Tyhee Lake Phytoplankton Summary Report 2021-2022

Overview

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

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

Sample Site (EMS#)	Dates
TYHEE LAKE @ DEEP STN (E216924)	2021-04-27
	2021-09-02
	2022-04-28
	2022-08-15
	Total= 4 samples

Figure 1: Aerial view of Tyhee Lake

Samples contained low densities of diatoms and green algae; the dominant diatom genus was *Tabellaria*.

Spring samples contained high densities of flagellates but low densities of cyanobacteria. Summer samples contained low densities of flagellates but high densities of cyanobacteria (Figure 2).

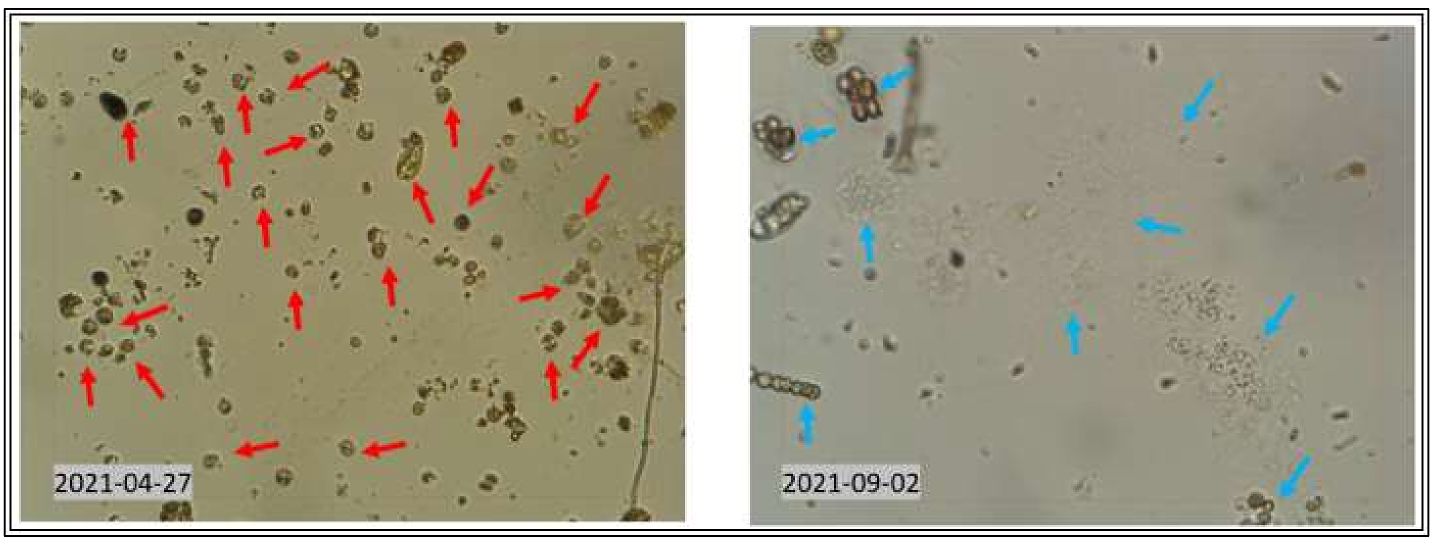

Figure 2: Compositional change of algal community between spring and summer in Tyhee Lake; cyanobacteria are indicated by blue arrows and flagellates are indicated by red arrows

Overview (continued)

Chrysophyta dominated total biovolume at 47% (Figure 3). Dominant Chrysophyta members included flagellates *Chromulina* and *Dinobryon* (Figure 4).

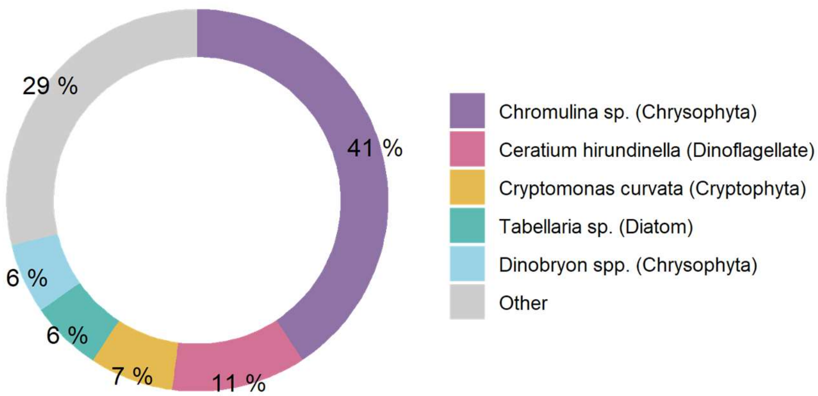

Figure 3: Dominant organisms from Tyhee Lake @ Deep Stn (E216924) as percent of total biovolume

Chrysophyta taxa are advantageous and disadvantageous in freshwater systems, depending on their context. Some Chrysophyta are known to produce odor chemicals described as fishy, and others eat bacteria and reduce negative odor compounds (Wehr et al., 2015). *Dinobryon* blooms are associated with unpleasant fishy odors, and one species of *Dinobryon* is linked with toxins that can affect fish vitality (Cantrell & Long, 2013; Conrad, 2013).

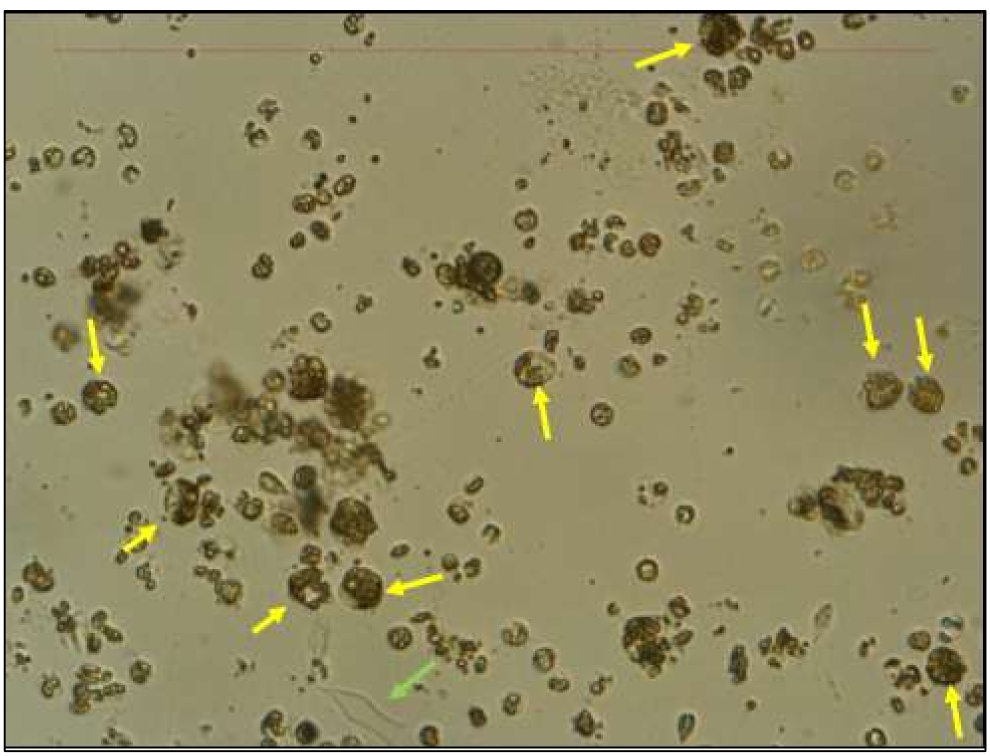

Figure 4: EMS site #E216924 demonstrating high abundance of micro-flagellates, Chromulina (yellow arrows), and Dinobryon (green arrow) species

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

Cyanobacteria concentrations were much higher in summer samples. Dominant genera included *Anabaena*, *Anacystis*, and *Aphanizomenon* (Figure 5).

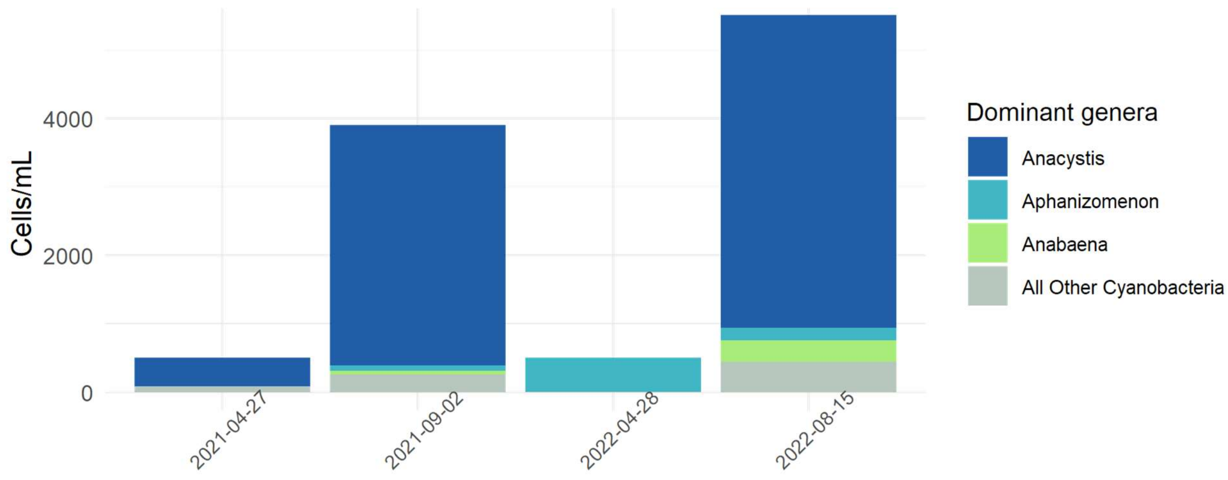

Figure 5: cell abundance for dominant cyanobacteria genera on Tyhee Lake

During blooms, species of *Anabaena* and *Aphanizomenon* can produce both negative odor/taste compounds and toxic secondary metabolites. *Anabaena* blooms can quickly accumulate, develop odor metabolites, and color water systems (EPA, 2022). Other 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 Tyhee Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Anacystis	3688	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD, Anatoxins (-a) ATX, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT
Aphanizomenon	497	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Anabaenopeptins APT, Taste and Odor
Anabaena	315	Lyngbyatoxin LYN, Apoptogen Toxin (ApopTX), Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT, Taste and Odor

Note: * = counted in samples

Cyanobacterial Presence (Continued)

Dominant species of cyanobacteria identified in Tyhee Lake can produce cyanotoxins (Table 2).

Tyhee Lake displayed a range of cyanobacteria levels in the negligible-low risk categories, with a mean cyanobacteria abundance of 2,606 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Tyhee Lake compared to alert levels defined by authorities including the WHO and EPA.

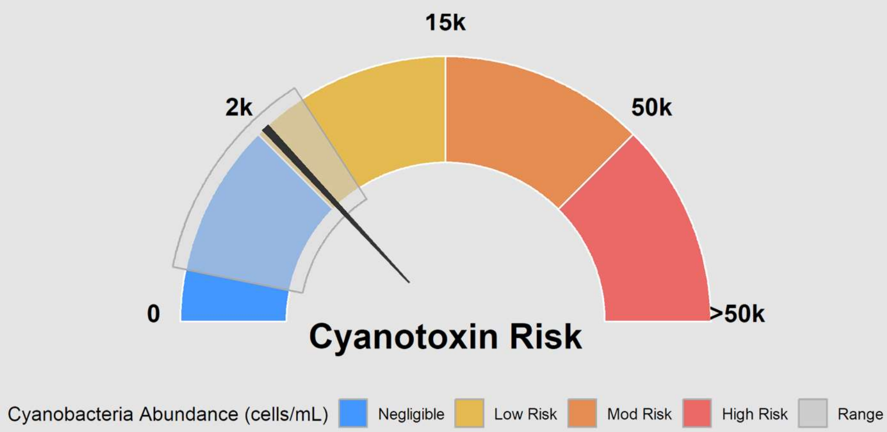

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Tyhee Lake

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 is highlighted in Figure 7 three *Dinobryon* cells dwarf adjacent colony of approximately 50 cyanobacteria cells (*Anacystis*).

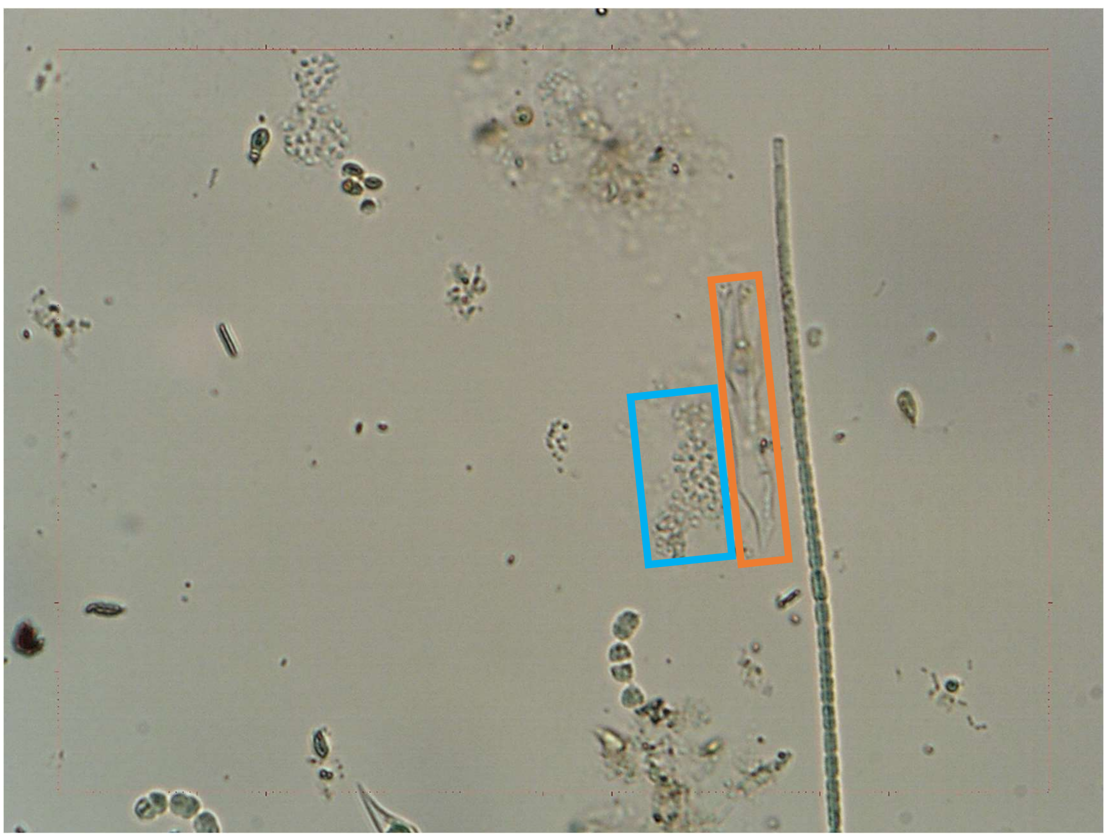

Figure 7: Size comparison of three Dinobryon cell (orange box) to Anacystis colony (blue box)

Species Composition

Algae samples were identified to the genus level and grouped into broad alga types for analysis. The figures below display 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.

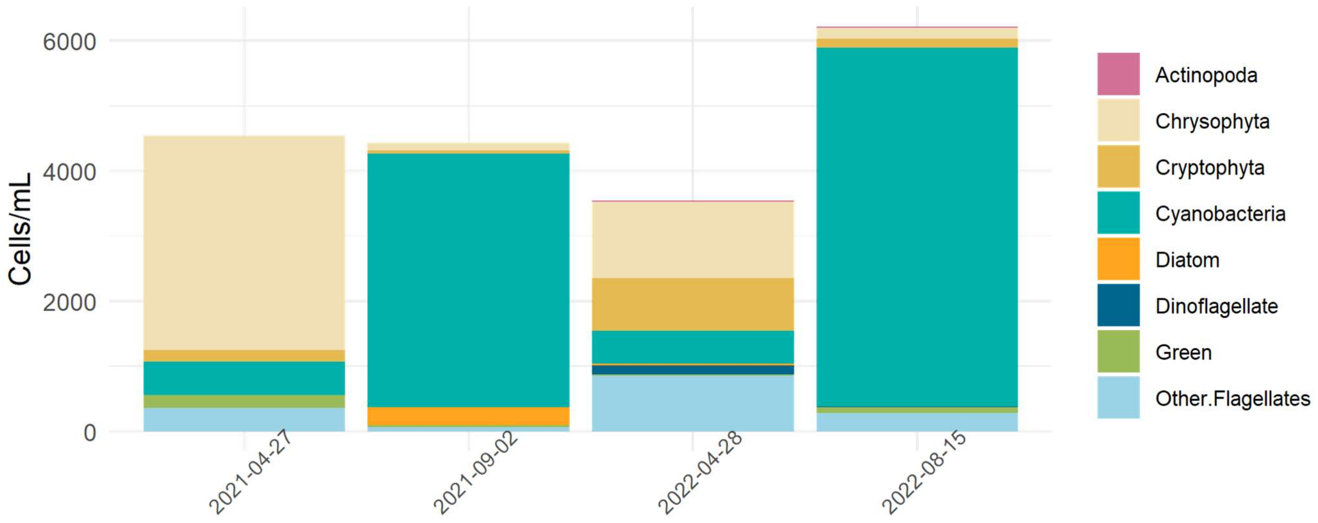

Figure 8: Cell abundance of high-level taxa groups on Tyhee Lake

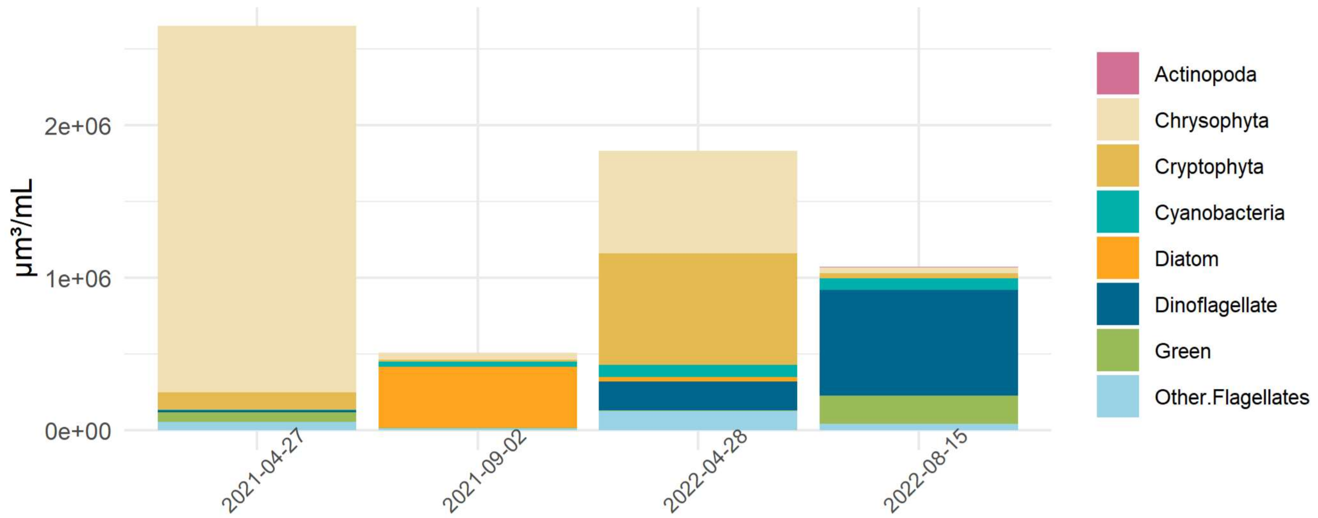

Figure 9: Biovolume of high-level taxa groups on Tyhee Lake

References

Cantrell, R., & Long, B. (2013). *Dinobryon*. PBWorks. http://ohapbio12.pbworks.com/w/page/51731561/Dinobryon

Conrad, J. (2013). *DINOBRYON, a Golden Alga*. Jim Conrad's Naturalist Newsletter. https://www.backyardnature.net/n/x/dinobryo.htm

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Lance, E., Petit, A., Sanchez, W., Paty, C., Gérard, C., & Bormans, M. (2014). Evidence of trophic transfer of microcystins from the gastropod Lymnaea stagnalis to the fish Gasterosteus aculeatus. *Harmful Algae*, *31*, 9–17. https://doi.org/10.1016/J.HAL.2013.09.006

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Appendix

Additional figures and raw data are listed below:

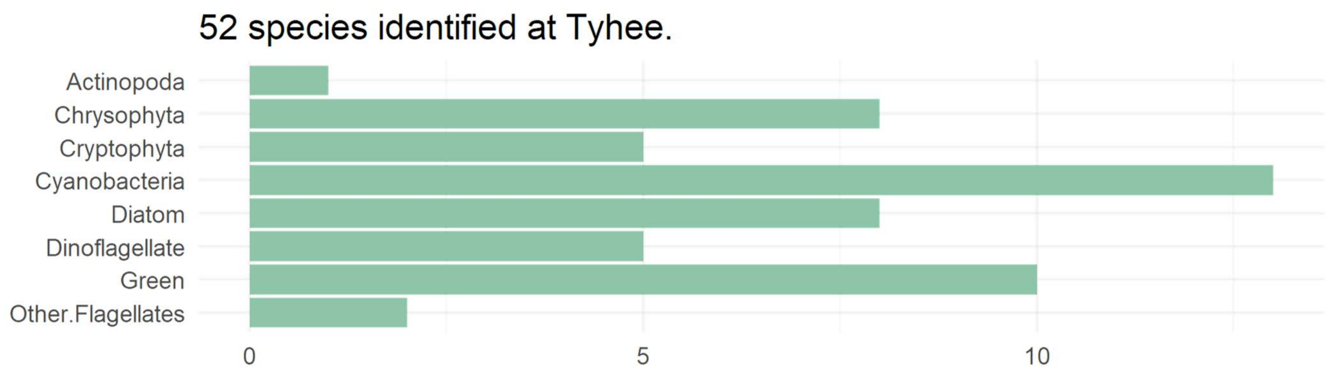

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: E216924	**Total Abundance (cells/mL):**	**4539**		
Collection Date: 2021-04-27	**Total Biovolume (µm³/mL):**	**2659161**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	15	22530	Chrysophyta	1515
Ochromonas sp.	27	5780	Chrysophyta	1455
Chrysochromulina sp.	1882	72387	Chrysophyta	2160
Chromulina sp.	1290	2279618	Chrysophyta	1717
Chrysococcus sp.	80	26562	Chrysophyta	1751
Cryptomonas sp.	53	98158	Cryptophyta	10635
Rhodomonas lacustris	125	13572	Cryptophyta	10663
Anacystis sp.	425	809	Cyanobacteria	609
Planktolyngbya sp.	80	994	Cyanobacteria	
Gymnodinium sp.	4	8474	Dinoflagellate	10031
Peridinium inconspicuum	4	7326	Dinoflagellate	10212
Pandorina sp.	194	62382	Green	5578
microflagellate	360	60569	Other.Flagellates	

Figure 11: Raw data from 2021-04-27 EMS site E216924

EMS ID: E216924	Total Abundance (cells/mL):	4435		
Collection Date: 2021-09-02	Total Biovolume (µm³/mL):	509227		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	19	28538	Chrysophyta	1515
Ochromonas sp.	49	10489	Chrysophyta	1455
Chrysochromulina sp.	46	1769	Chrysophyta	2160
Chromulina sp.	4	7069	Chrysophyta	1717
Dinobryopsis sp.	4	1074	Chrysophyta	1557
Cryptomonas sp.	4	7408	Cryptophyta	10635
Rhodomonas lacustris	46	4995	Cryptophyta	10663
Aphanocapsa sp.	76	240	Cyanobacteria	625
Aphanizomenon flos-aquae	76	12654	Cyanobacteria	1191
Anacystis sp.	3510	6679	Cyanobacteria	609
Chlorogloea sp.	106	2380	Cyanobacteria	824
Chroococcus minutus	91	3436	Cyanobacteria	654
Chroococcus sp.	38	1273	Cyanobacteria	654
Anabaena sp.	53	3974	Cyanobacteria	1100
Pseudanabaena limnetica	27	2481	Cyanobacteria	1175
Cyclotella meneghiniana	4	1814	Diatom	2439
Lindavia bodanica	8	8348	Diatom	
Fragilaria capucina	38	18451	Diatom	2932
Nitzschia sp.	4	367	Diatom	5070
Tabellaria sp.	137	368225	Diatom	3241
Palmodictyon sp.	30	6627	Green	9175
microflagellate	65	10936	Other.Flagellates	

Figure 12: Raw data from 2021-09-02 EMS site E216924

EMS ID: E216924	Total Abundance (cells/mL):	3549		
Collection Date: 2022-04-28	Total Biovolume (µm³/mL):	1854813		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	23	3870	Actinopoda	
Chrysochromulina sp.	304	11693	Chrysophyta	2160
Chromulina sp.	102	180249	Chrysophyta	1717
Dinobryon spp.	228	361715	Chrysophyta	1515
Ochromonas sp.	539	115383	Chrysophyta	1455
Cryptomonas sp.	38	70378	Cryptophyta	10635
Cryptomonas curvata	68	428396	Cryptophyta	10635
Cryptomonas ovata	30	65276	Cryptophyta	10635
Cryptomonas erosa	57	100996	Cryptophyta	10635
Rhodomonas lacustris	615	66775	Cryptophyta	10663
Aphanizomenon flos-aquae	497	82753	Cyanobacteria	1191
Synechocystis sp.	8	268	Cyanobacteria	799
Lindavia intermedia	8	7072	Diatom	
Lindavia bodanica	15	15652	Diatom	
Nitzschia spp.	8	3158	Diatom	5070
Gymnodinium sp.	34	72028	Dinoflagellate	10031
Gymnodinium helveticum	11	43480	Dinoflagellate	10031
Parvodinium sp.	76	41903	Dinoflagellate	
Glenodinium sp.	19	37963	Dinoflagellate	10174
Ankistrodesmus falcatus	15	2121	Green	5877
microflagellate	854	143684	Other.Flagellates	

Figure 13: Raw data from 2022-04-28 EMS site E216924

EMS ID: E216924	**Total Abundance (cells/mL):**	**6221**		
Collection Date: 2022-08-15	**Total Biovolume (µm³/mL):**	**1074740**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	19	3197	Actinopoda	
Chrysochromulina sp.	42	1615	Chrysophyta	2160
Mallomonas sp.	4	12097	Chrysophyta	1598
Ochromonas sp.	106	22691	Chrysophyta	1455
Spumella sp.	15	110	Chrysophyta	1491
Cryptomonas sp.	4	7408	Cryptophyta	10635
Cryptomonas erosa	8	14175	Cryptophyta	10635
Rhodomonas lacustris	133	14441	Cryptophyta	10663
Anabaena sp.	315	23618	Cyanobacteria	1100
Anacystis sp.	827	1574	Cyanobacteria	609
Anacystis incerta	57	125	Cyanobacteria	609
Anacystis delicatissima	3688	8056	Cyanobacteria	609
Aphanocapsa sp.	114	360	Cyanobacteria	625
Aphanizomenon flos-aquae	186	30970	Cyanobacteria	1191
Chroococcus minutus	121	4568	Cyanobacteria	654
Gomphosphaeria sp.	34	1508	Cyanobacteria	714
Snowella sp.	129	554	Cyanobacteria	
Pseudanabaena limnetica	42	3859	Cyanobacteria	1175
Ceratium hirundinella	4	690615	Dinoflagellate	10397
Sphaerocystis sp.	19	4111	Green	9169
Elakatothrix sp.	8	1536	Green	9412
Oocystis solitaria	8	1843	Green	5827
Oocystis lacustris	15	7420	Green	5827
Tetraedron sp.	8	1400	Green	5661
Quadrigula chodati	30	8775	Green	5938
Closterium acutum	4	160836	Green	7257
microflagellate	281	47278	Other.Flagellates	

Figure 14: Raw data from 2022-08-15 EMS site E216924