Problems and perspectives of using warm waters of the state district power station in solving the provision of the population with fish

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Abstract. One of the sources of increasing fish production in Russia is intensive fisheries development of cooling reservoirs of thermal power plants and nuclear power plants. Cooling reservoirs have a unique temperature regime, which differs from natural water bodies by a higher temperature throughout the year. The increased water temperature causes changes in the quantitative and qualitative composition of the forage reserve, the ichthyofauna, the habitat of the hydrobiont and creates favorable opportunities for the introduction of a complex of thermophilic fishes and enhance the fish productivity of water bodies. The rise in water temperature also accelerates chemical and biochemical processes, promotes the intensive decomposition of organic substances, influences the gas regime of the reservoir, as a result, there may be overseas phenomena and the death of fish in cooling reservoirs. Therefore, the growing of aquaculture objects, the most resistant to high temperatures and temperature and gas changes, is becoming topical.

Introduction
The most large-scale single use of water is the production of electricity, where it is used mainly for cooling and condensing steam produced by turbines of thermal power plants. At the same time, water is heated by an average of 7 °C, then dumped directly into rivers and lakes, being the main source of additional heat, called "thermal pollution". The temperature of water used in thermal power plants for steam cooling increases by 3-10 °C, and sometimes up to 20 °C. Powerful power plants noticeably heat up the waters in the rivers and bays on which they are located. In the summer, when the demand for electrical energy for air conditioning is very high and its production increases, these waters often overheat. The term "thermal pollution" refers specifically to such cases, because excess heat reduces the solubility of oxygen in water, accelerates the rate of chemical reactions and, consequently, affects the life of animals and plants in water intake basins [1]. Under such conditions, a change in the fish-breeding zone may occur.

The effect of thermal pollution on water bodies
The protection of aquatic biological resources, the improvement of the ecological status of water bodies at the current stage should be based on the reproduction of aquaculture facilities. It is the reproduction of aquatic biological resources that is the basis for the successful development of aquaculture in the reservoirs of the Volga region [2].
The main problem is the high temperature background in the summer. Against the backdrop of climate change in the Volga region of Russia, when the natural temperature background in some years reaches more than 30 °C, thermal contamination of power plants becomes a critical factor due to oxygen deficiency and overseas phenomena. With the change in the water temperature in the water body, the gas exchange in fish changes, and the concentration of free oxygen in water changes [1].

The deterioration of the oxygen regime of the reservoir-cooler leads to a reduction in the number of herds of fish, the replacement of valuable commercial species by weed, and the occurrence of parasitic diseases of the ichthyofauna. The impact of numerous and powerful sources of anthropogenic chemical, biological and thermal pollution in conditions of regulated flow contributes to a significant extension of the initial period of formation of the oxygen regime of the reservoir. The accumulation of the biomass of algae and its decomposition at the end of the growing season in a limited part of the water area of the reservoir leads to the accumulation of nutrients. This, in turn, reduces the pH of the aqueous medium, which increases the solubility and mobility of heavy metal ions, their desorption from the bottom sediments of the reservoir-cooler, the transition of toxic heavy metal salts into water. From the bottom sediments, phosphorus enters the aquatic environment, and as a result, the eutrophication process accelerates [3; 5].

Their important feature is a seasonal thermocline. As the surface waters warm up in the summer, a temperature gradient is established with denser and colder water at the bottom and a warmer one at the surface. This is not at all surprising, except that the change in temperature, with increasing depth, is not gradual. Instead, a sharp break occurs a few meters down, while the cold water is locked down. The fission line is thermocline. This delineation of two large masses of water is very important for fish. Typically, the wind can mix water, and raise the cold, oxygen-rich water from the depths. However, thermocline blocks the mixing of water at different temperatures, resulting in a lack of oxygen and massive fish loss [4].

In summer, when the surface waters are warm, algae multiply intensively, which promotes the spread of microscopic life. In itself, this is fine, until the algae switch from photosynthesis (the process of producing oxygen) to respiration (oxygen uptake), in low light, for example, at night or during prolonged cloudy periods. This process significantly reduces the concentration of oxygen in the water, and the fish begins to die from suffocation. However, the situation may worsen even more when algae begin to die off at a rapid pace. In the biological decomposition caused by bacteria, a considerable amount of oxygen is used, which reduces its concentration in the water even more. People can also significantly aggravate the problem of lack of oxygen in the water. This occurs when water is contaminated with certain types of nutrients, including manure drainage or fertilizer from farms. Phosphorus and nitrogen from these effluents fall into water bodies and are fixed in algae, because of what they consume more oxygen [5].

So, for example, in August 2016 according to the materials of the press service of BUSINESS Online in Zainskoe reservoir, 170 tons of fish were killed. Zainsk fish farm is the only farm in Tatarstan, located in a warm pond. It is located on the river Steppe Zai, on which the reservoir is organized. It is a "warm body of water", where, as a rule, it discharges hot water. Zainskaya GRES uses it as a cooler.

The reservoir under ordinary conditions cools the water discharged by Zainskaya GRES, but in 2016 this did not happen. The reason is an abnormal heat and, in addition, a 100% load of the Zainskaya GRES. The water temperature reached critical levels for 40 degrees Celsius, there was an oxygen starvation of the fish, there was a loss of her literally in two hours. In the fish farm, carps and carnivores were killed. So, for 2016 the production of commercial fish by specialized fish farms was 212 tons, while in 2015 the figure was twice as high-429 tons. The damage to the fish farm, according to its director, was 35-40 million rubles [6].

**Perspective objects of industrial cultivation on elevated warm waters**

A particularly attractive object of high-grade nutrition is the fish, which gives easily digestible protein. The optimal level of consumption of fish products should be at least 20 kg/year per capita (with the
Institute of Nutrition of the Academy of Medical Sciences of Russia recommended physiological norm of 23.7 kg/year. Currently, the level of consumption of fish and seafood in Russia is 18 kg/year, which completely does not meet the needs of the population (Figure 1) [7].

![Figure 1. Average annual fish consumption in Russia.](image)

To meet the population's demand for fish products, it is important to grow fish in fish farms. One of the promising forms of fish farming has been the use of warm waters of reservoirs-coolers. Its integrated development allows not only to create by the method of pasture aquaculture the uterine livestock of thermophilic species of fish and to establish their reproduction, but also to use the considerable possibilities of cage farming on the cooling pond for growing viable planting material. Effective use of cage farming for the cultivation of commercial fish.

If earlier in the summer temperatures the recommended object of industrial cage fish culture was carp, and herbivorous fish were introduced into the body of water as biomeliorators, in modern conditions it is necessary to change the recommended objects of industrial fish farming.

Under these conditions, one of the most interesting objects of growing on warm waters is the Clarceum catfish, which prefers higher water temperatures than carp, and is practically insensitive to oxygen because of its biological characteristics. The value of the clarium catfish determines good growth, effective feed intake, the ability to adapt to different growing conditions, including high planting density, and excellent taste qualities. This thermophilic fish: the temperature optimum lies in the range 25 - 30 °C, at a temperature of 17-19 °C it ceases to feed, perishes during a prolonged stay in water with a temperature of 14-15 °C, but can withstand a short decrease to 5 °C. Clarias withstand a high percentage of water in the nitrogen compound. The Claire's catfish provides buoyancy for itself with the help of air coming from the nadzhibural cavity. This is due to the fact that it is in the plane that the ejaculatory organ of respiration is located (Figure 2). On the second and fourth bronchial arc, and it is located, abundantly covered with vascularized tissue, has branched formations. With its help, clarias separate oxygen from the air. Connects the nadestial cavity with the pharynx. If the oxygen content in the water is low, then to breathe in air the catfish cat rises to the surface of the water.
Breathing with the help of atmospheric air allows the fish to live out of the water for a long time, move along the ground and even be in muddy water. Clariscatfish feels best when the concentration of dissolved oxygen in the water exceeds 4.3 mg/l and access to the surface is unlimited. As soon as the reservoir ceases to be comfortable for the clariscatfish, it passes into another pond. A comfortable environment for the clariscatfish is water with pH 6.5-8, it is resistant to temperature changes, withstands the salt level in water to 10 ppm [8].

Claristic catfish do not represent sanitary - epidemiological and ecological danger. And precisely because, this species has been reproduced in hatcheries for many generations without contact with other hydrobionts, which could be intermediate hosts of parasites, including those that pose a danger to humans, so the probability of accidental infection of such parasites is virtually excluded. Clarium catfish under variable and constant temperature jumps, has a high tolerance to diseases, in particular immunity to parasites of Dactylogyrus [9].

In conditions of unstable thermal regime, the fish of the North American complex are also promising for growing in the pond on the non-soft waters of the state district power station: large, small and black buffalo. The first species is especially valuable. Bigger Buffalo - a fast-growing and large fish, not inferior to the growth rate of carp, reaches a weight of 45 kg. It well tolerates turbid water, it is not exacting to the hydrochemical regime. In contrast to the carnivores in reservoir-coolers, natural spawning is possible. Valuable fishing quality is the ability of buffalo to gather in flocks in the bottom layers and its accessibility for catching by active fishing gear.

The rise in water temperature will intensify the development of shallow water in the shallows, which will create the possibility of introducing a white cupid, a consumer of macrophytes, into the pond.

Another promising area of use of warm waters of the state district power station is the growing of rainbow trout in the cold season. In Russia, rainbow trout and its forms are practically the only object of aquaculture of salmon breeding and so far constitute an insignificant part of the total volume of fish products produced [10]. Trout has high economic-useful attributes. Data characterizing the female: the total survival rate during the period of growing the two-year-olds (including the incubation of caviar) is 60%. The waste of three-year-olds is equal to 5% of the number of two-year-olds. The average weight of commercial two-year-olds is 250 g, three-year-olds - 1.5 kg. The yield of commercial fish per female during the cultivation of two-year-olds will be 270, three-year-olds - 3420 kg.

Along with the rainbow trout, its passage form - steelhead salmon and closely related species - lake trout, belong to the most common objects of aquaculture of salmonids. Steelhead salmon transfers the temperature rise to 28 °C. According to the pattern of growing is identical to rainbow trout. Due to late maturation, the planting material of steelhead salmon can be successfully used for cage fish culture in the northern regions of our country, where the growing season starts in April-May.
Thus, the cultivation of fish species more resistant to fluctuations in the temperature and gas regimes of reservoirs will make it possible to use the potential of warm waters of energy facilities much more efficiently.

References

[1] Safronov E N and Varyukhin A V 2003 Temperature of water in pond fish farming Zoo industry 11 12-5
[2] Kalaida M L 2016 Current state and tasks of aquaculture development in the Republic of Tatarstan (Saratov: Scientific Book) p 152
[3] Danilov-Danilyan V I and Losev K S 2008 Water consumption and its deficit: the ecological aspect Global environmental problems of Russia (Moscow: Nauka) p 35-9
[4] Pavlov D S and Mochek A D 2006 Ecology of fish in the Ob-Irtysh basin (Moscow: Fellowship of Scientific Publications of KMK) p 596
[5] Morozova O G, Morozov S V, Pen R Z, Repyah S M 2002 Formation of the oxygen regime of the reservoir-cooler BGRES-1 Izv. universities. Chemistry and Chemical Technology 45(6) 185-8
[6] BUSINESS Online: https://www.business-gazeta.ru/article/339972
[7] Extreme A A 2012 The power of the word [legal regulation issues of the development of the fishery complex of the Russian Federation] Fish protection of Russia 3 20-7
[8] Nikiforov A I and Mailkova A I 2005 Morphological features of Soma Clarias gariepinus Freshwater aquaculture: state, trends and development prospects Collection of scientific articles devoted to the 60th anniversary of the Scientific Research Fishery Station 56-8
[9] Pillow S B 2006 Clarion catfish and its use in aquaculture Status and prospects of development of farmer fish culture in the arid zone 71-4
[10] Esavkin Y I 2012 Intensive technology of freshwater trout breeding Dissertations of Doct. s.-. n. p 299