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Quantitative Development and Distribution of Zooplankton in Medium Lakes of the Kostanay Region (North Kazakhstan Region)

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ABSTRACT

The assessment of water resources plays an important environmental and economic role, since it allows developing an effective program of regional development with regard to the environmental load. The hydro-chemical regime of lakes includes water temperature, content of biogenic elements, total mineralization, oxygen regime, and other parameters (transparency, color, and smell). However, this assessment cannot be considered full, since it does not take into account the effect of human activity. Therefore, various systems of water monitoring have been developed, one of which is the assessment of zooplankton. The state of zooplankton is a universal marker. The quantitative and qualitative assessment allows monitoring the physical and chemical state of water resources and assessing their bio-pruduction potential. This research investigated zooplankton communities in lakes Aksuat, Altybai and Taly (Kostanay Region, Kazakhstan). The qualitative composition and dominant species of zooplankton was determined; their population dynamic was monitored. The oxygen regime of lakes remained stable; no oxygen deficiency was found. The lakes have favorable conditions for the development of zooplankton. This also provides favorable conditions for commercial fish farming if the main diet of fish is zooplankton.

KEYWORDS
Species composition, lakes mineralization, water condition, zooplankton population, bio-production potential

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Introduction

Kazakhstan has great potential for inland water fishery. Not including the Caspian Sea, the total area of waterbodies is about 5 million ha (Kan, Kegenova & Sapargalieva, 2012). The territory of the country, besides the Aral Sea, Lake Balkhash, Zaisan, has waterbodies, the full development whereof can improve fishing significantly. The underdevelopment of the fishing industry in Kazakhstan is primarily caused by insufficient investigation of its biological resources and the lack of justification of their use for the fishery purposes (Mitrofanov & Mamilov, 2015). However, the need for their full development by

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the fishing industry is obvious. In addition, the lakes are located near large industrial cities and the supply of the population with high-quality fishery products will be a special concern for the fishing industry of Kazakhstan (Karimov et al., 2005).

The combination of dry climate, cold temperatures, and flat terrain created a hydrographic image of the territory, which created a river network in the elevated parts and a large number of small enclosed lakes (Salnikov et al., 2015).

Surface water resources of the Kostanay Region comprise of river flows, ephemeral streams flowing mainly during the high-water period, and water reserves in a large number of small and medium lakes and reservoirs, canals and service water reservoirs. The main waterway of the region is the Tobol River, which is almost entirely regulated by artificial reservoirs that supply water to big cities and irrigated areas; however, these reservoirs have recently they lost their reproductive value (Baimukhamedova, Nurlanova & Akhmetova, 2012).

The main functional characteristic of any waterbody its level of bio-productivity (Chen, Shu & Jeppesen, 2013; Hölker et al., 2015). The level of biological productivity is closely related to the nature of catchment basin, the geographical location of the waterbody, and abiotic environmental factors (Finkenbinder et al., 2014).

Most inland fresh waterbodies of Kazakhstan are mesotrophic and eutrophic. At the same time, the high bio-production capacities of waterbodies in this region are virtually unutilized and have low fish productivity indicators (Fedorov, 2014).

A number of researchers are engaged in the study of the fish productivity of inland waterbodies in Kazakhstan (Fedorov, 2014; Ponomareva, Metallov & Levina, 2014; Kan, Kegenova & Sapargalieva, 2012; Goryunova & Danko, 2014; Anuryeva & Tsoy, 2014). However, to this day, the medium lakes of the Kostanay Region of Kazakhstan are understudied in terms of their use application for economic purposes. There is no information on the state of ecosystem of lakes Aksuat, Altybai, and Taly, their lake cenosis, assessment of the qualitative composition of water, dominant species of zooplankton, and their population dynamic. Research in this area will be relevant and will find practical application in the development of fishery production in the Kostanay Region.

One of the main components of aquatic ecosystems is zooplankton, which forms the basis of all aquatic food chains (Yermolaeva, 2014). Phytoplankton is the source giving rise to any biological activity in different waterbodies (Pinel-Alloul et al., 2013). Zooplankton organisms are sensitive to habitat changes (Yurista et al., 2014). A change in species composition in the plankton community, habitat change, population dynamics, and other factors are the parameters of the ecological status of aquatic ecosystems (Ponomareva, Metallov & Levina, 2014).

A great number of factors affects the composition, distribution, and change of planktonic organisms within the same waterbody. Water temperature is an especially important physical factors (Kurochkin & Alymov, 2012). Water salinity and nutrient content are very important chemical factors (Biswas, Farzanegan & Thum, 2012).

Biological productivity of waterbodies is based on the amount of oxygen dissolved in water, water mineralization, presence and ratio of ions (Bhatnagar et al., 2013). The total concentration of salts is an important factor of quality (species) distribution of planktonic organisms by waterbody types. The concentration of nitrogen and phosphorus nutrient salts is a factor of quantitative distribution, i.e. productivity. Highly productive waterbodies are the ones, in which the amount of nitrogen salts ranges from 0.5 mg/L to 1 mg/L, phosphorus in the form of P2O5 – from 0.1 mg/L to 0.5 mg/L, and calcium (CaO) – from 60 mg/L to 100 mg/L (Raymont, 2014). The greatest and most intensive formation of biological resources takes place in waterbodies with a constant source of replenishment of biogenic substances (Achal, Mukerjee & Sudhakara, 2013). These substances usually enter the waterbody by sheet wash or from subsurface soil.

Thus, despite the fact that nowadays there are many suggested factors for an accurate assessment of the trophic level, biological productivity of a specific waterbody, determination of quality (species) distribution of planktonic organisms of waterbodies, the problem of the ecological status of a number of waterbodies in the North Kazakhstan Region is understudied.

The issues of natural waterbody trophicity (Frumin & Krashanovskaya, 2015), biodiversity (Baimukanov, 2012; Lopatin et al., 2012), and influence of temperature and salt regime on the quantitative development of the major groups of phytoplankton and zooplankton (Karapun et al., 2013; Kurochkin & Alymov, 2012) have been studied extensively. Many studies focus on the parameters of fish productivity in pond fish farms of Kazakhstan (Anuryeva & Tsoy, 2014; Goryunova & Danko, 2014; Kan, Kegenova & Sapargalieva, 2012; Ponomareva, Metallov & Levina, 2014). A number of scientists investigated the manmade impact on the ecological, hydrochemical, and geochemical parameters of lakes (Valkova et al. 2012; Kolpakova et al., 2015; Pavlichenko, Dzhunusova & Burakov, 2013). Environmental factors impact the species composition of zooplankton in lakes (Afonina & Itigilova, 2014; Yermolaeva, 2013). Biomass and structural parameters depend on the effect of cyanobacteria as a carbon source for zooplankton in a eutrophic lake environment (Prendergast & Kelly, 2012; de Kluijver et al., 2012). However, despite the fact that the parameters of environmental, qualitative, and quantitative composition of closed waterbodies have been studied extensively, the problem of bioresources of medium lakes in the Kostanay Region for fishery purposes remains understudied.

Aim of the Study

Investigated zooplankton communities in lakes Aksuat, Altybai and Taly (Kostanay Region, Kazakhstan)

Research questions

What is characteristic of water in lakes Aksuat, Altybai and Taly (Kostanay Region, Kazakhstan)?

Materials and methods

Study sites

This research investigated lakes Aksuat, Altybai, and Taly, located in the Kostanay Region (North Kazakhstan Region). The research was carried out during the summer observation period in 2013-2014.

Lake Aksuat is formed by the waters of the Obagan River; it is shallow, mainly 1.5-meter-deep; the lake area is 210 ha.

Lake Altybai. The total area of the lake is 102 ha; the maximum depth is 2 m; the minimum depth is 1 m. The shores are flat; the southeastern part has a large area overgrown with emergent and submerged vegetation; a growth area of 20-50 m stretches from the shore deep into the lake. The color of water is greenish. The bottom of the lake is sandy and silty. The lakeside is flat. Macrophytes include cane, reed, sedge, cattail, buckwheat amphibious, hornwort, etc. The average water temperature did not exceed 22 °C on the surface; the temperature was 20 °C when zooplankton samples were taken.

Lake Taly. An overflow lake with a total area of 1391 ha. The maximum depth is 2.2 m; the minimum depth is 0.5 m; the transparency is low – 0.3 m on average; the bottom is silty. Aquatic vegetation includes macrophytes: bulrush, cattail, pondweed, and reeds, which grow from the shore inland to a distance of 10-150 m or even deeper in some areas. The overall growth is very high.

The hydrochemical and hydrobiological parameters were determined in the three selected lakes.

Sample collection and preparation

Three samples from three different stations were taken to characterize the qualitative and quantitative composition of zooplankton organisms across the lake water.

The tests were conducted according to standard procedures. Quantitative processing of zooplankton was carried out according to the procedure (Hansen et al., 2004). Sampling was made using a small model of Upstein net once per 10 days. 50 liters of water were filtered. Mill gas No. 70 was used. Zooplankton was fixed with 4% formalin solution with the addition of sucrose.

Taxonomic and weight determination

Identification of zooplankton organisms used guides for entomostracans (Morgalev et al., 2015), Cladocera (Bekker, 2011), copepods (Yen & Strickler, 1996; Bechstein et al., 2011), and rotifers. Zooplankton samples were taken from three different spots in each waterbody, which were calculated in the Bogorov chamber (Bogorov, 1974). The sediments were examined to account for rare large forms and ovulatory specimens. Fifty specimen of each species were measured with regard to the stage of development and gender in order to determine the production of zooplankton. Tables of average weights were used to calculate the biomass of zooplankton organisms (McCauley, 1984).

Results

Water condition

The examination of the hydrochemical regime of waterbodies in the Kostanay Region (Lake Aksuat, Lake Altybai, and Lake Taly) was carried out in June-August of 2013-2014.

Water temperature, total mineralization, content of biogenic elements, oxygen regime, and other parameters of the physical properties of water that affect the development of biological resources of waterbodies (transparency, color and odor of the water) were identified.

During the collection of the material, the average water temperature was 22 °C in Lake Aksuat, 20 °C in Lake Altybai, and 24 ºC in Lake Taly.

Water transparency in lakes Aksuat and Altybai was high – 49 cm and 65 cm, respectively. It was slightly higher than the standard for fish waterbodies. In Lake Taly, the transparency did not exceed the standard (Table 1).

According to transparency, Lake Altybai is eutrophic, while the lakes Aksuat and Taly are high-eutrophic. In the studied lakes, the color slightly exceeded the standard: 36º in Lake Altybai and 20-25º in lakes Aksuat and Taly.

The investigation of water odor showed that it was 1 in lakes Aksuat and Taly (odor is detected empirically in the laboratory at a temperature of 20 °C) and 2 in Lake Altybai (odor can be felt).

Table 1. Physical properties of water

Lakes	*Parameters*	*Physical properties of water*		
		Transparency, font, cm	Color, degrees	Odor, points
Aksuat	$\bar{X} \pm S\bar{x}$	49 ± 0.91	25 ± 0.82	1.5 ± 0.41
	Cv,%	2.89	5.66	47.14
Altybai	$\bar{X} \pm S\bar{x}$	63 ± 1.61	36 ± 0.88	1.5 ± 0.41
	Cv,%	4.49	3.93	47.14
Taly	$\bar{X} \pm S\bar{x}$	29 ± 0.82	20 ± 0.77	1.5 ± 0.41
	Cv,%	4.88	7.07	47.14

Due to the nature of the geological and geographical location of the Kostanay Region, which lies at the northern end of the Ural mountain range, the soil composition is diverse, while the climate is characterized by high aridity. The chemical composition of the natural water area is closely related to the composition and structure of soil. The soil forms the salt composition of water and the level of mineralization and determines the quality and abundance of biogenic substances in water. In addition, of one of the main factors in the formation of the salinity range of waterbodies in steppe areas is wind and temperature regime.

Lake mineralization

The study of lake mineralization found that in Lake Aksuat, the average mineral content ranged from 382.84 to 480 mg/L. The highest mineral content was found in Lake Aksuat; the lowest – in Lake Taly (375.3 mg/L) (Table 2).

In terms of the classification of water by mineralization level, i.e., on the amount of ions contained in the water, the studied lakes Aksuat, Altybai, and Taly can be classified as insipid. The amount of ions contained in water does not exceed 1 g/kg.

Table 2. Water mineralization of lakes in the Kostanay Region, mg/L

Parameters	*Aksuat*		*Altybai*		*Taly*	
	2013	2014	2013	2014	2013	2014

June	351.2	367.9	254.4	377.8	232.2	198.5
July	422.6	435.16	295.9	395.2	268.1	287.9
August	488.4	496.8	367.3	478.5	356.4	356.2
September	507.61	510.83	485.33	519.63	471.57	493.8
$\bar{X} \pm S\bar{x}$	480 ± 23.24	382.84 ± 55.23	464.44 ± 36.6	365.36 ± 58.91	379.3 ± 60.55	375.3 ± 59.01
P	≥ 0.95	≥ 0.99	≥ 0.99	≥ 0.99	≥ 0.99	≥ 0.99

The biogenic element regime is determined by a number of factors, which is why their dynamic is complex. It depends on the biological and biochemical processes in the waterbody (Table 3).

Table 3. Content of biogenic substances, mg/L

Lake	*Year of sampling*	NO_2	NO_3	SO_4	Ca^+	Mg^+
Aksuat	2013	5.17	0.0012	46.52	10.17	4.63
	2014	4.43	0.001	46.82	10.28	5.07
	$\bar{X} \pm S\bar{x}$	4.8 ± 0.30	0.001	46.67±0.12	10.23±0.62	4.85±0.18
	Cv,%	10.9	12.86	8.3	7.4	6.41
	P	≥ 0.05	≥ 0.05	≥ 0.001	≥ 0.001	≥ 0.05
Altybai	2013	3.52	0.001	47.72	11.17	4.5
	2014	3.56	0.001	46.02	10.60	4.63
	$\bar{X} \pm S\bar{x}$	3.54 ± 0.02	0.001	46.87 ± 0.9	10.89± 0.23	4.57± 0.05
	Cv,%	7.8	11.4	46.58 0.1	3.7	2.01
	P	≥ 0.001	≥ 0.05	≥ 0.01	≥ 0.01	≥ 0.001
Taly	2013	7.55	0.01	49.77	8.94	4.07
	2014	6.76	0.02	47.77	9.2	3.77
	$\bar{X} \pm S\bar{x}$	7.16± 0.32	0.01	48.77±0.82	9.07± 0.11	3.92± 0.12
	Cv,%	7.81	47.14	2.9	2.03	5.41
	P	≥ 0.95	≥ 0.95	≥ 0.99	≥ 0.999	≥ 0.99

The greatest amount of NO_2 ions was found in Lake Taly. In different years, it was 6.76-7.5 mg/L. The smallest amount was found in Lake Altybai – from 3.52 to 3.54 mg/L. The content of nitrites in all lakes was approximately at the same – 0.001 mg/L. The maximum amount of sulfuric acid salt was found in Lake Taly. In addition, a low content of calcium ions was discovered in all studied lakes. The greatest amount of calcium in the form of CaO was found in Lake Altybai in 2013 – 11.17 mg/L. This amount is 6-10 times smaller than the biological standards that provide for high productivity of waterbodies; therefore, it can be a limiting factor for growing fish. The magnesium content is also low – 3.92-4.85 mg/L on average. Calcium-to-magnesium ratio is about 3:1.

Oxidation and oxygen regime

Permanganate value in the studied waterbodies is low which indicates a low content of organic substances. During our observations, the amplitude of the oscillation permanganate oxidation was within 2.33-4.67 (Table 4).

Table 4. Oxidation and oxygen regime in Kostanay Region lakes, mg/L

Parameter	*Aksuat*	*Altybai*	*Taly*

	2013	2014	2013	2014	2013	2014
Permanganate value, mg/L	4.67±0.33	4.67±0.33	2.33±0.33	3±0.58	2.33±0.33	2.33±0.33
O_2 content in water, mg/L:						
at the surface	8.47±0.23	8.23±0.44	7.93±0.22	7.7±0.17	8.7± 0.40	8.67±0.26
at the bottom	7.23±0.41	6.87±0.15	6.27±0.12	6.6±0.06	6.87±0.20	6.65±0.37
Oxygen balance	1.23±0.34	1.37±0.52	1.67±0.18	1.1±0.12	1.83±0.22	2±0.45

The level of accumulation of organic substances in the water in these lakes is low, which implies an adequate level of dissolved oxygen. This research confirmed this assumption. It was found that the oxygen regime in these lakes was stable; no oxygen deficiency was found during the observation period. The difference between the surface water temperature of the upper and lower reaches is negligible. The averaged difference in oxygen content on the surface and at the bottom was: 1.23 mg/L in Lake Aksuat in 2013 and 1.37 mg/L in 2014; 2.33 mg/L and 3 mg/L, respectively, in Lake Altybai; 2.33 mg/L in Lake Taly throughout the entire observation period. The correlation in the "oxidation – oxygen balance" couple in the water was negative (r = -0.68).

Such conditions do not allow for temperature stratification, which could cause fish kill phenomena. Lakes with such an oxygen regime may be used for commercial cultivation of zooplanktophages that are demanding to oxygen regime, for instance, Peled.

As previously noted, the characterization of lakes by chemistry groups used O. A. Alekin's (1970) classification. On this basis, lakes Altybai and Aksuat belong to the sulfate class, calcium group, type one, while Lake Taly belongs to the hydrocarbonate class, calcium group, type two.

Zooplankton composition

The research found that zooplankton in studied waterbodies was not rich in composition (Table 5). Three species of cladocerans, two species of copepods, and two species of rotifers were found in Lake Aksuat (*Daphnia cusullata, D. longispina M., Bosmina longristos M., Diaptomus sp., Keratella quadrata Muller., Asplanhna priodonta M.*). *D. longispina M. and Diaptomus sp.* dominated the community of the above taxa. The zooplankton community in Lake Altybai included seven species: four species of cladocerans, three species of copepods, and one species of rotifers; seven species of zooplankton were found in Lake Taly: four, two, and one species, respectively.

Table 5. Species composition of zooplankton in Kostanay Region lakes

Zooplankton	*Lake*		
	Aksuat	Altybai	Taly
Cladocera (Cladoceran)			
Daphnia cucullata juveniles	+	+	+
D.longispina M.	+	+	+
Bosmina longristos M.	+	-	+
Ceriodaphnia sp.	-	+	+
Copepoda (Copepods)			
Macrocyclops albidus	+	-	+
Cyclops viridis	-	+	-
Acantacyclops sp.	-	+	-

Diaptomus sp.	+	+	+
	Rotatoria		
Keratella quadrata M.	+	-	-
Asplanhna priodonta M.	+	-	-
Brachionus angularis Gosse	-	+	-
Hexarthe miza H.	-	-	+
Number of species	7	7	7

The analysis of obtained data showed that the total population of zooplankton in Lake Aksuat was 139.40 thousand specimen/m^3 in 2013 and 131.17 thousand specimen/m^3 in 2014. The dominant species were *Diaptomus sp.* and *Daphnia longispina.* The population of *Diaptomus sp.* ranged from 43 to 45.73 thousand specimen/m^3. The greatest number of *Daphnia longispina* was found in 2013 – 43.67; the lowest – in 2014 – 43.57 thousand specimen/m^3. D. cusullata constituted 13.08-14.34% of the community. The population of cyclops ranged from 24.37 to 26.87 thousand specimen/m^3, at 17.48-20.48% specific abundance (Table 6).

Table 6. Population and abundance of zooplankton in Lake Aksuat

Parameter	*2013*	*2014*
Total population, thousand/m^3	139.40 +5.16	131.17 +5.11
Diaptomus sp.	43 +5.20	45.73+4.76
Cyclops sp.	24.37+ 3.37	26.87 +4.15
Daphnia longispina	43.67 +2.33	43.57 +2.17
D. cucullata	20 +1.15	17.17 +2.60
Bosmina longirostris	8.37 +0.32	7.8 +0.32
Specific abundance, %		
Diaptomus sp.	30.8	34.8
Cyclops sp.	17.48	20.48
Daphnia longispina	31.3	33.21
D. cucullata	14.34	13.08
Bosmina longirostris	6	4.57

The total biomass of zooplankton was 6.86 g/m3 in 2013 and 6.80 g/m3 in 2014. Daphnia longispina dominated in the total biomass – they ranged from 2.61 to 2.62 g/m3 or about 38% of occurrence rate. Bosmina longirostris had the lowest biomass – 0.064 g/m3 on average. In Lake Altybai, the total population of crustaceans during the study years ranged from 128 to 133.73 thousand/m3. The dominating species were Diaptomus sp. (32.3-34.37%) and Daphnia longispina (29.6-32.4%). The lowest population was that of D. cucullata - 18-20.20 thousand specimen/m3 with 14.06-15.1% specific abundance (Table 7).

Table 7. Population and abundance of zooplankton in Lake Altybai

Parameter	*2013*	*2014*
Total population, thousand/m^3	128±9.07	133.73±8.38
Diaptomus sp.	44±4.51	43.2±5.0
Cyclops sp.	28±2.52	27.23±2.27
Daphnia longispina	38±6.56	43.33±7.15
D. cucullata	18±0.58	20.20±2.42
Specific abundance, %		

Diaptomus sp.	34.37	32.3
Cyclops sp.	21.8	20.36
Daphnia longispina	29.6	32.4
D. cucullata	14.06	15.1

The biomass of zooplankton in different years ranged from 6.87 to 7.16 g/m^3. Despite the domination of Diaptomus species in this waterbody, the greatest percentage of specific biomass was that of *Daphnia longispina* (from 33.18% to 36.17%) and *Cyclops sp.* (from 30.4% to 32.6%). *Diaptomus sp.* was a subdominant species – 22.2–23.2%. *D. Cusullata* had the lowest biomass – 0.72-0.8 g/m^3 (10.48-11.17%). The population of zooplankton communities in Lake Taly was 194.9–197.9 thousand specimen/m^3 with dominating *Diaptomus sp.* and *Daphnia longispina*. Their specific abundance was 33.5-34.12 and 29.05-29.65%, respectively. The smallest population was that of *Bosmina longirostris* (Table 8).

Table 8. Population and abundance of zooplankton in Lake Taly

Parameter	*2013*	*2014*
Total population, thousand/m^3	197.33±0.88	194.9±3.21
Diaptomus sp.	67.33±0.88	65.3±0.82
Cyclops sp.	41±1.15	42.9±0.90
Daphnia longispina	57.33±1.45	57.87±1.28
D.cucullata	21±1.15	16.7±2.36
Bosmina longirostris	10.67±0.88	10.97±1.3
Specific abundance, %		
Diaptomus sp.	34.12	33.5
Cyclops sp.	20.77	22.01
Daphnia longispina	29.05	29.69
D.cucullata	10.64	8.56
Bosmina longirostris	5.4	5.62

Biomass and specific biomass of zooplankton in Lake Taly in 2013–2014 ranged from 9.91 g/m^3 10.07 g/m^3. During this period, *Daphnia longispina* and *Cyclops sp.* dominated in the lake in terms of biomass. The dominating species in the lake in terms of population – *Diaptomus sp.* – was subdominant in terms of biomass with an occurrence rate of about 24%.

Charts (Figures 1, 2) were built to study the dependence of the parameters that characterize the state of zooplankton communities on salinity.

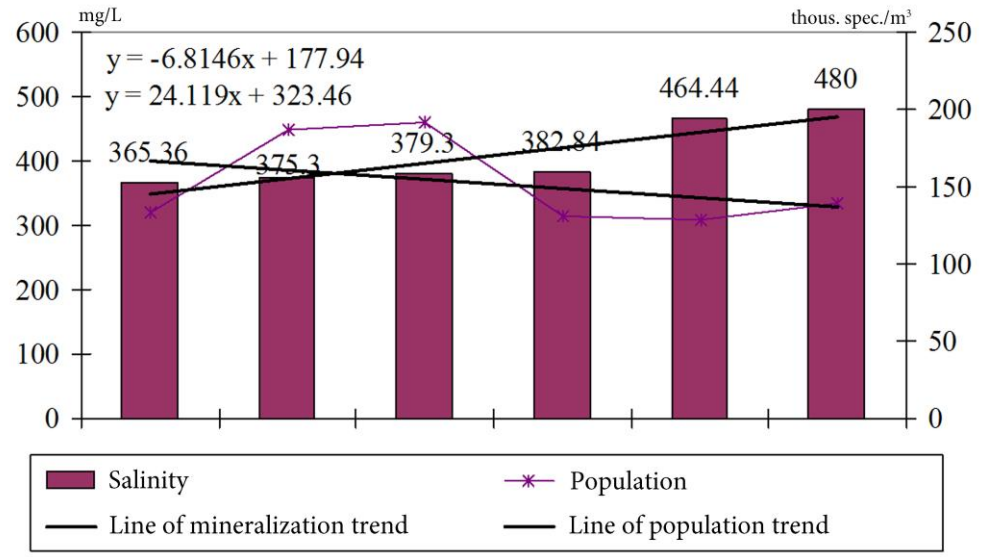

Figure 1. Dependence of zooplankton population on water salinity in the Kostanay Region

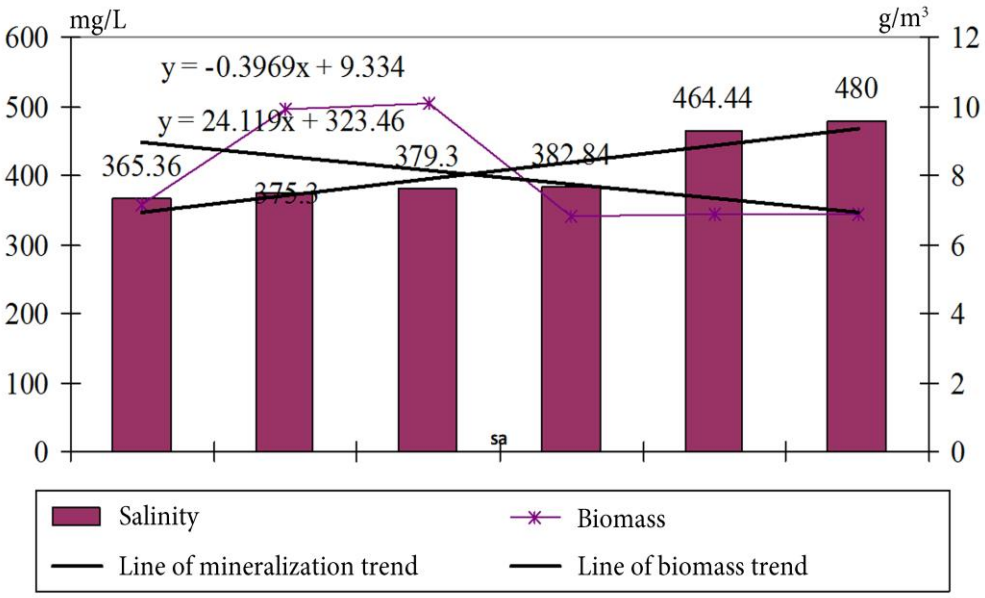

Figure 2. Dependence of zooplankton biomass on water salinity in the Kostanay Region

Thus, an inverse relationship was discovered. This is shown by the linear trends and equations describing the trend. In addition, correlation coefficients were calculated for more an accurate assessment of the relationship in the pairs of characteristics. Their value confirms the conclusion regarding the inverse relationship of characteristics: r = -0.44 for the "mineralization – population" pair and r = -0.50 for the "mineralization – biomass" pair.

Body weight distribution

The construction of the distribution areas by weight and body length of zooplankton that live in the lakes of the North Kazakhstan Region shows that the population is in equilibrium (Li et al., 2016). The distribution of specimens in populations is close to a Gaussian curve, which indicates that the distribution in the intraspecific structure is normal (Figures 3-6). A characteristic feature of the variation curves for dominant species is a high concentration of specimens in modal and adjacent classes.

The analysis of the area of *Diaptomus sp.* body weight distribution in the studied water shows that the population is divided into two size groups weighing from 0.031 mg to 0.0394 mg and from 0.0394 mg to 0.0478 mg (Figure 3).

The area of *Diaptomus sp.* body length distribution has a form similar to a Gaussian curve with a high concentration of specimens in modal and paramodal classes – 78.5% in theoretical calculations and 60% in empirical calculations. The asymmetry coefficient of the curve is 0.06. This suggests that the population is in a state of dynamic equilibrium (Figure 4).

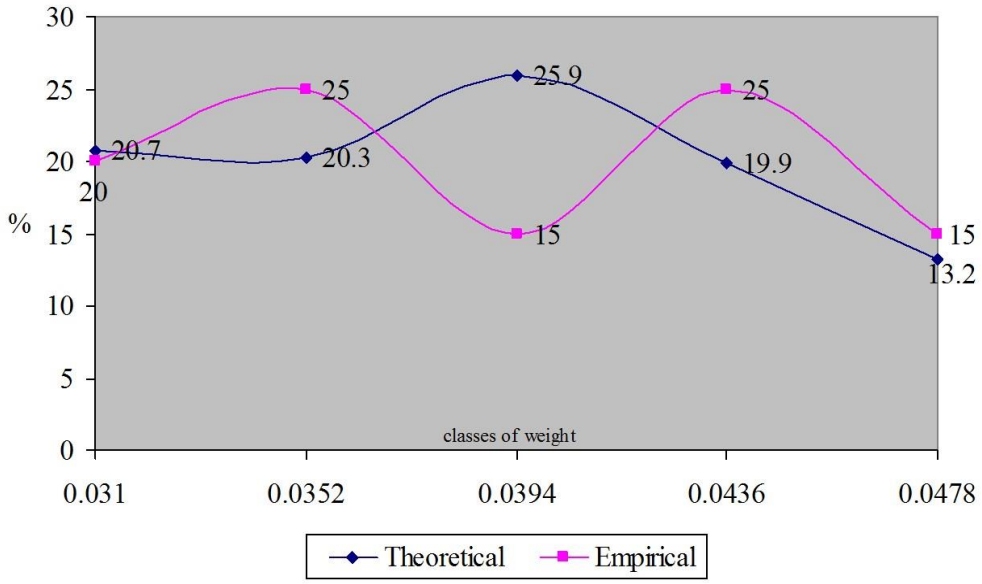

Figure 3. Area of *Diaptomus sp.* body weight distribution

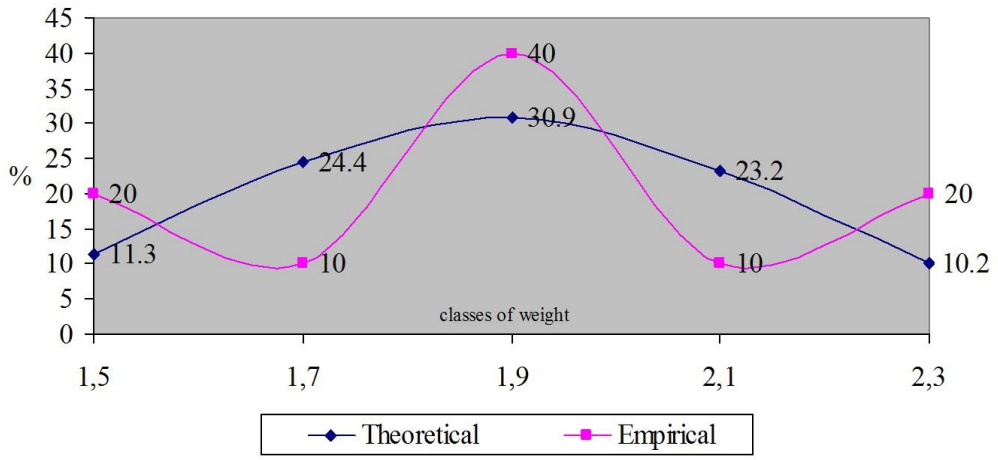

Figure 4. Area of *Diaptomus sp.* body length distribution

The empirical variation curve that characterizes the population of *D. longispina* in terms of body weight has two peaks; therefore, in terms of body weight, the population is divided into two groups: up to 0.37 mg and above. However, the theoretical curve has a correct shape (Figure 5).

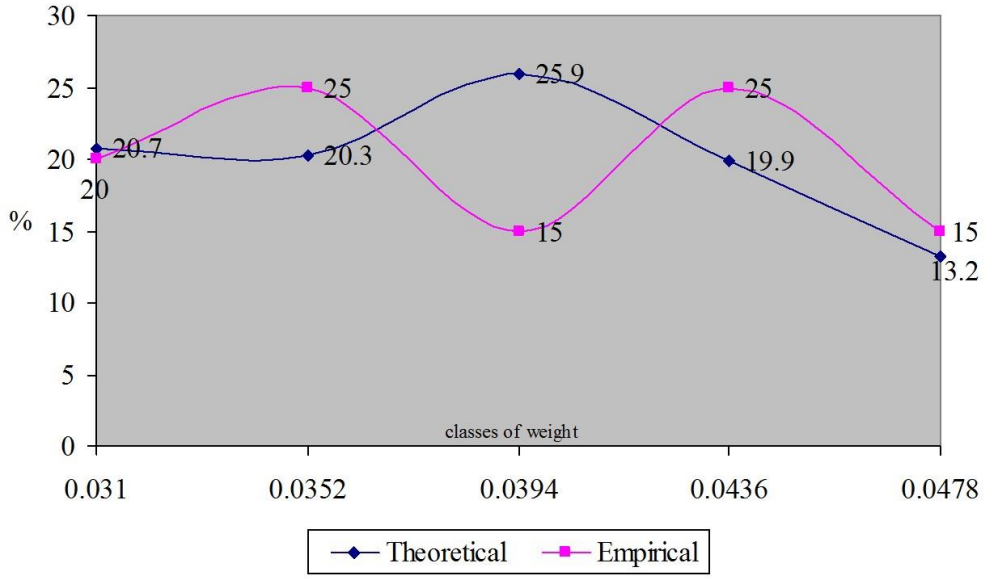

Figure 5. Area of *D. longispina* body weight distribution

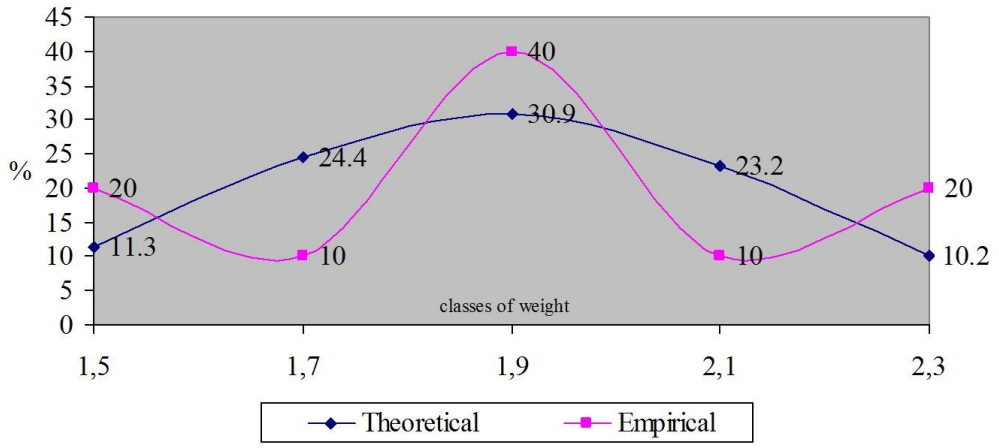

Figure 6. Area of *D. longispina* body length distribution

The theoretical distribution area calculated for the population of *D. longispina* in terms of body length is close to a Gaussian curve. The empirical curve is shifted along the X-axis to the right, which indicates an accumulation of big specimens in the population. The number of specimens in modal and paramodal classes is 84% for theoretical calculations and 70% for empirical calculations (Figure 6).

This form of areas is characteristic for populations in a state of equilibrium.

Discussion

The study of the hydrological regime of lakes Aksuat, Altybai, and Taly in the Kostanay Region determined the water temperature, content of biogenic elements, total mineralization, oxygen regime, and other parameters of physical properties of water affecting the development of biological resources of waterbodies (transparency, color, smell).

Due to the nature of the geological and geographical location of the Kostanay Region, which lies at the northern end of the Ural mountain range, the soil composition is diverse, while the climate is characterized by high aridity. The chemical composition of the natural water area is closely related to the composition and structure of soil. The soil forms the salt composition of water and the level of mineralization and determines the quality and abundance of biogenic substances in water (Lisi et al., 2013). In addition, of one of the main factors in the formation of the salinity range of waterbodies in steppe areas is wind and temperature regime (Lofton, Whalen & Hershey, 2014).

The research assessed water mineralization in lakes Aksuat, Altybai, and Taly. It was found that the nitrite content in all lakes during the study period of 2013-2014 remained at the same level – 0.001 mg/L, while the low level of calcium ions (up to 11.17 mg/L) was 6-10 times smaller than the biological standards that provide for high productivity of waterbodies. This can be a limiting factor for growing fish. The magnesium content was also low – 3.92-4.85 mg/L on average. The low permanganate value in the studied waterbodies indicates a low content of organic substances. A low level of accumulation of

organic substances in the water of the studied lakes indicates a stable level of dissolved oxygen (Thurman, 2012).

The total concentration of salts is an important factor of quality (species) distribution of planktonic organisms by waterbody types. The concentration of nitrogen and phosphorus nutrient salts is a factor of quantitative distribution, i.e. productivity (Monteagudo-Mera et al., 2012). The effect of mineralization on growth and development of the plankton community was confirmed. In addition, water mineralization depends on the water content of the year and is subject to significant seasonal and interannual fluctuation, which affects the rate of growth and development of aquatic organisms (Kurochkin & Alymov, 2012).

During the research, the average water temperature in the lakes in summertime was: 22 °C in Aksuat, 20 °C in Altybai, and 24 ºC in Taly. At the same time, a slight difference between the temperature of water surface of the upper and lower reaches of lakes makes temperature stratification (which could cause fish kill phenomena) impossible. One of the main factors affecting the duration of development and survival of zooplankton and its quantitative and qualitative characteristics is the temperature 21±1.5 °C (Karapun et al., 2013). Significant disturbances of biological regime were found when the water in waterbodies was heated by more than 6 °C – displacement of cold-loving forms of organisms, biological productivity reduction, and reduction of the zooplankton species composition.

Quantitative parameters of zooplankton developed most intensively in spring and summer, with maximum temperatures of 28.5 °C (Kurochkin & Alymov, 2012). However, bursts of activity in the areas of waterbodies with water temperatures close to the minimum (21.6 °C) were discovered.

The production of zooplankton species populations in the studied lakes was determined based on quantitative data – growth (linear and weight), duration of individual stages of fertility, and information about the dependence of these values on the environmental conditions. Specific dominant species (D. longispina, Diaptomus. sp.) were studied to obtain a more precise description of the zooplankton community in the lakes of the Kostanay Region. It was found that the population was in a state of dynamic equilibrium (Leoni, Garibaldi & Gulati, 2014; Bozelli et al., 2015).

The reliability of the results is proven by statistical processing of data on water mineralization, biogenic substances content, species composition, and population of zooplankton in the waterbodies, as well as the results of correlation analysis of population (Figure 1) and biomass (Figure 2) dependence on lake water mineralization. In addition, graphic material (Figures 3, 4) features a model showing the theoretical distribution areas of zooplankton organisms by body weight and length; the area shape is typical for populations in equilibrium. This result correlates with other climate conditions (Dam, 2013; Leoni, Garibaldi & Gulati, 2014; Bozelli et al., 2015).

The desk studies of literature proved the lack of scientific data on the hydrochemical regime and bio-productivity potential of lakes in the North Kazakhstan Region – Lake Aksuat, Lake Altybai, and Lake Taly.

Conclusion

The lakes in the Kostanay Region that were studied during the summer of 2013-2014 had a stable hydrological and hydro-chemical regime and bio-

productivity potential. This enables using them for commercial cultivation of zooplanktophages that are demanding to oxygen regime, for instance, Peled. The obtained results give recommend Lake Aksuat, Lake Altybai, and Lake Taly for the development of fishery production.

In Kostanay Region lakes, the largest number of zooplankton was found in Lake Taly – 194.9-197.9 thousand specimen/m^2. In Lake Aksuat and Lake Altybai, this parameter was 128.00-139.40 thousand specimen/m^2. *Diaptomus sp.* (30-35% occurrence) and *Daphnia longispina* (30-32% occurrence) dominate in all lakes.

In Kostanay Region lakes, the largest biomass of zooplankton was found in Lake Taly – 9.91-10.07 g/m^3. This parameter was approximately similar in Lake Aksuat and Lake Altybai – 6.8-6.86 and 6.87-7.16 g/m^3, respectively. *Daphnia longispina* dominated in all lakes in terms of biomass – 38.0% of specific biomass in Lake Taly and Lake Aksuat, and 33.2-36.2% of specific biomass in Lake Altybai.

A negative correlation was found in pairs of characteristics related to mineralization: r = -0.44 for the "mineralization – population" pair and r = -0.50 for the "mineralization – biomass" pair.

The area of *Diaptomus sp.* body length distribution has a form similar to a Gaussian curve with a high concentration of specimens in modal and paramodal classes – 78.5% in theoretical calculations and 60% in empirical calculations.

Hydrological, hydro-chemical and biological regimes of lakes impact the seasonal fluctuations of the quantity and quality of aquatic organisms. The lakes of Kostanay Region have favorable oxygen and temperature regimes and composition of mineralization, therefore, they can be used for fishery production. Waterbodies of the North Kazakhstan can be used for commercial cultivation of zooplanktophage, for instance, *Coregonus peled* (Northern whitefish).

Disclosure statement

No potential conflict of interest was reported by the authors.

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