Pennask Lake Phytoplankton Summary Report 2021-2022

Overview

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

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

Sample Site (EMS#)	Dates
PENNASK LAKE AT CENTRE (0603071)	2021-05-19
	2021-08-16
	2022-05-17
	2022-08-15
Total= 4 samples	

Samples demonstrated seasonal shifts; small diatom and flagellate blooms in the spring and cyanobacteria blooms in the summer samples (Figure 2).

Cyanobacteria concentrations were higher in the summer samples relative to spring samples. While algal community composition responds rapidly to environmental changes (diatom blooms in the spring followed by elevated densities of cyanobacteria in the summer), the scale of the cyanobacteria increases observed in Pennask Lake could be reflective of unbalanced nutrient swings between seasons.

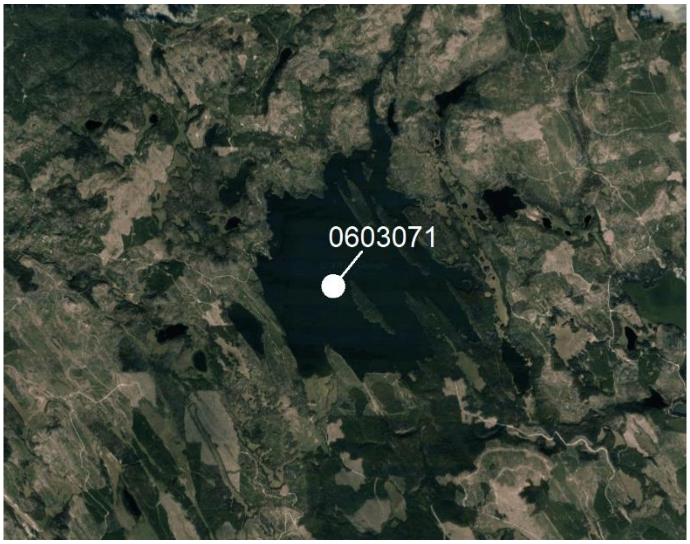

Figure 1: Aerial view of Pennask Lake

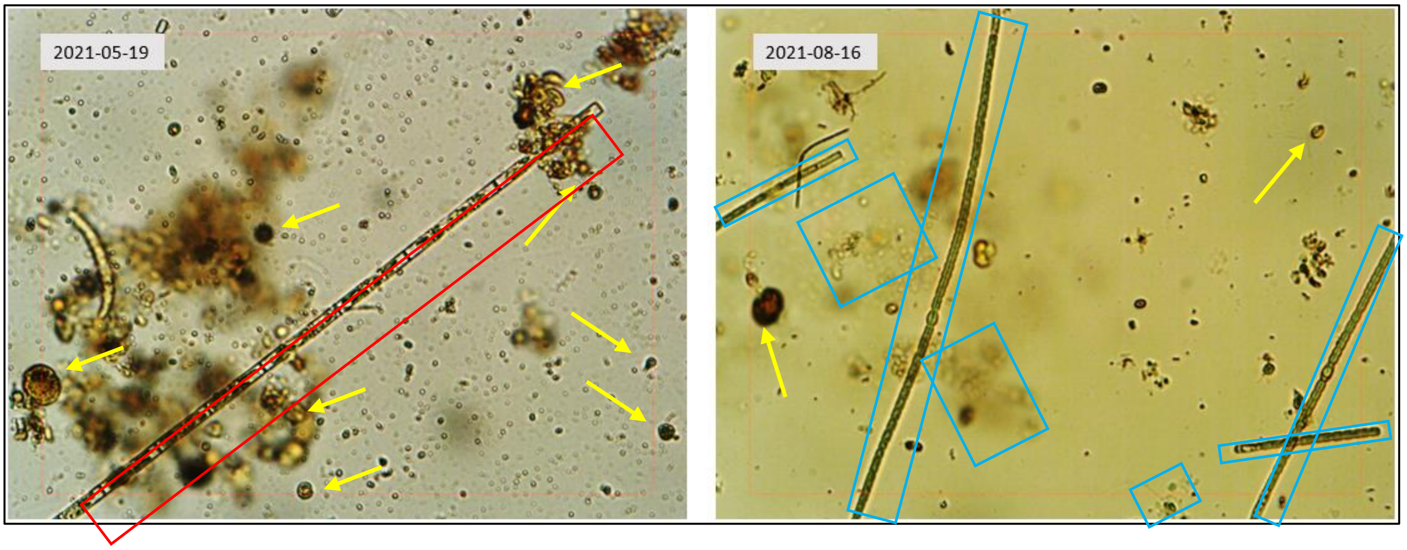

Figure 2: 400x magnification of algal composition in spring vs summer samples; diatoms (red box), flagellates (yellow arrows), cyanobacteria (blue boxes)

Overview (continued)

Cyanobacteria frequently dominate algal communities in total cell count, but because of their small cell size their biomass is usually low relative to the other types of algae present. It is atypical that 27% of total biomass in Pennask Lake samples are composed of *Aphanizomenon flos-aquae* varieties (Figure 3).

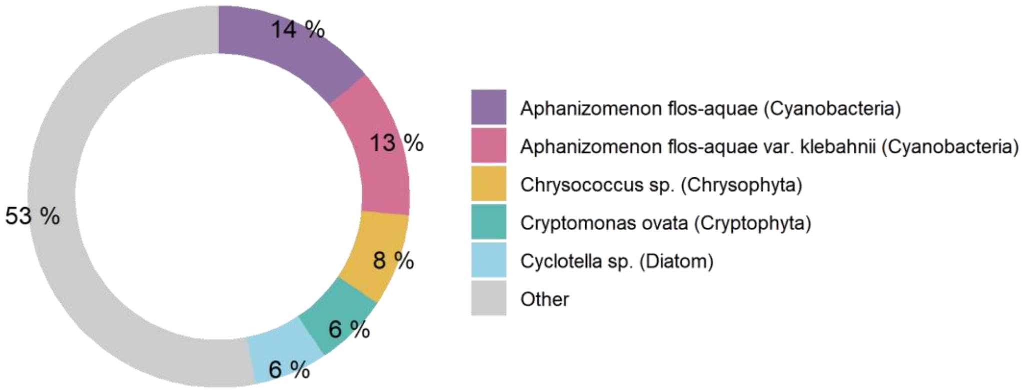

Figure 3: Dominant organisms from Pennask Lake (0603071) as percent of total biovolume

Summer samples contained large amorphous clouds of degraded cyanobacteria and bacteria alongside live healthy cells (Figure 4). Degraded cyanobacteria could represent threats to public health as cyanotoxins are typically released during cell death (EPA, 2022).

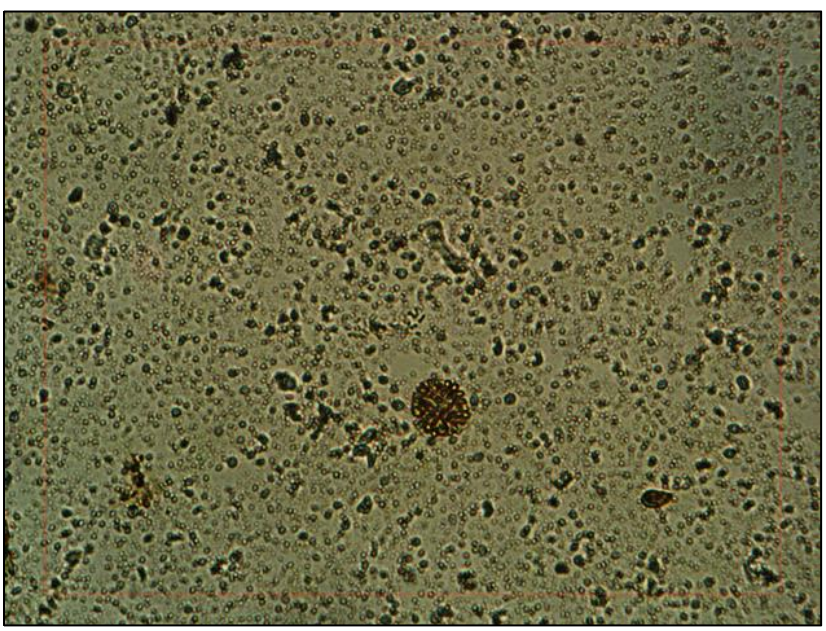

Figure 4: 400x magnification of EMS site 0603071 collected on 2021-08-16 demonstrating a background of degraded bacteria/cyanobacteria

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 densities of cyanobacteria; *Aphanocapsa* was the dominant genus counted (Figure 5), but *Aphanizomenon* dominated biovolumes (Figure 3). *Anacystis* was also frequently identified.

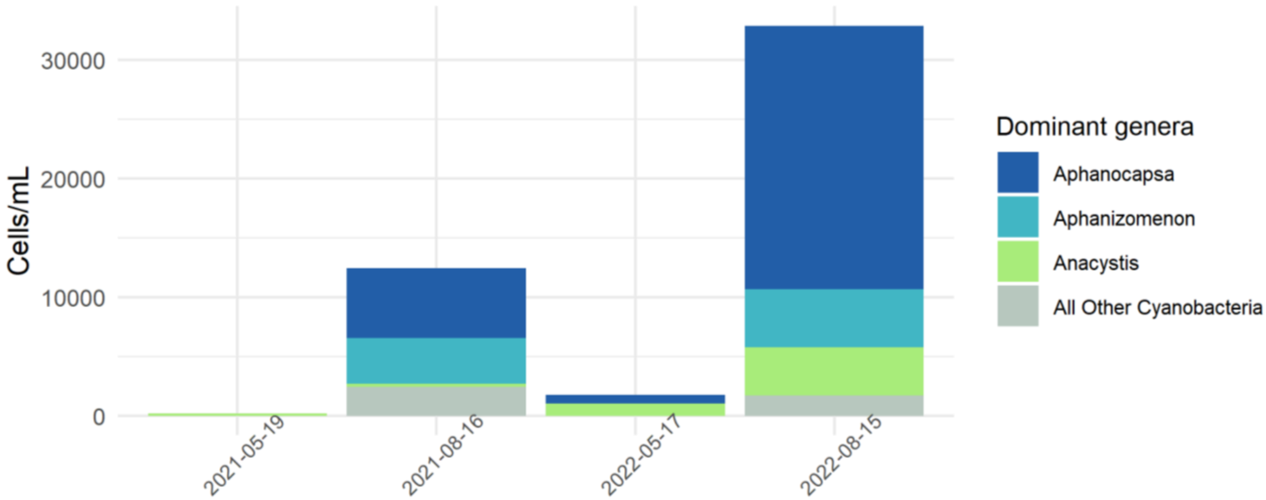

Figure 5: cell abundance for dominant cyanobacteria genera on Pennask Lake

During blooms, species of *Aphanizomenon* produce both negative odor/taste compounds and toxic secondary metabolites. *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). 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 Pennask Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Aphanocapsa	22237	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, BMAA
Anacystis	4060	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD, Anatoxins (-a) ATX, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT
Aphanizomenon	3074	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Nodularins NOD, 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 Pennask Lake are capable of producing cyanotoxins (Table 2).

Pennask Lake displayed cyanobacteria levels in the negligible to moderate-risk category, with a mean cyanobacteria abundance of 11,824 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Pennask Lake compared to alert levels defined by several authorities including the WHO and EPA.

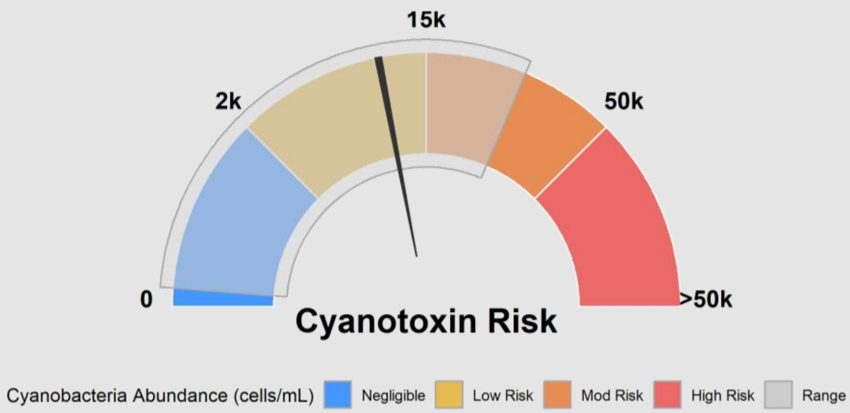

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Pennask Lake

Algae are a diverse morphological group. Despite a variety of sizes within each taxonomic group Desmids, diatoms, green algae, and Dinoflagellates frequently dwarf cyanobacteria and micro-flagellates. Cyanobacteria and micro-flagellates recurrently 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 can be seen in Figure 7 where a Desmid cell dwarfs the adjacent cyanobacteria and micro-flagellate cell.

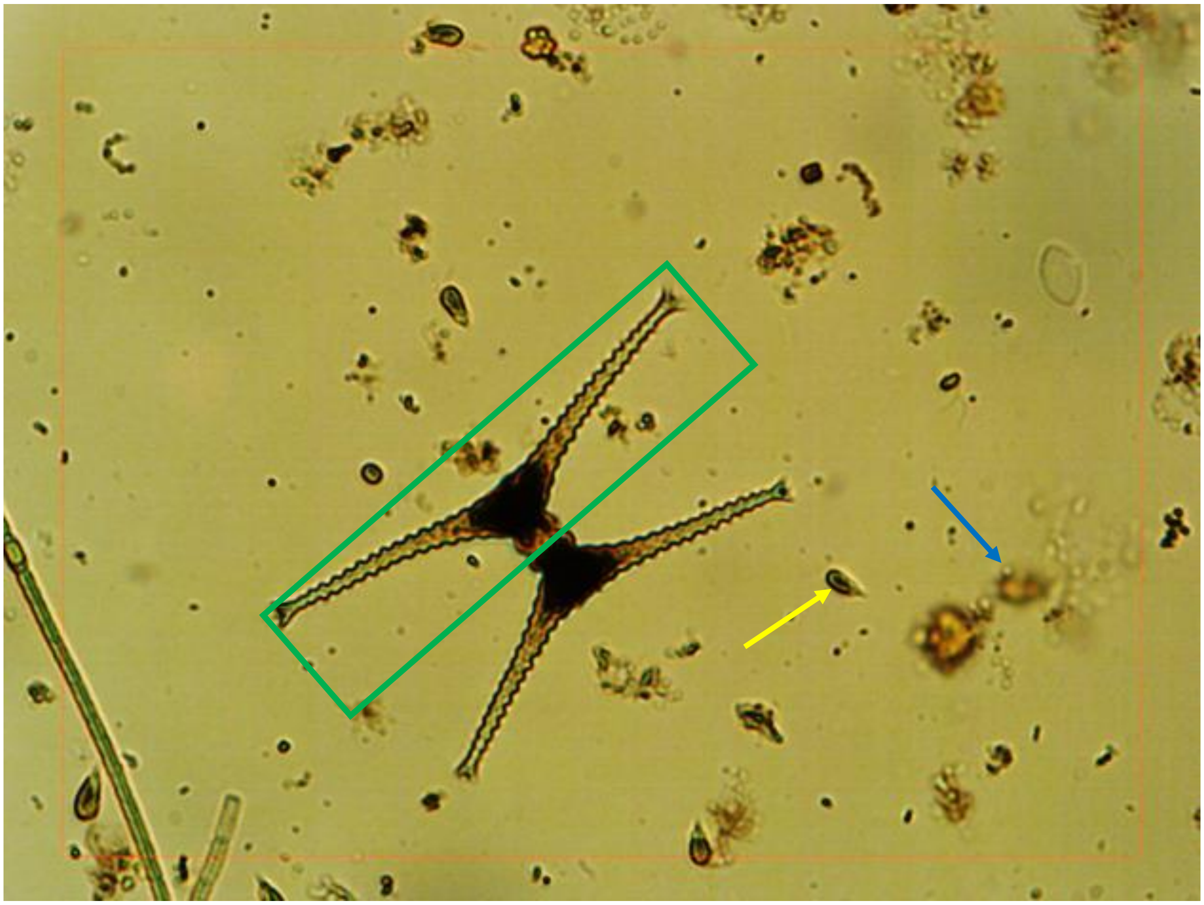

Figure 7: Size comparison of a Desmid cell (green box) vs a cyanobacteria cell (blue arrow) vs a micro-flagellate (yellow arrow)

Species Composition

Algae samples were identified to the species level and grouped into broad alga types for analysis. The figures below display the total cell counts for each broad algae group alongside the biovolume represented by each of these groups. The difference between Figure 8 (cell abundance) and Figure 9 (biovolume) illuminates the difference between cell abundance and biovolume.

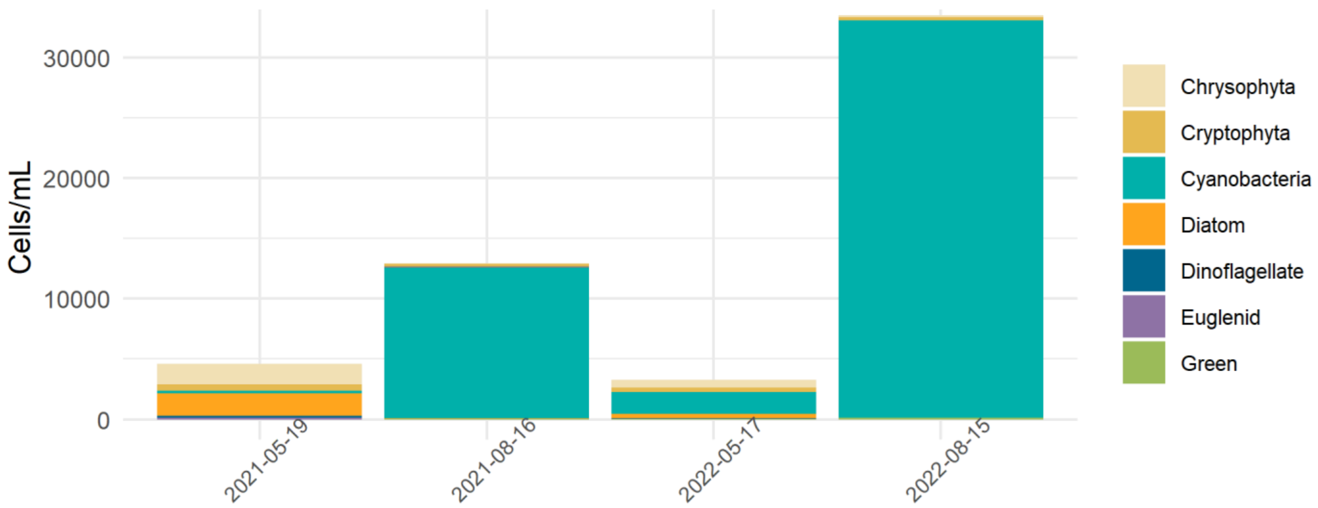

Figure 8: Cell abundance of high-level taxa groups on Pennask Lake

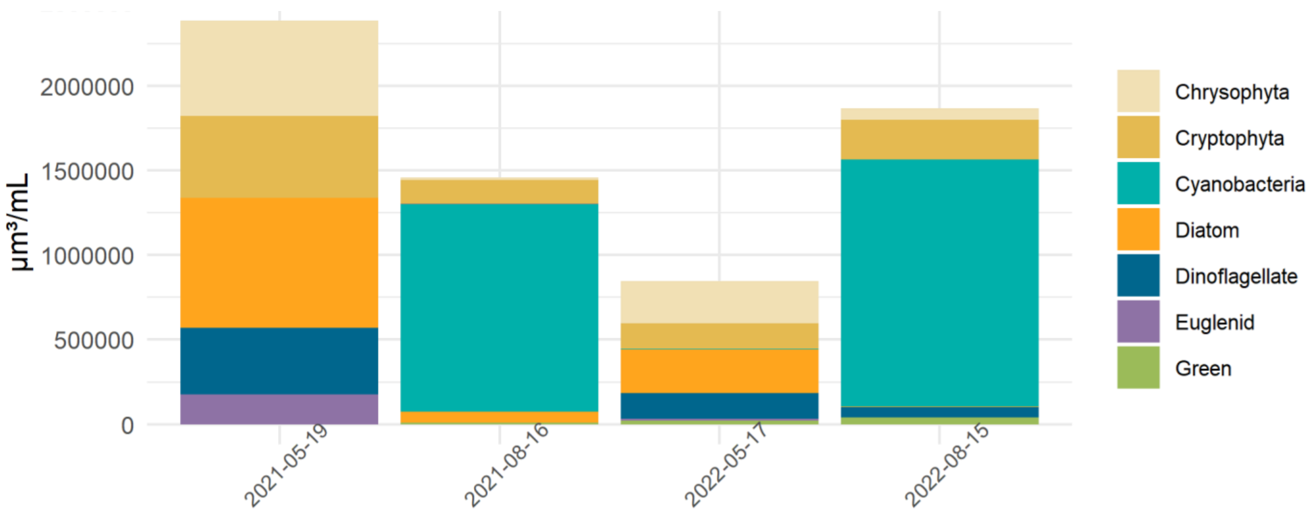

Figure 9: Biovolume of high-level taxa groups on Pennask Lake

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

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:

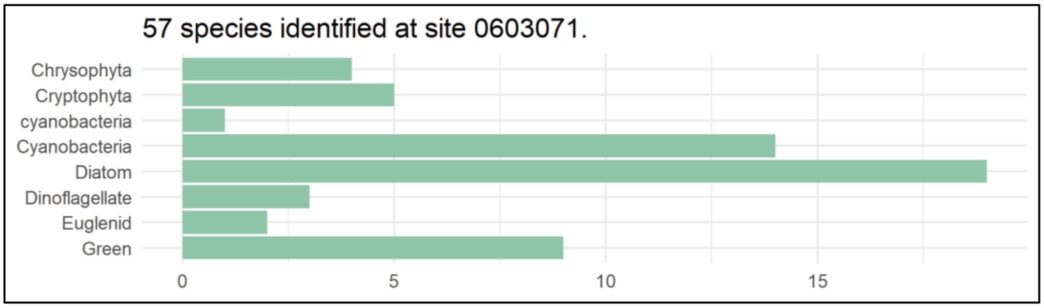

Figure 10: Unique species observed in Pennask Lake sorted into higher level taxa

EMS ID: 0603071	**Total Abundance (cells/mL):**	**4597**	
Collection Date: 2021-05-19	Total Biovolume (µm³/mL):	2386541	
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**
Chroomonas acuta	76	41057	Chrysophyta
Ochromonas sp.	175	37462	Chrysophyta
Chrysococcus sp.	1465	486416	Chrysophyta
Cryptomonas sp. Large	23	103605	Cryptophyta
Cryptomonas ovata	114	248051	Cryptophyta
Cryptomonas marssonii	46	93926	Cryptophyta
Rhodomonas lacustris	357	38762	Cryptophyta
Anacystis cyanea	190	286	Cyanobacteria
Achnanthidium minutissima var linearis	15	2015	Diatom
Aulacoseira granulata	106	34866	Diatom
Aulacoseira italica	15	7488	Diatom
Aulacoseira sp.	53	87217	Diatom
Asterionella formosa	8	5571	Diatom
Cocconeis placentula	8	13034	Diatom
Cyclotella sp.	1525	404833	Diatom
Diatoma hiemale	8	8424	Diatom
Fragilaria crotonensis	23	11168	Diatom
Frustulia soror	8	9544	Diatom
Gomphonema constrictum	8	37514	Diatom
Hannaea arcus	8	5749	Diatom
Meridion circulare	15	12541	Diatom
Navicula sp.	8	5655	Diatom
Nitzschia sp. small	8	5655	Diatom
Stephanodiscus niagarae	8	84010	Diatom
Tabellaria fenestrata	8	21502	Diatom
Gomphonema cf. gracile	8	11075	Diatom
Peridinium sp.	23	103750	Dinoflagellate
Glenodinium sp.	144	287720	Dinoflagellate
Trachelomonas volvocina	121	96356	Euglenid
Trachelomonas sp.	23	81289	Euglenid

Figure 11: Raw data from 2021-05-19 EMS site 0603071

EMS ID: 0603071	**Total Abundance (cells/mL):**	**12926**	
Collection Date: 2021-08-16	Total Biovolume (µm³/mL):	1459437	
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**
Chroomonas acuta	15	8103	Chrysophyta
Ochromonas sp.	8	1713	Chrysophyta
Chrysococcus sp.	23	7637	Chrysophyta
Cryptomonas sp. Large	15	67569	Cryptophyta
Cryptomonas ovata	15	32638	Cryptophyta
Cryptomonas marssonii	8	16335	Cryptophyta
Rhodomonas lacustris	182	19761	Cryptophyta
Gomphosphaeria cf. aponina	106	5058	cyanobacteria
Anabaena circinalis	144	44679	Cyanobacteria
Anabaena flos-aquae	1366	265856	Cyanobacteria
Anabaena planctonica	364	124254	Cyanobacteria
Anacystis cyanea	304	458	Cyanobacteria
Aphanizomenon flos-aquae var. klebahnii	1412	364116	Cyanobacteria
Aphanizomenon flos-aquae	2413	401775	Cyanobacteria
Aphanocapsa elachista	5912	16509	Cyanobacteria
Chroococcus dispersus	273	3859	Cyanobacteria
Pseudanabaena limnetica	46	4227	Cyanobacteria
Planktolyngbya sp.	212	2635	Cyanobacteria
Aulacoseira italica	46	22963	Diatom
Cyclotella sp.	8	2124	Diatom
Gomphonema constrictum	8	37514	Diatom
Oocystis sp.	8	151	Green
Scenedesmus sp.	8	1869	Green
Schroederia setigera	30	7634	Green

Figure 12: Raw data from 2021-08-16 EMS site 0603071

EMS ID: 603071	**Total Abundance (cells/mL):**	**3287**		
Collection Date: 2022-05-17	**Total Biovolume (µm³/mL):**	**845267**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chroomonas acuta	311	168008	Chrysophyta	10613
Ochromonas sp.	311	66575	Chrysophyta	1455
Chrysococcus sp.	38	12617	Chrysophyta	1751
Cryptomonas curvata	8	50400	Cryptophyta	10635
Cryptomonas ovata	30	65276	Cryptophyta	10635
Rhodomonas lacustris	349	37894	Cryptophyta	10663
Anacystis cyanea	1002	1508	Cyanobacteria	609
Aphanocapsa cf. delicatissima	774	2445	Cyanobacteria	625
Aulacoseira granulata	167	54931	Diatom	590863
Aulacoseira italica	15	7488	Diatom	590863
Asterionella formosa	8	5571	Diatom	3116
Cyclotella glomerata	114	71733	Diatom	2439
Fragilaria crotonensis	68	33018	Diatom	2932
Stephanodiscus niagarae	8	84010	Diatom	2415
Peridinium sp.	30	135326	Dinoflagellate	10212
Glenodinium sp.	8	15984	Dinoflagellate	10174
Trachelomonas volvocina	15	11945	Euglenid	9690
Monoraphidium cf. contortum	23	15238	Green	5990
Monoraphidium cf. kormakovae	8	5300	Green	5990

Figure 13: Raw data from 2022-05-17 EMS site 0603071

EMS ID:603071	**Total Abundance (cells/mL):**	**33492**		
Collection Date: 2022-08-15	**Total Biovolume (µm³/mL):**	**1866858**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chroomonas acuta	83	44838	Chrysophyta	10613
Kephyrion sp.	8	1676	Chrysophyta	1764
Ochromonas sp.	53	11346	Chrysophyta	1455
Chrysococcus sp.	23	7637	Chrysophyta	1751
Cryptomonas curvata	23	144899	Cryptophyta	10635
Cryptomonas ovata	30	65276	Cryptophyta	10635
Rhodomonas lacustris	235	25516	Cryptophyta	10663
Anabaena wisconsinense	91	28588	Cyanobacteria	1100
Anabaena circinalis	15	4654	Cyanobacteria	1100
Anabaena flos-aquae	607	118137	Cyanobacteria	1100
Anabaena spiroides var. crassa	212	127293	Cyanobacteria	1100
Anabaena planctonica	364	124254	Cyanobacteria	1100
Anacystis cyanea	4060	6112	Cyanobacteria	609
Aphanizomenon flos-aquae var. klebahnii	1799	463912	Cyanobacteria	1191
Aphanizomenon flos-aquae	3074	511835	Cyanobacteria	1191
Aphanocapsa cf. delicatissima	22237	70250	Cyanobacteria	625
Chroococcus dispersus	243	3435	Cyanobacteria	654
Woronichinia naegeliana	182	2478	Cyanobacteria	
Nitzschia sp. small	8	5655	Diatom	5070
Glenodinium cf. halli	30	59942	Dinoflagellate	10174
Oocystis borgei	8	5068	Green	5827
Quadrigula closteroides	61	17843	Green	5938
Ankyra lanceolata	8	1709	Green	
Stichogloea cf. doederleinii	38	14505	Green	1879

Figure 14: Raw data from 2022-08-15 EMS site 0603071