Трансформация экосистем
Ecosystem Transformation

ISSN 2619-0931 Online
www.ecosysttrans.com

DOI 10.23859/estr-230303
EDN ITKCYQ
UDC 639.21

Article

State of Lake Onega fish community under fishery pressure

Aleksandra V. Kartanovich, Lidia A. Belicheva*, Anna V. Guzhieva

Karelian Branch of FSBSI "VNIRO" ("KarelNIRO"), ul. Anokhina 29A, Petrozavodsk, 185035 Russia

**belicheva.karelniro@yandex.ru*

Abstract. The article gives a characteristic of fish catches (2018–2022) in Lake Onega – the main commercial fishery waterbody of Karelia. The official five-year statistics is evidence of the stable development of its fishery sector. Fishing is mostly conducted in the Karelian part of the lake. Decline in captures of all biological resources and predominance of smelt and vendace in the catches are noted. Actual exploitation of commercial fish during the last two years reached 68–78% of TAC and RC. In some years, this indicator even exceeded 100% for some species. Currently, biomass and commercial stocks of the main fishing species vary insignificantly.

Keywords: fish community, commercial fish species, commercial stock, catches, rate of fishing, age and length-weight parameters

Funding. The study was carried out as a part of State Task of FSBSI VNIRO

ORCID:
A.V. Kartanovich, https://orcid.org/0000-0003-1354-4237
L.A. Belicheva, https://orcid.org/0000-0002-2219-8922
A.V. Guzhieva, https://orcid.org/0000-0002-6467-5651

To cite this article: Kartanovich, A.V. et al., 2023. State of Lake Onega fish community under fishery pressure. *Ecosystem Transformation* **6** (4), 141–154. https://doi.org/10.23859/estr-230303

Received: 03.03.2023
Accepted: 05.06.2023
Published online: 13.11.2023

DOI 10.23859/estr-230303
EDN ITKCYQ
УДК 639.21

Научная статья

Состояние ихтиофауны Онежского озера в условиях современного промысла

А.В. Картанович, Л.А. Беличева*, А.В. Гужиева

Карельский филиал ФГБНУ «ВНИРО» («КарелНИРО»), Россия, 185035, г. Петрозаводск, ул. Анохина, д. 29А

**belicheva.karelniro@yandex.ru*

Аннотация. В статье представлена характеристика уловов рыб в период с 2018 по 2022 гг. на основном промысловом водоеме Республики Карелия – Онежском озере. Анализ данных официальной статистики за последние 5 лет свидетельствует о стабилизации количества рыбодобывающих организаций и их производственной базы. Промысловая нагрузка, главным образом, сосредоточена в карельской части водоема. Показано, что официальный вылов сократился по всем видам водных биоресурсов, в уловах преобладают корюшка и ряпушка. Отмечается, что фактическое изъятие промысловых видов в озере в последние два года составляет в среднем 68–78% от ОДУ и РВ, по некоторым видам в отдельные годы освоение превышает 100%. На современном этапе фиксируется незначительное колебание показателя биомассы промыслового запаса основных добываемых видов рыб.

Ключевые слова: рыбное сообщество, промысловые виды, промысловый запас, уловы, освоение, биологические показатели

Финансирование. Работа выполнена в рамках Государственного задания ФГБНУ «ВНИРО».

ORCID:
А.В. Картанович, https://orcid.org/0000-0003-1354-4237
Л.А. Беличева, https://orcid.org/0000-0002-2219-8922
А.В. Гужиева, https://orcid.org/0000-0002-6467-5651

Для цитирования: Картанович, А.В. и др., 2023. Состояние ихтиофауны Онежского озера в условиях современного промысла. *Трансформация экосистем* **6** (4), 141–154. https://doi.org/10.23859/estr-230303

Поступила в редакцию: 03.03.2023
Принята к печати: 05.06.2023
Опубликована онлайн: 13.11.2023

Introduction

Nowadays, economic development of lakes is closely related with intensive exploitation of natural resources and increasing anthropogenic loads on freshwater ecosystems. Therefore, the conservation of aquatic biological resources is among the urgent problems of the fishery industry. According to the Food and Agriculture Organization of the United Nations (FAO, 2022), a steady increase in industrial fishery (of the inland waters as well) has been noted worldwide over the past 50–70 years. However, since the late 1970s, a proportion of stocks fished beyond the level of biological sustainability is growing. Intensive fishing is partly responsible for stocks depletion and loss of the commercial value of some species.

Often, fishing is concentrated in the large water bodies which are also exposed to a high anthropogenic stress. At the same time, fishery activities on numerous medium and small-size lakes are constantly declining. Lake Onega is one of the largest in Russia and the second largest freshwater waterbody in Europe. In terms of catches, it is a persistent leader among the reservoirs of the Northwestern Region of Russia. By its fishing significance, the lake ranks first in the Republic of Karelia.

A total of 20 fish species form a resource base of Lake Onega (Bioresources of Lake Onega, 2008). Similar to other large water bodies, fishing load distribution is extremely uneven here. Fishery is primarily aimed at harvesting valuable commercial species that may affect all fish populations, reduce abundance and biomass of commercially important species, as well as lead to the loss of their commercial value.

The purpose of this study is to assess the level of fishing loads and the current state of the main commercial fish of Lake Onega.

Materials and methods

Lake Onega is situated in the European North of Russia. In natural state, the surface area of the lake is 9720 km^2, 250 km^2 of which fall on 1500 islands. The water volume of the lake reaches 295 km^3, the average and maximum depths are 30 and 120 m, respectively. The lake length from north to south makes up 248 km and from west to east – 96 km; the coastline stretches for 1810 km; the indentation of the coastline is 5.12 (Onezhskoe ozero..., 2010). Most of the lake area (about 57%) is represented by the sites with depths of 20–60 m. The large size and prolonged water exchange (13.6 years) contribute to ecosystem stability and conservation of the lake. Being oligotrophic, its main part provides a stable food base for fish (Bioresursy Onezhskogo ozera, 2008).

After the construction (1953) of the Upper Svir Hydroelectric Power Station, the water level of the lake increased by 30 cm. Its basin is of tectonic origin located at 33.3 m a.s.l. In the Onega catchment, 1152 rivers run, 52 of which are more than 10 km long. The rivers Vodla, Shuya and Suna provide about 58% of water river inflow, while the river Svir is the only Lake's outflow.

Three RF subjects jointly use Lake Onega. Within the administrative boundaries of the Republic of Karelia, the water area covers about 835 th. ha (86.1% of the surface area), including the islands with the area of 24.5 th. ha in the northern and central parts of the lake. Its southern part belongs to Vologda (119 th. ha) and Leningrad (15.3 th. ha) Oblasts (Sostoyanie..., 2007).

In the study, we used archival materials and official fishing statistics of the Departments of State Control, Supervision and Fish Protection in the Republic of Karelia, St. Petersburg and Leningrad Oblast, as well as the Northwestern Territorial Administration of Vologda Oblast.

The current state of fish population in Lake Onega was analyzed on the base of the ichthyological material taken from various fishing gears (seines, trap nets, fishweirs, fixed nets with different mesh size) during the studies of 2018–2022. We used standard methods for fishing, analysis, and laboratory processing of the material (Lakin, 1990; Petrova et al., 2011; Pravdin, 1966). Fish weight, commercial length, sex, maturity, and age were determined. The names of fish were given in accordance with Sterligova O.P. at al. (2016).

The choice of the method for estimating stocks depended on the commercial and biological species data, including their completeness and reliability. For assessing the stock size, total allowable catches (TAC) and recommended catch (RC), we used the methodological guidelines (Babayan, 2000; Metodicheskie rekommendatsii po izpol'zovaniyu..., 1990, Metodicheskie rekommendatsii po kontrolu..., 2000). To estimate the amount of amateur catches, the survey data, own observations, and expert assessments were applied.

For stock estimates, the VPA-based method (Pope, 1972; Pope and Shepherd, 1982; Riker, 1979) and natural mortality rates calculated from the L.A. Zykov method (1986) were used. The levels of TAC and RC were set using standards for safe annual exploitation of aquatic biological resources (Malkin, 1999). In calculations, we used the data on official and actual (expert) catches, length-weight parameters and age series of fish for the current and previous years. The performed mass measurements were extrapolated using the Ford-Walford method in the estimates.

Results and discussion

In terms of fish captures, Lake Onega is a leading valuable fishery reservoir in the Republic of Karelia. Its ichthyofauna consists of 47 fish species and subspecies from 13 families. The life cycle of most species is associated with the lake or its tributaries.

Currently, the official fishery statistics registers 13 fishing species: Atlantic salmon *Salmo salar* Linnaeus, 1758, common whitefish *Coregonus lavaretus* (Linnaeus, 1758), pike perch *Sander lucioperca* (Linnaeus, 1758), char *Salvelinus lepechini* (Gmelin, 1788) , European vendace *Coregonus albula* (Linnaeus, 1758), European smelt *Osmerus eperlanus* (Linnaeus, 1758), bream *Abramis brama* (Linnaeus, 1758), roach *Rutilus rutilus* (Linnaeus, 1758), perch *Perca fluviatilis* Linnaeus, 1758, common ruff *Gymnocephalus cernuus* (Linnaeus, 1758), common pike *Esox lucius* Linnaeus, 1758, burbot *Lota lota* (Linnaeus, 1758), three-spined stickleback *Gasterosteus aculeatus* Linnaeus, 1758. It should be noted that since 2020, freshwater salmon of the Republic of Karelia (including the population of the River Shuya) has been listed in the RF Red Book[1] and excluded from the list of aquatic biological resources permitted for commercial fishing in the inland waters (except for the inland sea waters) of the Russian Federation[2].

Over the past 5 years (2018–2022), the total fish catches varied greatly within 1324–1895 tons (Fig.). Among RF subjects, the Karelia share of catches ranged from 80 to 93%, Vologda – from 7 to 19%, and Leningrad Oblast – from 0.5 to 1%. In 2022, the recorded captures in the Vologda part of the lake amounted to 99.6 tons (7.5%), while in the Leningrad one – 13.1 tons, or 0.99% of the total catch in the lake.

Fishery rates in 2022 in all three regions turned out to be the lowest over the past 5 years showing a drop in the catches of almost all major commercial species (except for perch). In 2022, in the Karelian part of the lake, the declared catch of all aquatic biological resources reduced to 1212.1 tons (91.5% of the total catch). Observed decrease in catches was recorded for commercially valuable fish species (such as bream and pike) and fish with low commercial value (ruff, burbot, roach). As compared to 2021, such a reduction in the catch of 2022 was observed for ruff, burbot, roach, bream, and pike – 86%, 20.4%, 22.5%, 29.5%, and 43.6%, respectively. As in the previous years, smelt and vendace prevailed reaching 76.5% of the commercial catch in the Karelian part. Here, their catches in 2022 reduced insignificantly and made up 452.8 and 473.2 tons, or 87.4% and 99.9% of the level of 2021, respectively.

In Lake Onega, the VPA model-based assessment of stocks of the main commercial fish species using natural and commercial mortality rates is carried out every year. For the last 5 years, these are stocks of whitefish, pike perch, vendace, smelt, burbot, perch, and bream. From 2018, commercial stocks of the listed fish species are above the average long-term values and tend to decrease. In 2021, they were 17367 tons (Table 1), or 1582 tons less than in the previous year because of reduced stocks of short-cycle species, i.e. vendace and smelt, which basically specify the importance of the lake in terms of commercial fishery and are characterized by greatly varying catches. In general, the exploitation of major commercial species in the last two years was far from optimum level (which is estimated around 20% of the total commercial stock according to G.P. Rudenko (1986) and reached only 9.5% and 9.0% respectively. In 2020–2021, this indicator for whitefish was 13.0% and 13.2%, vendace –12.5% and 11.6%, and perch – 10.9% and 14.8%, respectively.

Analysis of statistical data, actual catches at stationary fishing sites and captures made by fishing teams in different years shows that official statistics underestimated actual fishing level by 1.5–2 times. Thus, the unreported fish extraction approximately coincides with the expert assessments, which estimate that the actual catch is 1.5–2 times higher (Table 2). The earlier publications devoted to the

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

[2] Order of the Ministry of Agriculture of the Russian Federation No. 501 dated October 6, 2017 “On approval of the list of types of aquatic biological resources for which industrial fishing is carried out in the inland waters of the Russian Federation, with the exception of the inland sea waters of the Russian Federation, and on the recognition of the orders of the Ministry of Agriculture of the Russian Federation as invalid”.

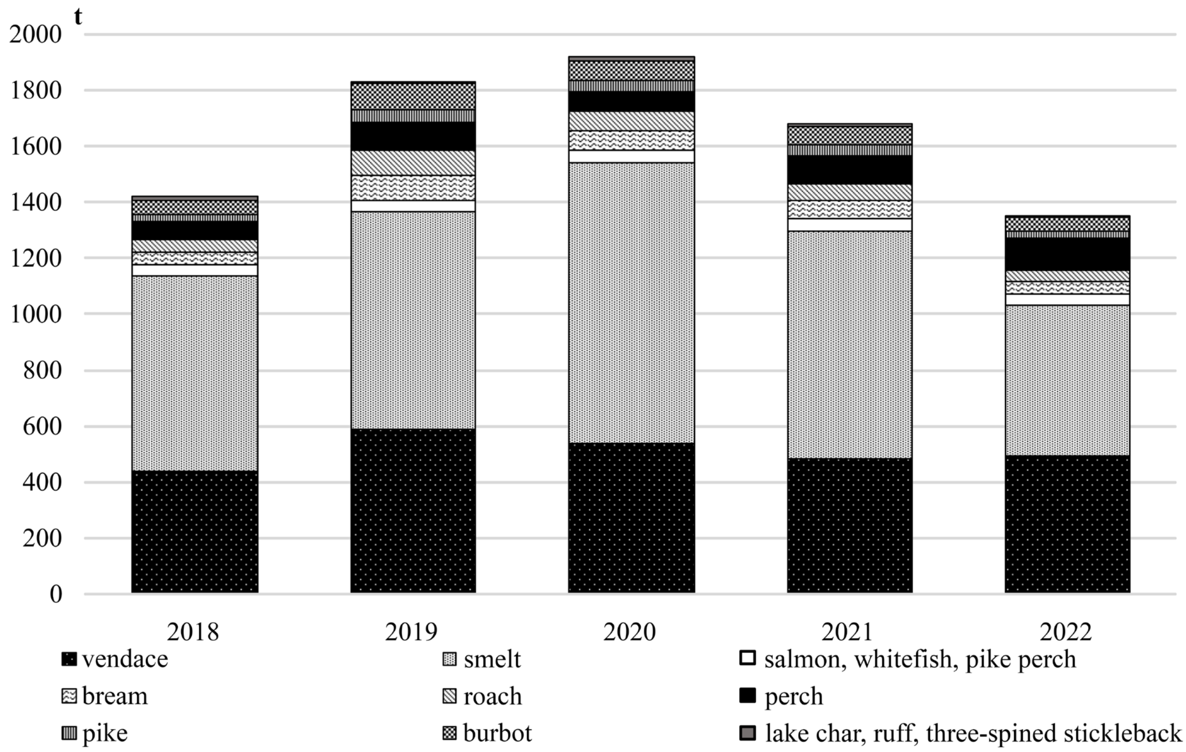

Fig. 1. Volumes of official catches in Lake Onega.

fisheries of Lake Onega also report about the insufficient control and unreliable fishery data (Lipatov and Veselov, 2005).

The data analysis suggests that in fact more than 13% of fish of the commercial stock are exploited on the average. From the official data it follows that fishing of the main commercial species makes up on average 44–50% of TAC and RC. In recent years, actual (expert) catches reach approximately 68–78% and in some years may even exceed 100% for some species (e.g. whitefish, pike perch, and bream).

The data analysis of catches for the last 50 years shows the occurrence of maximum captures of whitefish in the period of intensive fishery of 1985–1990 (115.8 t) and their decline starting from the early 1990s (Lukin et al., 2012). Whitefish in Lake Onega is represented by several ecological forms. Because of the introduced fishery restrictions[3], the organized fishing of only lacustrine (not river-lake) forms is currently implemented. Official statistics demonstrates a clear downward trend in the total catch of whitefish in this lake. At present (2018–2022), whitefish annual catches are at a very low level (average: 18.2 t) that corresponds to the catches of the years 2007–2010 (Lukin et al., 2012). For the past 5 years, the level of exploitation reached on average 70% of TAC (changing from 58.2% to 77.8%). It should be noted that in 2020–2022 in Leningrad Oblast, whitefish catch was not recorded at all; in the Vologda part of the lake, it was noted only in 2020 and amounted to 0.866 tons (86.6%). During 5-year period, age series of whitefish in net catches in the Karelian part of Lake Onega were represented by 7–10 age groups, mostly by individuals aged 4+–6+. Our observations and the analysis of the long-term age structure have revealed some rejuvenation of the population along with a gradual decrease in the proportion of older age groups. The average length of whitefish in 2018–2022 varied from 30.9 (2022) to 33.8 cm (2019) and weight – from 403.6 to 545.1 g, respectively. The parameters were the highest in the years with a larger share of older age groups found in the catches (2019).

Widespread in Onega pike perch is traditionally fished in the northeastern part of the lake. Along with whitefish pike perch is the most valuable commercial species. In the 1990s, pike perch fishing dropped,

[3] Order of the Ministry of Agriculture of Russia No. 292 dated May 13, 2021 “On approval of fishing rules for the Northern Fishery Basin”.

Table 1. Commercial stocks of major fish species of Lake Onega in 2020–2021.

Fish species	Commercial stock, t		Statistical catch, t		Commercial stock exploitation level, %	
	2020	2021	2020	2021	2020	2021
Pike perch	286.8	297.6	26.4	27.6	9.2	9.3
Whitefish	134.2	129.6	17.5	17.1	13.0	13.2
Vendace	4320.0	4138.7	540.5	484.8	12.5	11.7
Smelt	11700.0	10304.0	1001.0	814.5	8.6	7.9
Burbot	816.0	788.6	73.1	64.3	9.0	8.2
Bream	652.0	674.3	69.2	61.5	10.6	9.1
Perch	675.0	669.2	73.3	99.3	10.9	14.8
Total	**18584.0**	**17002.0**	**1757.1**	**1569.1**	**9.5**	**9.0**

but then stabilized at the level of 23.5–24.5 tons (Lukin et al., 2012). In 2018 – 2022 (like in the 2000s), changes were insignificant: levels of annual catches varied within 19.7–27.6 tons (average for 5 years: 24.5 t) and reached on average 71.7% of TAC (changing from 59.7% to 80.0%). Thus, pike perch like whitefish are among the major exploited fishery species. In the Leningrad Oblast, pike perch fishing in 2021–2022 was not recorded at all; in 2020, it amounted to 0.6 t (60% of TAC). In the Vologda part of the lake, its captures were unstable. For instance, in 2020 and 2022, this indicator was about 0.8 tons (on average 77.5% of TAC), while in 2021 – zero. The age structure of pike perch catches for the past 5 years is presented by 12 age groups (maximum age: 15+), starting from 3+. In net catches, individuals aged 5+–9+ years usually dominated; the proportion of fish aged 13+ and older was under 5%; the average weight of individuals varied from 1.13 (2019) to 1.59 kg (2020) and their length – from 42.9 to 48.3 cm, respectively.

Vendace is the most important commercial resource of the lake. Over the past 50 years, its catch was maximum in the second half of the 1980s (841.8 t), then the average-five-year values fluctuated within 309.0–453.4 tons (Lukin et al., 2012). According to official statistics, the commercial fishing of vendace varied (since 2018) from 437 to 591 tons (average: 509.4); its share in the total catch reached 31–33%. The level of exploitation was quite high compared to set RC, but lower than 50%. In 2018–2020, the age structure of spawning vendace considerably changed; there were individuals from 4 age groups (from 1+ to 4+) with predominance of three-year-olds. In 2021, the proportion of fish aged 1+ and 2+ was almost equal. In 2022, the predominance of individuals aged 1+ influenced its biological parameters as follows: the average length in the period under review varied from 12.7 (2021) to 13.8 cm (2018) and mass – from 19.5 (2019) to 23.9 g (2022) being, however, within the long-term values.

In lake Onega catches, the largest share (70% of the total catch in some years) always falls on smelt, the most abundant pelagic fish (Barsova and Sergeeva, 2017; Sergeeva and Barsova, 2016). In 2018–2022, this indicator was within 539.0–1001.1 tons (average: 766.5) being significantly lower than in the second half of the 2000s (1200 t) (Sergeeva and Barsova, 2016). The level of exploitation for the considered 5 years varied as 26.9–55.6% (average: 42.1%) of set RC showing a downward trend for the last two years. Observed trend probably related to the modern version of the Fishing Rules for the Northern Fisheries Basin, which impede smelt fishing in Petrozavodsk Bay of Lake Onega – a place of its mass spawning. Nevertheless, smelt still ranks first in the total catch here. During the period under review, smelt fishing was conducted only in Republic of Karelia and Vologda Oblast. In recent years, age structure of smelt population was represented by 6–8 groups with maximum age of 9 completed years. The age composition of abundant groups differed. Usually three-and four-year-old fish are most abundant. In 2022, three-year-olds dominated with a high proportion of two-year-olds. Note that it is typical for inter-annual fluctuations of this species. In 2018–2022, the average biological parameters of smelt were within the mean long-term values (Barsova and Sergeeva, 2017; Sergeeva and Barsova, 2016): its length varied from 8.7 (2018) to 9.2 cm (2019–2020); weight – from 4.5 (2018 and 2022) to 6.2 g (2020).

Table 2. Catch, TAC and extraction of major commercial fish species.

Fish species	Statistical catch, t		Expert catch of all users, t		Commercial stock exploitation level, %		TAC (RC),t		Statistical assessment of TAC (RC) achieving, %		Expert assessment of TAC (RC) achieving, %	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Pike perch	26.4	27.6	52.8	55.2	18.4	18.5	33	35	80.0	78.9	160.0	157.7
Whitefish	17.5	17.1	35.1	34.2	26.1	26.4	24	23	72.9	74.3	145.8	148.7
Vendace	540.5	484.8	810.7	727.2	18.8	17.6	1300	1300	41.6	37.3	62.4	55.9
Smelt	1001	814.5	1501.5	1221.7	12.8	11.9	1800	1800	55.6	45.3	83.4	67.9
Burbot	73.1	64.3	109.6	96.5	13.4	12.2	155	150	47.2	42.9	70.7	64.3
Bream	69.2	61.5	138.4	123.0	21.2	18.2	65	80	106.5	76.9	212.9	153.8
Perch	73.3	99.3	109.9	148.9	16.3	22.3	160	150	45.8	66.2	68.7	99.3
Total	**1757.1**	**1569.1**	**2758.0**	**2406.7**	**14.8**	**13.9**	**3537**	**3538**	**49.7**	**44.3**	**78.0**	**68.0**

In Lake Onega, burbot is mainly a by-catch species of whitefish, pike perch and smelt. Though legally organized fishing is not implemented in the lake, this fish is harvested annually both in the Karelian, Vologda and Leningrad parts of the lake. In 2018–2022, annual catches of burbot ranged from 51.3 to 92.3 tons (average: 66.6 t), and from 42.9 to 59.6% of set RC (average: 45.5%). In terms of the average long-term fishing rates, a slight decrease (compared to the 2000s) is noted. The habitat conditions of burbot in the reservoir are characterized as favorable. Over the past 5 years, the age structure was presented by 8 age groups (maximum age: 10+), starting from group 3+; individuals aged 4+–6+ prevailed in the catches. Burbot from Lake Onega is characterized by a highly variable growth rate (Kharlamov and Kovalenko, 2019): its average weight in catches of 2018–2022 varied from 0.59 (2021) to 1.21 kg (2019), while length – from 40.8 to 51.4 cm, respectively.

Perch is spread almost throughout the lake being especially abundant in the northeastern part. There is no organized commercial perch fishery in the waterbody. According to official statistics, catch volumes for the past 5 years varied widely from 62.7 to 114.9 tons (average: 89.8 t). The comparison of the fishing data for the last 50 years is evidence of its consistently high catch volumes after some drop in the 1990s (Lukin et al., 2012). The exploitation over the past 5 years ranged from 41.8 to 76.6% (average: 57.0%) of RC. In net catches, the age structure of perch was represented by 6–13 age groups. In 2020–2021, individuals aged 5+–8+ (and in other years – 7+–10+) dominated. The comparison of modern and previously published data on the age structure (Lukin et al., 2012) suggests an increase in the proportion of older age groups nowadays. In 2018–2022, perch length varied on average from 20.2 (2020) to 24.2 cm (2019); weight – from 135.5 to 341.9 g, respectively.

In Lake Onega, bream is not abundant. Despite wide distribution of bream, its share in the total catches is insignificant. According to official data, its total catch in the lake over the past 5 years largely fluctuated from 43.4 (2018) to 90.3 tons (2019) (average: 61.8 tons) corresponding to the level of 2007–2010 (Lukin et al., 2012). Compared to set levels of RC, the exploitation changed significantly (exceeding 100% in some years) and reached 82.5% on the average. Along with perch and roach, bream is a by-catch species because of the abandoned specialized fishery in the waterbody. Lake Onega is the northern border of the native range of bream, that affects its biological parameters providing a relatively low growth rate, late and prolonged maturation, and a long life cycle (up to 30 years). During the past 5 years, the age structure of bream catches was presented by 11–15 age groups (maximum age: 18+), starting from 4+. Annually, individuals aged 5+–12+ mainly dominated in the catches, however, in 2021, 4+–5+ prevailed that changed biological parameters of this species. For instance, its average weight made up 0.283 kg and length – 21 cm. In other years, the average mass reached 0.580 kg and length – 28.8 cm.

In general, fishery in this lake was characterized by seasonal variability. The first peak occurred in May–June, the time of spring-spawning species (50–70% of the annual catch); the second – in August-October, when whitefish dominated in the catches. During these periods, fixed fishing gears were mostly used (trap nets, fishweirs, stakes, fixed nets). Moreover, the increased fishing was recently recorded in November–December (up to 5% of the annual catch). In the ice period, fishermen used fixed nets, sometimes throw nets. The trends towards later ice formation and earlier ice clearance in Lake Onega (Krupneishie ozera..., 2015) also made the effect on its winter catch.

It is obvious that the level of catches is directly related with fishery intensity (i.e. the number of users and their fishery base). In 2021, the total number of the organized users (mainly individual entrepreneurs) amounted to 93, the number of amateur fishermen – about 350 people. In 2022, the first indicator increased to 94, whereas the second dropped to 300 people. In the Leningrad Oblast, only 3 organizations are currently engaged in fishing and in Vologda Oblast – 4 (including research organizations). In the Republic of Karelia, the number of fishery participants reduced from 88 to 87 in 2021 and 2022, respectively.

Official statistics provided by the fisheries protection authorities (North-Western Territorial Administration of the Federal Agency for Fishery) does not contain the precise information about the number of fishing gears used in Vologda and Leningrad Oblasts in 2021–2022. For the Republic of Karelia, such data are available only for few users. Because of this, it is hard to analyze officially permitted and used fishing gear in the lake fishery. Hence, we have to present just the tentative data on

Table 3. Lake Onega fishery participants and their base.

Year	2018	2019	2020	2021	2022
Number of organized users	75	90	93	92	94
Number of fishermen	250–300	300–350	350	357	308
Stake nets, pcs.	up to 4000	up to4600	up to 5000	more than 5500	more than 5000
Throw nets, seines, pcs.	1	1	0	0	0
Trap nets, fishweirs, pcs.	89	45	74	78	81
Pelagic trawls, pcs.	2	2	1	0	0
Fixed nets, pcs.	50	50	35	39	36
Catch per fisherman per year, t	5.1	5.5	5.4	4.6	4.3
Number of fixed nets per fisherman, pcs.	15	14	14	15	16

the employed fishing tools and the number of users in Lake Onega (Table 3).

In water bodies of Karelia, including Lake Onega, fishery participants mainly set nets with a mesh of 16–36 mm (small mesh) and 48–55 mm (medium mesh) and many fewer – large-mesh nets (60 mm and more). Stationary traps of filtering-type (stake nets, trap nets, throw nets, etc.) and pelagic trawls were used mostly for fishing dominant pelagic species – vendace and smelt. In 2021–2022, pelagic trawls were not employed in the lake at all.

In recent years, along with the reduced number of professional fishermen, the use of linmeshing fishing gears (nets) has significantly increased, whereas filter-type fishing gears (stationary nets, trap nets) – decreased. Currently, some stabilization in the number of fishery organizations and their production base is noted.

It should be noted that within the boundaries of the Republic of Karelia, fishing is carried out in order to maintain the traditional way of life and economic activities of the indigenous peoples of the RF North[4]. Their fishing tools are similar to those used in the commercial fishery; the share of captures in the total fishery has considerably declined in recent years. According to statistics of the Head Department of the Federal Agency for Fishery, one fishery organization and four entrepreneurs fished in 2021–2022 and captured less than 0.1% of the total catch in this part of the lake (less than 1 t).

The latest official data on the amateur and sport fisheries at Lake Onega are available for 2016. In particular, two organizations (FSBSI “Karelrybvod” and “Karelsky Barents-Rybak” LLC) fished for whitefish and pike perch in 3 fishing sites under 3 permits. As a result, a total of 0.188 tons of pike perch were extracted (1% of the total catch of this species in the lake).

Currently, official statistics does not keep records of fish volumes caught by amateur fishermen on a free basis and without licenses in accordance with the Fishing Rules. Experts state that the amateur catch in the Karelian part of the reservoir in 2010–2022 is estimated as 150 tons. It is worth noting that unorganized fishing (with violation of fishing rules) is omnipresent and unreported in fact.

Conclusion

Fishery problems of Lake Onega and other water bodies are similar (Barsova, 2017; Konovalov and Borisov, 2014; Levashina and Ivanov, 2014; Lukin et al., 2018; Rudenko, 2018). First of all, this is the lack of appropriate accounting of catch volumes because of intensive poaching and unaccounted

[4] Federal Law No. 166-FZ of December 20, 2004 “On fishing and conservation of aquatic biological resources”.

amateur captures, as well as discrepancy between the data provided by the organized users and the actual catches.

Despite the recent stabilization of the situation with the number of the organized participants and fishing gears used, the recorded commercial catches in the lake tend to decline. In 2022, the captures were the lowest over the past 5 years in all three regions. In addition, the reduced fishing of almost all major commercial species (except for perch) is noticeable. In our opinion, it is caused both by economic (abandoned both trawling and fishing of certain species due to their low profitability) and management (changes in fishing rules) reasons.

The statistics analysis suggests that fish resources of the lake are exploited extremely unevenly. Recent commercial stocks are estimated above the average long-term values but tend to decline. In 2020–2021, this indicator fluctuated slightly (5%). Actual (expert) catches average to 14–15% of the commercial stocks and 68–78% of RC, exceeding 100% for some species (whitefish, pike perch, bream) in some years.

Recent variability of length and weight parameters of major commercial fish species is within the average annual values, and can be explained both by peculiar species biology and shifts in the dominant age groups.

References

Babayan, V.K., 2000. Predostorozhnyi podkhod k otsenke obshchego dopustimogo ulova (ODU) [Precautionary approach for total allowable catch assessment]. All-Russian Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russia, 191 p. (In Russian).

Barsova, A.V., 2017. Analiz promyslovogo ispol'zovaniia ryb Vodlozerskogo vodokhranilishcha za piatiletnii period (2011–2015) [Analysis of commercial fishing in Vodlozerskoye storage reservoir over a five year period (2011-2015)]. *Trudy KarNC RAN [Transactions of the Karelian Research Centre RAS]* **4**, 41–48. (In Russian). https://doi.org/10.17076/them540

Barsova, A.V., Sergeeva, T.I., 2017. Promyslovye ulovy i biologicheskie pokazateli koriushki (*Osmerus eperlanus* (L.)) Onezhskogo ozera v sovremennykh usloviiakh [Commercial catches and biological parameters of smelt (*Osmerus eperlanus* (L.)) of Lake Onega in modern conditions]. *Uchenye zapiski Petrozavodskogo gosudarstvennogo universiteta [Proceedings of Petrozavodsk State University]* **169** (8), 95–97. (In Russian).

Bioresursy Onezhskogo ozera [Bioresources of Lake Onega], 2008. Kukharev, V.I., Lukin, A.A. (eds.). Karelian Research Centre RAS, Petrozavodsk, Russia, 272 p. (In Russian)

FAO, 2022. The State of World Fisheries and Aquaculture (2022). Towards Blue Transformation. FAO, Rome, Italy, 266 p. https://doi.org/10.4060/cc0461en

Kharlamov, A.M., Kovalenko, V.N., 2019. Rybokhozyaistvennaya kharakteristika nalima – *Lota lota* (L.) Onezhskogo ozera na sovremennom etape [Fisheries characteristic of burbot *Lota lota* (L.) of Lake Onega at the present stage]. *Materialy II Mezhdunarodnoi konferentsii "Ozera Evrazii: problemy i puti ikh resheniia" [Proceedings of the II International Conference "Lakes of Eurasia: Problems and Solutions"]*. Kazan, Russia, 346–351 (In Russian).

Konovalov, A.F., Borisov, M.Ya., 2014. Sovremennoe sostojanie i ispol'zovanie vodnyh biologicheskih resursov osnovnyh rybohozjajstvennyh vodoemov Vologodskoj oblasti [Modern status and use of water biological resources in the important fishery waterbodies of Vologda Region]. *Rybnoe khozyaistvo [Fisheries]* **1**, 59–62. (In Russian).

Krupneishie ozera-vodokhranilishha Severo-Zapada ETR: sovremennoe sostoyanie i izmeneniya ekosistem pri klimaticheskikh i antropogennykh vozdeistviyakh [Current state and changes of ecosystems of large lakes-reservoirs of the North-West European territory of Russia under climate change and human impact], 2015. Filatov, N.N. (ed.), Karelian Research Centre RAS, Petrozavodsk, Russia, 375 p. (In Russian).

Lakin, G.F., 1990. Biometriia [Biometry]. Vysshaia shkola, Moscow, USSR, 352 p. (In Russian).

Levashina, N.V., Ivanov, V.P., 2014. Promyslovoe ispol'zovanie populyatsii leshha *Abramis brama* (Linnaeus, 1758) v Volgo-Kaspiyskom rayone [Commercial exploration of a population of bream (*Abramis brama* Linnaeus, 1758) in the Volga-Caspian region]. *Vestnik AGTU. Seriya: Rybnoe khozyaistvo [Vestnik of Astrakhan State Technical University. Series: Fishing industry]* **2**, 37−49. (In Russian).

Lipatov, D.S., Veselov, A.E., 2005. Raspredelenie rybnogo promysla v Onezhskom ozere (na primere 2004 goda) [Distribution of fisheries over Lake Onego in 2004]. In: *Lososevidnye ryby Vostochnoy Fennoskandii [Salmonids fish of Eastern Fennoscandia]*. Karelian Research Centre RAS, Petrozavodsk, Russia, 63–70. (In Russian).

Lukin, A.A., Shchurov, I.L., Shirokov, V.A., Babiy, A.A., Ivanov, S.I., 2012. Rybnoe soobshchestvo Onezhskogo ozera v usloviiakh intensivnogo promysla [Onega Lake fish community under intensive fishery]. *Uchenye zapiski Petrozavodskogo gosudarstvennogo universiteta [Proceedings of Petrozavodsk State University]* **127** (6), 12–19. (In Russian).

Lukin, A.A., Nikitina, T.V., Lukina, Y.N., 2018. Sostoyanie populyatsii sudaka (*Sander lucioperca* L.) ozera Il'men' v usloviyah intensivnogo promysla [State of pikeperch (*Sander lucioperca* L.) population in Lake Ilmen in the context of intensive commercial fishing]. *Vestnik rybohozjajstvennoj nauki [The Bulletin of Fisheries Science]* **5** (1), 26–34. (In Russian).

Malkin, E.M., 1999. Reproduktivnaia i chislennaia izmenchivost' promyslovykh populiatsii ryb [Reproductive and stock variability of commercial fish populations]. All-Russian Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russia, 146 p. (In Russian).

Metodicheskie rekomendatsii po ispol'zovaniiu kadastrovoi informatsii dlia razrabotki prognoza ulovov ryby vo vnutrennikh vodoemakh (chast' 1) [Methodological recommendations for using cadastral information in prediction of fish availability in inland waterbodies (Part 1)], 1990. All-Russian Research Institute of Fisheries and Oceanography (VNIRO), Moscow, USSR, 56 p. (In Russian).

Metodicheskie rekomendatsii po kontroliu za sostoianiem rybnykh zapasov i otsenke chislennosti ryb na osnove biostatisticheskikh dannykh [Methodological recommendations for fish stocks state control and abundance assessment from biostatistical data], 2000. Malkin, E.M., Borisov, V.M. (eds.).All-Russian Research Institute of Fisheries and Oceanography-Central Directorate for Fishery Expertise and Standards (VNIRO-TsUREN), Moscow, Russia, 36 p. (In Russian).

Onezhskoe ozero. Atlas [Onego Lake. Atlas], 2010. Filatov, N.N. (ed.). Karelian Research Centre RAS, Petrozavodsk, Russia, 151 p. (In Russian).

Petrova, L.P., Babii, A.A., Glibko, O.Ya., 2011. Metodicheskoe posobie po organizatsii i vedeniiu ikhtiologicheskogo monitoringa na vnutrennikh vodoemakh [Guidelines for organization and management of ichthyological monitoring in inland water bodies]. Karelian Branch of State Research Institute of Lake and River Fisheries (GosNIORKh), Petrozavodsk, Russia, 60 p. (In Russian).

Pope, J.G., 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. *International Commission of Northwest Atlantic Fisheries Resources Bulletin* **9**, 65–74.

Pope, J.G., Shepherd, J.G., 1982. A simple method for the consistent interpretation of catch-at-age data. *ICES Journal of Marine Science* **40**, 176–184.

Pravdin, I.F., 1966. Rukovodstvo po izucheniiu ryb [Reference guide for fish study]. Food Industry, Moscow, USSR, 376 p. (In Russian).

Riker, U.E., 1979. Metody otsenki i interpretatsii biologicheskikh pokazatelei populiatsii ryb [Methods for assessment and interpretation of biological parameters of fish populations]. Food Industry, Moscow, USSR, 408 p. (In Russian).

Rudenko, G.P., 1986. Ispol'zovanie energeticheskogo podkhoda v rybolovstve i rybovodstve [Energy approach in fishery and fish farming]. *Transactions of State Research Institute of Lake and River Fisheries (GosNIORKh)* **252**, 45–50. (In Russian).

Rudenko, G.P., 2018. Voprosy regulirovanija promysla na primere sudaka *Sander lucioperca* iz juzhnoj chasti Ladozhskogo ozera [The issues of fishery regulation: the case of zander *Sander lucioperca* from the southern part of Lake Ladoga]. *Voprosy rybolovstva [Problems of Fisheries]* **19** (2), 226–237. (In Russian).

Sergeeva, T.I., Barsova, A.V., 2016. Rybokhoziaistvennoe znachenie koriushki (*Osmerus eperlanus* (L.)) Onezhskogo ozera v sovremennykh usloviiakh [Fishery value of Onega Lake smelt (*Osmerus eperlanus* l.) in modern conditions]. *Uchenye zapiski Petrozavodskogo gosudarstvennogo universiteta [Proceedings of Petrozavodsk State University]* **161** (8), 97–100. (In Russian).

Sostoyanie vodnykh ob'ektov Respubliki Kareliia. Po rezul'tatam monitoringa v 1998–2006 gg [Status of water objects in Republic of Karelia. According to 1998-2006 monitoring results], 2007. Lozovik, P.A. et al. (eds.). Karelian Research Centre RAS, Petrozavodsk, Russia, 210 p. (In Russian).

Sterligova, O.P., Ilmast, N.V., Savosin, D.S., 2016. Kruglorotye i ryby presnykh vod Karelii [Cyclostomata and fish of Karelia freshwaters]. Karelian Research Centre RAS, Petrozavodsk, Russia, 224 p. (In Russian).

Zykov, L.A., 1986. Metod otsenki koeffitsientov estestvennoi smertnosti, differentsirovannykh po vozrastu ryb [Method of natural mortality rate assessment for age differentiated fish]. *Izvestia GosNIORKh [Proceedings of State Research Institute of Lake and River Fisheries]* **243**, 14–22. (In Russian).

Список литературы

Бабаян, В.К., 2000. Предосторожный подход к оценке общего допустимого улова (ОДУ). ВНИРО, Москва, Россия, 191 с.

Барсова, А.В., 2017. Анализ промыслового использования рыб Водлозерского водохранилища за пятилетний период (2011–2015). *Труды КарНЦ РАН* **4**, 41–48. https://doi.org/10.17076/them540

Барсова, А.В., Сергеева, Т.И., 2017. Промысловые уловы и биологические показатели корюшки (*Osmerus eperlanus* (L.)) Онежского озера в современных условиях. *Ученые записки Петрозаводского государственного университета* **169** (8), 95–97.

Биоресурсы Онежского озера, 2008. Кухарев, В.И., Лукин, А.А. (ред.). КарНЦ РАН, Петрозаводск, Россия, 272 с.

Зыков, Л.А., 1986. Метод оценки коэффициентов естественной смертности, дифференцированных по возрасту рыб. *Известия ГосНИОРХ* **243**, 14–22.

Коновалов, А.Ф., Борисов, М.Я., 2014. Современное состояние и использование водных биологических ресурсов основных рыбохозяйственных водоемов Вологодской области. *Рыбное хозяйство* **1**, 59–62.

Крупнейшие озера-водохранилища Северо-Запада Европейской территории России: современное состояние и изменения экосистем при климатических и антропогенных воздействиях, 2015. Филатов, Н.Н. (отв. ред). КарНЦ РАН, Петрозаводск, Россия, 375 с.

Лакин, Г.Ф., 1990. Биометрия. Высшая школа, Москва, СССР, 352 с.

Левашина, Н.В., Иванов, В.П., 2014. Промысловое использование популяции леща *Abramis brama* (Linnaeus, 1758) в Волго-Каспийском районе. *Вестник АГТУ. Серия: Рыбное хозяйство* **2**, 37−49.

Липатов, Д.С., Веселов, А.Е., 2005. Распределение рыбного промысла в Онежском озере (на примере 2004 года). В: *Лососевидные рыбы Восточной Фенноскандии*. КарНЦ РАН, Петрозаводск, Россия, 230 с.

Лукин, А.А., Щуров, И.Л., Широков, В.А., Бабий, А.А., Иванов, С.И., 2012. Рыбное сообщество Онежского озера в условиях интенсивного промысла. *Ученые записки Петрозаводского государственного университета* **127** (6), 12–19.

Лукин, А.А., Никитина, Т.В., Лукина, Ю.Н., 2018. Состояние популяции судака (*Sander lucioperca* L.) озера Ильмень в условиях интенсивного промысла. *Вестник рыбохозяйственной науки* **5** (1), 26–34.

Малкин, Е.М., 1999. Репродуктивная и численная изменчивость промысловых популяций рыб. ВНИРО, Москва, Россия, 146 с.

Методические рекомендации по использованию кадастровой информации для разработки прогноза уловов рыбы во внутренних водоемах (часть 1), 1990. ВНИРО, Москва, СССР, 56 с.

Методические рекомендации по контролю за состоянием рыбных запасов и оценке численности рыб на основе биостатистических данных, 2000. Малкин, Е.М., Борисов, В.М. (ред.). ВНИРО-ЦУРЭН, Москва, Россия, 36 с.

Онежское озеро. Атлас, 2010. Филатов, Н.Н. (ред.). КарНЦ РАН, Петрозаводск, Россия, 151 с.

Петрова, Л.П., Бабий, А.А., Глибко, О.Я., 2011. Методическое пособие по организации и ведению ихтиологического мониторинга на внутренних водоемах. Карельское отделение ГосНИОРХ, Петрозаводск, Россия, 60 с.

Правдин, И.Ф., 1966. Руководство по изучению рыб. Пищевая промышленность, Москва, СССР, 376 с.

Рикер, У.Е., 1979. Методы оценки и интерпретации биологических показателей популяций рыб. Пищевая промышленность, Москва, СССР, 408 с.

Руденко, Г.П., 1986. Использование энергетического подхода в рыболовстве и рыбоводстве. *Сб. науч. тр. ГосНИОРХ* **252**, 45–50.

Руденко, Г.П., 2018. Вопросы регулирования промысла на примере судака *Sander lucioperca* из южной части Ладожского озера. *Вопросы рыболовства* **19** (2), 226–237.

Сергеева, Т.И., Барсова, А.В., 2016. Рыбохозяйственное значение корюшки (*Osmerus eperlanus* (L.)) Онежского озера в современных условиях. *Ученые записки Петрозаводского государственного университета* **161** (8), 97–100.

Состояние водных объектов Республики Карелия. По результатам мониторинга в 1998–2006 гг., 2007. Лозовик, П.А. и др. (отв. ред.). КарНЦ РАН, Петрозаводск, Россия, 210 с.

Стерлигова, О.П., Ильмаст, Н.В., Савосин, Д.С., 2016. Круглоротые и рыбы пресных вод Карелии. КарНЦ РАН, Петрозаводск, Россия, 224 с.

ФАО, 2022. Состояние мирового рыболовства и аквакультуры – 2022. На пути к “голубой” трансформации. ФАО, Рим, Италия, 266 с. https://doi.org/10.4060/cc0461ru

Харламов, А.М., Коваленко, В.Н., 2019. Рыбохозяйственная характеристика налима – *Lota lota* (L.) Онежского озера на современном этапе. *Материалы II Международной конференции «Озера Евразии: проблемы и пути их решения»*. Казань, Россия, 346–351.

Pope, J.G., 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. *International Commission of Northwest Atlantic Fisheries Resources Bulletin* **9**, 65–74.

Pope, J.G., Shepherd, J.G., 1982. A simple method for the consistent interpretation of catch-at-age data. *ICES Journal of Marine Science* **40**, 176–184.