Journal of Siberian Federal University. Biology 2018 11(4): 306-320
~ ~ ~

УДК 574.583

Planktonic Communities in the Torey Lakes (Zabaikalsky Krai) in a Low Water Year

Ekaterina Yu. Afonina* and Natalya A. Tashlykova
Institute of Natural Resources, Ecology and Cryology SB RAS
16a Nedorezov Str., Chita, 672014, Russia

Received 22.09.2018, received in revised form 27.09.2018, accepted 10.12.2018

Lakes Barun-Torey and Zun-Torey are the largest water bodies in Zabaikalsky Krai, and they are characterized by long-term cyclic changes in the water level. Samples of the planktonic community (algae and invertebrates) were collected from the Torey Lakes in June, August, and October in the dry 2016. Collection and processing of the samples was carried out using standard hydrobiological methods. The aim of the study was to investigate the planktonic communities in the Torey Lakes. The lakes were in different hydrological phases: Barun-Torey was in the initial filling phase (with isolated small lakes present on the dried bed), and Zun-Torey was in the shallowing phase. Considerable differences were observed between the compositions and structures of the planktonic communities, which were determined by the mineral content of the water. Diverse littoral plankton developed, consisting of 2-25 taxa of algae (total number of taxa – 46) and 2-15 species of invertebrates (total number of species – 29) in the oligohaline small lakes on the bottom of Lake Barun-Torey. The abundance and biomass of aquatic organisms varied within very wide limits: for phytoplankton – from 0.7 × 10^3 to 1260.0 × 10^3 cells / L and from 0.1 to 1271.0 mg / m^3, and for zooplankton – from 9.2 × 10^3 to 19370.0 × 10^3 individuals / m^3 and from 3.8 to 361.7 g / m^3. Freshwater and euryhaline species were dominant. In polyhaline Lake Zun-Torey, the phytoplankton consisted of 3-12 taxa of algae (total number of taxa – 18), and the invertebrate fauna included only 3 species. The abundance of phytoplankton varied from 12.4 × 10^3 to 310.7 × 10^3 cells / L and a biomass from 1.0 to 14.7 mg / m^3, and the abundance of zooplankton varied from 55.1 × 10^3 to 1656.0 × 10^3 individuals / m^3 and a biomass from 1.1 to 85.5 g / m^3. Euryhaline and halophilic species dominated.

Keywords: phytoplankton, zooplankton, species composition, abundance, biomass, the Torey Lakes.

Citation: Afonina E.Yu., Tashlykova N.A. Planktonic communities in the Torey Lakes (Zabaikalsky Krai) in a low water year. J. Sib. Fed. Univ. Biol., 2018, 11(4), 306-320. DOI: 10.17516/1997-1389-0074.

* Corresponding author E-mail address: kataf@mail.ru

Особенности планктонных сообществ Торейских озер (Забайкальский край) в маловодный год

Е.Ю. Афонина, Н.А. Ташлыкова
Институт природных ресурсов, экологии и криологии СО РАН
Россия, 672014, Чита, ул. Недорезова, 16а

Озера Барун-Торей и Зун-Торей являются самыми крупными водоемами в Забайкальском крае, для них характерна хорошо выраженная цикличность, проявляющаяся в многолетних изменениях уровня воды. Материалом для работы послужили пробы, собранные на Торейских озерах в июне, августе, октябре в маловодный 2016 г. Сбор и обработка материалов проводилась согласно стандартным гидробиологическим методам. Целью работы стало изучение особенностей развития планктонных биоценозов Торейских озер, одновременно находящихся в разных гидрологических фазах: Барун-Торей – в начальной фазе наполнения, Зун-Торей – в фазе снижения уровня воды. В районе северной оконечности высохшего Барун-Торея в пределах дна его ложа отмечались мелкие водоемы, источником питания которых служила многолетняя мерзлота и разгрузка подземных вод по разлому, проходящему по западному берегу озера. В Зун-Торее продолжался процесс обмеления водоема, который закончился практически полным его высыханием осенью 2017 г. Состав и структура фитопланктона и зоопланктона в разные гидрологические периоды имели существенные различия, определяемые уровнем минерализации озерных вод. В олигогалинных водоемах котловины Барун-Торея развивался литоральный планктоценоз, состоящий из 46 таксонов водорослей (при колебаниях от 2 до 25) и 29 видов беспозвоночных (при колебаниях от 2 до 15). Значения численности и биомассы гидробионтов колебались в очень широких пределах: фитопланктон – от 0,7 до 1260,0 тыс. кл/л и от 0,1 до 1271,0 мг/м^3, зоопланктон – от 9,2 до 19370,0 тыс. экз/м^3 и от 3,8 до 361,7 г/м^3. Доминировали пресноводные и эвригалинные виды. Альгофлора полигалинного оз. Зун-Торей состояла из 18 таксонов (при варьировании от 3 до 12), фауна беспозвоночных – из 3 видов. Количественные показатели варьировали от 12,4 до 310,7 тыс. кл/л и от 1,0 до 14,7 мг/м^3 для фитопланктона, и от 55,1 до 1656,0 тыс. экз/м^3 и от 1,1 до 85,5 г/м^3 – для зоопланктона. Преобладали эвригалинные и галофильные виды.

Ключевые слова: фитопланктон, зоопланктон, видовой состав, численность, биомасса, Торейские озера.

Introduction

The southeast Transbaikal region, with its arid and extremely continental climate, is characterized by morphodynamic variability (Bazhenova, 2013). The interdecadal cycles, which last 27-35 years, are controlled by the variations in atmospheric moistening, with relatively moist and very cold periods alternating with dry and relatively warm periods (Obyazov, 2012). Long-term cyclic changes have been observed in the levels of the largest water bodies of the Zabaykalsky Krai – the Torey Lakes. Two lakes (Barun-Torey and Zun-Torey) constitute one hydrological system; they are connected by a channel. In high water years, the surface area of Lake Barun-Torey reaches 550 km^2, the volume is 1.4 km^3, the maximum depth is 4.3 m, and the average depth is 2.5 m. There are approximately ten islands in the lake, and their number varies depending on the water level. The bottom of the lake is flat, and the deepest parts are in the centre of the lake. The shoreline is crenelated, with abundant headlands and bays. Two rivers flow into the lake: the Uldza (Uldza-Gol) River, which flows up from the south and forms a vast estuary, and the Imalka River, which flows into the lake from the west. The outflow only occurs in high water years, while in dry years, the riverbeds dry up. Because of this and a decrease in precipitation, the lake quickly becomes shallow, and its surface area shrinks, sometimes resulting in the drying-up of the lake. Lake Zun-Torey is round, with a weakly indented shoreline and a single island, which turns into a peninsula when the water level lowers. When the water is high, the surface area of this lake is 285 km^2, the volume is 1.6 km^3, the maximum depth is 6.5 m, and the average depth is 4.5 m. The greatest depth is in the northern part of the lake, and the lake bed drops steeply. The lake is mainly fed by the outflow from Lake Barun-Torey. When the water level decreases, the shallow Barun-Torey dries up sooner (Zamana, Obyazov, 2004).

In the 20th and 21st centuries, low lake levels were recorded from 1903-1904, 1921-1922, and 1944-1947 (the basins of the Torey Lakes were dry), in 1951 (the level of Lake Barun-Torey was low, and Zun-Torey was dry), and from 1981-1982 and 2009-2011 (Lake Barun-Torey was dry, and the level of Zun-Torey was low). The highest lake levels were observed from 1963-1965 and 1998-1999 (Frish, 1972; Krendelev, 1986; Obyazov, 2012). In 2016, the lakes were in different phases of the hydrological cycle. At the northernmost point of Lake Barun-Torey, there were small water bodies on its bottom; they were fed by permafrost and groundwater discharge through the fracture at the western shore of the lake. Lake Zun-Torey was in the shallowing phase, at the end of which, in autumn 2017, it was almost dry. The purpose of this study was to investigate the development of planktonic communities in the Torey Lakes that were in different hydrological phases: while Lake Barun-Torey was in the initial phase of filling, the level of Lake Zun-Torey was lowering.

Materials and Methods

Phytoplankton and zooplankton of the Torey Lakes were investigated in June, August, and October 2016. In Lake Zun-Torey, samples were collected at three coastal sites: in the west, north, and southwest. Barun-Torey samples were collected from small water bodies on the dry bed of the lake; the area of each water body was approximately 50 m^2, and the depth was no more than 50 cm (Table 1, Fig. 1).

Phytoplankton samples were collected from the water surface into 1-L plastic bottles. To collect zooplankton samples, 10-50 L of water was filtered through a plankton net (mesh size = 94 μm). Samples were fixed in a 4% formaldehyde solution and processed in the laboratory using standard methods (Methodical recommendations…, 1984; Sadchikov, 2003). Phytoplankton biomass was determined by measuring the volume of individual cells or colonies of algae, and specific weight was taken equal to unity. Volumes of algae were equated to volumes of the corresponding geometric shapes (Sadchikov, 2003). The biomass of zooplankters was estimated using equations of the relationship between body length and dry mass (Balushkina, Vinberg, 1979; Ruttner-Kolisko, 1977). The source of the names of the algal taxa was the

Table 1. Physical and geographic parameters of the lakes studied in 2016

Lake	Position	Point name	Sampling date	TDS, mg/L	Water temperature, ºC	pH
Barun-Torey	N50°13'37.0" E115°40'12.1"	B-T 1	10.06.2016	–	19.5	8.4
	N50°14'04.3" E115°40'04.9"	B-T 2	10.06.2016	–	16.6	–
			01.08.2016	–	28.2	–
			08.10.2016	–	–	–
	N50°14'05.6" E115°40'04.0"	B-T 3	10.06.2016	–	15.1	8.5
			01.08.2016	0.8	–	–
	N50°13'56.3" E115°39'51.2"	B-T 4	01.08.2016	1.0	–	–
	N50°13'72.97" E115°39'02.97"	B-T 5	08.10.2016	1.0	4.4	8.2
	N50°13'65.13" E115°38'88.01"	B-T 6	08.10.2016	1.6	4.7	8.5
	N50°13'82.63" E115°39'161.13"	B-T 7	08.10.2016	0.9	4.6	8.2
Zun-Torey	N50°01'11.3" E115°44'39.7"	Z-T 1	10.06.2016	–	20.5	9.2
	N50°06'25.6" E115°41'51.7"	Z-T 2	01.08.2016	21.3	21.7	9.5
			08.10.2016	–	–	–
	N50°08'47.47" E115°47'51.76"	Z-T 3	01.08.2016	18.5	24.8	9.4
			08.10.2016	–	–	–

Note: "–" no data.

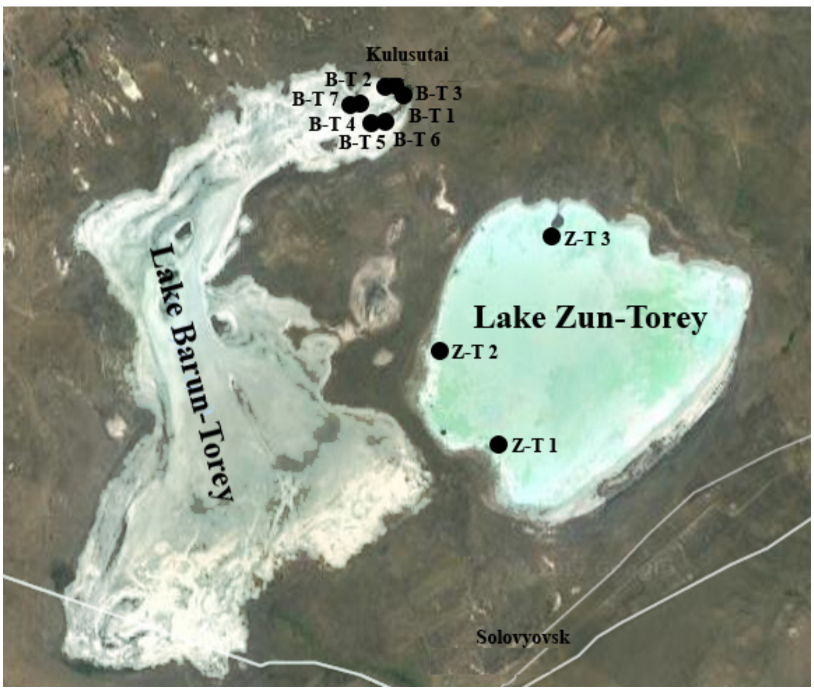

Fig. 1. Map of the sampling sites in the Torey Lakes in 2016

world's largest algological site, AlgaeBase (Guiry, Guiry, 2016). Dominant species were determined using the ranking function of relative species abundance (Fedorov, Gilmanov, 1980).

At the time of sampling, water temperature, pH, and total dissolved solids (TDS) were measured using an Aquaread multiparametric sensor for water analysis (Great Britain).

Results

The water in Lake Zun-Torey was difficult to access because of sticky mud covering the bottom of its coastal zone. At the sampling location, the depth of the mud reached 50 cm, and the thickness of the water layer was no greater than 10 cm. Water in Lake Zun-Torey and the water bodies in Barun-Torey were of an albescent colour, except in the water body at the village of Kulusutay (B-T 2), where water was grey-brown because it was used as a watering place for farm animals. The Secchi depth was 5-10 cm. In the water bodies of Barun-Torey, TDS content was 0.8-1.6 mg/L, and the pH was 8.2-8.5; in Lake Zun-Torey, TDS content was 18.5-21.3 mg/L, and the pH was 9.2-9.5.

Phytoplankton of the Torey Lakes comprised 51 algal taxa below the genus level, which were representatives of 7 phyla: Cyanobacteria, Bacillariophyta, Cryptophyta, Heterokontophyta, Charophyta, Chlorophyta, and Euglenophyta. The greatest contribution to the taxonomic diversity was made by green algae, diatoms, and cyanobacteria, which constituted 78.5% of the total algae (Tables 2, 3).

The list of zooplankton in the Torey Lakes contained 30 species and subspecies: Rotifera comprised 13 taxa, Copepoda 7 species, and Cladocera 10 species (Tables 4, 5).

Phytoplankton of Lake Zun-Torey were represented by 18 taxa of five phyla. The total number of algae varied between 12.4 and 310.7 × 10^3 cells/L, and their biomass was between 1.0 and 14.7 mg/m^3. The highest values were observed in October, and the lowest were observed in August. In June, the numerically dominant algae types were cyanobacteria (*Planktolyngbya contorta*) and green algae (*Oocystis submarina*); in August and October, the major type was green algae (*Oocystis* species and *Coenococcus planctonicus*) (Table 6).

Zooplankton of Lake Zun-Torey comprised three species. In early summer, they reached 275.0 × 10^3 individuals/m^3 and 40.9 g/m^3, with *Metadiaptomus asiaticus*

Table 2. The taxonomic structure of phytoplankton in the Torey Lakes in 2016

Phylum	Number of						% of the total number of taxa
	classes	orders	families	genera	species	varieties, forms	
Cyanobacteria	1	3	4	4	5	6	11.8
Bacillariophyta	3	6	6	6	5	6	11.8
Cryptophyta	1	1	1	1	1	1	2.0
Heterokontophyta	1	1	1	1	1	1	2.0
Charophyta	3	3	4	4	2	4	7.8
Chlorophyta	2	5	13	19	27	28	54.9
Euglenophyta	1	1	2	2	2	5	9.8
Total	**12**	**20**	**31**	**37**	**43**	**51**	**100**

Table 3. Taxonomic composition and ecogeographical characteristics of planktonic algae in the Torey Lakes in 2016

Taxon	Lake Barun-Torey										Lake Zun-Torey					Ecogeographical characteristic*			
	10.06			01.08			08.10				10.06	01.08		08.10					
	B-T 1	B-T 2	B-T 3	B-T 2	B-T 3	B-T 4	B-T 2	B-T 5	B-T 6	B-T 7	Z-T 1	Z-T 2	Z-T 3	Z-T 2	Z-T 3	GR	Hab	H	A
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CYANOBACTERIA																			
Merismopedia tenuissima Lemmermann 1898	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	c	P-B	hl	–
Planktolyngbya contorta (Lemmermann) Anagnostidis & Komárek 1988	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	c	P	–	–
Oscillatoria planctonica Woloszynska 1912	-	+	+	+	+	+	+	-	-	-	-	+	+	-	-	c	P	i	–
O. tenuis C. Agardh ex Gomont 1892	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	c	P-B	hl	–
Oscillatoria sp$_1$.	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	–	–	–	–
Spirulina major Kützing ex Gomont 1892	-	+	-	-	-	-	+	-	-	-	+	-	+	+	+	–	–	–	–
BACILLARIOPHYTA																			
Cyclotella meneghiniana Kützing 1844	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-	–	P	–	alf
Aulacoseira sp$_1$.	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	–	–	–	–
Diatoma vulgaris Bory 1824	-	-	+	+	-	+	-	-	-	+	-	+	-	+	-	c	P-B	i	-
Ulnaria ulna (Nitzsch) Compère in Jahn et al. 2001	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	alf
Nitzschia graciliformis Lange-Bertalot & Simonsen 1978	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	c	P-B	i	alf
Cymatopleura solea (Brébisson) W. Smith 1851	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	alf
CRYPTOPHYTA																			
Cryptomonas marssonii Skuja 1948	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	c	P	i	–
HETEROKONTOPHYTA																			
Chrysococcus rufescens Klebs 1892	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c	P	hb	–
CHAROPHYTA																			
Closterium strigosum Brébisson 1856	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	Ha	P-B	–	–
Micrasterias sp$_1$.	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	–	–	–	–

Continuation Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Elakatothrix genevensis (Reverdin) Hindák 1962	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
Cosmarium sp_1.	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	–	–	–	–
CHLOROPHYTA																			
Chlamydomonas pertusa Chodat 1896	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	–	P	–	–
Chlamydomonas sp_1	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	–	–	–	–
Carteria klebsii (P.A. Dangeard) Francé 1893	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	c	P	i	-
Rusalka fusiformis (Matvienko) T. Nakada in Nakada et al. 2008	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	-
Chlorogonium euchlorum (Ehrenberg) Ehrenberg 1836	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	–	–	–	–
Pseudopediastrum boryanum (Turpin) E. Hegewald in Buchheim et al. 2005	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	c	P-B	i	i
Oocystis submarina Lagerheim 1886	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	c	P-B	i	–
O. rhomboidea Fott 1933	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	–	–
O. parva West & G.S. West 1898	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	–	P	–	–
Coenococcus planctonicus Korshikov 1953	-	-	+	+	-	-	-	-	-	-	-	+	+	-	-	Ha	P	–	–
Ankyra ancora (G.M. Smith) Fott 1957	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ha	P	–	–
Schroederia setigera (Schröder) Lemmermann 1898	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-	c	P	i	–
Monoraphidium arcuatum (Korshikov) Hindák 1970	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	c	P-B	–	–
M. contortum (Thuret) Komárková-Legnerová in Fott 1969	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	c	P-B	–	–
M. obtusum (Korshikov) Komárková-Legnerová 1969	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	b	P-B	–	–
M. griffithii (Berkeley) Komárková-Legnerová 1969	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
Coelastrum microporum Nägeli in A. Braun 1855	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	c	P-B	–	–
Scenedesmus arcuatus (Lemmermann) Lemmermann 1899	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	–
Desmodesmus bicaudatus (Dedusenko) P.M. Tsarenko 2000	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
D. communis (E. Hegewald) E. Hegewald 2000	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	–
Tetradesmus lagerheimii M.J. Wynne & Guiry 2016	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
T. obliquus (Turpin) M.J. Wynne 2016	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	c	P-B	i	–

Continuation Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Chlorolobion sp_1.	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	–	–	–	–
Tetraëdron incus (Teiling) G.M. Smith 1926	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	c	P-B	i	–
Actinastrum hantzschii Lagerheim 1882	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
Closteriopsis acicularis (Chodat) J.H. Belcher & Swale 1962	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	c	P-B	i	–
Lemmermannia komarekii (Hindák) C. Bock & Krienitz in Bock et al. 2013	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	Ha	P-B	–	–
L. triangularis (Chodat) C. Bock & Krienitz in C. Bock et al. 2013	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	–	–
EUGLENOPHYTA																			
Euglena acus (O.F. Müller) Ehrenberg 1830	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	–	P	–	–
Euglena sp_1.	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	–	–	–	–
Euglena sp_2.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	–	–	–	–
Phacus caudatus Hübner 1886	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	c	P-B	i	alf
Phacus sp_1.	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	–	–	–	–
Total	**3**	**4**	**11**	**25**	**7**	**9**	**14**	**2**	**0**	**2**	**4**	**12**	**5**	**3**	**3**	–	–	–	–

Note: «+» – the species is present, «-» – absent, «–» – no data; «*» – from: Barinova et al., 2006. Geographic range (GR): c – cosmopolite, HA – Holarctic. Habitat (Hab): P – planktonic, P-B – planktonic/benthic. Halobility (H): hl – oligohalobic-halophilic, i – indifferent and/or neutrophilic, hb – oligohalobic-halophobic. Acidification (A): alf – alkaliphilic.

Table 4. Taxonomic structure of zooplankton in the Torey Lakes in 2016

Taxa	Rotifera	Cladocera	Copepoda	Total
Class	2	1	1	4
Order	4	1	2	7
Family	7	4	2	13
Genus	9	8	5	22
Species and subspecies	**13**	**10**	**7**	**30**

Table 5. Taxonomic composition and ecogeographical characteristics of zooplankton in the Torey Lakes in 2016

Taxon	Ecogeographical characteristic		Lake Barun-Torey										Lake Zun-Torey		
			10.06			01.08			08.10						
	ZG	Hab	B-T 1	B-T 2	B-T 3	B-T 2	B-T 3	B-T 4	B-T 2	B-T 5	B-T 6	B-T 7	10.06	01.08	08.10
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ROTIFERA															
Habrotrocha sp.	–	–	-	-	-	+	+	+	-	-	-	-	-	-	-
Rotaria sp.	–	–	-	-	+	-	-	-	-	-	-	-	-	-	-
Lecane luna (Müller, 1776)	C	L, Ph	-	-	-	-	+	+	-	-	-	-	-	-	-
Euchlanis meneta Myers, 1930	H, P	Eut	-	-	-	-	-	+	-	-	-	-	-	-	-
Tripleuchlanis plicata plicata (Levander, 1894)	H	Ph, L	-	-	-	-	-	+	-	-	-	-	-	-	-
Brachionus urceus (Linnaeus, 1758)	C	Eut	-	-	-	-	+	-	-	-	-	-	-	-	-
B. angularis Gosse, 1851	C	Eut	-	-	-	-	+	+	-	-	-	-	-	-	-
B. variabilis (Hempel, 1896)	H	Pl	-	+	+	+	+	+	-	-	-	-	-	-	-
B. plicatilis asplanchnoides Charin, 1947	H	Pl	-	-	-	-	-	-	-	-	-	-	-	+	-
B. calyciflorus anuraeiformis Brehm, 1838	C	–	-	-	-	-	+	-	-	-	-	-	-	-	-
Asplanchnopus multiceps (Schrank, 1793)	C	Ph	-	-	-	-	-	+	-	-	-	-	-	-	-
Synchaeta sp.	–	–	+	-	-	-	-	-	-	-	-	-	-	-	-
Polyarthra vulgaris Carlin, 1943	P	Pl	-	-	-	-	+	-	-	-	-	-	-	-	-
CLADOCERA															
Daphnia magna Straus, 1820	H	Pl	+	+	+	+	+	+	+	-	-	-	-	-	-
D. sinensis Gu, Xu, Li, Dumont et Han, 2013	H	Pl	-	-	-	-	-	-	-	+	+	+	-	-	-
Simocephalus vetulus (Müller, 1776)	P	L, Ph	+	-	-	-	+	+	+	-	-	-	-	-	-
Ceriodaphnia pulchella Sars, 1862	P	Eut	+	-	-	-	-	+	+	-	-	-	-	-	-
Chydorus sphaericus (Müller, 1785)	C	Eut	+	-	+	+	-	+	+	-	-	-	-	-	-
Pleuroxus aduncus (Jurine, 1820)	C	L, Ph	-	-	-	-	-	-	+	-	-	-	-	-	-
Alona rectangula Sars, 1862	C	Eut	-	-	-	-	+	+	+	-	-	-	-	-	-

Continuation Table 5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A. guttata Sars, 1862	C	Ph, L	-	-	-	-	-	-	+	-	-	-	-	-	-
Macrothrix laticornis (Jurine, 1820)	C	Bt	-	-	-	-	-	-	-	+	+	-	-	-	-
Moina brachiata (Jurine, 1820)	P	Pl	-	+	+	+	+	+	-	-	-	-	+	+	-
COPEPODA															
Metadiaptomus asiaticus (Uljanin, 1875)	H	Pl	-	-	-	-	-	-	+	+	+	+	+	+	+
Eucyclops arcanus Alekseev, 1990	P	Pl	-	+	+	-	-	-	-	-	-	-	-	-	-
E. serrulatus (Fischer, 1851)	C	Eut	+	-	-	+	+	-	-	-	-	-	-	-	-
Acanthocyclops vernalis (Fischer, 1853)	P	Eut	+	-	-	-	-	-	-	-	-	-	-	-	-
A. venustus (Norman et Scott, 1906)	P	Bt	-	+	+	-	-	-	-	-	-	-	-	-	-
Megacyclops viridis (Jurine, 1820)	C	Eut	-	-	-	+	+	+	+	-	-	-	-	-	-
Thermocyclops dybowskii (Lande, 1890)	H	Pl	-	-	-	+	+	+	-	-	-	-	-	-	-
Total			7	5	7	8	14	15	9	3	3	2	2	3	1

Note: «+» – species found in plankton, «-» – species not found, «–» – no data. Zoogeography (ZG) (from: Boxshall, Defaye, 2008; Forro et al., 2008; Segers, 2008): C – cosmopolite, H – holarctic, P – palearctic. Habitat (Hab) (from: Kutikova, 1970; Dumont, Negrea, 2002; Dussart, Defaye, 2002, 2006): Eut – eurytopic, Pl – planktonic, Ph – phytophilic, L – littoral, Bt – benthic.

being the dominant species. In August, the total number of zooplankton varied between 55.1 and 1656.0 × 10^3 individuals/m^3, and their biomass was between 1.1 and 85.5 g/m^3. The major species was *M. brachiata*. In October, the samples contained only *Metadiaptomus*: 175.1-507.5 × 10^3 individuals/m^3 and a biomass of 21.9-61.1 g/m^3 (Table 6).

Water bodies on the bed of Barun-Torey contained 46 algal taxa of seven phyla, and the greatest diversity (25) was observed in August. The numbers and biomass of algae varied between 16.8 and 86.2 × 10^3 cells/L and between 6.2 and 103.0 mg/m^3 in June, between 39.0 and 1260.0 × 10^3 cells/L and between 23.2 and 1271.0 mg/m^3 in August and between 0.7 and 523.5 × 10^3 cells/L and between 0.1 and 544.3 mg/m^3 in October, respectively. The dominant species were green algae (*Monoraphidium obtusum*, *Chlamydomonas* species, *Tetraëdron incus*, and *Coenococcus planctonicus*) and cyanobacteria (*Oscillatoria* species) (Table 6).

The number of zooplankton species in Barun-Torey water bodies varied from 2 (October) to 15 (August). In summer, the density of zooplankters was very high, with their number and biomass reaching 465.0-19370.0 × 10^3 individuals/m^3 and 21.1-361.7 g/m^3 in June and 246.5-2216.7 × 10^3 individuals/m^3 and 16.9-260.4 g/m^3 in August. In October, these parameters were considerably lower: 9.2-168.4 × 10^3 individuals/m^3 and 3.8-20.4 g/m^3. In June, the major zooplankton species were the rotifer *Brachionus variabilis* and the crustaceans *Chydorus sphaericus*, *Daphnia magna*, *Eucyclops serrulatus* and *Acantocyclops venustus*; in August and October, the zooplankton community was dominated by copepods (*Thermocyclops dybowski, E. serrulatus, Megacyclops viridis*) and cladocerans (*Ceriodaphnia pulchella*, *Simocephalus vetulus*, *Daphnia sinensis*, *D. magna*, *Macrothrix laticornis*) (Table 6).

Discussion

Changes in total dissolved solids caused by dilution and evaporation concentration (Zamana, Borzenko, 2010) affect all components of the ecosystem, including planktonic communities. According to the Venice System (Kozhova, 1987), Barun-Torey small water bodies were classified as oligohaline, and the water in Zun-Torey was polyhaline. Planktonic communities developing in aquatic environments with different chemical compositions differ in their species diversity and abundance. Ecogeographical analysis of phytoplankton showed that the algae in the study water bodies were mainly represented by species that are planktonic/benthic (70.2%), have a wide geographic range (87.5%), are indifferent to water salinity (88.8%) and are alkaliphilic (61.5%). Zooplankton were dominated by species with a wide geographic range (44%) and eurybionts (48%). As all water bodies were shallow and the water was turbid (with transparency no greater than 10 cm), they were mainly inhabited by planktonic/benthic algae and eurytopic invertebrates, which can develop in both benthic and planktonic ecosystems.

The diversity of the plankton in the Barun-Torey water bodies that were in the filling phase was greater (46 algal taxa and 29 species of invertebrates) than in the shallowing Lake Zun-Torey (18 taxa and 3 species, respectively). The quantitative parameters of the aquatic organisms in the small water bodies were many times higher than the corresponding parameters in Lake Zun-Torey. The largest number of phytoplankton cells was 4 times higher, and the largest phytoplankton biomass was 85 times higher; the corresponding parameters of zooplankton were 12 and 4 times higher, respectively. The lowest density of organisms in the Barun-Torey water bodies was observed in autumn, and the highest was in summer. In contrast, in Lake Zun-Torey, algal numbers and

Table 6. Changes in some characteristics of the plankton in the lakes in 2016

Lake/site		Sampling date	Phytoplankton				Zooplankton			
			n	N_{phyto}	B_{phyto}	Dominants	n	N_{zoo}	B_{zoo}	Dominants
Barun-Torey	B-T 1	10.06	3	16.8	6.2	*M. obtusum*	7	465.0	21.1	*Ch. sphaericus, D. magna, E. serrulatus*
	B-T 2		4	66.1	32.3	*Oscillatoria* species	5	19370.0	361.7	*B. variabilis, M. brachiata*
	B-T 3		11	86.2	103.0	*C. planctonicus*	7	3695.4	87.2	*B. variabilis, A. venustus*
	B-T 2	01.08	25	1260.0	1271.0	*Chlamydomonas* species	8	550.4	260.4	*D. magna, T. dybowski, E. serrulatus*
	B-T 3		7	39.0	23.2	*T. incus*	14	2216.7	16.9	*T. dybowski, B. angularis, P. vulgaris*
	B-T 4		9	160.5	32.5	*Oscillatoria* species	15	246.5	22.7	*T. dybowski, C. pulchella, D. magna*
	B-T 2	08.10	14	523.5	544.3	*Chlamydomonas* sp. *N. graciliformis*	9	106.9	6.0	*M. viridis, M. asiaticus, D. magna, S. vetulus*
	B-T 5		2	0.7	3.5	*Euglena* sp_1.	3	168.4	20.4	*D. sinensis, M. asiaticus*
	B-T 6		0	0	0	–	3	71.0	11.6	*D. sinensis, M. laticornis*
	B-T 7		2	0.7	0.1	*M. contortum*	2	9.2	3.8	*D. sinensis, M. asiaticus*
Zun-Torey	Z-T 1	10.06	4	40.8	9.7	*P. contorta, O. submarina*	2	275.0	40.9	*M. asiaticus*
	Z-T 2	01.08	12	12.4	1.0	*C. planctonicus*	2	1656.0	85.5	*M. brachiata*
	Z-T 3		5	39.8	3.0		3	55.1	1.1	
	Z-T 2	08.10	3	310.7	14.7	*Oocystis* species	1	175.1	21.9	*M. asiaticus*
	Z-T 3		3	94.7	13.2		1	507.5	61.1	

Note: n – number of taxa; N_{phyto} – phytoplankton number, thousand cells/L; B_{phyto} – phytoplankton biomass, mg/m^3; N_{zoo} – zooplankton number, thousand individuals/m^3; B_{zoo} – zooplankton biomass, g/m^3.

biomass were lower in the high-temperature season than when the water was cooling. In both lakes, the major contribution to the numbers and biomass of the algae was made by cyanobacteria and green algae, and they were also dominant in other lakes of the same type (Doyle, 1990; Vesnina et al., 2005; Zhao et al., 2005; Afonina, Tashlykova, 2018). In the water bodies of Barun-Torey, the flora of small-celled Chlorococcales were more diverse. The zooplankton of the water bodies of Barun-Torey were dominated by freshwater and brackish-water representatives of heleoplankton, while Lake Zun-Torey was mainly inhabited by saltwater zooplankton. The rapid development of some aquatic species in the Barun-Torey water bodies is typical of shallow-water ecosystems in arid regions and is caused by the instability of the habitats associated with cyclic climate variations (Kirilyuk et al., 2012). The ecosystem of Lake Zun-Torey follows the trend common for salt lakes, where lower water levels lead to a higher salinity and pH and, hence, to poorer species diversity (Gorlacheva et al., 2014; Itigilova et al., 2014). As the chemical properties of the water change, the total numbers and biomass of aquatic organisms may either increase (Echaniz, Vignatti, 2011; Vignatti et al., 2017) or decrease (Balushkina et al., 2009; Litvinenko et al., 2013).

Conclusion

The list of phytoplankton and zooplankton in the Torey Lakes in the low-water 2016 consisted of 51 algal taxa and 30 species and subspecies of invertebrates. Phytoplankton and zooplankton were mainly represented by euryhaline species with a wide geographic range. The main factor determining the composition and structure of phytoplankton and zooplankton communities is the mineral content of lake water. Conditions in shallow oligohaline water bodies in the basin of Barun-Torey, which were in the filling phase, were favourable for the development of diverse and abundant littoral planktonic communities, with 46 algal taxa and 29 species of invertebrates. The numbers and biomass of aquatic organisms varied widely: phytoplankton between 0.7 and 1260.0 × 10^3 cells/L and between 0.1 and 1271.0 mg/m^3 and zooplankton between 9.2 and 19370.0 × 10^3 individuals/m^3 and between 3.8 and 361.7 g/m^3. The major species were freshwater and euryhaline. In the drying polyhaline Lake Zun-Torey, phytoplankton and zooplankton communities consisted of a few species (18 algal taxa and 3 species of zooplankton). The number and biomass of phytoplankton varied between 12.4 and 310.7 × 10^3 cells/L and between 1.0 and 14.7 mg/m^3, and the corresponding parameters of zooplankton varied between 55.1 and 1656.0 × 10^3 individuals/L and between 1.1 and 85.5 g/m^3. Euryhaline and halophilic species dominated.

Acknowledgements

The authors are deeply grateful to researchers at the Laboratory of Aquatic Ecosystems at INREC SB RAS G.Ts. Tsybekmitova and M.Ts. Itigilova for their assistance in collecting hydrobiological samples. The study was performed for the project of the Program for Basic Scientific Research IX.137.1.1.

References

Afonina E.Y., Tashlykova N.A. (2018) Plankton community and the relationship with the environment in saline lakes of Onon-Torey plain, Northeastern Mongolia. *Saudi Journal of Biological Sciences*, 25 (2): 399-408

Balushkina E.V., Golubkov S.M., Golubkov M.S., Litvinchuk L.F., Shadrin N.V. (2009) Effect of abiotic and biotic factors on the structural and functional organization of the saline lake ecosystems. *Journal of General Biology* [Zhurnal obshchey biologii], 70 (6): 504-514 (in Russian)

Balushkina E.B., Vinberg G.G. (1979) The relationship between body weight and length in planktonic animals. *General principles of study of aquatic ecosystems*. Leningrad, Nauka, p. 169-172 (in Russian)

Barinova S.S., Medvedeva L.A., Anisimova O.V. (2006) *Diversity of algal indicators in the environmental assessment*. Tel-Aviv, Pilies Studio, 498 p. (in Russian)

Bazhenova O.I. (2013) Current dynamics of fluvio-lacustrine systems of Onon-Torei High Plain (Southern Transbaikalia). *Tomsk State University Journal*, 371: 171-177 (in Russian)

Boxshall G.A., Defaye D. (2008) Global diversity of copepods (Crustacea: Copepoda) in freshwater. *Hydrobiologia*, 595 (1): 195-207

Doyle W.S. (1990) Changes in lake levels, salinity and the biological community of Great Salt Lake (Utah, USA), 1847-1987. *Hydrobiologia*, 197: 139-146

Dumont H.J., Negrea S.V. (2002) *Guides to the identification of the microinvertebrates of the continental waters of the world. 19. Introduction to the class Branchiopoda.* Leiden, Backhuys Publishers, 398 p.

Dussart B.H., Defaye D. (2002) *World directory of Crustacea Copepoda of Inland Waters. I – Calaniformes*. Leiden, Backhuys Publishers, 276 p.

Dussart B.H., Defaye D. (2006) *World directory of Crustacea Copepoda of Inland Waters. II – Cyclopiformes*. Leiden, Backhuys Publishers, 354 p.

Echaniz S.A., Vignatti A.M. (2011) Seasonal variation and influence of turbidity and salinity on the zooplankton of a saline lake in central Argentina. *Latin American Journal of Aquatic Research*, 39 (2): 306-315

Fedorov V.D., Gilmanov T.G. (1980) *Ecology*. Moscow, Moscow State University, 464 p. (in Russian)

Forro L., Korovchinsky N.M., Kotov A.A., Petrusek A. (2008) Global diversity of cladocerans (Cladocera; Crustacea) in freshwater. *Hydrobiologia*, 595 (1): 177-184

Frish V.A. (1972) The Torean experiment. *Nature* [Priroda], 2: 60-64 (in Russian)

Gorlacheva E.P., Tsybekmitova G.Ts., Afonin A.V., Tashlikova N.A., Afonina E.Yu., Kuklin A.P., Saltanova N.V. (2014) Lake-margin ecosystems of saline lakes of the Borzya group (Zabaikalsky Krai, Russia) during the initial filling phase. *Chinese Journal of Oceanology and Limnology*, 32 (4): 871-878

Guiry M.D., Guiry G.M. (2016) AlgaeBase. Retrieved July 10, 2010; from http://www.algaebase.org.

Itigilova M.Ts., Dulmaa A., Afonina E.Yu. (2014) Zooplankton of lakes of the Uldza and Kerulen river valleys of northeastern Mongolia. *Inland Water Biology*, 7 (3): 249-258

Kirilyuk V.E., Tkachuk T.E., Kirilyuk O.K. (2012) The influence of climate change on habitats and biota in the Daurian Eco-region. *Problems of adaptation to climate change in the basins of the Dauria rivers: ecological and water management aspects*. Chita, Ekspress-izdatel’stvo, p. 46-62 (in Russian)

Kozhova O.M. (1987) *Introduction to hydrobiology*: *a training manual*. Krasnoyarsk, Krasnoyarsk University, 244 p. (in Russian)

Krendelev F.P. (1986) Periodicity of filling and drying in the Toreian lakes (Southeast Transbaikalia). *Reports of the Academy of Sciences of the USSR* [Doklady AN SSSR], 287 (2): 396-400 (in Russian)

Kutikova L.A. (1970) *Rotifers of the USSR fauna (Rotatoria).* Leningrad, Nauka, 744 p. (in Russian)

Litvinenko L.I., Litvinenko A.I., Boyko E.G., Kutsanov K.V. (2013) Effect of environmental factors on the structure and functioning of biocoenoses of hyperhaline water reservoirs in the South of Western Siberia. *Contemporary Problems of Ecology*, 6 (3): 252-261

Methodical recommendations on material collection and processing in hydrobiological studies in freshwater water bodies: Zooplankton and its production (1984) Leningrad, GosNIOPH, 34 p. (in Russian)

Obyazov V.A. (2012) Climate change and hydrological regime of rivers and lakes in the Daurian ecoregion. *Problems of adaptation to climate change in the basins of the Daurian rivers: ecological and water management aspects*. Chita, Ekspress-izdatel'stvo, p. 24-45 (in Russian)

Ruttner-Kolisko A. (1977) Suggestions for biomass calculation of plankton rotifers. *Arch. Hydrobiol. Beih. Ergebn. Limnol*., 8: 71-76

Sadchikov A.P. (2003) *Methods of freshwater phytoplankton analysis.* Moscow, Universitet i shkola, 157 p. (in Russian)

Segers H. (2008) Global diversity of rotifers (Rotifera) in freshwater. *Hydrobiologia*, 595 (1): 49-59

Vesnina L.V., Mitrofanova E.Yu., Lisitsyna T.O. (2005) Plankton of salted lakes of the territory of a closed runoff (the South of West Siberia, Russia). *Siberian Journal of Ecology* [Sibirskiy ekologicheskiy zhurnal], 12 (2): 221-233 (in Russian)

Vignatti A.M., Cabrera G.S., Canosa M., Echaniz S.A. (2017) Environmental and zooplankton parameter changes during the drying of a saline shallow temporary lake in central Argentina. *Universitas Scientiarum*, 22 (3): 177-200

Zamana L.V., Borzenko S.V. (2010) Hydrochemical regime of salt lakes in the South-Eastern Transbaikalia. *Geography and Natural Resources* [Geografiya i prirodnyye resursy], 4: 100-107 (in Russian)

Zamana L.V., Obyazov V.A. (2004) Dynamics of the level and hydrochemical regime in the Toreian lakes in 20^{th} century. *Scientific basis for the conservation of watersheds: interdisciplinary approaches to the management of natural resources.* Ulan-Ude, Buryat Science Center, p. 98-99 (in Russian)

Zhao W., Zheng M.P., Xu X.Z., Liu X.F., Guo G.L., He Z.H. (2005) Biological and ecological features of saline lakes in northern Tibet, China. *Hydrobiologia*, 541: 189-203