# REAL-TIME AND COMPREHENSIVE MODELS FOR PREDICTING MICROCYSTIN CONCENTRATIONS AT OHIO RECREATIONAL LAKES

D.S. Francy[1], E. A. Stelzer[1], C.D. Ecker[1], J.L. Graham[2], K.A. Loftin[2], P. Struffolino[3], Brady, A.M.G.[1], and R.N. Bushon[*1]

[1]USGS Ohio Water Science Center, Columbus, OH; [2]USGS Kansas Water Science Center, Lawrence, KS; [3]University of Toledo, Oregon, OH

## Abstract

Cyanobacterial harmful algal blooms (cyanoHABs) and associated toxins, such as microcystin, are a major global water-quality issue. CyanoHAB prediction is complicated and site specific because of the many factors affecting toxin production, but it is an important goal for public health protection. Monitoring a suite of chemical, biological, and physical parameters provides the foundation needed to predict cyanoHABs.

Data were collected at Lake Erie and inland lake sites weekly to monthly from May–November 2013–14. Physical parameters were measured at the time of sampling and composite samples collected from the swimming area were analyzed for toxins, nutrients, phytoplankton, and cyanobacterial genes. Weather, hydrologic, and water-quality data were evaluated for use as factors in real-time and comprehensive predictive models.

Throughout each season, the cyanobacterial community and the dominant taxa associated with peak microcystin concentrations were unique to individual lakes. Statistically significant correlations between microcystin concentrations and factors for real-time predictions included phycocyanin, turbidity, pH, discharge from a nearby river, and Secchi depth; continuous monitor measurements provided the highest correlations. Significant factors for comprehensive predictions included measures of cyanobacterial biovolume and abundance, cyanobacterial genes, and nutrients.

HarshaBuoy1

## Methods

**Sampling sites and frequency**: Monthly at 8 beach sites during 2013 and weekly at 5 recreational sites at 3 lakes during 2014.

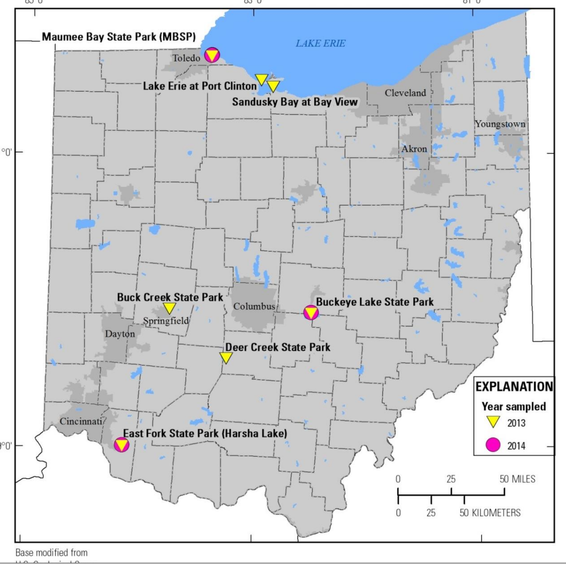
**Sampling procedures:** Samples from several subsample locations in the swimming area were composited into bottles and processed and preserved for laboratory analyses. Physical parameters were measured at each subsample location using a water-quality sonde.

**Laboratory analyses.** Cyanotoxins, nutrients, phytoplankton, and cyanobacterial genes.

**Continuous monitors and environmental data**: Continuous water-quality data were provided by sondes located 1 mi north of Harsha Main (operated by U.S. Environmental Protection Agency) and 6 miles northeast of Maumee Bay State Park (MBSP) Lake Erie beach, outside the City of Toledo water intake crib (operated by LimnoTech). Weather and hydrologic data were compiled from available on-line sources.

**Factors were evaluated for two modeling scenarios:**

- **Real-time** models include easily- or continuously-measured factors and available environmental data that do not require discrete sample collection.
- **Comprehensive** models use results from samples collected and analyzed in a laboratory along with real-time factors.

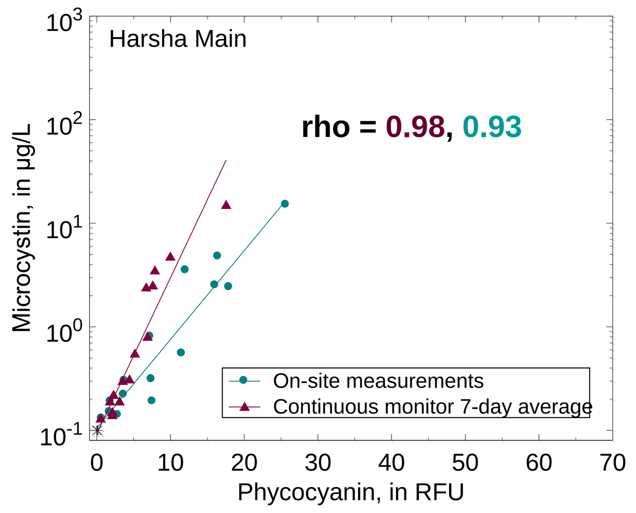




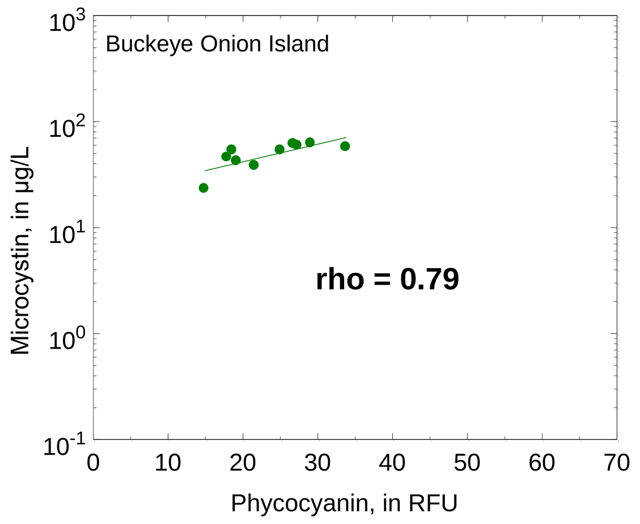
## Physical water-quality factors

Continuous water-quality monitor data compiled for different time periods were significantly correlated (Spearman's correlations) to microcystin concentrations at the two sites where these data were available; the most significant time period for each parameter is shown in the table below. Phycocyanin was significantly correlated to microcystin concentrations at three beaches with weekly data, whether measured with a continuous or hand-held monitor.

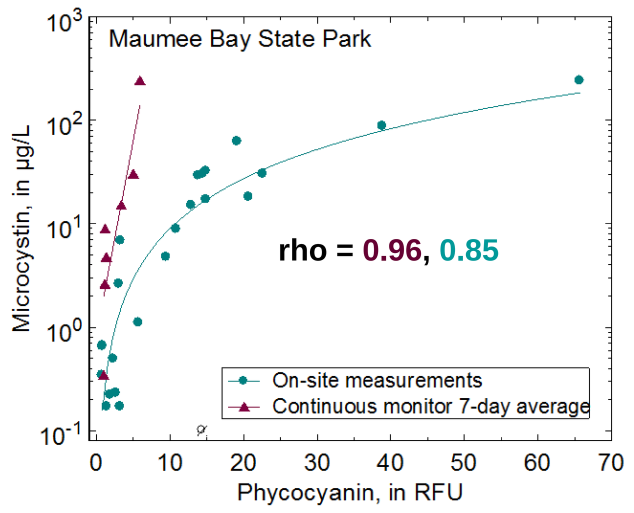
| Continuous monitors—correlations to microcystin concentrations | | | | |
|---|---|---|---|---|
| Most significant average time period for each variable | Harsha (n=17) | | Maumee Bay (n=8) | |
| | rho | p | rho | p |
| Phycocyanin, 7-day | 0.98 | <0.0001 | 0.96 | <0.0001 |
| Dissolved oxygen, 14-day | 0.88 | <0.0001 | -- | -- |
| Oxidative reductive potential, 24-hr | -- | -- | -0.98 | <0.0001 |
| pH, 7-day or 14-day | 0.83 | <0.0001 | 0.77 | 0.0724 |
| Temperature, instantaneous 10 a.m. or 14-day | 0.73 | 0.0031 | 0.71 | 0.1108 |
| Chlorophyll, 24-hour or 3-day | 0.53 | 0.0358 | -0.24 | 0.5706 |









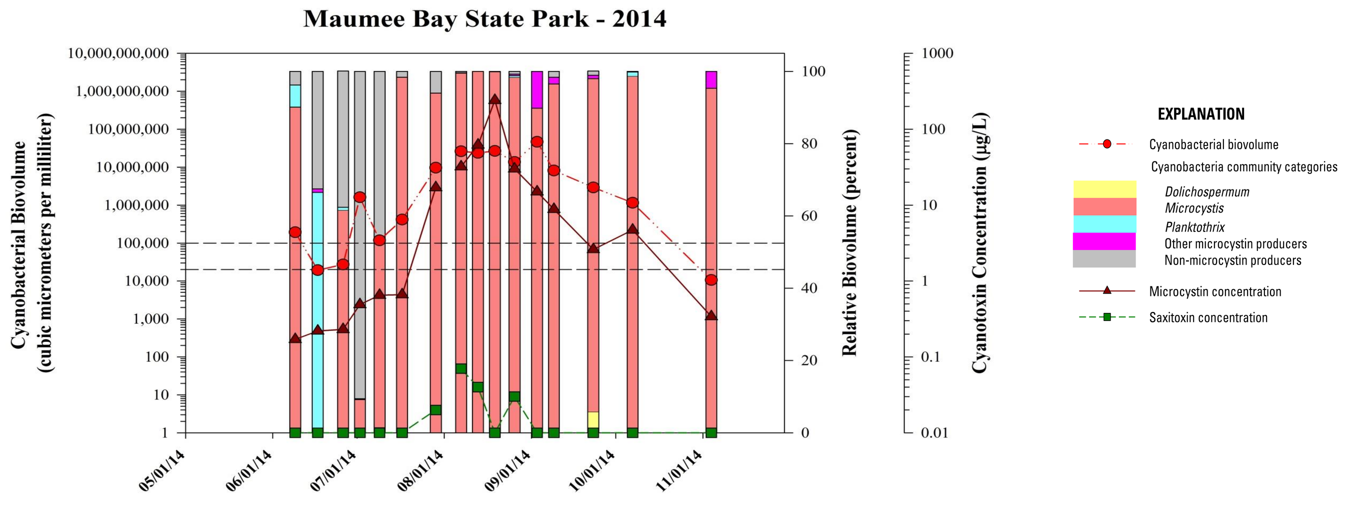




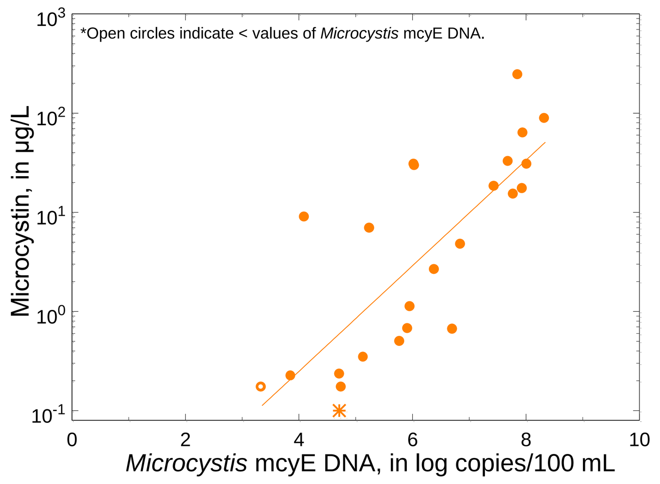
## Results at Lake Erie and an inland lake beach

### Maumee Bay State Park

The cyanobacterial community was variable in June and early July and *Microcystis* dominated from mid July through November. Microcystin and saxitoxin were both detected in Maumee Bay and concentrations peaked in late summer. Microcystin was significantly correlated (p≤0.05) with real-time and comprehensive variables.





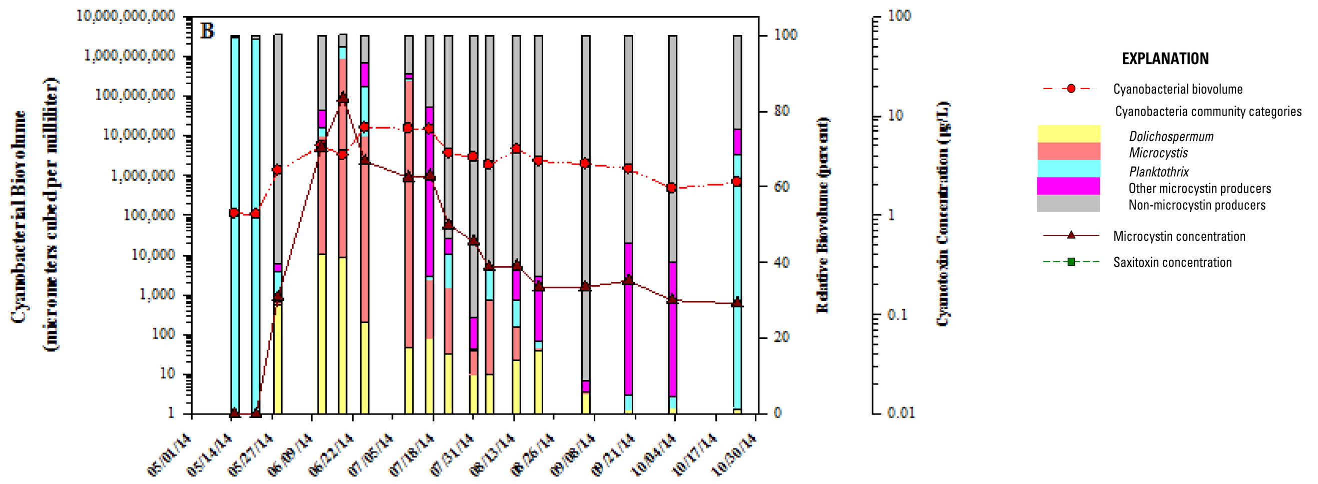




| Highest Spearman's correlations to microcystin (n=24) | | |
|---|---|---|
| **Real-time model factors** | **rho** | **p** |
| Phycocyanin, turbidity, pH | 0.76 – 0.85 | <0.0001 |
| Maumee River discharge, daily mean ,3 d before sample | -0.69 | 0.0002 |
| Secchi depth | -0.67 | 0.0004 |
| Algae category | 0.62 | 0.0012 |
| **Comprehensive model factors** | | |
| *Microcystis*, cyanobacteria biovolume or abundance | 0.84 – 0.87 | <0.0001 |
| *Microcystis mcyE* DNA, *Microcystis* by qPCR | 0.73 – 0.82 | <0.0001 |
| Total phosphorus | 0.78 | <0.0001 |
| Ammonia, nitrate + nitrite | -0.64 – -0.78 | <0.0001 |

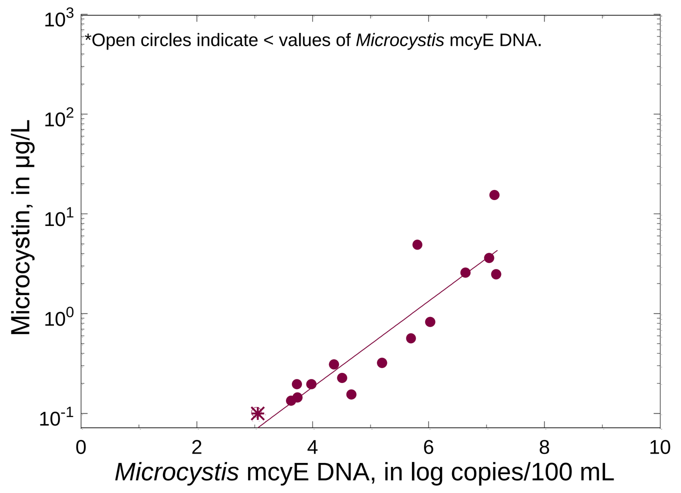
### Harsha Main Beach

At Harsha Main, *Planktothrix* dominated the cyanobacterial community in May and late October, *Anabaena* and *Microcystis* were substantial portions from late May through August, and non-microcystin producing taxa were dominant from late-July through early-October. Microcystin was detected from June through October and concentrations peaked in late June. Microcystin was significantly correlated (p≤0.05) with real-time and comprehensive variables.





| Highest Spearman's correlation to microcystin (n=17) | | |
|---|---|---|
| **Real-time model factors** | **rho** | **p** |
| Phycocyanin, turbidity, and pH | 0.73 – 0.93 | <0.0001 |
| Algae category | 0.72 | 0.0010 |
| Secchi depth | -0.69 | 0.0022 |
| Chlorophyll and water temperature | 0.59 –0.63 | A0.0095 |
| **Comprehensive model factors** | | |
| *Microcystis mcyE* DNA, *Microcystis* or *Anabaena* qPCR | 0.90 – 0.92 | <0.0001 |
| Cyanobacteria BV; *Microcystis*, *Anabaena*, abundance or BV | 0.63 – 0.90 | <0.0001 |
| Cyanobacterial abundance, cyanobacteria qPCR | 0.58 – 0.63 | A0.0116 |
| Ammonia, nitrate + nitrite, orthophosphate | -0.48 – -0.53 | A0.0400 |





## Conclusions

The results of this study showed that environmental factors are promising for use in site-specific models for cyanoHABs at freshwater lakes. Continuous water-quality measurements over multiple days showed the highest correlations to microcystin concentrations. Future studies should focus on collecting more frequent data on several consecutive days each week before, during, and after the cyanoHAB season to develop robust site-specific models.

**Partners**

- **University of Toledo – Daryl Dwyer, Pam Struffolino, and students**
- **Clermont County Soil and Water Conservation District – John McManus, Alex Delvalle, Hannah Gonzalez**
- **Erie County Health Dept – Craig Ward and Bob England**
- **Ohio Department of Natural Resources – Jean Backs, Jason Wesley, and staff at Buckeye Lake**
- **USEPA – Joel Allen, Chris Nietch, and Dana Macke**
- **USACE – Kamryn Tufts, Steve Foster, and Jade Young**
- **Ohio EPA—Linda Merchant-Masonbrink and Heather Raymond**

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