



Results and perspectives of fish population studies in the central lake-river system of the Meschera lowland

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The study presents results of studies of fish fauna inhabiting the central lake-river system of the Meschera lowland. It includes the following structural elements: river Buzha, Klepiki (Great) lakes, river Pra, supplementary system of river Pra (tributaries, channels, inlets, oxbows and lakes), watershed lakes of river Pra's high floodplain, lakes of River Oka and river Pra combined floodplain. Studied lake-river system is characteristic of having a high share of phytophilous fish species with long and average life cycle duration – bream, zope, ide, silver bream and pike. Optimal conditions of their reproduction are present in the river Pra's supplementary system, especially in the inlets, oxbows and lakes of average size as well as in lakes of River Oka and river Pra combined floodplain. We suggest that the shallow Klepiki lakes and, possibly, river Buzha play an important role in the reproduction of these species. However, there is few data on the last two elements of the lake-river system.

The studied part of Meschera lake-river system is notable for high fecundity of fish inhabiting it. Under favorable climatic conditions and the absence of anthropogenic press (poaching) present structure of fish fauna with high abundance of phytophilous fish species with long and average life cycle duration is likely to remain in a stable state.

Keywords: lake-river system, hydrography, Meschera lowland, fish fauna.

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Introduction

Meschera – lowland, located in the interfluvium of the Oka, the Moskva River and the Klyazma. The total length of it from north to south is 190 km, and from west to east – 210 km. Most of Meschera is covered with forests and swamps, it occupies the east of Moscow, the south of Vladimir and the northern territory of the Ryazan regions. Oka – right tributary

of the Volga River and the second largest after the Kama River, enters the Meshcherskaya lowland below the confluence of the Moskva River (Krivtsov et al., 2008).

The central lake-river waterway of Meschera – the river Pra (the tributary of the Oka) and its associated waterbodies – carries out water exchange with the mother River Oka and is of great importance

in “replenishing” its fish stocks in the Meshcherskaya lowland area. The river Pra not only itself provides extensive areas for spawning, having a wide (up to 2 km) floodplain, but also serves as a link between the Oka and the shallow water system of the Klepiki (Great) lakes.

Meshcherskaya lake-river system is unique for the entire Oka basin. The study of such lake-river systems is currently one of the most promising directions in ichthyology and in hydrobiology in general (Barskaya, 2005; Denisov et al., 2009; Novoselov et al., 2013). Other large and medium-sized tributaries of the Oka River (Ugra, Zhizdra, Moskva, Pronya, Para, Moksha, etc.), even if they have a subordinate system of waterbodies, do not have lake systems in their upper reaches. In addition, some of them are located within the Central Russian Upland, where rivers usually do not form floodplains

(Milkov and Gvozdetsky, 1976), and therefore, the development of the limnophilous complex of long-cycle and medium-cycle commercially important fish species does not occur (Nikolsky, 2013). The study of fish population of such lake-river systems makes it possible to evaluate their role in the life cycle of various fish species, primarily as spawning grounds and feeding grounds in the Oka basin. They are also of great importance because the diversity of biotopes of the system allows them to be inhabited by fish species that are characteristic of the whole territory of Meshchera (Ivanchev and Ivancheva, 2010).

Special scientific literature on the ichthyofauna of the upper reaches of the river Pra and Klepiki (Great) lakes is relatively few, and unevenly distributed on the time scale. Two articles devoted to the study of fish are known for the Klepiki lakes. One of them dealt with various questions of the biology of the goldfish of Lake Velikoye (Ponomarenko, 1963), and in the other (Spanovsky and Grigorash, 1963), along with the general commercial characteristic of lakes, there are data on fish species composition. Thus, nine fish species were noted for Klepiki lakes: common pike, bream, gold fish, ide, sunbleak, roach, common ruffe, river perch and loach. This work also indicates that bream in the Klepikovskiy lakes is small, and all other species, especially the sunbleak, ruffe, river perch and loach, are numerous or common. Even though fragmented, this information is very interesting and important, since they are based on specially conducted studies and can be used in the future for comparison.

Part of the information on fish in the area of interest is given by Babushkin (1990) and Babushkin and Babushkina (2004).

On the river Pra and its subordinate system, ichthyofauna characteristics are given in a number of works (Ivanchev and Ivancheva, 2010, 2015a, b). Data were obtained in 2002–2011 during fishery surveys conducted on rivers (Pra, Belaya, Sovka) using a fine-mesh beach seine. These studies have shown that a complex of dominant species on river Pra includes long-cycle and medium-cycle phytophils within its entire length: bream, silver bream and roach; zope, ide and river perch are common as well. Zope, bream, ide, roach and pike are common and numerous in the tributaries of Pra – rivers Sovka and Belaya. Wels catfish is common in the lower reaches of Pra. No modern scientific data on the ichthyofauna of Klepiki lakes is available.

The purpose of this study is to assess the role of various aquatic elements in the lake-river system of Meschera lowland in maintaining the existing structure of fish population, characterized by a large proportion of commercially important long-cycle and medium-cycle phytophils – bream, zope, ide, pike, wels catfish, etc.

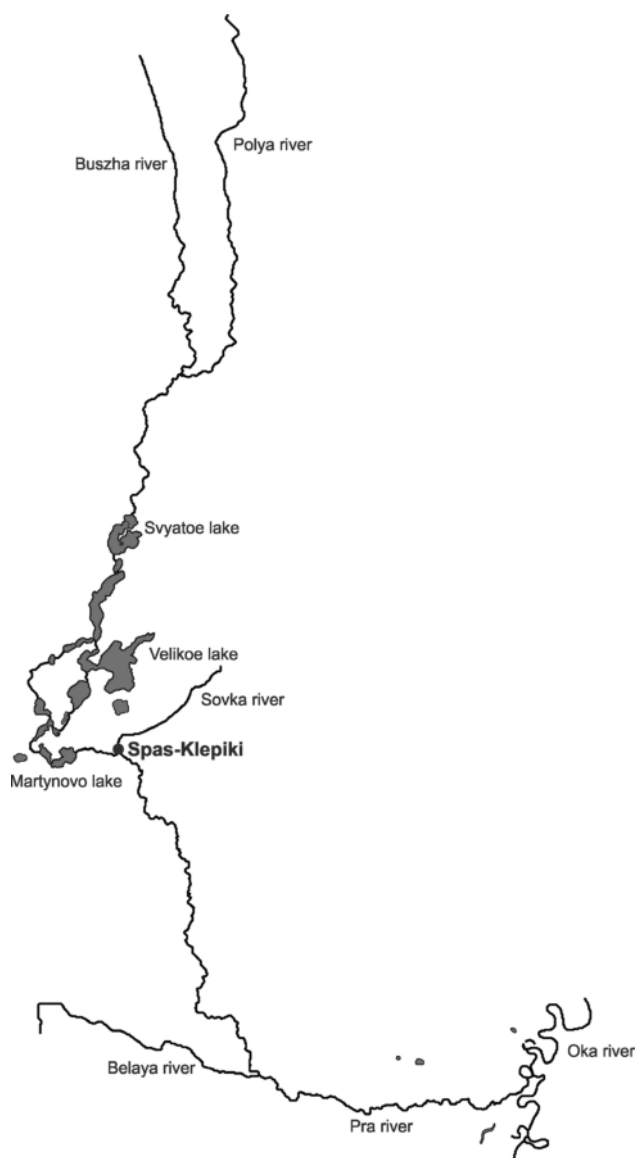


Fig. 1. Scheme of the studied area.

Material and methods

Description of the research area

The central lake-river waterway of Meschera begins in the Vladimir region, where it is represented by Buzha River. Buzha is closely connected with the Klepiki lakes – a system of lakes at the junction of the Vladimir, Ryazan and Moscow regions. The total area of the Great Lakes is 55.15 km². The northernmost lake of the system – Svyatoye, with an area of 960 hectares – is located on the border of the Moscow and Vladimir regions. River Buzha flows into it, and river Pra that connects all the main lakes of the system flows out. After the lakes Imles and Dubovoye Pra divides into two channels, forming the so-called Meschera lake ring. The left one flows through the Shagara and Ivanovskoye lakes, the first of which is connected with the lake Velikoye, the largest of the Klepiki lakes (2,200 hectares). The right flows through another Svyatoye lake, heavily overgrown Shaturskoye and Valdevo lakes, and then lake Sokorevo (Borutsky, 1928). All of them are connected to each other by ducts, being included in the lake system of river Pra. The lowest lake of the system is Martynovo, after which the Pra flows to the town of Spas-Klepiki by two channels, forming a system of marshy islands. The final fusion of the ducts occurs in front of the village of Pervushkino (Krivtsov et al., 2008) (Fig. 1). Two deep-water lakes, Lebedinoe and Bloye are somewhat apart from the system of lakes not connecting with them by permanent channels. The latter have connection to the main system of lakes only during the spring flood. Throughout the entire length of the Pra up to its confluence with the Oka, such large lakes are not found on its path, but in the middle, and especially in the lower reaches of the river, Pra has a highly developed subordinate system. Klepiki lakes are of glacial origin, their depth usually does not exceed 2 m, and most of the lakes are winterkill: in winter the smallest waterbodies can freeze to the bottom (Table 1).

The length of Pra is 167 km, the area of the basin is 5,520 km²; it flows into the Oka in 479 km

from its mouth. The bed of the river is sandy, in some places silted, the width in the middle is 25–50 m, the depth is 0.5–2.0 m, heavily snagged. The channel meanders strongly, forming a large number of bends, channels, inlets and oxbows. Pra has several tributaries. According to its hydrochemical composition it is a winterkill river (Grobova, 2008), so in autumn fish usually migrate downstream into Oka.

Thus, we can distinguish the following elements of the central lake-river system of the Meschera lowland: 1) the Buzha River, 2) the Klepiki (Great) Lakes, 3) the Pra River, 4) the additional system of the Pra River (tributaries, streams, inlets, oxbows and lakes), 5) watershed lakes of Pra's high floodplain, 6) lakes of the common Oka-Pra floodplain. They differ among themselves in terms of hydrological parameters, and in many cases there is an alternation of lentic and limnic character. In addition, the elements of the lake-river system of the Meschera lowland we mention, differ in terms of the nature and extent of the ice cover destruction: on rivers it passes at an earlier time in the form of an ice drift. Then the waterbodies of the subordinate system Pra and the lakes of the common Oka-Pra floodplain are freed, from which the ice is either carried away by the current along the river or diverges in shallow waters. Ice on the watershed lakes of the high floodplain of Pra and Klepiki lakes thaws last. This determines the terms of fish spawning run. The unification of the majority of the system's elements into a single whole occurs during the flood on the Oka, and the individual elements among themselves – during the frequent autumn-winter floods. On the whole, it should be noted that neither Klepiki lakes nor the Pra river provide the conditions for the full life cycle of different fish species, but they provide many of them with vast areas for spawning and feeding on the Meschera segment of the Oka River.

Material and methods

The material used in the preparation of this work was collected during 2002–2017 using various fishing gear. Most of the fish were caught using a fine-

Name	Area (hectares)	Maximum depth, m	Volume, 10 ³ m ³
Velikoye	2040.4	1.5	14901
Ivanovskoye	602.7	1.0	3571
Shagara	374.4	1.0	1870
Bloye (Belozerye)	307.6	2.0	3738
Bloye	33.8	52.3	4315
Martynovo	246	1.6	–
Sokorevo	198	1.9	–

Table 1. Main morphological characteristics of Klepiki lakes (for average water level) from Komarov (2013).

Note: "–" – no data.

Fish species		Klepiki lakes	River Pra	Pra subordinate system	Watershed lakes of river Pra high floodplain	Lakes of common Oka-Pra floodplain
1	Sterlet sturgeon <i>Acipenser ruthenus</i> Linnaeus, 1758	-	+	+	-	+
2	Blue bream <i>Abramis ballerus</i> (Linnaeus, 1758)	+	+	+	+	+
3	Bream <i>Abramis brama</i> (Linnaeus, 1758)	+	+	+	+	+
4	White eye bream <i>Abramis sapa</i> (Pallas, 1814)	+	+	+	-	+
5	Bleak <i>Alburnus alburnus</i> (Linnaeus, 1758)	-	+	+	-	+
6	Asp <i>Aspius aspius</i> (Linnaeus, 1758)	-	+	+	-	+
7	Silver bream <i>Blicca bjoerkna</i> (Linnaeus, 1758)	+	+	+	+	+
8	Prussian carp <i>Carassius auratus</i> (Linnaeus, 1758)	+	+	+	+	+
9	Goldfish <i>Carassius carassius</i> (Linnaeus, 1758)	+	-	+	+	+
10	Carp <i>Cyprinus carpio</i> Linnaeus, 1758	-	+	-	-	+
11	Gudgeon <i>Gobio gobio</i> (Linnaeus, 1758)	-	+	-	-	-
12	Sunbleak <i>Leucaspis delineatus</i> (Heckel, 1843)	+	+	+	+	+
13	Ide <i>Leuciscus idus</i> (Linnaeus, 1758)	+	+	+	+	+
14	Common dace <i>Leuciscus leuciscus</i> (Linnaeus, 1758)	-	+	+	-	-
15	Sablefish <i>Pelecus cultratus</i> (Linnaeus, 1758)	-	+	+	-	+
16	Lake minnow <i>Phoxinus phoxinus</i> (Berg, 1949)	-	-	-	+	-
17	Amur bterling <i>Rhodeus sericeus</i> (Pallas, 1776)	-	-	-	-	+
18	Whitefin gudgeon <i>Romanogobio albipinnatus</i> (Lukasch, 1933)	-	+	-	-	-
19	Roach <i>Rutilus rutilus</i> (Linnaeus, 1758)	+	+	+	+	+
20	Rudd <i>Scardinius erythrophthalmus</i> (Linnaeus, 1758)	-	+	+	+	+
21	Tench <i>Tinca tinca</i> (Linnaeus, 1758)	+	-	+	+	+
22	Stone loach <i>Barbatula barbatula</i> (Linnaeus, 1758)	-	+	+	-	-
23	Siberian spined loach <i>Cobitis melanoleuca</i> Nichols, 1925	-	+	-	-	-
24	Spined loach <i>Cobitis taenia</i> Linnaeus, 1758	-	+	-	-	-
25	European weatherloach <i>Misgurnus fossilis</i> (Linnaeus, 1758)	+	+	+	+	+
26	Wels catfish <i>Silurus glanis</i> Linnaeus, 1758	-	+	+	-	+
27	Pike <i>Esox lucius</i> Linnaeus, 1758	+	+	+	+	+
28	Burbot <i>Lota lota</i> (Linnaeus, 1758)	-	+	+	-	+
29	Ruffe <i>Gymnocephalus cernuus</i> (Linnaeus, 1758)	+	+	+	+	+
30	Perch <i>Perca fluviatilis</i> Linnaeus, 1758	+	+	+	+	+
31	Zander <i>Sander lucioperca</i> (Linnaeus, 1758)	-	+	+	-	+
32	Volga zander <i>Sander volgensis</i> (Gmelin, 1789)	-	-	-	-	+
33	Amur sleeper <i>Perccottus glenii</i> Dybowski, 1877	+	+	+	+	+
Species in total		15	28	25	16	26

Table 2. Ichthyofauna of the central lake-river system of Meschera lowland.

mesh beach seine with a mesh of 6.5 mm and a length of 15 m and a set of kapron trammel gill nets with a length of 75 m and a height of 2 m with a mesh of 18, 30, 40x45 and 60 mm. In addition, nylon gill nets with a mesh of 12, 22, 25, 30 and 40 mm, length of 30 m and a height of 1.2 m were used. Gill nets were set along the shores, with preference to areas that are “in the shade” of the water flow; on the lakes they were located either parallel to the macrophyte beds, or, if the lakes were small, they were set across. Both in the river Pra and on the lakes the beach seine was used on depths up to 1.3 m.

Species, sex and age structure of foraging aggregations as well as data on the morphology of fish were evaluated when catching fish with a set of gill nets. In addition, some materials collected by the authors during the spring observations of spawning fish accumulations since 1970 have been used in the discussion. Caught fish were measured (standard length), weighed, and the scales were taken for age determination (Chugunova, 1959; Pravdin, 1966).

Fish names are given according to Reshetnikov (2002a, b), taking into account the latest changes (Reshetnikov, 2010). When characterizing the abundance of species, Tereshchenko and Nadirov (1996) system was mainly used with changes (Ivanchev and Ivancheva, 2010). We considered the species rare if its share in catches is <0.1%, small – 0.1–1.0%, usual – 1.1–5.0%, numerous – 5.1–10.0%, dominant – >10% and superdominant – >50%.

Indexes based on the Shannon function (Pielow, 1975) were used to describe the species diversity of samples. Quantitative samples of macrozoobenthos were taken using Ekman–Burge bottom sampler with a capture area of 0.01 m² in 4–6 replications, in total 97 combined samples were processed. Laboratory processing of the collected material was carried out according to the standard methodology adopted in the IBIW RAS (Mitropolsky and Mordukhai-Boltovskoy, 1975). The status of benthic communities was assessed by the following parameters: abundance

(N, ind./m²), biomass (B, g/m²), Pantle – Buck index (S), Shannon species diversity index (H, bit/ind.). The quantitative level of feeding capacity of waterbodies for benthophagous fishes is determined by the fishery scale developed by GosNIORKh (Pidgayko et al., 1968). All invertebrate groups except mollusks are referred to as “soft” benthos. The whole “soft” benthos, as well as mollusks with a shell size of less than 14 mm (Zhivoglyadova and Frolenko, 2017) are referred to as “forage” fraction of the zoobenthos.

Data on the water level in river Pra were obtained at the meteorological station of the Oka Reserve.

Results and discussion

Ichthyofauna of the central lake-river system of Meschera lowland

Information on the taxonomic composition of fish fauna of various sections of the central lake-river system of the Meschera lowland is presented in Table 2.

In total 33 species of fish were recorded the central lake-river system of the Meschera lowland, but none of the five presented elements of the system showed a complete set of region’s ichthyofauna. The maximum number of species was found in river Pra, a close number is observed in the waterbodies of the subordinate system of river Pra and in the lakes of Oka and Pra shared floodplain. A significantly smaller number of species, nonetheless forming similar abundance is noted in different types of lakes: Klepiki and watershed lakes of high floodplain (Table 2). It is worth noting that the watershed lakes of Pra high floodplain are connected with Oka and Pra through mires and channels in the years of high floods, therefore making it possible to exchange fish between all structural elements of the system. This fact is particularly important because winterkill watershed lakes receive fish and are able to make up for ichthyofauna composition and numbers during such events.

Fish species	Number of individuals	Share, %
Silver bream	7	17.5
Prussian carp	3	7.5
Ide	2	5.0
Roach	18	45.0
Ruffe	4	10.0
Perch	6	15.0
Total	40	100.0

Table 3. Lake Ivanovskoye fish population structure in 2017.

Fish species	Headwaters		Middle reaches		Lower reaches		Total	
	2002–2009	2017	2002–2009	2017	2002–2009	2017	2002–2009	2017
Blue bream	3.73	1.61	0.47	–	2.27	1.54	2.44	1.41
Bream	28.67	1.56	17.81	2.3	20.99	15.84	22.37	5.45
White eye bream	–	–	–	–	0.09	–	0.07	–
Bleak	0.03	–	0.11	–	1.37	–	0.99	–
Silver bream	36.07	15.07	50.95	0.51	19.76	25.31	25.59	16.12
Prussian carp	–	0.1	–	–	–	–	–	0.06
Gudgeon	0.88	0.14	1.77	1.28	3.90	1.43	3.10	0.62
Sunbleak	0.47	0.76	0.04	–	0.20	–	0.25	0.47
Ide	2.51	22.26	4.96	19.95	5.58	13.86	4.88	19.76
Common dace	0.01	–	0.06	–	1.40	0.33	1.00	0.09
Sablefish	–	–	–	–	<0.01	–	<0.01	–
White fin gudgeon	0.03	0.14	0.09	–	1.31	0.55	0.95	0.23
Roach	14.83	25.72	19.43	68.54	37.86	32.89	31.57	32.54
Rudd	–	–	0.11	–	0.02	–	0.02	–
Stone loach	–	0.05	0.02	0.26	0.03	–	0.02	0.06
Siberian spiked loach	–	–	–	–	0.11	–	0.08	–
Spiked loach	0.01	–	–	–	0.11	–	0.08	–
European weatherloach	0.01	–	–	–	<0.01	–	<0.01	–
Wels catfish	–	–	–	–	<0.01	–	<0.01	–
Pike	0.69	2.13	1.14	–	1.23	1.1	1.11	1.61
Burbot	–	–	–	–	0.02	–	0.01	–
Ruffe	1.12	11.46	0.76	–	3.04	6.16	2.46	8.74
Perch	10.89	18.9	2.24	7.16	0.70	0.99	2.98	12.78
Zander	–	–	–	–	<0.01	–	<0.01	–
Amur sleeper	0.05	0.1	0.04	–	<0.01	–	0.02	0.06
Total number of individuals	12970	2111	4638	391	43529	909	61137	3411
Species in total	16	14	16	7	24	11	24	15

Table 4. Structure of fish population in different sections of river Pra in 2007–2009 and 2017.

Note: «–» – no data.

Fish population and its forage base in various types of water bodies

1. Klepiki lakes

The study of Klepiki lakes is at the initial stage at present. We surveyed lake Ivanovo - one of the largest in the system of lakes. Its area is 640.2 hectares. The lake is shallow and densely covered with aquatic vegetation (reed, narrowleaf cattail and lakeshore bulrush). In winter, it is one of the first to be subjected to winterkill, if weather conditions of the winter period contribute to it. Only six species have been identified in the lake (Table 3). Apparently, this list is not complete including only the most numerous species. The index of Shannon's species diversity for this lake is 2.2, and the coefficient of dominance is 0.15.

2. The river Pra

We surveyed fish population of river Pra in 2002–2009 and 2017 (Table 4, 5). In 2002–2009, structure of fish population in all parts of river Pra was almost the same: everywhere the dominant complex was composed of three species – bream, silver bream, roach. Perch was included in the list of dominant species only in the upper reaches. In 2017, the structure of the dominant species complex varied in different areas. Ide and roach were among dominants in all sections of the river, while bream dominated only in the lower reaches, silver bream – in the upper and lower, and perch and ruffe – only in the upper reaches.

The proportion of phytophilous long-cycle and

Indices	Headwaters	Middle reaches	Lower reaches
Shannon's species richness index	2.29/2.62	2.05/1.37	2.60/2.48
Domination coefficient	0.42/0.31	0.48/0.51	0.43/0.28
Number of species	16/14	14/7	24/11

Table 5. Structural indices of fish population in different sections of river Pra in 2007–2009/2017, %.

medium-cycle (commercially important) fish species in river Pra is much higher (by 1.5–11.4 times) than in the other small and medium rivers running along the Meschera lowland (Table 6), except for those rivers (Ushna) that do not have their own valley, but flow in the flood plain of the mother river (Oka). In addition, the greatest number of species was found in river Pra (Table 6). It seems that the relief of Pra's bed is most favorable for the reproduction and feeding of many species of fish, mainly phytophilous.

3. Subordinate system of river Pra

Subordinate waterbodies and ducts river Pra differ greatly in the duration of connection with the river, size, shape, etc. Of these, we have information on fish population of the following formations: 1) channels, 2) tributaries, 3) inlets, 4) oxbows and medium-sized lakes, 5) small floodplain lakes (Table 6).

In our opinion, it is expedient here to clarify concepts and terms for the designation of hydrological objects. Channels are watercourses connected with the river with both ends throughout the year and having a clearly defined flow. Judging by species structure and nature of dominance (Table 6), fish population differs from that of the river only by a smaller proportion of the rheophilic species complex. Decrease of the current velocity and, correspondingly, the increase in the eutrophication of this section of the river serve as the ecological basis of this structure.

Inlets are waterbodies connected to the river by

one end located downstream. River's sand deposits covered with meadow vegetation or shrubbery block the upper end. In shallow and dry years, inlets can become completely unlinked from the river by the end of the summer. In some cases, they connect with the river by a narrow and shallow stream. In total, twenty species of fish were found in river Pra's inlets. For individual waterbodies, this index varied from 8 to 16 species. Roach, bream and silver bream dominated in the inlets. This type of subordinate waterbodies is one of the most numerous in river Pra. Due to the constant connection with the river, inlets are of great importance in the formation of the fish population of the river, as they provide conditions for habitat for the limnophilous species at all most important stages of the life cycle – spawning, growth of juveniles, foraging of spawners.

The largest number of species lives in the inlets and channels of river Pra. Apparently, these formations on the basis of biotic properties provide fish with the greatest variety of habitats. This is especially true for channels that have a large length and complex configuration.

Floodplain lakes and oxbows of the river Pra also have a fairly rich faunal composition of fish, but due to the greater homogeneity of habitats they are inferior to inlets in terms of species composition. The smallest number of species was recorded in the tributaries of river Pra and small floodplain lakes.

Fish species	Pra	Ushna	Lamsha	Kishya	Gus'
Pike	1.11	2.99	15.64	0.63	2.04
Blue bream	2.44	0.41	0	0	0
Bream	22.37	17.77	0.33	0.03	9.66
White eye bream	0.07	0	0	0	0.02
Prussian carp	0	0.12	0	0.12	0
Goldfish	0	0.59	0	0	0
Silver bream	25.59	24.63	0	5.74	3.85
Ide	4.88	3.17	4.23	0.12	1.23
Roach	31.57	36.54	0	0.63	19.06
Rudd	0.02	3.69	0.65	0.46	0.75
Tench	0.01	0	0	0.09	0
Wels catfish	0.01	0	0	0	0
Perch	2.98	4.81	40.71	0.17	2.19
Total	91.05	94.72	61.56	7.99	38.8
Species total	25	16	10	17	21

Table 6. Share of phytophilous long- and mid-cycle fish in the rivers of Meschera lowland in 2007–2009, %

Species	Channels		Tributaries		Inlets		Oxbows and lakes		Small floodplain lakes	
	2006–2009 (n=2)	2010–2017 (n=3)	2006–2009 (n=4)	2010–2017 (n=3)	2006–2009 (n=7)	2010–2017 (n=8)	2006–2009 (n=7)	2010–2017 (n=5)	2006–2009 (n=7)	2010–2017 (n=2)
Blue bream	2.4–3.8	0–18.7	0–18.7	0–2.9	0–5.9	0–32.3	0–5.5	0.1–9.6	0–0.3	–
Bream	10.2–22.5	0–8.3	0–8.3	5.6–14.0	14.3–35.9	0–33.5	0–34.0	0–3.6	0–18.8	–
Bleak	0–12.4	–	–	–	0–4.4	0–21.7	0–26.3	0–8.3	0–0.3	–
Asp	–	–	–	–	0–0.2	0–12.3	–	–	–	–
Silver bream	0.1–9.2	0–1.0	0–1.0	–	1.5–25.3	0–20.4	0–11.6	0–6.7	–	–
Prussian carp	–	–	–	–	–	0–3.1	0–2.5	0–5.6	0–1.0	4.4–13.5
Goldfish	–	–	–	0–0.1	0–1.9	0–6.2	0–79.7	0–12.7	0–43.2	0.2–21.6
Gudgeon	0–0.9	0–7.1	0–7.1	–	–	–	–	–	–	–
Sunbleak	0–1.7	0–68.4	0–68.4	0–29.6	0–0.1	0–0.1	0–60.2	0–2.0	0–12.5	–
Ide	5.3	0–9.4	0–9.4	4.1–6.1	0.5–5.1	0–6.2	0–4.7	0–13.7	0–32.4	–
Common dace	0–2.8	0–0.5	0–0.5	0–0.9	0–0.1	–	0–0.1	0–0.5	–	–
Sablefish	–	–	–	–	0–0.4	0–2.2	–	–	–	–
White fin gudgeon	0–1.0	–	–	–	–	–	–	–	–	–
Roach	11.0–35.1	10.5–72.9	10.5–72.9	45.5–75.8	25.0–67.5	7.7–83.3	0–50.3	0.1–56.1	0–50.8	–
Rudd	–	–	–	–	0–2.6	0–5.8	0–7.6	0–14.1	–	–
Tench	–	–	–	–	0–15.7	0–4.6	0–7.9	0–13.4	–	0–0.1
Stone loach	0–0.1	0–0.5	0–0.5	0–0.4	–	–	0–0.1	–	–	–
Siberian spiked loach	0–0.8	–	–	–	–	–	–	–	–	–
European weatherloach	0–0.1	0–0.1	0–0.1	0–0.1	–	0–23.1	0–3.4	0–23.5	0–29.4	0.1–2.7
Wels catfish	0–0.11	–	–	–	0–0.1	0–1.5	–	–	–	–
Pike	0.9–3.8	0–10.6	0–10.6	2.9–7.1	1.0–4.8	0–6.2	1.2–31.9	0.4–36.6	5.2–83.9	0–5.4
Ruffe	1.5–2.3	0–1.1	0–1.1	0–2.8	0–1.3	0–13.0	0–0.3	0–2.9	–	–
Perch	0.7–66.1	1.6–45.8	1.6–45.8	3.2–9.1	3.1–14.7	0.5–7.9	0–81.0	0–7.2	0–20.2	–
Zander	–	–	–	–	0–0.2	0–0.1	–	–	–	–
Amur sleeper	–	0–1.0	0–1.0	0–3.4	0–0.8	0–1.5	0–40.9	0–65.1	0–65.0	56.8–95.3
Number of species	9–16	3–11	3–11	5–9	8–15	8–16	6–15	9–15	4–9	–
Species in total	17	14	14	13	19	20	18	17	12	–

Table 7. Structure of fish population in waterbodies and watercourses of river Pra's subordinate system, %.
Note: n – number of surveyed waterbodies, “–” – no data.

Species	Watershed lakes of Pra's high floodplain		Lakes of common Oka-Pra floodplain	
	2006–2009 (n=7)	2010–2017 (n=8)	2006–2009 (n=6)	2010–2017 (n=4)
Sterlet sturgeon	–	–	0–0.2	–
Blue bream	–	0–0.9	0–39.4	0–16.9
Bream	0–3.1	0–9.0	0–16.7	0–5.7
White eye bream	–	–	0–0.3	0–0.4
Bleak	–	–	0–18.6	0–1.1
Asp	–	–	0–0.2	0–0.2
Silver bream	0–11.5	0–1.6	0–13.0	0–55.6
Prussian carp	0–69.2	0–38.5	0–2.0	0–45.2
Goldfish	0–29.2	0–14.4	0–0.8	0–0.5
Gudgeon	–	–	0–0.1	–
Sunbleak	0–12.5	0–60.7	0–15.6	0–18.3
Ide	0–3.9	0–0.4	0.8–8.3	0–1.2
Common dace	–	–	0–1.8	–
Lake minnow	–	0–33.7	–	–
Sablefish	–	–	0–2.7	0–8.6
White fin gudgeon	–	–	0–1.3	–
Amur bitterling	–	–	0–20.9	0–0.1
Roach	0–76.8	0–57.7	9.5–51.5	0.5–63.5
Rudd	0–74.6	0–69.5	0–5.7	0–10.2
Tench	0–1.1	0–2.5	0–0.4	0–2.0
Stone loach	–	–	0–1.0	–
Siberian spiked loach	–	–	0–0.1	–
Spiked loach	–	–	0–0.3	–
European weatherloach	0–92.4	0–46.7	0–0.4	0–2.0
Wels catfish	–	–	0–0.6	0–0.2
Burbot	–	–	0–0.4	–
Pike	0.3–9.0	0–0.4	0.5–5.3	0–1.0
Ruffe	0–0.6	0–0.3	0–6.0	0–2.8
Perch	0–22.8	0–40.3	1.8–35.6	0–18.6
Zander	–	–	0–0.3	0–0.6
Amur sleeper	0–77.3	0–99.5	0–18.2	0–23.4
Number of species	3–9	2–12	7–22	7–20
Species in total	14	16	30	22

Table 8. Structure of fish population in watershed lakes of river Pra high floodplain and lakes of common Oka-Pra floodplain, %. Note: n – number of surveyed waterbodies, “–” – no data.

The structure of fish population of the tributaries is a depleted variant of such of river Pra. In winter, tributaries play an important role allowing fish to survive during winterkills, as many of the tributaries are streams with strongly aerated water (Ivanchev and Ivancheva, 2010).

Middle-sized lakes and oxbows are relatively small waterbodies with an area of 1–3 hectares, located in the floodplain of Pra and therefore flooded annually during high water. They differ greatly in depth,

thickness of bottom sediments of organic remains, amounts of aquatic vegetation. As a rule, they are all prone to winterkill. Usually, 7–15 fish species were found in these waterbodies. The total number of species noted in these type of waterbodies was 18. There are 11 species found in the dominant complex in this type of floodplain lakes, which indicates their important role for these species as a spawning site. Most of their young, apparently, migrate to the river during the flood while the remaining individuals die-

off in winter. However, in years with a high water level in these reservoirs and the river, there were no signs of oxygen deficit in such lakes. Therefore, along with the floodplains and tributaries, they can also be considered as an important link in the formation of the fish population of river Pra. Another important aspect of the significance of these lakes is their role as a habitat for such limnophilous species as tench, loach, rudd, gold and silver crucian carp. They contribute to the stabilization of the population of these species, their conservation in the region and, thus, the formation of biodiversity in the region. In addition, floodplain lakes of medium size are the main recipients of the invasive species – Amur sleeper.

The area of small lakes varies from 0.1 to 0.5 hectares. We found the to be inhabited by 4–9 species (13 in total). Waterbodies of this type have the most unstable structure of the fish population, which depends on species staying here after the flood. The most permanent inhabitant is the pike, which is a dominant or a superdominant in most of these waterbodies. Other typical inhabitants are goldfish, loach and Amur sleeper. The latter species inhabits even those lakes, where pike numbers are significant, mainly due to the presence of dense macrophyte beds serving as refuge.

Similar to the previous category of waterbodies, small lakes serve as one of the main habitats for species of fish that can withstand very low oxygen

content (up to 0.5 cm³/l) – goldfish, loach and Amur sleeper. In addition, they serve as spawning grounds for phytophilous fish species, but this is significant only in years with high floods and slow rates of flood water escape.

Thus, the highest proportion of long-cycle and medium-cycle phytophilous fish species (bream, silver bream, roach, pike) is observed in the channels, floodplains and lakes of Pra floodplain (Table 7). Under favorable autumn-winter conditions in the absence of winterkills, the stocks of these species substantially replenish fish population of the entire lake-river system of river Pra in the following year.

4. Watershed lakes and lakes of the common Oka-Pra floodplain

In total 16 fish species were observed in the watershed lakes of river Pra high floodplain while the number of species in individual waterbodies varied from 2 to 12 species. Dominant complex comprised of nine limnophilous species. These lakes act as the main habitat for goldfish and Prussian carp, lake minnow, roach, rudd, loach and perch. Abundance of Amur sleeper can be very high in individual lakes in the absence of pike and perch (Table 8).

5. Lakes of the common Oka-Pra floodplain

Lakes of the common Oka-Pra floodplain have a closer connection with the Oka River than the previous type of reservoirs. They are inhabited by a much larger number of fish species – 30 species for

Taxa	Waterbody									
	River Pra		Oxbows		Inlet		Lake Ivanovskoye (flow-through)		Isolated lake in the vicinity of Grishino settl.	
	N	B	N	B	N	B	N	B	N	B
Oligochaeta	<u>183</u> 45.9	<u>0.181</u> 8.7	<u>44</u> 11.4	<u>0.125</u> 2.3	<u>33</u> 9.9	<u>0.04</u> 0.8	<u>482</u> 30.0	<u>0.762</u> 12.2	-	-
Mollusca	<u>71</u> 17.8	<u>0.72</u> 34.4	<u>135</u> 35.0	<u>2.107</u> 39.1	<u>108</u> 32.3	<u>1.915</u> 36.9	<u>38</u> 2.4	<u>1.846</u> 29.4	<u>75</u> 28.5	<u>0.400</u> 16.2
Crustacea	<u>6</u> 1.5	<u>0.124</u> 5.9	<u>54</u> 14.0	<u>0.332</u> 6.2	<u>50</u> 15.0	<u>0.322</u> 6.2	<u>17</u> 1.1	<u>0.406</u> 6.5	-	-
Odonata	<u>23</u> 5.7	<u>0.27</u> 12.9	<u>61</u> 15.8	<u>1.614</u> 30.0	<u>88</u> 26.3	<u>2.54</u> 49.0	-	-	<u>63</u> 24.0	<u>0.552</u> 22.3
Chironomidae	<u>52</u> 13.0	<u>0.112</u> 5.4	<u>43</u> 11.1	<u>0.118</u> 2.2	-	-	<u>1013</u> 63.1	<u>2.912</u> 46.4	-	-
Others	<u>64</u> 16.0	<u>0.686</u> 32.4	<u>49</u> 12.7	<u>1.09</u> 20.2	<u>55</u> 16.5	<u>0.371</u> 7.2	<u>55</u> 3.4	<u>0.345</u> 5.5	<u>125</u> 47.5	<u>1.524</u> 61.5
Total	<u>399</u> 100	<u>2.093</u> 100	<u>386</u> 100	<u>5.386</u> 100	<u>334</u> 100	<u>5.188</u> 100	<u>1605</u> 100	<u>6.271</u> 100	<u>263</u> 100	<u>2.476</u> 100

Table 9. The rate of average values of abundance (N, ind./m²) and biomass (B, g/m²) of "forage" benthos groups of river Pra and floodplain waterbodies (July–August, 2017).

Note: over the line – absolute values of abundance and biomass, under the line – their percentage; "–" – no data.

all lakes of this type and 7–22 in single lakes. Eleven species are considered dominant, and in contrast to the watershed lakes, among them there are zope, bream, bleak, silver bream, etc., more characteristic of lake-river biotopes. Therefore, these lakes are important in providing spawning grounds for these commercially valuable species.

All types of studied waterbodies, with the exception of river Pra, are characterized by a good forage base for benthic-feeding fish and their juveniles, being considered as highly nutritious according to the fishery scale. According to the “soft” benthos content, waterbodies are medium-nutritious (3.273–4.425 g/m²), “forage” benthos – the level of foraging base is “above the average” (5.188–8.145 g/m²). The best forage conditions for adult fish are in oxbows (8.145 g/m²), for young fish – lake Ivanovo (4.425 g/m²). A relatively large number of “forage” benthos in the flowing lake Ivanovo (6.271 g/m²) makes it suitable for good growth and development of young and adult fish

The proportion of “soft” benthos was minimal in the channel of river Pra in spite of the fact that the total average biomass of bottom dwellers of the river considerably exceeded the indices of other types of waterbodies, due to the dominance of large bivalve mollusks of *Unio*, *Tumidiana*, *Anodonta* genera. The quantitative characteristics of forage zoobenthos are presented in Table 9.

Despite the fact that the average values of biomass of “soft” and “forage” benthos in river Pra were low, feeding conditions for the different age groups of the benthic fishes varied greatly at different stations of the river from the upper to the lower reaches. The best indicators for the biomass of the “soft” and “forage” benthos were the stations in the middle reaches of the river near the village Grishino and in the vicinity of Makarovo village (Table 10). On the stations close to the river’s headwaters (near the village of Frolovo) and in the lower reaches (near Brykin Bor village), the biomass of the “forage” benthos was lower by 1.1–2.3% than in the middle

reaches near village Grishino and Makarovo, and the values of the “soft” benthos biomass available for juvenile fish, are lower by 1.4–2.8%. The lowest values of the total biomass, as well as “forage” and “soft” benthos were found on stations near the town of Spas-Klepiki and Deulino village. According to the Pantle – Buck index, the level of pollution of the river before it flows into lake Ivanovo, in the vicinity of Spas-Klepiki, near Grishino, in the vicinity of Deulino and close to Brykin Bor refers to the β -mesosaprobic zone, in the vicinity of Makarovo – to the oligosaprobic. Despite the fact that the level of contamination of the river at most stations turned out to be close, there is a decrease in the biomass of benthos in the vicinity of Spas-Klepiki and Deulino. This is probably related to the anthropogenic impact (Spas-Klepiki) and tourism (Deulino village) (Table 10).

It is established that of all the biotopes studied, the most productive ones develop on soils represented by sand, clay and silty alluvium (2147 individuals/m², 381.412 g/m²). According to the biomass of “soft” and “forage” benthos, the best values were observed on silts with plant residues. The poorest in biomass were biocenoses with black silt bottoms (18 individuals/m², 0.03 g/m²).

The main spawning characteristics of dominant fish species

The dominant fish species of the central lake-river system of the Meschera lowland are pike, zope, bream, silver bream, ide, roach, ruffe and perch. Absolute individual and population fecundity of mass species are presented in Table 11. Fecundity indices of fish species in the Meschera lake-river system are quite comparable, and for some species they exceed those observed in the Middle Volga (Lukin, 1948; Lukin and Steinfeld, 1949; Steinfeld, 1949). Thus, many fish species have quite favorable conditions for spawning in the study area.

The fish population of the river Pra and its associated waterbodies are more influenced by flood level on the territory and weather conditions during

Station	N, ind./m ²	B, g/m ²			S	H, bit/ind.
		Total biomass	“Soft” benthos	“Forage” benthos		
Vic. Frolovo vill. (before lake Ivanovskoye)	532	85.131	1.151	2.591	2.0	2.02
Vic. Spas-Klepiki	398	4.690	0.060	0.960	2.0	2.10
Vic. Grishino settl.	257	2479.876	3.664	4.142	2.0	2.09
Vic. Makarovo vill.	362	13.582	2.302	2.983	1.9	2.03
Vic. Deulino vill.	94	0.030	0.030	0.030	2.8	0.80
Vic. Brykin Bor settl.	348	149.073	0.902	1.854	2.3	2.83

Table 10. Average quantitative indices of macrozoobenthos state in river Pra (2017).

Fish species	Individual absolute fecundity, x10 ³ eggs (Meschera lowland)	Individual absolute fecundity, ind. eggs (Middle Volga)	Population absolute fecundity, x10 ³ eggs/100 spawners of both sexes
Roach	<u>49</u> 2–136	<u>–</u> 1–95.3	4856.8
Bream	<u>216.5</u> 50–512	<u>–</u> 1–95.3	5272.1
Silver bream	<u>73</u> 13–197	<u>44</u> –	6148
Perch	<u>28.5</u> 2.3–87.3	<u>–</u> –	–
Blue bream	<u>23.5</u> 8–53	<u>–</u> 10.8	–
Pike	<u>31</u> 8.9–105.4	<u>–</u> 30.9	–
Ide	<u>68.8</u> 11.2–257.4	<u>–</u> 11.2–102.6	2977.7
Prussian carp	<u>115</u> 25–197	<u>–</u> –	–
Goldfish	<u>187</u> 35–375	<u>–</u> –	–
Sablefish	<u>7.2</u> 3.1–27.7	<u>–</u> 5.7–23.8	–
Ruffe	<u>2–17.5</u> 6.2	<u>–</u> –	–

Table 11. Fecundity indices of some mass fish species.

Note: over the line – average value, under the line – range; “–” – no data.

the reproduction of fish. With decreasing levels of spring floods, the areas of spawning grounds diminish and the possibilities of fish passage to the spawning grounds in Klepiki lakes are reduced.

According to the long-term observations in the Okskiy Reserve (Onufrenya, 2012), flood (the interconnection of floodplain waterbodies) starts from the moment when the water level in the river Pra passes a mark of 296 cm above the average. According to the data in Fig. 2, after a minimum in 1996 to 2013, the flood on Pra was regular, and in the next four years, although occurring in 2014, 2016 and 2017, was extremely low. This is reflected in the spawning success of phytophiles spawning in mid- and late spring: zope and bream, as well as silver bream, although the last species can successfully spawn on riverbed vegetation (Ivanchev and Ivancheva, 2010). Early spawning ide and pike often manage to spawn

at a still high level of water, although the rapidly falling waters of the flood can adversely affect the survival of the eggs (Ivanchev and Ivancheva, 2010). Apparently, the spawning of 3–4-year-old ide females (Table 12) and 4–5-year-old bream females (Table 13) observed since the beginning of 2000 is an adaptive response of the population necessary to maintain abundance.

Poaching has a very strong effect on fish numbers. This is a constantly acting factor, which was once reported by Spanovsky and Grigorash (1963). During the spawning run of fish in the upper reaches of the river Pra, the river is completely blocked by various fishing gear in the narrowest areas. Apparently, the fish now are being caught in larger numbers, as net fishing gear has become more available and the population is possesses larger numbers of various types of transport.

Age, years	1970–1980		1981–1990		1991–2000		2001–2010		2011–2017	
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males
3	0.1	0.1	0	0	0	0	0.9	1.4	0.8	1.3
4	1.7	2.7	0	0.5	2.5	2.5	4.2	9.4	3.4	7.6
5	7.2	14.8	3.3	4.8	10.0	7.5	11.7	20.2	9.8	15.7
6	10.8	12.9	8.3	12.7	7.5	15.0	10.3	21.2	13.1	13.1
7	6.5	8.8	7.6	12.5	3.8	8.7	3.8	8.0	5.5	10.2
8	5.4	6.5	6.3	10.1	8.8	10.0	1.9	5.6	5.1	10.2
9	3.9	4.0	7.0	7.0	6.3	7.5	0	1.4	1.3	1.7
10	2.9	4.3	4.1	4.4	3.8	2.5	0	0	0	0.4
11	2.0	1.7	2.0	5.1	0	1.2	0	0	0.4	0.4
12	1.0	1.0	1.5	1.6	1.2	0	0	0	0	0
13	0.5	1.0	0.6	0.2	1.2	0	0	0	0	0
14	0.1	0	0.2	0.2	0	0	0	0	0	0
15	0.1	0	0	0	0	0	0	0	0	0
Share in the population, %	42.2	57.8	40.9	59.1	45.1	54.9	32.8	67.2	39.4	60.6
Abundance, ind.	345	472	222	321	36	44	70	143	93	143

Table 12. Structure of the spawning part of ide population.

Age, years	1970–1980		1981–1990		1991–2000		2001–2010		2011–2016	
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males
3	0	0	0	0	0	0	0	0.2	0	0
4	0	9.7	0	0.9	0	7.6	1.5	5.9	0	0
5	3.2	20.7	5.2	7.0	8.7	6.3	8.9	13.3	2.2	10.9
6	8.6	21.2	14.0	21.8	10.1	12.8	8.9	20.0	5.1	19
7	7.5	12.4	12.2	9.1	10.1	15.2	4.4	8.1	5.8	13.1
8	3.0	4.0	4.8	8.3	5.1	7.6	3.7	6.7	6.6	8.8
9	1.1	1.6	1.7	5.2	1.3	6.3	5.2	0.7	5.1	5.1
10	1.1	0.6	1.7	0.4	3.8	5.1	3	3	5.1	4.4
11	1.6	0.6	2.6	1.7	0	0	1.5	0.7	2.2	1.5
12	0.8	0.6	1.3	0.4	0	0	0.7	0.7	2.2	2.2
13	0.5	0.3	0.9	0.4	0	0	0.7	0.7	0	0
14	0	0.6	0	0	0	0	1.5	0	0.7	0
15	0.3	0	0.4	0	0	0	0	0	0	0
Share in the population, %	27.7	72.3	44.8	55.2	39.1	60.9	40	60	35	65
Abundance, ind.	103	269	103	127	31	48	54	81	48	89

Table 13. Age and sex structure of bream in various periods.

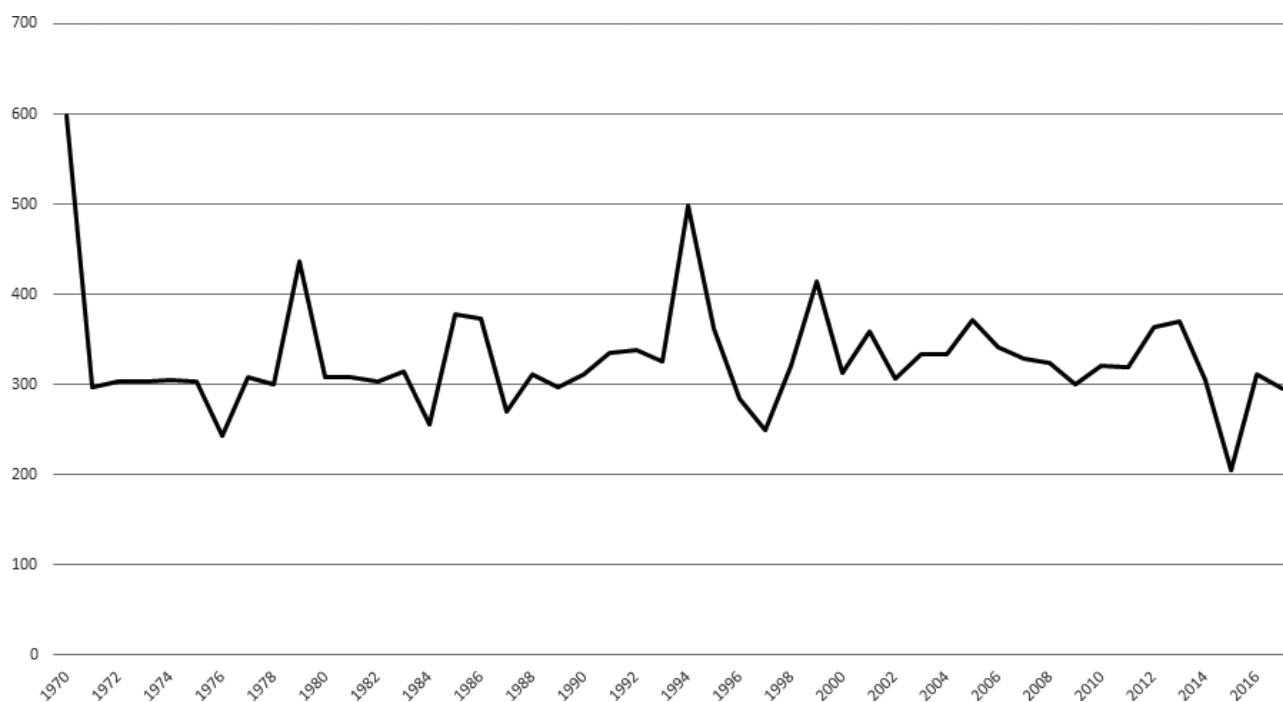


Fig. 2. Dynamics of river Pra maximum flood level in 1970–2017.

Conclusion

The central lake-river system of the Meschera lowland is unique for the Oka basin in its ecological and hydrological properties. The fish population of the most important link of the main watercourse – the river Pra and its subordinate system – have a fairly high species richness and species diversity. Spawning indices of long-cycle and medium-cycle phytophilous species are also high and close to those of the Middle Volga. During the period of observations of 2002–2017 the stable abundance of most species of fish was noted: zope, white-eye bream, bleak, silver bream, common gudgeon, sunbleak, common dace, sablefish, white-finned gudgeon, roach, rudd, stone loach, spined and Siberian loach, European weatherloach, wels catfish, pike, burbot, ruffe, perch, zander and Amur sleeper. The abundance of Prussian carp has increased everywhere. Abundance of bream has decreased but judging by the age structure of the spawners, the spawning part of the population is in a fairly stable state: for the entire time of observations of spawning aggregations, the largest number of females over the age of 7 years is observed in the last current period. Therefore, an increase in the abundance of this species is possible in the future. Decreased flood level in Pra and poaching are factors producing the greatest effect on fish numbers.

The results of the study of Klepiki (Meschera lake ring) show their high potential for spawning and feeding of many species of fish. Warmed shallows, overgrown with macrophytes, represent extensive areas with high numbers of food organisms for juveniles and adult fish.

In the future, it is necessary to clarify the role of deep lakes (Beloye, Lebedinoye) for the fish population of the Meschera watercourse, the identification of wintering pits, in particular. Composition of ichthyofauna in the northernmost element of the system – the Buzha River with the tributary, river Polya is of undoubted scientific interest. All previously studied structural units of the lake-river system of Meschera have connect with the mother river Oka almost every year, so that fish population may be exchanged. The mouth of river Buzha is more than 200 kilometers from the Oka, the migration routes of fish pass through a complex system of lakes and channels, and there is still no idea of the ways of “fish exchange” of this river with Oka.

The successful functioning of all links of the lake-river system under favorable climatic conditions and the absence of anthropogenic press (poaching) will probably contribute to the preservation of a high number of long-cycle and medium-cycle phytophilous species.

References

- Babushkin, G.M., 1990. Ryby (Zhivotnyy mir Ryazanskoy oblasti) [Fish (Fauna of the Ryazan Region)]. Ryazanskiy pedagogicheskiy institute [Ryazan Pedagogical Institute], Ryazan, Russia, 125 p. (In Russian).
- Babushkin, G.M., Babushkina, T.G., 2004. Zhivotnyy mir Ryazanskoy oblasti: Pozvonochnyye zhivotnyye [Fauna of the Ryazan Region: Vertebrate animals]. Ryazanskiy pedagogicheskiy institute

- [Ryazan Pedagogical Institute], Ryazan, Russia, 288 p. (In Russian).
- Barskaya, Yu.Yu., 2005. Parazitofauna lososevidnykh ryb ozerno-rechnoy sistemy Paanayarvi-Olanga i osobennosti yeye formirovaniya [Parasitofauna of salmonid fishes of the lake-river system of Paanajarvi-Olanga and features of its formation]. *Avtoreferat dissertatsii na soiskaniye uchennoy stepeni kandidata biologicheskikh nauk [Candidate of science in biology dissertation abstract]*. St. Petersburg, Russia, 26 p. (In Russian).
- Borutskiy, E.V., 1928. Obshchiy ocherk vodoyemov Meshcherskoy nizmennosti [A general sketch of Meschera lowland waterbodies]. *Trudy Kosinskoy biologicheskoy stantsii MOIP [Proceedings of Kosinskaya Biological station MSSN]* 7–8, 7–24. (In Russian).
- Chugunova, N.I., 1959. Rukovodstvo po izucheniyu vozrasta i rosta ryb [A guide to studying the age and growth of fish]. Nauka, Moscow, USSR, 164 p. (In Russian).
- Denisov, D.B., Kashulin, N.A., Terent'yev, P.M., Val'kova, S.A., 2009. Sovremennyye tendentsii izmeneniya bioty presnovodnykh ekosistem Murmanskoy oblasti [Current trends in the biota of freshwater ecosystems in the Murmansk region]. *Vestnik MGTU [Bulletin of Moscow State Technical University]* 12 (3), 525–538 p. (In Russian).
- Grobova, O.V., 2008. Kratkaya gidrokhimicheskaya kharakteristika reki Pry v nizhnem techenii (po dannym regulyarnykh nablyudeniy v rayone pos. Brykin Bor v 1996–2006 gg.) [Brief hydrochemical characteristics of the river Pra in the lower reaches (according to the regular observations in the area of Brykin Bor in 1996–2006)]. *Trudy Okskogo zapovednika [Proceedings of the Oka Reserve]* 26, 188–195. (In Russian).
- Ivanchev, V.P., Ivancheva, E.Yu., 2010. Kruglorotyye i ryby Ryazanskoy oblasti i prilozhashchikh territoriy [Cyclostomes and fish of the Ryazan region and adjacent territories]. Golos gubernii, Ryazan, Russia, 292 p. (In Russian).
- Ivanchev, V.P., Ivancheva, E.Yu., 2015a. Ikhtiofauna nekotorykh rek basseyna Sredney Oki v Ryazanskoy oblasti [Ichthyofauna of some rivers of the Middle Oka basin in the Ryazan Region]. *Trudy Okskogo zapovednika [Proceedings of the Oka Reserve]* 33, 147–165. (In Russian).
- Ivanchev, V.P., Ivancheva, E.Yu., 2015b. Rybnoye naseleniye malykh rek Meshcherskoy nizmennosti (Ryazanskaya oblast'), podvergshikhsya spryamleniyu rusel [Fish population of small rivers of Meschera lowland (Ryazan Region), subject to channel straightening]. *Voprosy rybolovstva [Fisheries issues]* 16 (1), 79–86. (In Russian).
- Komarov, M.M., 2013. Ozero Beloye – unikal'nyy prirodnyy ob'ekt na territorii Ryazanskoy oblasti [Lake Beloe – a unique natural object on the territory of the Ryazan region]. *Vestnik Ryazanskogo gosudarstvennogo universiteta im. S.A. Yesenina [Bulletin of the S.A. Yesenin Ryazan State University]* 41(2), 126–145. (In Russian).
- Krivtsov, V.A., Anan'yeva, S.I., Babushkin, G.M., Vodorezov, A.V., Davydova, I.Yu., Zatsarinnyy, I.V., Kazakova, M.V., Klopotov, V.I., Komarov, M.M., Krivtsova, L.D., Lobov, I.V., Tobratov, S.A., Uskov, V.A., Fionina, E.A., Khlebosolova, O.A., Yukhina, I.N., 2008. Priroda Ryazanskoy oblasti [The nature of the Ryazan region]. Ryazan State University, Ryazan, Russia, 407 p. (In Russian).
- Lukin, A.V., 1948. Zavisimost' plodovitosti ryb i kharaktera ikh ikrometaniya ot usloviy obitaniya [Dependence of fish fecundity and the nature of their spawning from habitat conditions]. *Izvestiya AN USSR [Proceedings of the USSR Academy of Sciences]* 5, 565–574. (In Russian).
- Lukin, A.V., Shteynfel'd, A.L., 1949. Plodovitost' glavneyshikh promyslovykh ryb Sredney Volgi [Fecundity of main commercial fishes of the Middle Volga]. *Izvestiya Kazanskogo filiala AN USSR. Seriya biologicheskaya i sel'skokhozyaystvennaya [Proceedings of the Kazan branch of the USSR Academy of Sciences. Biological and agricultural series]* 1, 87–106. (In Russian).
- Mitropolsky, V.I., Mordukhai-Boltovskoy, F.D. (eds.), 1975. Metodika izucheniya biogeotsenozov vnutrennikh vodoyemov [The methodology of studying biogeocenoses of the inland waterbodies]. Nauka, Moscow, USSR, 240 p. (In Russian).
- Mil'kov, F.N., Gvozdetskiy, N.A., 1976. Fizicheskaya geografiya SSSR. Obshchiy obzor. Yevropeyskaya chast' SSSR. Kavkaz [Physical Geography of the USSR. General review. European part of the USSR. Caucasus]. 4-th edition. Mysl', Moscow, USSR, 448 p. (In Russian).
- Nikol'skiy, G.V., 2013. Izbrannyye trudy [Selected Works]. Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia, 600 p. (In Russian).

- Novoselov, A.P., Studenov, I.I., Pavlenko, V.P., 2013. Ekologicheskoye raznoobrazie ikhtiofauny presnovodnykh vodoyemov Belomorsko-Kuloyskogo poluostrova (Arkhangel'skaya oblast') [Ecological diversity of ichthyofauna of freshwater waterbodies of the White Sea-Kuloi Peninsula (Arkhangelsk region)]. *Arktika: ekologiya i ekonomika* [Arctic: ecology and economics] 4 (12), 70–80. (In Russian).
- Onufrenya, M.V., 2012. Gidrologicheskiy rezhim vodoyemov Okskogo zapovednika (2001–2010 gg.) [Hydrological regime of Okskiy Reserve waterbodies (2001–2010)]. *Trudy Okskogo zapovednika* [Proceedings of the Oka Reserve] 27, 421–445. (In Russian).
- Pidgayko, M.P., Aleksandrov, B.M., Ioffe, T.S.I., Maksimova, L.P., Petrov, V.V., Savateyeva, Ye.B., Salazkin, A.A., 1968. Kratkaya biologo-produktsionnaya kharakteristika vodoyemov Severo-Zapada SSSR [Brief biology-production characteristics of waterbodies in the North-West of the USSR]. *Izvestiya GOSNIORKh* [News of the State Research Institute of Lake and River Fisheries] 67, 205–228. (In Russian).
- Pielow, E.C., 1975. Ecological diversity. Wiley-Interscience, New York, USA, 165 p.
- Ponomarenko, V.P., 1963. Zolotoy karas' ozera Velikogo [Goldfish of lake Velikoye]. *Trudy Okskogo zapovednika* [Proceedings of the Oka Reserve] 5, 87–93. (In Russian).
- Pravdin, I.F., 1966. Rukovodstvo po izucheniyu ryb [Guide to fish studies]. Nauka, Moscow, USSR, 376 p. (In Russian).
- Reshetnikov, Yu.S. (ed.), 2002. Atlas presnovodnykh ryb Rossii [Atlas of freshwater fish in Russia]. Vol. 1. Nauka, Moscow, Russia, 379 p. (In Russian).
- Reshetnikov, Yu.S. (ed.), 2002. Atlas presnovodnykh ryb Rossii [Atlas of freshwater fish in Russia]. Vol. 2. Nauka, Moscow, Russia, 251 p. (In Russian).
- Reshetnikov, Yu.S. (ed.), 2010. Ryby v zapovednikakh Rossii. Presnovodnyye ryby [Fish in the reserves of Russia. Freshwater fish]. KMK Scientific Press, Moscow, Russia, 627 p. (In Russian).
- Shteynfel'd, A.L., 1949. Guster (Blicca bjoerkna L.) Sredney Volgi i yeye znachenie v rybnom promysle [Silver bream (*Blicca bjoerkna* L.) of the Middle Volga and its importance in the fishing industry]. *Trudy Tatarskogo otdeleniya Vsesoyuznogo nauchno-issledovatel'skogo instituta ozornogo i rechnogo rybnogo khozyaystva* [Proceedings of the Tatar branch of the All-Union Scientific Research Institute of Lake and River Fisheries] 5, 35–45. (In Russian).
- Spanovskaya, V.D., Grigorash, V.A., 1963. Ikhtiofauna Spas-Klepikovskikh ozyor i yeye osobennosti [Ichthyofauna of Spas-Klepiki lakes and its features]. *Trudy Okskogo zapovednika* [Proceedings of the Oka Reserve] 5, 27–56. (In Russian).
- Tereshchenko, V.G., Nadirov, S.N., 1996. Formirovaniye struktury rybnogo naseleniya predgornogo vodokhranilishcha [Formation of the structure of the fish population of the pre-mountainous reservoir]. *Voprosy ikhtiologii* [Ichthyology Issues] 36 (2), 169–178. (In Russian).
- Zhivoglyadova, L.A., Frolenko, L.N., 2017. Kharakteristika kormovoy bazy ryb-bentofagov nizhnego Dona [Characteristics of forage base of benthophagous fish of lower Don]. *Izvestiya TINRO* [Proceedings of Pacific Research Institute of Fisheries and Oceanography] 189, 139–146. (In Russian).