Charlie Lake Phytoplankton Summary Report 2021-2022

Overview

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

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

Sample Site (EMS#)	Dates
CHARLIE L. DEEP STATION 1.2 KM EAST OF PARK (0400390)	2021-06-02 2021-08-25 2022-05-25 2022-08-09
	Total= 4 samples

Figure 1: Aerial view of Charlie Lake

Summer samples contained large monocultural blooms of toxin producing cyanobacteria (Cyanobacterial Presence). Spring samples contained low densities of cyanobacteria but higher concentrations of diatoms.

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).

Spring samples collected in Charlie Lake demonstrated diatom degradation, indicative of lowering silica levels in the late spring (Figure 2). *Asterionella* was the dominant genus of spring diatoms in Charlie Lake (Figure 3).

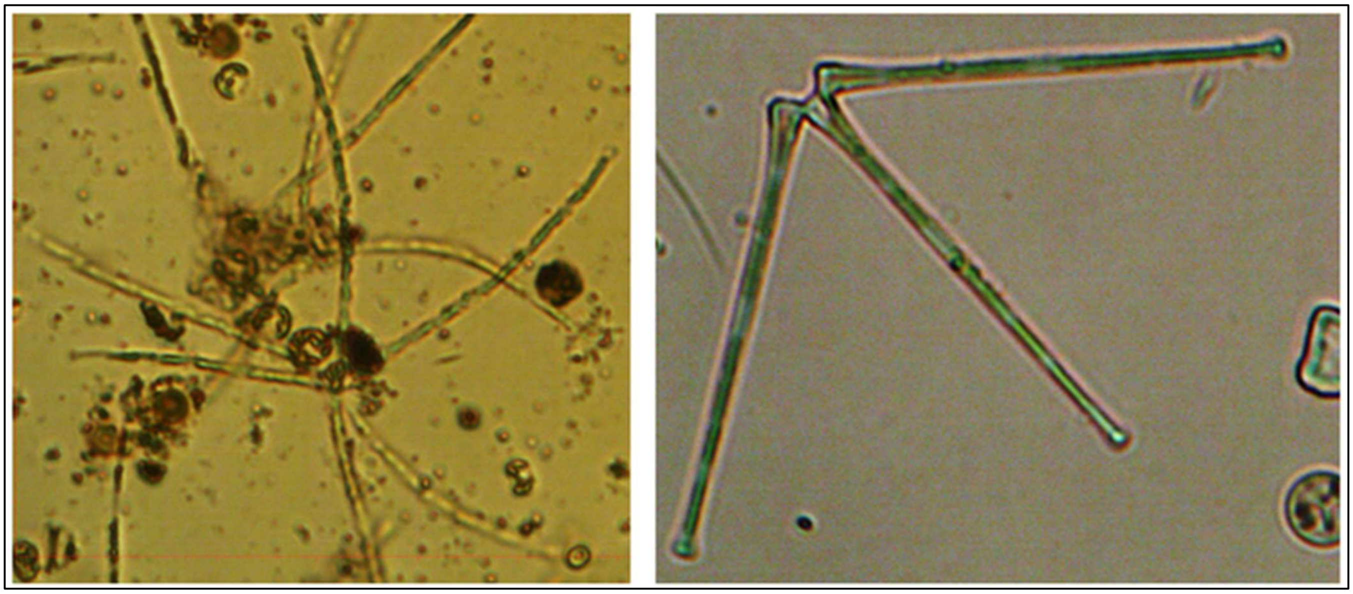

Figure 2: Degraded spring Asterionella (left) vs. summer Asterionella (right)

Overview (continued)

Cyanobacteria often dominate algae counts, but because of their small cell size cyanobacteria biovolume is typically low relative to other agal types. The large biovolume of the cyanobacteria *Aphanizomenon flos-aquae* (85%) reflects its large abundance in Charlie Lake (Figure 3).

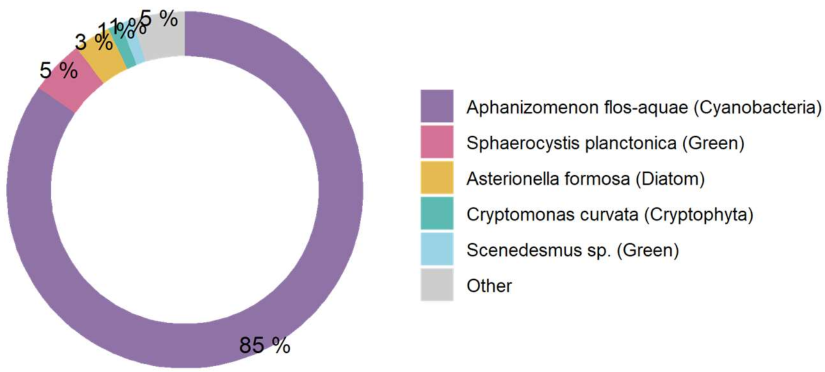

Figure 3: Dominant organisms from Charlie L. Deep Station 1.2 Km East of Park (0400390) as percent of total biovolume

Spring samples contained low concentrations of cyanobacteria and high concentrations of degraded diatoms. Summer samples contained large monocultural blooms of *Aphanizomenon* (Figure 3; Figure 4). While algal communities respond rapidly to environmental changes, including diatom blooms in the spring followed by cyanobacteria in the summer, the scale of cyanobacterial blooms observed in Charlie Lake could be reflective of nutrient imbalances (Figure 4).

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).

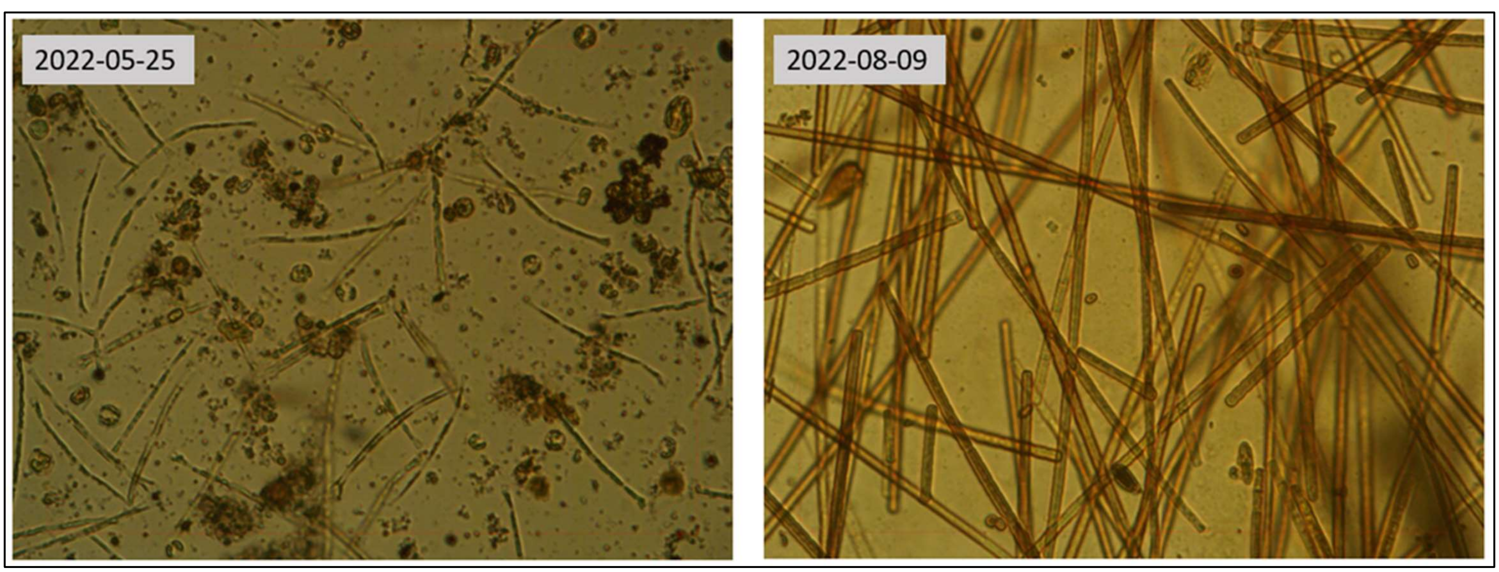

Figure 4: Contrasting algal community composition in the spring (dense diatoms bloom) vs. summer (dense cyanobacteria bloom)

Cyanobacterial Presence

Spring samples contained low concentrations of cyanobacteria and summer samples contained high concentrations of cyanobacteria (Figure 5). *Aphanizomenon* dominated both summer samples.

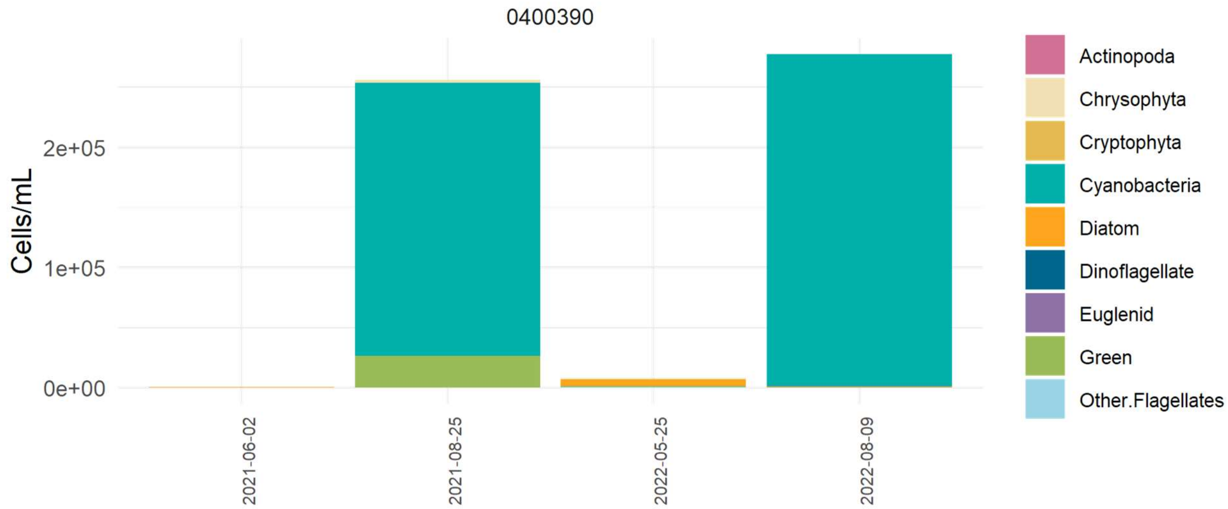

Figure 5: cell abundance for dominant cyanobacteria genera on Charlie Lake

Aphanizomenon is a filamentous, nitrogen-fixing cyanobacteria capable of forming dense, odorous and toxic blooms in both low and high inorganic nitrogen environments. A*phanizomenon* cells can produce liver toxins, nerve toxins, and skin irritants upon cell lysis (Cirés & Ballot, 2016). *Aphanizomenon flos aquae* dominated all summer counts but *Pseudoanabaena* species and *Coelosphaerium naegelianum* were also observed. *Pseudoanabaena* and *Coelosphaerium* species are 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 Charlie Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Aphanizomenon	273760	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Anabaenopeptins APT, Taste and Odor
Pseudanabaena	13756	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Anatoxins (-a) ATX, BMAA, Taste and Odor
Lyngbya	1480	Lyngbyatoxin LYN, Aplysiatoxins APL, 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 Charlie Lake are capable of producing cyanotoxins (Table 2). Charlie Lake displayed cyanobacteria levels in the high risk category depending on the season (large cyanobaceria blooms in the summer).

Charlie Lake has a mean cyanobacteria abundance of 125,732 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Charlie Lake as compared to alert levels defined by several authorities including the WHO and EPA.

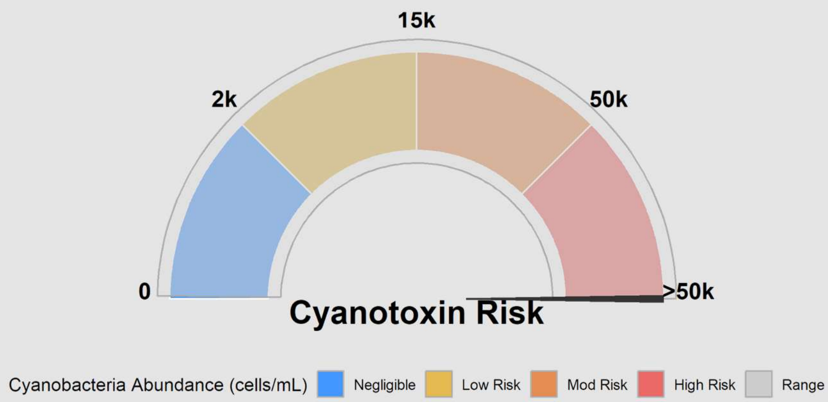

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Charlie Lake

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. The cyanobacterial blooms in Charlie Lake are so dense that they dominate in biovolume. Due the monocultural nature of Charlie Lake the cell abundance figures and biovolume both highlight *Aphanizomenon* as the dominant genus (Figure 7; Figure 8; Figure 9).

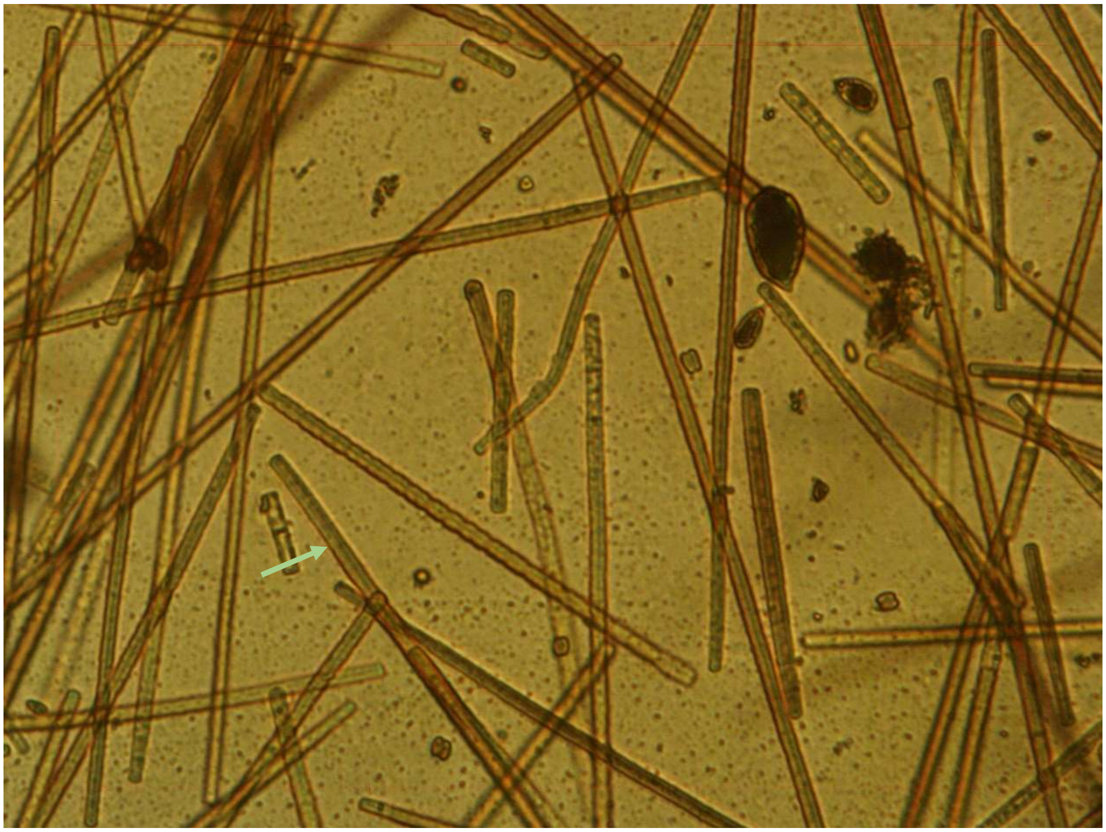

Figure 7: 400x magnification of Aphanizomenon flos aquae strands (green arrow)

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. Note the dominance of cyanobacteria in both Figure 8 (cell abundance) and Figure 9 (biovolume).

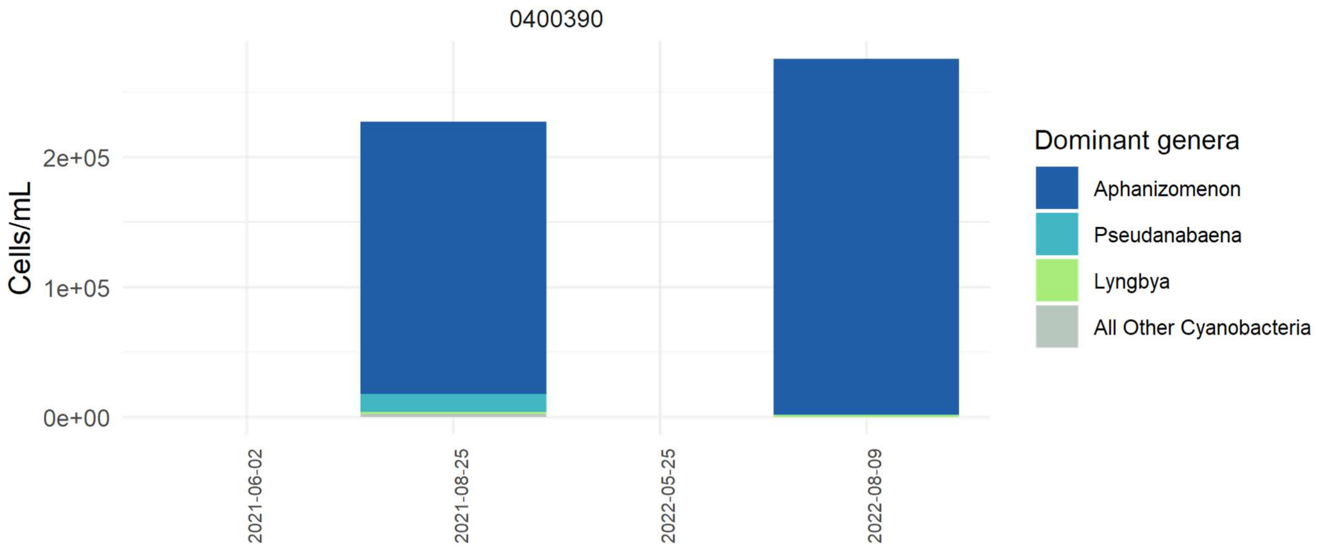

Figure 8: Cell abundance of high-level taxa groups on Charlie Lake

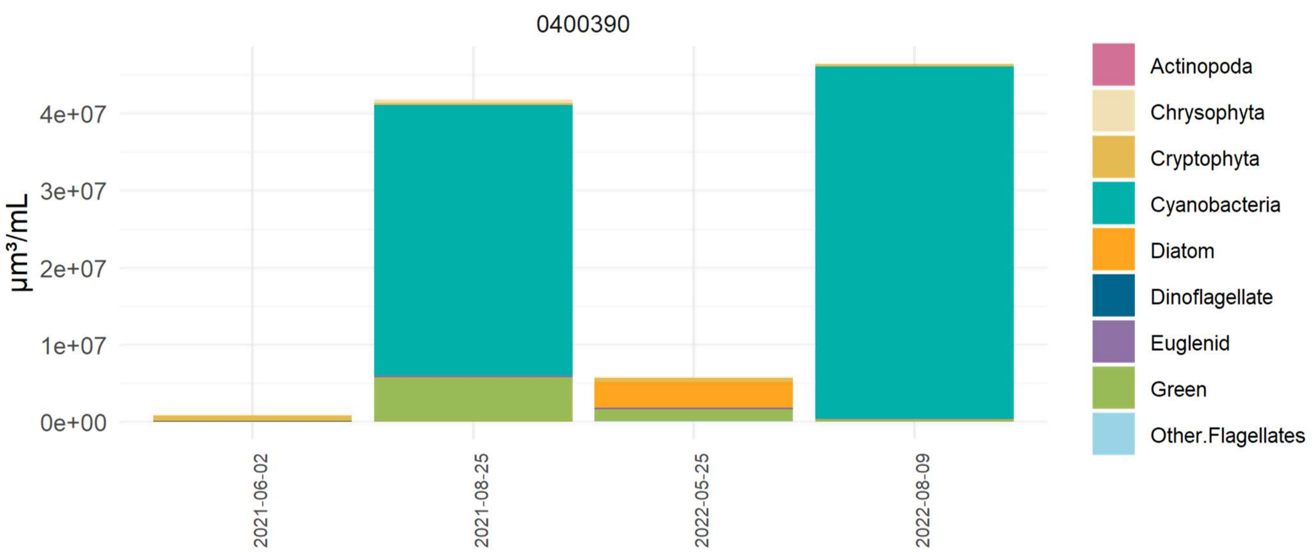

Figure 9: Biovolume of high-level taxa groups on Charlie Lake

References

Cirés, S., & Ballot, A. (2016). A review of the phylogeny, ecology and toxin production of bloom-forming Aphanizomenon spp. and related species within the Nostocales (cyanobacteria). *Harmful Algae*, *54*, 21–43. https://doi.org/10.1016/j.hal.2015.09.007

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

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

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:

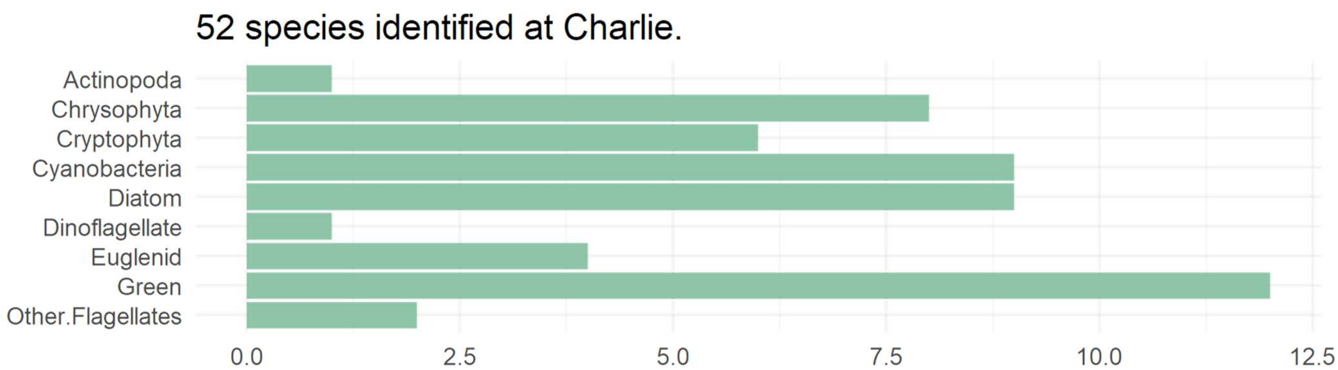

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 400390	**Total Abundance (cells/mL):**	**747**		
Collection Date: 2021-06-02	**Total Biovolume (µm³/mL):**	**851525**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	4	6008	Chrysophyta	1515
Mallomonas sp.	8	24194	Chrysophyta	1598
Ochromonas sp.	4	856	Chrysophyta	1455
Chrysococcus sp.	8	2656	Chrysophyta	1751
Cryptomonas curvata	61	384296	Cryptophyta	10635
Cryptomonas ovata	76	165367	Cryptophyta	10635
Cryptomonas marssonii	49	100052	Cryptophyta	10635
Rhodomonas lacustris	27	2932	Cryptophyta	10663
Aphanizomenon flos-aquae	19	3164	Cyanobacteria	1191
Anabaena flos-aquae	38	7396	Cyanobacteria	1100
Aulacoseira granulata	4	1316	Diatom	590863
Asterionella formosa	15	10445	Diatom	3116
Eunotia sp.	326	48501	Diatom	3337
Fragilaria capucina	8	3884	Diatom	2932
Nitzschia sp.	11	1009	Diatom	5070
Urosolenia sp.	4	25164	Diatom	590843
Gymnodinium sp.	8	16948	Dinoflagellate	10031
Paranema sp.	8	4771	Euglenid	
Phacus sp.	4	16287	Euglenid	9766
Asterococcus sp.	11	12654	Green	9178
Oocystis sp.	8	151	Green	5827
Closteriopsis acicularis	4	4712	Green	5926
Scenedesmus sp.	15	3501	Green	6104
microflagellate	23	3870	Other.Flagellates	
UID flagellate	4	1391	Other.Flagellates	

Figure 11: Raw data from 2021-06-02 EMS site 0400390

EMS ID: 400390	**Total Abundance (cells/mL):**	**255950**		
Collection Date: 2021-08-25	**Total Biovolume (µm³/mL):**	**41838194**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Ochromonas sp.	2049	438627	Chrysophyta	1455
Chrysococcus sp.	247	82010	Chrysophyta	1751
Cryptomonas curvata	38	239398	Cryptophyta	10635
Rhodomonas lacustris	152	16504	Cryptophyta	10663
Aphanizomenon flos-aquae	209312	34851371	Cyanobacteria	1191
Anacystis sp.	2391	4550	Cyanobacteria	609
Anabaena helicoidea	152	20056	Cyanobacteria	1100
Pseudanabaena sp.	13756	153272	Cyanobacteria	1175
Lyngbya birgei	1480	1385	Cyanobacteria	870
Trachelomonas scabra	76	252136	Euglenid	9690
Sphaerocystis planctonica	21610	4675526	Green	9169
Tetraedron minimum	76	9348	Green	5661
Scenedesmus sp.	4592	1071627	Green	6104
Closteriopsis acicularis	19	22384	Green	5926

Figure 12: Raw data from 2021-08-25 EMS site 0400390

EMS ID: 400390	**Total Abundance (cells/mL):**	**8059**		
Collection Date: 2022-05-25	**Total Biovolume (µm³/mL):**	**5856875**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	4	673	Actinopoda	
Chrysochromulina sp.	767	29501	Chrysophyta	2160
Chromulina sp.	15	26507	Chrysophyta	1717
Dinobryon spp.	8	12692	Chrysophyta	1515
Mallomonas sp.	8	24194	Chrysophyta	1598
Ochromonas sp.	201	43028	Chrysophyta	1455
Dinobryopsis sp.	15	4029	Chrysophyta	1557
Cryptomonas sp.	68	125939	Cryptophyta	10635
Cryptomonas curvata	49	308697	Cryptophyta	10635
Cryptomonas ovata	46	100091	Cryptophyta	10635
Rhodomonas lacustris	110	11944	Cryptophyta	10663
Anabaena sp.	11	825	Cyanobacteria	1100
Aphanizomenon flos-aquae	15	2498	Cyanobacteria	1191
Synechocystis sp.	8	268	Cyanobacteria	799
Aulacoseira sp.	38	62533	Diatom	590863
Asterionella formosa	4512	3141804	Diatom	3116
Eunotia cf. zasuminensis	653	111802	Diatom	3337
Ulnaria acus	4	4167	Diatom	970000
Gymnodinium sp.	4	8474	Dinoflagellate	10031
Trachelomonas sp.	65	229729	Euglenid	9690
Ankistrodesmus sp.	11	1729	Green	5877
Monoraphidium sp.	171	113289	Green	5990
Schroederia sp.	4	1018	Green	
Closterium acutum	23	924805	Green	7257
Didymocystis fina	8	2155	Green	55858
Chlamydomonas sp.	827	494829	Green	5448
microflagellate	414	69655	Other.Flagellates	

Figure 13: Raw data from 2022-05-25 EMS site 0400390

EMS ID: 400390	**Total Abundance (cells/mL):**	**287190**		
Collection Date: 2022-08-09	**Total Biovolume (µm³/mL):**	**46889884**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chromulina sp.	30	53014	Chrysophyta	1717
Ochromonas sp.	30	6422	Chrysophyta	1455
Cryptomonas sp.	30	55561	Cryptophyta	10635
Cryptomonas curvata	30	188998	Cryptophyta	10635
Cryptomonas ovata	15	32638	Cryptophyta	10635
Cryptomonas erosa	15	26578	Cryptophyta	10635
Rhodomonas lacustris	167	18133	Cryptophyta	10663
Anabaena sp.	137	10272	Cyanobacteria	1100
Anacystis sp.	121	230	Cyanobacteria	609
Aphanizomenon flos-aquae	273760	45582247	Cyanobacteria	1191
Lyngbya birgei	1199	1122	Cyanobacteria	870
Microcystis viridis	1457	48825	Cyanobacteria	747
Pseudanabaena cf. minima	531	16546	Cyanobacteria	1175
Trachelomonas sp.	30	106029	Euglenid	9690
Didymocystis fina	1229	331082	Green	55858
Coelosphaerium naegelianum	8318	396876	Green	791
microflagellate	91	15311	Other.Flagellates	

Figure 12: Raw data from 2022-08-09 EMS site 0400390