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science for a changing world

The feasibility of developing models for predicting microcystin concentrations in freshwater recreational lakes

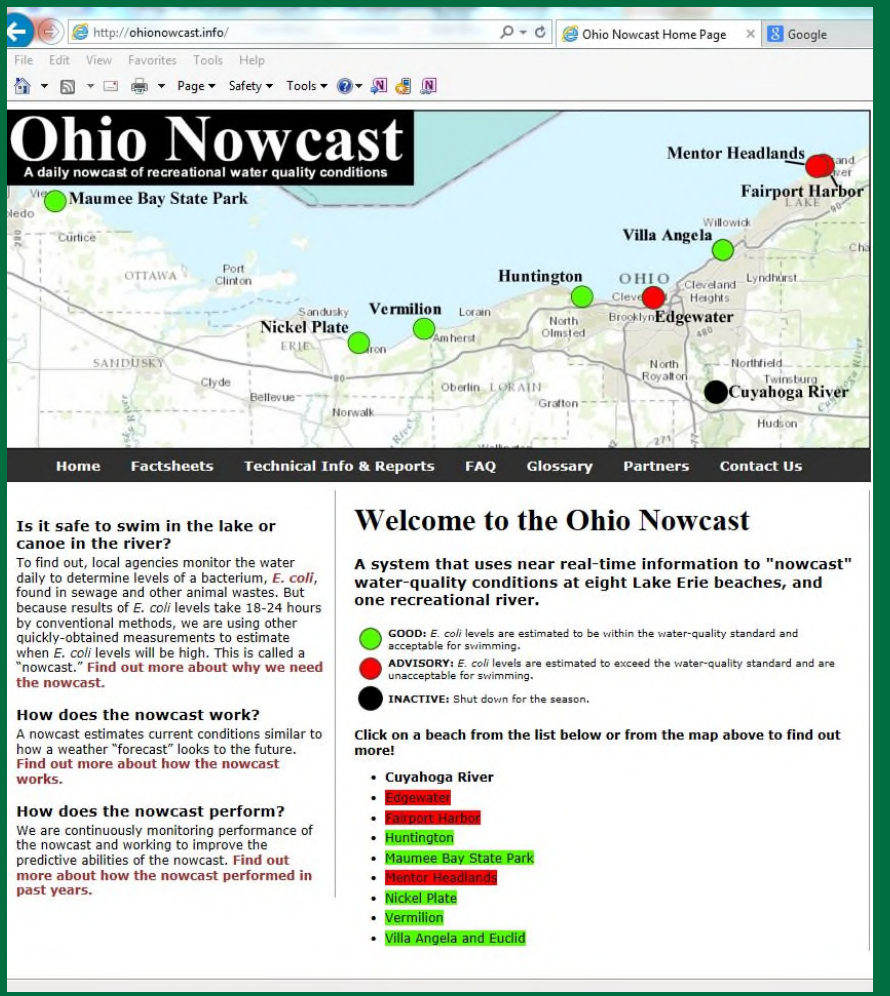
10th National Monitoring Conference

May 4, 2016

U.S. Department of the Interior
U.S. Geological Survey

A nowcast for cyanobacterial harmful algal blooms (cHABs)?

- Focus sample collection when toxins are likely to be elevated
- Provide real-time swimming advisories to the public
- Help optimize drinking-water treatment and intake options for current conditions



http://ohionowcast.info/

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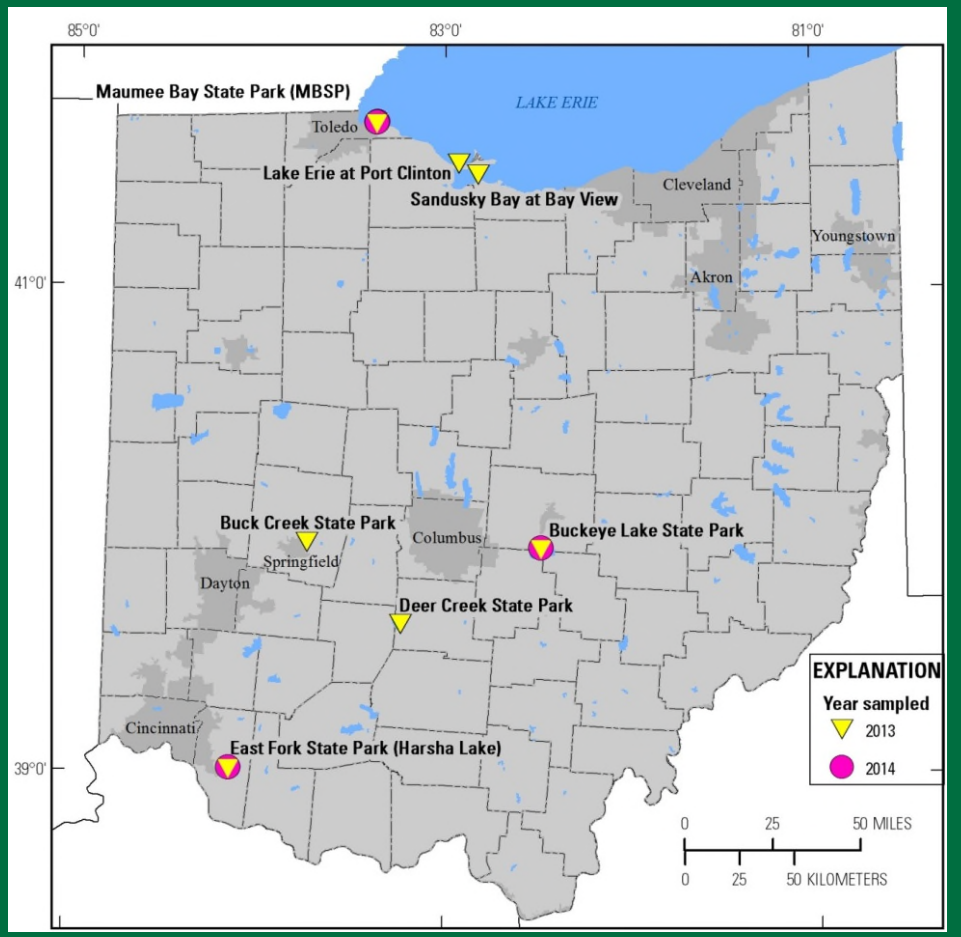
Objectives: 2013-14 recreational study

- Identify factors that can be used in models to estimate toxin levels
  - Cyanobacterial molecular assays and cell counts
  - Phycocyanin and chlorophyll pigment measurements
  - Nutrient concentrations
  - Weather and hydrology



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Sampling procedures

- Weekly to monthly, May–Nov
- Composited 3 to 6 sub-samples
- In-situ measurements
- Split and preserved samples

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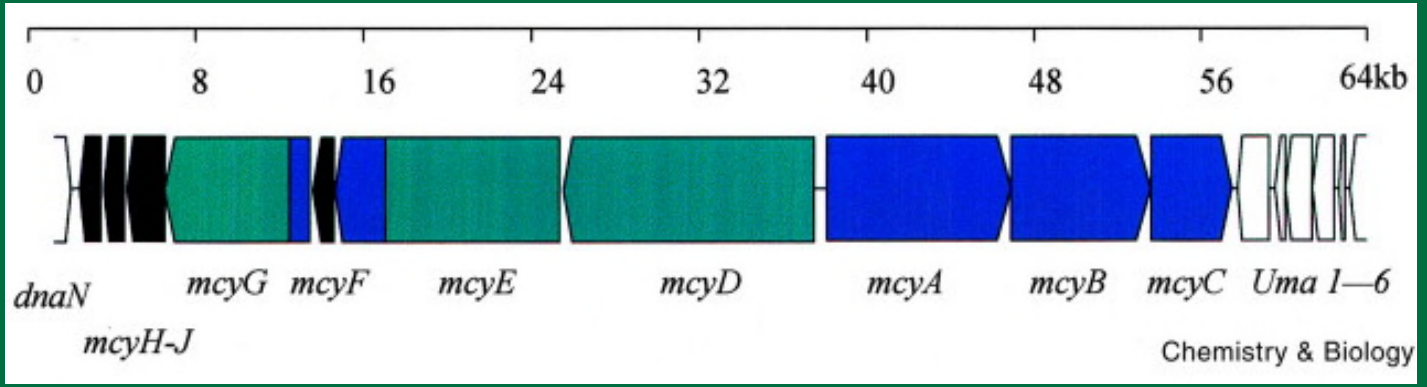
Cyanobacterial qPCR assays

1. General cyanobacteria
2. General *Microcystis* and *Dolichospermum (Anabaena)*
3. Genus-specific *mcyE* assays for *Microcystis*, *Planktothrix*, and *Dolichospermum*—DNA for the presence of toxin gene
4. Genus-specific *mcyE* assays for above genera—RNA for the active expression of the toxin gene



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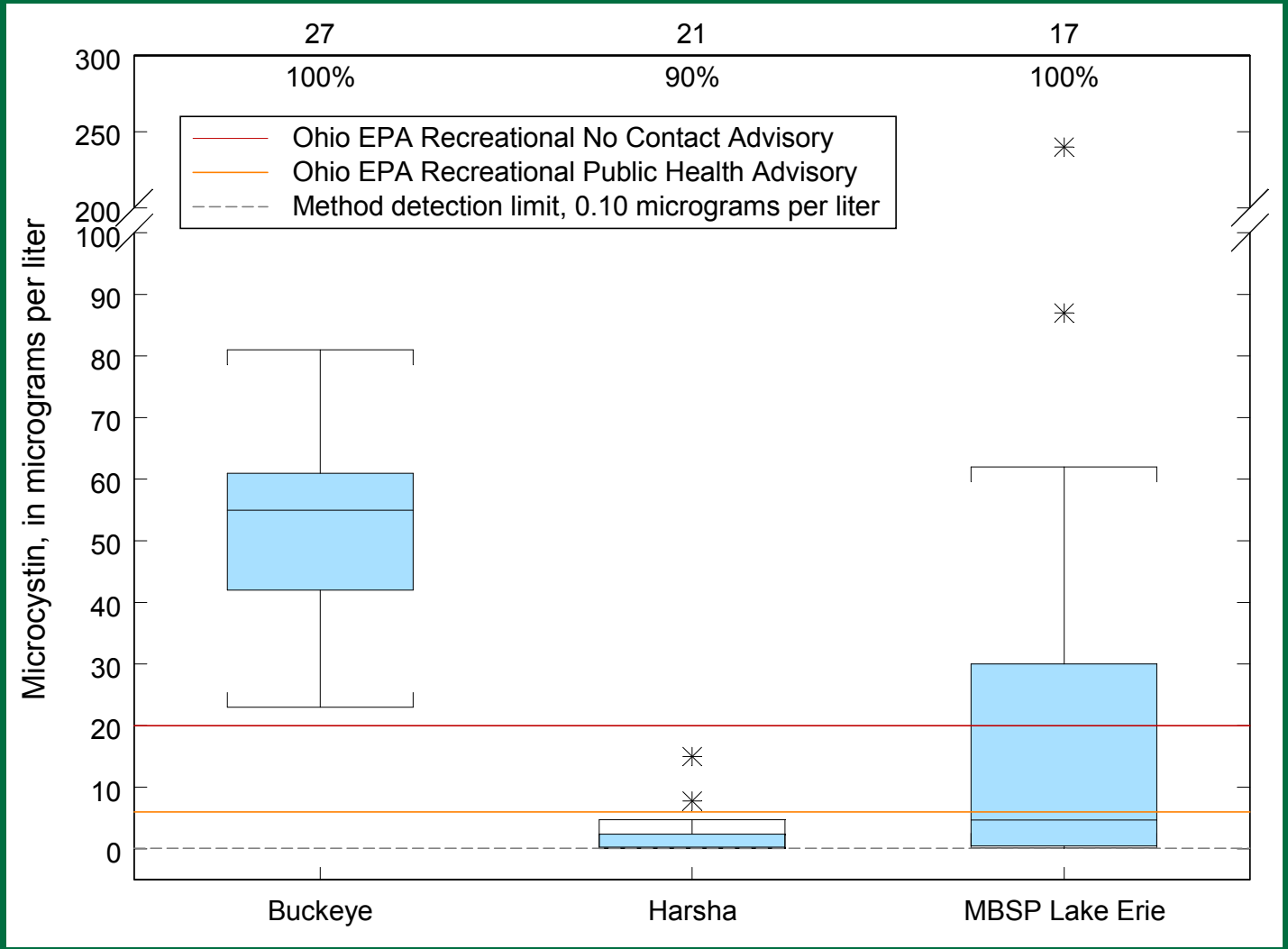
Results 2014—Microcystin by ELISA

EXPLANATION

n	Number of samples
X%	Percentage of detections
✳	Outliers[1]
	Upper whisker[2]
	75th percentile
	Median of detections
	25th percentile
	Lower whisker[2]



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Two different modeling scenarios (for estimating microcystin concentrations)

- **Real-time** models include factors that are easily or continuously measured
- **Comprehensive** models use factors that include results from a sample collected and analyzed in a laboratory

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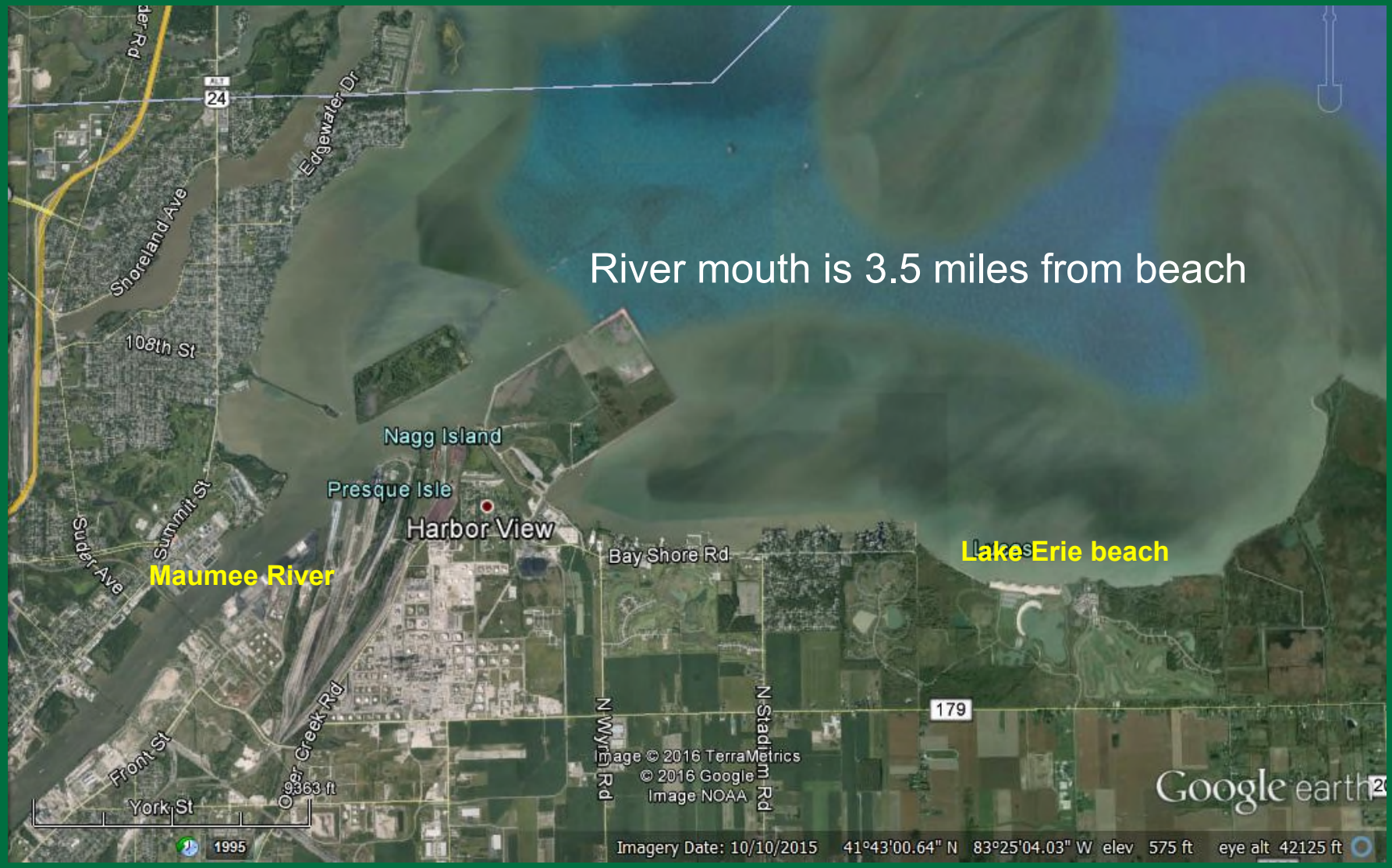
Maumee Bay State Park 2013–14



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Maumee Bay State Park 2013–14

Highest Spearman's correlations to microcystin (n=24, A=average)		
Real-time model factors	**rho**	**p**
Phycocyanin, turbidity, pH	**0.76 – 0.85**	**<0.0001**
Maumee River stream flow, daily mean, 3 d prior	**-0.69**	**0.0002**
Secchi depth	**-0.67**	**0.0004**
Algae category	**0.62**	**0.0012**
Streamflow, 14 d or 30 d, average or peak	**-0.48 – 0.56**	**A0.0085**
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**
Microcystis mcyE RNA	**0.58**	**0.0109**

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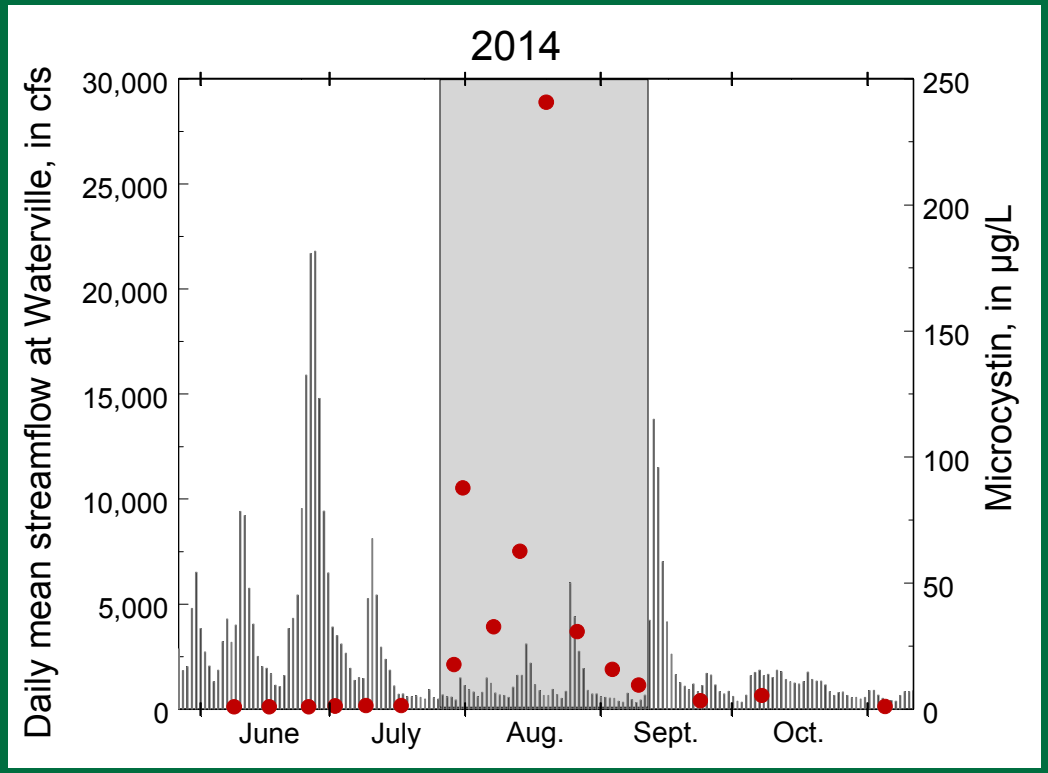
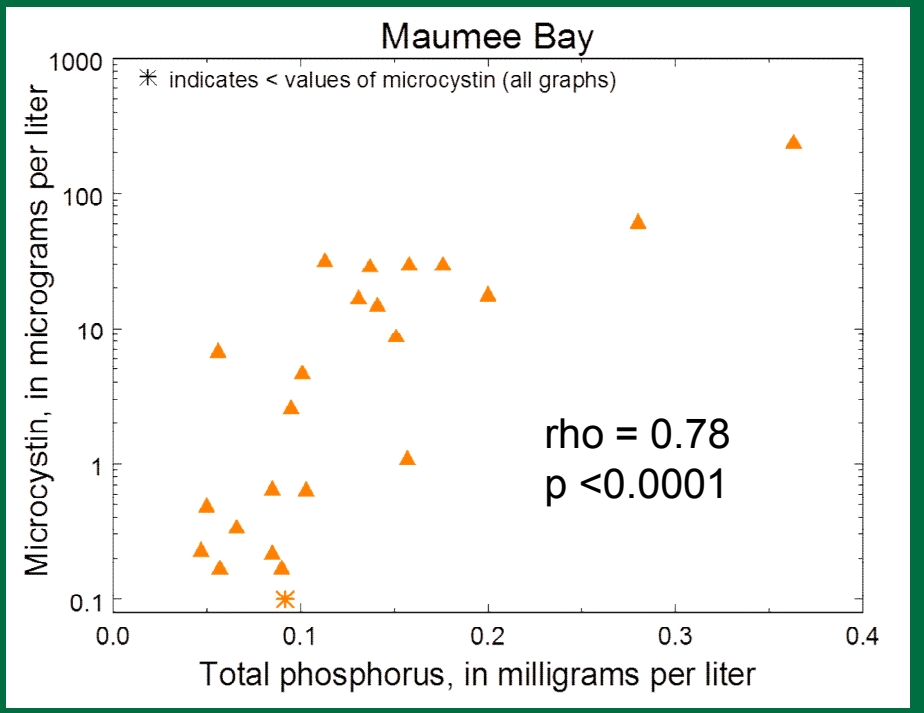
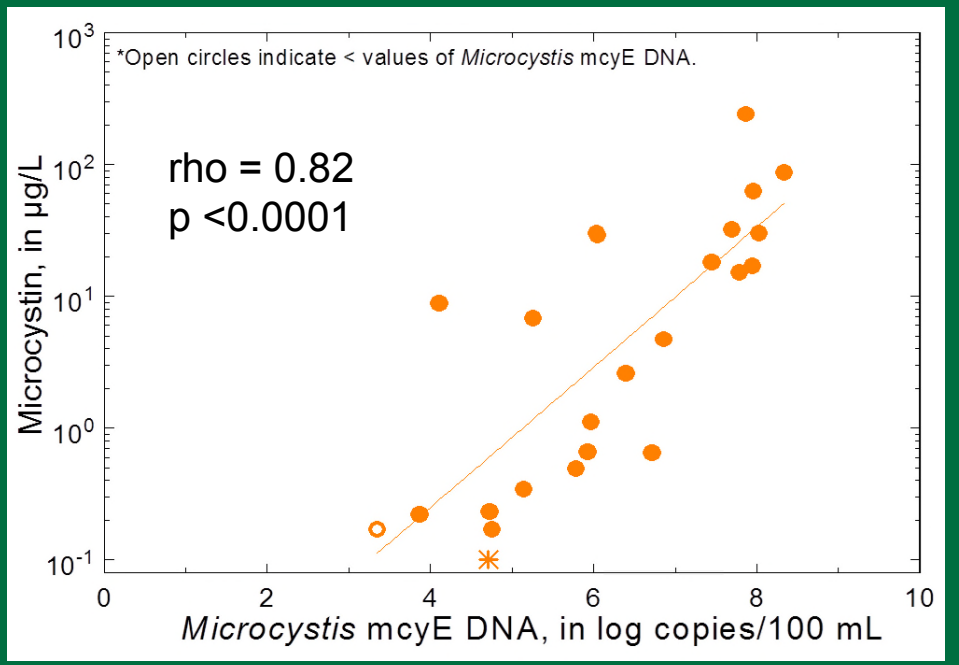
Factors significantly correlated to microcysin







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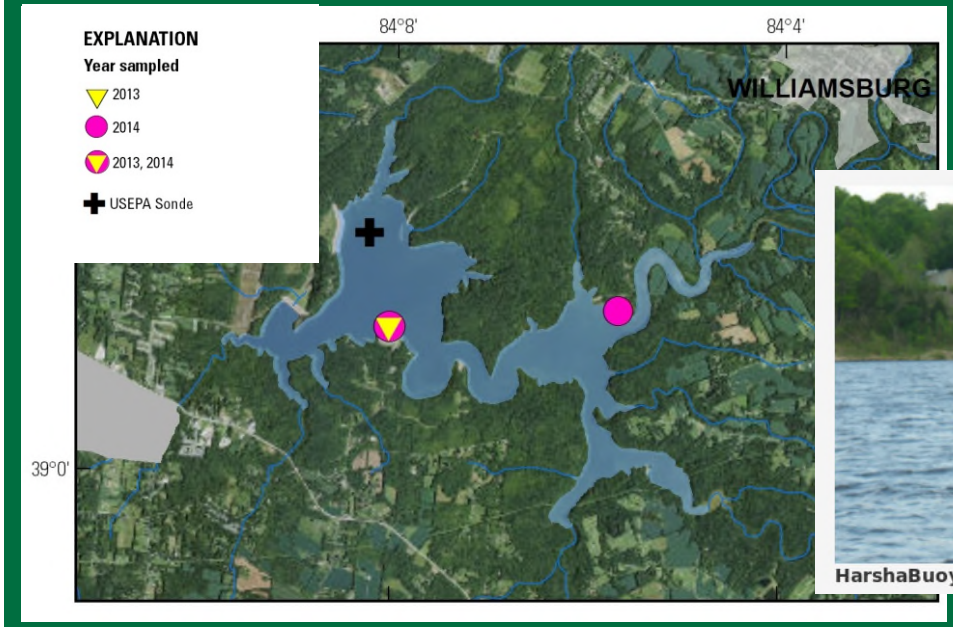
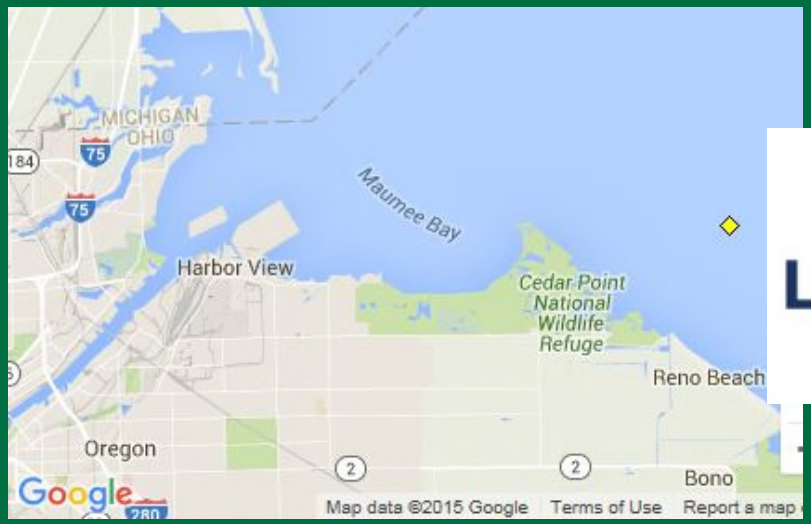
Continuous monitor data



Harsha Lake

- 5/15–11/24/14



Toledo Water Intake

LimnoTech

Water Environment | Scientists Engineers

Maumee Bay State Park

- 8/7–11/6/14

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Continuous monitor and microcystin concentrations

Time period for each variable with highest correlation	Harsha (n=17)		Maumee Bay (n=8)	
	rho	p	rho	p
Phycocyanin, 7-day	0.98	<0.0001	0.96	<0.0001
ph, 7-day or 14-day	0.83	<0.0001	0.77	0.0724
Temperature, inst. 10 am or 14-day	0.73	0.0031	0.71	0.1108
Chlorophyll, 24-hr or 3-day	0.53	0.0358	-0.24	0.5706
Specific conductance, 3-day	-0.20	0.4473	-0.20	0.7040

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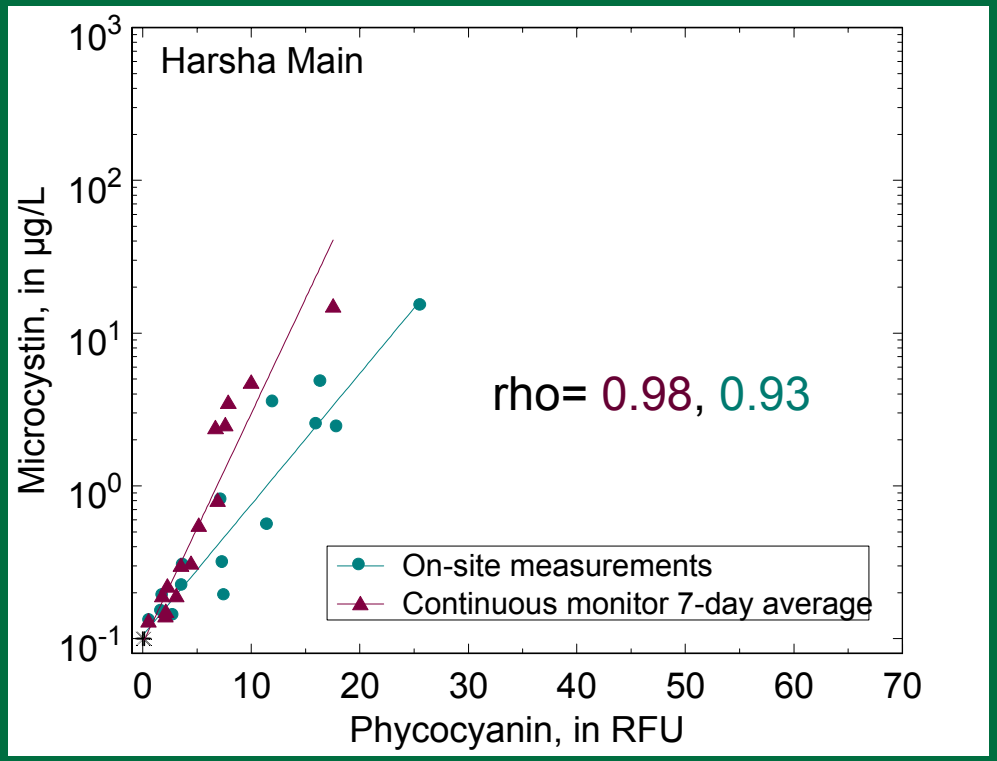
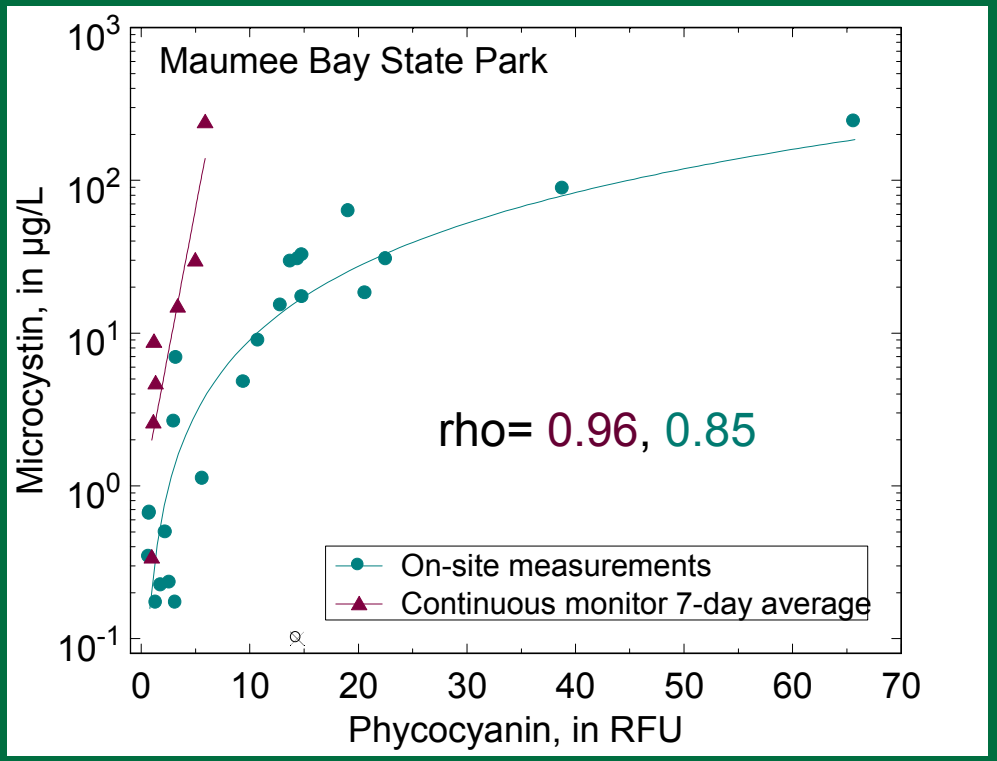
Real-time estimates of microcystin from phycocyanin





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Conclusions: 2013–15 study

- Measures of the algal community and pH were strongly correlated with microcystin concentrations
  - Phycocyanin, cyanobacterial biovolume, cyanobacterial gene concentrations
- Continuous monitor measurements over multiple days showed the highest correlations to microcystin
- Need multi-year data collection with samples collected on several consecutive days each week

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Developing models for estimating microcystin concentrations: 2016–17

- Model development at MBSP and Harsha Lake
- Identify factors related to microcystin concentrations at 7 drinking-water plant intake sites and 1 boater site

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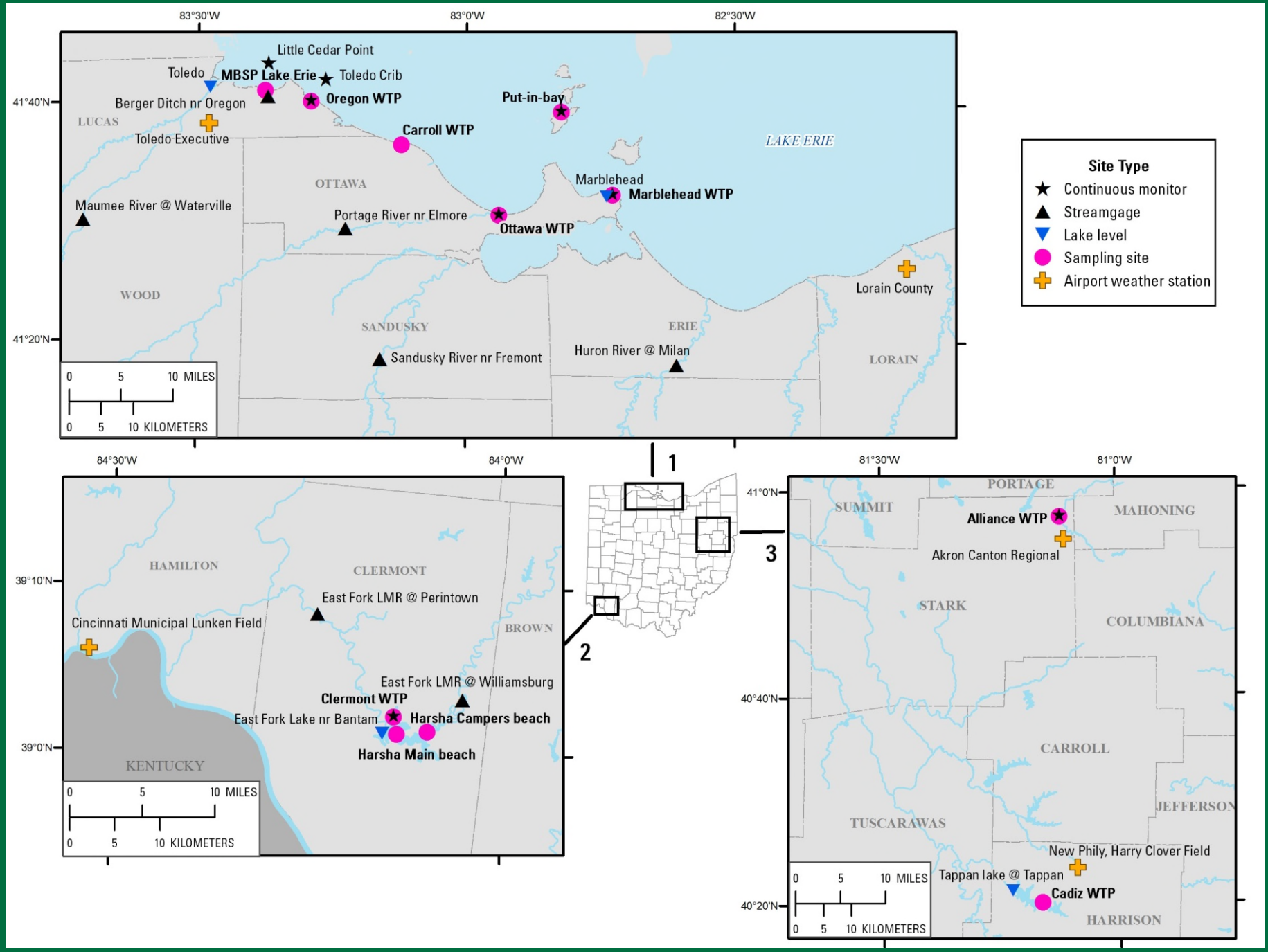
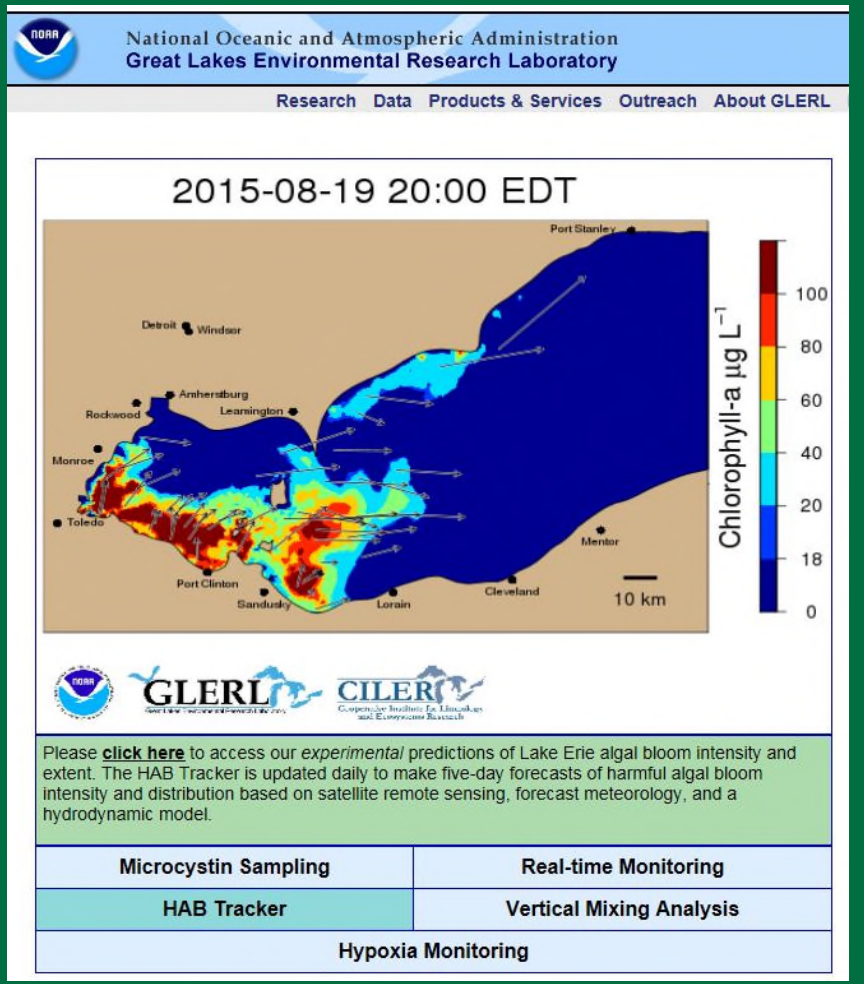
Monitoring, sampling, and data sites



Modeling—satellite imagery data

- Satellite data for specified locations
- Includes estimates of cell counts obtained from images
- Current counts and forecasted counts for next 3 days
- Counts at mid-day



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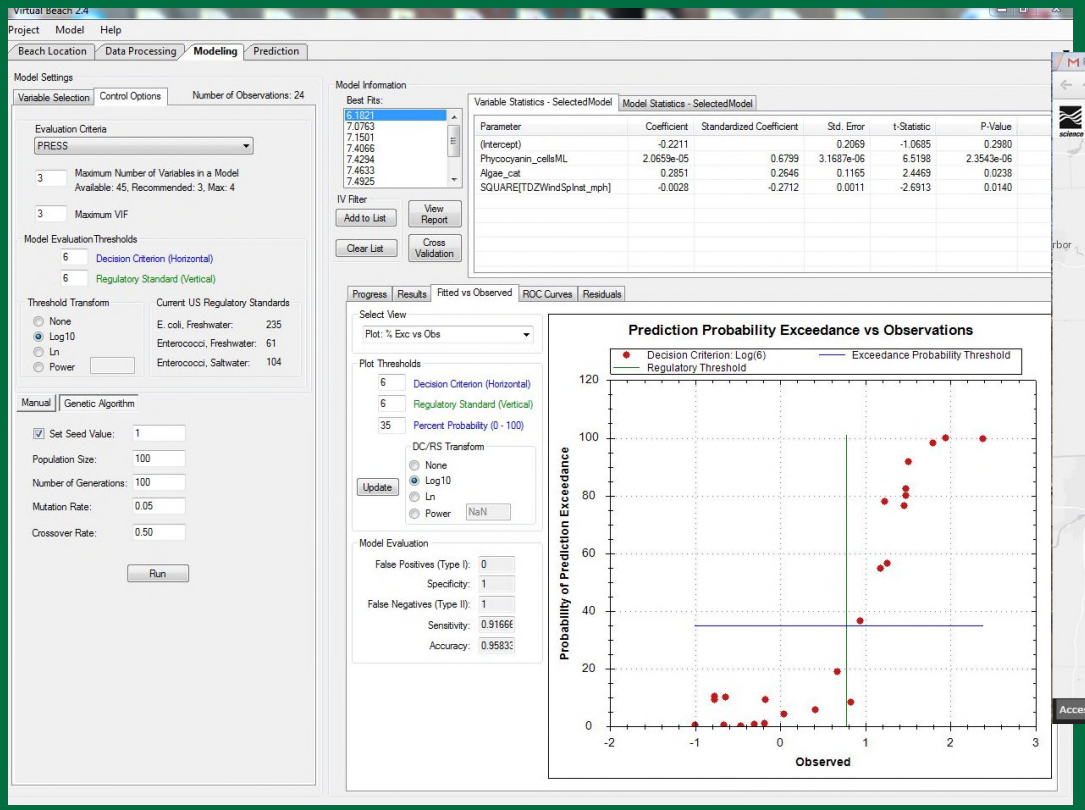
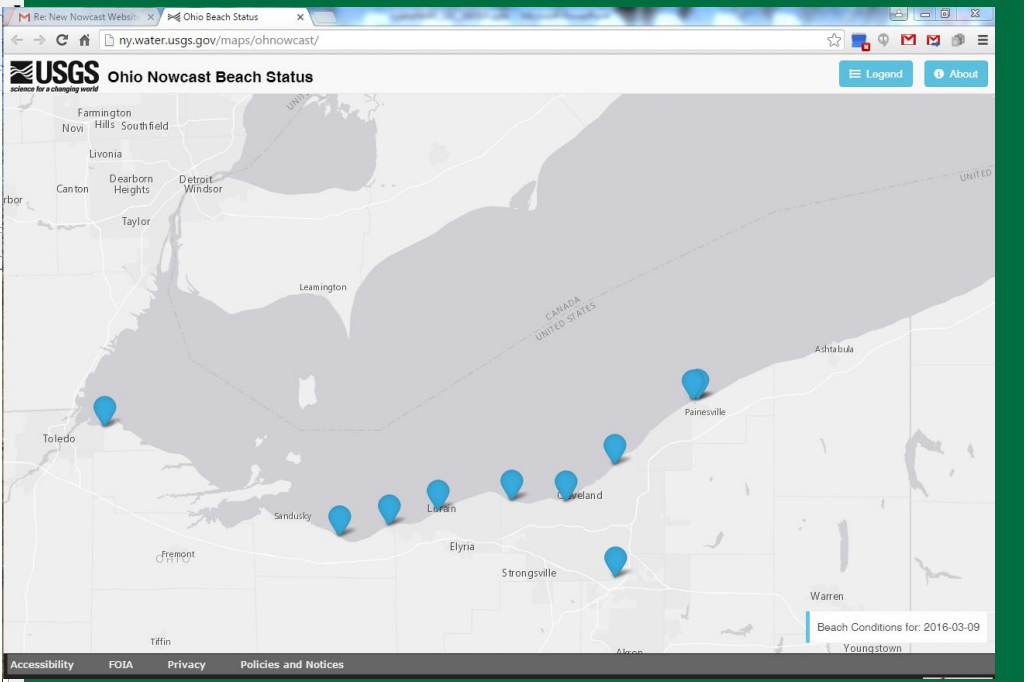
Virtual Beach Modeling

- Free software developed by USEPA
- Developed for predicting *E. coli* concentrations





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USGS Scientific Investigations Report 2015-5120

Water Quality, Cyanobacteria, and Environmental Factors and Their Relations to Microcystin Concentrations for Use in Predictive Models at Ohio Lake Erie and Inland Lake Recreational Sites, 2013–14

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Acknowledgements

- University of Toledo: Pam Struffolino, Daryl Dwyer, and students
- Clermont County Soil and Water Conservation District: John McManus, Alex Delvalle, and Hannah Gonzalez
- Erie County Health Dept: Craig Ward and Bob England
- LimnoTech: Ed Verhamme
- Ohio Department of Natural Resources: Jean Backs, Jason Wesley and staff
- USEPA: Joel Allen, Chris Nietch, Dana Macke
- Ohio EPA: Linda Merchant-Masonbrink and Heather Raymond

Funded by Ohio Water Development Authority and USGS Cooperative Water Program

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