

Ecological state of Tudakul reservoir in Uzbekistan and estimation of fish capture in last decades

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Abstract. The problem of anthropogenic impact of the Tudakul reservoir has not been spared. In the first years of the reservoir's existence, its ichthyofauna was formed by the fish of the Zarafshan River, which were represented by both rheophiles and limnophiles, and initially it consisted of 11 aboriginal species and introduced fish. This paper gives a brief physical-geographical, hydrological, hydrochemical, hydrobiological characteristics of the Tudakul reservoir. An assessment of the ecological state of the reservoir, ichthyofauna and fish catch in it over the past decade is given. Recommendations for the rational use of the Tudakul reservoir are given.

1 Introduction

Hydroconstruction and regulation of river flows, construction of irrigation canals, carried out since the middle of the last century, destroyed the isolating barriers for aquatic organisms and connected all the main river basins of the Amu Darya, Zarafshan, Kashkadarya, Syrdarya and others [1, 5-8]. All these factors led to the mixing of fauna and the independent dispersal of a large number of aquatic organisms.

Significant acclimatization activities carried out in the Central Asian region also contributed to the emergence of new alien fish species in the region [2, 9]. Along with the objects of acclimatization, not cultivated low-value and weedy fish species were introduced into pond farms, and later into natural reservoirs. Alien invaders, as a result of naturalization, having reached a high number, put pressure on the aboriginal ichthyofauna, gradually displacing and assimilating their ecological niches [2, 3]. As a result of such an onslaught on the part of the invaders, the historical structure of the fish population of water bodies was disrupted, the habitat and the area of distribution of native fish species changed [3].

The problem of anthropogenic impact of the Tudakul reservoir has not been spared. In the first years of the reservoir's existence, its ichthyofauna was formed by the fish of the Zarafshan River, which were represented by both rheophiles and limnophiles, and initially it consisted of 11 aboriginal species and introduced fish [1-4, 10].

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With the arrival of the Amudarya water through the Amu-Bukhara main canal (ABMC) (1965), the qualitative and quantitative composition of the ichthyofauna of the Tudakul reservoir changed. Along with the water, 11 species characteristic of the Amu Darya fauna entered the reservoir [4].

In subsequent publications, it is reported about the penetration of 4 more fish species through the ABMC. Thus, based on the analysis of literary sources, the list of fish that lived in the Tudakul reservoir by the end of the 20th century included 30 species [5].

At present, the ichthyofauna of the Tudakul reservoir includes about 29 species. The most widely represented in the ichthyofauna of the reservoir is the cyprinid family - 22 species (75%), the remaining 7 families include 1 species each (5%). Analysis of the modern composition of the ichthyofauna of the Tudakul reservoir showed that 16 introduced alien species (56.5%) occupied the dominant position in the fauna, of which 10 species are representatives of the Far Eastern fauna [6].

2 Materials and methods

The Tudakul reservoir is located quite close to the consumer markets of the Navoi, Samarkand and Bukhara viloyats, which further enhances its fishery importance. The Tudakul reservoir is the largest artificial bulk reservoir of the Navoi region, created on the basis of Lake Tudakul in the early 50s of the last century [1, 2].

The area of the Tudakul reservoir is 22,000 hectares, the volume is about 2 billion m³, the maximum depth is 17 m, and the average depth is 5-7 m. The Tudakul reservoir belongs to the reservoirs with seasonal regulation of irrigation flow. It fills up in the autumn-winter period; the water level usually decreases depending on the water content of the year from April-May and continues until the end of October [1-4].

Before the commissioning of the Amu-Bukhara Canal, the Tudakul reservoir was a recipient of the excess waters of the Zarafshan River, and after that it began to be filled with water from the Amu Darya River, which contributes to the penetration of its fauna through the irrigation system into the Tudakul reservoir [3, 6].

The hydrological regime of the reservoir has developed under the influence of various anthropogenic factors and, to some extent, affects its fisheries. The water level is subject to significant fluctuations, which depends on a number of factors; irrigation water inflow from the Zarafshan and Amu Darya rivers, water intake for irrigation, evaporation from the water surface. The withdrawal of water for irrigation or watering from the reservoir is carried out by gravity, while the water enters the reservoir through a canal to the Kyzyltepa pumping station, and then is used for irrigation [1-3].

The water of the Tudakul reservoir has a slightly alkaline reaction, the pH values are in the range of 8.61-8.78, the salinity of the water is at the level of 484.1-1,619.2 mg/l. The maximum water temperature does not exceed 28 °C, the oxygen content varied within 7.38-11.6 mg/l, the transparency of the water was at the level of 15-175 cm according to the Secchi disk [2, 3].

The nature of the coastline: the northwestern and northeastern coasts have rather steep slopes; the eastern coast gradually turns into an undulating plain adjacent to the hills.

Vegetation is typical for the steppe zone. A significant part of the steppes adjacent to the reservoir is used for growing crops [4].

Geology, relief, soils, vegetation, climate have determined a kind of hydrological regime of the entire basin. The runoff of the main waterway of the reservoir, the Amu-Bukhara Canal, directly depends on the water content of the year. The low water content of the basin, a very low flow modulus, a large irregularity of flow over the years and according to the seasons of the year, the insignificant role of groundwater supply are characteristic features of this reservoir [4, 7, 8].

The formation of the hydrochemical indicators of the Tudakul reservoir is influenced by the waters feeding it (tributaries, atmospheric), the characteristics of the basin (relief, geology, soils, vegetation, climate), internal factors and the level of pollution [3, 4].

The surface waters of the Tudakul reservoir, according to Alekin's classification, belong to the sulfate class of the calcium group. In the group of anions, SO_4^{2-} ions predominate; on average, they account for more than 70% of the total amount of anions. HCO_3^- and Cl^- ions are subordinate to the sulfate ion, their content is much lower and averages 23 and 7%, respectively. The group of cations is dominated by calcium; its share is 45% of the total amount of cations. The share of magnesium ions and $\text{Na} + \text{K}$ accounts for an average of 21 and 31%, respectively. The total mineralization does not exceed 1600 mg/l, the value of the total hardness varies from 5 to 7.5 meq/l, which refers them to the class of slightly mineralized, soft waters.

The hydrochemical factors that adversely affect the ecosystem of the reservoir include the river. Zarafshan. Agricultural wastewater is introduced into the reservoir mainly with the waters of the river. The phytoplankton of the Tudakul reservoir is represented by 186 species, varieties and forms of algae, of which blue-green (*Cyanophyta*) - 47 species, diatoms (*Bacillariophyta*) - 100 species, green (*Chlorophyta*) - 25 species, pyrophytic (*Dinophyta*) - 7 species, cryptophytic (*Cryptophyta*) - 3 species, *Euglenophyta* - 3 species, Golden (*Cryzophyta*) - 1 species.

The dominant complex of phytoplankton communities was represented, first of all, by producers, among which diatoms, blue-green and green algae reach the greatest development and diversity. Pyrophytic, cryptophytic, and euglenic algae were noted with a low abundance [1].

Zooplankton of the Tudakul reservoir is represented by 15 species of which *Rotifera* - 10 species, *Cladocera* - 3, *Copepoda* - 2. The dominant species among rotifers are: *Euchlanis dilatata*, *Keratella tropica*; cladocer - *Diaphanosoma mongolianum*; copepod - *Thermocyclops vernalis*. In the formation of the zooplankton biomass of the Tudakul reservoir, *Copepoda* plays a significant role, or rather *Thermocyclops vernalis*, from *Cladocera* - *Diaphanosoma mongolianum*. The number of zooplankton organisms is 35,390.5 specimen/ m^3 and biomass - 193.12 mg/ m^3 [2].

In the macrozoobenthos of the reservoir, only 9 species of organisms were found, including the larvae of dipterans — chironomids (2 species), oligochaetes (3 species), molluscs (1 species), amphipods (1 species), shrimps (1 species) and mysids (1 species). *Chironominae*, oligochaete of the family *Tubificidae*, brackish aquatic species of mollusks *Corbicula fluminalis*, shrimp *Macrobrachium nipponense asper*, and mysid *Mesomysistowalevskyi*. Larvae of chironomids and oligochaetes, typical inhabitants of the bottom of eutrophic reservoirs, which also form the basis of the abundance and biomass of the reservoir, are typical species in all seasons of the study. Quantitative indicators of the development of macrozoobenthos in the Tudakul reservoir in the summer period range from 90-160 specimens/ m^2 , and the biomass 0.5-3.5 mg/ m^2 .

3 Results and discussion

The Tudakul reservoir is the main commercial reservoir of the Navoi region of Uzbekistan, providing up to 90% of marketable fish. The commercial productivity of the reservoir and the species composition of catches varied significantly from year to year.

In the 70s-80s, the main fishing gears used in the reservoir were: seines, fixed nets. During this period, the basis of the fishery was made up of such species as carp, wels catfish, white amur, zander, eel, silver carp and bream. The total annual catch was usually 450-859 tonnes, on average for 1970-1980 and the average catch was 671 tons per year.

In 2002, the founder of the Shams-Navoi enterprise built a fish nursery with ponds on the bank of the reservoir, which he stocked with larvae from fish farms in the Tashkent region. In 2003-2004, an incubation workshop was built. Since 2003, they began to stock fish with underyearlings of carp, silver carp, white amur and eel. Individuals of the first stocked stock (autumn 2002) began to enter the fishery in 2004, and were completely fished in 2005. Stocking is carried out annually, there are no breaks.

By the mid-2000s, the nature of the fishery and the qualitative composition of fish caught in the reservoir had changed. In catches, the importance of valuable farmed species - cyprinids - has increased. Later, they occupied a leading position in the fishery.

Thus, the level of natural actual productivity of the reservoir can be considered 160 - 200 tons per year.

At the Tudakul reservoir, sufficiently high indicators of commercial fish productivity were achieved; in general, the fishing situation was assessed as unstable. It can be seen that the share of carp has decreased (both in tonnes and as a percentage of the catch); catches fluctuated according to the seasons of the year, but did not fall below 13.8 tonnes per month. In general, the fishing situation at the Tudakul reservoir at the present time should be characterized as follows.

The main target was carp, one year at the end of the 2020s, bream, zander, silver carp were the main ones. The list of species important for fishing in different years included carp, silver carp, zander, eel, bream. Species such as wels catfish, white amur, bream, and eels have always been included in the list of those present in the catches (Fig. 1.)

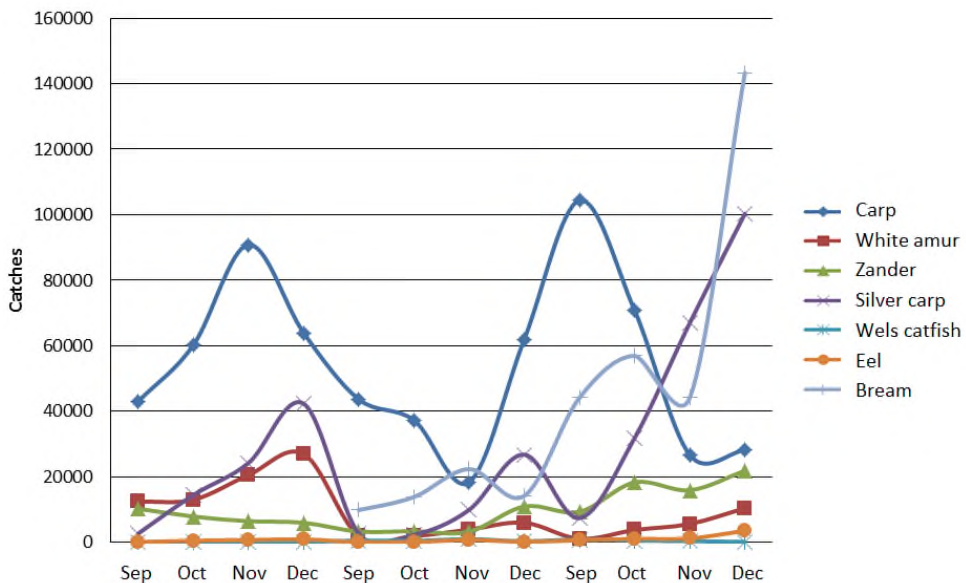


Fig. 1. Dynamics of the catch of the Tudakul reservoir, in kgs (2018-2020).

In general, we have the following ideas about the fish species in the fishery in the Tudakul reservoir in the 2000s.

Carp - dominated in catches in 2003-2020, was the main target of the catch. In 2020 alone, less than 330.9 tons/year of carp were caught (Fig. 2). Until 2008, carp was the only major fishing target. The peculiarity of carp in catches is its source of appearance in the reservoir. There is both natural spawning and stocking of the reservoir at the underyearling stage, and of a very large size (much more than the normative 25 g), which means at a very viable stage.

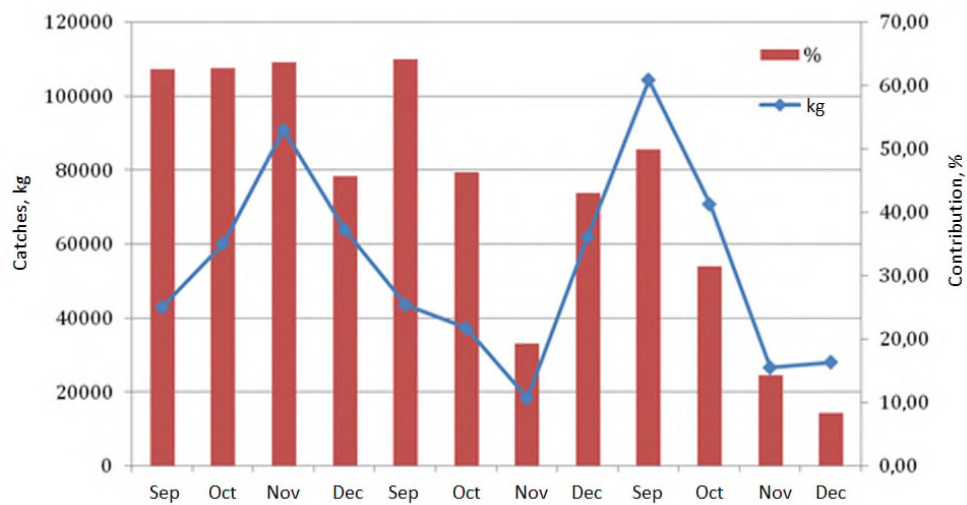


Fig. 2. dynamics of the catch and the relative contribution of carp in the catch of commercial fish in the Tudakul reservoir by years 2018-2020.

An unambiguous idea is given by the catches of silver carp. In some years, silver carps were important for fishing, this type of massive strategy of annual stocking of fish with very large underyearlings. In the autumn-winter period of the year, fishing was focused on schools of fish accumulated during this period (in September-February). This indicates that the technology of non-water fishing for silver carp has been mastered (Fig. 3).

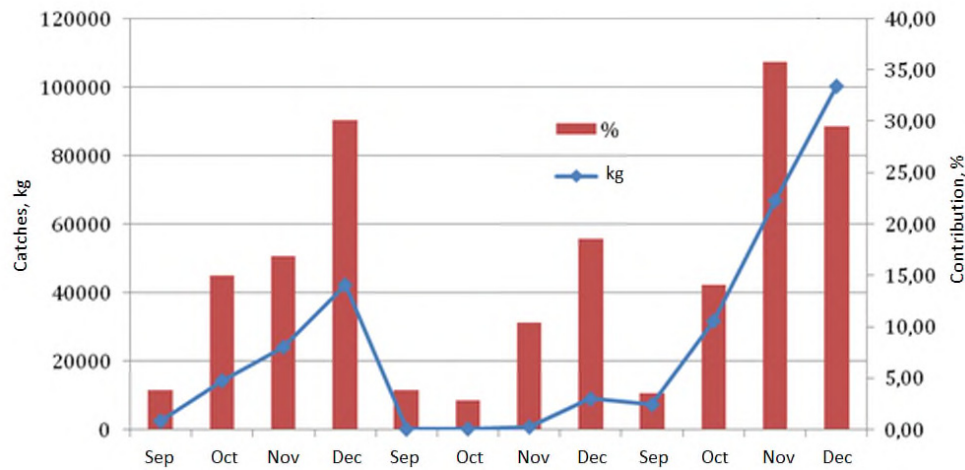


Fig. 3. Dynamics of the catch and the relative contribution of silver carp in the catch of commercial fish in the Tudakul reservoir by years 2018-2020.

The data on the catch of white amur confirm that the catch increases in the autumn-winter period, so in December 2018 the catch was 26.9 tons in equity participation, carp - 19% in January the catch was 12.6 tons, 13% (Fig. 4).

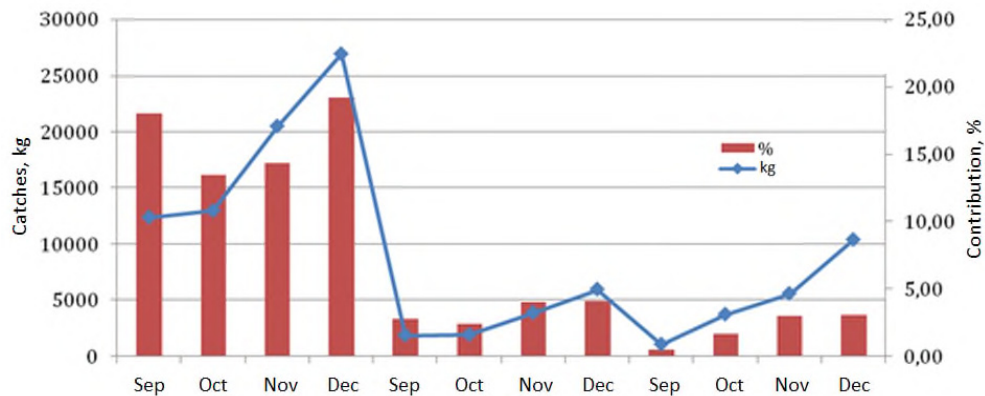


Fig. 4. Dynamics of the catch and the relative contribution of white amur in the catch of commercial fish in the Tudakul reservoir by years 2018-2020.

With regard to zander, there is a feeling that fishing in the first half of the 2000s did not focus on this species, did not cover this species. Apparently, fishermen simply did not know how to catch them on such a scale. In 2020, this species was caught in large numbers up to 60 tons and accounted for 32% of the total catch. It is clear that this massive catch of pike perch in the reservoir led to an increase in the total catch of commercial fish, a further increase in catch does not affect the increase in the share in the total catch. Zander stocks reproduce naturally (Fig. 5).

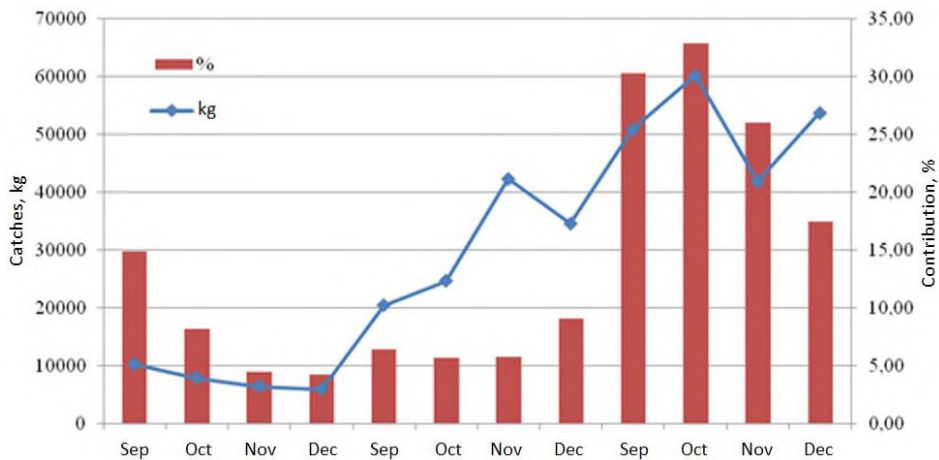


Fig. 5. Dynamics of the catch and the relative contribution of zander in the catch of commercial fish in the Tudakul reservoir by years 2018-2020.

Such valuable fish species as eel and common catfish are insignificant in the catches in the Tudakul reservoir, but the increase in the share in the catches varies in direct proportion to the catch volume (Fig. 6).

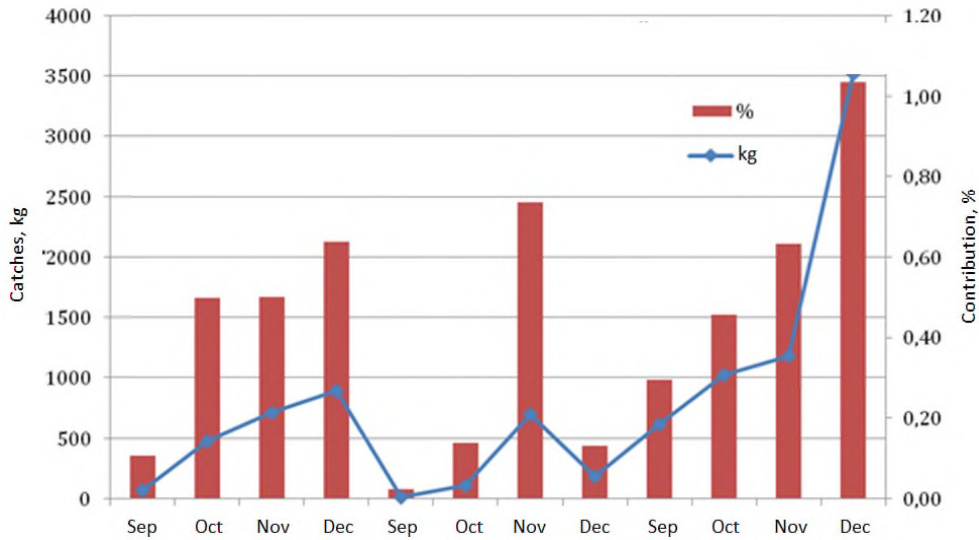


Fig. 6. Dynamics of the catch and the relative contribution of eel in the catch of commercial fish in the Tudakul reservoir by years 2018-2020.

Of the entire ichthyofauna of the Tudakul reservoir, only 10 species of fish are present in the catches. From commercially valuable, in demand, incl. at the international level, only zander, since the second half of the 2000s, has become an important and main fishing target. The composition of the population of commercial fish has stabilized and the increase in catch is explained with an increase in the number, but the percentage ratio remained within the established composition. Two other valuable fish species - eels and wels catfish - are present in the catches in scanty quantities, but their share of the catch increases with an increase in their volume in the catches. Zander are among the most valuable species at the international level, but some increase in the catch volume is not accompanied by an increase in the share in the total catch. For zander, the stability of the share in the fishing load is characteristic, since its value depends on the populations of small, weedy, and low-value fish in the reservoir.

4 Conclusions

Wastewater is brought into the reservoir mainly with the waters of the river. Fisheries statistics indicate that the maximum fish catches in the Tudakul reservoir were obtained in 2020, where the basis of the fishery was formed by valuable acclimatized species - carp, white amur, silver carp, bream and zander. The replenishment of the carp herd occurred exclusively through stocking and natural reproduction, which led to sharp fluctuations in the size of catches from year to year.

Effective fishery use of the high potential production potential of the Tudakul reservoir in the future should be based on the cultivation of valuable cyprinid fish species that make optimal use of the fodder base of the reservoir, as well as when carrying out recommended fish breeding operations in the reservoir, in order to avoid food competition between farmed and low-value species, it is expedient to develop a technology for the creation of brood herds of catfish and snakeheads.

The most promising developments in technology will be work on the creation of broodstock of wels catfish and eels, the development of technology for their large-scale artificial reproduction and, possibly, stocking the reservoir.

Stable annual catches of farmed species can only be ensured if the reservoir is regularly stocked with viable planting material. Undoubtedly, the rational use of natural fish stocks in the Tudakul reservoir can also be determined by the regulation of fish populations such as zander, eels and wels catfish.

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