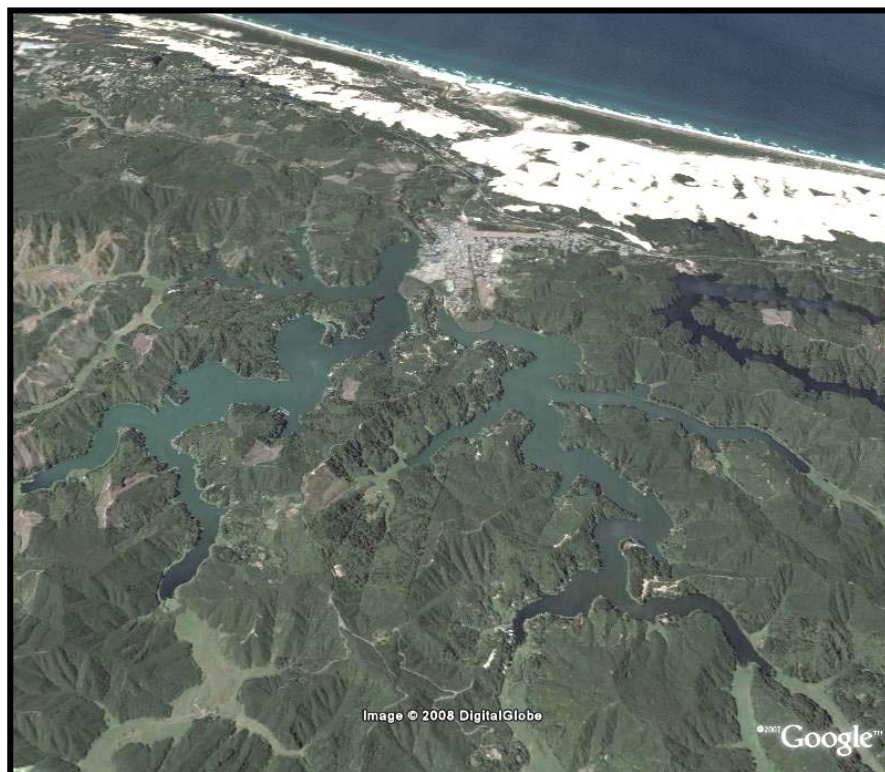

TENMILE LAKES TOXIC ALGAL SAMPLING PROGRAM: 2008 DATA SUMMARY
REPORT



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BACKGROUND

As a continuation of previous toxic algal monitoring, Tenmile Lakes were sampled in 2008 to assess the dynamics of the potentially toxigenic blue-green algal species, *Microcystis aeruginosa* and various *Anabaena* species. *Microcystis* produces hepatotoxins (known as microcystins), and *Anabaena* produces both neurotoxins (anatoxin-a) and microcystin. Both toxins are capable of harmful effects to animals and humans (Chorus and Bartram 1999). A toxic bloom of *M. aeruginosa* was first documented in Tenmile Lakes in September of 1997, prompting the Oregon Department of Health to issue a health advisory recommending that the lakes not be used for drinking water and that contact recreation be avoided (Kann and Gilroy 1997). The goal of 2008 sampling, performed by the Tenmile Lakes Basin Partnership, was to determine presence and cell density of these potentially toxic species at a limited number of sampling stations. Cell density of potentially toxigenic species was then compared to drinking water guidance levels for lakes and reservoirs (e.g., Yoo et al. 1995; Chorus and Bartram 1999).

METHODS

Four stations (2 in each lake) were sampled to cover a major arm and open-water location in each lake (Fig. 1). Stations S8 and N16 are centrally located and S3 and N11 are located near the terminus of Templeton Arm and Big Creek Arm, respectively. These stations were sampled 7 times beginning June 23rd and ending September 22nd, 2008.

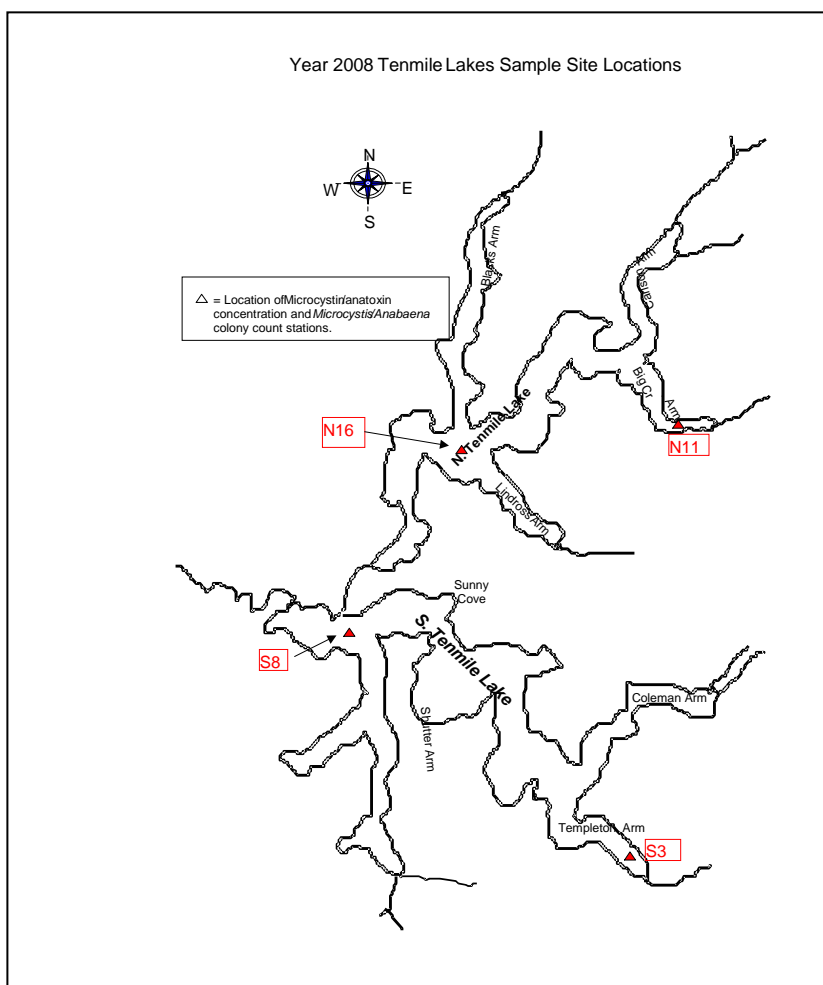


Figure 1. Location of standard toxic algal sampling stations in Tenmile Lakes, 2008.

Because the goal of the *M. aeruginosa* and *Anabaena* sampling was to detect conditions that may pose human health hazards, samples were collected mid-day and integrated over the upper 1/3 of the water column at the open-water stations (S8 and N16), and over the entire water column at the shallow stations (S3 and N11). At each of the established sampling locations a vertical tow ranging between 1 to 2.5 meters of the water column (depending on location) was made using a 64- μ m plankton net.

The filtered contents of 3 replicate hauls were composited in a bucket and then placed in a 250 ml opaque sample bottle containing 1% Lugol's preservative and shipped to plankton taxonomist Jim Sweet of Aquatic Analysts, INC., who performed a microscopic analysis for *Microcystis* and *Anabaena* density (cells ml⁻¹). For toxin analyses the contents of 3 replicate hauls taken with a tube sampler were composited in a bucket and then placed in a 1 liter bottle with no preservative and frozen at the TLBP office. If counts received the following week from Aquatic Analysts, INC showed that cell counts considerably exceeded the Alert Level 2 threshold of 2000 cells ml⁻¹, the frozen samples would then be shipped overnight air on ice to CyanoLab (division of GreenWater Labs in Palatka, FL) for the enzyme linked immunosorbent assay (ELISA) of microcystin toxin and the LC/MS analysis to determine anatoxin-a (Note: because health advisories and media outreach are initiated based upon cell density and not toxin concentration, toxin analysis is not prioritized when budgetary constraints exist or when cell counts are below 15,000 cells/ml). As shown below, because there were no Alert Level 2 exceedances of *Microcystis*, no toxin samples were analyzed in 2008.

RESULTS

2008 Trends

Samples from the first sample trip of June 23rd showed that only one station (S3) exceeded the WHO Alert Level 1 guideline (Yoo et al. 1995; also known as the increased vigilance level for drinking water systems) of 500 cells ml⁻¹ (Table 1; Figure 2) for potentially toxigenic species (the species *Gloeotrichia echinulata* had a cell density of 1,052 cells per ml). The combined density of MSAE and GTEC is computed because GTEC is a potential microcystin producer (Carey et al. 2007). Levels of *Anabaena flos-aquae* and *planctonica* were present at levels that were less than 350 cells/ml. None of the stations exceeded the Alert Level 2 guideline of 2000 cells/ml (at which time DHS and local health services typically issue a public alert for drinking water lakes and reservoirs).

Biovolume at all stations on June 23rd tended to be dominated by the cyanobacterium *Aphanizomenon flos-aquae*, the diatom *Asterionella formosa*, and an unidentified flagellate, with *Gloeotrichia* accounting for only 2.4% of the biovolume at S3 (Electronic Appendix I).

On July 7th levels of potentially toxigenic cyanobacteria remained low with a slight increase occurring on July 28th when either *Microcystis* or *Gloeotrichia* at sample stations S3, N11, and N16 (Table 1) exceeded the WHO Alert Level 1 guideline. Combined levels of *Anabaena flos-aquae*, *A. planctonica*, and *A. circinalis* also exceeded Alert Level 1 at S3 and N11. Again, none of the stations exceeded the Alert Level 2 guideline for drinking water systems (Table 1; Figure 2).

Table 1. Tenmile Lakes Algal Cell Density for Potentially Toxicogenic Species, 2008.

Station	Date	<i>Microcystis aeruginosa</i> (cells/ml)	<i>Gloeotrichia echinulata</i> (cells/ml)	<i>Microcystis</i> + <i>Gloeotrichia</i> (cells/ml)	<i>Anabaena flos-aquae</i> (cells/ml)	<i>Anabaena planktonica</i> (cells/ml)	<i>Anabaena circinalis</i> (cells/ml)	<i>Anabaena sp.</i> (cells/ml)	Total <i>Anabaena</i> (cells/ml)
S3	6/23/2008	0	1051.9	1051.9	0	0	0	0	0
S8	6/23/2008	0	0	0	0	151	0	0	151
N11	6/23/2008	0	0	0	0	53	0	0	53
N16	6/23/2008	0	0	0	331	0	0	0	331
S3	7/7/2008	218	290	508	8	71	0	0	79
S8	7/7/2008	0	0	0	0	0	413	0	413
N11	7/7/2008	954	0	954	0	413	0	0	413
N16	7/7/2008	244	0	244	0	230	0	0	230
S3	7/28/2008	1253	0	1253	20	471	147	0	638
S8	7/28/2008	0	0	0	0	398	0	0	398
N11	7/28/2008	0	976	976	151	1454	0	0	1605
N16	7/28/2008	520	0	520	0	174	0	0	174
S3	8/11/2008	0	0	0	38	3977	0	0	4015
S8	8/11/2008	952	0	952	0	2048	0	0	2048
N11	8/11/2008	0	0	0	199	5588	0	0	5787
N16	8/11/2008	1579	0	1579	0	415	0	0	415
S3	8/26/2008	683	0	683	0	2377	0	0	2377
S8	8/26/2008	1210	0	1210	0	3087	0	0	3087
N11	8/26/2008	217	0	217	0	3101	0	0	3101
N16	8/26/2008	1019	0	1019	14	6133	0	0	6147
S3	9/8/2008	222	0	222	0	4778	0	0	4778
S8	9/8/2008	1569	0	1569	0	2747	92	0	2839
N11	9/8/2008	782	0	782	6	1241	0	0	1247
N16	9/8/2008	1463	0	1463	0	4690	0	0	4690
S3	9/22/2008	373	0	373	0	1663	0	0	1663
S8	9/22/2008	422	0	422	0	214	0	0	214
N11	9/22/2008	905	0	905	0	752	0	0	752
N16	9/22/2008	1159	0	1159	0	941	0	0	941

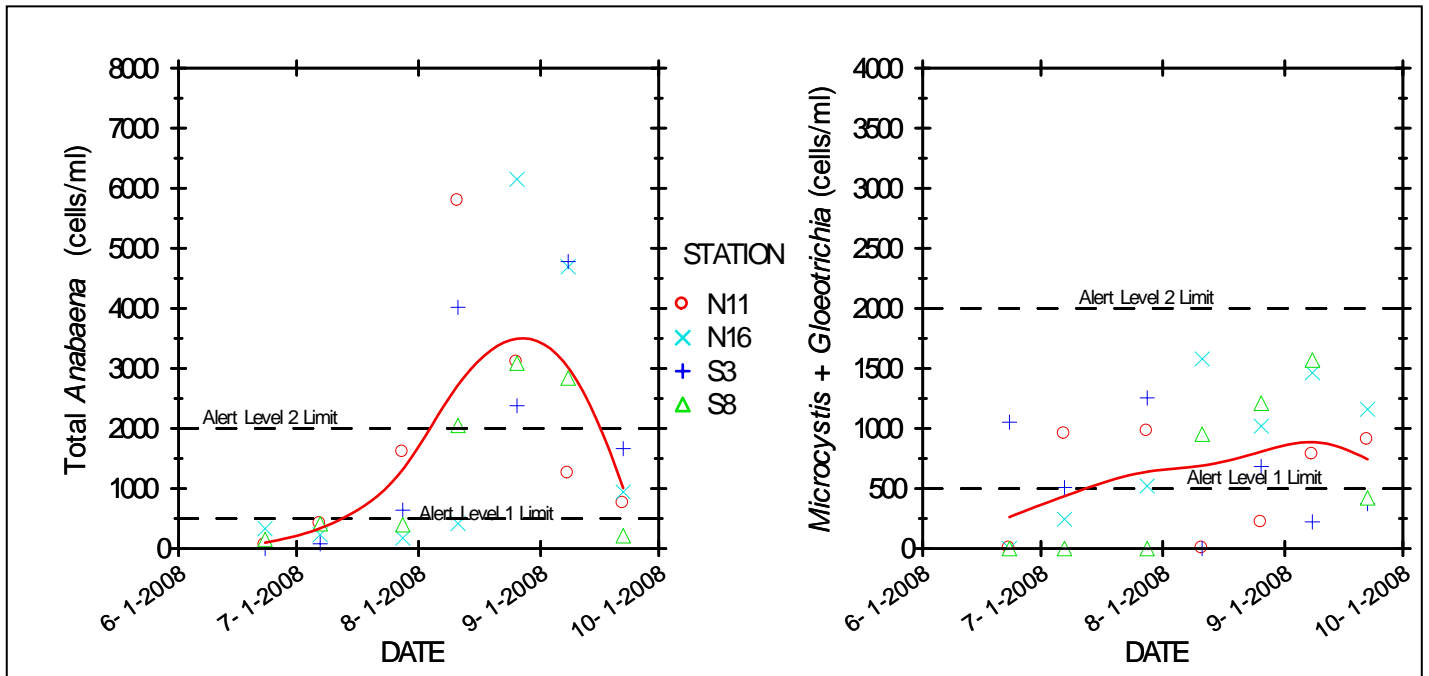


Figure 2. Cell Density of *Microcystis aeruginosa* and total *Anabaena sp.* in Tenmile Lakes, 2008 (red line is distance weighted least squares-dwls trend line).

Biovolume at all stations on July 28th was predominated by the cyanobacterium *Aphanizomenon flos-aquae*, with a maximum value of 28,803 cells/ml at S8 (Electronic Appendix 1). Although this exceeds the drinking water Alert Level 2 guideline, this species has not demonstrated toxin production in Oregon. *A. planctonica* as well as various Chrysophytes, Cryptophytes, and Diatoms comprised the remainder of the biovolume on July 28th.

By Aug 11th *Microcystis* cell densities at sample stations S8 and N16 (Table 1; Figure 2) exceeded the WHO Alert Level 1 guideline of 500 cells/ ml, and total *Anabaena* (combined levels of *Anabaena flos-aquae*, *A. planctonica*, and *A. circinalis*), although remaining just below Alert Level 1 at N16 increased at stations S3, S8, and N11 to exceed the Alert Level 2 guideline of 2000 cells/ml (station N11 at 5787 cells per ml exceeded the Alert Level 2 guideline by 2.9 times). However, as stated in previous Technical Memos, the predominant *Anabaena* species was *Anabaena planctonica* (Electronic Appendix I), a species less commonly associated with toxin production.

Aside from N11 which was dominated by *Anabaena planktonica* (56.9% by biovolume) on August 11th, biovolume at remaining stations continued to be dominated by the cyanobacterium *Aphanizomenon flos-aquae*, with a maximum cell density value of 18,677 cells/ml at N16 (Electronic Appendix 1). *A. planctonica* as well as various Chrysophytes, Cryptophytes, and Diatoms comprised the remainder of the biovolume, with diatom biovolume increasing in importance since the last sample date.

On Sep 8th *Microcystis* cell densities remained low and did not exceed Alert Level 2 at any stations (Figure 2). The levels of total *Anabaena* since the previous sample period of 8/26/08 declined at N11 and N16, increased at S3, and remained similar at S8, causing the overall trend to remain similar or even show a slight decline (Figure 2; red dwls trend line). Total *Anabaena* at S3, S8, and N16 exceeded the Alert Level 2 guideline value.

Anabaena planktonica continued to account for the majority of algal biomass on Sep 8th, dominating at all stations by between 76.2-90.3% of the biovolume (Electronic Appendix 1). *Aphanizomenon flos-aquae* remained at less than 10% of the biovolume, and the diatom *Melosira granulata* increased in importance at south lake stations.

At the final seasonal sampling period of Sep 22nd, *Microcystis* cell density remained below Alert Level 2, and total *Anabaena* density at all stations declined from September 8th, with no exceedances of the Alert Level 2 guideline for drinking water systems (Table 1; Figure 2).

Anabaena planktonica continued to account for the majority of algal biomass, dominating at all stations by between 43.6-66.7% of the biovolume (Electronic Appendix 1). However, ABPL dominance decreased overall and the diatom *Melosira* increased in importance.

Because reported levels indicate the general trend but can not guarantee that levels of potentially toxigenic species at a particular location do not exceed guideline values, and the fact that cyanobacterial cells have been reported in home-owner drinking water treatment systems (see Kann 2007), drinking water protection efforts should always be in place. Patchy distribution of algae and accumulation in localized areas is compellingly demonstrated by photographs taken by a homeowner on 9-19-08 in the vicinity of sampling station N16 on North Tenmile Lake (Figure 3). Although levels of all potentially toxigenic cyanobacteria were well below the recreational guidelines of 40,000 cells/ml for *Microcystis* or 100,000 cells/ml for *Anabaena* or *Aphanizomenon* at the regular sampling stations (Table 1), the photo in Figure 3 indicates concentrations far higher than those measured at nearby N16. If the predominant species was *A. planktonica* similar to N16, then toxin values would likely have been low; however, if the predominant species was *Microcystis* then the probability for high toxin concentrations increases. Thus, as previously stated in the below disclaimer: "...those utilizing the lake for drinking water should always follow Oregon Health Division recommendations for purification (attached). In addition, recreational users should always avoid contact with water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance."

These data indicate that although cell density levels were still relatively low with respect to recreational guidelines (e.g., which would be 100,000 cells/ml for *Anabaena* and 40,000 cells/ml for *Microcystis*; Stone and Bress 2007) that the potential to exceed drinking water standards and to locally exceed recreational guidelines continues to exist in Tenmile Lakes.

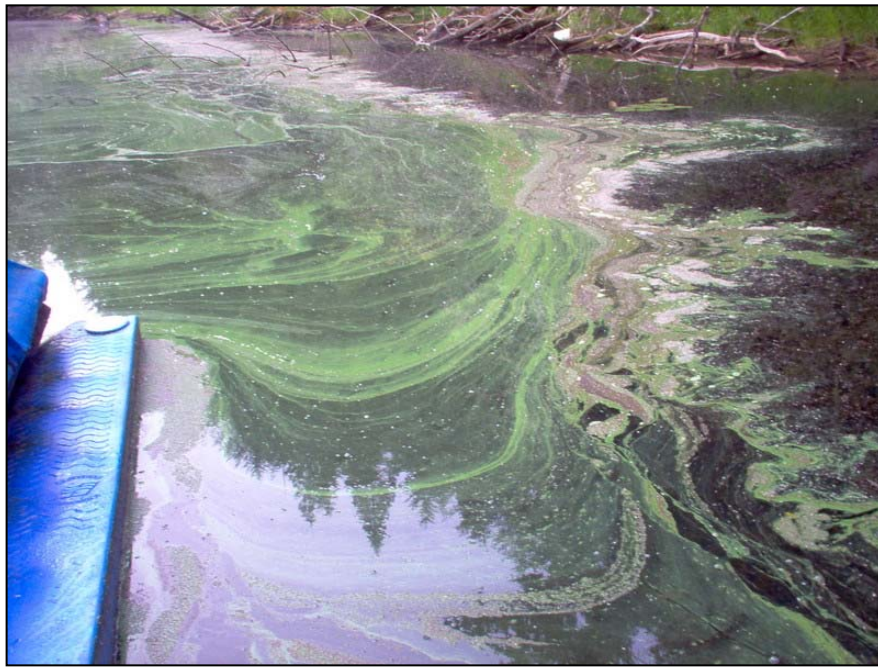


Figure 3. Photo of shoreline area of North Tenmile Lake near N16; photo taken 9-19-08

2002-2008 Comparison

Unlike 2007 when density and consistency of detection of *Microcystis* in Tenmile Lakes was somewhat higher than all previous years, values in 2008 were more similar overall to years 2003-2006 (Figure 4a,b). In addition, 2008 was the only other year besides 2004 where no exceedances of the Alert Level 2 guideline occurred (Figure 4a).

Although somewhat lower than 2007, total *Anabaena* density remained noticeably higher in 2008 than for the previous 2002-2006 period, with 10 occurrences when cell density exceeded the Alert Level 2 guideline (Figure 4). However, as noted above, the predominant *Anabaena* species was *Anabaena planktonica* (Table 1), a species less commonly associated with toxin production than *Anabaena flos-aquae*.

Disclaimer

Due to the patchy nature of blue-green algal blooms it is possible for higher *Microcystis* and *Anabaena* densities (and therefore higher microcystin or anatoxin concentrations) to be present in areas not sampled in this survey, particularly along shorelines or during calm conditions of little to no wind. Given the lakes' demonstrated history of toxic *Microcystis* and *Anabaena* blooms, and the fact that all areas of the lake cannot be tested at all times, those utilizing the lake for drinking water should always follow Oregon Health Division recommendations for purification. In addition, recreational users should always avoid contact with water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance. Moreover, because pets or other domestic animals are the most likely to ingest contaminated water, these animals should not be allowed access to the lakeshore whenever either noticeable surface concentrations of algae or an obvious green to blue-green appearance is evident.

A fact sheet about *Microcystis aeruginosa* and recommendations for water treatment may be obtained from the Coos County Health Department at (541) 756-2020 or from DHS at www.oregon.gov/DHS/ph/envtox/mafact.shtml

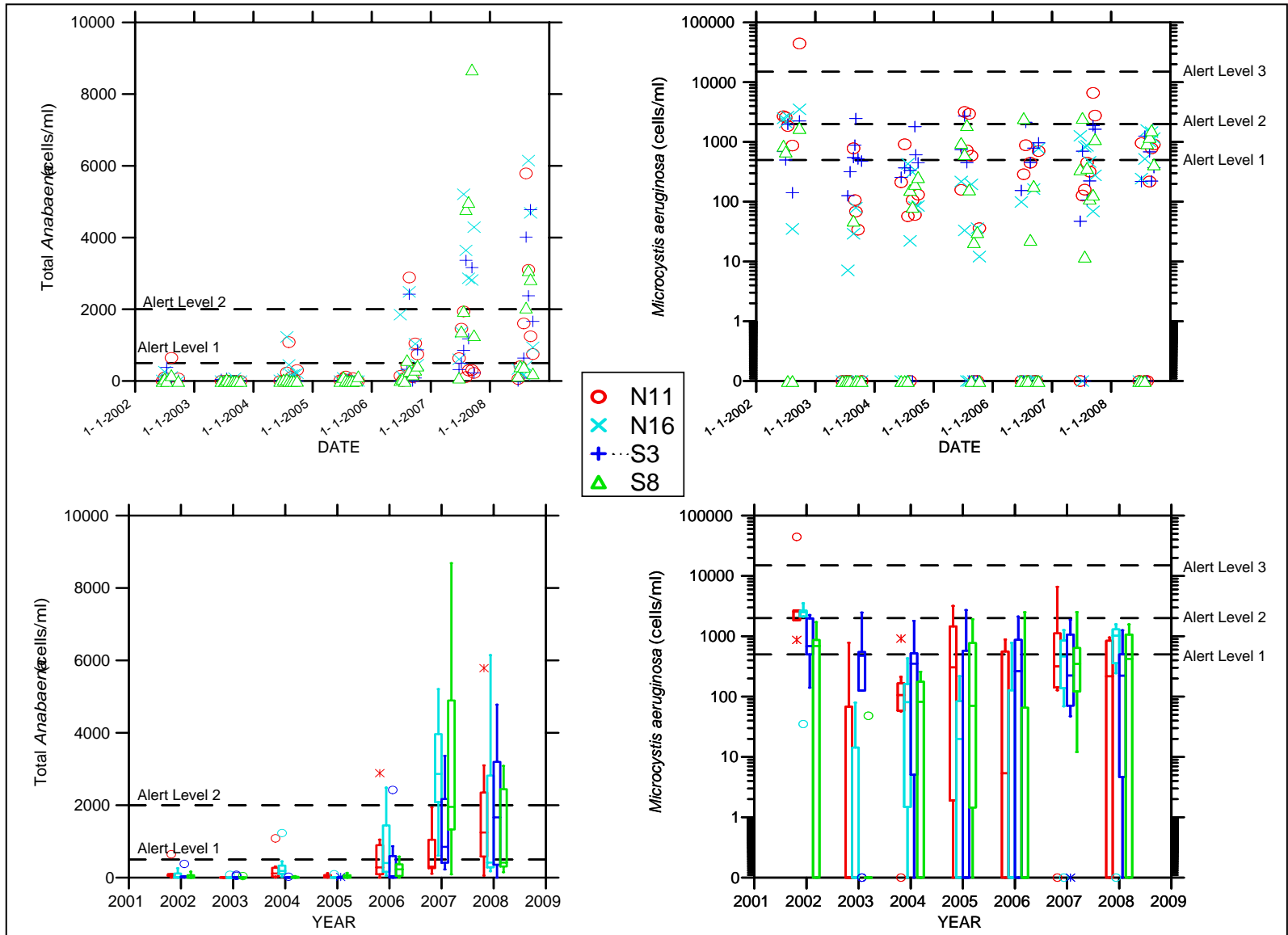


Figure 4. Cell density of *Microcystis aeruginosa* and *Anabaena flos-aquae* in Tenmile Lakes, 2002-2007; time-series of individual data points (a), and box plots grouped by station (b).

Literature Cited

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Electronic Appendix I: Aquatic Analysts, Inc Phytoplankton Reports (attached electronically)