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Geographic information mapping methods as a basis for systematization of environmental monitoring data on the Angara River system

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ABSTRACT. This work proposes a model for the application of cartographic and geographic information mapping methods to systematize environmental monitoring data. In particular, based on the results of sampling and study of biological material (roach, Rutilus rutilus (Cyprinidae, Cypriniformes)) from the Angara River system, we obtained an array of information this could be processed and organized on its basis by means of a cartographic presentation of research materials on the state of the environment of water bodies in the Irkutsk region.

Keywords: Angara River, aquatic biological resources, water bodies, geographic information technologies, water pollution, information technology, cartography, axial skeleton, phenotypic deviations, Rutilus rutilus, ecology.

1. Introduction

Formation of unified thematically structured information base on the ground of geographic information technologies, which will be regularly replenished with statistics on the general ecological state of monitored water bodies can be a useful tool for evaluating situation and determining ways for the optimal implementation of economical and managerial actions by organizations operating in the field of water bodies. This work aims to test methods of geographic information mapping in the field of environmental monitoring of water bodies. The assessment of the state of surface water in the Angara River is based on a biological indication method, including the study of axial skeleton phenotypic deviations in roach, *Rutilus rutilus* (Cyprinidae, Cypriniformes).

2. Materials and methods

Samples were taken with gill nets at four stations of the Angara river near large settlements in the summer of 2016-2017 (Table 1, Fig. 1). Mature roaches, *R. rutilus*, at the age of three-four years served as the study material

To characterize study areas, we used the data presented in official sources for the period that corresponds to the early ontogenesis of roach shown in the samples (O sostoyanii…, 2016).

Osteometric analysis and the study of skeletal anomalies were carried out according to previously developed methods (Yakovlev and Izyumov, 1988; Chebotareva et al., 2016). The indicator proposed by L.A. Zhivotovsky (1982) was used as the diversity measure of vertebrate phenotypes and anomalies within populations.

$$\mu_{zh} = (\sqrt{p_1} + \sqrt{p_2} + \cdots + \sqrt{p_m})$$

The reliability of differences between the samples was evaluated using the X^2 parameter (adjusted for continuity) (Lakin, 1990). Statistical processing of the material was carried out in the R analysis system (Mastitsky and Shitikov, 2014).

Geographic information mapping is based on the digital modelling of the map using semantic data arrays that reflect the required indicators. A MapInfo geographic information software package was used as a platform basis to form a geographically linked information base (Korosov and Korosov, 2002).

3. Results and discussion

During the study, we determined some quantitative and qualitative indicators of vertebral phenotypic deviations. The highest occurrence and diversity of phenotypic deviations are typical of the populations subject to chronic anthropogenic impact.

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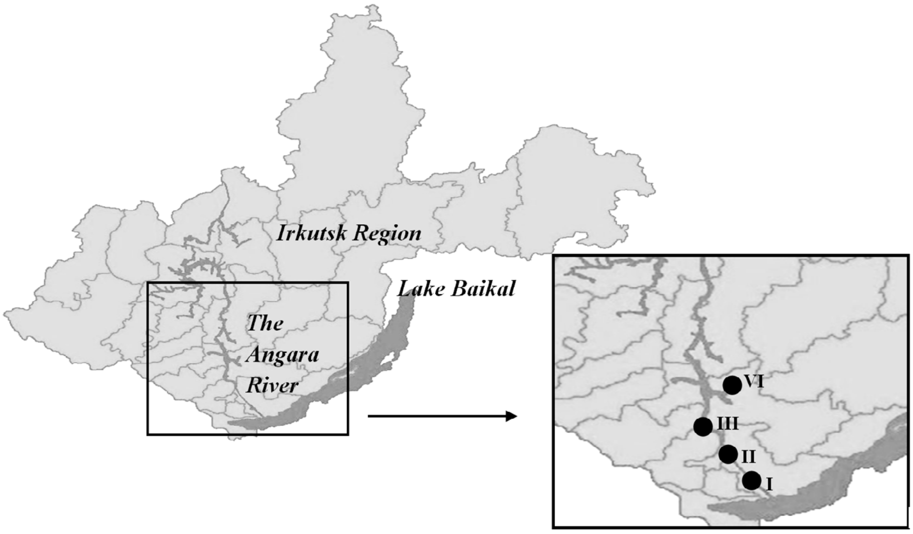

Fig.1. Location of the sampling stations, the Angara River (Irkutsk Region), 2016-2017.

The trend of an increase in individuals with anomalies is typical of the populations living downstream of the Angara River, which corresponds to the data on the quality of surface waters in the Irkutsk Region for the study period.

Based on the obtained data and the section on the map of the Irkutsk Region, we have developed a thematic material that includes gradient zoning of the water area of the Angara system, which reflects the level of deviations and disturbances in roach development interpolated to certain sites of the water area, correlating with the degree of pollution of the aquatic environment. In addition to the zoning, cartographic material includes semantic filling of each site of thematic zoning with statistical information.

4. Conclusion

In the future, we plan to form a universal geographic information cartographic model of the ecological state of natural objects (water resources) to apply its results for the general monitoring of the ecological situation, planning and control of the use of water objects and aquatic biological resources in production, environmental and other types of economic activities performed by the state and its subjects.

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Table 1. The structure of the study material and brief description of the study areas

Station No.	Station location on the Angara River	Station description	Pollution class	Sampling size, ind.
I	The Angara River 15 km from The Irkutsk Hydroelectric Power Station (Irkutsk HPS), near wastewater treatment plant of the city of Irkutsk (Aleksandrovskiy highway)	Backwater, low current, rocky-oozy bottom. Total area of ca. 600 m^2, average depth 1.5 m.	Class 1 “conditionally clean”	64
II	The Angara River 46 km from Irkutsk HPS, 2 km downstream from the town of Angarsk	Backwater, low current, rocky-oozy bottom. Total area of 350 m^2, average depth 2 m.	Class 2 “slightly polluted”	52
III	The Angara River 90 km from Irkutsk HPS, 2 km downstream from the town of Usolye-Sibirskoye	Backwater, low current, rocky-sandy bottom, total area of 420 m^2, average depth 2 m.	Class 3 “slightly polluted”	60
IV	Bratsk Reservoir (upper section), Obus Bay, 210 km from Irkutsk HPS, 70 km from the station III	Bay, no current, sandy bottom, total area of 800 m^2, depth of up to 7 m.	Class 2 «slightly polluted»	65

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