Original article
UDC 639.371.5
https://doi.org/10.24143/2073-5529-2022-1-54-64

Reconnaissance of Lake Simaki in North-Kazakhstan region for organizing lake commercial fish farm

V. V. Fefelov[1], N. B. Bulavina[2], S. Zh. Assylbekova[3]*, A. N. Tumenov[4], A. V. Shutkarayev[5]

[1–5]Fisheries Research and Production Center, LLP,
*Almaty, Republic of Kazakhstan, assylbekova@mail.ru **

Abstract. Fishery is a traditional industry for North-Kazakhstan region and, therefore, restoration and organization of lake aquaculture enterprises will provide a significant rise in the economy of the region and creation of new jobs. Scale of the lake commercial fish farm development as a component of commercial fish farming, improvement of its contribution into delivery of food supplies to population depend first of all on the degree of its massive involvement. Status of Lake Peschanoye (Simaki) allows utilizing it for fish commercial cultivation. Application of science-based systems in organizing the lake commercial fish farm will raise efficiency of using natural biopotential of this reservoir and correspondingly enlarge the volumes of production and quality of fish products. In 2021, the researches were conducted on Lake Peschanoye (Simaki). During the researches the hydrological regime of the lake was studied; the samples were taken and processed for hydrochemical and hydrobiological analysis; the material was collected to estimate the condition of ichtyofauna. Generally, the hydrological regime of Lake Peschanoye (Simaki) is found favorable for fish habitat. According to the research results of the year 2021, Lake Peschanoye (Simaki) is a freshwater reservoir with a total mineralization of 875.5 mg/dm^3 which allows using it for obtaining commercial fish roe that will provide a greater economic effect from the lake's utilization. According to the average value of the zoobenthos biomass, Lake Peschanoye (Simaki) belongs to a β-mesotrophic water reservoir which corresponds to the medium level of trophicity. According to the development of food reserves, the recommended volumes of stocking with commercial species are the following: northern whitefish (planktophage) – 4 500 larvae per ha (average value for the Northern Kazakhstan) and carp (benthophage) - 350 yearlings per ha. Pike stocking is recommended as an additional rearing target that will also act as a bio-ameliorator in the fight against the Amur sleeper.

Key words: Lake Simaki, physiographic characteristics, food reserves, hydrochemical regime, lake commercial fish farm, whitefish, carp

Acknowledgment: the research is funded by the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan (Grant No. BR10264236).

For citation: Fefelov V. V., Bulavina N. B., Assylbekova S. Zh., Tumenov A. N., Shutkarayev A. V. Reconnaissance of Lake Simaki in North-Kazakhstan region for organizing lake commercial fish farm. *Vestnik of Astrakhan State Technical University. Series: Fishing Industry*. 2022;1:54-64. (In Russ.) https://doi.org/10.24143/2073-5529-2022-1-54-64.

Научная статья

Рекогносцировка озера Симаки Северо-Казахстанской области для организации на его базе озерно-товарного рыбоводного хозяйства

В. В. Фефелов[1], Н. Б. Булавина[2], С. Ж. Асылбекова[3]*, А. Н. Туменов[4], А. В. Шуткараев[5]

[1–5]ТОО «Научно-производственный центр рыбного хозяйства»,
*Алматы, Республика Казахстан, assylbekova@mail.ru **

Аннотация. Рыбное хозяйство для Северо-Казахстанской области является традиционной отраслью, поэтому восстановление и организация предприятий озерной аквакультуры позволит обеспечить существенный подъем экономики области и создание новых рабочих мест. Масштабность развития озерно-товарного рыбоводного хозяйства как слагаемого товарного рыбоводства, усиление его вклада в обеспечение населения продовольствием зависит, прежде всего, от степени его массовости. Статус оз. Песчаное (Симаки) позволяет использовать его для товарного выращивания рыбы. Применение научно обоснованных систем ведения озерно-товарного рыбного хозяйства позволит повысить эффективность использования естественного биопотенциала этого водоема и, соответственно, увеличить объемы производства и качество рыбной продукции. Работы на оз. Песчаное (Симаки) выполнялись в течение 2021 г. За период исследований был изучен гидрологический режим озера, отобраны и обработаны пробы на гидрохимический и гидробиологический анализ, собран материал для оценки состояния ихтиофауны. В целом гидрологический режим оз. Песчаное (Симаки) является благоприятным для обитания рыб. По результатам исследований 2021 г. оз. Песчаное (Симаки) является прес-

ным водоемом с общей минерализацией 875,5 мг/дм^3, это позволяет использовать его для заготовки рыбоводной икры, что даст больший экономический эффект от эксплуатации водоема. Согласно средней величине биомассы зообентоса оз. Песчаное (Симаки) относится к β-мезотрофным водоемам, что соответствует среднему уровню трофности. В соответствии с развитием кормовой базы рекомендуются следующие объемы зарыбления объектов товарного выращивания: пелядь (планктофаг) – 4 500 экз. личинки на га (среднее значение для Северного Казахстана), карп (бентофаг) – 350 экз. сеголеток на га. В качестве дополнительного объекта выращивания рекомендуется зарыблять щуку, которая также будет выполнять функцию биологического мелиоратора по борьбе с ротаном-головешкой.

Ключевые слова: озеро Симаки, физико-географическая характеристика, кормовая база, гидрохимический режим, озерно-товарное рыбоводное хозяйство, сиговые, карп

Благодарности: исследование финансируется Министерством экологии, геологии и природных ресурсов Республики Казахстан (Грант № BR10264236).

Для цитирования: *Фефелов В. В., Булавина Н. Б., Асылбекова С. Ж., Туменов А. Н., Шуткараев А. В.* Рекогносцировка озера Симаки Северо-Казахстанской области для организации на его базе озерно-товарного рыбоводного хозяйства // Вестник Астраханского государственного технического университета. Серия: Рыбное хозяйство. 2022. № 1. С. 54–64. https://doi.org/10.24143/2073-5529-2022-1-54-64.

Introduction

The main problem of effective using the natural biopotential of water reservoirs is the development and consistent application of science-based systems in conducting lake commercial fish farm. It is necessary to assess the local reservoirs, which will allow increasing their fish productivity. Based on the researches, the level of suitability of reservoirs for commercial use is determined; the regimes are developed for fish reclamation and commercial utilization of water bodies. During the researches of morphometric, hydrological, hydrochemical and hydrobiological parameters of lakes, the form of their use in extensive, intensive or combined regime is determined, as well as the possibility is determined to calculate the yield of fish products [1]. As a result of the conducted researches, the theoretical and practical bases have been formed and proposals have been made for applying methods of conducting LCFF in the North-Kazakhstan Region in modern economic conditions. The research data obtained may serve as a ground for developing the fish breeding and cultivation technologies in terms of Kazakh aquaculture corresponding to standard and technological documentation applied to natural-climatic and economic conditions of fish farms of the North Kazakhstan. Thus, a high degree of fishery utilization of lakes is achieved providing profitability of the production with no harm to environment.

Materials and methods of study

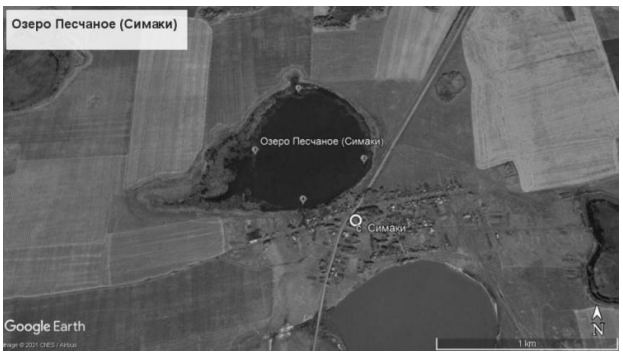
The research was conducted on Lake Peschanoye (Simaki) in 2021. During this period, the lake's hydrological regime has been studied; the samples have been taken and processed for hydrochemical and hydrobiological analysis, the material has been collected to estimate the condition of ichtyofauna. The number and location of sampling stations have been determined due to methodological recommendations for collecting and processing of materials during hydrobiological studies [2–4]. Coordinates of the stations were determined using GPS navigation system.

Coordinates and locations of the integrated sampling stations are shown below in Table 1 and corresponding Figure.

Table 1

Coordinates of sampling stations

Station No	Coordinates
1	N 54^{0}44′23.64″, E 67^{0}47′43.90″
2	N 54^{0}44′06.08″, E 67^{0}48′07.53″
3	N 54^{0}44′08.23″, E 67^{0}47′28.28″
4	N 54^{0}43′56.99″, E 67^{0}47′45.67″



Schematic map of Lake Peschaniye (Simaki) and location of sampling stations

The depth of all sampling stations was measured; the character of bottom sediments was determined; the samples were taken for hydrochemical analysis to determine quantitative and qualitative composition of

plankton and benthos organisms (zooplankton and zoobenthos). Besides the stations abovementioned, the depth was measured in the deep section along the largest width and length of the reservoir with 50 m intervals. Hydrochemical samples were taken along the nets of stations with next fixing and processing at laboratory under available methods [5]. Chemical analysis was conducted according to the following ingredients: ionic composition, total salinity, total hardness, hydrogen index, gas regime, biogen content (ammonium, nitrates, nitrites and phosphates), and permanganate oxidation. Zooplankton material was collected by decanting 100 l of water through the Epstein plankton net with consequent fixing with formalin and identifying organisms at laboratory according to popular identifiers [6]. Quantitative processing of zooplankton samples were performed at the laboratory by counting method under the microscope according to modern methods. In order to calculate biomass, individual weights of organisms were calculated using linear weight equations based on their examples [7]. The benthos was collected using a Petersen grab (S – 1/40 m^2). The samples were analyzed according to generally accepted procedures [4]. Popular identifiers were used in determining the species composition of the benthos organisms [6–9].

In order to study the ichthyofauna, the fish were caught by gillnets with a mesh size of 20 to 70 mm. The material was processed both at the field and laboratory. According to the guidelines [10–12], the species identity of fish was determined, abundance was counted (per species), the length was measured without caudal fin and body weight (Q and q), sex and stage of maturity. The samples were labeled and fixed with 10% formalin solution for laboratory work. Age of the fish was determined by the scales due to manuals. Names of fish taxonomic units are given according to the summary "Fish of Kazakhstan" [13–15].

Commercial abundance and biomass of the fish were estimated according to the methodology for passive fishing gear [16]. The calculation was carried out according to the Formula

$$N = QS/CKP,$$

N – abundance or biomass, thous.pcs./tons; Q – average abundance or biomass according to catch data; S – area of the water reservoir for reserach period, ha; C – area covered (ha) determined due to the total number of nets used for accounting of commercial count; K – coefficient of catching potential of the nets used by us was 0.5; P – probability of catching fish in the net due to the angle of attack [17].

The number of collected and analyzed samples is shown in the Table 2.

Table 2

Amount of the material collected and processed

Samples collected and processed				
Hydrochemistry	**Zooplankton**	**Zoobenthos**	**Fish for biological analysis**	**Nets and gears**
15	8	8	219	8

All calculations were performed on a PC using Excel program.

To write this biological justification, we use literature on this theme and stock materials of Fisheries Research and Production Center LLP.

Research outcomes

Physicogeographical and hydrological characteristics of Lake Peschanoye (Simaki). Lake Peschanoye (Simaki) is located in Zhambyl district of the North-Kazakhstan region 0.1 km to the north of Simaki village. Table 3 shows the coordinates and location of Lake Peschanoye (Simaki).

Table 3

Coordinates and location of Lake Peschanoye (Simaki)

Lake	District	Location	Coordinates
Peschanoye (Simaki)	Zhambyl	0.1 km N from Simaki Village	N $54^0 44' 07.44''$ E $67^0 47' 44.98''$

The water reservoir is located at an absolute height of 132 meters above the sea. Table 4 consists of the main characteristics of Lake Peschanoye (Simaki).

Table 4

Characteristics of Lake Peschanoye (Simaki)

Lake	Altitude above sea level, m	Area of water reservoir, ha	Length, km	Maximum width, km	Length of lake shore, km	Lakeshore enlargement
Peschanoye (Simaki)	132	98.6	1.63	1.10	4.32	1.22
Lake	Maximum depth, m		Average depth, m		Volume of water mass, million m^3	
Peschanoye (Simaki)	6.5		4.1		4.01	

In the course of research we conducted 100 depth measurements and, according to the results of these measurements, the maximum depth was 6.5 m. Average depth of the reservoir was 4.1 m.

Water catchment area is significantly ploughed (up to 90%), and as about undeveloped part of the catchment area, there are steppe herbs in some parts and forest patches. From the south-west, the catchment is limited by regional highway Senzharka-Nikolayevka. Feeding is due to atmospheric precipitation, inflow of melt water and rainwater. Bottom sediments are represented by black and grey silts that are most developed in the eastern part of the reservoir. Bottom sediments are represented by black and gray silt that reached the maximum depth of 0.4 m in the central part of reservoir. Generally, the hydrological regime of Lake Peschanoye (Simaki) is favorable for fish habitat [18]. Analysis of hydrochemical parameters of Lake Peschanoye (Simaki). Lake Peschanoye (Simaki) is a fresh water reservoir with total salinity of 875.5 mg/dm^3, according to the research conducted in 2021. Table 5 represents the main hydrochemical parameters of water from Lake Peschanoye (Simaki).

Table 5

Hydrochemical parameters of the water from Lake Peschanoye (Simaki)

Date	pH	O_2, mg/dm^3	Biogenic compounds, mg/dm^3				Organic substance, mg/dm^3
			NH_4	NO_2	NO_3	P_{PO4}	
07.2021	6.63	8.76	0.46	0.002	4.31	0.03	15.2

Table 6 consists of information on total hardness and ionic composition of the water from Lake Peschanoye (Simaki).

Table 6

Total hardness and ionic composition of the water from Lake Peschanoye (Simaki)

Hardness, mg-eq./dm^3	Ca^+, mg/dm^3	Mg^+, mg/dm^3	Cl^-, mg/dm^3	SO_4^-, mg/dm^3	HCO_2^-, mg/dm^3	$K^+ + Na^+$, mg/dm^3	Mineralization, mg/dm^3
5.01	19.0	54.8	182.6	69.2	370.0	179.9	875.5

According to the content of main cations and anions, exceedance of maximum permissible concentrations for fishery water reservoirs was noted in 2021 only for magnesium content (by 1.37 times). Active reaction of pH medium was 6.63 (water is slightly acidic). Water hardness is 5.01 mg-eq./l (medium hardness). In general, the hydrochemical regime of Lake Peschanoye (Simaki) is favorable for commercial cultivation of whitefish and carp.

Estimation of natural food reserve of Lake Peschanoye (Simaki). Aquatic vegetation. Hard emergent vegetation is developed mainly at the depth up to 1.5m, and is represented by reed cenoses. In general, the water reservoir is covered by reed cenoses in the form of a strip of vegetation with the width up to 100 m stretching along the shore. Extent of hard emergent vegetation is 16 ha or 16.2%. Soft submerged vegetation is developed over a larger area. Thus, different species of pondweed are spread practically on 30% of the lake area; the fennel-leaved pondweed is mostly spread among pondweed.

Zooplankton of Lake Peschanoye (Simaki) in 2021 was represented by three groups of aquatic invertebrates: rotifers, branchiopods and paddle crustaceans. In zooplankton structure 14 taxa were identified of which rotifers (Rotatoria) - 5, bristleworms (Cladocera) - 6 and paddle crustaceans (Copepoda) - 6 species (Table 7).

Table 7

Taxonomic composition of zooplankton of Lake Peschanoye (Simaki) in 2021

Taxa	Frequency of incidence, %
Rotatoria	
Brachionus angularis (Gosse)	75
B. quadridentatus hyphalmiros Tschugunoff	100
Hexarthra fennica (Levander)	25
Keratella cochlearis cochlearis (Gosse)	100
Rotifera sp.	50
Cladocera	
Bosmina kessleri (Uljanin)	50
B. longilostris (O. F. Muller)	100
Daphnia galeata (Sars)	25
Daphnia longispina (O. F. Muller)	100
Daphnia magna (Straus)	25
Sida crystallina (O. F. Muller)	75
Copepoda	
Cyclops vicinus Uljanin	50
Cyclops sp.	25
Diaptomidae castor Jurine	75
Eudiaptomus graciloides (Lilljeborg)	50
Eucyclops serrulatus (Fischer)	25
Mesocyclops leuckarti (Claus)	100
Total taxa	17

The most common species of rotifers are *B. q. hyphalmiros* and *K. c. cochlearis* that were observed in all samples taken from Lake Peschanoye (Simaki). The most common species of branchiopods are *B. longilostris* and *D. longispina* that are part of the zooplankton habitat community in all studied biotopes. From paddle crustacean, the type *M. leuckarti* is also widespread. Table 8 shows abundance and biomass of the main zooplankton groups.

Table 8

Abundance (A, thous.pcs./m^3) and biomass (B, g/m^3) of the main zooplankton groups

Group	Station 1		Station 2		Station 3		Station 4	
	A	B	A	B	A	B	A	B
Rotatoria	28.8	0.01	24.4	0.01	24.0	0.01	25.6	0.01
Cladocera	26.8	0.60	25.6	0.95	24.8	1.02	41.6	1.12
Copepoda	29.6	1.50	28.4	1.40	23.4	1.29	22.8	1.27
Total	85.2	2.11	78.4	2.36	72.2	2.32	90.0	2.40

The samples from Station 4 were the most common of the three presented groups. In the zooplankton composition, Cladoceras dominated averaging 37.6% of the total abundance; Copepoda dominated in biomass.

Table 9 shows the characteristics of fish food organisms (zooplankton).

Table 9

Characteristics of fish food organisms (zooplankton)

Main groups	Abundance, thousand pcs./m^3	Biomass, g/m^3
Rotatoria	25.7	0.01
Cladocera	29.7	0.92
Copepoda	26.1	1.37
Total	81.5	2.3

Average abundance of planktonic organisms in the water body in 2021 was 81.5 thous.pcs./m³. Branchybilled crustaceans are the dominant group in terms of abundance, and equal to 36.4%. Average biomass of zooplankton organisms in the water body is 2.30 g/m^3. Dominant role in the formation of planktonic community biomass belonged to paddle crustaceans - 59.6%. According to the average value of zooplankton biomass, Lake Peschanoye (Simaki) belongs to β-mesotrophic water bodies with an average trophic level (S. P. Kitayev).

Zoobenthos in 2021 was represented by representatives of Oligohchaeta, Hirudinea, Crustacea, Insecta, Mollusca groups. Taxonomic composition of macrozoobenthos is shown in the Table 10.

Table 10

Taxonomic composition of the zoobenthos of Lake Peschanoye (Simaki)

Group, species	Peschanoye (Simaki)
	Frequency of incidence, %
Class Gastropoda	
Lymnaea stagnalis (Linne)	50
Physa adversa (Costa)	25
Class Oligochaeta	
Aulodrilus pluriseta (Piguet)	25
Lumbricus sp.	50
Tubifex tibifex (O. F. Müller)	100
Class Hirudinea	
Glossiphonia complanata Linnaeus	25
Erpobdella octoculata Linnaeus	50
Class Crustacea	
Gammarus lacustris (Sars)	100
Class Insecta	
Gerris costae (Herrich-Schaeffer)	25
Tanypus Meigen	100
Hyphydrus ovatus Linnaeus	25
Chironomus plumosus Linnaeus	100
Sigara lateralis (Leach)	50
Gyrinus substriatus Stephens	50
Limnephilus sp.	25
Chaoborus sp.	50
Total	16

The most spread representatives of Gastropodas were *Lymnaea stagnalis* (Linne) which were present in all samples from Lake Peschanoye (Simaki). Species *T. tibifex* was the most widespread from *Oligochaetas*, and species *T. meigen* and *Ch. plumosus* dominated from the class Insecta.

Table 11 shows abundance and biomass of the main groups of zoobenthos organisms in Lake Peschanoye (Simaki).

Table 11

Abundance (A, pcs./m^3) and biomass (B, g/m^3) of the main zooplankton groups

Group	Station 1		Station 2		Station 3		Station 4	
	A	B	A	B	A	B	A	B
Mollusca	80	4.04	40	2.89	0	0.00	40	2.78
Oligohchaeta	400	0.56	160	0.22	240	0.34	320	0.45
Hirudinea	40	0.81	0	0.00	40	0.67	80	1.38
Crustacea	80	1.33	40	0.67	80	1.39	80	1.43
Insecta	1 200	3.60	440	1.08	520	1.36	960	2.76
Total	1 800	10.34	680	4.86	880	3.76	1 480	8.80

Zoobenthos biomass in 2021 was 6.95 g/m^2 with a total abundance of 1 210 pcs./m^2. *C. plumosus* dominated in the zoobenthos composition according to the quantity which constitutes 37.6% of the total abundance; shell fish *L. stagnalis* dominated due to biomass indicators, which makes 34.6% of the total biomass. According to the average zoobenthos biomass value, Lake Peschanoye (Simaki) belongs to β - mesotrophic water bodies that correspond to the average trophicity level [19]. Table 12 represents characteristics of fish food organisms (zoobenthos).

Table 12

Characteristics of fish food organisms (zoobenthos)

Main groups	Abundance, pcs./m^2	Biomass, g/m^2
Mollusca	40	2.43
Oligohchaeta	280	0.39
Hirudinea	40	0.72
Crustacea	70	1.21
Insecta	780	2.20
Total	1 210	6.95

Conducted researches show the possibility to cultivate commercial fish in Lake Peschanoye (Simaki). According to the outcomes it has been determined that Lake Peschanoye (Simaki) is a water body with a total mineralization equal to 875, mg/dm³ and moderate pollution; the lake is β - mesotrophic water body with an average level of trophicity. Due to development of food reserve, it is recommended to plant the stocking material of the fish indicated in the Table 13.

Table 13

Recommendations for food reserve

Water reservoir	Food supply for zooplankton	Food supply for benthos	Ecological condition of aquatic organisms	Need for acclimatization of food invertebrates	Need for stocking	Suggestions for fishing gears
Lake Peschanoye (Simaki)	medium	medium	Moderate pollution	no	Whitefish, carp, pike	Use fixed sand trap nets for Carp and fixed nets for Northern whitefish.

Estimation of current ichtyofauna composition of Lake Peschanoye (Simaki). Ichthyofauna of Lake Peschanoye (Simaki) in 2021 was represented by silver carp, Amur sleeper, roach, pike, carp and northern whitefish (Table 14).

Table 14

Composition of ichthyofauna species of Lake Peschanoye (Simaki)

Name of species			Status of the species
Latin	Kazakh	English	
Carassius gibelio (Bloch)	Кәмдігі мөңке	Silver Carp	Commercial, autochthonous
Rutilus rutilus (L.)	Торта	Roach	Commercial, autochthonous
Cyprinus carpio (L.)	Тұқы	Carp	Commercial, introduced
Esox lucius L.	Шортан	Pike	Commercial, autochthonous
Coregonus peled	Пелядь	Northern whitefish	Commercial, introduced
Perccottus glenii Dybovski	Ротан-головешка	Amur Sleeper	Not commercial, introduced

Silver carp is the most widely spread species in water bodies of the North Kazakhstan. It feeds mainly on animal food - zooplankton and zoobenthos, although sometimes it consumes aquatic vegetation. Table 15 shows the main biological parameters of silver carp of Lake Peschanoye (Simaki).

Table 15

Main biological characteristics of silver carp

Age range	Length, cm (min-max)	Average length, cm	Weight, g (min-max)	Average weight, g	Amount, pcs.	% (of caught individuals)
5+	20.6-22.8	21.2	355-425	386.7	3	50.0
6+	23.0-25.0	24.2	410-571	502.1	2	33.3
7+	28.2	28.2	904	904	1	16.7
				Total	6	100

Silver carp population is represented in Lake Peschanoye (Simaki) by age groups from 5+ to 7+ y. o. The most abundant age group in the silver carp population is 5+ y.o. specimens. Age group 6+ accounts for 33.3% of the total number. Growth rate of the silver carp in Lake Peschanoye (Simaki) is quite high for our region.

Peculiarity of the silver carp of the North Kazakhstan is almost complete absence of males in its populations. The eggs are fertilized by golden carp or other carp species resulting in that only females survive from them. All caught specimens were females.

Low abundance of the silver carp in Lake Peschanoye (Simaki), as well as absence of juveniles in catches may indicate the success of land-reclamation fishing and other fish-farming activities.

Roach is an autochthonous species inhabiting most non-marine water bodies. Most catches are juveniles. Table 16 summarizes the main biological parameters of roach in Lake Peschanoye (Simaki).

Table 16

Main biological parameters of roach

Age range	Length, cm (min-max)	Average length, cm	Weight, g (min-max)	Average weight, g	Numbers, pcs.	% (of caught individuals)
2+	12.8-16.0	15.1	48-94	67.3	34	50.7
3+	15.0-17.9	16.7	80-123	99.3	16	23.9
4+	18.0-21.5	20.4	110-199	144.2	8	11.9
5+	20.7-23.8	22.5	161-286	216,3	6	9
6+	23.4-25.6	24.2	302-397	349.5	2	3
7+	27.1	27.1	432	432	1	1.5
				Total	67	100

Roach population is represented in Lake Peschanoye (Simaki) by age group from 2+ to 7+ y. o. The most abundant age group in the roach population is specimens of 2+ y. o. which constitute 50.7% of the total number. Growth rate of the roach is relatively high for the water reservoirs of our region.

Roach reaches sexual maturity in the third year of living, and at 2+ years the sex ratio is approximately 1 : 1.3 in favor of females, at 3+ years the females share is increased, and at 7+ years only females are observed in the population. In general, the sex ratio is 1 : 1.5 in favor of females.

Spawning of roach in our region takes place in April-May at a water temperature of 6 to 8 °C. At this time, roach gather in flocks and migrate to shallow coastal waters where they lay their eggs on aquatic vegetation. During the spawning season, males acquire characteristic mating attire - epithelial tubercles on scales and gill lids and become rough to the touch.

In Lake Peschanoye (Simaki), the roach is one of the main foods for pike.

Carp is the most valuable species among cultivation objects, having been introduced at one time to many water bodies of the North Kazakhstan. It was introduced into Lake Peschanoye (Simaki) as a commercial specimen; stocking was carried out with larvae and different-aged specimens.

We caught species with weights from 968g to 2 200 g at the age 1+ and 2+ y. o. (Table 17).

Table 17

Main biological parameters of carp

Age range	Length, cm (min-max)	Average length, cm	Weight, g (min-max)	Average weight, g	Numbers, pcs.	% (of caught individuals)
1+	32.0-34.7	33.8	968-1 227	1 114	8	57.1
2+	33.8-40.4	37.2	1 154-2 200	1 805	6	42.9
				Total	14	100

Carp population is represented in Lake Peschanoye (Simaki) by individuals of the age group 1+ to 2+ y. o. due to catch results. 1+ age group was the most abundant in the population accounting for 27.8% of the total number. Growth rate of the carp is quite high.

In our region, carp reaches sexual maturity in the third - fourth year of living. It spawns in summer in calm, warm weather at a water temperature of 18-20 °C. It spawns in shallow water and on freshly covered vegetation, splashing noisily and jumping out of the water. Fertility, depending on the size, varies from 100 thousand to 1.5 million eggs.

Pike is an autochthonous species to the Ob-Irtysh basin and inhabits the majority of non-marine water bodies. It lives mostly singly in a coastal zone forming shoals during spawning and in late autumn (Table 18).

Table 18

Main biological parameters of pike

Age range	Length, cm (min-max)	Average length, cm	Weight, g (min-max)	Average weight, g	Numbers, pcs.	% (of caught individuals)
1+	31.5-37.5	35.4	297-494	388	5	35.7
2+	41.0-47.1	43.5	620-956	798	5	35.7
3+	49.8-56.3	53.2	1 087-1 960	1 485	4	28.6
				Total	14	100

Pike was brought to Lake Peschanoye (Simaki) in 2019 as a biological ameliorator to control of Amur sleeper.

Northern whitefish is one of the promising commercial species. At normal planting density, peled yearlings reach 120-180 g weight in October-November; two-year-olds reach 200-250 g. Number of this species is rather high in Lake Peschanoye (Simaki), as we caught 118 specimens. Table 19 shows main biological parameters of the northern whitefish of Lake Peschanoye (Simaki).

Table 19

Main biological parameters of northern whitefish

Age range	Length, cm (min-max)	Average length, cm	Weight, g (min-max)	Average weight, g	Numbers, pcs.	% (of caught individuals)
0+	17.1-18.3	17.8	89-110	99.4	118	100
				Total	388	100.0

200 thousand peled with larvae were put into Lake Peschanoye (Simaki) during this year. Despite the fact that there are predators (pike, Amur sleeper), northern whitefish in the reservoir has grown to normal values. Growth rate of northern whitefish is rather high for our region.

Due to the fact that this species is an object of commercial cultivation and is almost incapable for natural reproduction, estimation of the dynamics of size, age and even sex composition is senseless from the biological point. Besides, the catches contained only immature specimens.

Northern whitefish reaches sexual maturity in the third year of life. Incubation period lasts 170-180 days. Hatching of the larvae takes place between April and May.

Northern whitefish feeds on zooplankton and zoobenthos organisms. It tolerates temperature increase up to 25-30 °C, but the most optimal ongrowing period takes place at water temperature 15-20 °C.

Due to the fact that Lake Peschanoye (Simaki) is located outside the natural habitat of the northern whitefish, this species is only the object of commercial cultivation and its abundance in the reservoir is maintained by stocking.

Amur sleeper is a weed fish species. We caught three specimens with a length from 13.4 to 16.0 cm and weight from 82 to 120 g. Presence of this fish is not favorable in the reservoir, as it feeds on the caviar, and consumes juveniles which bring to negative result in cultivation of commercial species.

Results of discussion

Development of recommendations for preparation and utilization of Lake Peschanoye (Simaki) for commercial fish breeding. Due to the researchers conducted in 2021 on Lake Peschanoye (Simaki), we have developed recommendations for preparation and utilization of Lake Peschanoye (Simaki) taking into account the preparatory works performed earlier. The Lake commercial fish farm on Lake Peschanoye (Simaki) was established in 2019, the main direction of its utilization is to make a breed pond to keep breeding stock of the carp, pike and northern whitefish. In the period from 2019 to 2021, the following preparatory works were conducted by Vodoley-2017 LLP:

– arrangement of access roads;
– preparation of the tonnage areas;
– removal of excessive vegetation;
– snow retention and clearing of stream beds;
– aeration.

In addition to ongoing reclamation, in order to increase efficiency of the lake's utilization, ameliorative catching of native ichthyofauna (crucian carp) was carried out. Besides, the pike, predatory fish, was planted as a biological ameliorator to reduce weed species (Amur sleeper).

In order to determine reserves and fish productivity, we have made calculations based on the methodology for determination of abundance and reserves of passive fishing gear. Table 20 represents calculations under methodology of A. I. Kushnarenko and Ye. S. Lugarev [16].

Table 20

Calculation of abundance and biomass of fish populations in Peschanoye (Simaki) Lake

Parameters	Goldfish	Roach	Carp	Pike	Northern whitefish
Area of habitat, ha	84.6	84.6	84.6	84.6	84.6
Length of net, m	2.5	25.0	25.0	25.0	25.0
Number of nets, pcs.	8.0	8.0	8.0	8.0	8.0
Area covered, ha	3.2	4.7	6.4	3.2	25.8
Catchability coefficient	0.5	0.5	0.5	0.5	0.5
Average weight, kg	0.511	0.111	1.410	0.848	0.099
Abundance, thousands pcs.	1.400	10.778	1.648	3.268	3.461
Stocks, tons	0.71	1.20	2.32	2.77	0.34
Fish productivity, kg/ha	8.46	14.18	27.46	32.76	4.07

Since Lake Peschanoye (Simaki) is operated as a LCFF and fish populations are regulated artificially, we use the entire stock of fish resources to calculate fish productivity.

According to the table, we see that fish productivity of Lake Peschanoye (Simaki) in 2021 constituted 86.9 kg/ha. According to the Fish Farm Rules #1 456 dated December 31, 2004 (as amended and supplemented under the Resolution #566 of the Government of the Republic of Kazakhstan as of June 14, 2010), the Lake Commercial Fish Farm (LCFF) is a farm engaged in improvement of utilization of reservoirs for fish-culture by full or partial replacement of ichthyofauna by catching coarse fish, stocking, cultivating and subsequent catching of valuable fish species. The Fishery Regulations do not apply to LCFF. For further increase in fish productivity of Lake Peschanoye (Simaki), it is recommended to continue stocking of pike to control weed species (Amur sleeper). Besides, it is proposed to continue the work on commercial cultivation of carp and northern whitefish. Table 21 specifies stocking standards for Lake Peschanoye (Simaki) [20, 21].

Table 21

Stocking standards and estimated volume of commercial fish

Parameter	Carp	Whitefish	Pike
Area of water reservoir, ha	98.6	98.6	98.6
Age composition of stocking	yearlings	larvae	different age
Stocking rate, units/ha	350	4 500	50
Total stocking rate, thousand fish	34.5	450.0	4.93
Survival rate, %	20	5.0	To control the Amur sleeper
Stocking rate of marketable fish, g	600	100	
Volume of marketable fish, tons	4.14	2.25	
Fish productivity, kg/ha	42	22.8	

In Table 21 we can see that commercial cultivation of carp and whitefish by extensive way will increase fish productivity of Lake Peschanoye (Simaki) for carp to 42 kg/ha (1.5 times), and for whitefish to 22.8 kg/ha (5.6 times). Utilization of the lake as a LCFF should provide performance of the basic production stages, which increases efficiency of the reservoir utilization. Table 22 represents the main production stages of the commercial fish farming.

Table 22

Main production stages of commercial cultivation

Production stage	Time limits
Acquiring the whitefish larvae and lake stocking	April-May
Catching autochthonous species	April-September
Stocking the lake with different-age pike	June-September
Acquiring carp yearlings and lake stocking	September-October
Catching and sale of commercial fish	October-January
Further, perform production stages similar to the previous year	

Compliance with the recommended technological regulations, coordinated work of all services and departments of the LCFF will reduce negative impact of technical risks and force majeure situations to a minimum.

Conclusion

As a result of commercial cultivation of carp and whitefish by extensive way, we can increase fish productivity of Lake Peschanoye (Simaki) for carp up to 42 kg/ha (1.5 times), and for whitefish up to 22.8 kg/ha (5.6 times).

In 2021, the researches were conducted on Lake Peschanoye (Simaki). During this period, we studied the lake's hydrological regime, took samples, processed them for hydrochemical and hydrobiological analysis, and collected the material for estimation of the ichtyofauna.

Generally, the hydrological regime of Lake Peschanoye (Simaki) is favorable for fish habitat.

According to the researches, conducted in 2021, Lake Peschanoye (Simaki) is a freshwater reservoir with a total mineralization of 875.5 mg/dm^3. This allows us to utilize it for obtaining commercial fish caviar that will provide a greater economic effect from the lake's utilization.

Average number of planktonic organisms in the pond in 2021 was 81.5 thous.pcs./m^3 with a biomass of 2.30 g/m^3. According to the average value of zooplankton biomass, Lake Peschanoye (Simaki) belongs to β-mesotrophic water bodies with an average trophic level. Zoobenthos biomass was 6.95 g/m^2 with a total abundance of 1210 pcs./m^2. According to the average value of zoobenthos biomass, Lake Peschanoye (Simaki) is classified as β - mesotrophic water reservoir that corresponds to the average trophic level.

Recommended volumes for stocking of commercial cultivation objects are as follows taking into account a good level of development of the food reserve: northern whitefish (planktophage) – 4 500 larvae per ha (average value for the North Kazakhstan) and carp (benthophage) – 350 carp yearlings per ha. As an additional cultivation target, it is recommended to stock pike that will also act as a bio-ameliorator for amur sleeper.

References

1. *On approval of the Rules of preparing a biological justification for wildlife exploitation.* Order #104-O of the Minister of Environment and Water Resources of the Republic of Kazakhstan dated April 4, 2014.

2. *Methodological recommendations on collection and processing of materials during hydrobiological research in freshwater reservoirs. Zooplankton and its products*. Leningrad, 1982. 33 p.

3. *Methodical recommendations on collection and processing of material during hydrobiological research in freshwater reservoirs. Zoobenthos and its products*. Leningrad, 1983. 51 p.

4. *Brief methodological guidelines for making investigations to determine biological productivity of lakes.* Tyumen, 1971. 11 p.

5. *Guidelines on chemical analysis of surface waters of the land.* Leningrad, Gidrometeoizdat, 1977. 542 p.

6. *Definitions of freshwater invertebrates in the European part of the USSR.* Leningrad, Gidrometeoizdat, 1977. 510 p.

7. *Guidelines on methods of hydrobiological analysis of surface waters and bottom sediments*. Leningrad, Gidrometeoizdat, 1983. 239 p.

8. Mamayev B. M. *Identification of Insects by Larvae*. Moscow, Prosveshcheniye Publ., 1972. 399 p.

9. Pankratova V. Y. *Larvae and pupae of mosquitoes of the subfamily Orthocladinae of the USSR (Diptera, Chironomidae).* Leningrad, 1970. 344 p.

10. Pravdin I. F. *Fish Study Guide*. Moscow, Food Industry Publ., 1966. 376 p.

11. Chugunova N. I. *Fish Age and Growth Study Guideline.* Moscow, 1959. 165 p.

12. Nikolskiy G. V. *Ecology of fish.* Moscow, Higher School Publ., 1974. 376 p.

13. *Fish of Kazakhstan: in 5 volumes*. Almaty, Nauka Publ., 1987. Vol. 2. 200 p.

14. *Fish of Kazakhstan: in 5 volumes*. Alma-Ata, Nauka Publ., 1988. Vol. 3. 304 p.

15. *Fish of Kazakhstan: in 5 volumes*. Alma-Ata, Nauka Publ., 1989. Vol. 4. 312 p.

16. Kushnarenko A. I., Lugarev E. S. Estimation of the number of fish by catches with passive fishing gear. *Voprosy Ikhtiologii*, 1989, vol. 23-6, pp. 921-926.

17. Malkin Ye. M., Borissov V. M. *Methodological recommendations on fish stock monitoring and fish abundance assessment based on biostatic data.* Moscow, 2000. 32 p.

18. Philonets P. P., Omarov T. R. *Lakes of the Northern, Western and Eastern Kazakhstan (guidebook).* Moscow, Gidrometeoizdat, 1974. 78 p.

19. Kitayev S. P. On correlation of some trophic levels and "trophicity" scale of lakes of various natural zones. *Report of V Congress of All-Union Hydrobiological Society, Togliatti, 15-19 September, 1986*. Kuibyshev, 1986. Pp. 254-255.

20. *Freshwater Aquaculture Reference Dictionary*. Moscow, Stolichnaya typografiya, 2008. 112 p.

21. Kolomin Y. M. *Fish farming in the North Kazakhstan.* Petropavlovsk, ITS SKGU, 2003. 40 p.

Список источников

1. *On approval* of the Rules of preparing a biological justification for wildlife exploitation. Order #104-O of the Minister of Environment and Water Resources of the Republic of Kazakhstan dated April 4, 2014.

2. *Methodological* recommendations on collection and processing of materials during hydrobiological research in freshwater reservoirs // Zooplankton and its products. L., 1982. 33 p.

3. *Methodical* recommendations on collection and processing of material during hydrobiological research in freshwater reservoirs // Zoobenthos and its products. L., 1983. 51 p.

4. *Brief* methodological guidelines for making investigations to determine biological productivity of lakes. Tyumen, 1971. 11 p.

5. *Guidelines* on chemical analysis of surface waters of the land. L.: Gidrometeoizdat, 1977. 542 p.

6. *Definitions* of freshwater invertebrates in the European part of the USSR. L.: Gidrometeoizdat, 1977. 510 p.

7. *Guidelines* on methods of hydrobiological analysis of surface waters and bottom sediments. L.: Gidrometeoizdat, 1983. 239 p.

8. *Mamayev B. M.* Identification of Insects by Larvae. M.: Prosveshcheniye, 1972. 399 p.

9. *Pankratova V. Y.* Larvae and pupae of mosquitoes of the subfamily Orthocladinae of the USSR (Diptera, Chironomidae). L., 1970. 344 p.

10. *Pravdin I. F.* Fish Study Guide. M.: Food Industry, 1966. 376 p.

11. *Chugunova N. I.* Fish Age and Growth Study Guideline. M., 1959. 165 p.

12. *Nikolskiy G. V.* Ecology of fish. M.: Higher School, 1974. 376 p.

13. *Fish* of Kazakhstan: in 5 volumes. Almaty: Nauka, 1987. V. 2. 200 p.

14. *Fish* of Kazakhstan: in 5 volumes. Alma-Ata: Nauka, 1988. V. 3. 304 p.

15. *Fish* of Kazakhstan: in 5 volumes. Alma-Ata: Nauka, 1989. V. 4. 312 p.

16. *Kushnarenko A. I., Lugarev E. S.* Estimation of the number of fish by catches with passive fishing gear // Voprosy Ikhtiologii. 1989. V. 23-6. P. 921–926.

17. *Malkin Ye. M., Borissov V. M.* Methodological recommendations on fish stock monitoring and fish abundance assessment based on biostatic data. M., 2000. 32 p.

18. *Philonets P. P., Omarov T. R.* Lakes of the Northern, Western and Eastern Kazakhstan (guidebook). M.: Gidrometeoizdat, 1974. 78 p.

19. *Kitayev S. P.* On correlation of some trophic levels and “trophicity” scale of lakes of various natural zones // Report of V Congress of All-Union Hydrobiological Society, Togliatti, 15-19 September, 1986. Kuibyshev, 1986. P. 254–255.

20. *Freshwater* Aquaculture Reference Dictionary. M.: Stolichnaya typografiya, 2008. 112 p.

21. *Kolomin Y. M.* Fish farming in the North Kazakhstan. Petropavlovsk: ITS SKGU, 2003. 40 p.

The article is submitted 11.02.2022; approved after reviewing 21.02.2022; accepted for publication 14.03.2022
Статья поступила в редакцию 11.02.2022; одобрена после рецензирования 21.02.2022; принята к публикации 14.03.2022

Information about authors / Информация об авторах

Viktor V. Fefelov – Head of the base station of the North branch in Petropavlovsk; Fisheries Research and Production Center, LLP; Nur-Sultan, Kenesary St. 43; Fefelov@fishrpc.kz

Nailya B. Bulavina – Senior Researcher of the Laboratory of Aquaculture; Fisheries Research and Production Center, LLP; Almaty, Suyunbay Avenue, 89 A; bulavina@fishrpc.kz

Saule Zh. Assylbekova – Doctor of Biological Sciences, Assistant Professor; Deputy General Director; Fisheries Research and Production Center, LLP; Ltd., Republic of Kazakhstan, Almaty, Suyunbay avenue, 89 A; assylbekova@mail.ru

Artur N. Tumenov – PhD; Director of the Western-Kazakhstan branch; Fisheries Research and Production Center, LLP; Uralsk, Zhangir Khan St., 45; Tumenov@fishrpc.kz

Azis V. Shutkarayev – Director of the Northern Branch; Fisheries Research and Production Center, LLP; Nur-Sultan, Kenessary St., 43; azis-62@mail.ru

Виктор Владимирович Фефелов – заведующий опорным пунктом Северного филиала г. Петропавловск; ТОО «Научно-производственный центр рыбного хозяйства»; Нур-Султан, ул. Кенесары 43; Fefelov@fishrpc.kz

Наиля Баймуратовна Булавина – старший научный сотрудник лаборатории аквакультуры; ТОО «Научно-производственный центр рыбного хозяйства»; Алматы, проспект Суюнбая, 89 А; bulavina@fishrpc.kz

Сауле Жангировна Асылбекова – доктор биологических наук, доцент; заместитель генерального директора; ТОО «Научно-производственный центр рыбного хозяйства»; Алматы, проспект Суюнбая, 89 А; assylbekova@mail.ru

Артур Насибуллаулы Туменов – PhD; директор Западно-Казахстанского филиала; ТОО «Научно-производственный центр рыбного хозяйства»; Уральск, ул. Жангир хана, 45; Tumenov@fishrpc.kz

Азис Васильевич Шуткараев – директор Северного филиала; ТОО «Научно-производственный центр рыбного хозяйства»; Нур-Султан, ул. Кенесары, 43; azis-62@mail.ru