Windermere Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from one site on Windermere Lake during 2021 and 2022 (Table 1; Figure 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
WINDERMERE L. OFF TIMBER RIDGE (0200052)	2021-05-17 2021-08-18 2022-04-20 2022-08-11
	Total= 4 samples

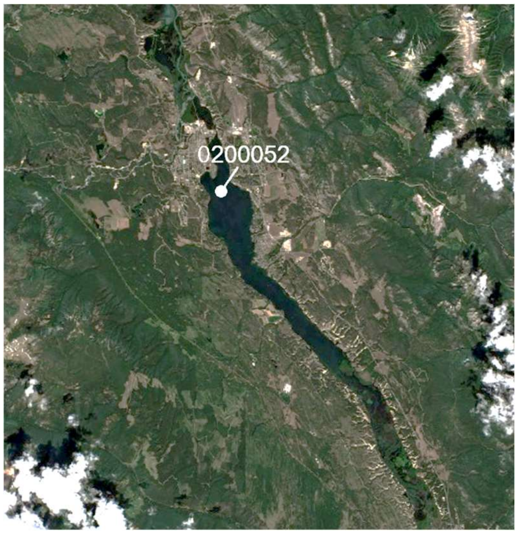

Figure 1: Aerial view of Windermere Lake

Samples collected in 2021 contained low densities of algae but high densities of degraded cyanobacteria, bacteria, and other debris relative to 2022 samples (Figure 2).

Elevated quantities of suspended debris can affect the health and aesthetics of a water system. Particulates in the water column can cause cloudy hues and provide attachment zones for pollutants; notably metals and bacteria (Water Science School et al., 2018).

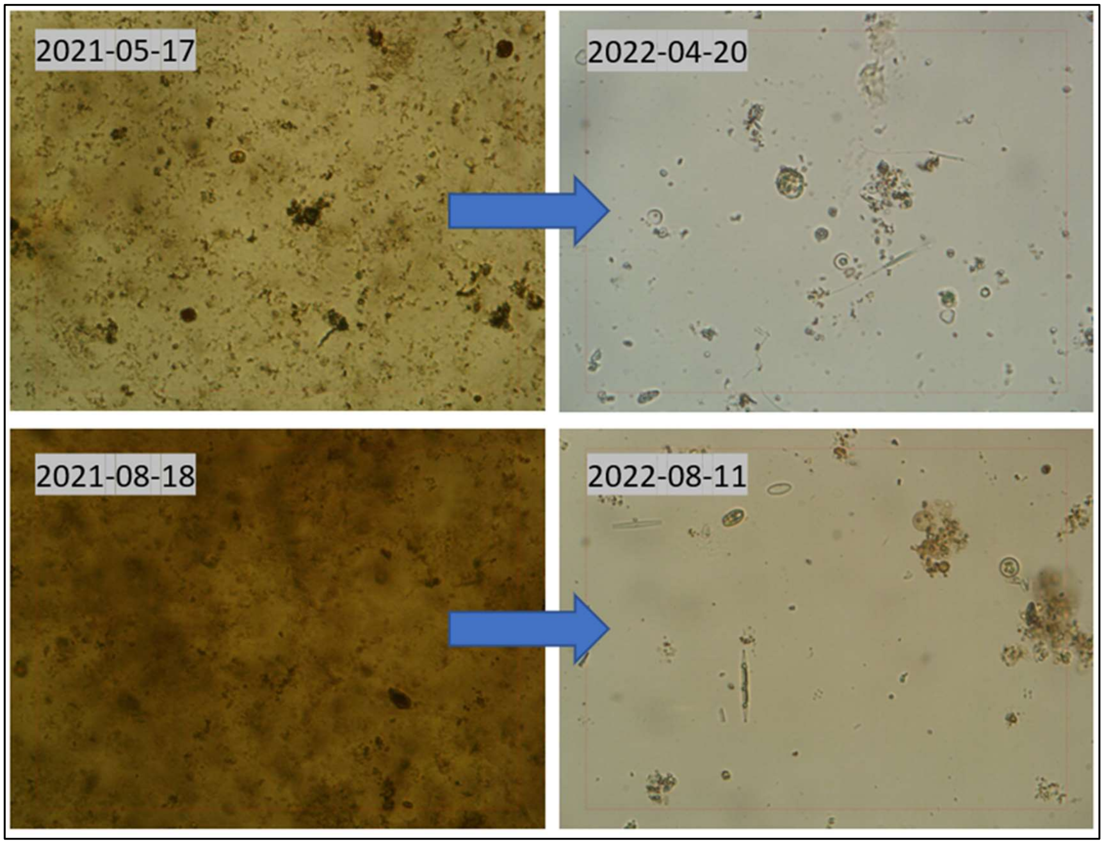

Figure 2: Comparison between samples collected in 2021 vs. samples collected in 2022

Overview (continued)

Chrysophyta genera dominated total biovolumes, specifically genus *Dinobryon* and *Dinobryopsis* (Figure 3).

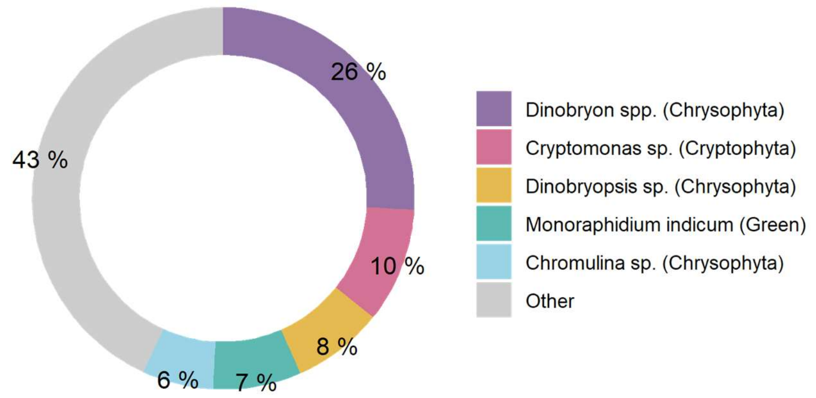

Figure 3: Dominant organisms from Windermere L. Off Timber Ridge (0200052) as percent of total biovolume

Dinobryopsis exceeded *Dinobryon* in counts, but *Dinobryopsis's* small size caused it to represent only 8% of total biovolume (Figure 3; Figure 4).

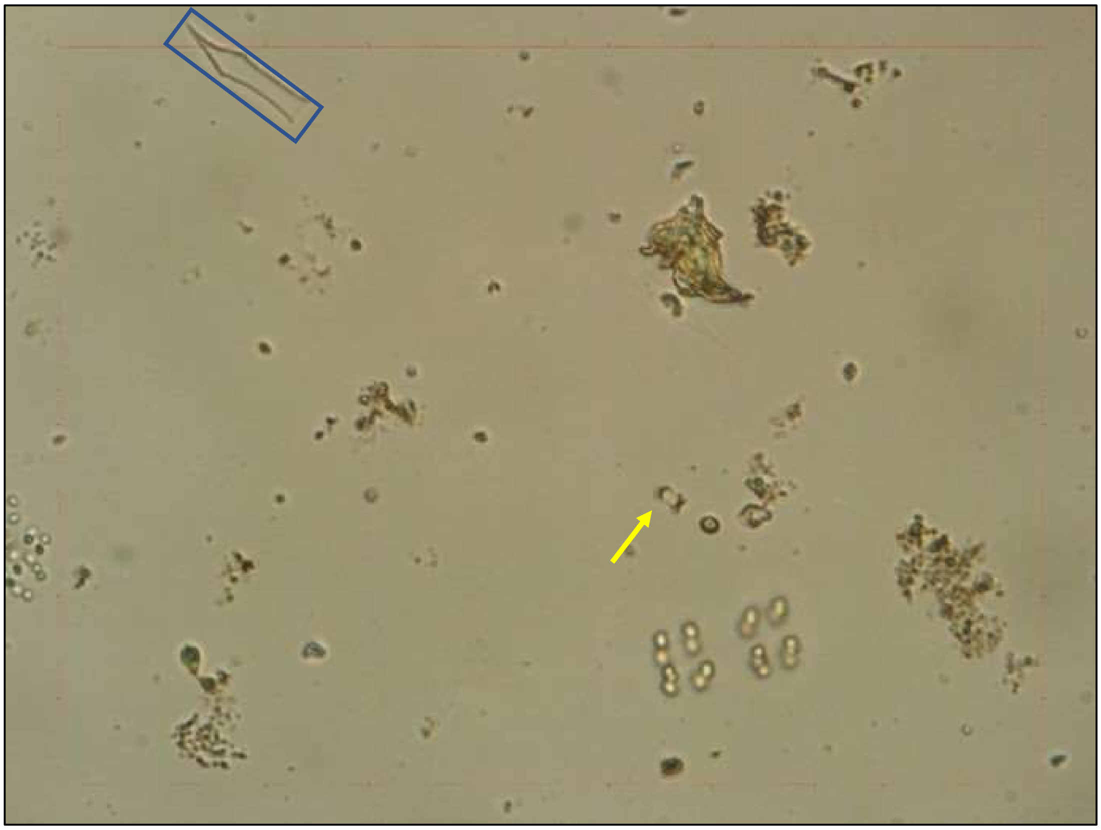

Figure 4: Size comparison between Dinobryon (blue box) and Dinobyopsis (yellow arrow)

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 levels of cyanobacteria compared to spring samples. Dominant genera include *Anacystis*, *Planktolyngbya*, and *Chroococcus* (Figure 5).

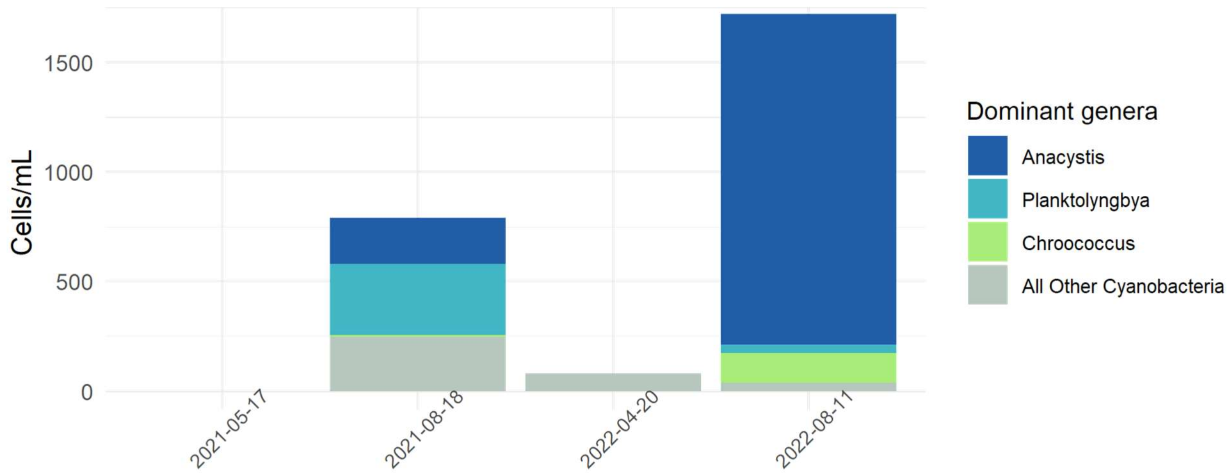

Figure 5: cell abundance for dominant cyanobacteria genera on Windermere Lake

Dominant cyanobacteria identified in samples 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 Windermere Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Anacystis	1127	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD, Anatoxins (-a) ATX, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT
Planktolyngbya	326	Lyngbyatoxin LYN, Microcystin MC, BMAA
Chroococcus	121	Microcystin MC, BMAA

Note: * = counted in samples

Cyanobacterial Presence (Continued)

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

Windermere Lake displayed a range of cyanobacteria levels in the negligible risk category, with a mean cyanobacteria abundance of 864 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Windermere Lake as compared to alert levels defined by several authorities including the WHO and EPA.

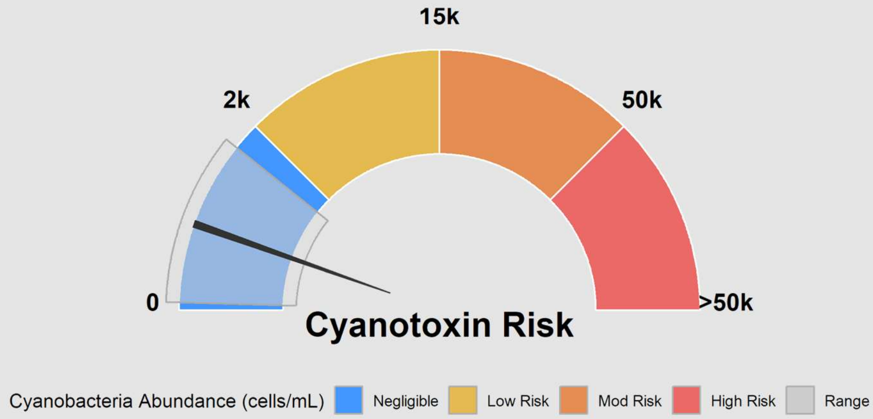

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Windermere Lake

One summer sample (2021-08-18) contained large amorphous clouds of degraded cyanobacteria and bacteria (Figure 7). Degraded cyanobacteria could represent threats to public health as cyanotoxins are usually contained within the cyanobacterial cells before cell death (EPA, 2022).

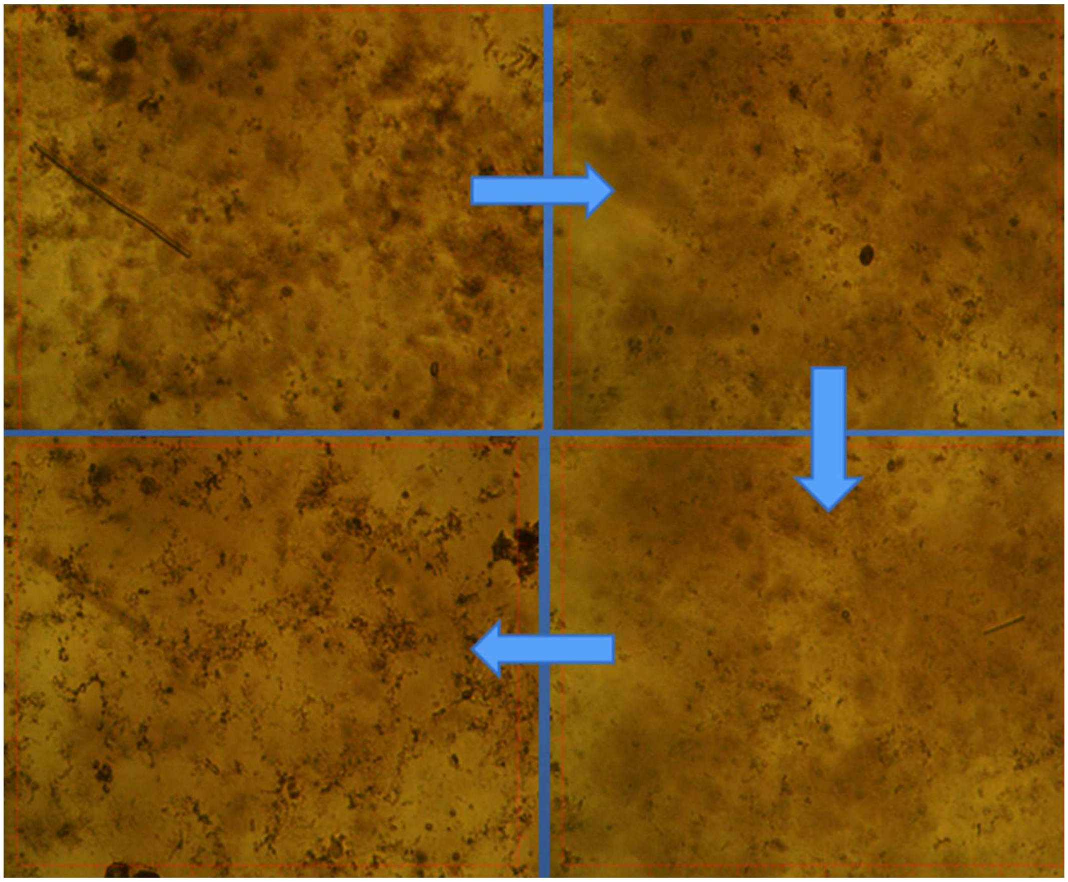

Figure 7: One microscopic frame highlighting visual obstruction in the 2021-08-18 sample. All photos were collected from the same microscopic frame but at different levels in the cloudy matrix.

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.

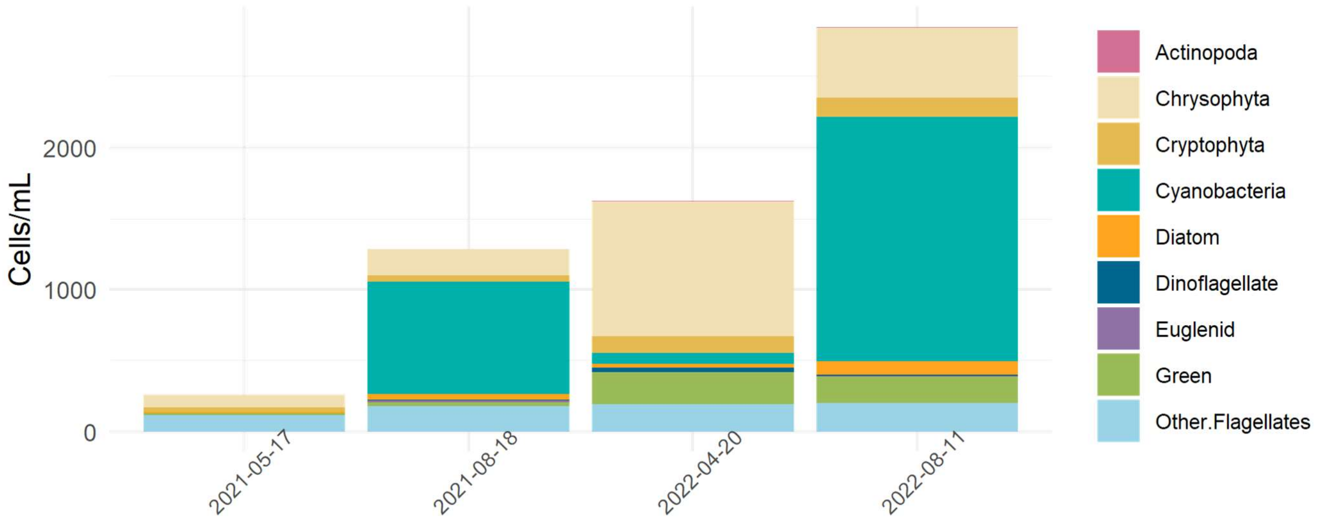

Figure 8: Cell abundance of high-level taxa groups on Windermere Lake

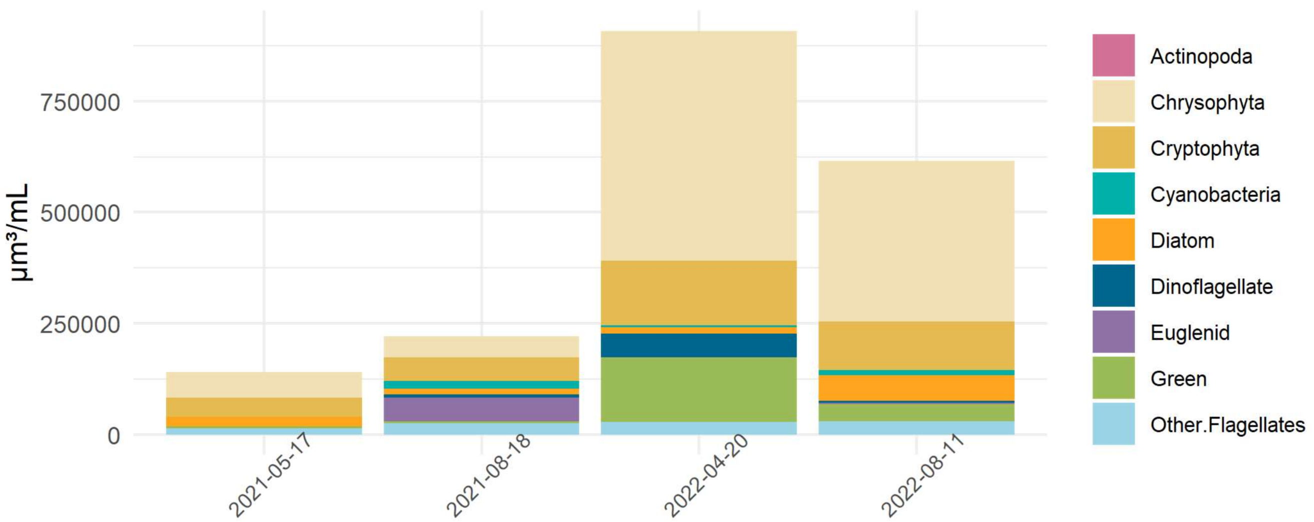

Figure 9: Biovolume of high-level taxa groups on Windermere Lake

References

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

Water Science School, Swanson, H. A., & Baldwin, H. L. (2018, June 18). *Turbidity and Water* . USGS.

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.

Stephanie Butt

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

Reviewed by:

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

Appendix

Additional figures and raw data are listed below:

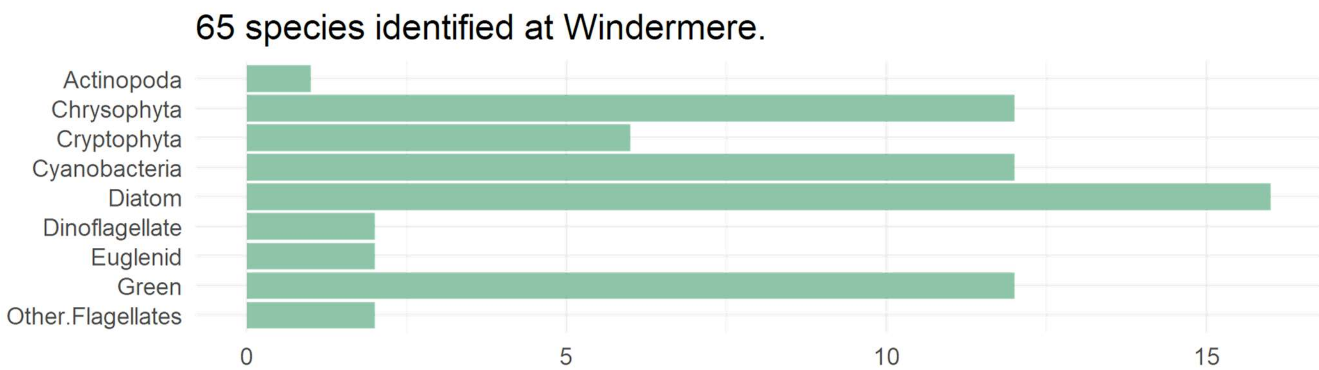

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 0200052	**Total Abundance (cells/mL):**	**260**		
Collection Date: 2021-05-17	**Total Biovolume (µm³/mL):**	**147191**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	34	51068	Chrysophyta	1515
Bitrichia sp.	4	459	Chrysophyta	
Ochromonas sp.	8	1713	Chrysophyta	1455
Chrysochromulina sp.	38	1462	Chrysophyta	2160
Chrysococcus sp.	8	2656	Chrysophyta	1751
Dinobryopsis sp.	19	5104	Chrysophyta	1557
Cryptomonas sp.	23	42597	Cryptophyta	10635
Rhodomonas lacustris	8	869	Cryptophyta	10663
Achnanthidium minutissimum	4	759	Diatom	590864
Ulnaria ulna	4	21019	Diatom	970000
Scenedesmus sp.	15	3501	Green	6104
microflagellate	95	15984	Other.Flagellates	

Figure 11: Raw data from 2021-05-17 EMS site 0200052

EMS ID: 0200052	Total Abundance (cells/mL):	1287		
Collection Date: 2021-08-18	Total Biovolume (µm³/mL):	224203		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	11	16522	Chrysophyta	1515
Bitrichia sp.	15	1720	Chrysophyta	
Ochromonas sp.	23	4924	Chrysophyta	1455
Chrysochromulina sp.	72	2769	Chrysophyta	2160
Chrysococcus sp.	65	21582	Chrysophyta	1751
Cryptomonas sp.	23	42597	Cryptophyta	10635
Cryptomonas marssonii	4	8167	Cryptophyta	10635
Rhodomonas lacustris	19	2063	Cryptophyta	10663
Anacystis sp.	209	398	Cyanobacteria	609
Chroococcus sp.	8	268	Cyanobacteria	654
Gloeocapsa punctata	57	239	Cyanobacteria	682
Lyngbya wollei	38	36	Cyanobacteria	870
Planktolyngbya sp.	326	4052	Cyanobacteria	
Pseudanabaena limnetica	114	10476	Cyanobacteria	1175
Synechocystis sp.	38	1273	Cyanobacteria	799
Achnanthidium minutissimum	15	2845	Diatom	590864
Gomphonema sp.	4	5508	Diatom	4911
Navicula spp.	4	2356	Diatom	3649
Nitzschia sp.	19	1742	Diatom	5070
Peridinium inconspicuum	4	7326	Dinoflagellate	10212
Trachelomonas sp.	15	53014	Euglenid	9690
Ankistrodesmus sp.	11	1729	Green	5877
Elakatothrix gelatinosa	15	2649	Green	9412
microflagellate	178	29948	Other.Flagellates	

Figure 12: Raw data from 2021-08-18 EMS site 0200052

EMS ID: 0200052	Total Abundance (cells/mL):	1625		
Collection Date: 2022-04-20	Total Biovolume (µm³/mL):	912499		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	4	673	Actinopoda	
Chrysococcus sp.	38	12617	Chrysophyta	1751
Chrysochromulina sp.	53	2039	Chrysophyta	2160
Chromulina sp.	11	19439	Chrysophyta	1717
Dinobryon sp.	30	45060	Chrysophyta	1515
Dinobryon spp.	171	271286	Chrysophyta	1515
Kephyrion sp.	156	32675	Chrysophyta	1764
Dinobryopsis sp.	493	132423	Chrysophyta	1557
Cryptomonas sp.	53	98158	Cryptophyta	10635
Cryptomonas curvata	4	25200	Cryptophyta	10635
Cryptomonas ovata	8	17407	Cryptophyta	10635
Rhodomonas lacustris	49	5320	Cryptophyta	10663
Planktothrix sp.	80	4453	Cyanobacteria	189420
Fragilaria tenera	8	3884	Diatom	2932
Lindavia intermedia	11	9723	Diatom	
Nitzschia palea	4	841	Diatom	5070
Gymnodinium sp.	19	40251	Dinoflagellate	10031
Parvodinium sp.	11	6065	Dinoflagellate	
Peridinium inconspicuum	4	7326	Dinoflagellate	10212
Ankistrodesmus falcatus	4	565	Green	5877
Monoraphidium indicum	212	140452	Green	5990
Cosmarium sp.	8	4002	Green	7848
microflagellate	194	32640	Other.Flagellates	

Figure 13: Raw data from 2022-04-20 EMS site 0200052

EMS ID: 0200052	Total Abundance (cells/mL):	2849		
Collection Date: 2022-08-11	Total Biovolume (µm³/mL):	616725		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	4	673	Actinopoda	
Chroomonas sp.	19	4320	Chrysophyta	10613
Chrysococcus sp.	72	23906	Chrysophyta	1751
Chrysochromulina sp.	99	3808	Chrysophyta	2160
Chromulina sp.	53	93659	Chrysophyta	1717
Bitrichia chodatii	11	3672	Chrysophyta	
Dinobryon spp.	137	217346	Chrysophyta	1515
Dinobryopsis sp.	49	13162	Chrysophyta	1557
Spumella sp.	53	389	Chrysophyta	1491
Cryptomonas curvata	4	25200	Cryptophyta	10635
Cryptomonas ovata	19	41342	Cryptophyta	10635
Cryptomonas erosa	19	33665	Cryptophyta	10635
Rhodomonas lacustris	95	10315	Cryptophyta	10663
Anacystis sp.	95	181	Cyanobacteria	609
Anacystis sp.	288	548	Cyanobacteria	609
Anacystis delicatissima	1127	2462	Cyanobacteria	609
Chroococcus dispersus var. minor	121	1711	Cyanobacteria	654
Chroococcus turgidus	15	5082	Cyanobacteria	654
Gloeocapsa aeruginosa	38	537	Cyanobacteria	682
Planktolyngbya sp.	38	472	Cyanobacteria	
Achnanthidium sp.	4	759	Diatom	590864
Achnanthidium minutissimum	8	1517	Diatom	590864
Cocconeis neodiminuta	8	12636	Diatom	3577
Cyclotella sp.	15	3982	Diatom	2439
Fragilaria crotonensis	4	1942	Diatom	2932
Fragilaria capucina	11	5341	Diatom	2932
Fragilaria sp.	4	1942	Diatom	2932
Lindavia intermedia	8	7072	Diatom	
Sellaphora pupula	15	13151	Diatom	590842
Navicula sp.	4	2827	Diatom	3649
Nitzschia acicularis	8	6316	Diatom	5070
Nitzschia palea	4	841	Diatom	5070
Parvodinium sp.	8	4411	Dinoflagellate	
Euglena sp.	4	2304	Euglenid	9620
Schroederia sp.	8	2036	Green	
Crucigenia quadrata	83	5075	Green	6225
Crucigenia tetrapedia	30	3675	Green	6225
Oocystis solitaria	8	1843	Green	5827
Oocystis lacustris	42	20776	Green	5827
Tetrastrum sp.	8	144	Green	6260
Scenedesmus aculeolatus	8	1867	Green	6104
microflagellate	201	33818	Other.Flagellates	

Figure 14: Raw data from 2022-08-11 EMS site 0200052