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Fish Reproduction Conditions of Volgograd Reservoir Near the Villages of Akhmat and Zolotoe Russia in 2020 in Comparison With Previous Years

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ABSTRACT

The article considers the conditions for the reproduction of fish in the waters of the Volgograd reservoir of the villages Akhmat and Zolotoe, such as level and temperature regimes, as well as production processes (the rate of gross photosynthesis, the rate of respiration of the plankton community, net primary production, which can serve as indicators of the state of the natural food base). According to the results of the fry survey in 2020, the conditions for the fish reproduction in the waters of the Volgograd reservoir of villages Akhmat and Zolotoe should be recognized as very unfavorable, which could be predicted by the dynamics of the level and temperature regimes. Black Sea sprat (Clupeonella cultriventris (Nordmann, 1840), as in previous years, is reproduced in the water area of the village of Zolotoe and is not reproduced in the water area of the village of Akhmat. The high food capacity of the studied water areas has a noticeable effect on the efficiency of reproduction of certain fish species in years with a more favorable level regime but is not able to compensate for the damage caused to the reproduction of fish by a particularly unfavorable regime of the water level in general.

KEY WORDS: PLANKTON, REPRODUCTION, TEMPERATURE, VOLGOGRAD RESERVOIR, WATER LEVEL.

INTRODUCTION

According to the literature, the success of fish breeding depends on the level and the duration of water standing at high elevations and the synchronization of water heating with the rise in the level, which ensures the maturation of reproductive products following the conditions for spawning, are very important. Successful reproduction and feeding of juvenile fish in the Volgograd reservoir require a slow rise in the water level to optimal levels by the end of April – early May (16.5-17 m of the Baltic System (BS)), a long standing (for 30-35 days) at maximum marks from the subsequent slow (from the beginning of June) lowering of the level to low-water levels in July (Biological substantiation of maintaining the optimal water level in the Volgograd reservoir to increase the productivity of the population of the main commercial valuable fish species, 2005).

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Globally, wildlife is disappearing faster than ever before, largely due to habitat degradation and fragmentation (Atlas of freshwater fish of Russia, 2002). The factors of such degradation and fragmentation include the operation of hydroelectric power plants. In a market economy, when the regulation of the operation of hydroelectric power plants is unprofitable for the shareholders of the energy sector, the problem of ensuring the success of fish reproduction can be solved by the efforts of the agricultural sector by influencing subordinate factors that vary in individual water areas (Tiulin et al., 2018; Tiulin et al., 2019; Tiulin et al., 2019; Ermolin et al., 2019 Tiulin et al., 2020; Kostin et al., 2021).

Correct assessment of the breeding conditions of fish is possible using an integrating indicator – fry survey data. The yield, which falls within the interval between 37.2 and 11.5 thousand ind./ha, corresponds to the average yield (the conditions for the reproduction of fish are average); the interval between 11.5 and 5.2 thousand ind./ha indicates low yield (breeding conditions are unfavorable); 37.2-79.4 thousand ind./ha – high yield

(breeding conditions are favorable). All values less than 5.2 thousand ind./ha correspond to a very low yield (very unfavorable breeding conditions), more than 79.4 thousand ind./ha – to a very high fry yield (highly favorable breeding conditions) (Ermolin et al., 2019; Tiulin et al., 2020; Boldyrev et al., 2021).

In 2020, the fish reproduction conditions in the waters of the villages Akhmat and Zolotoe were studied again. The purpose of this work is to assess the state of natural reproduction of commercial fish in the waters of the Volgograd reservoir of the villages Akhmat and Zolotoe based on observations of fry yield in 2020. To achieve it, the following tasks were completed: the study of such conditions for the reproduction of commercial fish as the temperature and level regimes of the Volgograd reservoir during the spawning period, production processes, the rate of gross photosynthesis, the rate of respiration of the plankton community, net primary production, and analysis of the data of fry survey in the studied water areas.

MATERIAL AND METHODS

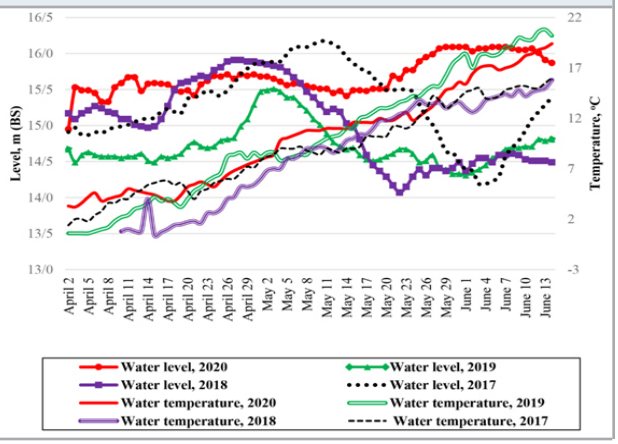
The curves of temperature and level regimes of the Volgograd reservoir were compiled based on data from the meteorological station near the city of Saratov. To study production processes in water areas, the daily flask exposure method was used (Phytoplankton and its products, 1984). In this case, three flasks are used. Oxygen in the control flask was fixed immediately after taking a water sample. Two other flasks (darkened with opaque material and light) were fixed on a pole and kept in a reservoir for 24 hours. Net primary production is the difference between the oxygen concentration in the light and control flasks, the respiration rate of the plankton community is the difference between the oxygen concentration in the control and dark flasks, and the gross photosynthesis rate is the difference between the oxygen concentration in the dark and light flasks. For greater accuracy, 9 flasks were used in each experiment.

The concentration of dissolved oxygen in the water was determined by the Winkler method (Muravyov, 2011) and using a Samara-2 oximeter. The data on the production processes were compared with the previously published data on the fry yield in the studied water areas (Tiulin, 2017; Tiulin et al., 2018; Tiulin et al., 2019; Tiulin et al., 2020). The material in terms of the fry yield was sampled from July to September 2020. The species of fry was established according to the A.F. Koblitskaya identification key (Koblitskaia, 2014). Samples were taken with a 10-m-long fry trawl, a 2-m-high wing, with an 8-mm wing mesh, and a 4 mm belly mesh. In total, in 2020, 33 fry hauls were carried out with a trawl, about five hundred specimens of juvenile fish were analyzed and measured. The relative abundance was calculated by bringing the data on the catches of fry trawl per unit area (Minin et al.,2007). The Brodskaia and Zenkevich index of dominance (ID) and the Shannon index of species diversity were calculated (Chief, 2005).

RESULTS AND DISCUSSION

In spring 2020, the Volgograd reservoir lacked any favorable conditions. Despite the relatively high, in comparison with 2019, water level, its rise towards optimal levels began only by the end of May; at the beginning of May, there was a prolonged decline, which threatens with drying out of eggs. These are significantly more unfavorable conditions in comparison with 2017-2019 (Tiulin, 2017; Tiulin et al., 2018; Tiulin et al., 2019 Tiulin et al., 2020). (Figure 1).

Figure 1: Changes in the water level and temperature in the Volgograd reservoir in spring 2017-2020 (according to the weather station near the city of Saratov)



A more correct assessment of the conditions of fish reproduction in the waters of the Volgograd reservoir near the villages Akhmat and Zolotoe can be obtained with an integrating indicator – fry yield (Ermolin et al., 2009). The fry survey (Table 1) in the water area near the villages of Zolotoe and Akhmat in 2020 found 12 and 8 species of fish, respectively (in 2019 – 11 and 10, respectively). The Shannon species diversity index has significantly decreased in comparison with 2019 for the water area near the village of Zolotoe and amounted to 1.82 (in 2019 – 2.26 (Tiulin, 2017)) and increased for the water area near the city of Akhmat – 2.47 (in 2019 – 1.36). In both water areas, the catches were dominated by commercial fingerlings: near the villages of Akhmat and Zolotoe their share was 72.8% and 50.1%, respectively (Tiulin et al., 2019; Tiulin et al., 2020; Boldyrev et al., 2021).

As in 2017-2019, Black Sea sprat (*Clupeonella cultriventris* (Nordmann, 1840)) is found in the water area of the village of Zolotoe in 2020. This species, as before, is absent in the water area near the village of Akhmat (Tiulin, 2017; Tiulin et al., 2018; Tiulin et al., 2019; Tiulin et al., 2020; Rudskaya et al., 2021). On a five-point fry yield scale (Ermolin et al., 2009), the fish reproduction conditions in the waters of the villages of Akhmat and Zolotoe in 2020 should be recognized as highly unfavorable. The intensity of production processes can serve as an indicator of the state of the natural food base, as evidenced by laboratory studies of samples of

phytoplankton, zooplankton, and zoobenthos (Tiulin et al., 2020; Popova and Pavlova 2021).

Figures 2 and 3 show the highest values of production indicators in 2017 and 2019, and the lowest – in 2018 and 2020. In this case, in terms of the level and temperature regimes, the most favorable years are 2017 and 2018, while the least favorable is 2020. Table 2 presents the values of the fish yield in different years in the considered water areas, on a five-point scale (Ermolin et al., 2009). High indicators of zooplankton biomass determined an outbreak of reproduction of the Black Sea sprat (Clupeonella cultriventris (Nordmann, 1840)) in the water area of the village of Zolotoe in 2017, which formed the basis of the catch with fry trawl (145,333 ind./ha) (Tiulin, 2017). At the same time, the main factor determining the efficiency of fish reproduction remains the hydrological regime of the reservoir.

The decline in the yield of juvenile Black Sea sprat and the yield of juvenile fish in general in 2018 may be due to the undermining of its natural food base – zooplankton which, in turn, is probably due to an unfavorable oxygen regime. In July 2018, in the shallow waters of the village of Zolotoe, an extremely low concentration of dissolved oxygen in the water was observed. In the same month, the biomass of phytoplankton (including diatoms and green algae) reached a minimum, which serves as food for many zooplanktons, including crustaceans of the genus Bosmina, which are the basis for feeding of fingerlings of the Black Sea sprat (Guliev and Meliakina, 2014; Tiulin et al., 2017; Tiulin et al., 2020; Popova and Pavlova 2021). A peak in the concentration of nitrate ions was also observed, which indicates that the water was polluted with organic matter.

Table 1. Composition of caught fry in the waters of the Volgograd reservoir near the villages Akhmat and Zolotoe in 2020.

Fish species	Catch composition									
	Akhmat					Zolotoe				
	ind./ha	ind., %	g/ha	g, %	ID	ind./ha	ind., %	g/ha	g, %	ID
Common roach	1	1.23	2.85	1.06	1.88	13	2.18	1.1	0.23	1.56
Common chub	15	19.75	33.11	12.34	25.57	252	43.83	335.9	68.41	121.33
Perch	22	28.40	159.66	59.48	67.33	14	2.42	25.5	5.18	7.85
Crucian carp	16	20.99	43.10	16,06	30.08	7	1.21	11.1	2.27	3.67
Asp	2	2.47	19.12	7.13	6.87	-	-	-	-	-
Common bream	-	-	-	-	-	1	0.24	8.9	1.81	1.47
Silver bream	-	-	-	-	-	1	0.24	0.8	0.17	0.45
Common bleak	4	4.94	1.33	0.50	2.56	242	42.13	88.6	18.05	61.09
Black Sea sprat	-	-	-	-	-	10	1.69	3.2	0.65	2.33
Broadnosed pipefish	15	19.75	3.04	1.13	7.76	28	4.84	6.7	1.36	5.69
Monkey goby	2	2.47	6.18	2.30	3.91	4	0.73	4.7	0.96	1.85
Bighead goby	-	-	-	-	-	1	0.24	2.4	0.48	0.76
Tubenose goby	-	-	-	-	-	1	0.24	2.1	0.42	0.71
Commercial	56	72.84	257.85	96.07	137.05	288	50.12	383.3	78.07	138.61
Non-commercial	21	27.16	10.56	3.93	16.94	287	49.88	107,6	21.93	73.28
Total	77	100	268.41	100	-	574	100	491.0	100	-
Shannon index	2.47	1.82								

The combination of these factors could lead to a collapse of the biomass of zooplankton in July 2018 in the water area of the village of Zolotoe, which, probably, together with an unfavorable oxygen regime, negatively affected the populations of fingerlings of the Black Sea sprat. The sprat eggs are pelagic (Atlas of freshwater fish of Russia, 2002) therefore, these fish are less in need of additional areas of spawning grounds, although the areas flooded together with the flood are important for the development of zooplankton, which is the basis for the feeding of juvenile sprat. Probably, the decisive importance in reducing the population of juveniles of the Black Sea sprat in the water area of the village of Zolotoe in 2018 compared to 2017 was played by limiting factors: an unfavorable oxygen regime and a critically low concentration of zooplankton, which is the basis of nutrition for this fish species.

The feeding of fish, which form the basis of catches in the water area of the village of Akhmat is mixed or consists of benthivorous fish (Tiulin et al., 2017; Rudskaya et al., 2021). Fingerlings of such fish have more opportunities to feed themselves, and the productivity of juvenile fish in this area in 2018 turned out to be moderate, due to a favorable level regime during the spawning period. The unfavorable situation with the natural food base in 2018 was also reflected in the production curves.

Table 2. Fish reproduction efficiency in the waters near the villages Akhmat and Zolotoe

Years	Fish yield (ind./ha)	
	Akhmat	Zolotoe
2017	770 (Very low)	146 833 (Very high)
2018	12 640 (Moderate)	11 748 (Moderate)
2019	636 (Very low)	498 (Very low)
2020	77 (Very low)	574 (Very low)

Figure 2: Production processes in the water area near the village of Akhmat in 2017-2020

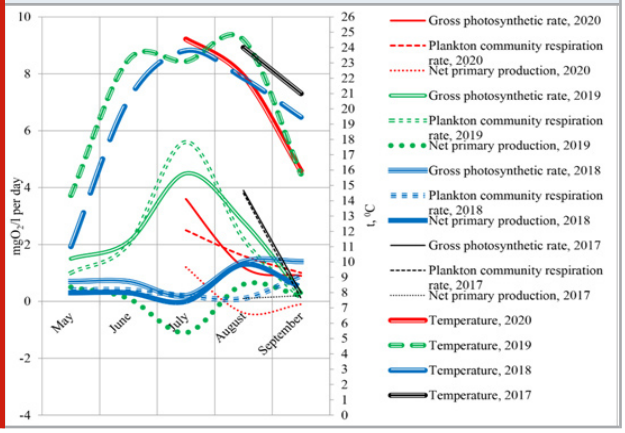
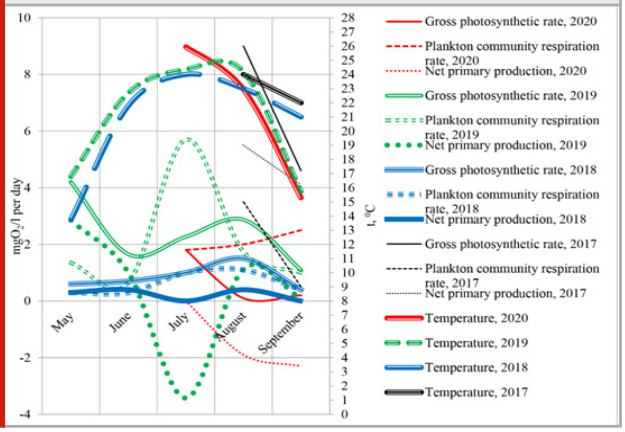


Figure 3. Production processes in the water area near the village of Zolotoe in 2017-2020



CONCLUSION

In 2020, the waters near the villages Akhmat and Zolotoe had very unfavorable fish reproduction conditions developed, which could be predicted by the dynamics of the level and temperature regimes. Black Sea sprat (*Clupeonella cultriventris* (Nordmann, 1840)), as in previous years, is reproduced in the water area of the village of Zolotoe and is not reproduced in the water area of the village of Akhmat. The high food capacity of the studied water areas has a noticeable effect on the efficiency of reproduction of certain fish species in years with a more favorable level regime but is not able to compensate for the damage caused to the reproduction of fish by a particularly unfavorable regime of the water level in general.

Conflict of Interest: Authors declares no conflicts of interests to disclose.

Ethical Clearance Statement: The Current Research Work Was Ethically Approved by the Institutional Review Board (IRB) of Agrarian University, Saratov, Russian Federation Russia.

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