Cluculz Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from one site on Cluculz Lake during 2021 and 2022 (Figure 1; Table 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
CLUCULZ L DEEP STN EAST ARM CENTER (0400502)	2021-05-25 2021-08-12 2022-05-17 2022-08-15
	Total= 4 samples

Figure 1: Aerial view of Cluculz Lake

Summer blooms of large toxin producing cyanobacteria were a key feature of Cluculz Lake (Cyanobacterial Presence). Spring samples contained low densities of cyanobacteria.

All samples contained low densities of diatoms, green algae, and dinoflagellates. Dominant diatom genera included *Aulacoseira* and *Tabellaria*. Spring samples collected in Cluculz Lake also demonstrated diatom degradation reflective of lowering silica levels in the late spring (Figure 2).

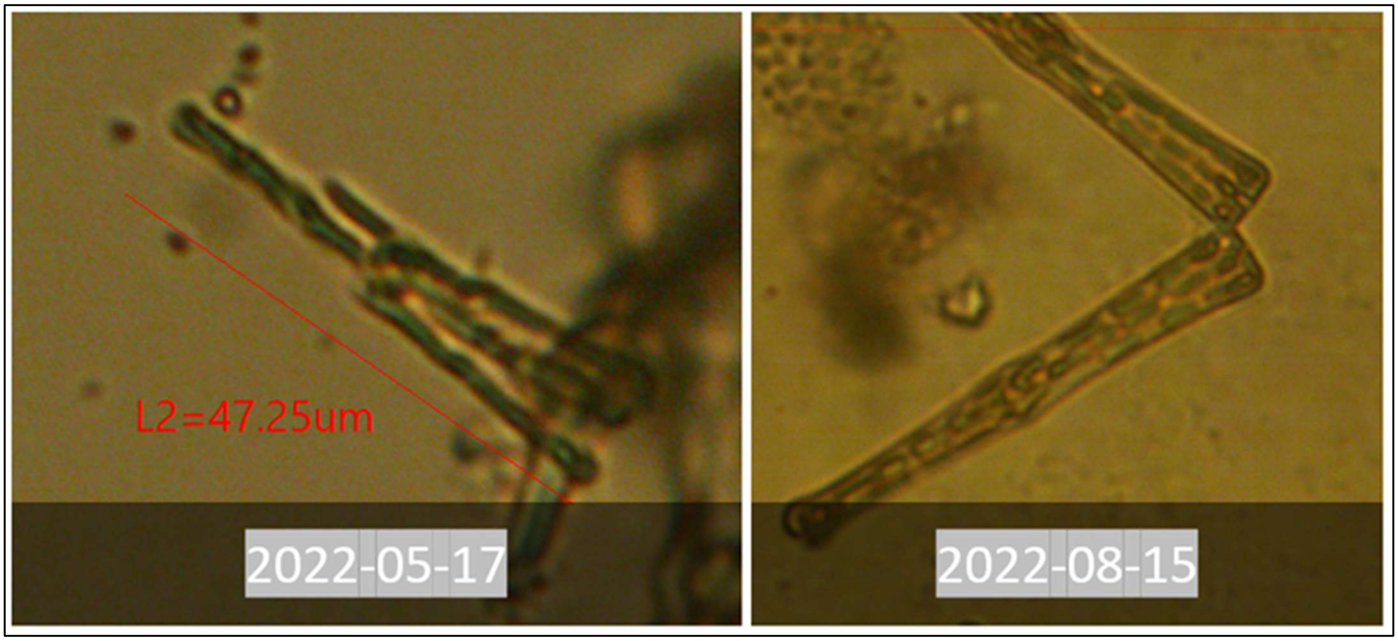

Figure 2: Degraded spring Tabellaria (left) vs. summer Tabellaria (right)

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 cyanobacteria (61%) in Cluculz Lake emphasizes their high concentrations (Figure 3).

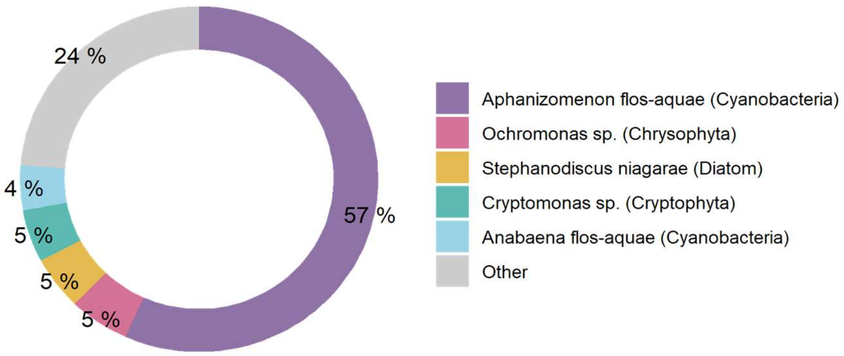

Figure 3: Dominant organisms from Cluculz L Deep Stn East Arm Center (0400502) as percent of total biovolume

All sites included moderate densities of micro-flagellates, specifically Cryptomonad species from Cryptophyta. Cryptomonads are favored components of freshwater food webs and are selectively consumed by several zooplankton, ciliates, and dinoflagellates (Wehr et al., 2015). Summer samples contained large amorphous clouds of degraded cyanobacteria and bacteria (Figure 4). Degraded cyanobacteria could represent threat to public health because cyanotoxins are usually contained within cyanobacterial cells before cell death (EPA, 2022).

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).

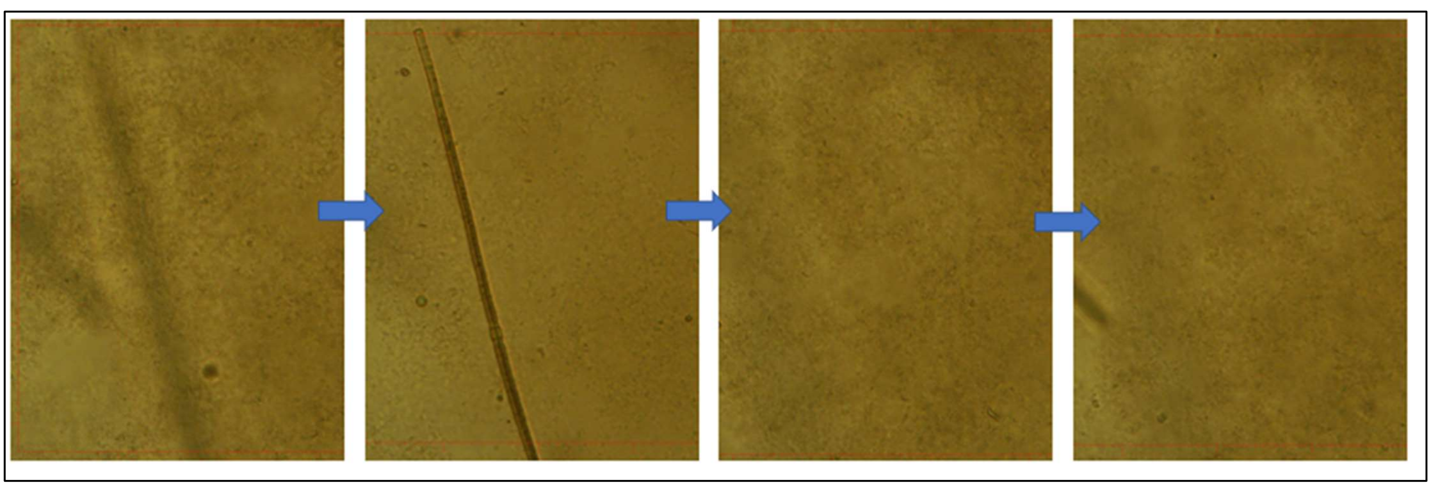

Figure 4: One microscopic frame with different panes of focus due to visual obstruction of degraded cyanobacteria/bacteria cloud

Cyanobacterial Presence

Spring samples contained low concentrations of cyanobacteria, but summer samples contained dense cyanobacteria blooms. Dominant genera included *Anabaena*, *Anacystis*, and *Aphanizomenon* (Figure 5).

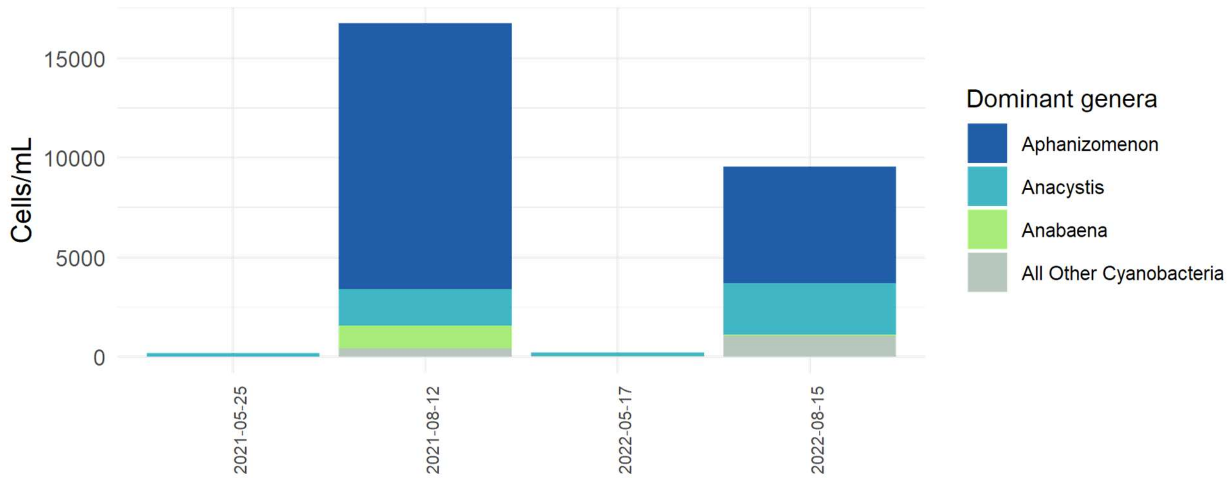

Figure 5: cell abundance for dominant cyanobacteria genera on Cluculz Lake

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 Cluculz Lake could be reflective of nutrient imbalances. *Aphanizomenon flos-aquae* dominated all summer counts but *Anacystis* and *Anabaena* species were also observed. *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). *Anacystis* and *Anabaena* species 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 Cluculz Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Aphanizomenon	13361	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Anabaenopeptins APT, Taste and Odor
Anacystis	2588	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD, Anatoxins (-a) ATX, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT
Anabaena	1150	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 Cluculz Lake can produce cyanotoxins (Table 2).

Cluculz Lake displayed cyanobacteria levels in the negligible to moderate-risk category, depending on the season. The mean cyanobacteria abundance was 6,680 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Cluculz Lake compared to alert levels defined by several authorities including the WHO and EPA.

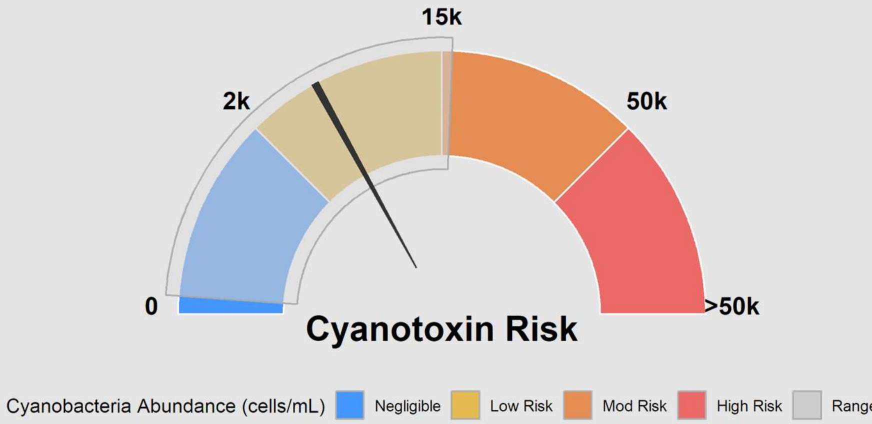

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Cluculz Lake

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 Cluculz Lake are dense enough to dominate in biovolume on some dates (Figure 7;Figure 8;Figure 9).

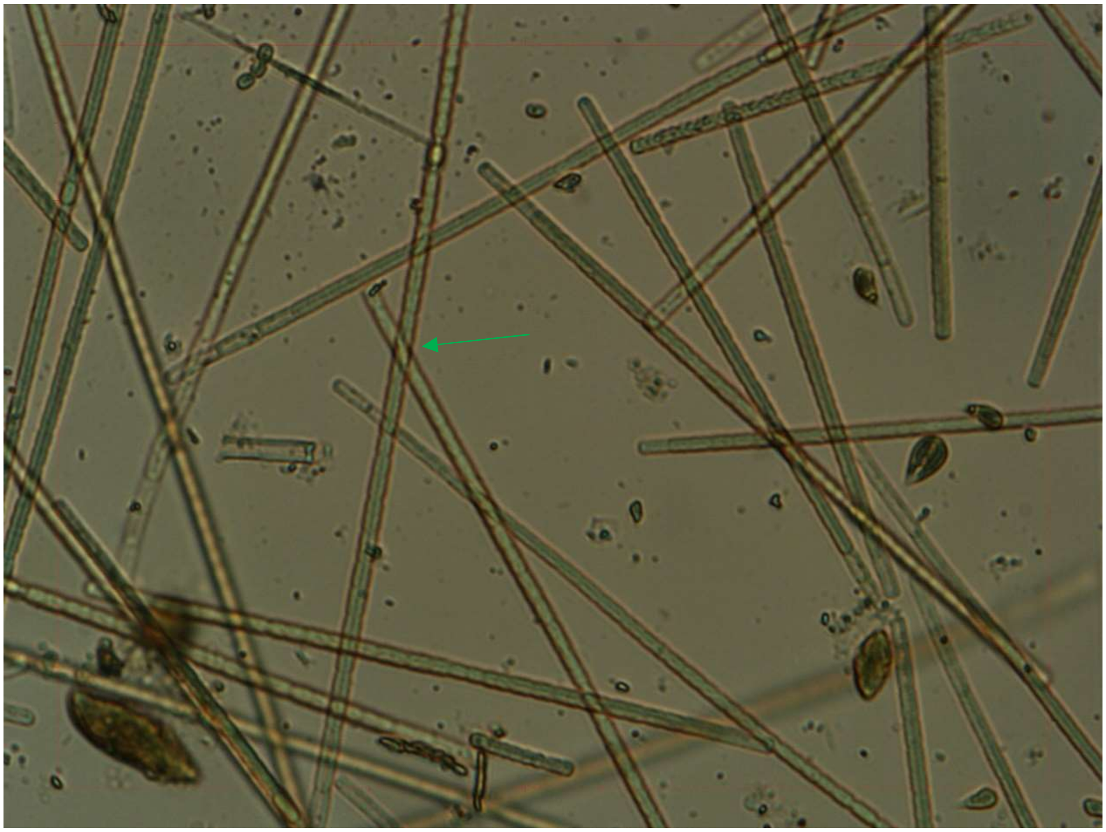

Figure 7: 400x magnification of Aphanizomenon flos aquae strands (green arrow)

Species Composition

All 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.

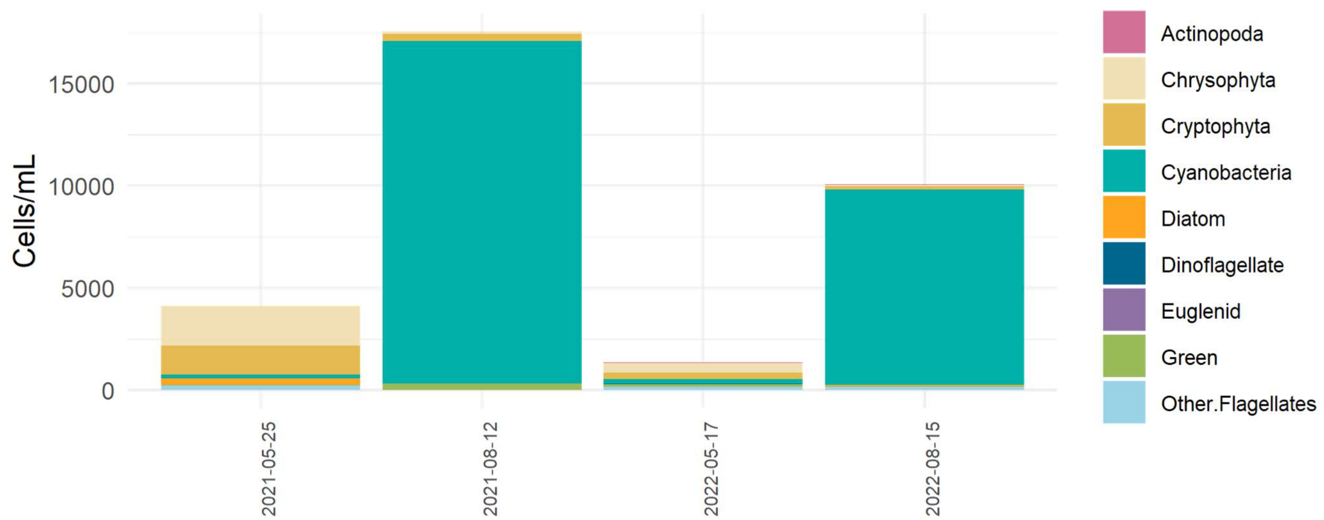

Figure 8: Cell abundance of high-level taxa groups on Cluculz Lake

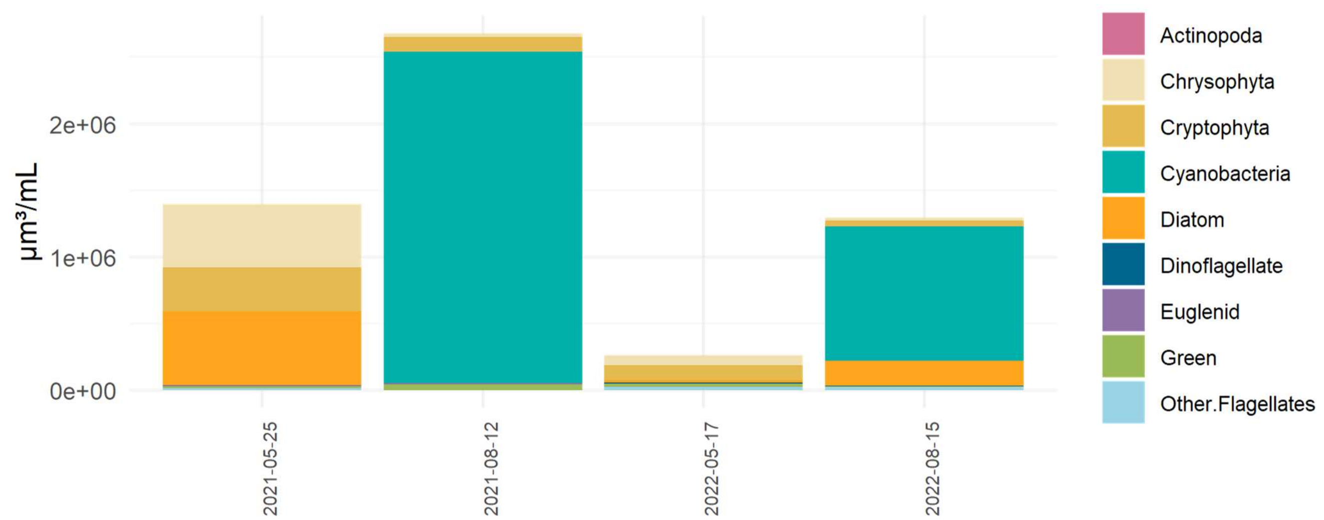

Figure 9: Biovolume of high-level taxa groups on Cluculz Lake

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

EPA. (2022, September). *Learn about Cyanobacteria and Cyanotoxins*. United States Environmental Protection Agency.

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

Wehr, J. D., Sheath, R. G., & Kociolek, P. (2015). *Freshwater Algae of North America* (Second). Elsevier Inc.

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

Report prepared by: Larratt Aquatic Consulting Ltd.

Stephanie Butt: Taxonomist, H. B.Sc., BIT.

Jamie Self: Senior Aquatic Biologist, R.P. Bio

Reviewed by:

Sara Knezevic: Senior Field Biologist, B.Sc., BIT.

Appendix

Additional figures and raw data are listed below:

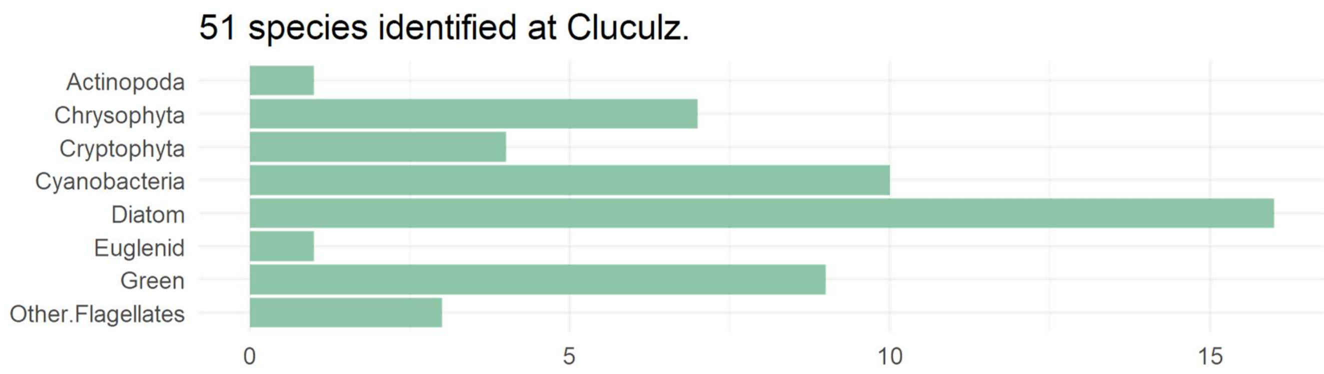

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 400502	**Total Abundance (cells/mL):**	**4127**		
Collection Date: 2021-05-2	**Total Biovolume (µm³/mL):**	**1448390**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	23	34546	Chrysophyta	1515
Ochromonas sp.	1100	235476	Chrysophyta	1455
Chrysochromulina sp.	212	8154	Chrysophyta	2160
Chroomonas sp.	57	12960	Chrysophyta	10613
Chrysococcus sp.	558	185270	Chrysophyta	1751
Dinobryopsis sp.	190	51035	Chrysophyta	1557
Cryptomonas sp.	99	183352	Cryptophyta	10635
Rhodomonas lacustris	1328	144191	Cryptophyta	10663
Anacystis sp.	163	310	Cyanobacteria	609
Anabaena flos-aquae	15	2919	Cyanobacteria	1100
Aulacoseira sp.	53	87217	Diatom	590863
Aulacoseira subarctica	68	36876	Diatom	590863
Eunotia sp.	19	2827	Diatom	3337
Asterionella formosa	80	55706	Diatom	3116
Fragilaria capucina	23	11168	Diatom	2932
Gomphonema sp.	4	5508	Diatom	4911
Navicula spp.	11	6480	Diatom	3649
Nitzschia sp.	19	1742	Diatom	5070
Stephanodiscus niagarae	27	283534	Diatom	2415
Ulnaria ulna	8	42038	Diatom	970000
Synedra tabulata	8	19440	Diatom	3013
Trachelomonas scabra	4	13270	Euglenid	9690
Ankistrodesmus sp.	8	1258	Green	5877
Cosmarium cf. depressum	8	6499	Green	7848
Chlamydomonas sp.	8	4787	Green	5448
UID flagellate	34	11827	Other.Flagellates	

Figure 11: Raw data from 2021-05-25 EMS site 0400502

EMS ID:400502	Total Abundance (cells/mL):	17564		
Collection Date:2021-08-12	Total Biovolume (µm³/mL):	2684130		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Ochromonas sp.	137	29327	Chrysophyta	1455
Chrysococcus sp.	4	1328	Chrysophyta	1751
Dinobryopsis sp.	15	4029	Chrysophyta	1557
Cryptomonas sp.	42	77786	Cryptophyta	10635
Rhodomonas lacustris	285	30945	Cryptophyta	10663
Aphanizomenon flos-aquae	13361	2224665	Cyanobacteria	1191
Anacystis sp.	1829	3480	Cyanobacteria	609
Anabaena flos-aquae	1150	223817	Cyanobacteria	1100
Limnothrix sp.	72	1018	Cyanobacteria	
Pseudanabaena limnetica	353	32438	Cyanobacteria	1175
Trachelomonas scabra	4	13270	Euglenid	9690
Crucigenia tetrapedia	304	37240	Green	6225
Chlamydomonas sp.	8	4787	Green	5448

Figure 12: Raw data from 2021-08-12 EMS site 0400502

EMS ID: 400502	Total Abundance (cells/mL):	1345		
Collection Date: 2022-05-17	Total Biovolume (µm³/mL):	268328		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	11	1851	Actinopoda	
Chrysococcus sp.	4	1328	Chrysophyta	1751
Chrysochromulina sp.	288	11077	Chrysophyta	2160
Chromulina sp.	15	26507	Chrysophyta	1717
Ochromonas sp.	148	31682	Chrysophyta	1455
Dinobryopsis sp.	8	2149	Chrysophyta	1557
Cryptomonas sp.	8	14816	Cryptophyta	10635
Cryptomonas curvata	8	50400	Cryptophyta	10635
Cryptomonas erosa	8	14175	Cryptophyta	10635
Rhodomonas lacustris	296	32139	Cryptophyta	10663
Anacystis sp.	178	339	Cyanobacteria	609
Planktolyngbya sp.	15	186	Cyanobacteria	
Planktothrix sp.	27	1503	Cyanobacteria	189420
Asterionella formosa	8	5571	Diatom	3116
Lindavia bodanica	8	8348	Diatom	
Nitzschia acicularis	4	3158	Diatom	5070
Nitzschia closterium	4	1579	Diatom	5070
Parvodinium sp.	15	8270	Dinoflagellate	
Oocystis sp.	19	358	Green	5827
Didymocystis bicellularis	83	22360	Green	55858
Scenedesmus arcuatus	15	1089	Green	6104
microflagellate	175	29443	Other.Flagellates	

Figure 13: Raw data from 2022-05-17 EMS site 0400502

EMS ID: 400502	Total Abundance (cells/mL):	10058		
Collection Date: 2022-08-15	Total Biovolume (µm³/mL):	1301018		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	4	673	Actinopoda	
Chrysochromulina sp.	27	1038	Chrysophyta	2160
Chromulina sp.	8	14137	Chrysophyta	1717
Ochromonas sp.	46	9847	Chrysophyta	1455
Cryptomonas curvata	4	25200	Cryptophyta	10635
Rhodomonas lacustris	148	16070	Cryptophyta	10663
Anabaena flos-aquae	57	11094	Cyanobacteria	1100
Anacystis sp.	2588	4924	Cyanobacteria	609
Aphanizomenon flos-aquae	5855	974883	Cyanobacteria	1191
Aphanocapsa sp.	782	2470	Cyanobacteria	625
Chroococcus dispersus var. minor	15	212	Cyanobacteria	654
Chroococcus turgidus	30	10164	Cyanobacteria	654
Planktolyngbya sp.	228	2834	Cyanobacteria	
Lindavia intermedia	4	3536	Diatom	
Lindavia bodanica	4	4174	Diatom	
Tabellaria fenestrata	68	182769	Diatom	3241
Parvodinium sp.	4	2205	Dinoflagellate	
Monoraphidium sp.	4	2650	Green	5990
Didymocystis fina	15	4041	Green	55858
microflagellate	167	28097	Other.Flagellates	

Figure 14: Raw data from 2022-08-15 EMS site 0400502