which the female lays eggs. The eggs of the zander female are laid in a nest, which is arranged by males in shallow water with sandy soil or under the rhizome of cane. The nest usually has a round or oval shape with a diameter of 50 cm and a depth of 15–20 cm. The male actively protects the nest and larvae, cleanses from silting and aerates the nest with the movements of the thoracic swimmers.

The smallest index of GSI is observed in June and reaches 0.6 %. After spawning the gonads of the zander go to the VI-II stage of maturity, containing empty follicular membranes and isolated oocytes that undergo resorption. During this period, the value of the GSI is minimal and, on average, does not exceed 2 %.

The scale of maturity of Volga zander`s sex products.

By the terms of development and progress of the phages of the sex glands, the Volga zander is not different from the zander, the maximum and minimum indices of the GSI in the Volga zander by the terms coincide with the indices of the GSI of zander. We have noticed that in the spring period the value of the GSI in the Volga zander females is 15–17% lower than that of the zander, and in the autumn period the difference is 20–25 %, which may be caused by the difference in the fertility rates of these species. In males, the difference in the values of the GSI in the spring period averages 7.5 %, and in the autumn, about 6 % (Fig. 4). During resorption, when the index reaches the minimum values, there was no significant difference between the GSI values of the two experimental species.

After mass spawning, the zander and the Volga zander are practically not found in the fishing gear, the males protect the laying eggs, and the females that fall into the stacked nets are weakened. Later their females and males go to growing period, at this time, the size of the GSI begins to grow. Upon completion of the resorption processes, the gonadity maturity reaches the minimum values.

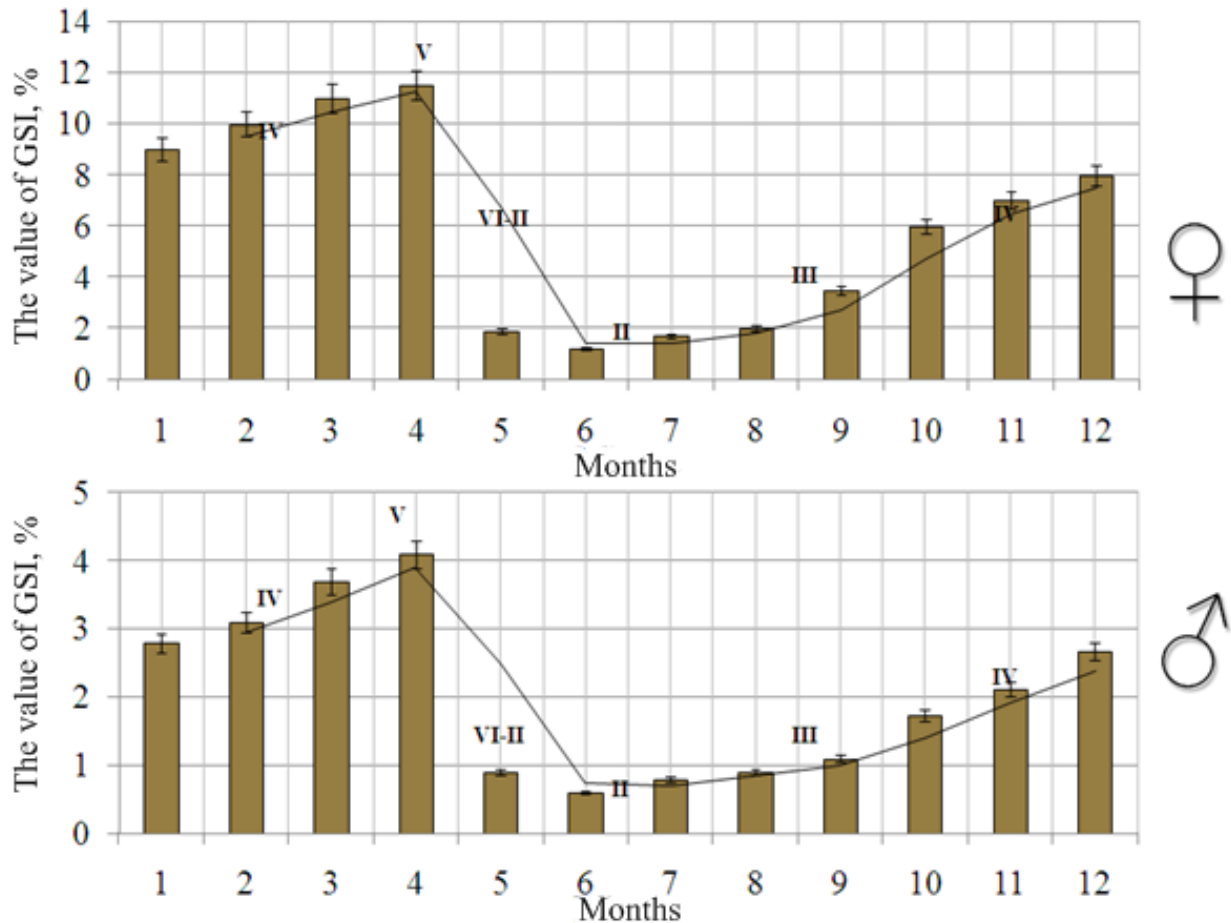


Figure 4. Indices of gonadosomatic index of the Volga zander in different months of the year: ♀ – females, ♂ – males.

Practical guidelines for restoring reproduction conditions.

In many regulated reservoirs, the natural reproduction of aboriginal fishes is subject to such significant stress factors as violation of the level regime in the spring, unsatisfactory spawning grounds, poaching fishing during spawning, etc. It is possible to fix the situation with shortage of spawning grounds with the help of integrated fish farming and reclamation measures, which are quite labor-intensive and expensive (creation of stationary spawning grounds, waterlogging, cleaning spawning grounds, dredging), or by using artificial spawning nests for the period of spawning that can improve the environment for spawning of fish in natural waters without significant investment in environmental measures (Marenkov, 2015).

The reproductive potential of zander and Volga zander under conditions of the Zaporizhzhya reservoir is being implemented today by no more than 30 % due to the degradation of natural spawning grounds and their low efficiency. In addition to improving the recreation zones of fish through restoration of water due to hydromechanized works, the most effective is the creation of artificial spawning grounds in the coastal areas of the Zaporizhzhia Reservoir, which traces the shortage of shallow water and bays (especially the upper and middle sections).

Currently, due to the considerable sedimentation of small rivers and lake sites, lithophils have lost some of the spawning areas of water reservoirs that can be offset by the creation of special spawning nests.

Lithophilic fish, such as zander, lay eggs in nests built on a sandy or muddy bottom of the pond. They clean the bottom from dirt, sludge and plant residues, and create a small saucer-like deepenings on a sandy bottom. Spawning of zander takes place in April – early May at a temperature of 11–15°C. Eggs of zander may be laid on the rhizome of typha, willow, vines, sometimes on a rock or on a solid bottom, and also on artificial spawning grounds, which are installed in reservoirs. A male is near a nest and protects eggs. Caviar, which fish lay in such a nest, is better protected from predators.

As spawning nests for zander, artificial disk spawning nests of polyvinylchloride can be used (Fig. 5). The nest has the form of a concave disc with a diameter of about 0.5 m, which is attached to a tripod in height 10–15 cm. The nest is characterized by strength and has a solid surface.

The spawning nest is installed at the bottom of the reservoir in places of zander`s spawning. During spawning, the zander lays eggs into the nest and protects them. In addition, at the edges of the nest, small periphytonic organisms can develop, which can serve as an initial feed for fish larvae.

Similar spawning nests are characterized by ease of use and versatility, as they are not destroyed under the influence of aggressive water environments. It is recommended to install 50 such disks per 1 hectare of water. Artificial spawning disk for lithophils should be grouped in 3–5 pcs.

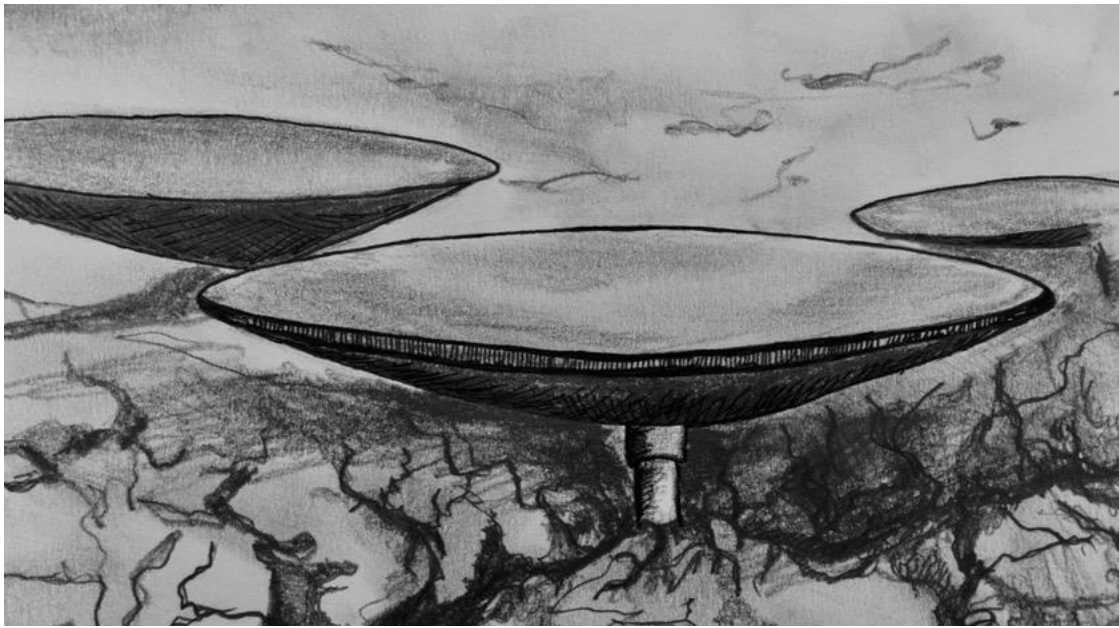


Figure 5. The construction of artificial spawning nest for lithophilic fish.

We have identified local populations of the Volga zander in the lower reaches of the Zaporizhzhia Reservoir, where it inhabits, breeds and feeds (Fig. 6). Volga zander, like the zander, builds nests, which it protects after spawning. In shallow waters near of the Kozlov Island (Goat Island) 48°22'54" N, 35°20'49" E, separate birch nests of Volga zander were located on spawning grounds of the zander, which is why these species can compete with each other in the places of joint spawning.

In order to improve the conditions for the reproduction of the Volga zander we designed artificial spawning nests, and identified the locations of their installation and the scheme of the points where the main spawning grounds of the Volga zander are located and where there is a lack of spawning substrate due to rubbing and silting the banks of the river. The construction of an artificial spawning nest for lithophilic fish (zander and Volga zander) is also proposed.

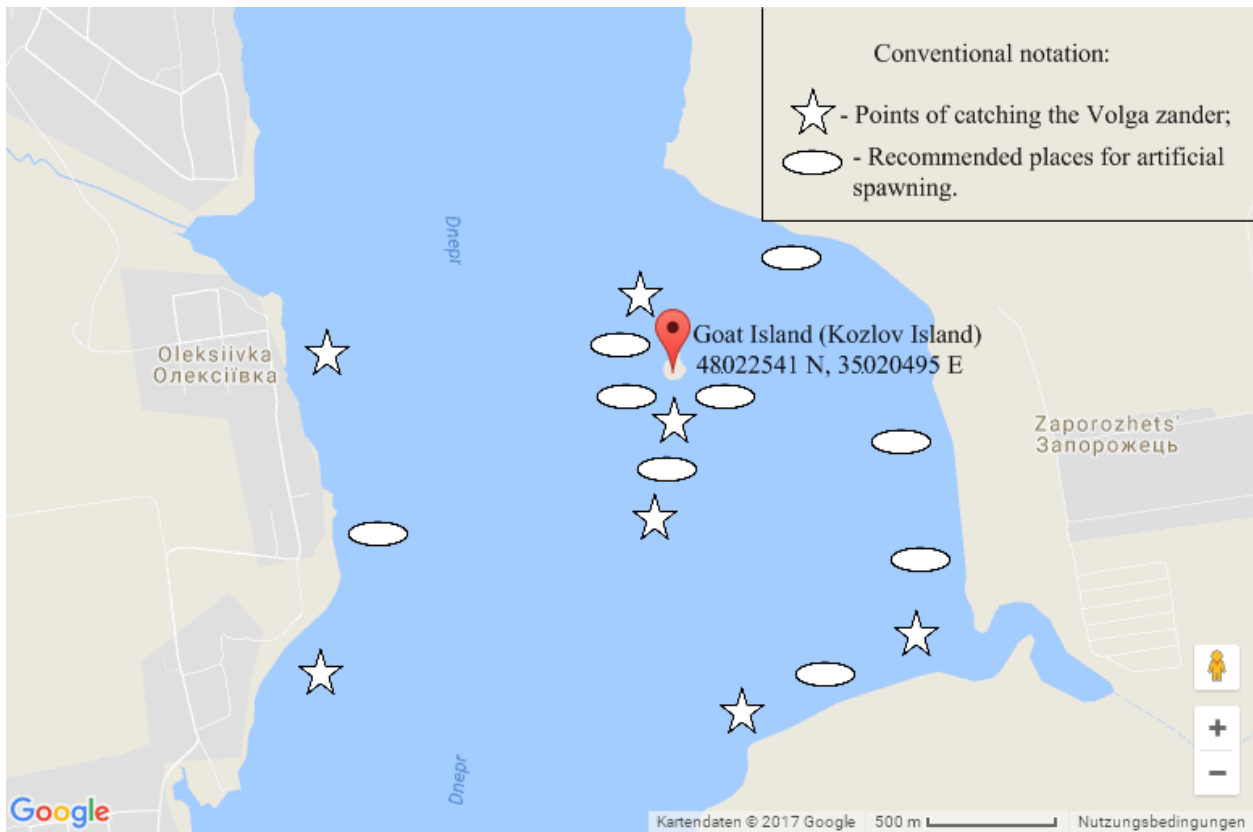


Figure 6. Local Areas of the Volga zander and its Places of Spawning.

The number of artificial spawning grounds should correspond to the reproductive potential of aboriginal fish in the process of their use. In addition, it is possible to significantly optimize the process of restoring valuable fish species due to the construction (on the basis of scientific and biological justifications) of natural-artificial spawning grounds such as stone ridges and nets, which will also serve as spawning ground, shelter for young fish and, accordingly, increase in the number of fish from fry to industrial sizes. The installation of artificial spawning nests is one of the ecological and economic ways to improve the conditions for the reproduction of fish in natural waters.

The installation and exploitation of artificial spawning grounds were discussed and formed the basis of the "Fisheries Development Program of the Dnipropetrovsk Region for 2010–2015" ([http://www.magd-rn.dp.gov.ua/OBLADM/Obldp.nsf/\(docweb\)/AF393D2B75534B89C2257776006BBC1B?OpenDocument&PrintForm/](http://www.magd-rn.dp.gov.ua/OBLADM/Obldp.nsf/(docweb)/AF393D2B75534B89C2257776006BBC1B?OpenDocument&PrintForm/)), but in fact during 2010–2015 this direction was not implemented.

The restoration of spawning grounds for industrial fish species is provided by legislative acts approved by the Cabinet of Ministers of Ukraine: "On Approval of the Concept of the National Program for the Conservation of Biodiversity for 2005–2025" (Order No. 675-r of September 22, 2004 <http://zakon2.rada.gov.ua/laws/show/675-2004-%D1%80>), "On Approval of the State Target Economic Program Development of the Fisheries for 2012–2016" (Resolution dated November 23, 2011, No. 1245 <http://zakon3.rada.gov.ua/laws/show/1245-2011-%D0%BF>).

The number of artificial spawning nests for zander is determined from a preliminary estimation of the reproductive core of the population, taking into account that for one spawning group, which can consist of one female and two males, the required area is 20 m². The number of spawning nests should correspond the number of females that will use them.

Installed artificial nests should be inspected daily for the presence of eggs, and in its absence they should be washed, gradually shaking it in the water column. In the case of detection of eggs in the spawning modules, the nest is noticed by a float with a tag, which marks the date of spawning.

To restore the population of the Volga zander and preserve the number of the zander, we have made calculations on the amount of artificial spawning that must be installed annually in the reservoir. It is recommended on a permanent basis to introduce artificial spawning nests within the lower reaches of the Zaporizhzhia reservoir during the spring period. It is necessary to gradually increase annually the number of spawning nests for zander and Volga zander to their optimum amount, which is 10 thousand pcs. including annually supplement: 5 thousand pieces in 2018; 5 thousand pieces in 2019.

Conclusions

The populations of experimental species of fish are in a depressed state. The share of zander in total catches in the Zaporozhye reservoir reaches no more than 2%; annual average catches are kept at the level of 9.25 tons. Industrial exploitation of the Volga zander in 2010 is generally prohibited by law; the species is included in the Red Data Book of Ukraine.

The age range of the Volga zander has 8 classes (2–9-years). The population core consisted of 3–5-year-old individuals (78 %). The share of elderly fish was 7 %. The length of the individuals was: 34.14 ± 1.55 cm in females, 31.18 ± 1.23 cm in males; the weight of females varied in the range from 180 g to 2.4 kg, with an average of 620.15 ± 108.10 g, and from 170.0 g to 1.2 kg with an average of 510.23 ± 56.16 g males.

The age range of the zander has 8 classes. The core of the industrial population consisted of 3–5-year-old individuals (from 22 to 31 % of each age group). The share of older fish populations was 6.5 %. The industrial length of pike perch was: 38.05 ± 4.26 cm in females and 33.19 ± 2.15 cm in males; the weight of females ranged from 280.0 to 4.2 kg, with an average of 1200.0 ± 103.2 g, and from 190.0 g to 1.1 kg with an average of 560.15 ± 106.58 g males.

The indicators of absolute fertility of the Volga zander varied in the range from 31 thousand eggs to 138.75 thousand eggs. The average fertility of the spawning population was 91.72 thousand eggs. Indices of absolute fertility of zander varied from 53 thousand eggs to 668.4 thousand eggs. The average fertility was 225 thousand eggs, which is twice higher than in Volga zander. Increasing fertility can serve as a signal of deterioration of the conditions for the zander in the Zaporozhye reservoir.

The largest value of GSI in zander females is noted in the second decade of April and reaches 14.1 ± 2.85 %. After spawning, the lowest GSI value in females is about 2 %. The highest rate of GSI in zander is in mid-April and reaches 4.3 %, when the zander builds a nest for spawning. The smallest index of GSI is observed in June and reaches 0.6 %.

In the spring, the value of the GSI in the Volga zander females is 15–17 % lower than that of the zander, and in the autumn, the difference is 20–25 %, which may be due to the difference in the fertility of these species. In males, the difference in GSI values in the spring period is an average of 7.5 %, and in the autumn it is 6 %. The development of the maturity scale of the sexual products of these species of fish allows adjusting the timing of the prohibition of their industrial catch.

The zander and Volga zander belong to a group of fish with synchronous growth of oocytes, a one-time and short-term type of spawning. By the features of oogenesis, females of these species of fish belong to a group of fish that hibernate with ovaries at IV stage of maturity.

In order to restore the population of the Volga zander and preserve the number of the zander, it is recommended to install artificial spawning nests in an optimal quantity of 10 thousand pieces: 5 thousand pieces in 2018; 5 thousand pieces in 2019.

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