

Okanagan Lake (Kelowna) Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from EMS site #0500236 on Okanagan Lake during 2021 and 2022 (Figure 1; Table 1). Algae were identified to the taxonomic level of species and grouped into broad alga types for analysis.

Table 1: Sample sites and dates sampled in 2021 and 2022

Sample Site (EMS#)	Dates
OKANAGAN L D/S KELOWNA STP (DEEP) (0500236)	2021-03-09
	2021-09-08
	2022-03-08
	2022-04-12
	2022-05-17
	2022-06-15
	2022-07-13
	2022-08-16
	2022-09-07
Total= 9 samples	

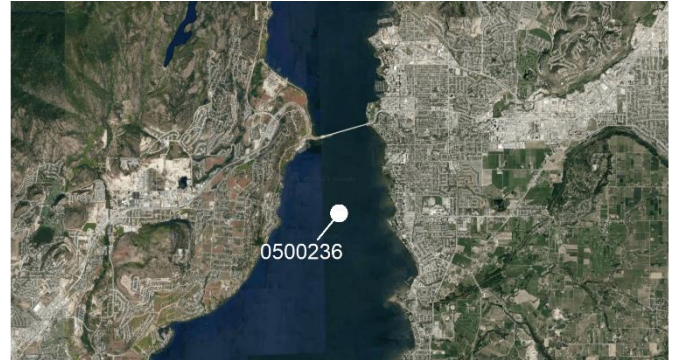


Figure 1: Aerial view of EMS site 0500236 on Okanagan Lake

Samples demonstrated seasonal patterns with elevated diatoms in the spring and elevated cyanobacteria in the summer.

Diatom concentrations were slightly elevated from March to June compared to July, August, and September. Spring blooms of diatoms are common and reflective of increased temperatures, light penetration, and silica in the water following ice thaw (Kong et al., 2021). Diatoms increase the resiliency and health of water systems through their ability to bloom in early spring, reduce nutrient levels, and prevent monoculture blooms of less desirable algae (Jrobyn, 2019). EMS site 0500236 collected on 2022-03-09 demonstrated diatom degradation indicative of lowering silica levels in the late spring (Figure 2).

Samples collected in August and September contained elevated concentrations of cyanobacteria compared to samples collected from March to July.

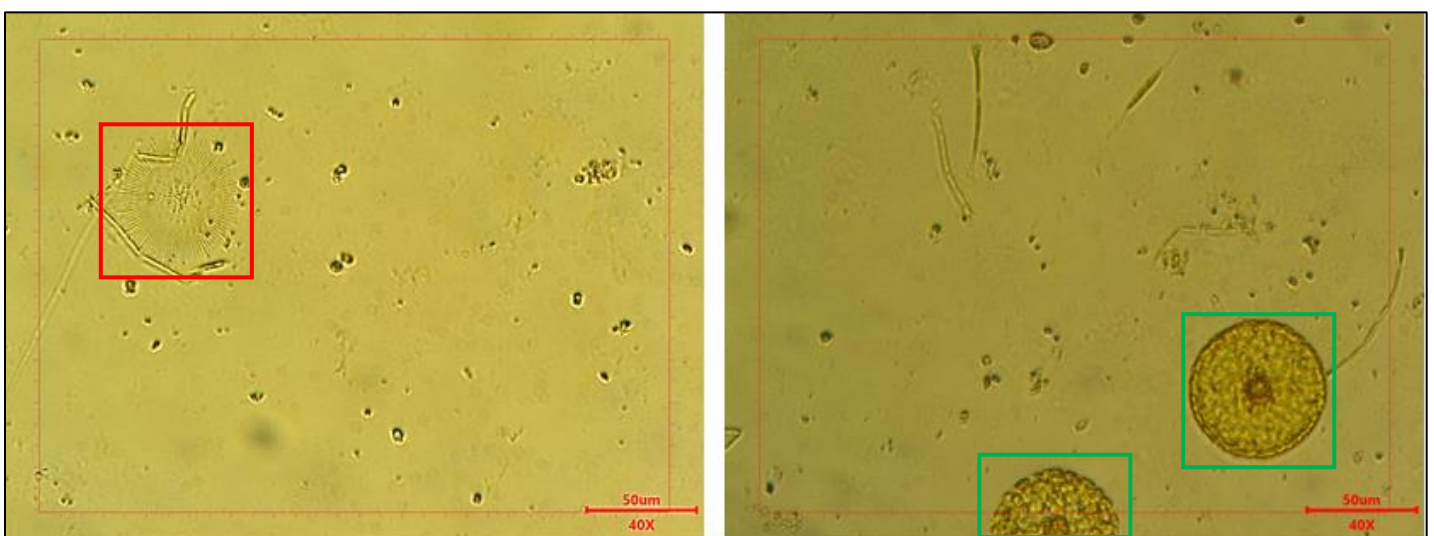


Figure 2: 400x magnification of EMS site 0500236 collected on 2022-03-09 demonstrating degraded *Stephanodiscus niagarae* diatoms. Red boxes in the right frame contain *Stephanodiscus niagarae* without silica shells, the green box in the left frame contains a detached silica shell

Overview (continued)

Small quantities of the diatom *Melosira undulata* were identified in Okanagan Lake. Despite low numbers, this diatom represented 27% of biovolumes because of its large size relative to other algae (Figure 3; Figure 4).

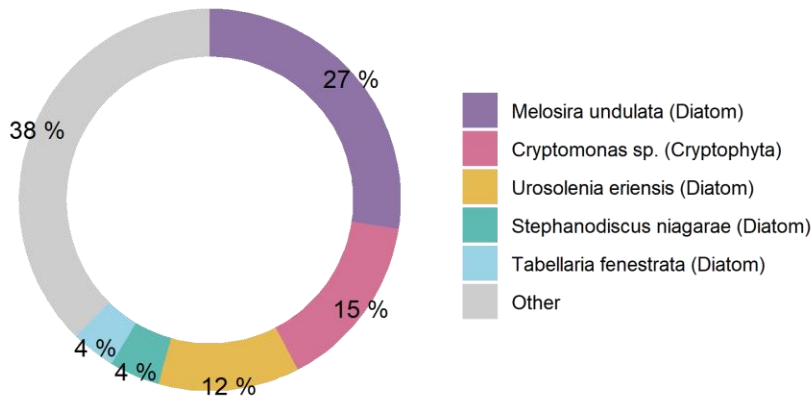


Figure 3: Dominant organisms from Okanagan Lake (Site 0500236) as percent of total biovolume

Samples collected in spring 2021 contained elevated densities of Cryptophyta (genus *Cryptomonas*; Figure 3). Cryptomonads are favored elements of freshwater food chains and are selectively consumed by several zooplankton, ciliates, and dinoflagellates (Wehr et al., 2015).

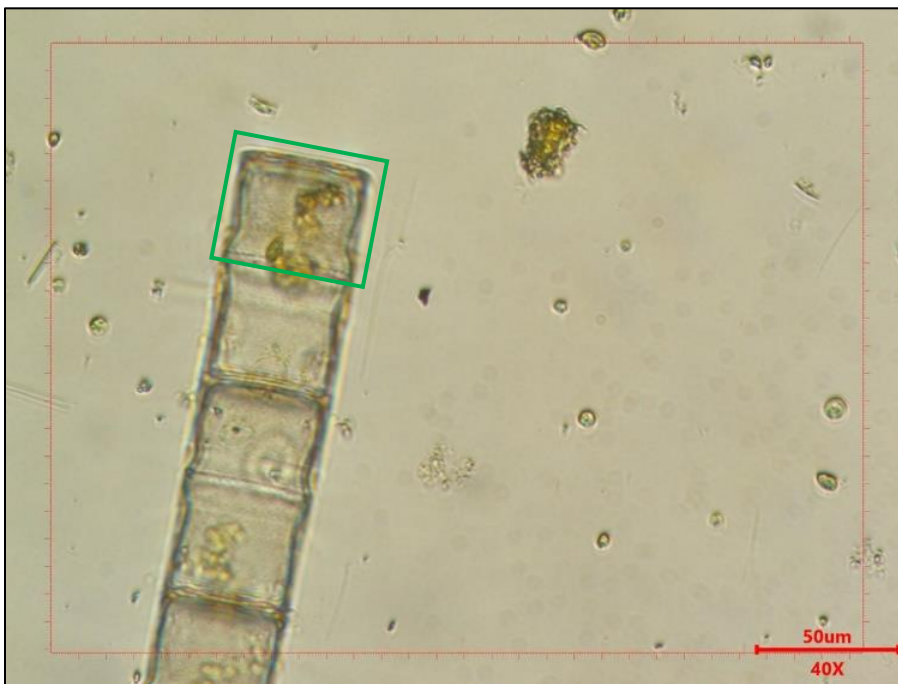


Figure 4: 400x magnification of EMS site 0500236 collected on 2022-04-12 demonstrating the size of one *Melosira undulata* cell (green box)

Algae – why should we care?

Algae blooms are becoming more frequent and severe worldwide due to excessive nutrient loading and warming summer lake temperatures. Diatom blooms can cause filter clogging, and odor issues.

Intense cyanobacteria blooms can threaten human safety and aquatic health through their toxicity. Illness related to cyanotoxins can include liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues. Cyanotoxins, including microcystins, are now known to accumulate in the food chain (Lance et al., 2014). Fish from lakes with heavy cyanobacteria blooms can have higher toxin concentrations than the lake water (Greer et al. 2021) and consuming them can increase the risk of liver disease (Zhao et al., 2020).

Cyanobacterial Presence

Summer samples contained elevated densities of cyanobacteria. *Planktolyngbya* was the dominant genus counted, *Anacystis* and *Anathece* were also frequently encountered.

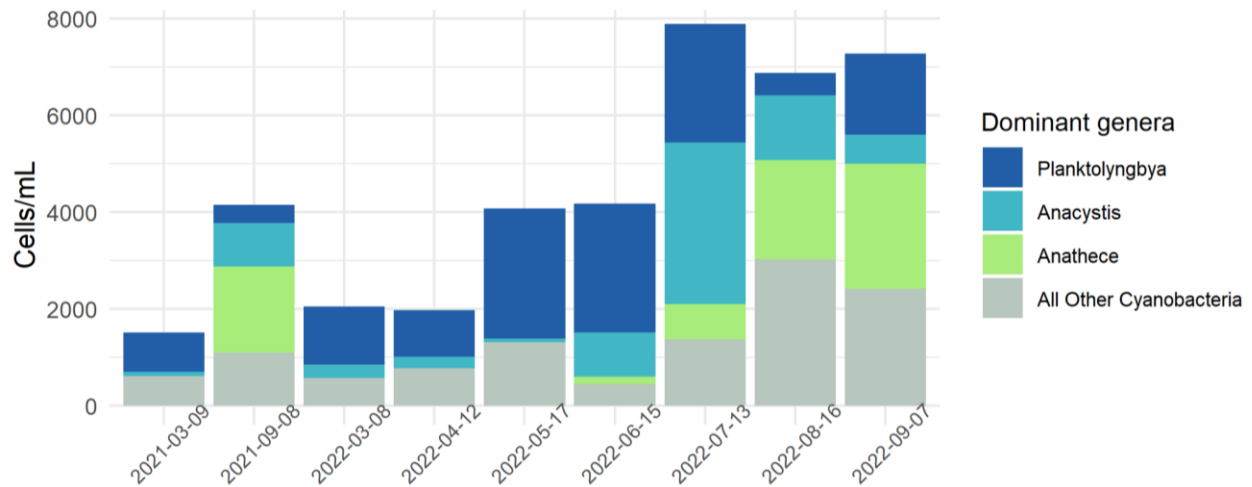


Figure 5: cell abundance for dominant cyanobacteria genera on Okanagan Lake (Kelowna)

Dominant cyanobacteria identified in the summer samples are also associated with several cyanotoxins that represent risks to public health (Table 2). Illness related to cyanotoxins can include liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues (Lance et al., 2014).

Table 2: Dominant genera of cyanobacteria on Okanagan Lake (Kelowna) and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
<i>Anathece</i>	2580	No toxins identified
<i>Anacystis</i>	2277	Lyngbyatoxin.LYN, Lipopolysaccharide.LPS, Microcystin.MC, Nodularins.NOD, Anatoxins...a..ATX, BMAA, Cyanopeptolins..CPL, Anabaenopeptins.APT
<i>Planktolyngbya</i>	2004	Lyngbyatoxin.LYN, Microcystin.MC, BMAA

Note: * = counted in samples

Cyanobacterial Presence (Continued)

Dominant species of cyanobacteria found in Okanagan Lake (Kelowna) are capable of producing cyanotoxins (Table 2).

Okanagan Lake (Kelowna) displayed cyanobacteria levels in the negligible to low-risk category, with a mean cyanobacteria abundance of 4,441 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Okanagan Lake (Kelowna) compared to alert levels defined by several authorities including the WHO and EPA.

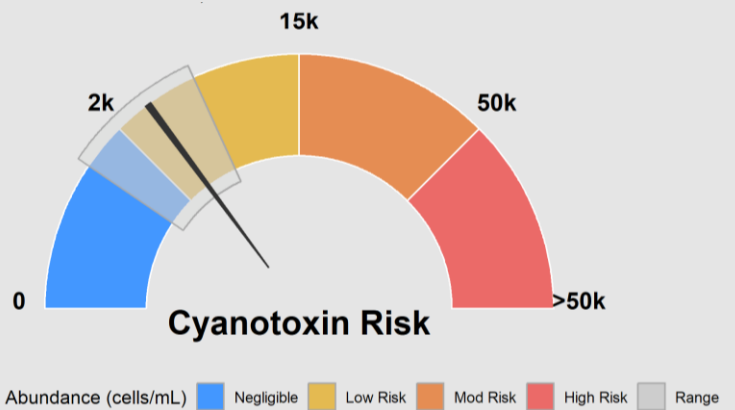


Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Okanagan Lake (Kelowna)

Cyanobacteria frequently dominate algal communities in total cell count, but because of their small cell size their biovolume is usually low relative to the other types of algae present. This is highlighted in Figure 7 where a *Asterionella* (diatom), *Mallomonas* (Chrysophyta), and *Dinobryon* (Chrysophyta) dwarf an adjacent *Anacystis* (cyanobacteria) cell.



Figure 7: Size comparison of an *Asterionella* (red box), *Mallomonas* (yellow box), *Dinobryon* (orange box), and *Anacystis* (blue circle) cell

Species Composition

Algae samples were identified to the species level and grouped into broad algae types for analysis. The figures below display the total cell counts for each broad algae group alongside the biovolume represented by each of these groups. The difference between Figure 8 (cell abundance) and Figure 9 (biovolume) illuminates the difference between cell abundance and biovolume.

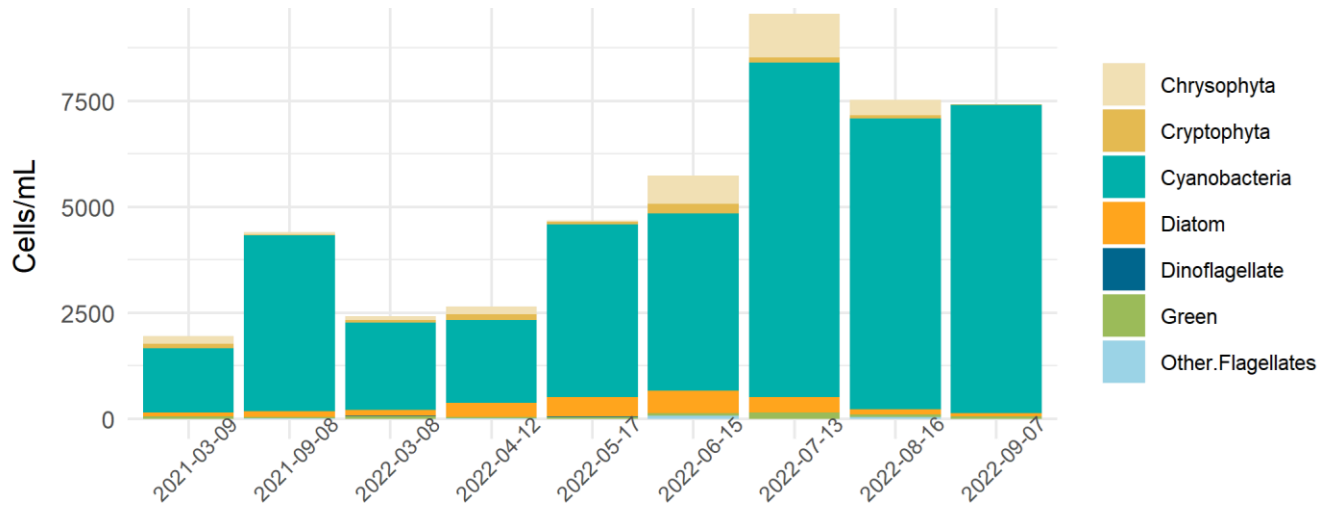


Figure 8: Cell abundance of high-level taxa groups on Okanagan Lake (Kelowna)

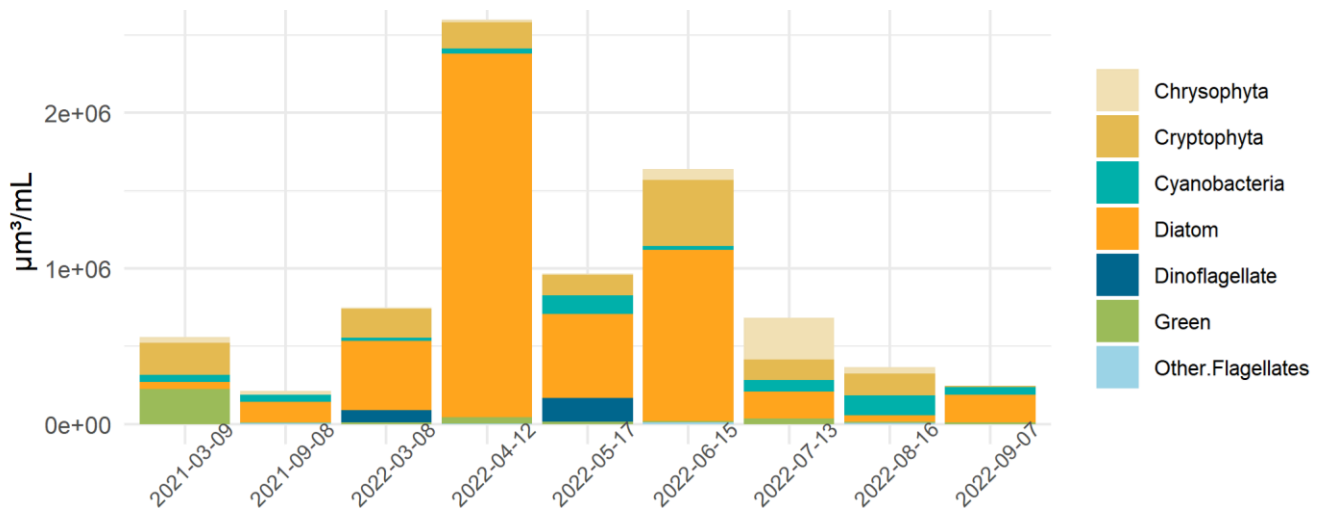


Figure 9: Biovolume of high-level taxa groups on Okanagan Lake (Kelowna)

References

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- Kong, X., Seewald, M., Dadi, T., Friese, K., Mi, C., Boehrer, B., Schultze, M., Rinke, K., & Shatwell, T. (2021). Unravelling winter diatom blooms in temperate lakes using high frequency data and ecological modeling. *Water Research*, 190, 116681. <https://doi.org/10.1016/J.WATRES.2020.116681>
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- Zhao, Y., Yan, Y., Xie, L., Wang, L., He, Y., Wan, X., & Xue, Q. (2020). Long-term environmental exposure to microcystins increases the risk of nonalcoholic fatty liver disease in humans: A combined fisher-based investigation and murine model study. *Environment International*, 138, 105648. <https://doi.org/10.1016/J.ENVINT.2020.105648>

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Appendix

Additional figures and raw data are listed below:

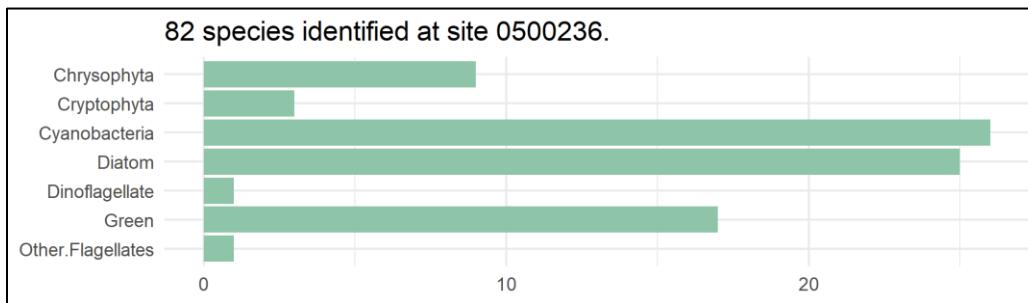


Figure 10: Unique species observed in Okanagan Lake (Kelowna) sorted into higher level taxa

Table 3: Raw data from 2022 Samples

Report.Name	High.Level.Taxa	ITIS Genus Number	Date.Sampled	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)
Aulacoseira ambigua	Diatom	590863	2022-03-08	106	91577
Aulacoseira granulata	Diatom	590863	2022-03-08	30	7363
Stephanodiscus niagarae	Diatom	2415	2022-03-08	8	343612
Ankistrodesmus falcatus	Green	5877	2022-03-08	15	5460
Chlorella vulgaris	Green	5811	2022-03-08	8	905
Elakatothrix gelatinosa	Green	9412	2022-03-08	15	1268
Oocystis sp.	Green	5827	2022-03-08	15	628
Schroederia setigera	Green	NA	2022-03-08	8	2262
Anacystis cyanea	Cyanobacteria	609	2022-03-08	266	470
Gloeothece rupestris	Cyanobacteria	703	2022-03-08	15	414
Planktolyngbya sp.	Cyanobacteria	NA	2022-03-08	660	4147
Planktolyngbya limnetica	Cyanobacteria	NA	2022-03-08	546	4596
Oscillatoria tenuis	Cyanobacteria	917	2022-03-08	68	3314
Phormidium granulatum	Cyanobacteria	992	2022-03-08	493	7579
Cryptomonas sp.	Cryptophyta	10635	2022-03-08	46	178378
Ochromonas sp.	Chrysophyta	1455	2022-03-08	91	10292
Rhodomonas lacustris	Cryptophyta	10663	2022-03-08	15	7634
Gymnodinium sp.	Dinoflagellate	10031	2022-03-08	8	79432
Aulacoseira granulata	Diatom	590863	2022-09-07	61	14972
Stauroneis anceps	Diatom	4127	2022-09-07	15	162860
Oocystis parva	Green	5827	2022-09-07	61	8783
Anathece clathrata	Cyanobacteria	NA	2022-09-07	2580	2702
Aphanothece sp.	Cyanobacteria	636	2022-09-07	121	760
Aphanocapsa sp.	Cyanobacteria	625	2022-09-07	1366	8147
Anacystis cyanea	Cyanobacteria	609	2022-09-07	607	1073
Anabaena sp.	Cyanobacteria	1100	2022-09-07	137	5712
Anabaena variabilis	Cyanobacteria	1100	2022-09-07	137	6151
Planktolyngbya limnetica	Cyanobacteria	NA	2022-09-07	1670	14059
Pseudanabaena limnetica	Cyanobacteria	1175	2022-09-07	653	11796
Rhodomonas lacustris	Cryptophyta	10663	2022-09-07	15	7634

Report.Name	High.Level.Taxa	ITIS Genus Number	Date.Sampled	Abundance (cells/mL)	Biovolume (µm³/mL)
Achnantheidium minutissimum	Diatom	590864	2022-04-12	15	1272
Aulacoseira granulata	Diatom	590863	2022-04-12	106	26016
Aulacoseira sp.	Diatom	590863	2022-04-12	23	12645
Asterionella formosa	Diatom	3116	2022-04-12	23	4312
Cocconeis placentula	Diatom	3577	2022-04-12	8	9640
Lindavia bodanica	Diatom	NA	2022-04-12	8	12566
Lindavia ocellata	Diatom	NA	2022-04-12	68	13352
Melosira undulata	Diatom	2290	2022-04-12	15	2198612
Nitzschia sp.	Diatom	5070	2022-04-12	8	3000
Nitzschia acicularis	Diatom	5070	2022-04-12	8	3528
Ulnaria acus	Diatom	970000	2022-04-12	38	19202
Tabellaria fenestrata	Diatom	3241	2022-04-12	8	31790
Ankistrodesmus falcatus	Green	5877	2022-04-12	8	2912
Chlorella vulgaris	Green	5811	2022-04-12	15	1696
Closteriopsis acicularis	Green	5926	2022-04-12	8	38457
Anacystis cyanea	Cyanobacteria	609	2022-04-12	228	403
Planktolyngbya sp.	Cyanobacteria	NA	2022-04-12	562	3531
Planktolyngbya limnetica	Cyanobacteria	NA	2022-04-12	402	3384
Limnothrix redekei	Cyanobacteria	NA	2022-04-12	114	16116
Merismopedia tenuissima	Cyanobacteria	727	2022-04-12	91	200
Pseudanabaena limnetica	Cyanobacteria	1175	2022-04-12	228	4119
Phormidium granulatum	Cyanobacteria	992	2022-04-12	342	5257
cf. Dinobryon cyst	Chrysophyta	NA	2022-04-12	159	14569
Cryptomonas sp.	Cryptophyta	10635	2022-04-12	30	116333
Ochromonas sp.	Chrysophyta	1455	2022-04-12	8	905
Rhodomonas lacustris	Cryptophyta	10663	2022-04-12	106	53947
Chroomonas sp.	Chrysophyta	10613	2022-04-12	8	980
UID flagellate	Other.Flagellates	NA	2022-04-12	8	1047
Achnantheidium minutissimum	Diatom	590864	2022-05-17	30	2545
Aulacoseira granulata	Diatom	590863	2022-05-17	46	11290
Lindavia bodanica	Diatom	NA	2022-05-17	30	47124
Lindavia ocellata	Diatom	NA	2022-05-17	121	23758
Cymbella sp.	Diatom	4795	2022-05-17	15	25447
Cymbella cf. cymbiformis	Diatom	4795	2022-05-17	15	53093
Urosolenia eriensis	Diatom	590843	2022-05-17	15	135717
Staurosira construens	Diatom	590848	2022-05-17	121	18246
Stephanodiscus hantzschii	Diatom	2415	2022-05-17	15	42412
Tabellaria fenestrata	Diatom	3241	2022-05-17	46	182792
Ankistrodesmus falcatus	Green	5877	2022-05-17	46	16745
Anacystis cyanea	Cyanobacteria	609	2022-05-17	76	134
Planktolyngbya sp.	Cyanobacteria	NA	2022-05-17	1336	8394
Planktolyngbya limnetica	Cyanobacteria	NA	2022-05-17	1351	11373
Limnothrix redekei	Cyanobacteria	NA	2022-05-17	653	92316
Merismopedia tenuissima	Cyanobacteria	727	2022-05-17	121	266
Phormidium granulatum	Cyanobacteria	992	2022-05-17	455	6995
Snowella lacustris	Cyanobacteria	NA	2022-05-17	76	318

Report.Name	High.Level.Taxa	ITIS Genus Number	Date.Sampled	Abundance (cells/mL)	Biovolume (µm³/mL)
Dinobryon sertularia	Chrysophyta	1515	2022-05-17	15	5475
cf. Dinobryon cyst	Chrysophyta	NA	2022-05-17	15	1374
Cryptomonas sp.	Cryptophyta	10635	2022-05-17	30	116333
Rhodomonas lacustris	Cryptophyta	10663	2022-05-17	30	15268
Gymnodinium sp.	Dinoflagellate	10031	2022-05-17	15	148935
Achnanthydium minutissimum	Diatom	590864	2022-06-15	15	1272
Aulacoseira ambigua	Diatom	590863	2022-06-15	30	25918
Aulacoseira granulata	Diatom	590863	2022-06-15	61	14972
Asterionella formosa	Diatom	3116	2022-06-15	15	2812
Lindavia bodanica	Diatom	NA	2022-06-15	30	47124
Lindavia ocellata	Diatom	NA	2022-06-15	61	11977
Fragilaria radians	Diatom	2932	2022-06-15	121	84700
Urosolenia eriensis	Diatom	590843	2022-06-15	91	823349
Stephanodiscus hantzschii	Diatom	2415	2022-06-15	15	42412
Ulnaria acus	Diatom	970000	2022-06-15	76	38404
Ulnaria nana	Diatom	970000	2022-06-15	15	9000
cf. Coelastrum microporum	Green	NA	2022-06-15	15	1696
Elakatothrix gelatinosa	Green	9412	2022-06-15	30	2535
UID green coccoid	Green	NA	2022-06-15	15	3676
Anathece clathrata	Cyanobacteria	NA	2022-06-15	152	159
Anacystis cyanea	Cyanobacteria	609	2022-06-15	76	134
Anacystis cf. delicatissima	Cyanobacteria	609	2022-06-15	835	755
Gloeotheca rupestris	Cyanobacteria	703	2022-06-15	61	1684
Lyngbya sp.	Cyanobacteria	870	2022-06-15	228	2865
Planktolynngbya sp.	Cyanobacteria	NA	2022-06-15	2004	12592
Planktolynngbya limnetica	Cyanobacteria	NA	2022-06-15	668	5624
Pseudanabaena limnetica	Cyanobacteria	1175	2022-06-15	61	1102
Snowella litoralis	Cyanobacteria	NA	2022-06-15	91	381
cf. Dinobryon cyst	Chrysophyta	NA	2022-06-15	258	23640
Cryptomonas sp.	Cryptophyta	10635	2022-06-15	91	352877
Ochromonas sp.	Chrysophyta	1455	2022-06-15	364	41167
Rhodomonas lacustris	Cryptophyta	10663	2022-06-15	137	69725
UID flagellate	Other.Flagellates	NA	2022-06-15	76	9948
Chrysococcus sp.	Chrysophyta	1751	2022-06-15	46	7407
Asterionella formosa	Diatom	3116	2022-07-13	61	11438
Cyclotella meneghiniana	Diatom	2439	2022-07-13	30	5890
Lindavia bodanica	Diatom	NA	2022-07-13	61	95819
Lindavia ocellata	Diatom	NA	2022-07-13	30	5890
Fragilaria crotonensis	Diatom	2932	2022-07-13	152	38000
Ulnaria acus	Diatom	970000	2022-07-13	30	15159
cf. Coelastrum microporum	Green	NA	2022-07-13	121	13685
Mougeotia sp.	Green	7055	2022-07-13	30	23295
Anathece clathrata	Cyanobacteria	NA	2022-07-13	729	763
Aphanocapsa sp.	Cyanobacteria	625	2022-07-13	425	2535
Anacystis cyanea	Cyanobacteria	609	2022-07-13	2277	4024
Anacystis cf. delicatissima	Cyanobacteria	609	2022-07-13	1062	961

Report.Name	High.Level.Taxa	ITIS Genus Number	Date.Sampled	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)
Gloeothece rupestris	Cyanobacteria	703	2022-07-13	30	828
Planktolyngbya sp.	Cyanobacteria	NA	2022-07-13	1062	6673
Planktolyngbya limnetica	Cyanobacteria	NA	2022-07-13	1396	11752
Oscillatoria tenuis	Cyanobacteria	917	2022-07-13	911	44394
Dinobryon sertularia	Chrysophyta	1515	2022-07-13	334	121915
Dinobryon bavaricum	Chrysophyta	1515	2022-07-13	121	25089
Mallomonas tonsurata	Chrysophyta	1598	2022-07-13	30	63335
cf. Dinobryon cyst	Chrysophyta	NA	2022-07-13	91	8338
Cryptomonas sp.	Cryptophyta	10635	2022-07-13	30	116333
Nano Cryptomonads	Cryptophyta	NA	2022-07-13	91	16677
Ochromonas sp.	Chrysophyta	1455	2022-07-13	425	48066
Chrysochromulina sp.	Chrysophyta	2160	2022-07-13	30	673
Aulacoseira granulata	Diatom	590863	2022-08-16	46	11290
Nitzschia sp.	Diatom	5070	2022-08-16	15	5625
Ulnaria acus	Diatom	970000	2022-08-16	46	23244
Gloeocystis planctonica	Green	6355	2022-08-16	61	8771
Anathece clathrata	Cyanobacteria	NA	2022-08-16	2049	2146
Aphanocapsa sp.	Cyanobacteria	625	2022-08-16	1639	9775
Anacystis cyanea	Cyanobacteria	609	2022-08-16	926	1636
Anacystis cf. delicatissima	Cyanobacteria	609	2022-08-16	425	385
Chroococcus limneticus	Cyanobacteria	654	2022-08-16	30	2114
Anabaena sp.	Cyanobacteria	1100	2022-08-16	759	31644
Anabaena affinis	Cyanobacteria	1100	2022-08-16	471	79903
Planktolyngbya sp.	Cyanobacteria	NA	2022-08-16	455	2859
Merismopedia punctata	Cyanobacteria	727	2022-08-16	121	254
Dinobryon bavaricum	Chrysophyta	1515	2022-08-16	15	3110
cf. Dinobryon cyst	Chrysophyta	NA	2022-08-16	46	4215
Cryptomonas sp.	Cryptophyta	10635	2022-08-16	30	116333
Ochromonas sp.	Chrysophyta	1455	2022-08-16	288	32572
Rhodomonas lacustris	Cryptophyta	10663	2022-08-16	46	23411
Chrysochromulina sp.	Chrysophyta	2160	2022-08-16	15	337
UID flagellate	Other.Flagellates	NA	2022-08-16	46	6021

Table 4: Raw data from 2021 EMS site 0500236

Report.Name	High.Level.Taxa	ITIS.Genus.Number	Date.Sampled	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)
Aulacoseira ambigua	Diatom	590863	2021-03-09	27	8354
Aulacoseira granulata	Diatom	590863	2021-03-09	38	12499
Cyclotella meneghiniana	Diatom	2439	2021-03-09	4	1587
Eunotia sp.	Diatom	3337	2021-03-09	4	595

Report.Name	High.Level.Taxa	ITIS.Genus.Number	Date.Sampled	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)
Tabellaria					
fenestrata	Diatom	3241	2021-03-09	8	21502
Ankistrodesmus sp.	Green	5877	2021-03-09	8	1258
Elakatothrix cf.					
gelatinosa	Green	9412	2021-03-09	23	4416
Closterium sp.	Green	7257	2021-03-09	4	55906
Closterium gracile	Green	7257	2021-03-09	8	6355
Closterium					
aciculare	Green	7257	2021-03-09	11	153741
Closteriopsis					
acicularis	Green	5926	2021-03-09	4	4712
Anacystis cyanea	Cyanobacteria	609	2021-03-09	95	143
Planktolyngbya sp.	Cyanobacteria	NA	2021-03-09	448	5569
Planktolyngbya					
limnetica	Cyanobacteria	NA	2021-03-09	368	1883
Limnothrix sp.	Cyanobacteria	NA	2021-03-09	228	3223
Pseudanabaena					
limnetica	Cyanobacteria	1175	2021-03-09	376	34551
Cryptomonas sp.	Cryptophyta	10635	2021-03-09	110	203725
Ochromonas sp.	Chrysophyta	1455	2021-03-09	167	35750
Chrysochromulina					
sp.	Chrysophyta	2160	2021-03-09	4	154
Chroomonas sp.	Chrysophyta	10613	2021-03-09	11	2501
Aulacoseira					
ambigua	Diatom	590863	2021-09-08	8	2475
Lindavia ocellata	Diatom	NA	2021-09-08	8	1327
Cymbella sp.	Diatom	4795	2021-09-08	8	13547
Fragilaria					
crotonensis	Diatom	2932	2021-09-08	76	36902
Ulnaria acus	Diatom	970000	2021-09-08	15	15627
Tabellaria					
fenestrata	Diatom	3241	2021-09-08	23	61819
Oocystis parva	Green	5827	2021-09-08	15	3372
Tetraedron					
minimum	Green	5661	2021-09-08	8	984
Anathece cf.					
clathrata	Cyanobacteria	NA	2021-09-08	1783	7469
Anacystis sp.	Cyanobacteria	609	2021-09-08	896	1705
Chroococcus sp.	Cyanobacteria	654	2021-09-08	76	2547
Anabaena sp.	Cyanobacteria	1100	2021-09-08	357	26768
Lyngbya sp.	Cyanobacteria	870	2021-09-08	228	179
Planktolyngbya sp.	Cyanobacteria	NA	2021-09-08	304	3779
Planktolyngbya					
limnetica	Cyanobacteria	NA	2021-09-08	76	389
Limnothrix sp.	Cyanobacteria	NA	2021-09-08	30	424
Oscillatoria sp.	Cyanobacteria	917	2021-09-08	137	1227
Oscillatoria tenuis	Cyanobacteria	917	2021-09-08	266	2382
Dinobryon sp.	Chrysophyta	1515	2021-09-08	8	12016

Report.Name	High.Level.Taxa	ITIS.Genus.Number	Date.Sampled	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)
Ochromonas sp. Rhodomonas lacustris	Chrysophyta	1455	2021-09-08	53	11346
UID flagellate	Cryptophyta	10663	2021-09-08	8	869
	Other.Flagellates	NA	2021-09-08	15	5218