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DIATOMS FROM HOT SPRINGS FROM KURIL AND SAKHALIN ISLANDS (FAR EAST, RUSSIA)

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1. Introduction

Hot springs have received a tremendous amount of attention recently, particularly as they relate to microbial organisms. They have been sites where interesting and useful DNA has been extracted and developed to a diverse set of academic and applied uses (Arnheim et al., 1990; Watson et al., 1992). Hot springs were one of the first sites of discovery of a third domain of life, the Archaea (Barns et al., 1994, 1996). Extreme environments such as hot springs have become more interesting for those who are seeking to discover life on places other than earth within our own solar system, and beyond. Thus, hot springs may represent analog habitats that life forms can withstand; what we humans perceive to be "extreme," i.e., very cold, hot, with different chemical compositions.

Much has been made of the prokaryotes in these extreme environments, particularly Cyanobacteria (e.g., Brock and Brock, 1967), but much less has been documented relative to the eukaryotes. Thermal resistance of thermophilic and mesothermic algal species is high, and they successfully live and thrive in water bodies with temperatures of 30–84°C. A group of eukaryotes that does seem to occupy a wide set of ecological niches are the diatoms, and species are known to occur in, on and around ice, as well as extremely acid and hot waters.

Hot springs have been recorded from all continents on earth except Antarctica. Surveys of diatoms from hot springs, though the number of studies is limited, have been accomplished in many of the regions of the world. We present in Table 1, a partial listing of the surveys of diatoms from hot springs around the world.

Hot springs also offer the opportunity to test hypotheses regarding the biogeography of microbial organisms. Kociolek and Spaulding (2000) detailed a number of families, genera, and species that appear to be localized in their

Table 1. Partial listing of hot springs by continent and country in which diatoms have been recorded.

Continent/country	Hot springs	References
Asia		
Russia	Kamchatka	Petersen, 1946
Russia	Kamchatka	Yoshitake et al., 2008
India	Vajreshwari	Gonzalves, 1947
India	Various	Thomas and Gonzalves, 1965a, b, c, d, e, f
Sunda Islands	Various	Hustedt, 1937–1938
Japan	Toyama Prefecture	Emoto and Yoneda, 1942
Japan	Hokkaido	Yoneda, 1962
Japan	Shizuoka Prefecture	Kobayashi, 1957a
Japan	Shiobara	Kobayashi, 1957b
Japan	Various	Molisch, 1926
Japan	Various	Owen et al., 2008
Japan	Isobe Hot Springs	Fukushima et al., 2002
Japan	Various	Villeneuve and Pienitz, 1998
Europe		
Czech Republic	Carlsbad	Corda, 1840; Sprenger, 1930
Czech Republic	Various	Bilý, 1934
Italy	Triponzo	Dell'Uomo, 1986
Iceland	Various	Krasske, 1938; Biebl and Kusel-Fetzmann, 1966; Owen et al, 2008; Villeneuve and Pienitz, 1998
Spitsbergen	Various	Krasske, 1938
France	Chaudesaigues	Famin, 1933a, b
Azores	Various	Brock and Brock, 1967
North America		
USA	Yellowstone, MT	Mann and Schlichting, 1967; Stockner, 1967; Hobbs et al., 2009
USA	Mt. Rainier, WA	Stockner, 1967
USA	Ohanapecosh Hot Springs, WA	Stockner, 1968
USA	Alhambra, MT	Fairchild and Sheridan, 1974
USA	Lassen National Park, CA	Anderson, 1935
USA	Blue Lake Warm Spring, UT	Kaczmarska and Rushforth, 1983
Canada	Various	Villeneuve and Pienitz, 1998
South America		
San Salvador	Various	Hustedt, 1953
Africa		
Israel	Lake Kinneret region	Dor, 1974
Kenya	Lakes Elmenteita, Baringo	Mpawenayo and Mathooko, 2004
Burundi	Various	Mpawenayo et al., 2005
Zambia	Various	Compère and Delmotte, 1988
Nambia	Various	Schoeman and Archibald, 1988
Australia		
New Zealand	Various	Cassie, 1989; Cassie and Cooper, 1989; Owen et al., 2008
Java, Bali, Sumatra	Various	Hustedt, 1937–1938

distributions (vs. being widely distributed). And while Vyverman et al. (2007) attempted to further document patterns of diatom distributions that do not support an “everything is everywhere” model, their analysis lacks appropriate comparisons to understand biogeographic patterns and processes. Hot springs offer the possibility to examine habitats that may have similar temperatures and water chemistries, but occur in very different geographic locales, and see if they harbor and support similar or different species of diatoms.

Villeneuve and Pienitz (1998) compared floras of hot springs from Canada, Iceland, and Japan, and found that although they had similar environmental conditions, the structure of the diatom communities were quite different, especially with regard to species. Likewise, Owen et al. (2008) compared hot springs in Iceland, New Zealand, and Kenya, and the dominant taxa present in these systems were all quite in terms of major groups represented. However, Hobbs et al. (2009) found *Pinnularia acoricola* Hustedt and *Eunotia exigua* (de Brébisson *ex* Kützing) Rabenhorst in the hot springs of an acid habitat and noted that these taxa had also been reported from similar environments around the world (e.g., DeNicola, 2000).

Studies of hot springs algae in the eastern part of Russia are few. And, at present, studies on algal species diversity in hydrothermal environments of the Kuril Islands are still preliminary. There are several publications detailing results of investigations of hot spring algal floras of Kunashir Island. In the publication by Tereshkova with coauthors (1973), the authors provide some information on the cultivation procedure of four species of thermophilic blue-green algae (*Coccopedia* sp., *Synechococcus* sp., *Phormidium ambiguum* Gomont, and *P. foveolarum* (Montagne) *Gomont*. Sentzova (1991) described two species new to science – *Galdieria partita* Sentzova and *G. maxima* Sentzova (division Rhodophyta) from thermal acidic springs. Gromov et al. (1991) described a new acidophilic species of golden algae *Ochromonas vulcania* Gromov, Nikitina et Mamkayeva, from fumaroles of the Mendeleev Volcano. In Nikitina’s (2005) monographic survey, there are data on flora of blue-green algae of hydrothermal outlets of Goryachy Beach and the Mendeleev Volcano, and she reported 15 taxa from 3 classes, 4 orders, and 7 families. In a short publication, Nikulina (2007) presents preliminary information about algal flora of hot springs of Kurilsky Reserve located on Kunashir Island. Data of diatoms from hot springs on Kunashir Island were recorded for the first time by Nikulina (2007).

The representatives of blue-green algae in underwater hydrothermaes of Yankicha Island are known from Beljakova’s papers (2000a, b, 2001), which report 14 taxa of blue-green algae of two classes, two orders, and four families.

In this paper, we present the results of a biotic survey of freshwater and brackish diatoms from hot springs in eastern Russia, notably the several islands from the Kuril Islands and Sakhalin Island, and compare our results with others investigating hot springs from around the globe. This represents the first documentation of diatoms from hot springs on Shiashkotan, Yankicha, and Sakhalin Islands.

2. Materials and Methods

2.1. DESCRIPTION OF SAMPLING SITES

2.1.1. Kuril Islands

Kunashir Island: In August 1999, we investigated two streams in the area of the former Alekhino Settlement, both of which empty into Alekhin Bay. The water temperature was 48.1°C and 26°C at the time of sampling. Substrates were sand with a few small and medium-sized stones. These springs belong to the northern group of Alekhin springs located on the coast of the Golovnin Volcano facing the Sea of Okhotsk. According to the published data, water of this group of springs is referred to as calcium-sodium, sulfate-chloride thermae, with pH = 4–5, T = 50–55°C (Markhinin and Stratula, 1977).

In the caldera of Golovnin Volcano, periphyton (benthic) samples were taken from a hot spring in the solfatara field, at the foot of the southern slope of Central-East cupola of the volcano in January 2007. There were five groups of solfataras with thermal spring outlets distinguished, and water temperature varied from 60°C to 103°C, water chemistry sharply differs even within a group: from circumneutral and alkaline (pH = 6–8.5) hydrocarbonate-sulfate and sodium-calcium to acidic (pH = 2–2.5) sulfate and sodium (Markhinin and Stratula, 1977).

Periphyton algae were also sampled in “Stolbovskiye” thermal springs and a stream flowing from one of them in August 1999 and April 2007. The studied springs are located on the western coast of the island, 2 km south of Stolbchaty Cape. In August 1999, the water temperature was 40°C in the hot spring and 24°C in the brook downstream; habitats included small- and medium-sized stones. Stolbovskiye springs belong to circumneutral (pH = 6.7–7.0) nitric, sodium chloride-sulfate thermae, and their water temperature reaches 82°C (Zharkov and Poberezhnaya, 2008).

Shiashkotan Island: We studied periphyton diatoms collected from the hydrothermal boil located on the sea shore Voskhodnaya Bay, within 15 m of the water edge, between Obvalny Cape and Bobrovy Island (the side facing the Sea of Okhotsk) in August 1999. The water temperature reached 71°C at the time of sampling; the habitat included small- and medium-sized stones.

Literature data only are known for the hot springs of Obvalny Cape located on the Pacific side of Shiashkotan Island, on the Makarovsky Isthmus. According to their water composition, the springs are identified as sodium chloride, with general mineralization of 13.3 g/L, water temperature of 60°C, and pH = 6.98 (Markhinin and Stratula, 1977).

Yankicha Island: Periphyton algae were sampled in hydrothermal spring baths at their origin and the effluent streams in Kraternaya Bay in August 1999. The water temperature of the springs varied from 50°C to 60°C at the time of sampling; substrates in the baths consisted of sand, and in streams, small, medium-sized and large stones on sandy bottoms. These thermal springs belong to the South-East solfatara field, their water temperature reaches 101°C, pH = 2.8–3.7. In their chemical composition, the springs are similar to the surrounding seawater; in hydrochemical type, they are sodium chloride, with mineralization of 25–27 g/L (Markhinin and Stratula, 1977).

2.1.2. Sakhalin Island

Phytoplankton and periphyton algae were collected in hot springs located on the shore of Dagi Bay in the northeast coast of Sakhalin Island. The water temperature was 37°C in the springs and 40.6°C in reservoir at the time of sampling. Substrates in the stream included sand, small and medium stones, with stratum of silt. According to the literature, water of Dagi hydrothermal springs is characterized as being hydrocarbonate-sodium chloride in composition, alkaline (pH = 7–8), and water temperature varied from 20°C to 55°C (Karpunin et al., 1998; Zharkov, 2008).

2.2. SAMPLE PROCESSING

All samples were cleaned by the method of Swift (1967), and processed into permanent microscope slides. Light microscope observations were made with a Nikon “Alphaphot 2” and a Carl Zeiss “Axioskop 40.” Diatom photos were taken at the “Biotechnology and Genetic Engineering” on the campus of Institute of Biology and Soil Sciences, Far East Branch of Russian Academy of Sciences (head V.P. Bulgakov). Permanent slides are housed at Institute of Biology and Soil Sciences, Far Eastern Branch of Russian Academy of Sciences, Vladivostok, Russia.

3. Results and Discussion

3.1. KURIL ISLANDS

The diatom flora of Kuril Islands hot springs and the watercourses formed by them is represented by 145 species (162 species, varieties and forms) of 3 classes: Coscinodiscophyceae, Fragilariophyceae, and Bacillariophyceae (Table 2). In the taxonomic structure of the flora, the best represented genera include *Pinnularia* with 13 taxa, *Nitzschia* with 12 taxa, and *Navicula* with 10 species and varieties.

Kunashir Island: Biofilms on stones in the sulphureous spring flowing on the coast of Alekhin Bay is dominated by the diatoms *Nitzschia capitellata*, *N. palea, Pinnularia acidophila*, and *P. acidojaponica*. The species *Diatoma vulgare, Eunotia implicata, Gomphonema parvulum*, and *Nitzschia nana* also have high abundance estimates. The algal flora of another hot spring in Alekhin Bay watershed has similar floristic composition; however, occurrence of the species is characterized as solitary or rare (Table 3).

The composition of diatom flora of the hot spring in caldera of Golovnin Volcano is extremely poor and is represented by 25 intraspecific taxa of diatoms from the classes Fragilariophyceae and Bacillariophyceae. The frequency of the algae was negligible, solitary to not rare, and only *Placoneis elginensis* was estimated as solitary to very frequent (Table 3).

Table 2. Taxonomic composition of hot springs algae of Kuril (Kunashir, Shiashkotan, and Yankicha) and Sakhalin Islands.

Class	Order	Family	Genera	Species	Varieties and forms	Percent
Kuril Islands						
Coscinodiscophyceae	4	6	6	11	12	7.4
Fragilariophyceae	4	5	13	22	27	16.7
Bacillariophyceae	9	20	33	112	123	75.9
Total	17	31	52	145	162	100
Sakhalin Island						
Coscinodiscophyceae	7	10	11	17	17	12.4
Fragilariophyceae	3	4	11	15	17	12.4
Bacillariophyceae	10	24	40	99	103	75.2
Total	20	38	62	125	137	100

A hot spring and a stream with its origin from the spring ("Stolbovskiye" group of springs) had similar structure of diatom communities in August 1999. Stone biofilms in the thermal source were represented by *Rhoicosphenia abbreviata* developed in mass, as well as by species with lower abundance – *Nitzschia palea*, *N. nana*, *Planothidium lanceolatum*, and *Synedra ulna* (Table 3). *Gomphonema parvulum*, *Synedra ulna*, *Planothidium lanceolatum*, and *Nitzschia nana* were dominant in the stream. Subdominant taxa were *Melosira varians*, *Rhoicosphenia abbreviata*, *Achnanthidium minutissima*, *Navicula cryptotenella*, and *Nitzschia palea.*

The hydrothermal springs on Stolbchaty Cape that we studied in April 2007 are characterized by algal communities dominated by the diatoms *Tryblionella apiculata* and *Nitzschia capitellata* in combination with the following subdominants: *Amphora veneta* f. *capitata*, *Caloneis molaris*, *Encyonema hebridicum*, *Navicula cryptotenella*, and *Nitzschia nana*.

Shiashkotan Island: In a hot spring on Shiashkotan Island, 44 taxa of diatoms have been recorded. *Hannaea arcus* var. *linearis* f. *recta* had the highest abundance estimate; it was very frequent from this locality (Table 3).

Yankicha Island: In thermal springs and in streams flowing from them, *Navicula elginensis* and *Nitzschia aurariae* developed in mass in stone fouling. In addition, populations of *Diatoma vulgare* and *Nitzschia thermaloides* were abundant (Table 3).

3.2. SAKHALIN ISLAND

The diatom flora of Sakhalin hot springs is represented by 125 species (131 species, varieties, and forms) of 3 classes: Coscinodiscophyceae, Fragilariophyceae,

Table 3. Species composition of algae of hot springs of Kuril Islands and Sakhalin Island.

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
	Bacillariophyta											
	Coscinodiscophyceae											
	Coscinodiscales											
	Coscinodiscaceae											
1.	*Bacterosira fragilis* (Gran) Gran	–	–	–	–	–	1	P	mh	–	–	a-a
	Heliopeltaceae											
2.	*Actinoptychus senarius* (Ehrenberg) Ehrenberg	–	–	–	–	–	1	–	–	–	–	–
	Thalassiosirales											
	Thalassiosiraceae											
3.	*Thalassiosira bramaputrae* (Ehrenberg) Håkansson et Locker	–	–	–	–	–	1	–	–	–	β	–
4.	*Th. eccentrica* (Ehrenberg) Cleve	–	–	–	–	–	1	P	mh	i	–	b
5.	*Th. gravida* Cleve	–	–	–	–	–	1	P	mh	i	–	b
6.	*Th. nativa* Sheshukova–Poretzkaya	–	–	–	–	–	1	–	–	–	–	–
7.	*Th. nordenskiöldii* Cleve	–	–	–	–	1–2	–	P	hl	–	–	b
	Stephanodiscaceae											
8.	*Cyclotella meneghiniana* Kützing	1	–	–	–	–	–	B-P	hl	alf	α-β	k
9.	*C. striata* (Kützing) Grunow	–	–	–	–	–	1	–	hl	–	–	–
	Paraliales											
	Paraliaceae											
10.	*Paralia sulcata* (Ehrenberg) Cleve	–	–	–	–	–	1–3	P	mh	–	–	b
	Melosirales											
	Melosiraceae											

(continued)

Table 3. (continued)

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
11.	*Melosira dickei* (Thwaites) Kützing	1	2–3	–	–	–	–	B-P	i	i	–	–
12.	*M. moniliformis* (O.F. Müller) Agardh	–	–	–	3	1–2[a]	–	B-P	hl	–	–	k
13.	*M. nummuloides* Agardh	–	–	–	–	1–2[a]	–	—	mh	–	–	–
14.	*M. varians* Agardh	1–4[a]	1	–	–	1	1[a]	B-P	i	alb	β	k
	Aulacoseirales											
	Aulacoseiraceae											
15.	*Aulacoseira ambigua* (Grunow) Simonsen.	–	–	–	–	–	1[a]	P	i	alf	α-β	k
16.	*A. distans* (Ehrenberg) Simonsen var. *distans*	–	1	–	–	–	–	B-P	i	acf	χ-o	b
17.	*A. distans* var. *lirata* (Ehrenberg) Bethge	–	–	–	–	1	–	B-P	–	–	–	–
18.	*A. granulata* (Ehrenberg) Simonsen	1	1–2	–	–	1	1	P	i	alf	β	k
19.	*A. italica* (Kützing) Simonsen	1	–	–	–	–	1	P	i	alf	o-β	k
20.	*A. subarctica* (O.F. Müller) Haworth	–	–	–	–	–	1–2	P	i	alb	α-β	k
	Triceratiales											
	Triceratiaceae											
21.	*Cerataulus turgidus* (Ehrenberg) Ehrenberg	–	–	–	–	–	1	B-P	–	–	–	–
22.	*Odontella aurita* (Lyngbye) Agardh	–	–	–	–	1	1	B-P	mh	alf	–	–
	Plagiogrammaceae											
23.	*Dimeregramma fulvum* (Gregory) Ralfs	–	–	–	–	1	–	B	–	–	–	–
24.	*D. minor* (Gregory) Ralfs	–	–	–	–	–	1	–	–	–	–	–
	Chaetocerotales											
	Chaetoceraceae											

25.	*Chaetoceros* sp.	–	–	–	–	–	1	–	–	–	–	–
	Fragilariophyceae Fragilariales Fragilariaceae											
26.	*Asterionella formosa* Hassall	–	1[a]	1	1	1–2	–	P	i	alf	o-β	k
27.	*Ctenophora pulchella* (Ralfs) Williams et Round	1	1–2	–	–	1	1	B-E	mh	alf	β-α	b
28.	*Fragilaria capucina* Desmazières var. *capucina*	1–2[a]	1[a]	–	–	–	–	B-P	i	alf	o-β	k
29.	*F. capucina* var. *gracilis* (Østrup) Hustedt	–	–	–	–	–	1	–	–	–	β-α	–
30.	*F. capucina* var. *rumpens* (Kützing) Lange-Bertalot	–	–	–	–	–	1	B	i	acf	o	k
31.	*F. crotonensis* Kitton	1–2[a]	1[a]	–	1	–	–	P	i	alf	o-β	b
32.	*F. nitzschioides* Grunov	–	–	–	–	1	–	B	i	i	–	k
33.	*F. vaucheriae* (Kützing) J.B. Petersen	1–2[a]	1[a]	–	1[a]	1–2	1	E	i	alf	β	k
34.	*Fragilariforma bicapitata* (A. Mayer) Williams et Round	–	–	–	–	–	1	B	hb	acf	o-β	b
35.	*F. virescens* (Ralfs) Williams et Round	1	–	–	–	–	–	B	hb	i	χ	a-a
36.	*Hannaea arcus* (Ehrenberg) Patrick var. *arcus*	–	1	1	–	1	1	B	i	alf	χ	a-a
37.	*H. arcus* var. *amphioxys* (Rabenhorst) Patrick	1	–	–	–	–	–	B	i	alf	χ-o	a-a
38.	*H. arcus* var. *linearis* (Holmboe) R. Ross	–	1	1	–	1	–	B	i	alf	χ	a-a
39.	*H. arcus* var. *linearis* f. *recta* (Cleve) Foged	1–3[a]	1[a]	–	5[a]	1–2[a]	–	B	i	alf	χ	a-a
40.	*Staurosira construens* (Ehrenberg) Grunow f. *subsalina*	–	–	1	–	–	2	B	i	alf	β	k
41.	*S. construens* f. *venter* (Ehrenberg) Bukhtiyarova	1	–	–	–	–	4	B	i	alf	o	k

(continued)

Table 3. (continued)

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
42.	*S. pinnata* (Ehrenberg) D. M. Williams and Round	–	–	–	–	–	2[a]	B	hl	alf	β–α	k
43.	*Synedra inaequalis* H. Kobayasi	–	1	–	–	–	1	B	–	–	–	–
44.	*S. ulna* (Nitzsch) Ehrenberg var. *ulna*	1–6[a]	1–3[a]	1	1[a]	1[a]	1–2	B	i	alf	β-α	k
45.	*S. ulna* var. *oxyrhynchus* (Kützing) Van Heurck	–	–	–	–	–	1	B	–	–	β-α	–
46.	*Tabularia fasciculata* (Agardh) Will. and Round	–	1	–	–	1–2	1	B-E	hl	–	–	k
	Diatomaceae											
47.	*Diatoma anceps* (Ehrenberg) Kirchner	1	1	–	–	1	–	B	hb	alf	o-χ	a-a
48.	*D. hiemale* (Lyngbye) Heiberg	1[a]	1–2	–	1	–	–	B	hb	i	χ	a-a
49.	*D. mesodon* (Ehrenberg) Kützing	1–2[a]	1	–	2	1[a]	–	B	hb	alf	χ	a-a
46.	*D. moniliforme* Kützing	–	–	–	–	1	–	B-P	hl	–	β-α	k
50.	*D. vulgare* Bory	1[a]	1–5[a]	2–3	2[a]	1–4[a]	1[a]	B-P	i	alb	β	b
51.	*Meridion circulare* (Greville) Agardh var. *circulare*	1	1	–	1	–	1	B	hb	alf	χ-o	k
52.	*M. circulare* var. *constrictum* (Ralfs) Van Heurck	1–2[a]	1	–	1	–	–	B	hb	alf	χ-o	k
	Tabellariales											
	Tabellariaceae											
53.	*Tabellaria fenestrata* (Lyngbye) Kützing	–	–	–	1	–	–	B-P	hb	acf	β	b
54.	*T. flocculosa* (Roth) Kützing	1	1	1	1	1	1[a]	B-P	hb	acf	o-χ	a-a
	Licmophorales											
	Licmophoraceae											

55.	*Licmophora communis* (Heiberg) Grunov	–	–	–	–	1	–	B	–	–	–	–
	Striatellales											
	Striatellaceae											
56.	*Grammatophora angulosa* Ehrenberg	–	–	–	1	–	–	B	–	–	–	–
	Rhabdonematales											
	Rhabdonemataceae											
57.	*Rhabdonema minutum* Kützing	–	–	–	–	–	1	–	–	–	–	–
	Bacillariophyceae											
	Eunotiales											
	Eunotiaceae											
58.	*Eunotia arcus* Ehrenberg	–	1	–	–	–	–	B	hb	acf	o	k
59.	*E. bilunaris* (Ehrenberg) Mills var. *bilunaris*	2	1–2[a]	–	–	1	1	B	i	acf	β	k
60.	*E. bilunaris* var. *linearis* (Okuno) Lange-Bertalot and Nörpel	–	–	–	–	1	–	B	–	–	o	–
61.	*E. denticulata* (Brébisson) Rabenhorst	–	1	–	–	–	–	B	–	acf	–	–
62.	*E. exigua* (Brébisson) Rabenhorst	1	1–2	2[a]	–	–	–	B	i	acf	χ	k
63.	*E. glacialis* Meister	–	–	–	–	–	1	B	–	acf	ρ	k
64.	*E. implicata* Nörpel, Lange-Bertalot and Alles	1[a]	1–4[a]	–	–	–	–	B	–	–	–	–
65.	*E. muscicola* Krasske	1	—	–	–	–	–	B	–	acf	–	–
66.	*E. parallela* Ehrenberg var. *angusta* Grunov	–	–	–	–	–	1	B	–	–	–	–
67.	*E. pectinalis* (O.F. Müller) Rabenhorst	1	1	–	–	–	–	B	hb	acf	χ	k
68.	*E. praerupta* Ehrenberg	1	1	1	1	–	–	B	hb	acf	χ	k
69.	*E. tenella* (Grunow) Hustedt	–	–	–	–	1	–	B	hb	acf	χ-o	k
	Anomoeoneidaceae											

(continued)

Table 3. (continued)

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
70.	*Anomoeoneis sphaerophora* (Ehrenberg) Pfitzer	–	–	–	–	–	1–5[a]	P-B	hl	alb	χ-β	k
	Mastogloiales											
	Mastogloiaceae											
71.	*Aneumastus tusculus* (Ehrenberg) D.G. Mann et Stickle	–	–	–	–	1	–	B-P	i	alf	o-χ	k
72.	*Mastogloia elliptica* (Agardh) Cleve	–	–	–	–	–	1	B	mh	alf	–	k
73.	*M. smithii* Thwaites ex W. Smith	1–2[a]	1	–	–	1	1	B	mh	alf	β	k
	Cymbellales											
	Rhoicospheniaceae											
74.	*Rhoicosphenia abbreviata* (Agardh) Lange-Bertalot	2–6[a]	1–2	–	1	1[a]	1[a]	B	hl	alf	β	k
	Cymbellaceae											
75.	*Brebissonia boeckii* (Ehrenberg) O'Meara	–	–	–	–	1	–	B	mh	–	–	b
76.	*Cymbella affinis* Kützing	1	1	1	1[a]	1–2[a]	1	B	i	alf	o–β	b
77.	*C. cistula* (Ehrenberg) Kirchner	1	–	–	–	–	–	B	i	alf	β	b
78.	*C. gracilis* (Ehrenberg) Kützing	–	–	–	–	–	1	B	hb	i	β	a-a
79.	*C. lanceolata* (Ehrenberg) Van Heurck	1	–	–	–	–	–	B	i	alf	β	–
80.	*C. naviculiformis* Auerswald	1	–	–	–	–	–	B	i	i	o	k
81.	*C. pusilla* Grunov	1	–	–	–	–	–	B	i	alf	–	k
82.	*C. subleptoceros* (Ehrenberg) Kützing	–	–	–	1	–	–	B	–	–	–	–
83.	*C. tumida* (Brébisson) Van Heurck	1	1	–	–	1	–	B	i	alf	o	b
84.	*Encyonema hebrridicum* Grunow ex Cleve	4[a]	–	–	–	–	–	B	i	i	o	a-a

85.	*E. minutum* (Hilse ex Rabenhorst) D.G. Mann	1[a]	1	1	1–2[a]	1	1	B	i	i	o	k
86.	*E. silesiacum* (Bleisch in Rabenhorst) D.G. Mann	1–3[a]	1	–	1–2[a]	1	1	B	i	alf	α	k
87.	*Placoneis elginensis* (Gregory) E.J. Cox	1[a]	–	1–4[a]	–	2–6[a]	1	B	i	i	o-β	k
	Gomphonemataceae											
88.	*Didymosphenia geminata* (Lyngbye) M. Schmidt	–	–	–	–	–	1	B	i	i	χ	a-a
89.	*Gomphoneis olivaceum* (Hornemann) Dawson ex Ross et Sims	1–2[a]	1	–	1	1	1	B	i	alf	β	b
90.	*G. quadripunctatum* (Østrup) Dawson ex Ross et Sims	1–3[a]	1	–	–	–	1	B	i	i	–	b
91.	*Gomphonema acuminatum* Ehrenberg var. *acuminatum*	1	1	–	–	–	–	B	i	alf	β	b
92.	*G. acuminatum* var. *coronatum* (Ehrenberg) W. Smith	1	–	–	–	–	1	B	i	alf	β	b
93.	*G. angustatum* (Kützing) Rabenhorst	2–3[a]	1–2[a]	1	2[a]	1	1–6[a]	B	i	alf	o	b
94.	*G. angustum* Agardh	–	–	–	1	–	–	B	i	alf	o	b
95.	*G. clavatum* Ehrenberg	–	1	–	–	1	–	B	i	i	o	k
87.	*G. intricatum* Kützing var. *vibrio* (Ehrenberg) Cleve	1	–	–	–	–	–	B	i	–	–	b
96.	*G. parvulum* (Kützing) Kützing var. *parvulum*	2–6[a]	1–4[a]	1	2[a]	1–2	2–4[a]	B	i	alf	β	b
97.	*G. parvulum* var. *lagenula* (Kützing) Frenguelli	3[a]	1	–	–	–	–	B	i	alf	–	k
98.	*G. truncatum* Ehrenberg	–	1	–	1	1	–	B	i	alf	β	b
99.	*Reimeria sinuata* (Gregory) Kociolek et Stoermer	1–2	1	–	1	–	1–2	B	i	alf	β	b
	Achnanthales											
	Achnanthaceae											

(continued)

Table 3. (continued)

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
100.	*Achnanthes brevipes* Agardh var. *intermedia* (Kützing) Cleve	–	–	–	–	–	1	B	–	–	–	–
101.	*A. coarctata* (Brébisson) Grunow	–	–	–	1–2	–	1	B	i	i	o	a-a
102	*A. exigua* Grunow var. *exigua*	1–2[a]	–	–	–	–	1	B	i	alf	β	k
103.	*A. exigua* var. *capitata* Hustedt	1–3[a]	–	–	–	–	–	B	–	–	–	–
104.	*A. hungarica* Grunow	–	–	–	–	–	1–6[a]	B	mh	alf	o-α	k
105.	*A. lanceolata* Brébisson ex Kützing var. *lanceolata*	1–6[a]	1–2[a]	–	1	1	1	B	i	alf	χ-β	k
106.	*A. lanceolata* var. *elliptica* Cleve	1–2[a]	1	–	–	–	–	B	i	alf	–	a-a
107.	*A. lanceolata* var. *haynaldii* (Schaarschmidt) Cleve	1–3[a]	–	–	–	–	–	B	i	alf	χ-β	k
108.	*A. linearis* (W. Smith) Grunov	–	–	–	–	–	1	B	i	i	χ-o	k
	Achnanthidiaceae											
109.	*Achnanthidium minutissima* (Kützing) Czarnecki	1–4[a]	1[a]	1[a]	1	1	1	B	i	i	o-β	b
110.	*Eucocconeis flexella* Kützing	–	1	–	–	–	–	B	mh	i	o	a-a
	Cocconeidaceae											
111.	*Cocconeis disculus* (Schumann) Cleve	–	1	–	1–3[a]	1	1–2	B	i	–	–	–
112.	*C. pediculus* Ehrenberg	–	–	1	–	–	–	B	hl	alf	β	k
113.	*C. pinnata* Gregory	–	–	–	–	1–2	–	–	–	–	–	–
114.	*C. placentula* Ehrenberg var. *placentula*	–	1	–	1	–	1[a]	B	i	alf	β	b
115.	*C. placentula* var. *euglypta* (Ehrenberg) Grunow	1–3[a]	1[a]	1	1–2[a]	1[a]	1[a]	B	i	alf	–	b

116.	*C. placentula* var. *lineata* (Ehrenberg) Van Heurck	–	–	1	–	1	–	B	i	alf	–	b
117.	*C. scutellum* Ehrenberg	–	1	–	–	1–2	1[a]	B	hl	–	–	–
	Naviculales											
	Diadesmidaceae											
118.	*Luticula mutica* (Kützing) D.G. Mann	–	1	–	–	–	1	B	i	i	o-β	a-a
	Amphipleuraceae											
119.	*Frustulia ampipleuroides* (Grunow) A. Cleve-Euler	1	–	–	–	–	1[a]	B	hb	acf	–	a-a
120.	*F. rhomboides* (Ehrenberg) De Toni	1	1[a]	–	–	–	–	B	hb	acf	o-χ	a-a
121.	*F. vulgaris* Thwaits	1–3[a]	1	–	–	–	1	B	hb	alf	o	b
	Neidiaceae											
122.	*Neidium ampliatum* (Ehrenberg) Krammer	1	1	–	–	–	–	B	hb	i	o	k
123.	*N. bisulcatum* (Lagerst.) Cleve	–	–	–	–	–	1	B	hb	i	o-β	b
	Sellaphoraceae											
124.	*Fallacia pygmaea* (Kützing) Stickle	–	1	–	–	–	1	B	mh	alf	α	b
125.	*Sellaphora pupula* (Kützing) D.G. Mann	–	–	–	–	–	1	B	hl	i	o-χ	k
	Pinnulariaceae											
126.	*Caloneis bacillum* (Grunow) Cleve	–	1	–	1	–	–	B-P	i	alf	o	k
127.	*C. molaris* (Grunow) Krammer	1–4[a]	–	–	–	–	–	B	i	i	–	a-a
128.	*C. silicula* (Ehrenberg) Cleve var. *silicula*	1	1	–	–	–	1	B	i	alb	o	k
129.	*C. silicula* var. *truncatula* Grunow	–	–	–	–	1	–	B-P	i	alf	–	k
130.	*Caloneis–Scoliopleura*	–	–	–	–	–	1–3	–	–	–	–	–
131.	*Chamaepinnularia krookii* (Grunow) Lange-Bertalot and Krammer	–	–	–	–	–	1	B	–	–	–	–

(continued)

Table 3. (continued)

№	Algal taxa	Kunashir: Stolbchaty Cape	Kunashir: Alekhin Bay	Kunashir: Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	Ecological–geographical characteristic: B	H	pH	S	G
132.	*Pinnularia acidojaponica* Idei et Kobayasi	1[a]	1–6[a]	1–3[a]	1	1	1	B	–	acf	–	–
133.	*P. acidophila* Hofmann et Krammer	–	1–6	–	1	1	–	B	–	acf	–	–
134.	*P. alpina* W. Smith	–	–	–	–	–	2	B	i	–	–	a–a
135.	*P. borealis* Ehrenberg	1	1	–	–	1	2	B	i	i	χ	a-a
136.	*P. brebissonii* (Kützing) Rabenhorst	–	–	–	–	1	–	B	i	i	α-β	b
137.	*P. major* (Kützing) Rabenhorst	1	–	–	–	–	–	B	i	acf	β	b
138.	*P. microstauron* (Ehrenberg) Cleve	1–2[a]	–	–	–	–	–	B	i	i	o	b
139.	*P. neomajor* Krammer	1	–	–	–	–	–	B	–	acf	o-χ	–
140.	*P. obscura* Krasske	1[a]	1–3	–	–	–	1	B	–	–	–	–
141.	*P. parvulissima* Krammer	–	–	–	–	–	1	B	–	–	–	–
142.	*P. rhombarea* Krammer	1	–	–	–	–	–	B	–	–	–	–
143.	*P. rupestris* Hantzsch	–	–	–	–	–	1	B	–	acf	–	–
144.	*P. stomatophora* (Grunow) Cleve	1	–	–	–	–	–	B	–	–	–	–
145.	*P. subgibba* Krammer var. *undulata* Krammer	1[a]	–	–	–	–	–	B	–	–	o	–
146.	*P. subrupestris* Krammer	–	1	–	–	–	1	B	–	–	–	–
147.	*P. viridiformis* Krammer	1[a]	1	–	–	–	1[a]	B	–	–	–	–
148.	*P. viridiformis* Krammer morphotype 2	–	–	–	–	–	1	B	–	acf	–	–
149.	*P. viridis* (Nitzsch) Ehrenberg	–	1	–	–	–	–	B	i	i	β	b
	Diploneidaceae											
150.	*Diploneis elliptica* (Kützing) Cleve	1–2[a]	1	–	–	–	1	B	i	alf	o	k
151.	*D. interrupta* (Kützing) Cleve	–	–	–	–	–	1–2	B	mh	i	–	k
152.	*D. oblongella* (Naegeli ex Kützing) Ross	–	–	–	–	–	1	B	i	alf	o–α	k

153.	*D. ovalis* (Hilse) Cleve	1[a]	1	–	–	–	1	B	hl	alf	β	b
154.	*D. pseudovalis* Hustedt	–	–	–	–	–	1	B	mh	alf	–	b
155.	*D. smithii* (Brébisson) Cleve var. *smithii*	–	–	–	–	–	1	B	mh	alf	–	k
156.	*D. smithii* var. *rhombica* Mereschk.	–	–	–	–	–	1	B	hl	–	–	–
	Naviculaceae											
157.	*Navicula avenacea* (Brébisson et Godey) Brébisson	1–3[a]	1	1	1	1	–	B	i	acf	β	–
158.	*N. capitata* Ehrenberg	1	1	–	–	1	–	B	hl	alf	β-α	k
159.	*N. capitata* var. *hungarica* (Grunow) R. Ross	1	1	–	1	–	–	B	hl	alf	β	b
160.	*N. cryptocephala* Kützing	1–2[a]	1–2[a]	1	1	1[a]	1[a]	B-P	hl	alf	α	k
161.	*N. cryptotenella* Lange-Bertalot	2–4[a]	1–2[a]	–	1[a]	1	1[a]	B	i	alf	β	k
162.	*N. digitoradiata* (Gregory) Ralfs	–	–	–	–	1	1–4[a]	B	hl	alf	–	k
163.	*N. directa* (W. Smith) Ralfs	–	–	–	–	1[a]	1	B-P	mh	–	–	–
164.	*N. elegans* W. Smith	–	–	–	–	–	1	B	hl	–	–	–
165.	*N. integra* (W. Smith) Ralfs	1–2	1	–	–	–	1	B	mh	i	χ-o	a-a
166.	*N. menisculus* Schumann	1	–	–	–	–	–	B	hl	alf	β-α	k
167.	*N. peregrina* (Ehrenberg) Kützing	–	–	–	–	–	1–2[a]	B	mh	alf	–	k
168.	*N. placentula* (Ehrenberg) Grunow	–	1	–	–	–	–	B	i	alf	β	k
169.	*N. protracta* Grunow	–	–	–	–	–	1	B	hl	i	χ-β	k
170.	*N. radiosa* Kützing	1	–	–	–	1	1	B	i	i	o-β	k
171.	*N. rhynchocephala* Kützing	–	–	–	–	–	1	B	hl	–	β-α	–
172.	*N. salinarum* Grunow	–	–	–	–	–	1	B	mh	–	–	–
173.	*N. slesvicensis* Grunow	1[a]	1[a]	–	–	–	1–2[a]	B	hl	i	β	k
174.	*N. tripunctata* (O.F. Müller) Bory	–	–	–	–	–	1	B	i	i	β	k
175.	*Petroneis marina* (Ralfs) D.G. Mann	–	–	–	–	–	1–2	B	eu	–	–	b
	Cosmioneidaceae											
176.	*Cosmioneis pusilla* (W. Smith) D.G. Mann and Stickle	–	–	–	–	–	1	B	hl	i	o-β	k
	Pleurosigmataceae											

(continued)

Table 3. (continued)

№	Algal taxa	Kunashir: Stolbchaty Cape	Kunashir: Alekhin Bay	Kunashir: Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	Ecological–geographical characteristic: B	H	pH	S	G
177.	*Gyrosigma acuminatum* (Kützing) Rabenhorst	1	–	–	–	–	–	B	i	alb	β	b
178.	*G. attenuatum* (Kützing) Rabenh.	–	–	–	–	–	1	B-P	i	alf	χ	k
	Stauroneidaceae											
179.	*Stauroneis phoenicenteron* (Nitzsch) Ehrenberg	–	–	–	–	–	1	B	i	i	χ-o	k
180.	*Trachyneis aspera* (Ehrenberg) Cleve	–	–	–	–	–	1	B-P	mh	–	–	–
	Thalassiophysales											
	Catenulaceae											
181.	*Amphora copulata* (Kützing) Schoeman et Archibald	–	–	–	–	–	1–2	B	i	alf	–	k
182.	*A. holsatica* Hustedt	–	–	–	–	–	1	B	–	–	β-α	–
183.	*A. normanii* Rabenhorst	1–2[a]	1	–	–	1[a]	1	B	hb	alf	β-α	b
184.	*A. ovalis* (Kützing) Kützing.	1[a]	1	–	–	1[a]	1[a]	B	i	alb	o-β	k
185.	*A. pediculus* (Kützing) Grunow	1–2[a]	–	–	1	–	–	B	i	alb	β	k
186.	*A. veneta* Kützing f. *capitata* E.Y. Haworth	5[a]	1	–	–	–	–	B	i	alb	β	b
	Bacillariales											
	Bacillariaceae											
187.	*Bacillaria paradoxa* Gmelin	–	–	–	–	1	–	P	mh	alb	β	k
188.	*B. socialis* Grunov	–	–	–	–	–	1	B-P	mh	–	–	–
189.	*Denticula kuetzingii* Grunow	1	1	–	–	1	–	B	i	alf	β	b
190.	*Hantzschia amphioxys* (Ehrenberg) Grunow	1	1	–	–	1	1	B	i	alf	α	k
191.	*H. distinctepunctata* (Hustedt) Hustedt	–	2	–	–	–	–	B	i	–	–	k

192.	*H. marina* (Donkin) Cleve in Cleve and Grunov	–	1	–	–	–	–	B	hl	–	–	–
193.	*Neodenticula seminae* (Simonsen and Kanaya) Akiba and Yanagisawa	–	–	–	–	–	1	–	–	–	–	–
194.	*Nitzshia amphibia* Grunow	–	–	–	–	–	1–2	B-P	i	alf	o	k
195.	*N. aurariae* Cholnoky	–	–	–	–	2–6[a]	–	B	i	–	–	k
196.	*N. brevissima* Grunov	1	–	–	–	–	–	B	hl	i	o-β	k
197.	*N. capitellata* Hustedt	2–6[a]	1–6[a]	–	–	–	–	B	i	alb	o	k
198.	*N. communis* Rabenhorst	–	–	–	–	–	1	B-P	i	alf	o	k
199.	*N. compressa* (Bailey) Boyer var. *elongata* (Grunow) Lange-Bertalot	–	–	–	–	–	1	B	hl	–	–	k
200.	*N. dissipata* (Kützing) Grunow	1[a]	1[a]	–	–	1	1[a]	B	i	alf	o-β	b
201.	*N. fonticola* Grunov	1–2[a]	1–2[a]	–	1	1	1	B	i	alf	o	b
202.	*N. frustulum* (Kützing) Grunow	1–3[a]	–	–	–	–	1[a]	B	hl	alb	o	k
203.	*N. linearis* W. Smith	1–2[a]	1[a]	–	–	1	–	B	i	i	o	b
204.	*N. nana* Grunow	2–6[a]	1–4[a]	1[a]	1	1	1–3[a]	B	mh	–	–	b
205.	*N. palea* (Kützing) W. Smith	3–5[a]	1–6[a]	1	2[a]	1	–	B	i	i	α	k
206.	*N. paleacea* (Grunow) Grunow	2[a]	1[a]	1[a]	1[a]	–	–	P	i	alf	o-β	k
207.	*N. pellucida* Grunow	–	–	–	–	1	–	B	hl	–	–	k
208.	*N. recta* Hantsch	1	–	–	–	–	–	B	i	alf	α-β	b
209.	*N. sigma* (Kützing) W. Smith	–	–	–	–	–	1	B	–	–	–	k
210.	*N. thermaloides* Hustedt	–	–	1	–	4[a]	–	–	hl	–	–	–
211.	*N. vermicularis* (Kützing) Hantzsch	–	–	–	–	1	–	B	i	alf	β	k
212.	*Thalassionema nitzschioides* (Grunow) Van Heurck	–	–	–	–	–	1	B-P	–	–	–	–
213.	*Tryblionella apiculata* Gregory	1–6[a]	1	–	–	–	1–5[a]	B	mh	alf	β	k
214.	*T. granulata* (Grunow) D.G. Mann	–	–	–	–	–	1	B-P	–	–	–	–
215.	*T. hungarica* (Grunow) D.G. Mann	–	–	–	–	–	1	B-P	mh	alf	α-β	k
216.	*T. levidensis* W. Smith	–	1	–	–	–	1–2	B	hl	alf	α	b
217.	*T. marginulata* (Grunow) D.G. Mann	1	–	–	–	–	–	–	hl	–	–	–

(continued)

Table 3. (continued)

		Kunashir						Ecological–geographical characteristic				
№	Algal taxa	Stolbchaty Cape	Alekhin Bay	Golovnin Volcano	Shiashkotan	Yankicha	Sakhalin	B	H	pH	S	G
218.	*T. punctata* W. Smith	–	–	–	–	–	1	B	mh	–	–	k
	Rhopalodiales											
	Rhopalodiaceae											
219.	*Epithemia adnata* (Kützing) Brébisson	–	–	–	–	–	1	B	i	alb	β-α	k
220.	*Epithemia adnata* var. *porcellus* (Kützing) R. Ross	1	–	–	–	–	1	B	i	alb	β	k
221.	*E. sorex* Kützing	–	–	–	–	–	1	B	i	alf	o-α	k
222.	*Rhopalodia acuminata* Krammer	1–2[a]	1	–	–	–	1	B	hl	–	–	–
223.	*Rh. gibba* (Ehrenberg) O. Müller	–	–	–	–	–	1	B	i	alb	χ-o	k
224.	*Rh. gibberula* (Ehrenberg) O. Müller	–	–	–	–	–	1	B	mh	i	–	k
225.	*Rh. musculus* (Kützing) O. Müller	–	–	–	–	–	1	B-P	mh	alb	–	k
226.	*Rh. operculata* (Agardh) Hakansson	–	–	–	–	–	1	B	–	–	–	–
227.	*Rh. rupestris* (W. Smith) Krammer	–	1	–	–	–	–	B	–	–	o	a-a
	Surirellales											
	Surirellaceae											
228.	*Surirella angusta* Kützing	1	1	–	–	1	–	B	i	alf	β	k
229.	*S. brebissonii* Krammer et Lange-Bertalot	–	1	–	–	1	–	B	i	i	β	k
230.	*Surirella brebissonii* Krammer et Lange-Bertalot var. *kuetzingii* Krammer et Lange-Bertalot	–	–	–	–	–	2	B	–	–	β-α	–

231.	*S. minuta* Brébisson	1	–	–	–	–	–	B	i	alf	–	b
	Rhaphoneidales											
	Rhaphoneidaceae											
232.	*Delphineis surirella* (Ehrenberg) G. Andrews	–	–	–	–	–	1	–	–	–	–	–

To estimate the frequency of taxa occurrence at the stations, we used the six-point scale: 1 – solitary (one to five cells in the slide); 2 – rare (10–15 cells in the slide); 3 – not infrequent (25–30 cells in the slide); 4 – frequent (one cell in each row of the cover glass at magnification with immersion); 5 – very frequent (several cells under the same conditions); 6 – in bulk (several cells in each visual field under the same conditions) (Korde, 1956)

B (biotope): P – planktonic, B–P – benthic–planktonic, B – benthic, E – epiphytic, B–E – benthic–epiphytic. H (relation to salinity): eu – euhalobic, mh – mesohalobic, hl – halophilous, hb – halophobic, i – indifferent. pH (relation to pH of water): alf – alkaliphilous, alb – alkalibiontic, acf – acidophilous, i – indifferent. S (relation to saprobity of water): χ – xenosaprobous, χ-o – xeno-oligosaprobous, o-χ – oligo-xenosaprobous, χ-β – xeno-betamesosaprobous, o – oligosaprobous, o-β – oligo-betamesosaprobous, β – betamesosaprobous, o-α – oligo-alphamesosaprobous, β-α – beta-alphamesosaprobous, α-β – alpha-betamesosaprobous, α – alphamesosaprobous, ρ – polysaprobous. "–" – data absent. G (geographical distribution): a-a – arctic-alpine, b – boreal, k – cosmopolitan

[a]High guarantee of occurrence of cells in an alive status

and Bacillariophyceae (Table 2). The genera *Navicula*, *Pinnularia*, and *Nitzschia* have a leading place in diatom flora and contain 13, 9, and 8 taxa, respectively.

Diatom communities of periphyton and plankton have similar composition of species, but *Gomphonema angustatum*, *Anomoeoneis sphaerophora*, and *Tryblionella apiculata were* prevalent in periphyton samples and *Achnanthes hungarica* was relatively abundant in the plankton samples. The algal flora of Sakhalin hydrothermal springs is represented by common rheophilic diatoms, indifferent to salinity (e.g., *Hannaea arcus*, *Gomphonema parvulum*, *Didymosphenia geminata*, *Synedra ulna*, *Encyonema silesiacum*, *Planothidium lanceolatum*), but the number of maritime and brackish taxa is considerable (Table 3).

4. General Observations and Conclusions

Ten Sakhalin and Kuril Islands hot springs and reservoirs were investigated and 232 species, varieties, and forms of diatoms were discovered in them. Diatoms *Synedra ulna*, *Achnanthes hungarica*, *Planothidium lanceolatum*, *Rhoicosphenia abbreviata*, *Gomphonema angustatum*, *G. parvulum*, *Navicula slesvicensis*, *Pinnularia acidophila*, *P. acidojaponica*, *Anomoeoneis sphaerophora*, *Nitzschia capitellata*, *N. nana*, *N. palea*, and *Tryblionella apiculata* were dominant or more abundant in communities in different sampling sites with temperature from 24°C to 71°C.

Diatom communities investigated springs and reservoirs included from 23 (25) to 101 species (107 intraspecific taxa) (Table 3). The largest number of taxa is recorded for diatom communities in springs and reservoirs with water temperature from 37°C to 60°C (75–107 taxa). Hot springs with temperature above or below this interval had less number of taxa – from 25 to 59. Algal taxa with high guarantee of occurrence of cells in an alive status were recorded. An alive alga accounted a third part from all compositions of hot springs algal flora and represents 77 species, varieties, and forms (Table 3), and all frequent and bulk algae were composed in this number.

Kamchatka Peninsula is located geographically close to the Kuril and Sakhalin Islands, and also has a many hot springs. The algal flora of Kamchatka hot springs was investigated over a 100 years, by many authors: Schmidt, 1875–1959, 1885; Gutwinski, 1891; Cleve, 1894–1895; Elenkin, 1914; Petersen, 1946. Results of recent studies of diatoms from Kamtschatka hot springs described in the paper of Japanese and Russian authors (Yoshitake et al., 2008). Yoshitake with coauthors investigated algal flora of five hot springs from Kamchatka with water temperature from 18.0°C to 71.5°C and recorded 39 alive intraspecific taxa. Seven of them are dominant in the spring's algal communities: *Achnantes exigua*, *Amphora veneta*, *Caloneis bacillum*, *Neidium ampliatum*, *Nitzschia amphibia*, *N. frustulum*, and *Pinnularia marchica* Ilka Schönfelder.

Hot springs algal floras of Kamchatka and Kuril alongwith the Sakhalin Islands have great number of common species, but different dominants or more abundant in communities species. There were alive diatoms in common with hot

Table 4. Distribution of hot springs algae of Kuril and Sakhalin Islands into ecological and geographical groups.

	Kuril Islands		Sakhalin	
Ecological–geographical group	**Number of taxa**	**Percent**	**Number of taxa**	**Percent**
Biotop				
Benthic	131	80.9	99	72.3
Planktonic	7	4.3	8	5.8
Benthic–planktonic	17	10.5	17	12.4
Epiphytic	1	0.6	1	0.7
Benthic–epiphytic	2	1.2	2	1.5
No data	4	2.5	10	7.3
Total	162	100	137	100
Relation to salinity of water				
Euhalobic	–	–	1	0.7
Mesohalobic	12	7.4	25	18.3
Halophilic	23	14.2	20	14.6
Indifferent	88	54.3	54	39.4
Halophobic	17	10.5	8	5.8
No data	22	13.6	29	21.2
Total	162	100	137	100
Relation to pH of water				
Alkalibiontic	11	6.8	11	8.0
Acidophilous	18	11.1	50	36.5
Indifferent	27	16.7	23	16.8
Acidophilous	71	43.8	9	6.6
No data	35	21.6	44	32.1
Total	162	100	137	100
Relation to saprobity of water				
Xenosaprobous (χ, χ-o, o-χ)	21	13.0	11	8.0
Oligosaprobous (χ-β, o, o-β)	39	24.1	26	19.0
Beta-mesosaprobous (β-o, o-α, β, β-α)	44	27.2	35	25.6
Alphamesosaprobous (α-β, β-ρ, α, α-ρ)	9	5.5	8	5.8
Polysaprobous (ρ–α, ρ)	–	–	1	0.7
No data	49	30.2	56	40.9
Total	162	100	137	100
Geographical distribution				
Cosmopolitan	66	40.7	60	43.8
Boreal	43	26.5	27	19.7
Arctic-alpine	20	12.4	11	8.0
No data	33	20.4	39	28.5
Total	162	100	137	100

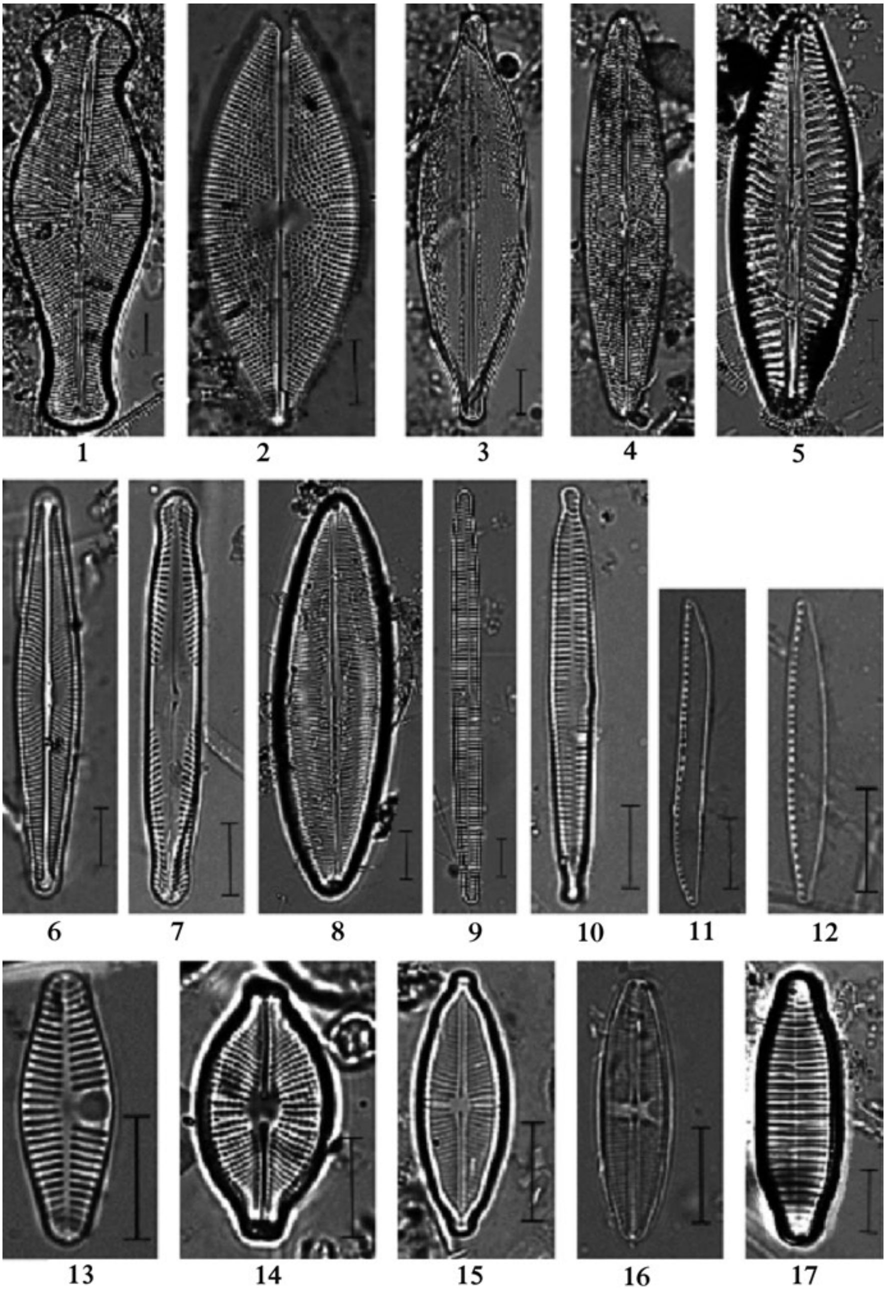
springs from Kamchatka, Kuril, and Sakhalin Islands: *Melosira varians*, *Hannaea arcus* var. *linearis* f. *recta*, *Diatoma mesodon*, *Eunotia bilunaris*, *Rhoicosphenia abbreviata*, *Encyonema silesiacum*, *Gomphonema parvulum*, *Achnanthes lanceolata*, *Cocconeis placentula*, *Frustulia rhomboides*, *Navicula cryptocephala*, *Nitzshia frustulum*, *N. nana*, and *N. palea.* It should be noted that all these species are typical representatives of coldwater springs, rivers, and lakes of Kuril and Sakhalin Islands (Nikulina, 2002, 2004, 2005, 2008).

Our research results indicate that with rise in temperature of water of reservoirs above 70°C, the diatom species composition becomes impoverished. However, a few species remain in the elevated temperatures and actively develop and even form masses. Bascially, it would appear that the vegetation of thermal springs consists of algae of cold waters which have adapted to high temperatures. Diatoms such as *Pinnularia acidojaponica*, *P. acidophila*, and *Nitzschia thermaloides* are true thermophilic species or characteristic representatives of hot waters. They were not registered in Kuril and Sakhalin rivers and streams with cold water.

The diatom flora analysis of the thermal springs from these three Kuril Islands has shown that information on algae being confined to particular habitats is known for 158 taxa or 97.5% of the general number of species, varieties, and forms recorded in the studied area. Most of the algae present are benthic and benthic–planktonic species, i.e., 80.9% and 10.5%, respectively (Table 4). Data on salinity preferences are known for 140 species, varieties, and forms (86.4% of the general number) of algae. The algae indifferent to salinity changes (they comprise 54.3%) and halophilic (13.3% of the total number of taxa) are the most numerous groups (Table 4). Data on pH preferences are known for 78.4% of species, varieties, and forms of algae recorded here, among those alkaliphilic species prevail (43.8%). Indicators of water saprobity are known for 113 taxa of algae or 69.8% of the general number of taxa in the algal flora of the studied area. Oligosaprobous and betamesosaprobous are the most abundant groups; they comprise 24.0% and 27.2%, respectively, of the taxa present. The share of the rest of the known saprobic groups makes up 18.5% (Table 4). Geographical distribution is known for 129 species, varieties, and forms, which comprises 79.6% of general number of algae. The share of widely distributed or cosmopolitan species is 40.7%, boreal 24.4%, and arctic-alpine 12.4% (Table 4).

Sakhalin hot springs diatom flora is characterized by prevalent benthic, indifferent to salinity, acidophilous and betamesosaprobous species (Figs. 1–17).

Figures 1–17. Figure 1 *Didymosphenia geminata* (Lyngbye) M. Schmidt. Figure 2. *Petroneis marina* (Ralfs) D.G. Mann. Figure 3. *Anomoeoneis sphaerophora* (Ehrenberg) Pfitzer. Figure 4. *Trachyneis aspera* (Ehrenberg) Cleve. Figure 5. *Pinnularia alpina* W. Smith. Figure 6. *Navicula avenacea* (Brébisson et Godey) Brébisson. Figure 7. *Pinnularia acidojaponica* Idei et Kobayasi. Figure 8. *Scolioneis* sp. or *Caloneis* sp. Figure 9. *Synedra ulna* (Nitzsch) Ehrenberg. Figure 10. *Hannaea arcus* var. *linearis* f. *recta* (Cleve) Foged. Figure 11. *Nitzcshia nana* Grunow. Figure 12. *N. palea* (Kützing) W. Smith. Figure 13. *Achnanthes lanceolata* Brébisson ex Kützing. Figure 14. *Cosmioneis pusilla* (W. Smith) D.G. Mann & Stickle. Figure 15. *Navicula integra* (W. Smith) Ralfs. Figure 16. *Achnanthes hungarica* Grunow. Figure 17. *Diatoma vulgare* Bory. Scale bars = 10 μm.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6. References

Anderson, C.A. (1935) Alteration of the lavas surrounding the hot springs in Lassen Volcanic National Park. J. Mineralog. Soc. Am. **20**: 240–252.

Arnheim, N., White, T. and Rainey, W. (1990) Application of PCR: organismal and population biology. BioScience **4**: 174–182.

Barns, S.M., Fundyga, R.E., Jeffries, M.W. and Pace, N.R. (1994) Remarkable archaeal diversity detected in a Yellowstone National Park hot spring environment. Proc. Natl. Acad. Sci. USA **91**(5): 1609–1613.

Barns, S. M., Delwiche, C.F., Palmer, J.D. and Pace, N.R. (1996) Perspectives on archaeal diversity, thermophily and monophyly from environmental rRNA sequences. Proc Natl Acad Sci USA **93**: 9188–9193.

Beljakova, R.N. (2000a) Synopsis of the benthic Cyanophyta flora of the Russian Far Eastern seas. 2. Chroococcales (Entophysalidaceae, Dermocarpellaceae, Xenococcaceae, Hydrococcaceae). Bot. J. **85**(11): 87–98 (in Russian).

Beljakova, R.N. (2000b) Synopsis of the benthic Cyanophyta flora of the Russian Far Eastern seas. 3. Oscillatoriales. Bot. J. **85**(12): 60–77 (in Russian).

Beljakova, R.N. (2001) Cyanophyta sinus Kraternaja (Insulae Kurilenses). Syst. plant. non vascular. **35**: 8–12 (in Russian).

Biebl, R. and Kusel-Fetzmann, E. (1966) Beobachtungen über das Vorkommen von Algen an Thermalstandorten auf Island. Österr. Bot. Z. **113**: 408–423.

Bilý, J. (1934) Píšбanské rozsivky (Additamentum ad floram Bacillariearum in thermis Píšбany crescentium.). Práce Mor. pбrodov. Spoleб Brno **9**(1): 1–17.

Brock, T.D. and Brock, M.L. (1967) The hot springs of the Furnas valley, Azores. Int. Rev. Gesamten Hydrobiol. **52**: 545–558.

Cassie, V. (1989) A contribution to the study of New Zealand diatoms. Bibl. Diatomol. **17**: 1–226.

Cassie, V. and Cooper, R.C. (1989) Algae of New Zealand thermal areas. Bibl. Phycol. **78**: 1–261.

Cleve, P.T. (1894–1895) Synopsis of the naviculoid diatoms. Kgl. Svensk. Vet. Acad. Handl. **26** (2), **27** (2). Kungliga Svenska vetenskapsakademien. Handlingar. Bandet 26, no. 2 – Vol. 1; Bandet 27, no. 3 – Vol. 2.

Compère P. and Delmotte A. (1988) Diatoms in two hot springs in Zambia (Central Africa), In: F.E. Round (ed.) *Proceedings of the Ninth International Diatom Symposium*. Biopress Ltd., Bristol, pp. 29–39.

Corda, A.J.C. (1840) Observations microscopiques sur les animalcules des eaux thermales de Carlsbad. Alm. Carlsbad (Prague) **10**: 186–221.
Dell'Uomo, A. (1986) Diatoms and other algae from the thermal-sulphur springs of Triponzo (Central Italy). Arch. Hydrobiol. Supplementband. Monographische Beiträge **73**: 79–91.
DeNicola, D. (2000) A review of diatoms found in highly acidic environments. Hydrobiologia **433**: 111–122.
Dor, I. (1974) Considerations about the composition of benthic algal flora in Lake Kinneret. Hydrobioogia **44**(2–3): 255–264.
Elenkin, A.A. (1914) Die Süsswasseralgen Kamtschatka's. Expédition Kamtschatka, organisée par Th.P. Riabouchinsky. Libre 2. Planetes cryptogams de Kamtschatka, Moscou. 402 pp.
Emoto, Y. and Yoneda, Y. (1942) Bacteria and algae of the hot springs in Toyama Prefecture. Acta Phytotax. Geobotanica. **11**(1): 7–26 (in Japanese).
Fairchild, E. and Sheridan, R.P. (1974) A physiological investigation of the hot spring diatom, *Achnanthes exigua* Grun. J. Phycol. **10**: 1–4.
Famin, M.A. (1933a) Action de la temperature sur les végétaux. Rev. Gen. Botanique **45**: 574–595.
Famin, M.A. (1933b) Action de la temperature sur les végétaux. Rev. Gen. Botanique **45**: 655–682.
Fukushima, H., Kobayashi, T. and Yoshitake, S. (2002) *Navicula tanakae* Fukush., Ts. Kobay. & Yoshit. nov. sp., new diatom taxon from hot spring. Diatom **18**: 13–21.
Gonzalves, E. (1947) The algal flora of the hot springs of Vajreswari near Bombay. Y. Univ. Bombay **16**: 22–27.
Gromov, B.V., Nikitina, V.H. and Mamkayeva, K.A. (1991) *Ochromonas vulcania* sp. nov. (Chrysophyceae) from the acidic spring on the Kunashir Island (Kurile Islands). Algologia **1**(2): 76–79 (in Russian).
Gutwinski, R. (1891) Algarum e lacu Baykal et e peninsula Kamtschatka a class, prof. Dr. B. Dybowski anno 1877 reportatam enumeratio. Nuova. Notarisia, 2, 300 pp.
Hobbs, W.O., Wolfe, A.P. Inskeep, W.P., Amskold, L. and Konhauser, K.O. (2009) Epipelic diatoms from an extreme acid environment: Beowulf Spring, Yellowstone National Park, USA. Nova Hedwig. Beih. **135**: 71–83.
Hustedt, F. (1937–1938) Systematische Untersuchungen über die Diatomeenflora vo Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. **15**: 131–506; **16**: 1–155; 639–790.
Hustedt, F. (1953) La flora de Diatomeas en Paredones Sobrehumedecidos en El Salvador. Comunicaciones del Instituto Tropical de Investigaciones Científicas de la Universidad de El Salvador, San Salvador. **2**(5–6): 129–138.
Kaczmarska, I. and Rushforth, S.R. (1983) The diatom flora of Blue Lake Warm Spring, Utah, USA Bibl. Diatomol. **2**: 1–123.
Karpunin, A.M., Mamonov, S.V., Mironenko, O.A. and Sokolov A.R. (1998) *Geological Nature Sanctuaries of Russia*. Lorien, Moscow, pp. 184–185 (in Russian).
Kobayashi, T. (1957a) Diatom vegetation of Izu Katase, Yatsu and Yugashima spas. Bot. Mag. Tokyo **70**: 69–74.
Kobayahsi, T. (1957b) Diatom vegetation of Shiobara spas. Bot. Mag. Tokyo **70**: 232–237.
Kociolek, J.P. and Spaulding, S.A. 2000. Freshwater diatom biogeography. Nova Hedwig. **71**: 223–241.
Korde, N.V. (1956) Survey procedure of biological study of bottom sediments, In: E.N. Pavlovsky and V.I. Zhadin (eds.) *The life of fresh waters of the USSR*. Publishing house of Academy Sciences of the USSR. Moscow, Leningrad, **4**(1): 383–413 (In Russian).
Krasske, G. (1938) Beiträge zur Kenntnis der Diatomeen-Vegetation von Island und Spitzbergen. Arch. Hydrobiol. **33**: 503–533.
Mann, J.E. and Schlichting, H.E. (1967) Benthic algae of selected thermal springs in Yellowstone National Park. Trans. Am. Microsc. Soc. **86**: 2–9.
Markhinin, E.K. and Stratula, D.S. (1977) Hydrothermaes of Kuril Islands. Nauka, Moscow: 212 (in Russian).

Molisch, H. (1926) *Pflanzenbiologie in Japan. Die Lebwelt in den heissen Quellen Japans*. Gustav Fisher, Jena, pp. 63–109.

Mpawenayo, B. and Mathooko, J.M. (2004) Diatom assemblages in the hot springs associated with Lakes Elmenteita and Baringo in Kenya. Afr. J. Ecol. **42**: 363–367.

Mpawenayo, B. Cocquyt, C. and Nindorera, A. (2005) Diatoms (Bacillariophyta) and other algae from the hot springs of Burundi (Central Africa) in relation with the physical and chemical characteristics of the water. Belg. J. Bot. **138**: 152–164.

Nikitina, V.N. (2005) Bluegreen algae (cyanobacteria) of nature thermal biotopes. Publishing house of Sankt-Petersburg University, St. Petersburg (in Russian).

Nikulina, T.V. (2002) The freshwater algal flora, In: S.Yu. Storozhenko (ed.) *Flora and Fauna of Kuril Islands (Material of International Kuril Island Project)*. Dalnauka, Vladivostok, pp. 21–34 (in Russian).

Nikulina, T.V. (2004) List of algae of inland reservoirs of Onekotan (Kuril Islands, Russia), In: P.V. Ivashov (ed.) *Biogeochemical and Hydroecological Research of Technogenic Ecosystems*. Dalnauka, Vladivostok, pp. 193–205 (in Russian).

Nikulina, T.V. (2005) Diatom algae (Bacillariophyta) from the south part of Sakhalin Island, In: S.Yu. Storozhenko (ed.) *Flora and fauna of Sakhalin Island (Materials of International Sakhalin Island Project)* **2**. Dalnauka, Vladivostok: pp. 8–20 (in Russian).

Nikulina, T.V. (2007) Algae of hot springs of "Kurilskiy" reserve, In: V.M. Starchenko (ed.) *Proceedings of VIII Far Eastern Conference on Nature Reserves Management and Studies.* BSPU, Blagoveshchensk, pp. 240–242 (in Russian).

Nikulina, T.V. (2008) Diatom algae of Atlasova Island (Kuril Islands, Russia), In: E.A. Makarchenko (ed.) *Vladimir Ya. Levanidov's Biennial Memorial Meetings*, vol. **4**, pp. 122–129. Dalnauka, Vladivostok (in Russian).

Owen, R.B., Renaut, R.W., and Jones, B. (2008) Geothermal diatoms: a comparative study of floras in hot springs systems of Iceland, New Zealand, and Kenya. Hydrobiologia **610**: 175–192.

Petersen, J.B. (1946) Algae collected by Eric Hultén on the Swedish Kamtschatka Expedition 1920–22, Especially from hot springs. Det Kgl. Danske Videnskabernes Selskab, Biologiske Meddelelser, **20**(1): 120 pp.

Schmidt, A.D. (1875–1959) Atlas der Diatmaceenkunde. Heft 120 pp., Tafeln 460 pp., Aschersleben-Leipzig.

Schmidt, C. (1885) *Hydrologische Untersuchungen XLIV, Thermalwässer Kamtschatka*. Memoiré de lé Academié imperiare des Sciences, St. Petersbourg.

Schoeman, F.R. and Archibald, R.E.M. (1988) Taxonomic notes on the diatoms (Bacillariophyceae) of the Gross Barmen thermal springs in South West Africa/Namibia. S. Afr. J. Bot. **54**: 221–256.

Sentsova, O.Ju. (1991) On the diversity of acido-thermophilic unicellular algaeof the genus Galdieria (Rhodophyta, Cyanidiophyceae). Bot. J. **76**(1): 69–79 (in Russian).

Sprenger E. (1930) *Bacillariales* aus den Thermen und der Umgebung von Karlsbad. Arch. Protistenkd. **71**: 502–542.

Stockner, J.G. (1967) Observations of thermophilic algal communities in Mount Rainier and Yellowstone National Parks. Limnol. Oceanogr. **12**: 13–17.

Stockner, J.G. (1968) The ecology of a diatom community in a thermal stream. Br. Phycol. Bull. **3**: 501–514.

Swift E. (1967) Cleaning diatoms frustules with ultraviolet radiation and peroxide. Phycologia **6**: 161–163.

Tereshkova, G.M., Yan, N.A., Kovrov, B.G. and Shtol, A.A. (1973) Characteristics of bluegreen algae from Island Kunashir hydrothermaes, In: N.S. Pechurkin, V.N. Belyanin and N. Shavkun (eds.) *Control for Biosynthesis of Microorganisms*. Kirensky Institute of Physics, Krasnoyarsk, pp. 164–165 (in Russian).

Thomas, J. and Gonzalves, E. A. (1965a) Thermal algae of Western India. I. Algae of the hot springs at Akloli and Ganeshpuri. Hydrobiologia **25**(3–4): 330–340.

Thomas, J. and Gonzalves, E. A. (1965b) Thermal algae of Western India. II. Algae of the hot springs at Palli. Hydrobiologia **25**(3–4): 340–351.

Thomas, J. and Gonzalves, E.A. (1965c) Thermal algae of Western India. III. Algae of the hot springs at Sav. Hydrobiologia **26**(1–2): 21–28.

Thomas, J. and Gonzalves, E.A. (1965d) Thermal algae of Western India. IV. Algae of the hot springs at Aravali, Tooral and Rajewadi. Hydrobiolcgia **26**(1–2): 29–40.

Thomas, J. and Gonzalves, E.A. (1965f) Thermal algae of Western India, VI. Algae of the hot springs at Unai, Lasundra and Unapdeo. Hydrobiologia **26**(1–2): 55–65.

Villeneuve, V. and Pienitz, R. (1998) Composition Diatomfere de quatre sources thermals au Canada, en Islande et au Japan. Diatom Res. 13: 149-175.

Vyverman, W., Verleyen, E., Sabbe, K., Vanhoutte, K., Sterken, M., Hodgson, D.A., Mann, D.G., Juggins, S., Van de Vijver, B., Jones, V., Flower, R., Roberts, D., Chepurnov, V., Kilroy, C., Vanormelingen, P. and De Wever, A. (2007) Historical processes constrain patterns in global diatom diversity. Ecology **88**: 1924–1931.

Watson, J.D., Gilman, M., Witkowski, J. and Zoller, M. (1992) *Recombinant DNA*. Scientific American Books, New York.

Yoneda, Y. (1962) Studies on the thermal algae of Hokkaido. Acta Phytotax. Geobot. **20**: 308–313.

Yoshitake, S., Fukushima, H. and Lepskaya, E.V. (2008) The diatom flora of some hot springs in Kamchatka, Russia, In: Y. Likhoshway (ed.) *Proceedings of the Nineteenth International Diatom Symposium*. Biopress Ltd., Bristol, pp. 151–168.

Zharkov, R.V. (2008) Daginskoe deposit of thermomineral waters in the north of Sakhalin Island, In: O.N. Likhacheva (ed.) *Proceedings of II Sakhalin Scientific School of Young*. Natural accidents: studying, monitoring, the forecast. Institute of Marine Geology and Geophysics, Yuzhno-Sakhalinsk, pp. 285–290 (in Russian).

Zharkov, R.V. and Poberezhnaya, T.M. (2008) Thermal waters show of Mendeleev Volcano and their landscape-geochemical features (Kunashir Island, Kuriles), In: N.G. Razzhigaeva and L.A. Ganzey (eds.) *Climatic Changes, Natural Catastrophes and Landscape Development of South Far East at Pleistocene-Holocene*. Dalnauka, Vladivostok, pp. 46–54 (in Russian).