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Review

Long-term dynamics of fish populations in lakes of the "Russian North" National Park

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Abstract. The work presents the integrated data on fish populations from 53 lakes of the "Russian North" National Park for a 120-year period. A total of 26 fish species from 7 orders and 8 families were recorded. In each of the studied reservoirs, from 1 to 25 species of fish were identified. Large lakes (Siverskoye, Zaulomskoye, Nikolskoye, Borodaevskoye, Ferapontovskoye, Blagoveshchenskoye, Tatarovskoye, and Kishemskoye) demonstrated the richest composition of fish populations. For the last 100 years, silver bream, pikeperch, sabrefish, chub, asp, zope, carp, and rudd entered the lakes from the River Sheksna and later from the Sheksna Reservoir through the canals of the Northern Dvina lock system. Because of deterioration of habitats and breeding conditions, smelt and whitefish disappeared from the water bodies at all. Inexpediency of a ban on industrial fishing in the lakes of the specially protected natural areas was substantiated.

Keywords: ichthyofauna, specially protected natural area, Vologda Oblast

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Научный обзор

Многолетняя динамика рыбного населения озер национального парка «Русский Север»

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Аннотация. В работе обобщены сведения о рыбном населении 53 озер национального парка «Русский Север» за 120-летний период. Отмечены 26 видов рыб из 7 отрядов и 8 семейств. В каждом из исследованных водоемов обнаружено от 1 до 25 видов рыб. Наиболее богатый состав рыбного населения наблюдается в более крупных озерах – Сиверском, Зауломском, Никольском, Бородаевском, Ферапонтовском, Благовещенском, Татаровском, Кишемском. Через каналы Северо-Двинской шлюзованной системы за последние 100 лет из р. Шексны, а затем из Шекснинского водохранилища в озера проникли густера, судак, чехонь, голавль, жерех, синец, сазан, красноперка. Вследствие ухудшения условий обитания и размножения исчезли из водоемов снеток и сиг. Обоснована нецелесообразность запрета на озерах особо охраняемой природной территории промышленного рыболовства.

Ключевые слова: ихтиофауна, особо охраняемая природная территория, Вологодская область

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Introduction

The specially protected natural area “Russian North” National Park is distinguished by its numerous water bodies. Here, 101 lakes with a total area of 3.3% are located. Among most limnetic in the region are the Belozersky and Kirillovsky landscapes (Borisov and Lobunicheva, 2012). In terms of area, the largest lakes are Pereshnoye (1308 ha), Itkolskoye (783 ha) and Siverskoye (774 ha). The deepest lakes in this region are also situated on the territory of the national park: the maximum depth of Lake Sodoshnoye reaches 40 m, Ferapontovskoye – 27 m, and Siverskoye – 26 m (Antipov, 1981). Hydrographically, the reservoirs of the “Russian North” National Park belong to the catchment basins of lakes Kubenskoye and Vozhe, as well as the Sheksna Reservoir. The history of the lakes of the study territory (currently included in the “Russian North” National Park) goes back 120 years. During investigations, our attention was primarily paid to studying the composition of fish populations, the fishery peculiarities of lakes, the possibilities of acclimatization of new fish species and the prospects for fish farming development.

The purpose of the work was to summarize the data on the ichthyofauna of the reservoirs of the “Russian North” National Park and the long-term dynamics of their fish population[1].

Material and methods

The review of fish populations in lakes at the territory of the “Russian North” National Park is based on the results of cadastral studies of the reservoirs of the Novgorod Provincial Zemstvo, the All-Union Scientific Research Institute of Lake and River Fisheries (St. Petersburg Branch of FSBSI “VNIRO”), the Vologda State Pedagogical Institute (Vologda State University), the Vologda Laboratory of GosNIORKh (Vologda Branch of FSBSI “VNIRO”), as well as the fishery statistics data for 1984–2007 and the materials of field studies conducted in 2008–2021 by the Vologda Branch of FSBSI “VNIRO” with participation of the authors. Fishing was implemented using fixed nets (mesh size: 20–60 mm) in different parts of the lakes and fine-meshed seines – in the coastal area. Over a 120-year period, 53 lakes were surveyed that is more than half of the total number of reservoirs located within the boundaries of the “Russian North” National Park (Fig. 1). Most often the largest lakes were investigated, i.e. Siverskoye, Zaulomskoye, Pokrovskoye, Nikolskoye, Itkolskoye, Borodaevskoye, Ferapontovskoye, Ermakovskoye, Ostolopovskoye, Egoryevskoye, and Kishemskoye.

The taxonomic status of fish species was given in accordance with the monograph “Fishes of Russian Nature Reserves” (Ryby v zapovednikakh Rossii, 2010). Fish affiliation to faunal complexes was determined based on the G.V. Nikolsky notions (1980) about the structure of the freshwater ecosystem fauna with some explanations. Representatives of the regional ichthyofauna were classified into ecological groups depending on water temperature, preferred substrate and time of spawning (Golovanov, 2013; Ryby v zapovednikakh..., 2010; Slynko and Tereshchenko, 2014**).**

Results

The first mention of fish in lakes located within the boundaries of the “Russian North” National Park can be found in N.Ya. Danilevsky (1862) in volume VI of “Fisheries Research in Russia” where the monks of the Kirillo-Belozersky Monastery told about an archimandrite who two hundred years ago transferred smelt, sterlet and pikeperch from Lake Beloozero to Siverskoye. As a result, sterlet and pikeperch did

[1] The materials of the article were presented at the XV regional scientific and practical conference “Local History (natural history) research in the European North” dedicated to the 30th anniversary of the creation of the “Russian North” National Park.

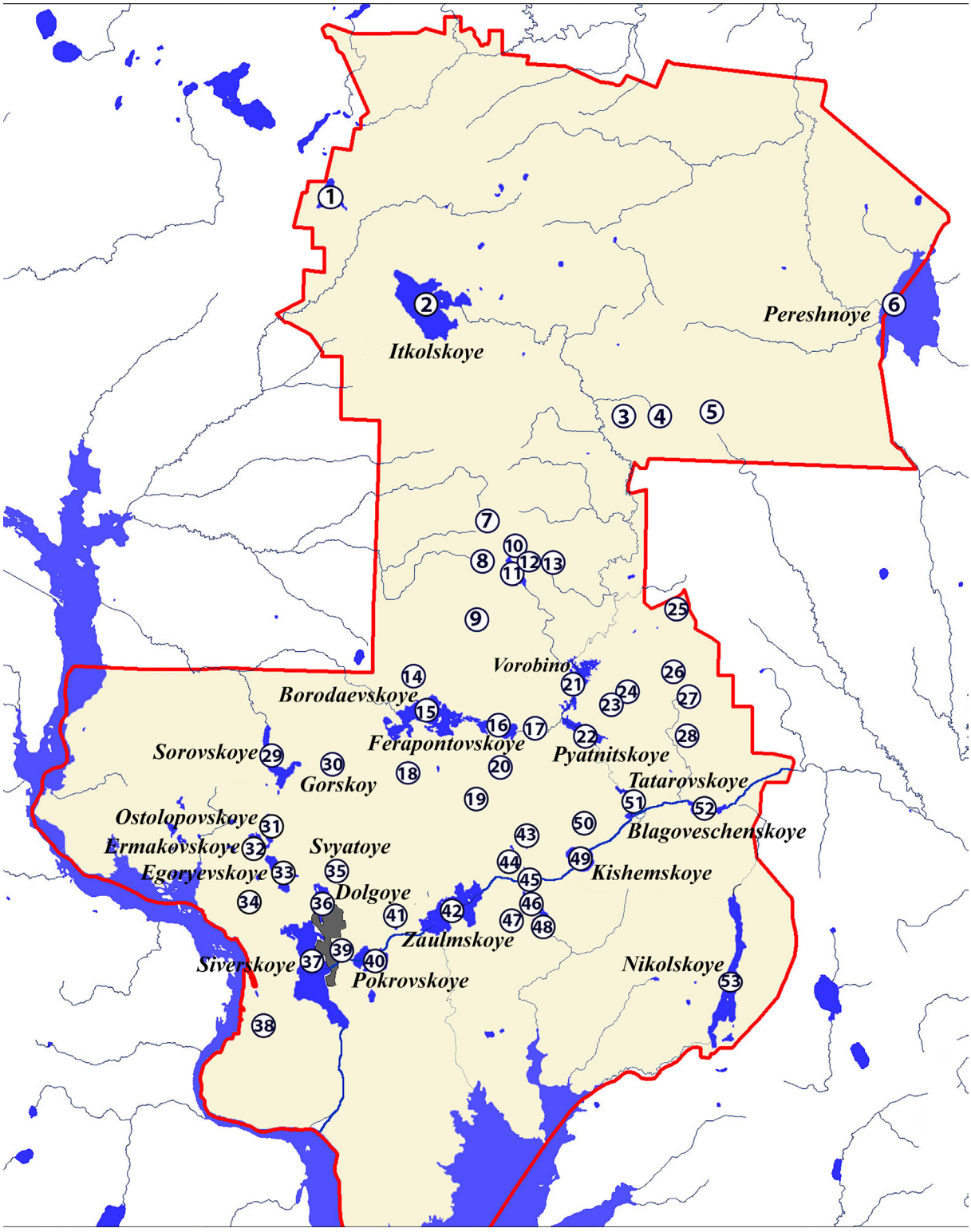

Fig. 1. Schematic map of the study lakes within the boundaries of the “Russian North” National Park (lakes’ numbering is given according to Appendix).

not survive, unlike smelt still caught in abundance there." When describing the A. Wurtemberg water system (currently corresponding to the Northern Dvina lock system), F.A. Arsenyev also mentioned about fishing of smelts, which were larger in size and called "Siverskiye". (Arsenyev, 1879).

The data on the composition of fish populations in lakes Siverskoye, Zaulomskoye, Kishemskoye, and Vazerinskoye were published by I.V. Kuchin (1902) in the Proceedings of the Imperial Free Economic Society. Later, he provided a fish list for lake Siverskoye in the Bulletin of the Novgorod Zemstvo (Kuchin, 1906). At the beginning of XX century, 10 species of fish were noted in lakes Siverskoye and Zaulomskoye: river perch *Perca fluviatilis* Linnaeus, 1758, roach *Rutilus rutilus* (Linnaeus, 1758), common pike *Esox lucius* Linnaeus, 1758, common ruff *Gymnocephalus cernuus* (Linnaeus, 1758), burbot *Lota lota* (Linnaeus, 1758), golden crucian carp *Carassius carassius* (Linnaeus, 1758), ide *Leuciscus idus* (Linnaeus, 1758), bleak *Alburnus alburnus* (Linnaeus, 1758), bream *Abramis brama* (Linnaeus, 1758), European smelt *Osmerus eperlanus* (Linnaeus, 1758), whereas in lake Vazerinskoye – 6 species (perch, roach, pike, burbot, crucian carp, ide), and in Kishemskoye – 5 species (perch, roach, pike, crucian carp, ide).

More detailed and extensive data on fish populations of water bodies of this territory at the beginning of XX century can be found in the Report to the Assembly of the Novgorod Provincial Zemstvo on fish farming and fisheries improvement in the Novgorod province (Klepinin, 1915). Out of 46 studied lakes in Kirillovsky district, 25 are located within the present boundaries of the "Russian North" National Park, where fish populations are represented by 13 fish species of commercial importance: perch, pike, roach, crucian carp, burbot, ruff, ide, bream, smelt, bleak, tench *Tinca tinca* (Linnaeus, 1758), common carp *Cyprinus carpio* (Linnaeus, 1758), whitefish *Coregonus lavaretus* (Linnaeus, 1758). The largest number (9 fish species) is noted in major reservoirs, i.e. lakes Siverskoye and Zaulomskoye. In contrast to the studies of I.V. Kuchin, bleak is not indicated in these reservoirs. Among the currently rare species is whitefish in Lake Blagoveshchenskoye, carp – in Pokrovskoye, and smelt – in lakes Siverskoye, Zaulomskoye, Borodaevskoye, Ferapontovskoye, and Spasskoye. Smelt and carp appeared in these lakes through the introduction made by the monks of the Kirillo-Belozersky and, apparently, Ferapontov monasteries.

At the beginning of XX century, 14 lakes were regularly fished throughout the year, and 11 lakes – only in summer. Almost 600 people were employed in fishery activities. Various types of seines (mutniks, brodniks, through nets), set traps (trap net, blow net, ryusy), as well as stake nets were used as fishing gear. To increase fish productivity of lakes and improve the qualitative composition of catches, it was recommended to stock pikeperch *Sander lucioperca* (Linnaeus, 1758), sabrefish *Pelecus cultratus* (Linnaeus, 1758), vendace *Coregonus albula* (Linnaeus, 1758), bream, tench and crucian carp, depending on the ecological characteristics of the reservoirs (Klepinin, 1915).

In the early 1930s, the All-Union Scientific Research Institute of Lake and River Fisheries conducted the cadastral studies of lakes in the Leningrad region, including partially the territory of Vologda Oblast (Berg, 1933). In total, the reporting materials contain the data on 40 reservoirs located within the boundaries of the "Russian North" National Park. The ichthyofauna of these lakes consists of 21 species of fish: perch, pike, roach, crucian carp, burbot, ruff, ide, bream, smelt, tench, bleak, carp, whitefish, sabrefish, silver bream *Blicca bjoerkna* (Linnaeus, 1758), verkhovka *Leucaspius delineatus* Heckel, 1843 , chub *Leuciscus cephalus* (Linnaeus, 1758), bullhead *Cottus gobio* (Linnaeus, 1758), mudfish *Cobitis taenia* (Linnaeus, 1758), stone loach *Barbatula barbatula* (Linnaeus, 1758), and gudgeon *Gobio gobio* (Linnaeus, 1758)[2, 3].

As follows from the previous studies, the population of lake Siverskoye is the richest (21 species). Along with commercial species, non-commercial ones (loach, mudfish, bullhead, verkhovka) were also included in the materials that contributed to its species richness. However, all fish, except for verkhovka, were reported to be single in catches. Noteworthy, saberfish, carp and chub migrated from the Sheksna River to Lake Siverskoye.

[2] Fishes of 102 lakes of the Leningrad region (based on materials of a selective expedition of 1932), 1932. Research report. All-Union Scientific Research Institute of Lake and River Fisheries, Leningrad, USSR, 131 p.

[3] Report on the results of a comprehensive fishery survey of lakes in the Leningrad region (based on materials from the 1932 expedition), 1933. Research report. All-Union Scientific Research Institute of Lake and River Fisheries, Leningrad, USSR, 131 p.

The implemented (in late 1920s) measures on new species acclimatization further influenced the species composition of fish populations (Tikhiy, 1941). For instance, 1.3 million fertilized eggs of Chud whitefish were released to lakes Siverskoye, Ferapontovskoye, Zaulomskoye, Nikolskoye, Egoryevskoye; 22.1 thousand of smelt producers – into lakes Nikolskoye, Egoryevskoye, Ostolopovskoye, Sorovskoye; 2.2 million eggs of pikeperch – in Lake Siverskoye, and 160 eugamic individuals of crucian carps – in Nikolskoye[4].

In the second half of the 1920s, there were 32 commercial lakes with a total annual catch of up to 136 tons (Kuchin, 1929). In the early 1930s, commercial fishing was carried out only in 18 lakes with a total catch estimated as 64 tons per year (or 18.5 kg/ha). All in all, 314 people were engaged in fishing of smelt, ruff, perch, pike, ide, crucian carp, bleak, and bream by seines, mutniks, ryusy, fixed nets and hook gear. Large water bodies were generally most productive. For example, the annual fish catch in lake Siverskoye in 1931 amounted to 71 kg/ha, Zaulomskoye – 40 kg/ha, Kishemskoye – 29 kg/ha, Nikolskoye and Itkolskoye – 23 kg/ha each[5].

In 1969, the Vologda State Pedagogical Institute studied fish populations of 30 lakes within the territory of the "Russian North" National Park (Antipov et al., 1981) and found 19 species (perch, pike, roach, crucian carp, burbot, ruff, ide, bream, smelt, tench, bleak, silver bream, whitefish, verkhovka, sabrefish, pike perch, gudgeon, asp *Aspius aspius* (Linnaeus, 1758), dace *Leuciscus leuciscus* (Linnaeus, 1758)[6]. Pikeperch was among new species in the ichthyofauna of the reservoirs of the Northern Dvina lock system (lakes Siverskoye, Zaulomskoye, Pokrovskoye, Vazerinskoye, Kishemskoye, Tatarovskoye), asp – in lakes Nikolskoye and Zaulomskoye, and dace – in Nikolskoye. Saberfish was also spread throughout. Compared to the 1930s, fishing here greatly declined. In the late 1960s, it was carried out on 12 lakes; stable industrial fishing (with seines, trap nets, bow nets, ryusy and fixed nets) remained only in Lake Siverskoye.

Later, the Vologda laboratory of GosNIORKh studied fish populations of the reservoirs of the National Park. Thus, in 1975, when elaborating the recommendations for the sustainable fishery management on the lakes of the Kirillov group, a comprehensive study of 11 lakes (Siverskoye, Zaulomskoye, Dolgoye, Egoryevskoye, Ermakovskoye, Ostolopovskoye, Konstantinovskoye, Okulovskoye, Sorovskoye, Ferapontovskoye, Borodaevskoye) was made[7]. The conducted research confirmed the habitat of 15 fish species: perch, pike, roach, crucian carp, burbot, ruff, ide, bream, smelt, bleak, silver bream, sabrefish, pikeperch, chub, zope *Abramis ballerus* (Linnaeus, 1758). In Lake Siverskoye, zope was discovered for the first time; it entered the reservoir through the Toporninsky Canal from the Sheksna Reservoir. Based on the research results of lakes Egorievskoye, Ermakovskoye, Ostolopovskoye, Okulovskoye, Sorovskoye, Ferapontovskoye, Borodayevskoye, it was recommended to create a feeding and nursery fish farm of intensive type with a total capacity of 43.7 tons per year to grow peled *Coregonus peled* (Gmelin, 1788), muksun *Coregonus muksun* (Pallas, 1814), bream and pike.

In 1986, to evaluate the fishery potential, Lake Palshemskoye was investigated[8] and, as a result, 9 fish species were recorded: perch, roach, pike, bream, ruff, silver bream, burbot, ide, and verkhovka. Ichthyologists estimated the natural fish productivity of the reservoir as 2 tons of fish per year. To increase this indicator, it was recommended to stock the lake with pikeperch, peled and carp (a domesticated form of common carp).

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[4] Accounting for the results of fish farming in lakes of the Leningrad region, 1935. Research report. All-Union Scientific Research Institute of Lake and River Fisheries, Leningrad, USSR, 125 p.

[5] Fishes of 102 lakes of the Leningrad region (based on materials of a selective expedition of 1932), 1932. Research report. All-Union Scientific Research Institute of Lake and River Fisheries, Leningrad, USSR, 131 p.

[6] Fishes of 102 lakes of the Leningrad region (based on materials of a selective expedition of 1932), 1932. Research report. All-Union Scientific Research Institute of Lake and River Fisheries, Leningrad, USSR, 131 p.

[7] Development of recommendations for the rational management of fisheries on the lakes of the Lozsko-Azat fish farm (final report on the 1st stage – Kirillov group of lakes), 1976. Research report. Vologda laboratory of "GosNIORKh", Vologda, USSR, 89 p.

[8] Fishery characteristics and ways to create a rational fishery on the lake Palshemskoye, 1986. Research report. Vologda laboratory of "GosNIORKh", Vologda, USSR, 21 p.

In 1996, in order to evaluate stocking (with baby fishes of valuable species) capabilities of water bodies of Vologda Oblast, lakes Sorovskoye, Ermakovskoye, Egoryevskoye and Itkolskoye were studied[9]. In research catches, 7 fish species were identified in Lake Sorovskoye (roach, bream, bleak, ruff, perch, pike and silver bream); 7 species (roach, bream, perch, crucian carp, pike, ruff, bleak) – in Egoryevskoye; 5 species (roach, bream, bleak, perch and pike) – in Ermakovskoye; 4 species (bream, roach, perch, ruff) – in Itkolskoye. In order to use food base for fish more rationally and increase the catches of more valuable species, it was recommended to introduce carp, pikeperch and Russian sturgeon *Acipenser gueldenstaedtii* (Brandt, 1833).

According to the fishery statistics, industrial fishing on the lakes of the "Russian North" National Park was implemented until 2007. Intensive and most regular fishing was noted in lakes Siverskoye and Zaulomskoye, a little less – in lakes Nikolskoye, Pokrovskoye, Itkolskoye, and in some years – on lakes Sorovskoye, Egoryevskoye, Dolgoye, Vazerinskoye, Borodaevskoye, Ilyinskoye, Pankovskoye and Pigasovo. In 1984–2007, the total annual fish catches varied from 1.2 to 44.5 tons in 2001 and 1995, respectively (Table 1).

The industrial catches included bream, pikeperch, pike, burbot, ide, roach, perch, zope, silver bream, bleak, asp, and smelt. Bream and such low-value species as roach, perch and silver bream prevailed in catches. Up to 20 fishermen were involved in fishing with seines, kurlands, ryusy and fixed nets. Often, fishiung occurred during the period of fish kill for reclamation purposes. The "Rybak" artel was the main fisher. It should be noted that industrial fishing in the lakes of the "Russian North" National Park has not been carried out since 2008 because of the amendments to paragraph 2 of Article 15 of Federal Law No. 33 "On Specially Protected Natural Areas"[10], which prohibits industrial fishing, but permits recreational and sport fishery activities within the boundaries of national parks.

To improve the species composition of catches and increase fish productivity of lakes, new species were repeatedly introduced into the reservoirs. In particular, in 1997, pikeperch and carp appeared in lakes Sorovskoye and Ermakovskoye. In 2000, bream was transferred from lake Zaulomskoye to Pankovskoye, while bream, pike and pikeperch – to Sorovskoye. In 1998, successful spawning of introduced pikeperch occurred in lakes Ermakovskoye and Sorovskoye, where baby fishes emerged in the catches of the years 2000 and 2001. At the end of the 2000s, some carps with annual body weight gain over one kilogram and weighing up to 12–14 kg were caught in these lakes. During the same period (2001, 2002), juvenile carp appeared in these lakes as a result of natural spawning (Konovalov, 2015).

In 2008–2021, the employees of the Vologda Branch of VNIRO investigated fish populations of 14 lakes located in the "Russian North" National Park: Itkolskoye, Borodaevskoye, Ferapontovskoye, Spasskoye, Ilyinskoye, Vorobino, Pyatnitskoye, Gorskoye, Siverskoye, Zaulomskoye, Pokrovskoye, Kishemskoye and Nikolskoye. Research catches contained 13 fish species (bream, perch, roach, ide, crucian carp, pike, silver bream, zope, pikeperch, ruff, bleak, sabrefish, rudd) obtained with fixed nets, and 9 species (bream, perch, roach, ide, pike, silver bream, ruff, bleak, mudfish) – with minnow seines. Rudd turned out to be a new species in the ichthyofauna of lakes Siverskoye, Kishemskoye, Nikolskoye and Spasskoye. The dominant species in most reservoirs included roach and perch; pike and silver bream had a significant proportion, much less common were golden crucian carp, ide, ruff, rudd, and single – zope, bleak, and saberfish (Table 2). As measures on artificial reproduction of aquatic biological resources, a total of 140 and 450 thousand of pike larvae were released in Lake Nikolskoye in 2017 and 2022, respectively. Besides, local residents released carp into this reservoir and grass carp *Ctenopharyngodon idella* (Valenciennes, 1844) into Lake Palshemskoye. Carp was successfully introduced since later it was regularly caught by amateur fishermen.

[9] Fishery-biological justification for stocking small lakes of the Vologda region with valuable fish species, 1996. Research report. Vologda laboratory of "GosNIORKh", Vologda, Russia, 64 p.

[10] Federal Law No. 33-FZ of March 14, 1995 "On Specially Protected Natural Areas".

Table 1. Dynamics of industrial catches in lakes of the “Russian North” National Park, kg.

Year	Number of lakes	Fish species															Total
		bream	pikeperch	common pike	burbot	roach	ide	zope	perch	silver bream	bleak	common ruff	sabrefish	asp	European smelt	small-size fish	
1984	4	10428	429	122	–	1447	–	362	–	–	–	–	–	–	–	16658	**29446**
1985	6	15605	126	261	67	1384	48	30	–	–	–	–	–	–	–	21298	**38819**
1986	5	10506	–	–	–	188	–	–	–	–	–	–	–	–	–	13947	**24641**
1987	5	5820	117	279	–	1025	–	93	–	–	–	–	–	–	–	7997	**15331**
1988	5	8274	87	150	–	258	–	178	–	–	–	–	16	–	–	18263	**27226**
1989	5	15992	77	49	–	–	–	352	–	–	–	–	–	34	–	17888	**34392**
1990	6	11550	124	251	–	1128	–	–	–	–	–	–	–	–	–	13370	**26423**
1991	5	10859	–	–	–	–	–	170	–	–	–	–	–	–	–	15029	**26058**
1992	6	9064	40	–	–	4436	–	793	363	–	–	–	–	–	–	15585	**30281**
1993	3	2709	8	–	–	–	–	21	–	–	–	–	–	–	–	8720	**11458**
1994	3	2547	99	140	–	17	–	287	406	–	–	–	–	–	–	12259	**15755**
1995	6	9452	307	756	–	75	10	257	286	–	–	–	–	–	50	33277	**44470**
1996	7	3507	229	546	8	88	84	224	239	–	–	–	–	–	–	38209	**43134**
1997	2	1838	50	138	17	–	7	287	34	–	–	–	–	–	–	4500	**6871**
1999	4	1297	40	204	–	128	–	187	11	–	–	–	–	–	–	2000	**3867**
2000	4	1585	20	–	–	8850	–	43	1930	1020	1131	–	–	–	–	–	**14579**
2001	2	218	–	16	–	662	7	–	175	–	150	–	–	–	–	–	**1228**
2002	2	721	19	63	3	1197	1	–	2472	205	450	–	–	–	–	–	**5131**
2003	2	–	–	25	–	1960		–	775	–	–	–	–	–	–	–	**2760**
2004	3	866	10	115	–	100	596	–	352	90	–	–	–	–	–	–	**2129**
2005	4	18182	162	1828	–	4579	568	50	1802	2733	–	–	–	–	–	–	**29904**
2006	4	9406	3	994	–	3005	446	–	1628	1411	156	542	–	–	–	–	**17591**
2007	3	6806	83	224	–	720	–	–	1092	720	–	343	–	–	–	–	9988

Discussion

Literary sources and stock materials contain the information for the whole study period (1902–2021) about the composition of fish populations in 53 lakes located on the territory of the “Russian North” National Park (Fig. 1, Appendix). In each surveyed reservoirs, from 1 to 25 fish species have been found. In most small-sized reservoirs, the ichthyofauna includes no more than three species and is represented by perch, pike, roach, burbot, or golden carp. More than 10 species are noted only in eight lakes: up to 25 –in lake Siverskoye; 19 – in Zaulomskoye; 16 – in Nikolskoye; 15 – in Borodaevskoye, Ferapontovskoye, Blagoveshchenskoye, Tatarovskoye, and Kishemskoye.

The analysis of the species composition of fish populations in the lakes of the “Russian North” National Park suggests that the morphometric parameters of water bodies and their belonging to the catchment (as natural driving factors), as well as the by-canals connection with other water bodies and the introduction of new species (as anthropogenic ones) play a crucial role in making effect on their ichthyofaunas. The richest composition of fish populations was characteristic of larger and deeper reservoirs of the Northern Dvina lock system. In XX century, by its channels, silver bream, pikeperch, sabrefish, chub, asp, zope, carp, and rudd were transported from the Sheksna River and then from the Sheksna Reservoir to the lakes under consideration.

Whitefish, previously discovered in lakes Blagoveshchenskoye, Tatarovskoye and Vorobino, belongs to a “whitefish-nelma” form currently dwelling in lake Kubenskoye and making spawning migrations to its tributaries (Lebedev, 1982).Whitefish appeared in lakes Siverskoye and Zaulomskoye in the 1930s–1960s due to released fertilized eggs of Chud whitefish. Smelt, carp and pikeperch entered the lakes of the national park probably due to invasion.

In faunal terms, the majority of fish species from the lakes of the “Russian North” National Park (11, or 43%) belongs to the lowland boreal faunal complex. First of all, they include the most widespread and numerous eurythermic and relatively heat-loving species (ide, pike, perch, roach, ruff), which breed in late April – first half of May on flooded vegetation or on overgrown dense sandy and rocky soils. Throughout the study period, these species formed the core of the ichthyocenoses of lakes, providing rather stable amount in catches.

A significant number of species (8, or 31%) refers to the Pontian freshwater complex, including quite widespread numerous relatively thermophilic species (bream, silver bream, rudd, bleak, zope), which spawn on vegetation remains in late May – June. The number and abundance of these species were gradually increasing. By the end of XX – beginning of XXI centuries from the secondary fishery objects they turned into dominant in the structure of catches. If in the first half of XX century bream was not included in the list of main commercial species, and silver bream, rudd, bluefish, sabrefish and pikeperch were not recorded at all, by the end of XX – beginning of XXI centuries, they became widespread species and often major fishing objects. An increase in number and abundance of more heat-loving representatives of the Pontian freshwater complex was a general trend in the dynamics of fish populations of Vologda water bodies in the last 50 years (Borisov, 2010; Konovalov and Borisov, 2015; Zelenetsky et al., 2017).

The boreal piedmont, Pontian amphi-boreal and arctic freshwater faunal complexes are much less represented. The boreal complex includes two species that are rare for the study lakes – stone loach and the common bullhead, playing little role in the ichthyocenoses of the reservoirs. The Pontian amphi-boreal complex is also represented by two species – pikeperch and carp. The appearance of these species is associated both with migrations from the Sheksna River and the Sheksna Reservoir, as well as with the undertaken measures on their release into lakes. Currently, the number of these species is growing, and they have become more common in catches (especially pikeperch).

The arctic freshwater complex includes smelt, whitefish and burbot. Their abundance has decreased throughout the observation period. Smelt is a vivid example. If in the first half of XX century, this fish was the main commercial species in lakes Ferapontovskoye, Borodaevskoye, Spasskoye, Siverskoye, Zaulomskoye, by the beginning of XXI century it completely disappeared or became rare. Nowadays, only few in number burbot is quite widespread in the reservoirs of the national park. Smelt, apparently, inhabit only lakes Siverskoye and Zaulomskoye. Whitefish have completely disappeared. The main reason for decline in number and extinction of these species is deterioration of breeding and feeding conditions because of water bodies eutrophication caused by climate warming (Bolotova, 2012).

Table 2. Structure of scientific fish catches with fixed nets in lakes of the “Russian North” National Park (2008–2021).

Fish species	Lake													
	Itkolskoye	Borodaevskoye	Ferapontovskoye	Spasskoye	Ilyinskoye	Vorobino	Pyatnitskoye	Gorskoye	Siverskoye	Zaulomskoye	Pokrovskoye	Kishemskoye	Palshemskoye	Nikolskoye
	Share by abundance, %													
perch	24.1	51.2	51.8	53.3	30.4	27.3	38.4	36.7	56.0	50.0	35.9	20.7	59.5	43.8
roach	12.4	10.0	21.5	6.5	7.6	27.3	38.4	63.3	10.1	2.4	2.2	22.5	39.2	18.2
bream	25.3	20.9	24.1	13.1	23.9	36.4	23.2	–	8.0	21.8	17.4	43.8	–	16.0
common pike	36.5	15.2	0.4	19.6	27.2	9.1	–	–	1.1	0.8	7.6	1.8	–	1.7
silver bream	–	–	–	–	–	–	–	–	19.3	17.7	31.5	7.1	–	13.2
crucian carp	1.8	1.9	–	2.8	10.9	–	–	–	–	–	–	–	–	0.3
ide	–	0.9	–	1.9	–	–	–	–	0.2	–	–	0.6	–	0.3
common ruff	–	–	2.2	–	–	–	–	–	2.1	–	–	–	1.4	0.8
pikeperch	–	–	–	–	–	–	–	–	1.4	6.5	3.3	0.6	–	–
rudd	–	–	–	2.8	–	–	–	–	0.5	–	–	3.0	–	5.8
zope	–	–	–	–	–	–	–	–	0.9	0.8		–	–	–
bleak	–	–	–	–	–	–	–	–	–	–	2.2	–	–	–
sabrefish	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–

Fish species	Lake													
	Itkolskoye	Borodaevskoye	Ferapontovskoye	Spasskoye	Ilyinskoye	Vorobino	Pyatnitskoye	Gorskoye	Siverskoye	Zaulomskoye	Pokrovskoye	Kishemskoye	Palshemskoye	Nikolskoye
	Share by biomass, %													
perch	11.8	23.0	49.2	20.0	11.8	18.1	35.6	38.6	59.5	42.5	22.2	23.0	57.9	34.2
roach	0.5	5.1	13.8	2.1	1.6	18.2	50.4	61.4	6.5	2.6	0.8	15.8	41.8	19.0
bream	18.0	16.0	28.6	9.2	20.7	26.3	14.0	–	9.6	26.6	15.5	47.7	–	24.5
common pike	68.9	52.4	8.0	62.7	57.0	37.4	–	–	2.6	3.7	40.7	6.0	–	7.3
silver bream	–	–	–	–	–	–	–	–	12.0	9.7	12.4	3.7	–	8.2
crucian carp	0.8	1.7	–	2.9	–	9.0	–	–	–	–	–	–	–	0.2
ide	–	1.9	–	2.7	–	–	–	–	0.8	–	–	0.5	–	2.6
common ruff	–	–	0.4	2.9	–	–	–	–	0.2	–	–	–	0.4	0.2
pikeperch	–	–	–	–	–	–	–	–	7.2	14.3	8.2	1.2	–	–
rudd	–	–	–	0.5	–	–	–	–	0.3	–	–	2.0	–	3.8
zope	–	–	–	–	–	–	–	–	0.8	0.7	–	–	–	–
bleak	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
sabrefish	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–

From conservation point of view, fish species included in the list of the fauna objects of the RF Red Book[11] and the list of rare and endangered species (intraspecific taxa) of animals of the Red Book of Vologda Oblast[12] are absent in fish populations of the "Russian North" National Park lakes.

Over the past 120 years, significant changes have occurred in the commercial use of the lakes in the study territory. If in the first half of XX century, the lakes were intensively fished, a variety of fishing gear was used and a large number of fishermen participated in this process, in its second half fishery activities gradually declined. After the establishment of the "Russian North" National Park in 1992 and with toughening the requirements to nature management, industrial fishing was completely prohibited in 2008. Due to the recreational attractiveness of the territory of the "Russian North" National Park, unorganized amateur fishing (mainly predatory fish species - pike, perch and pikeperch) currently thrives.

It is worth noting that there are no objective biological grounds for banning industrial fishing on lakes located on the study territory. A ban on industrial fishing in the absence of species listed in the federal or regional Red Books makes no significant effect on nature conservation. Moreover, the absence of industrial fishing, which has existed in these reservoirs for centuries, leads to some well-known negative processes in fish populations (Nikolsky, 1965; Pechnikov, 1980).

Seine catching, which prevails in the structure of industrial fishing in the reservoirs of the "Russian North" National Park, is aimed at removing individuals of different ages, primarily peaceful fish species, including bream, silver bream, and roach. This reduces intraspecific and between-species competition for food, increases the growth rate, as well as maturation time and fertility of fish. This is best manifested in bream, which in the conditions of Vologda Oblast (distinguished by its overgrowing reservoirs and favorable temperature conditions) has a high potential for reproduction. With decline in fishing pressure on a population, its number increases and, as a consequence, the growth rates slowdown and a slow-growing population is formed. Comparative analysis of the average-sized bream from lake Zaulomskoye demonstrates a significant reduction in the linear growth rates of all age groups in 2010, as compared to 1931 (Table 3). A similar phenomenon is also observed in populations of silver bream, roach and perch. The same situation occurred in the large fishery lake – Vozhe after the fishery re-orientation to large-size fish catching and seine fishing cessation (Zuyanova, 1994).

Thus, when choosing the mode of using the reservoirs situated within the boundaries of special protected natural areas (including national parks), a differentiated approach is required. In the absence of fish species included in the federal or regional Red Data Books, as well as at the existing fisheries, a total ban on industrial fishing is inappropriate. Industrial fishing (especially with seines) on the lakes of the "Russian North" National Park would preserve natural complexes, prevent water bodies from overgrowing, reduce the rate of fish community restructuring, as well as contribute to preservation of the traditional nature management in the region.

Conclusion

Over a 120-year period, in fish populations of 53 lakes located on the territory of the "Russian North" National Park, 26 fish species from 7 orders and 8 families were recorded. Carp family was particularly rich (16 species): three species belonged to the perch family, one species each – to balitoridae, brook loach, pike, smelt, whitefish, burbot, and sculpins**.** The richest composition was noted in fish populations of large lakes: Siverskoye, Zaulomskoye, Nikolskoye, Borodaevskoye, Ferapontovskoye, Blagoveshchenskoye, Tatarovskoye, Kishemskoye. In most small-size reservoirs, the ichthyofauna contained under three species and was represented by perch, pike, roach or golden carp. In XX century, pikeperch, sabrefish, chub, asp, zope, carp, and rudd appeared in the reservoirs due to migrations along the Northern Dvina lock system from the Sheksna River and later from the Sheksna Reservoir. Besides, the lakes of the National Park were replenished with new species through the release of fertilized eggs,

[11] Order of the Ministry of Natural Resources of the Russian Federation dated March 24, 2020 No. 162 "On approval of the list of fauna objects listed in the Red Book of the Russian Federation".

[12] Decree of the Government of the Vologda Region dated July 25, 2022 No. 942 "On approval of lists of rare and endangered species (intraspecific taxa) of plants, fungi and animals listed in the Red Book of the Vologda Region, lists of species (intraspecific taxa) of plants, fungi and animals in need in scientific monitoring in the Vologda region".

Table 3. Linear growth of fish in lake Zaulomskoye in different years (Data for 1931 are taken from the report "Fish of 102 lakes...", and for 2010 – our own data.

Year of study	Year of life									
	1	2	3	4	5	6	7	8	9	10
					bream					
1931	6.0	11.9	17.4	22.4	26.8	30.6	33.9	36.9	39.6	41.9
2010	5.6	9.4	11.6	13.8	16.5	19.3	22.6	25.0	27.2	30.0
					silver bream					
1931	5.0	10.1	11.2	13.7	16.8	19.0	20.0	–	–	–
2010	4.8	8.5	10.2	11.4	13.8	16.2	17.1	18.1	19.6	–
					perch					
1931	7.5	12.5	15.0	19.5	–	–	–	–	–	–
2010	3.7	9.1	12.2	13.7	16.2	19.8	21.5	23.5	27.5	–
					roach					
1931	5.3	8.5	11.5	13.7	15.7	17.1	–	–	–	–
2010	4.8	8.1	11.0	13.5	14.3	16.7	17.6	18.7	19.6	–

larvae or mature individuals of smelt, Chud whitefish, pikeperch, and carp. For the 120-year period, a decline in number or complete disappearance of most sensitive (to habitat conditions) species, i.e. whitefish and smelt, were recorded.

In faunal terms, 11 fish species from the lakes of the "Russian North" National Park belong to the lowland boreal and 8 – to the Pontian freshwater faunal complexes. At the same time, the arctic freshwater complex is represented only by three species, while the boreal piedmont and Pontian amphi-boreal complexes have two species each. From the second half of XX century, with deterioration of living conditions and climate warming, a decrease in number and disappearance of most vulnerable cold-water species of the freshwater arctic complex and, conversely, an increase in number and abundance of relatively heat-loving species of the Pontian freshwater and amphi-boreal complexes (bream, silver bream, rudd, blue bream, sabrefish and pikeperch) are noted.

In terms of fishing, the lakes of this territory are exploited insufficiently. Until mid of XX century, these reservoirs were intensively fished with a variety of fishing gear. Currently, industrial fishing on the lakes within the boundaries of the "Russian North" National Park is prohibited. The long-term fishery practice in the north-west of Russia and the study results of fish populations in the specially protected natural areas for the last decade are evidence of the inappropriateness of the total ban on industrial fishing, especially with seines.

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APPENDIX. Species composition of fish populations and ecological groups of fish in the lakes of the "Russian North" National Park. Faunal complexes: AF – arctic freshwater, BP – boreal piedmont, BL – boreal lowland, FAB – freshwater amphi-boreal, PF – Pontian freshwater. Ecological groups according to spawning time: ES – early spring, LS – late spring, SM – spring-summer, Au – autumn, W – winter. Ecological groups by spawning substrate: PH – phytophile, PP – psammo-phytophile, PM – psammophile, PL – psammo-lithophile. Ecological groups by water temperature: C – cold-water, E – eurythermic, W – relatively warm-water.

No.	Lake	Year of study	zope *Abramis ballerus*	bream *Abramis brama*	bleak *Alburnus alburnus*	asp *Aspius aspius*	silver bream *Blicca bjoerkna*	crucian carp *Carassius carassius*	common carp *Cyprinus carpio*	gudgeon *Gobio gobio*	verkhovka *Leucaspius delineatus*	chub *Leuciscus cephalus*
1	Palshemskoye-1	1913, 1969, 1986		+				+				
2	Itkolskoye	1913, 1931, 1969, 1996, 2009		+				+				
3	Osinovskoye	1931						+				
4	Ivanovskoye	1931, 1969						+				
5	Sodoshnoye	1931, 1969										
6	Pereshnoye	1969		+								
7	Yumpash	1913, 1969										
8	Rogach	1931										
9	Tyarbolovo	1913										
10	Borovskoye	1931										
11	Pankovskoye	1931, 1969		+	+			+				
12	Petryaevskoye	1913										
13	Onisimskoye	1931										
14	Kokovanevo	1931										
15	Borodayev-skoye	1913, 1931, 1969, 1975, 2021		+	+		+	+			+	
16	Ferapon-tovskoye	1913, 1931, 1969, 1975, 2021		+	+		+	+			+	
17	Spasskoye	1913, 1931		+				+				
18	Okulovskoye	1931, 1969, 1975		+	+			+				
19	Plakhinskoye	1931										

ide *Leuciscus idus*	dace *Leuciscus leuciscus*	sabrefish *Pelecus cultratus*	*roach Rutilus rutilus*	common rudd *Scardinius erythrophthalmus*	tench *Tinca tinca*	stone loach *Barbatula barbatula*	mudfish *Cobitis taenia*	common pike *Esox lucius*	European smelt *Osmerus eperlanus*	whitefish *Coregonus lavaretus*	burbot *Lota lota*	bullhead *Cottus gobio*	common ruff *Gymnocephalus cernuus*	river perch *Perca fluviatilis*	pikeperch *Sander lucioperca*	**Total**
+			+					+			+		+	+		**8**
+			+				+	+			+	+	+	+		**10**
																1
								+						+		**3**
								+			+		+	+		**4**
+			+					+			+		+	+		7
			+					+						+		**3**
			+					+						+		**3**
			+					+						+		**3**
			+					+						+		**3**
+			+					+						+		**7**
			+					+						+		**3**
			+					+						+		**3**
								+			+			+		**3**
+			+	+			+	+	+		+	+	+	+		**15**
+			+	+			+	+	+		+	+	+	+		**15**
+			+	+				+	+		+		+	+		**10**
+			+					+			+		+	+		**9**
								+			+			+		**3**

No.	Lake	Year of study	zope *Abramis ballerus*	bream *Abramis brama*	bleak *Alburnus alburnus*	asp *Aspius aspius*	silver bream *Blicca bjoerkna*	crucian carp *Carassius carassius*	common carp *Cyprinus carpio*	gudgeon *Gobio gobio*	verkhovka *Leucaspius delineatus*	chub *Leuciscus cephalus*
20	Ilyinskoye	1931, 2014										
21	Vorobino	1931, 1969, 2008		+	+		+	+				
22	Pyatnitskoye	1931, 1969, 2008		+	+							
23	Ozerki	1931						+				
24	Kastromka	1931						+				
25	Peregoro-dinskoye	1931						+				
26	Glubokovskoye	1931						+				
27	Melkoye	1931						+				
28	Britovskoye	1931										
29	Sorovskoye	1913, 1931, 1969, 1975, 1996		+	+			+	+			
30	Gorskoye	1913, 2013										
31	Ostolo-povskoye	1913, 1931, 1969, 1975		+	+			+				
32	Ermakovskoye	1913, 1931, 1969, 1975, 1996		+	+			+	+			
33	Egoryevskoye	1913, 1931, 1969, 1975, 1996		+	+			+	+		+	
34	Konstanti-novskoye	1913, 1969, 1975		+				+				
35	Svyatoye	1913			+							
36	Dolgoye	1913, 1931, 1969, 1975		+	+			+			+	
37	Siverskoye	1902, 1906, 1913, 1931, 1969, 1975, 2010, 2013	+	+	+	+	+	+	+	+	+	+
38	Kurikaevskoye	1969										
39	Lunskoye	1913						+				

ide *Leuciscus idus*	dace *Leuciscus leuciscus*	sabrefish *Pelecus cultratus*	*roach Rutilus rutilus*	common rudd *Scardinius erythrophthalmus*	tench *Tinca tinca*	stone loach *Barbatula barbatula*	mudfish *Cobitis taenia*	common pike *Esox lucius*	European smelt *Osmerus eperlanus*	whitefish *Coregonus lavaretus*	burbot *Lota lota*	bullhead *Cottus gobio*	common ruff *Gymnocephalus cernuus*	river perch *Perca fluviatilis*	pikeperch *Sander lucioperca*	**Total**
+			+					+			+		+	+		**6**
+			+					+	+	+	+		+	+		**12**
+			+					+						+		**6**
			+					+						+		**4**
+								+								**3**
								+						+		**3**
								+						+		**3**
								+						+		**3**
								+						+		**2**
+			+					+	+		+		+	+	+	**13**
			+					+			+		+	+		**5**
+			+		+			+	+		+		+	+	+	**12**
+			+		+			+			+		+	+	+	**12**
+			+		+		+	+			+	+	+	+		**14**
			+		+			+					+	+		**7**
+			+					+			+		+	+		**7**
+			+		+		+	+			+		+	+		**12**
+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	**25**
								+			+			+		**3**
+			+					+			+		+	+		**7**

No.	Lake	Year of study	zope *Abramis ballerus*	bream *Abramis brama*	bleak *Alburnus alburnus*	asp *Aspius aspius*	silver bream *Blicca bjoerkna*	crucian carp *Carassius carassius*	common carp *Cyprinus carpio*	gudgeon *Gobio gobio*	verkhovka *Leucaspius delineatus*	chub *Leuciscus cephalus*
40	Pokrovskoye	1913, 1931, 1969, 2010, 2011		+	+				+			
41	Bebishkino	1969		+				+				
42	Zaulomskoye	1902, 1913, 1931, 1969, 1975, 2010	+	+	+	+	+	+				
43	Belousovskoye	1931						+				
44	Krugloye	1931						+				
45	Pigasovo	1931, 1969		+		+		+				
46	Vazerinskoye	1902, 1913, 1931, 1969					+	+				
47	Vysokovskoye	1931						+				
48	Melekhovskoye	1913, 1931, 1969			+							
49	Kishemskoye	1902, 1913, 1931, 1969, 2010		+	+		+	+				
50	Palshemskoye-2	2013										
51	Tatarovskoye	1969		+	+		+				+	
52	Blagove-schenskoye	1913, 1931, 1969		+	+		+				+	
53	Nikolskoye	1913, 1931, 1969, 2010, 2013		+	+	+	+	+	+			
	Number of lakes with species		**2**	**25**	**20**	**4**	**10**	32	6	1	7	1
	Faunal complex		PF	PF	PF	PF	PF	BL	FAB	BL	PF	BL
	Spawning time		ES	LS	SM	LS	SM	SM	SM	SM	SM	LS
	Spawning substrate		PH	PH	PH	PL	PH	PH	PH	PM	PH	PL
	Preferred water temperature		W	W	W	E	W	W	W	E	W	E

ide *Leuciscus idus*	dace *Leuciscus leuciscus*	sabrefish *Pelecus cultratus*	*roach Rutilus rutilus*	common rudd *Scardinius erythrophthalmus*	tench *Tinca tinca*	stone loach *Barbatula barbatula*	mudfish *Cobitis taenia*	common pike *Esox lucius*	European smelt *Osmerus eperlanus*	whitefish *Coregonus lavaretus*	burbot *Lota lota*	bullhead *Cottus gobio*	common ruff *Gymnocephalus cernuus*	river perch *Perca fluviatilis*	pikeperch *Sander lucioperca*	**Total**
+		+	+					+	+		+		+	+	+	**12**
+			+					+					+	+		**7**
+		+	+		+		+	+	+	+	+	+	+	+	+	**19**
+								+								**3**
			+					+						+		**4**
+			+					+			+		+	+		**9**
+	+		+					+			+		+	+	+	**10**
														+		2
+			+					+			+		+	+		**7**
+		+	+	+			+	+			+	+	+	+	+	**15**
			+					+					+	+		**4**
+			+		+		+	+		+	+	+	+	+	+	**15**
+			+				+	+	+	+	+	+	+	+	+	**15**
+	+		+	+			+	+			+	+	+	+		**16**
31	2	4	40	7	8	1	11	51	10	5	31	10	31	50	10	53
BL	BL	PF	BL	PF	BL	BP	BL	BL	AF	AF	AF	BP	BL	BL	FAB	
ES	ES	LS	ES	SM	SM	SM	SM	ES	ES	Au	W	ES	LS	ES	LS	
PH	PM	PL	PH	PH	PH	PM	PH	PH	PM	PL	PM	PM	PP	PH	PP	
E	E	W	W	W	W	E	W	E	C	C	C	E	W	W	W	