Elk Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from one site on Elk Lake during 2021 and 2022 (Figure 1; Table 1). Algae were identified to the genus level and grouped into broad alga types for analysis.

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

Sample Site (EMS#)	Dates
ELK LAKE; CENTER (1100844)	2021-02-24
	2021-08-24
	2022-02-23
	2022-08-25
	Total= 4 samples

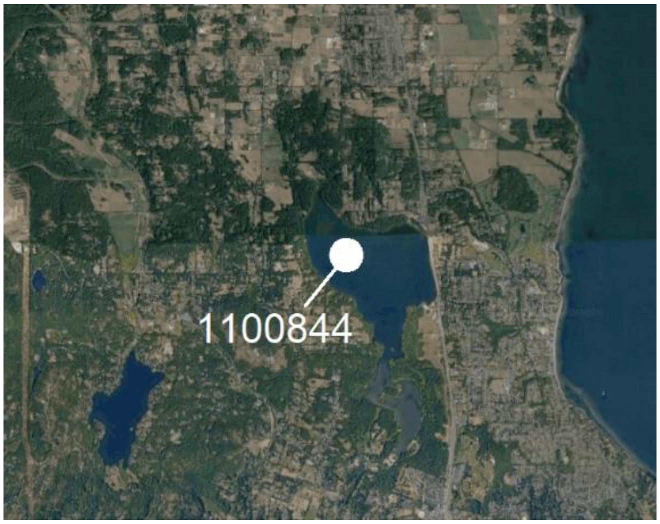

Figure 1: Aerial view of Elk Lake

Winter samples demonstrated higher densities of diatoms than summer samples. Late winter and spring diatom blooms are common and reflective of increased temperatures, light penetration, and silica in the water following ice-off (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). Late winter samples collected demonstrated diatom degradation reflective of lowering silica levels following a bloom (Figure 2).

Tabellaria fenestrata and *Stephanodiscus* sp. were the most common genera of diatom. Diatoms are integral to aquatic food webs because they are the foundation of the food web (jrobyn, 2019). Colony forming diatoms can avoid grazing pressures by developing into large colonies reducing their availability for zooplankton and microscopic invertebrates (Baker, 2012).

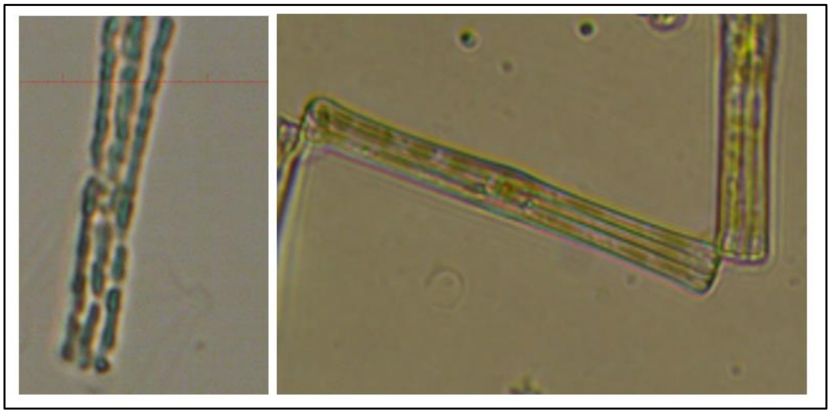

Figure 2: Degraded Tabellaria fenestrata in the late winter (left) vs intact Tabellaria fenestrate in late summer (right)

Overview (continued)

Ceratium, a dinoflagellate, dominated biovolume percentages (Figure 3). Physically *Ceratium* is a very large genus compared to most algae and can dominate biovolume percentages even when low in quantity (Figure 4; Figure 3).

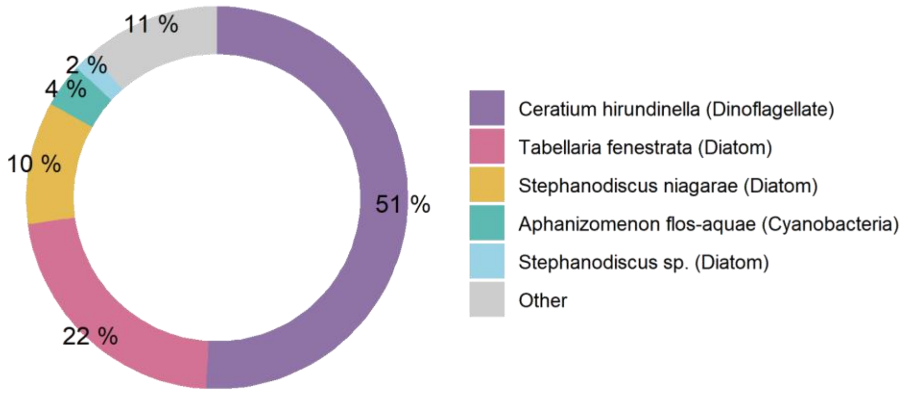

Figure 3: Dominant organisms from Elk Lake; Center (1100844) as percent of total biovolume

Marine species of *Ceratium* are associated with toxic red tides, however little evidence exists linking freshwater *Ceratium* blooms with the production of toxic secondary metabolites (*An Image-Based Key: Ceratium (Dinophyceae)*, 2017).

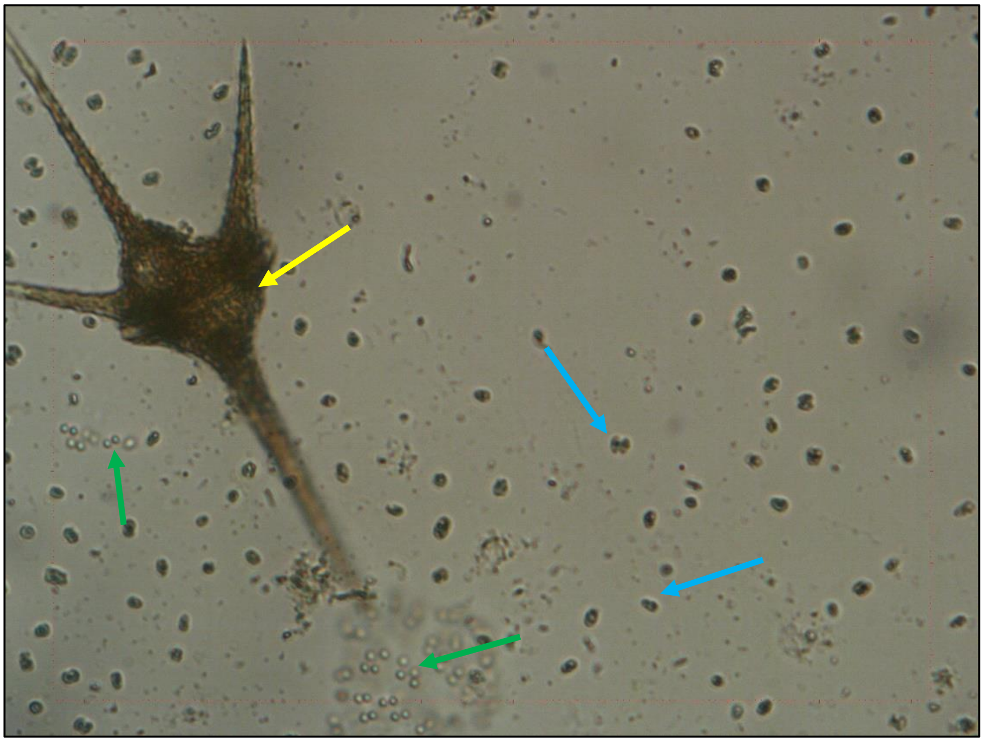

Figure 4: 400x magnification of a Ceratium cell (yellow arrow) surrounded by Woronichinia (blue arrows) and Snowella cells (green arrows)

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 contained higher concentrations of cyanobacteria than spring. Dominant genera include *Woronichinia*, *Aphanizamenon*, and *Snowella* (Figure 5).

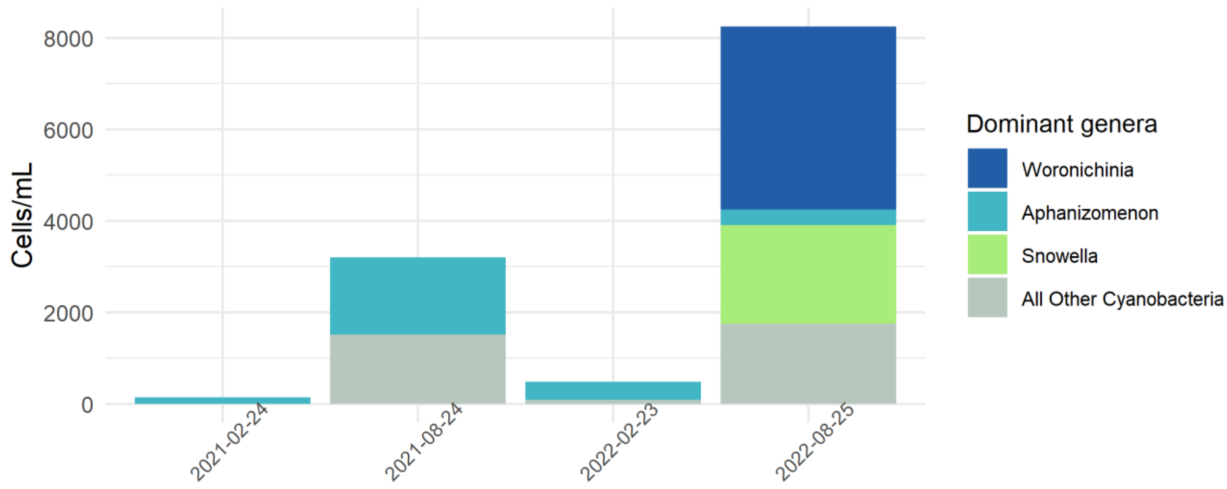

Figure 5: cell abundance for dominant cyanobacteria genera on Elk Lake

One sample contained a *Woronichinia* bloom that had been degraded due to the over-use of lugols (2022-08-25). *Woronichinia* is not associated with cyanotoxin release but is known to bloom in association with cyanobacterial genera that produce toxic blooms (Services CRD, 2018). *Snowella* and *Aphanizomenon* are associated with 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 Elk Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Woronichinia	4000	No data yet
Snowella	2152	Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD
Aphanizomenon	1689	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO , BMAA, Anabaenopeptins APT, Taste and Odor

Note: * = counted in samples

Cyanobacterial Presence (Continued)

Dominant species of cyanobacteria found in Elk Lake are capable of cyanotoxins (Table 2).

Elk Lake displayed cyanobacteria levels in the negligible-low risk category, with a mean cyanobacteria abundance of 3,013 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Elk Lake compared to alert levels defined by several authorities including the WHO and EPA.

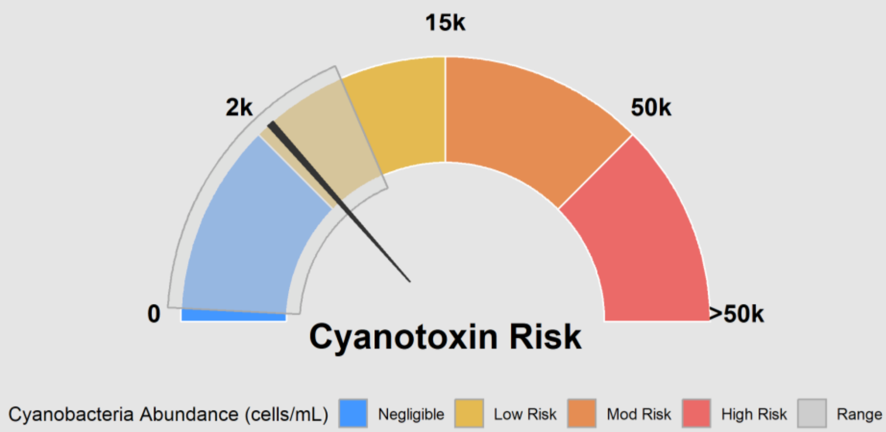

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Elk Lake

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 can be seen in Figure 7 where the single *Ceratium* cell is similar in size to approximately 100 cyanobacteria cells.

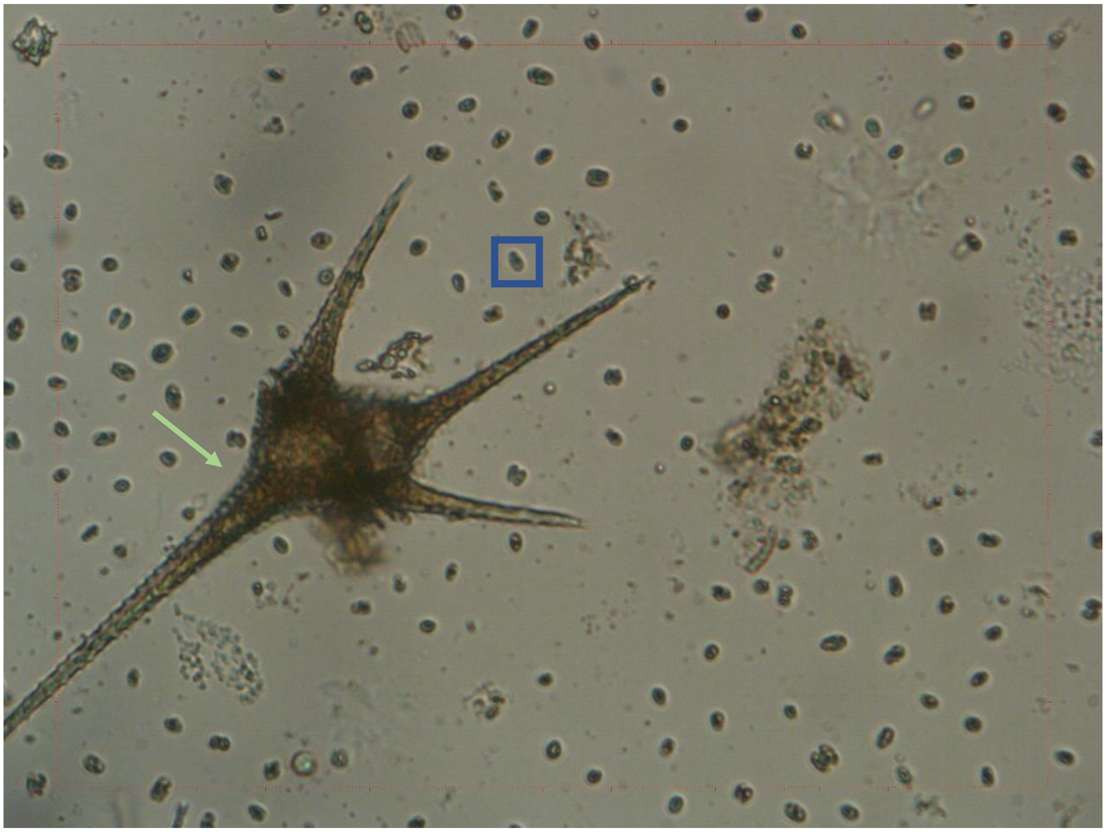

Figure 7: Size comparison of Ceratium (green arrow) to a Woronichinia cell (blue box)

Species Composition

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

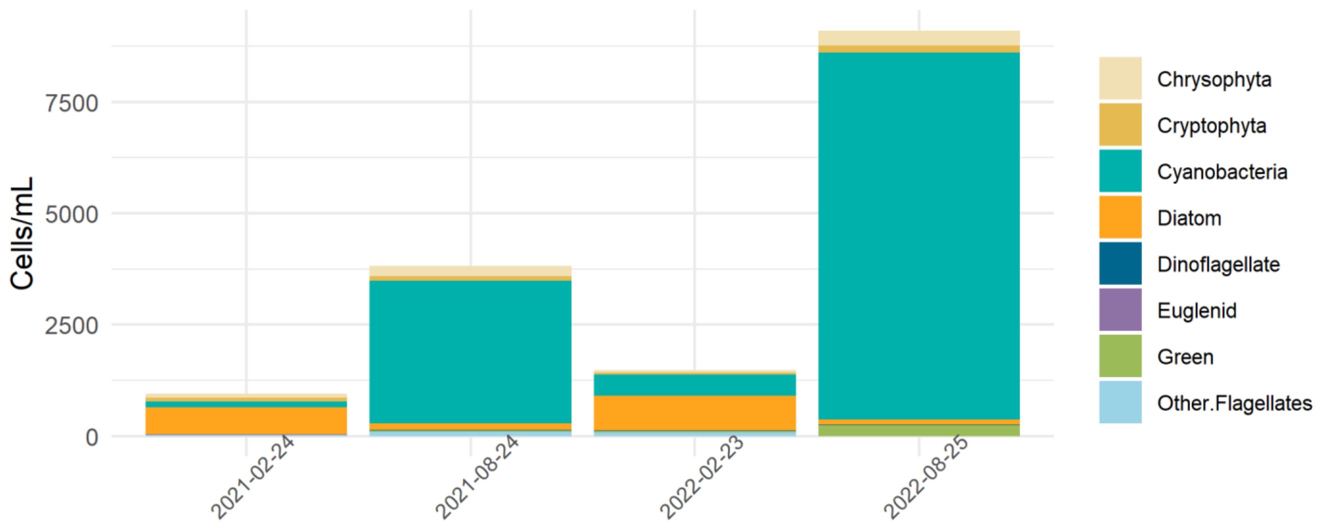

Figure 8: Cell abundance of high-level taxa groups on Elk Lake

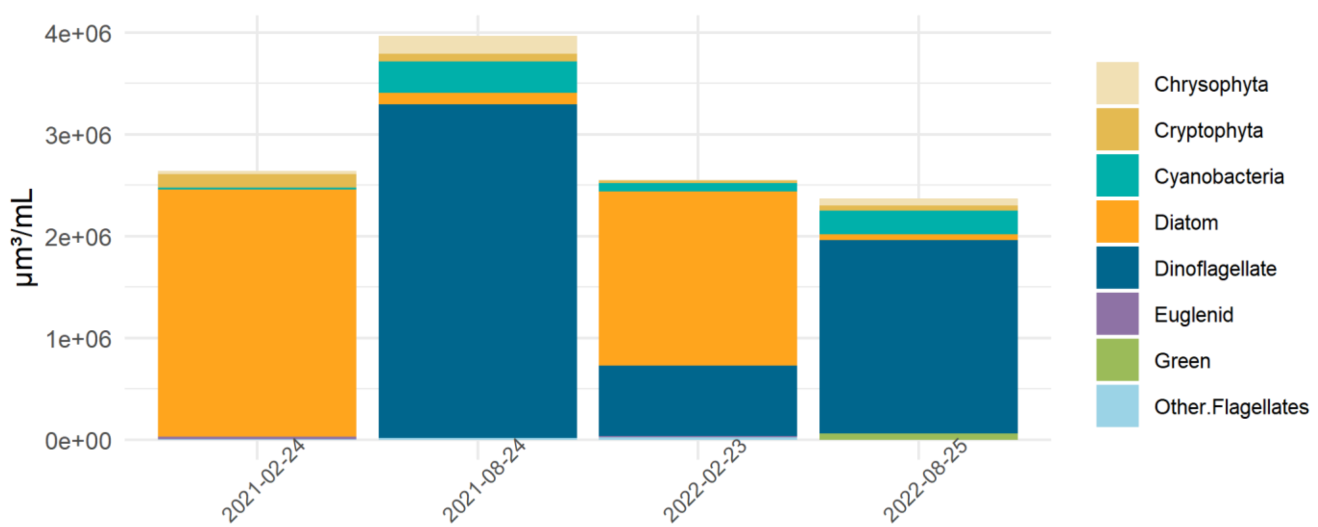

Figure 9: Biovolume of high-level taxa groups on Elk Lake

References

An Image-Based Key: Ceratium (Dinophyceae). (2017, November). University of New Hampshire.

Baker, A. L. et al. (2012). *Phycokey -- an image based key to Algae (PS Protista), Cyanobacteria, and other aquatic objects.* University of New Hampshire Center for Freshwater Biology. http://cfb.unh.edu/phycokey/phycokey.htm

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Services CRD, E. (2018). *ELK/BEAVER LAKE Technical Report-Investigation of In-Lake Remediation Options*. 13–14.

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:

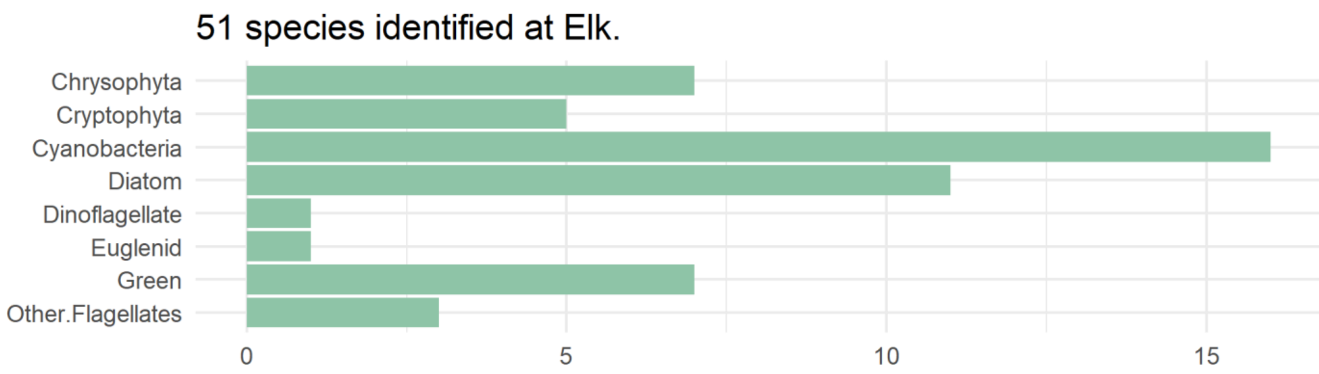

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 1100844	Total Abundance (cells/mL):	943		
Collection Date: 2021-02-24	Total Biovolume (µm³/mL):	2640524		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	8	12016	Chrysophyta	1515
Ochromonas sp.	65	13914	Chrysophyta	1455
Chrysochromulina sp.	15	577	Chrysophyta	2160
Dinobryopsis sp.	8	2149	Chrysophyta	1557
Cryptomonas sp.	34	62969	Cryptophyta	10635
Cryptomonas curvata	8	50400	Cryptophyta	10635
Cryptomonas marssonii	8	16335	Cryptophyta	10635
Rhodomonas lacustris	34	3692	Cryptophyta	10663
Aphanizomenon flos-aquae	133	22145	Cyanobacteria	1191
Aulacoseira sp.	83	136585	Diatom	590863
Stephanodiscus niagarae	114	1197142	Diatom	2415
Tabellaria fenestrata	406	1091237	Diatom	3241
Trachelomonas sp.	8	28274	Euglenid	9690
Ankistrodesmus falcatus	4	565	Green	5877
microflagellate	15	2524	Other.Flagellates	

Figure 11: Raw data from 2021-02-24 EMS site 1100844

EMS ID: 1100844	Total Abundance (cells/mL):	3811		
Collection Date: 2021-08-24	Total Biovolume (µm³/mL):	3971641		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	87	130674	Chrysophyta	1515
Mallomonas sp.	8	24194	Chrysophyta	1598
Ochromonas sp.	83	17768	Chrysophyta	1455
Chrysochromulina sp.	34	1308	Chrysophyta	2160
Chrysococcus sp.	8	2656	Chrysophyta	1751
Cryptomonas sp.	11	20372	Cryptophyta	10635
Cryptomonas curvata	4	25200	Cryptophyta	10635
Cryptomonas ovata	11	23935	Cryptophyta	10635
Rhodomonas lacustris	80	8686	Cryptophyta	10663
Aphanocapsa elachista var. planctonica	429	3510	Cyanobacteria	625
Aphanizomenon flos-aquae	1689	281226	Cyanobacteria	1191
Anacystis sp.	30	57	Cyanobacteria	609
Lyngbya wollei	95	89	Cyanobacteria	870
Anacystis nidulans	577	1260	Cyanobacteria	609
Anabaena flos-aquae	65	12651	Cyanobacteria	1100
Gloeocapsa aeruginosa	11	156	Cyanobacteria	682
Gloeocapsa punctata	76	318	Cyanobacteria	682
Gloeothece sp.	8	524	Cyanobacteria	703
Gomphosphaeria sp.	121	5368	Cyanobacteria	714
Lyngbya wollei	95	89	Cyanobacteria	870
Aulacoseira granulata	42	13815	Diatom	590863
Cocconeis fluviatilis	11	17374	Diatom	3577
Fragilaria crotonensis	87	42244	Diatom	2932
Frustulia rhomboides	4	16990	Diatom	4564
Tabellaria fenestrata	8	21502	Diatom	3241
Ceratium hirundinella	19	3280423	Dinoflagellate	10397
Ankistrodesmus falcatus	4	565	Green	5877
Elakatothrix gelatinosa	8	1413	Green	9412
Selenastrum minutum	4	113	Green	6249
microflagellate	102	17161	Other.Flagellates	

Figure 12: Raw data from 2021-08-24 EMS site 1100844

EMS ID: 1100844	Total Abundance (cells/mL):	1481		
Collection Date: 2022-02-23	Total Biovolume (µm³/mL):	2551734		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chrysochromulina sp.	46	1769	Chrysophyta	2160
Dinobryopsis sp.	15	4029	Chrysophyta	1557
Rhodomonas lacustris	34	3692	Cryptophyta	10663
Cryptomonas ovata	8	17407	Cryptophyta	10635
Aphanizomenon flos-aquae	391	65103	Cyanobacteria	1191
Anabaena planctonica	53	18092	Cyanobacteria	1100
Gloeocapsa aeruginosa	30	424	Cyanobacteria	682
Aulacoseira italica	148	73882	Diatom	590863
Cocconeis fluviatilis	4	6318	Diatom	3577
Fragilaria crotonensis	19	9226	Diatom	2932
Tabellaria fenestrata	524	1408395	Diatom	3241
Stephanodiscus sp.	68	194669	Diatom	2415
Lindavia sp.	23	20331	Diatom	
Ceratium hirundinella	4	690615	Dinoflagellate	10397
Trachelomonas sp.	4	14137	Euglenid	9690
Scenedesmus arcuatus	11	798	Green	6104
Ankistrodesmus falcatus	8	1131	Green	5877
Oocystis sp.	11	207	Green	5827
microflagellates	80	21509	Other.Flagellates	

Figure 13: Raw data from 2022-02-23 EMS site 1100844

EMS ID: 1100844	**Total Abundance (cells/mL):**	**9098**		
Collection Date: 2022-08-25	**Total Biovolume (µm³/mL):**	**2369221**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chrysochromulina sp.	68	2615	Chrysophyta	2160
Chromulina sp.	4	7069	Chrysophyta	1717
Ochromonas sp.	262	56086	Chrysophyta	1455
Cryptomonas sp.	15	27781	Cryptophyta	10635
Cryptomonas ovata	4	8704	Cryptophyta	10635
Rhodomonas lacustris	133	14441	Cryptophyta	10663
Anacystis sp.	1135	2160	Cyanobacteria	609
Aphanocapsa sp.	8	25	Cyanobacteria	625
Aphanizomenon flos-aquae	345	57444	Cyanobacteria	1191
Anabaena sp.	53	3974	Cyanobacteria	1100
Gloeocapsa punctata	61	256	Cyanobacteria	682
Lyngbya wollei	46	43	Cyanobacteria	870
Snowella litoralis	2152	102678	Cyanobacteria	
Synechocystis sp.	448	15013	Cyanobacteria	799
Woronichinia naegeliana	4000	54469	Cyanobacteria	
Cocconeis fluviatilis	4	6318	Diatom	3577
Fragilaria crotonensis	102	49527	Diatom	2932
Nitzschia sp.	4	367	Diatom	5070
Ceratium hirundinella	11	1899192	Dinoflagellate	10397
Ankistrodesmus sp.	4	629	Green	5877
Oocystis sp.	4	75	Green	5827
Didymocystis fina	220	59266	Green	55858
Scenedesmus arcuatus	15	1089	Green	6104

Figure 14: Raw data from 2022-08-25 EMS site 1100844