The role of reservoirs in changing the species composition of the ichthyofauna (on the example of the Kuibyshev reservoir)

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Abstract. The article presents data on the composition of the ichthyofauna of the Kuibyshev reservoir for the period (1957-2017). A list of fish in the reservoir is presented, compiled from recent studies, taking into account new taxonomic revisions and reports (13 units, 19 families, 47 genera and 59 species). During the existence of the reservoir, its ichthyofauna was replenished with 18 new species, 9 of which formed self-reproducing populations.

Introduction

Human economic activity, including the construction of canals and reservoirs, the activation of navigation, artificial introduction, cage culture of fish and many others lead to a change in the species composition of the ichthyofauna of water bodies and often to the expansion of the natural area of species. The Kuibyshev Reservoir is located in the industrial and densely populated area of the Middle Volga, belongs to multi-purpose reservoirs. The Kuibyshev Reservoir is the largest in Europe and in the Volga-Kama cascade, is regulating more than 90% of the water resources of the Volga basin [1]. The reservoir arose due to the regulation of the Volga River stream (1955-1957) by hydro-engineering structures of the Kuibyshev hydroelectric complex in the Zhiguli Mountains, which led to a significant change of the composition of the ichthyofauna.

In the first years after the Volga River damming, almost all the migratory fish species fell out the ichthyofauna composition [2]. During the sixty-year period of the existence of the reservoir, registered catches of these species occurred only in the first years after the creation of the reservoir, except of some cases [3]. Subsequent changes of the composition of the ichthyofauna took place due to acclimatization and fish-breeding activities conducted on the reservoir and accidental importation of species (incidental acclimatization), as well as penetration and dispersal of alien species both from the north and from the south, and still go on in present time [4].

The purpose of this work was to analyze the changes of the species composition of the ichthyofauna of the Kuibyshev Reservoir during period of its existence (1957-2017), the ways of alien species introducing and to compile a list of fish inhabiting in the reservoir, taking into account new
taxonomic revisions and summaries.

Table 1. Fish and fish composition of the Middle Volga River and Kuibyshev Reservoir

| Family                                      | River Volga | Reservoir 1957-1969 | Reservoir 1970-2017 |
|---------------------------------------------|-------------|-----------------------|----------------------|
| Fam. Petromyzontidae Bonaparte, 1832 – Minnow | +           | -                     | -                    |
| Number of species                           | 2           | -                     | -                    |
| Fam. Acipenseridae Bonaparte, 1831 – sturgeon | +           | +                     | +                    |
| Number of species                           | 5           | 3                     | 2                    |
| Fam. Anguillidae Rafinesque, 1815 – river eels | -           | +                     | +                    |
| Number of species                           | -           | 1                     | 1                    |
| Fam. Clupeidae Cuvier, 1816 - herrings      | +           | +                     | +                    |
| Number of species                           | 3           | 1                     | 1                    |
| Fam. Cyprinidae Fleming, 1822 - carp        | +           | +                     | +                    |
| Number of species                           | 25          | 24                    | 27                   |
| 1.1. Fam. Balitoridae Swainson, 1839 – baloric | +           | +                     | +                    |
| 1.2. Number of species                      | 1           | 1                     | 1                    |
| 1.3. Fam. Cobitidae Swainson, 1838 – void   | +           | +                     | +                    |
| 1.4. Number of species                      | 2           | 2                     | 3                    |
| 1.5. Fam. Siluridae Cuvier, 1816 – catfish   | +           | +                     | +                    |
| 1.6. Number of species                      | 1           | 1                     | 1                    |
| Fam. Esocidae Cuvier, 1816 – pike           | +           | +                     | +                    |
| Number of species                           | 1           | 1                     | 1                    |
| Fam. Osmeridae Regan, 1913 – smelt          | -           | +                     | +                    |
| Number of species                           | -           | 1                     | 1                    |
| Fam. Coregonidae Cope, 1872 – whitefish     | +           | +                     | +                    |
| Number of species                           | 1           | 2                     | 2                    |
| Fam. Thymallidae Gill, 1884 – grayling      | +           | -                     | +                    |
| Number of species                           | 1           | -                     | 1                    |
| Fam. Salmonidae Rafinesque, 1815 - salmonids| +           | +                     | +                    |
| Number of species                           | 3           | 2                     | 2                    |
| 1.7. Fam. Lotidae Bonaparte, 1837 – billets  | +           | +                     | +                    |
| 1.8. Number of species                      | 1           | 1                     | 1                    |
| Fam. Gasterosteidae Bonaparte, 1831 – sticky | -           | -                     | +                    |
| Number of species                           | -           | -                     | 3                    |
| 1.9. Fam. Syngnathidae Rafinesque, 1810 – needle | - | + |  + |
| 1.10. Number of species                     | -           | 1                     | 1                    |
| Fam. Cottidae Bonaparte, 1832 - kerchak, slingshot | + | + | + |
| Number of species                           | 1           | 1                     | 1                    |
| Fam. Percidae Cuvier, 1816 – percids        | +           | +                     | +                    |
| Number of species                           | 4           | 4                     | 4                    |
| Fam. Odontobutidae Hoese et Gill, 1993 - Headed | -           | -                     | +                    |
| Number of species                           | -           | -                     | 1                    |
| Fam. Gobiidae Fleming, 1822 – goby          | -           | -                     | +                    |
| Number of species                           | -           | 2                     | 5                    |
| Total species:                               | 51          | 48                    | 59                   |

Note: + - species of the family are marked in the reservoir; - family species in the reservoir are not found.
In the Middle Volga area, on the area of the Kuibyshev reservoir, before the regulation of the runoff (1955-1957) 51 species of fish were found. 36 species were the permanent inhabitants of the river, among which the most numerous were bream, pike, bluefish, roach, ide, perch, bleak, etc. Among the valuable commercial species, a lot of sterlets were found. Zander was observed in commercial value, although the herd was not so big. The commercial herd of river carp was insignificant, and the total commercial river catches during this period ranged from 1.35 to 1.91 thousand tons per year [5, 3].

Dams construction of the Zhiguli Hydroelectric Power Station on the Volga River radically changed the habitat of fish and adversely affected on the number of migratory species, significantly changing fish composition of the reservoir (Table 1).

The spontaneous formation of the ichthyofauna of the Kuibyshev reservoir during its formation, often unfavorable conditions for the reproduction of fish, prevented the creation of large commercial stocks of valuable species in the reservoir. While secondary and low-value fish, having high ecological flexibility, increased their numbers sharply. This was also promoted by the absence of large-scale works of the fish population reconstructing by increasing the number of economically important high-value species [5]. In the initial period of the reservoir formation, a number of fish-protecting measures, for example, acclimatization and fish-breeding operations, including a prohibition of fishing for sturgeon, bream and pike-perch, but allowing the capture of low-value fish and pike were carried out. At the same time during this period, in order to increase the carp population, 1 million young carps and 33 thousand of its producers, caught in the lower reaches of the Volga, were let out the flooding zone. In addition, about 1000 specimens of sturgeons were transplanted from the lower reaches of the reservoir and the output of pike-perch producers was planned [6].

In 1961, a fish lift was installed at the hydroelectric station dam from the lower tail of the Volga hydroelectric power station to the upper for passing fish (sturgeon, herring, etc.). For the period of fish lift functioning (from 1961 to 1988), about 13 million valuable species of fish were led to pass. After stop of fish lift functioning at the Volgograd hydroelectric power station in 1988 a single penetration of sturgeon, stellate sturgeon and whitefish continued through the shipping lock of the Saratov hydro system up to 1993, but the beluga was no longer marked [7].

According to Lukin [8] and Kuznetsov [3], after the construction of the dams on the Volga River, large spawning migrations of beluga to the Middle Volga and the Kama River ceased, and juvenile beluga did not occur from 1957 to 1962 in the reservoir. According to the authors, the remaining producers matured and spawned, and their young fishes were caught for several years.

The last recorded capture of the beluga was noted in the Kuibyshev Reservoir at the end of October 2000 on the border of the Volga-Kamsky and Tetyushsky reaches above the Tetyusha town. This was the female beluga in the fourth stage of maturity, weight 255 kg, and length 270 cm which was caught in the trawl. The age of the beluga was 48-54 years (51.75 ± 0.75). Probably, this fish appeared in the first years after the dam construction from the remaining producers. This is indicated by the ratio of the age of the reservoir and the age of caught fish.

Changes of the conditions of fish habitat in the reservoir affected the number of native species. Ecologically flexible species, capable of adaption to new conditions, not only remained numerous, but their numbers increased significantly. However, the number of carp and some rheophilic species such as the Volga substance, sterlet, etc. decreased as a result of the instability of the level regime in the spring spawning period. However, in new conditions, the number of pike-perch, borsch and perch began to increase.

According to our and literary data [9, 10], common and lake minnow, white gudgeon, moustached char, Siberian plucking, ordinary plucking, common loach, European grayling, brook trout, ordinary stalking occur in the mouths of rivers flowing into the reservoir. The absence of such species as the white-fronted gudgeon and the Siberian shchipovka [10] in some of the earliest fish lists of the Volga River and the Kuibyshev reservoir [11, 12] was explained by not sufficiently developed of the taxonomy at that time. But in our opinion, clear species criteria were not developed at that period. This is confirmed by the description of a white minnow in the identification guide of Berg [13], who was
noted in the Volga River near the Kazan city.

Thus, at present time 59 species of fish belonging to 13 orders, 19 families and 47 genera are found in the Kuibyshev reservoir. More than half of them - 30 species or 51.7% - commercial, 17 or 29.3 - invaders, 9 or 15.5% - rare species included in the Red Book of the Republic of Tatarstan.

**Conclusion**

At the present time, migratory fish species fall out from the fish population of the Kuibyshev reservoir, but species appeared that not inhabited previously, but was purposefully or independently introduced. Some of them have successfully naturalized, reached a sufficient number and are used in fishery. Others multiply and become common species with a local distribution. The Far Eastern pelagophilic herbivorous species did not naturalize, the number of which is supported by production volumes and controlled. These species, being valuable objects of pond cultivation, with optimum volumes of their production could be effectively used to grow in the natural conditions of the reservoir, which would contribute to improving fish productivity of the reservoir.

The ecological relationships of fish in the Kuibyshev reservoir formed. But due to the poor knowledge of the way of life of the majority of invaders and the lack of information of the dynamics of the number of their populations, it is difficult to assess their impact on the ecosystem of the reservoir. However, our own monitoring investigation demonstrates that the process of forming the ichthyofauna of the Kuibyshev reservoir is going on.

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