

Skaha Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from three sites on Skaha 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 2022

Sample Site (EMS#)	Dates
SKAHA L SOUTH BASIN (0500846)	2022-03-21
	2022-09-13
SKAHA L OPP, GILLIES (0500615)	2021-03-11
	2021-09-13
	2022-03-21
	2022-09-13
SKAHA L WEST OKANAGAN R MOUTH (0500453)	2022-03-21
	2022-09-13
Total= 8 samples	

Constant concentrations of flagellates, green algae, cyanobacteria, and diatoms were observed in Skaha Lake from spring to summer. Samples from EMS site #0500453 contained a small bloom of the diatom *Tabellaria* on 2022-03-21. Spring samples demonstrated diatom degradation indicative of lowering silica levels in the late spring (Figure 2).

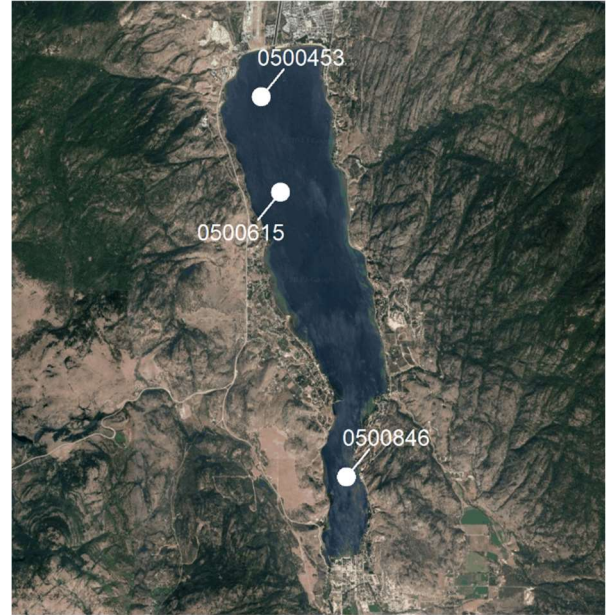


Figure 1: Aerial view of Skaha Lake

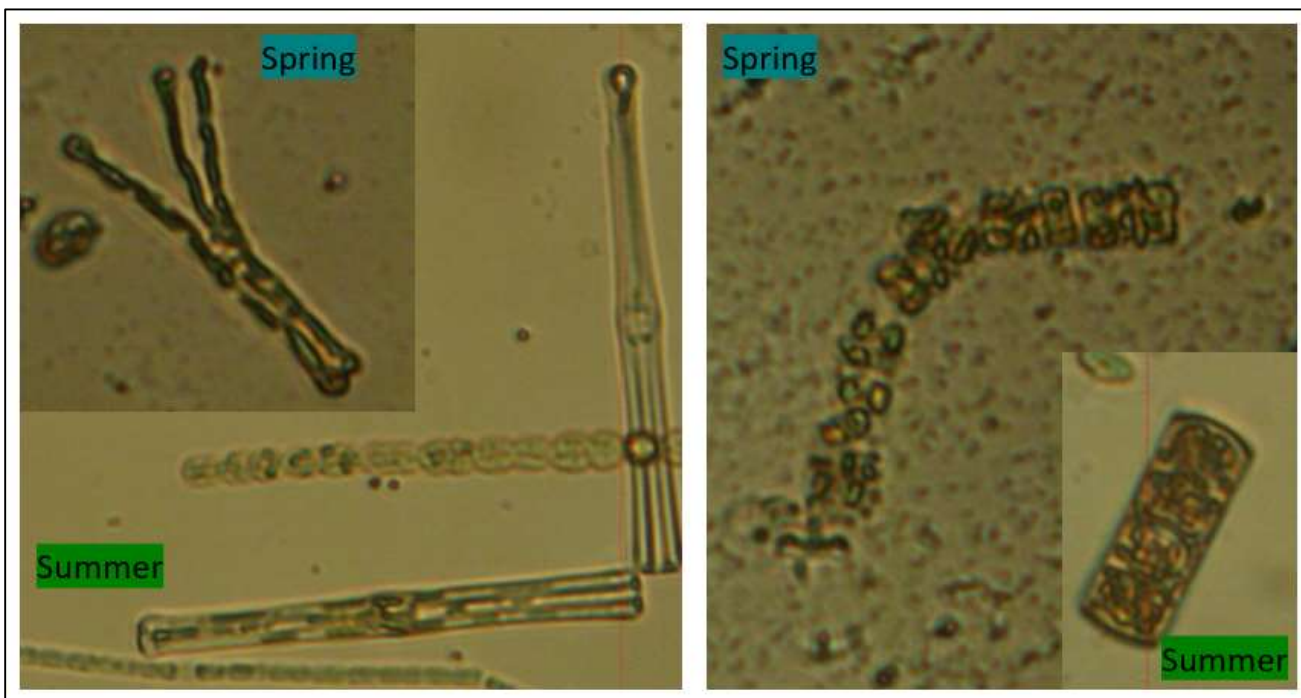


Figure 2: Degraded spring vs healthy summer diatoms (*Tabellaria* on the left and *Aulacoseira* on the right)

Overview (continued)

Diatoms and Cyanobacteria dominated Skaha Lake's total biovolumes (Figure 3). Spring and summer samples contained moderate concentrations of diatoms with one bloom of degraded *Tabellaria* (Figure 4). Summer samples contained blooms of *Anabaena* and *Planktothrix* species (Figure 4).

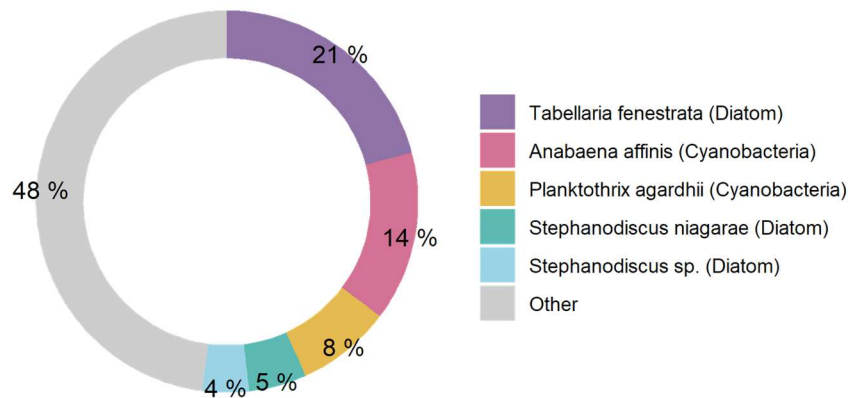


Figure 3: Dominant organisms from Skaha (all sites / dates) as percent of total biovolume

Diatoms are integral to aquatic food webs because they are the foundation of the food web (Jrobyn, 2019). Colony forming diatoms such as *Tabellaria* can avoid grazing pressures by developing into large colonies reducing their availability for zooplankton and microscopic invertebrates (Baker, 2012).

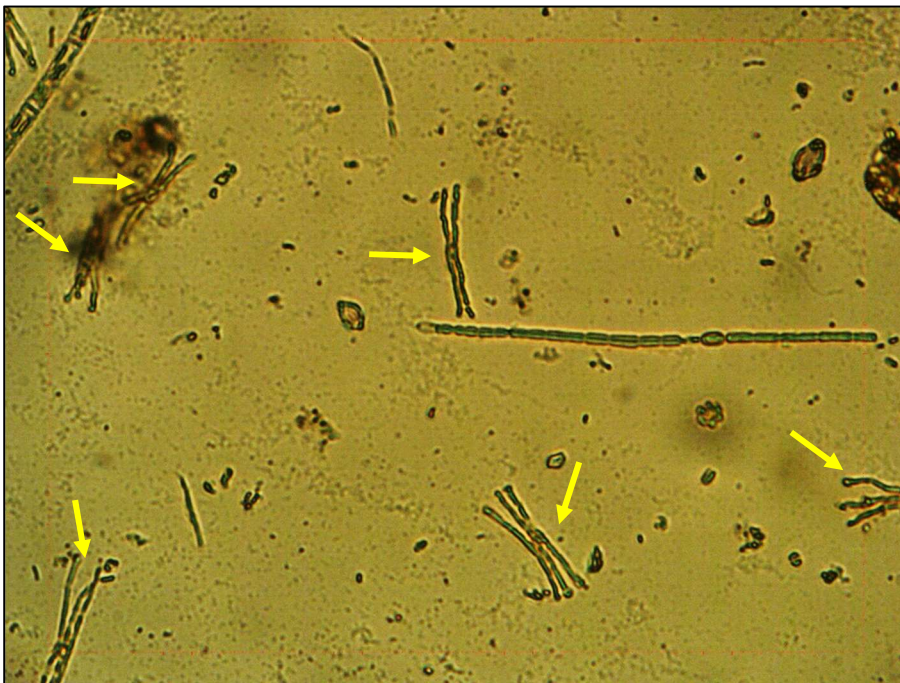


Figure 4: EMS site #500453 collected on 2022-03-21 containing a small bloom of degraded *Tabellaria* (yellow arrows)

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 samples contained elevated concentrations of cyanobacteria relative to spring samples. Dominant genera include *Planktolyngbya*, *Aphanocapsa*, and *Planktothrix* (Figure 5). *Anabaena* species were also frequently encountered. *Anabaena affinis* and *Planktothrix agardhii* dominated in biovolumes but *Planktolyngbya*, *Aphanocapsa*, and *Planktothrix* species dominated in cell abundance (Figure 3; Figure 5).

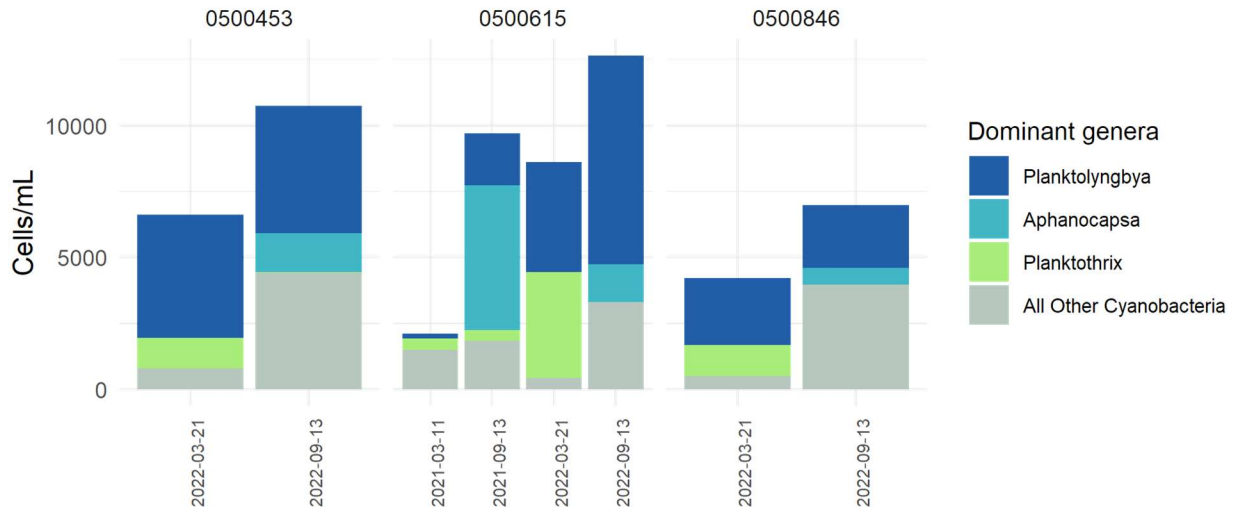


Figure 5: cell abundance for dominant cyanobacteria genera on Skaha Lake

During blooms, species of *Anabaena* and *Planktothrix* produce both negative odor/taste compounds and toxic secondary metabolites. *Planktothrix* species are long, slender, straight filaments that can form dense surface scums associated with strong earthy odors (EPA, 2022). *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 Skaha Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
<i>Planktolyngbya</i>	7916	Lyngbyatoxin LYN, Microcystin MC, BMAA
<i>Aphanocapsa</i>	5495	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, BMAA
<i>Planktothrix</i>	4007	Lyngbyatoxin LYN, Aplysiatoxins APL, Lipopolysaccharide LPS, 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 Skaha Lake can produce cyanotoxins (Table 2).

Skaha Lake displayed a range of cyanobacteria levels in the low risk category, with a mean cyanobacteria abundance of 7,707 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Skaha Lake compared to alert levels defined by authorities including the WHO and EPA.

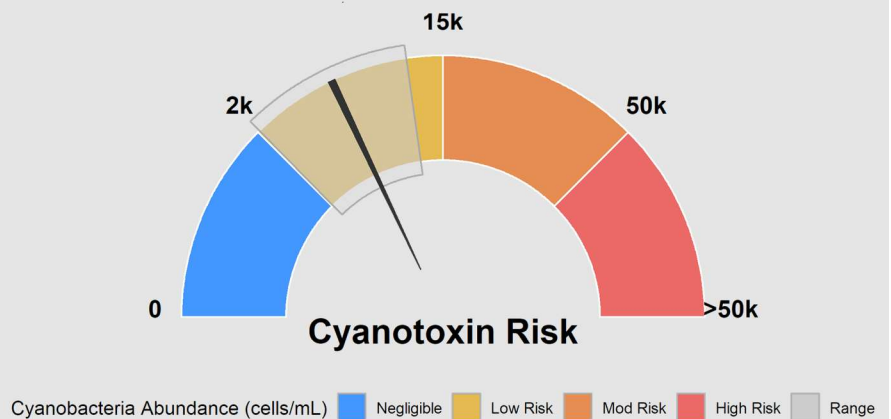


Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Skaha Lake

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 where a *Staurastrum* desmid cell is an equivalent size to approximately 50 cyanobacteria cells (*Anabaena*).

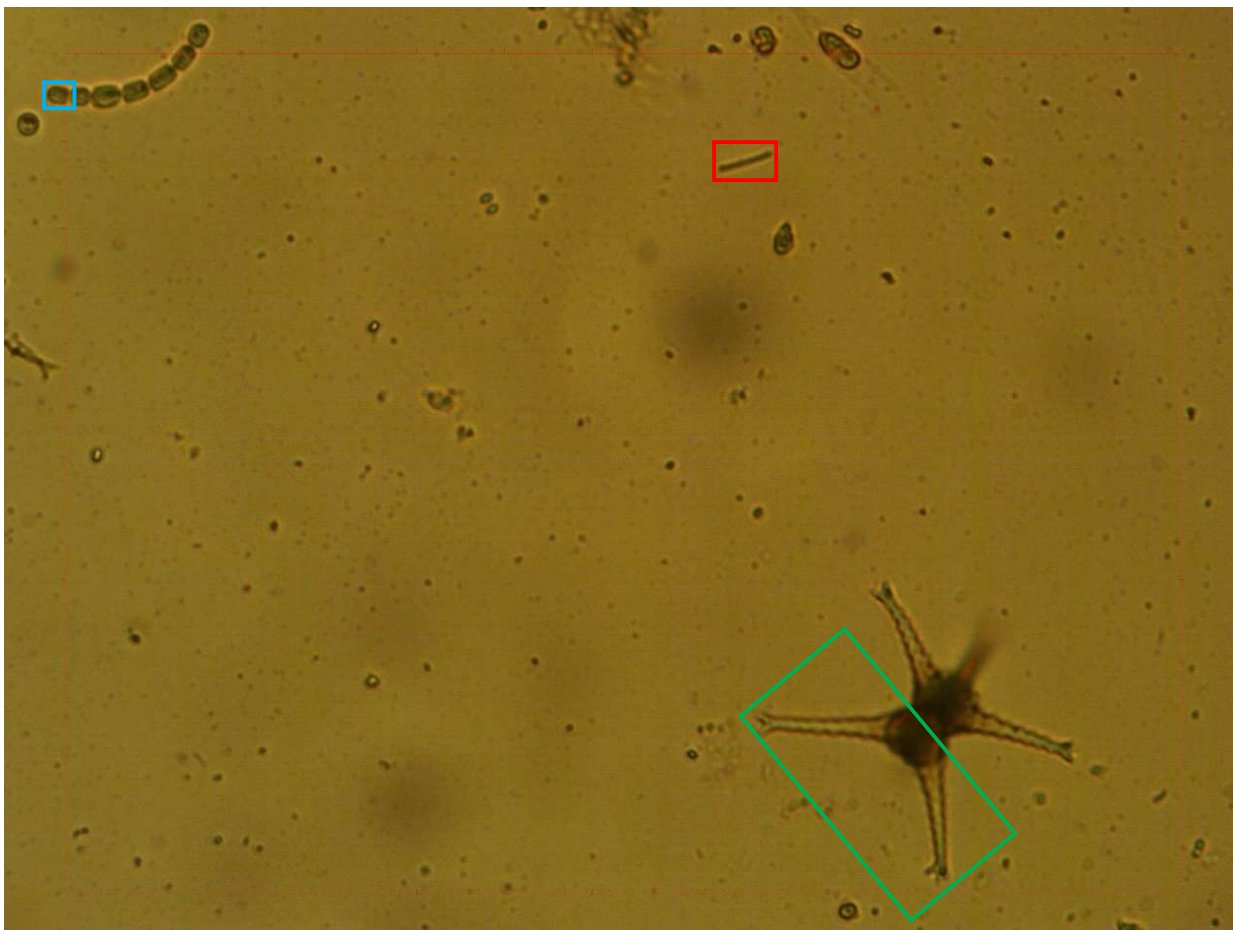


Figure 7: Size comparison of a *Staurastrum* cell (green box) to an *Anabaena* cell (blue box) to ~5 *Planktolyngbya* cells (red box)

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.

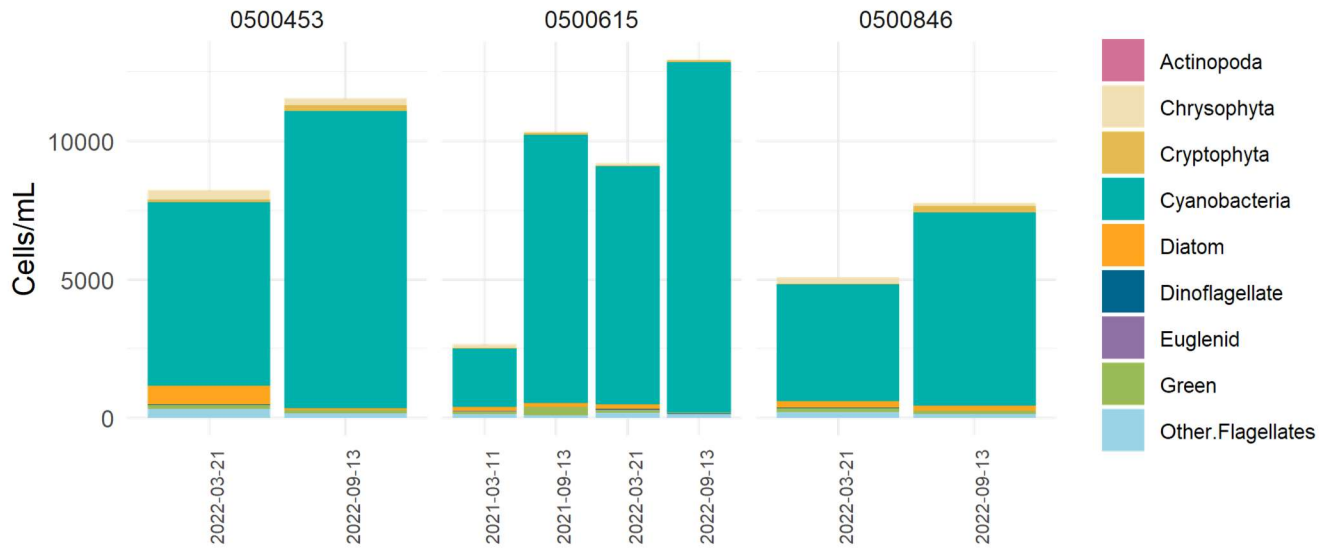


Figure 8: Cell abundance of high-level taxa groups on Skaha Lake

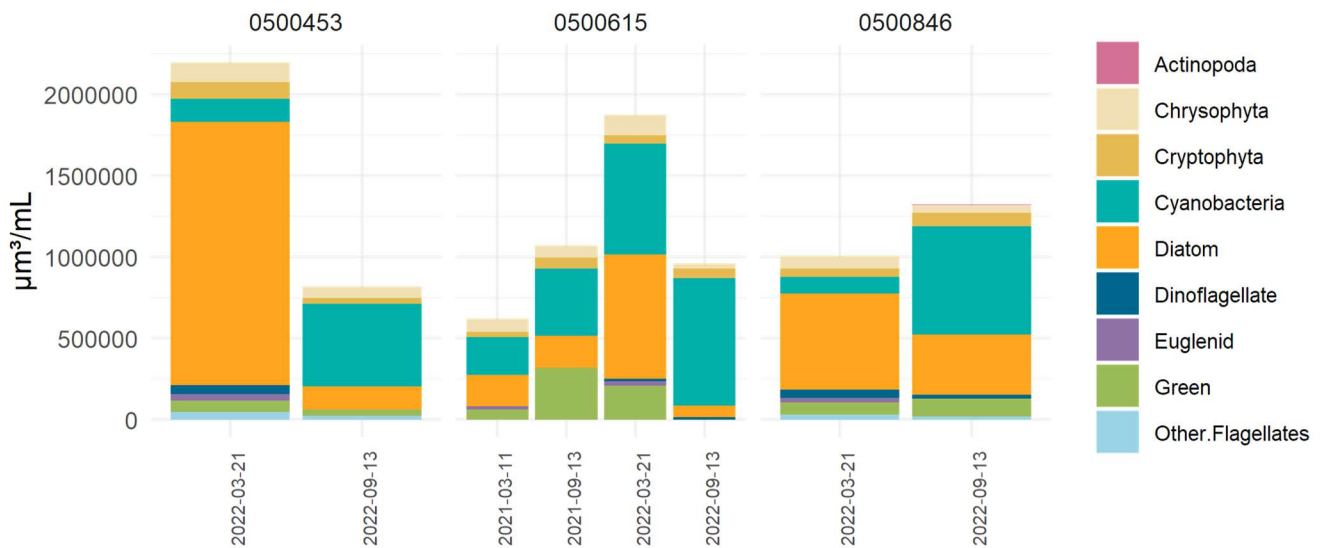


Figure 9: Biovolume of high-level taxa groups on Skaha Lake

References

- 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>
- 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>
- 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:

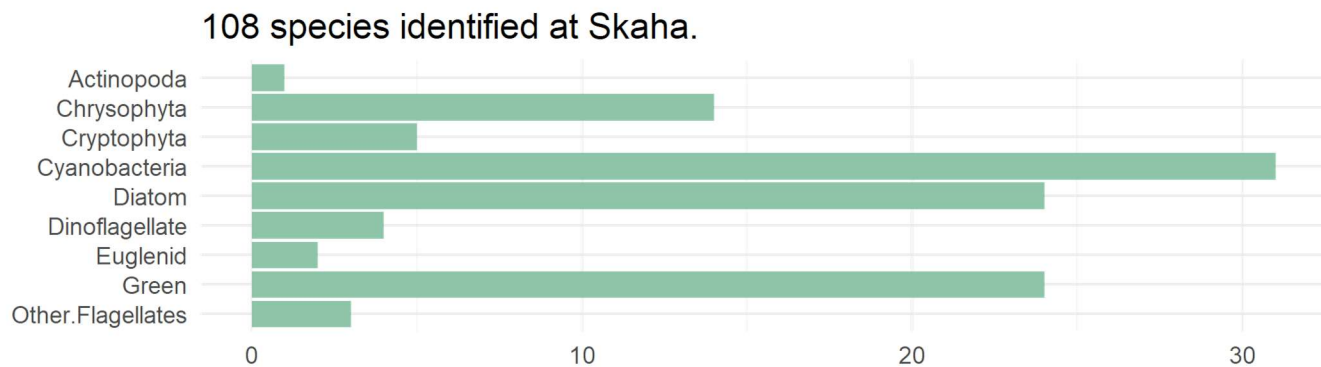


Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 0500615	Total Abundance (cells/mL):	2665	
Collection Date: 2021-03-11	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	622317	
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa
Chroomonas acuta	121	65366	Chrysophyta
Mallomonas urnaformis	8	15839	Chrysophyta
Cryptomonas erosa	8	14175	Cryptophyta
Cryptomonas ovata	8	17407	Cryptophyta
Anabaena flos aquae	144	39887	Cyanobacteria
Anacystis cyanea	76	114	Cyanobacteria
Aphanizomenon flos aquae	182	39289	Cyanobacteria
Planktolyngbya limnetica	182	931	Cyanobacteria
Pseudanabaena catenata	1093	79781	Cyanobacteria
Planktothrix agardhii	440	71923	Cyanobacteria
Achnanthisdium sp.	8	1188	Diatom
Tabellaria fenestrata	46	123638	Diatom
Cyclotella glomerata	15	9439	Diatom
Stephanodiscus sp. (senescent)	83	60299	Diatom
Lepocinclis sp.	23	19825	Euglenid
Monoraphidium indicum	61	42745	Green
Closterium limneticum	8	15708	Green
Schroederia indica	8	2036	Green
nanoflagellates	83	2499	Other.Flagellates
picoflagellates	68	228	Other.Flagellates

Figure 11: Raw data from 2021-03-11 EMS site 0500615

EMS ID: 0500615	Total Abundance (cells/mL):	10345	
Collection Date: 2021-09-13	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	1072161	
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa
Chroomonas acuta	8	4322	Chrysophyta
Dinobryon sertularia	15	18444	Chrysophyta
Mallomonas sp.	8	24194	Chrysophyta
Ochromonas sp.	8	1713	Chrysophyta
Chromulina sp.	15	26507	Chrysophyta
Cryptomonas ovata	30	65276	Cryptophyta
Rhodomonas lacustris	23	2497	Cryptophyta
Anacystis cyanea	76	114	Cyanobacteria
Anabaena affinis	311	89132	Cyanobacteria
Anabaena flos-aquae	486	94587	Cyanobacteria
Chroococcus limneticus	30	3831	Cyanobacteria
Aphanizomenon flos-aquae	744	123879	Cyanobacteria
Aphanocapsa elachista	5495	15344	Cyanobacteria
Phormidium tenue	68	2931	Cyanobacteria
Limnothrix redekei	38	4775	Cyanobacteria
Planktolyngbya limnetica	1973	10094	Cyanobacteria
Planktothrix agardhii	402	65711	Cyanobacteria
Aphanothece sp.	83	265	Cyanobacteria
Asterionella formosa	76	52920	Diatom
Lindavia bodanica	8	8348	Diatom
Fragilaria crotonensis	30	14567	Diatom
Stephanodiscus niagarae	8	84010	Diatom
Tabellaria fenestrata	15	40317	Diatom
Ankistrodesmus falcatus	8	1131	Green
Monoraphidium cf. indicum	137	271767	Green
Didymocystis bicellularis	30	8082	Green
Oocystis parva	30	6744	Green
Oocystis lacustris	46	22755	Green
Gloeocystis planctonica	30	2913	Green
Chodatella ciliata	8	3217	Green
nanoflagellates	53	1596	Other.Flagellates
picoflagellates	53	178	Other.Flagellates

Figure 12: Raw data from 2021-09-13 EMS site 0500615

EMS ID: 0500615	Total Abundance (cells/mL):	9207		
Collection Date: 2022-03-21	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	1876221		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Chroomonas acuta	38	20528	Chrysoophyta	10613
Ochromonas sp.	15	3211	Chrysoophyta	1455
Mallomonas urnaformis	46	102002	Chrysoophyta	1598
Cryptomonas curvata	8	50400	Cryptophyta	10635
Anacystis cyanea	379	571	Cyanobacteria	609
Planktolyngbya limnetica	4159	21277	Cyanobacteria	
Pseudanabaena catenata	61	4453	Cyanobacteria	1175
Planktothrix agardhii	4007	654988	Cyanobacteria	189420
Stephanodiscus niagarae	38	399047	Diatom	2415
Tabellaria fenestrata	137	368225	Diatom	3241
Peridinium inconspicuum	8	14652	Dinoflagellate	10212
Lepocinclis sp.	30	25858	Euglenid	9758
Monoraphidium indicum	68	45051	Green	5990
Closterium limneticum	8	15708	Green	7257
Closterium aciculare	8	147769	Green	7257
nanoflagellates	68	2048	Other.Flagellates	
picoflagellates	129	433	Other.Flagellates	

Figure 13: Raw data from 2022-03-21 EMS site 0500615

EMS ID: 0500615	Total Abundance (cells/mL):	12951		
Collection Date: 2022-09-13	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	961871		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Chroomonas acuta	8	4322	Chrysoophyta	10613
Ochromonas sp.	8	1713	Chrysoophyta	1455
Chromulina sp.	15	26507	Chrysoophyta	1717
Cryptomonas curvata	8	50400	Cryptophyta	10635
Rhodomonas lacustris	61	6623	Cryptophyta	10663
Anacystis cyanea	91	137	Cyanobacteria	609
Anabaena affinis	1768	506706	Cyanobacteria	1100
Anabaena circinalis	91	28235	Cyanobacteria	1100
Anabaena flos-aquae	30	5839	Cyanobacteria	1100
Aphanizomenon flos-aquae	1108	184487	Cyanobacteria	1191
Aphanocapsa elachista	1434	4004	Cyanobacteria	625
Gloeocapsa sp.	61	2653	Cyanobacteria	682
Planktolyngbya limnetica	7916	40497	Cyanobacteria	
Pseudanabaena catenata	152	11095	Cyanobacteria	1175
Nitzschia acicularis	8	6316	Diatom	5070
Ulnaria acus	23	23962	Diatom	970000
Ulnaria ulna	8	42038	Diatom	970000
Peridinium inconspicuum	8	14652	Dinoflagellate	10212
Tetraedron minimum	8	984	Green	5661
nanoflagellates	8	241	Other.Flagellates	
picoflagellates	137	460	Other.Flagellates	

Figure 14: Raw data from 2022-09-13 EMS site 0500615

EMS ID: 0500846	Total Abundance (cells/mL):	5239		
Collection Date: 2022-03-21	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	1018564		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Actinophryida	8	1346	Actinopoda	
Chrysochromulina sp.	38	1462	Chrysophyta	2160
Chromulina sp.	23	40644	Chrysophyta	1717
Dinobryon spp.	8	12692	Chrysophyta	1515
Ochromonas sp.	19	4067	Chrysophyta	1455
Dinobryopsis sp.	8	2149	Chrysophyta	1557
Rhodomonas sp.	129	14702	Chrysophyta	10663
Cryptomonas curvata	8	50400	Cryptophyta	10635
Rhodomonas lacustris	27	2932	Cryptophyta	10663
Gloeotheca sp.	15	982	Cyanobacteria	703
Spirulina major	140	2639	Cyanobacteria	1053
Pseudanabaena sp.	482	5371	Cyanobacteria	1175
Planktolyngbya sp.	2546	31647	Cyanobacteria	
Planktothrix sp.	1180	65685	Cyanobacteria	189420
Aulacoseira sp.	15	24684	Diatom	590863
Stephanodiscus sp.	68	194669	Diatom	2415
Tabellaria flocculosa	137	368225	Diatom	3241
Parvodinium sp.	4	2205	Dinoflagellate	
Glenodinium sp.	19	37963	Dinoflagellate	10174
Peridinium inconspicuum	8	14652	Dinoflagellate	10212
Trachelomonas sp.	8	28274	Euglenid	9690
Ankistrodesmus sp.	30	4717	Green	5877
Elakatothrix sp.	8	1536	Green	9412
Mougeotia sp.	4	3087	Green	7055
Monoraphidium indicum	87	57638	Green	5990
Closterium limneticum	4	7854	Green	7257
microflagellate	216	36342	Other.Flagellates	

Figure 15: Raw data from 2021-03-21 EMS site 0500846

EMS ID: 0500846	Total Abundance (cells/mL):	7790		
Collection Date: 2022-09-13	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	1330107		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Actinophryida	15	2524	Actinopoda	
Chroomonas sp.	4	909	Chrysophyta	10613
Chrysooccus sp.	15	4980	Chrysophyta	1751
Chrysochromulina sp.	57	2192	Chrysophyta	2160
Chromulina sp.	15	26507	Chrysophyta	1717
Dinobryon sp.	8	12692	Chrysophyta	1515
Cryptomonas sp.	4	7408	Cryptophyta	10635
Cryptomonas curvata	8	50400	Cryptophyta	10635
Rhodomonas lacustris	239	25950	Cryptophyta	10663
Anabaena sp.	42	3149	Cyanobacteria	1100
Anabaena helicoidea	421	55550	Cyanobacteria	1100
Anabaena affinis	1552	444801	Cyanobacteria	1100
Anacystis sp.	656	1248	Cyanobacteria	609
Anacystis delicatissima	512	1118	Cyanobacteria	609
Aphanizomenon flos-aquae var. klebahnii	448	115527	Cyanobacteria	1191
Aphanizomenon sp.	216	7634	Cyanobacteria	1191
Aphanocapsa sp.	645	2038	Cyanobacteria	625
Chroococcus limneticus	30	3831	Cyanobacteria	654
Gloeocapsa aeruginosa	23	325	Cyanobacteria	682
Merismopedia sp.	61	395	Cyanobacteria	727
Planktolyngbya sp.	2372	29484	Cyanobacteria	
Asterionella formosa	4	2785	Diatom	3116
Aulacoseira sp.	38	62533	Diatom	590863
Fragilaria tenera	11	5341	Diatom	2932
Gomphonema sp.	4	5508	Diatom	4911
Lindavia intermedia	8	7072	Diatom	
Tabellaria fenestrata	91	244588	Diatom	3241
Ulnaria nana	4	10500	Diatom	970000
Ulnaria acus	4	4167	Diatom	970000
Urosolenia sp.	4	25164	Diatom	590843
Gymnodinium sp.	8	16948	Dinoflagellate	10031
Parvodinium sp.	8	4411	Dinoflagellate	
Peridinium inconspicuum	4	7326	Dinoflagellate	10212
Crucigenia apiculata	8	1835	Green	6225
Mougeotia sp.	19	14663	Green	7055
Oocystis solitaria	4	922	Green	5827
Tetraedron minimum	4	492	Green	5661
Quadrigula chodati	15	4388	Green	5938
Staurodesmus subtriangularis	8	70941	Green	7182
Botryococcus braunii	34	5591	Green	6306
Chlamydomonas sp.	19	11369	Green	5448
microflagellate	148	24901	Other.Flagellates	

Figure 16: Raw data from 2021-09-13 EMS site 0500846

EMS ID: 0500453	Total Abundance (cells/mL):	8252		
Collection Date: 2022-03-21	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	2210389		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Chrysococcus sp.	4	1328	Chrysophyta	1751
Chrysochromulina sp.	49	1885	Chrysophyta	2160
Chromulina sp.	46	81289	Chrysophyta	1717
Ochromonas sp.	99	21193	Chrysophyta	1455
Dinobryopsis sp.	4	1074	Chrysophyta	1557
Rhodomonas sp.	156	17779	Chrysophyta	10663
Cryptomonas sp.	4	7408	Cryptophyta	10635
Cryptomonas curvata	8	50400	Cryptophyta	10635
Cryptomonas erosa	19	33665	Cryptophyta	10635
Rhodomonas lacustris	68	7383	Cryptophyta	10663
Anabaena sp.	23	1725	Cyanobacteria	1100
Aphanizomenon sp.	372	13148	Cyanobacteria	1191
Chroococcus limneticus	15	1915	Cyanobacteria	654
Pseudanabaena sp.	391	4357	Cyanobacteria	1175
Planktolyngbya sp.	4671	58061	Cyanobacteria	
Planktothrix sp.	1157	64405	Cyanobacteria	189420
Aulacoseira sp.	95	156333	Diatom	590863
Cocconeis neodiminuta	4	6318	Diatom	3577
Cyclotella sp.	4	1062	Diatom	2439
Fragilaria sp.	8	3884	Diatom	2932
Nitzschia spp.	8	3158	Diatom	5070
Stephanodiscus sp.	68	194669	Diatom	2415
Tabellaria fenestrata	459	1233689	Diatom	3241
Ulnaria acus	19	19795	Diatom	970000
Gymnodinium helveticum	4	15811	Dinoflagellate	10031
Parvodinium sp.	8	4411	Dinoflagellate	
Glenodinium sp.	19	37963	Dinoflagellate	10174
Trachelomonas sp.	11	38877	Euglenid	9690
Ankistrodesmus falcatus	30	4241	Green	5877
Mougeotia sp.	23	17750	Green	7055
Monoraphidium minutum	23	15238	Green	5990
Monoraphidium indicum	49	32463	Green	5990
Didymocystis planctonica	15	4041	Green	55858
microflagellate	319	53671	Other.Flagellates	

Figure 17: Raw data from 2022-03-21 EMS site 0500453

EMS ID: 0500453	Total Abundance (cells/mL):	11563		
Collection Date: 2022-09-13	Total Biovolume ($\mu\text{m}^3/\text{mL}$):	831187		
Report.Name	Abundance (cells/mL)	Biovolume ($\mu\text{m}^3/\text{mL}$)	High.Level.Taxa	ITIS Genus Number
Chrysochromulina sp.	148	5692	Chrysophyta	2160
Chromulina sp.	23	40644	Chrysophyta	1717
Dinobryon spp.	15	23797	Chrysophyta	1515
Spumella sp.	53	389	Chrysophyta	1491
Cryptomonas erosa	8	14175	Cryptophyta	10635
Rhodomonas lacustris	205	22258	Cryptophyta	10663
Anabaena sp.	99	7423	Cyanobacteria	1100
Anabaena affinis	1324	379456	Cyanobacteria	1100
Anabaena helicoidea	186	24542	Cyanobacteria	1100
Anacystis sp.	1556	2961	Cyanobacteria	609
Aphanizomenon sp.	592	20923	Cyanobacteria	1191
Aphanocapsa sp.	1476	4663	Cyanobacteria	625
Aphanothece sp.	471	1502	Cyanobacteria	636
Chroococcus dispersus var. minor	30	424	Cyanobacteria	654
Gloeocapsa punctata	30	126	Cyanobacteria	682
Gloeocapsa aeruginosa	102	1442	Cyanobacteria	682
Gloeothece sp.	30	1963	Cyanobacteria	703
Planktolyngbya sp.	4819	59900	Cyanobacteria	
Planktothrix sp.	30	1670	Cyanobacteria	189420
Achnantheidium sp.	4	759	Diatom	590864
Achnantheidium minutissimum	4	759	Diatom	590864
Aulacoseira sp.	15	24684	Diatom	590863
Fragilaria tenera	11	5341	Diatom	2932
Tabellaria fenestrata	19	51068	Diatom	3241
Ulnaria acus	8	8335	Diatom	970000
Urosolenia sp.	8	50328	Diatom	590843
Parvodinium sp.	15	8270	Dinoflagellate	
Crucigenia apiculata	61	13992	Green	6225
Elakatothrix sp.	15	2880	Green	9412
Monoraphidium sp.	8	5300	Green	5990
Monoraphidium minutum	8	5300	Green	5990
Quadrigula chodatii	8	2340	Green	5938
Didymocystis bicellularis	8	2155	Green	55858
Chlamydomonas sp.	15	8975	Green	5448
microflagellate	159	26751	Other.Flagellates	

Figure 18: Raw data from 2022-09-13 EMS site 0500453