The state of ichthyofauna of Yakutia in modern conditions

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Abstract. The article presents the results of many years of research on the fish fauna of Yakutia. Big changes in the general ecological situation, especially the influence of the anthropogenic factor, had a negative impact on individual structural indicators of populations.

1. Introduction
On the territory of Yakutia, almost 0.5 million rivers flow with a total length of more than 1.5 million km. Snow and rainwater and to a lesser extent glaciers, ice and groundwater take part in the feeding of rivers. Most rivers are characterized by high spring floods. Every year, rivers infuse about 900 km² of fresh water. The freezing season lasts 6-8 months, the thickness of the ice cover reaches 3 m. The total number of lakes with an area of 1 ha is about 709,000.

The most modern fish fauna are heterogeneous in origin; they are composed of various faunistic complexes. The distribution of fish of Yakutia is presented in the Table 1.

Table 1. Distribution of fishes in Yakutia according to their faunatal complexes.

| Arctic | Arcto-boreal | Boreal foothill | Boreal plain | Chinese plain | Other | Total |
|--------|--------------|----------------|--------------|---------------|-------|-------|
| (n=12) | 7            | 5              | 13           | 4             | 2     | 43    |
| %      | 28           | 16             | 12           | 30            | 9     | 100   |

2. Material and Methods
The main objects of our research were the fishes from the waters of Yakutia, living in conditions of anthropogenic pollution. A complete general biological analysis (morphometry, size-age composition, population estimation, etc.) was carried out for all of them. From June to December 1970-2018, the collection and processing of materials were carried out. The processing of caught fish was carried out according to the methods generally accepted in ichthyology (developed by I. F. Pravdin [1]), using the methodological instructions developed by M.V. Mina [2] and Yu. S. Reshetnikov [3]. They were verified according to the latest reports “Atlas of Freshwater Fish of Russia” [4].
3. Results

Arctic fish (28%) and arctic-boreal fish (16%), which together account for about half of the species list (44%), form the basis of the fish fauna. Typical arctic species are the coregonus (Coregonus clupeaformis), salvelinus (Salvelinus alpinus alpinus), and fourhorn sculpin (Myoxocephalus quadricornis). The boreal lowland complex follows them in the number of species (30%); the fish of the Boreal foothill complex (12%) is much smaller (this is the Siberian stone loach, the Siberian grayling, lenok, taimen, and malma). There are relatively many representatives of the Chinese lowland complex (9%), to which we refer the Soldatov’s Gobio, Czekanowski’s minnow, as well as the Amur and Lake minnow. The main range of this group of fish is located in the Amur basin (Russia) and in China. Among others, we would like to note the roach (Rutilus rutilus) as a representative of the Ponto-Caspian complex and catarotomus (Catostomidae), who clearly came from the region of North America.

Most of the rivers and lakes of Yakutia are located north of the Arctic Circle in the Arctic zone; therefore, the ichthyofauna of Yakutia has features of the Arctic fauna. As we move from the European part of the Arctic to Siberia, i.e. with an increasing continental climate, the number of Arctic species increases, with a general trend of decline in the total number of species (Table 1). This is one of the characteristic features of the Arctic ichthyofauna.

Another characteristic feature of the Arctic is the low endemism of ichthyofauna at the level of families (5%) and genera (2%). So, there is not a single endemic unit for the Arctic among all fish. Only 2 species (or 5%, Yakut loach and Chersky loach) of 43 species and subspecies of Yakutia are endemic. A small number of monotypic genera (nelma, burbot) is typical for Yakutia, as well as for the whole Arctic. There are well represented species with a wide, almost circumpolar range (omul, nelma, whitefish, arctic char, pike, perch, ruff) and with a complex intraspecific structure (omul, whitefish, and charrs).

It was noted earlier that polymorphism and omnivore are the characteristic features of the Arctic ichthyofauna, and these features equally apply to Yakutia’s water bodies. Properties such as burrowing in silt for the winter (two types of crucian carp, Carassius auratus and C. carassius) can be considered as one of the devices for living in these conditions. Broad whitefish (Coregonus nasus) spawns during freezing, and it develops in this mixture of ice and water at first. It is believed that in many whitefish fish, caviar can develop in the ice [5], [6].

There are several highly specialized fish in the food line in Yakutia. By the nature of feeding, benthophages (40%) and euryphages (29%) prevail, predators ichthyophages (19%) and zooplanktophages (10%) are relatively small, and only one detritophages species is represented (Siberian lamprey, 5%). At times, the Siberian bullhead, both smelt species and even the Siberian grayling and humpback whitefish go on to eat fish [7], [8]. The complexity of the structure of the northern ecosystems of Europe and Siberia is not achieved due to the diversity of the number of species, but due to the diversity of intraspecific forms that are energetically equivalent to independent species [9-11]. Therefore, a large intraspecific diversity of whitefish and salmon fishes is interpreted as a result of the evolution of northern ecosystems along the path of increasing the number of internal connections and stability of northern ecosystems.

According to the breeding pattern (type of spawning grounds and the method of laying caviar), all fish are divided into 4 groups. The most species lay caviar on sand (III, 26%) or on stony-pebbly soil (II, 19%), which is typical of many salmon, whitefish, grayling, lamprey, sturgeon, Lagovsky’s minnow, and Soldatov’s Gobio. The majority of carps lay caviar on vegetation (IV, phytophil, 19%). A special group consists of fishes that take care of the offspring (I, 17%). The salmon fishes (flax, pink salmon, chum salmon, loach) dig holes in the ground, where the female lays caviar, and the male fertilizes them with milt, after which the caviar are covered with soil. The caviar finsh choose a place for their nest under the stones, the caviar is deposited in the form of masonry on the underside of the stone and then guarded by the parents (usually by males). The males of the ninespine stickleback (Pungitius pungitius) build a nest from the grass. Then a female lays the caviar into them, and a male protects the nest with caviar all the time until their larvae appear. The main breeding strategy of fish in
the Arctic is designed so that the released larvae can find food and have time to grow in the short polar summer. Spawning, which occurs not every year or more, is characteristic of many fishes.

If one does not take into account the region of Anabar, then the specificity of this region (Khrom, Indigirka, Alazei, Kolyma) is that there is no longer Kamchatka lamprey, roach, ide, trout, small smelt. The areas of the Siberian and variegated cotto, fourhorn sculpin, perch, and ruff end there. Kolyma was the border, beyond which to the east, all sturgeon, many carp and all perch fishes did not pass. Only here, in the rivers of Kolyma, Alazei, and Indigirka, the first representative of the American fauna, *Catostomus*, appear. The malma (*Salvelinus malma*) appears in the Kolyma. The Pacific salmon spawning is also more frequent in that region, while the pink and chum salmons are in Indigirka and Kolyma).

One of the promising methods for assessing the anthropogenic effects is bioindication, when a degree of impact is assessed by the response reactions of the biological systems themselves. The content of mercury in the organs and tissues of fish varies in the most polluted areas, mostly in the diamond and gold mining industrial zones, from 1 to 3 MPC. As a result, the reduction in the number of fish species in the Vilyuy River is noted from 26 to 19. The excess of cadmium in freshwater fish in Yakutia is 1-2 MPC, while localizing mainly in the gills and liver of fish. The highest lead content was found in the Khroma River, where its content in organs and tissues was 1.0-1.7 MPC. In the Khroma River, the zooplankton biomass decreased from 80 to 4.2 mg / m^2.

4. Discussion

Thus, the water bodies of Yakutia, as well as all of Siberia (with the exception of Anadyr), belong to the Ledovitomsk province of the Siberian district, in which there are 3 districts: (a) Ob and Yenisei region, (b) Lena region (Olenek, Lena, Yana), and (c) Kolyma region (Khroma, Indigirka, Alazey, Kolyma).

The deterioration of water quality and changes have affected the structure of the whole community of freshwater ecosystems, ranging from invertebrate organisms to fish. First of all, this was manifested in the appearance of morpho-pathological anomalies in fish.

5. Conclusion

The whitefishes (*Coregonus*) are the most common species in the rivers of the Far North. It was shown that renal stone disease, pathologies in the skeleton and disturbances in the reproduction system were detected based on the analysis of changes in morpho-physiological indicators in natural water bodies. One of the measures for the biological diversity conservation is the organization of ichthyological monitoring, as well as the expansion of the geography of fishing due to the development of fish stocks in the upper and middle reaches of rivers. Another measure implies including the fish-rich lake systems and coastal areas in the fishery.

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