Long-term and Seasonal Trends in Phosphorus Loading to Lake Erie: Links to Harmful Algal Blooms with Insights from 2011 and 2012

Laura Johnson, David Baker, Peter Richards, Richard Stumpf, Aaron Roerdink, Rem Confesor, Jack Kramer, Ellen Ewing, and Barbara Merryfield

National Center for Water Quality Research
Heidelberg University

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Lake Erie Center

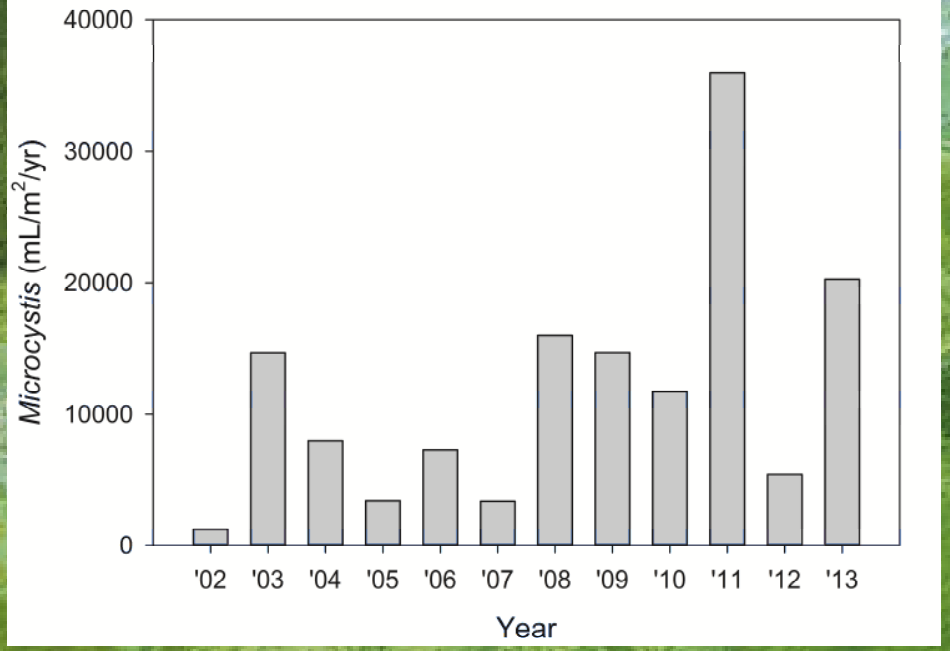
Tom Bridgeman

Algal blooms in Lake Erie have been increasing

2011 harmful algal bloom

Primarily *Microcystis aeruginosa*

Data from Tom Bridgeman, UT-LEC
see Bridgeman et al. 2013 JGLR

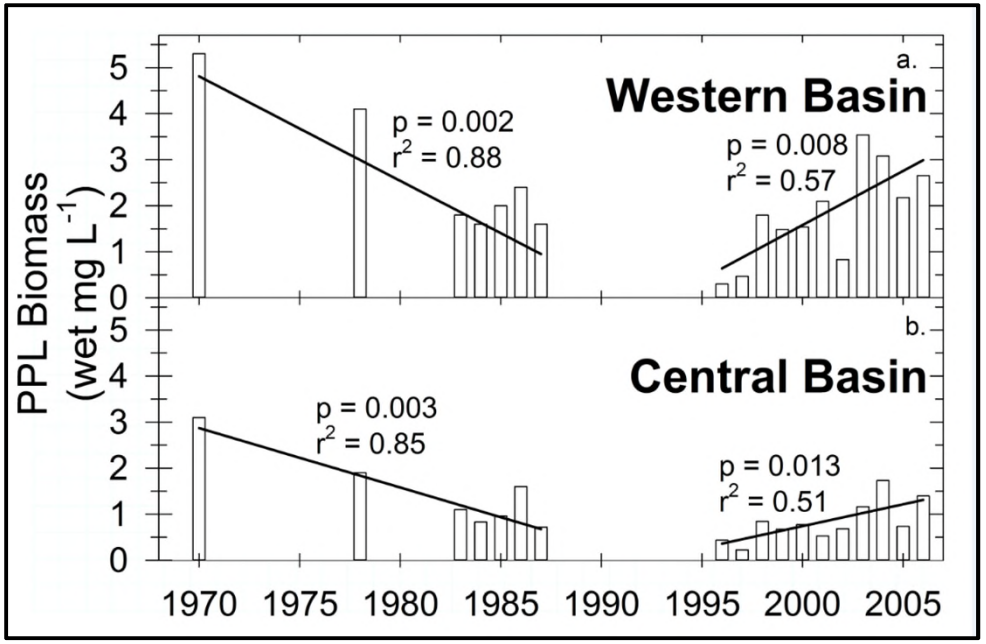


4 largest algal blooms since mid-1990s have occurred over the past 6 years

May 2013 issue of National Geographic

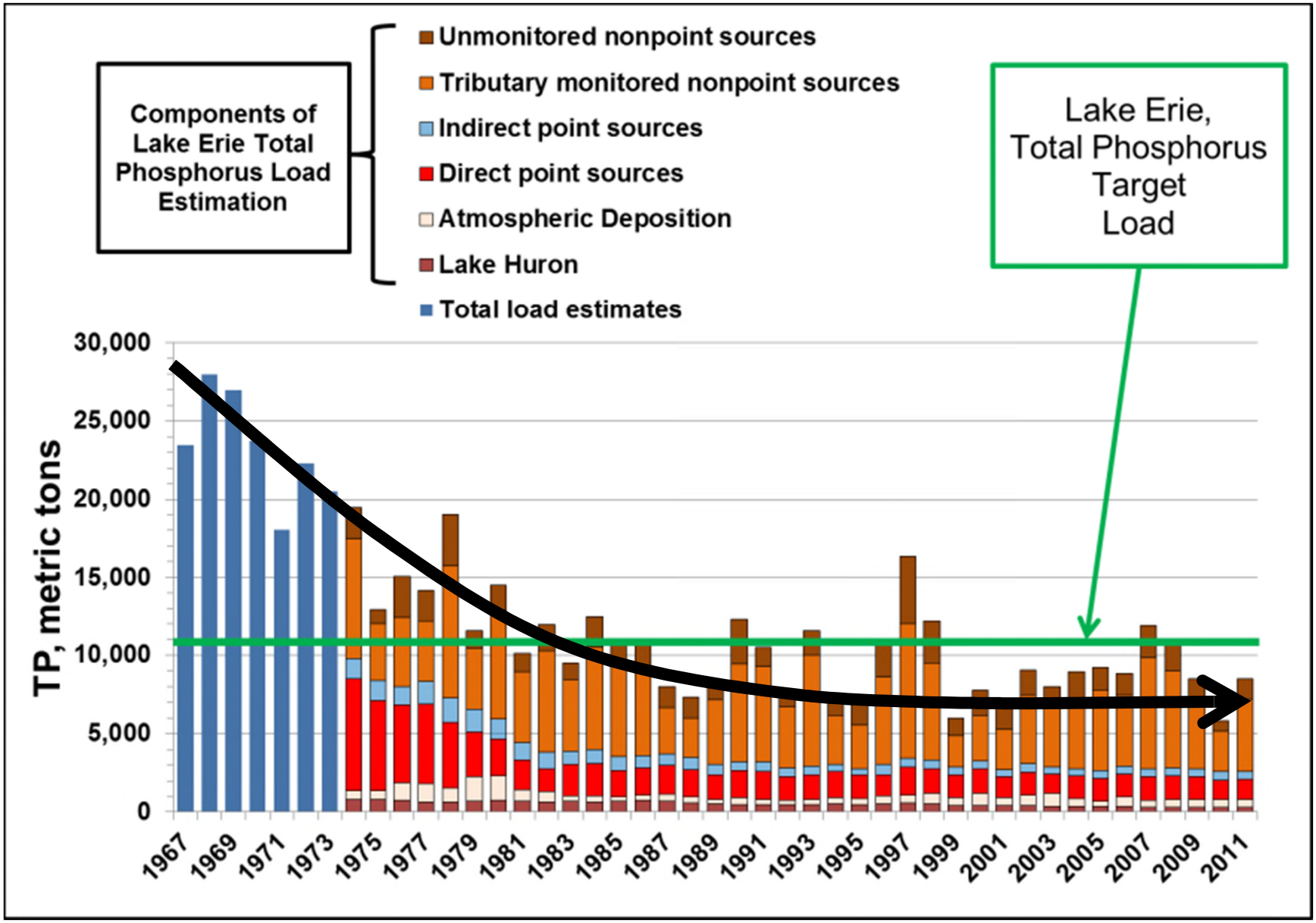
Algal blooms were prevalent in the 1970s and the lake appeared to recover in the mid-1990s

1971



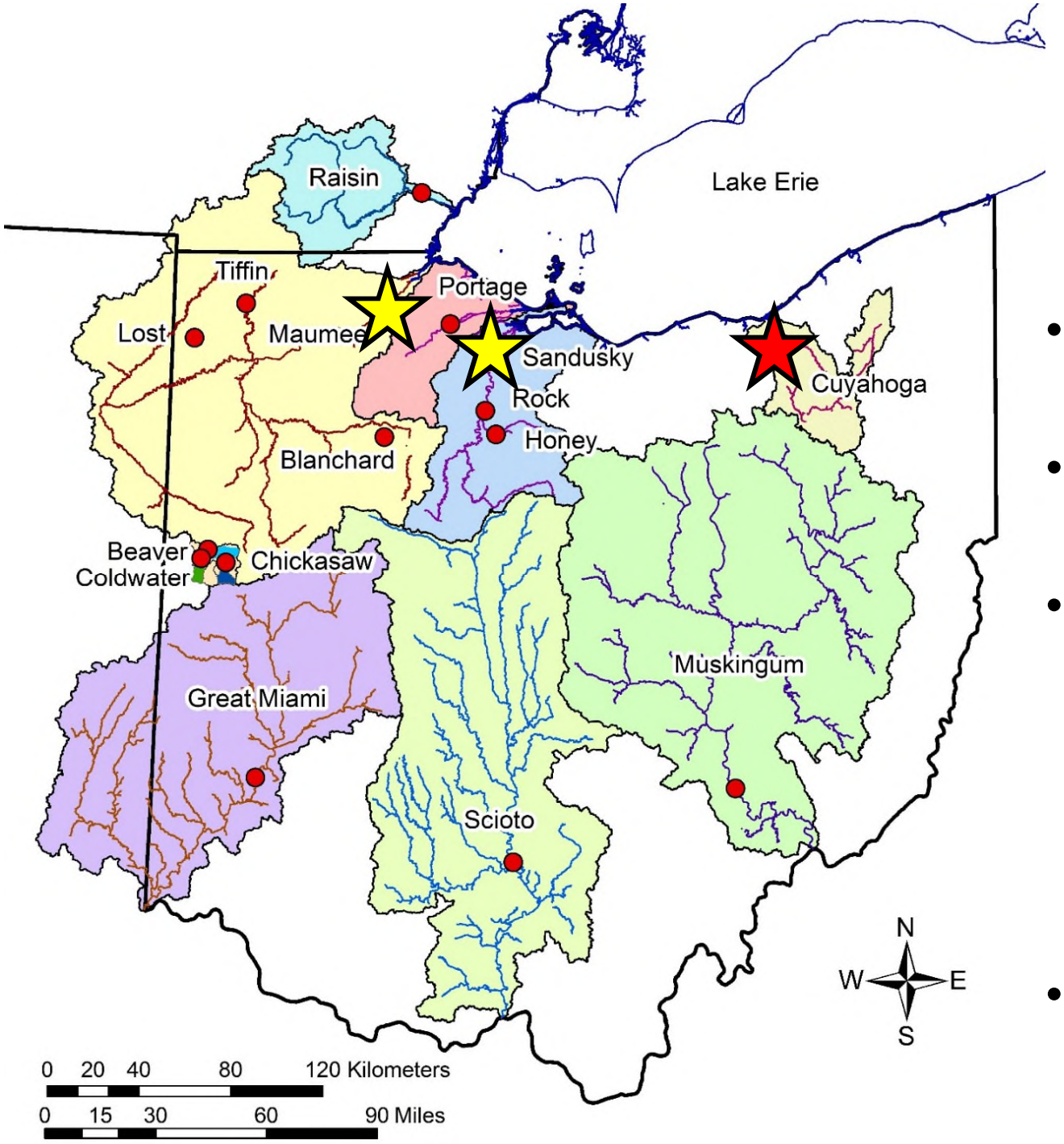
- Phytoplankton biomass
  - Kane et al. 2014, JGLR

Trends in Total Phosphorus



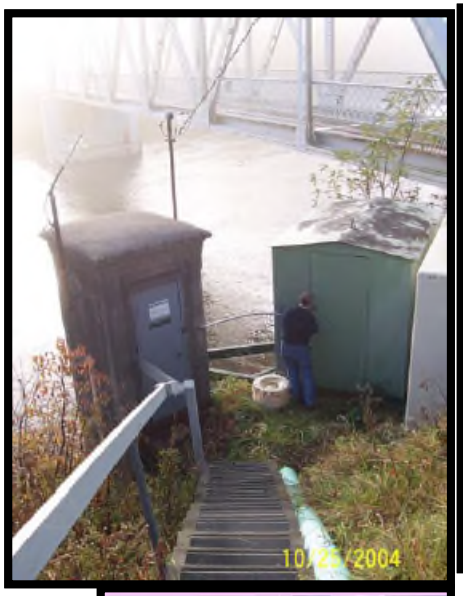
Why are algal blooms increasing?

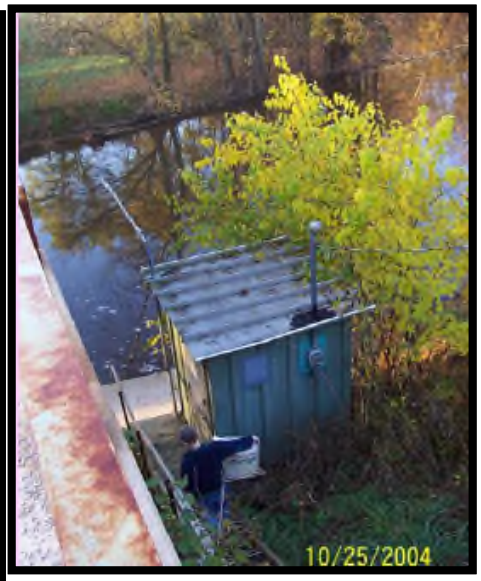
- Long-term trends in phosphorus and discharge
- 2011/2012 phosphorus loading and discharge



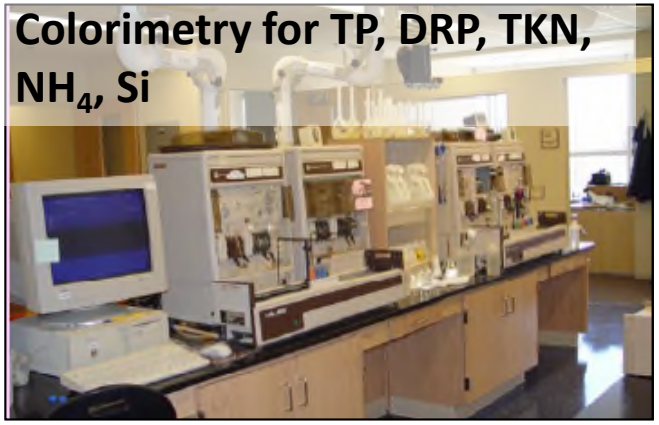
Heidelberg Tributary Loading Program

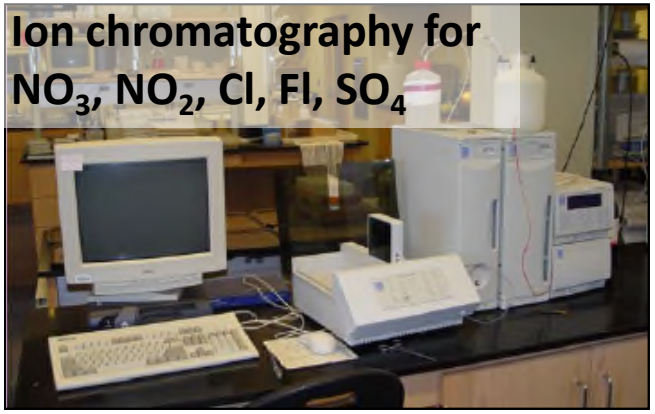
- 16 stations paired with USGS gages
- Monitoring began in 1975
- Longest, most detailed program of its kind in US
  - Over 142,000 water samples analyzed
- Focus today on Sandusky, Maumee, and Cuyahoga





- Samples collected 3x a day
- Analyzed for all major nutrients and suspended sediments

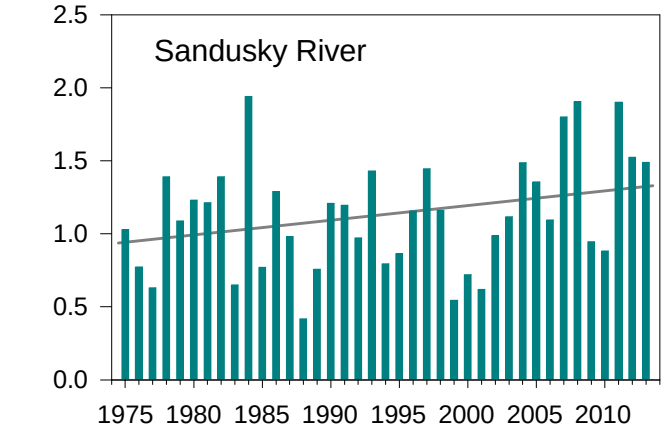




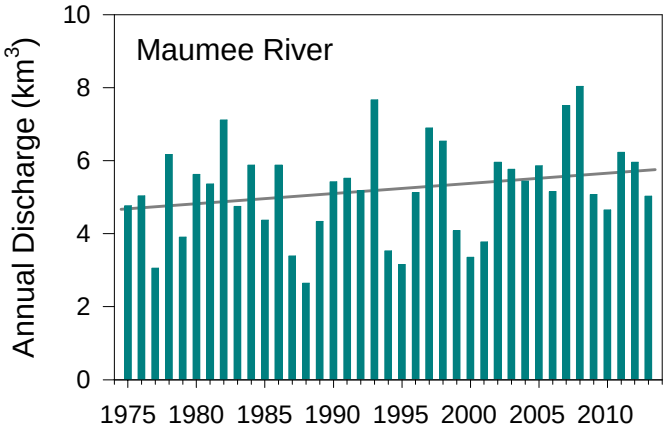
Long-term discharge and phosphorus trends

Annual discharge

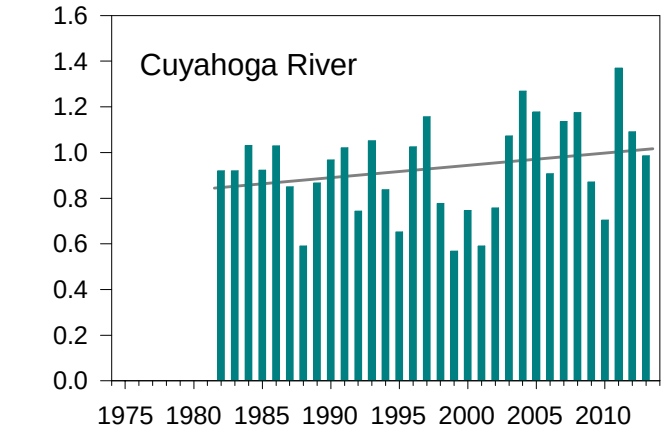
- Upward trend for all rivers over the period of record



$r^2 = 0.09$
P = 0.07



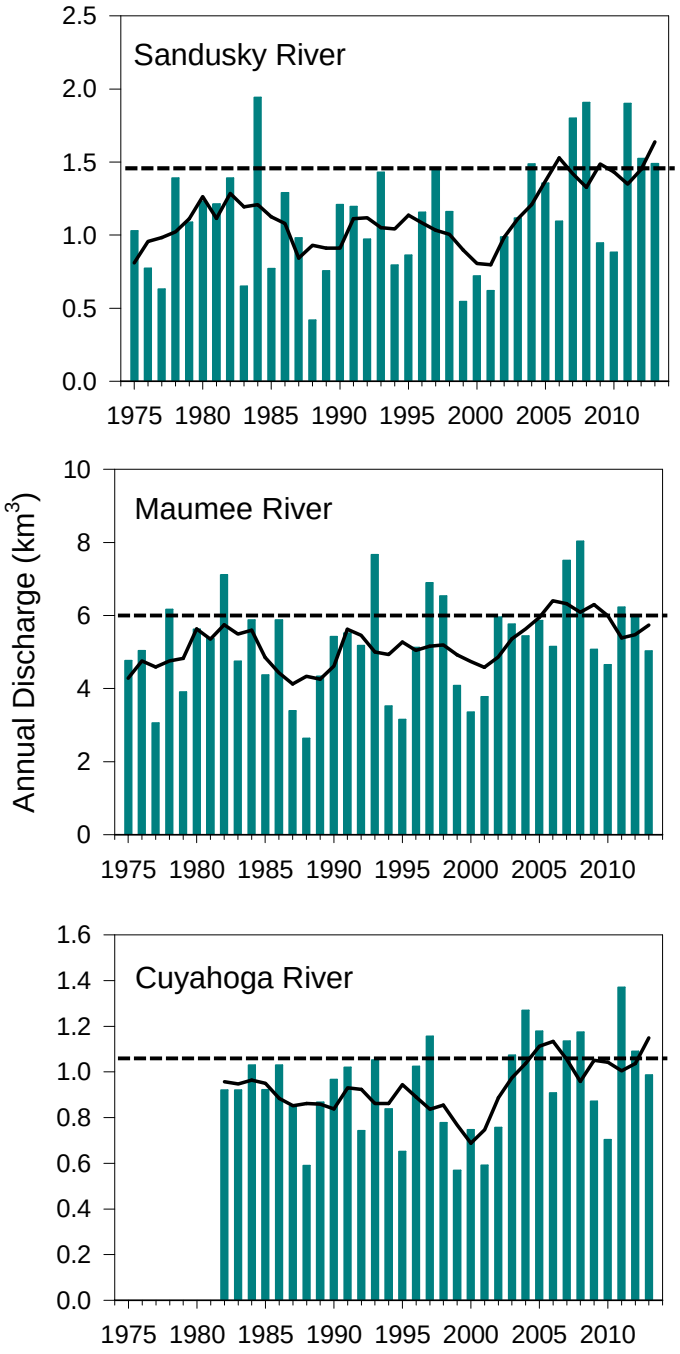
$r^2 = 0.06$
P = 0.14



$r^2 = 0.06$
P = 0.17

Annual discharge

- 5 year running mean show a marked increase since 2000

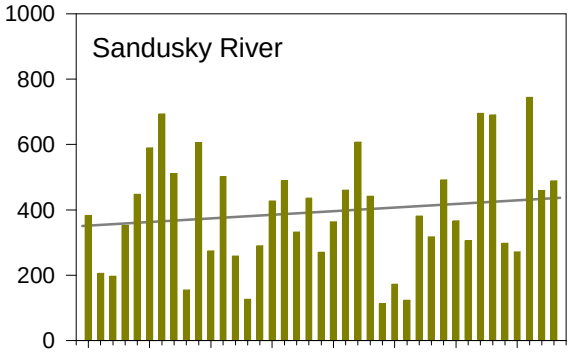


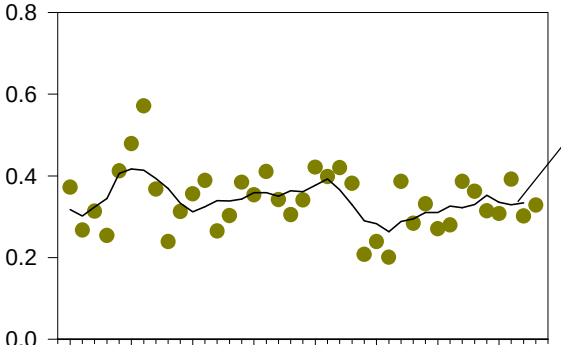
Annual total particulate P

77% of TP is particulate

TPP FWMC has decreased when analyzed via ANCOVA to correct for discharge, *(Richards et al. 2009 JSWC)*

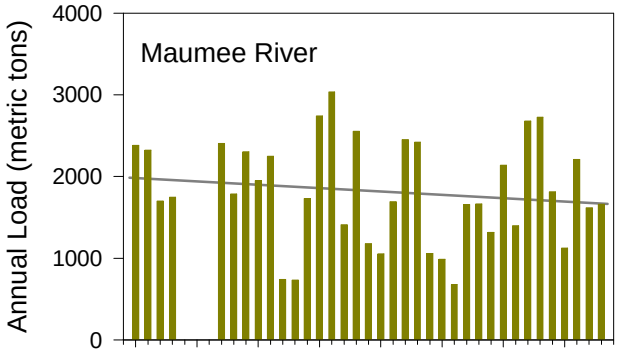
$r^2 = 0.02$
$P = 0.37$

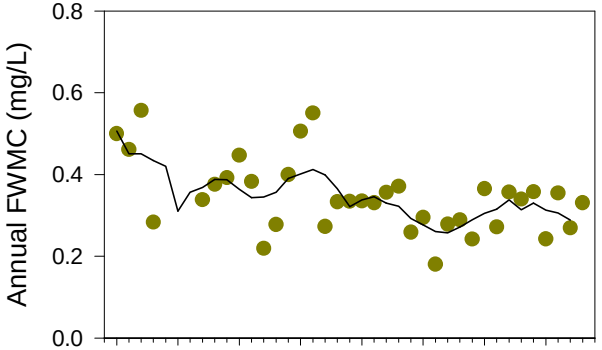




5 yr running mean

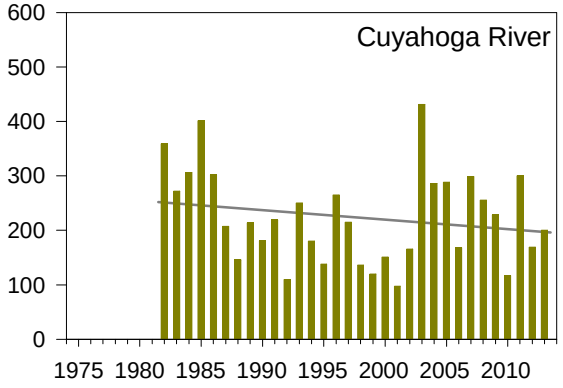
$r^2 = 0.02$
$P = 0.40$

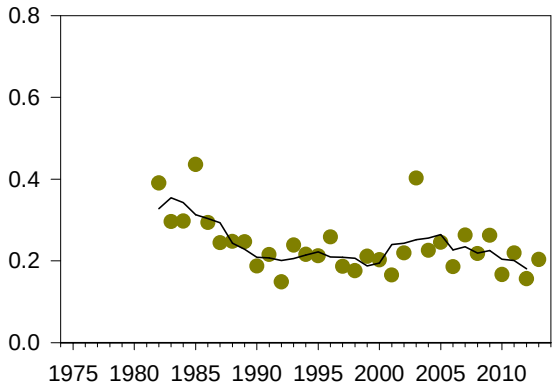




$r^2 = 0.25$
$P = 0.002$

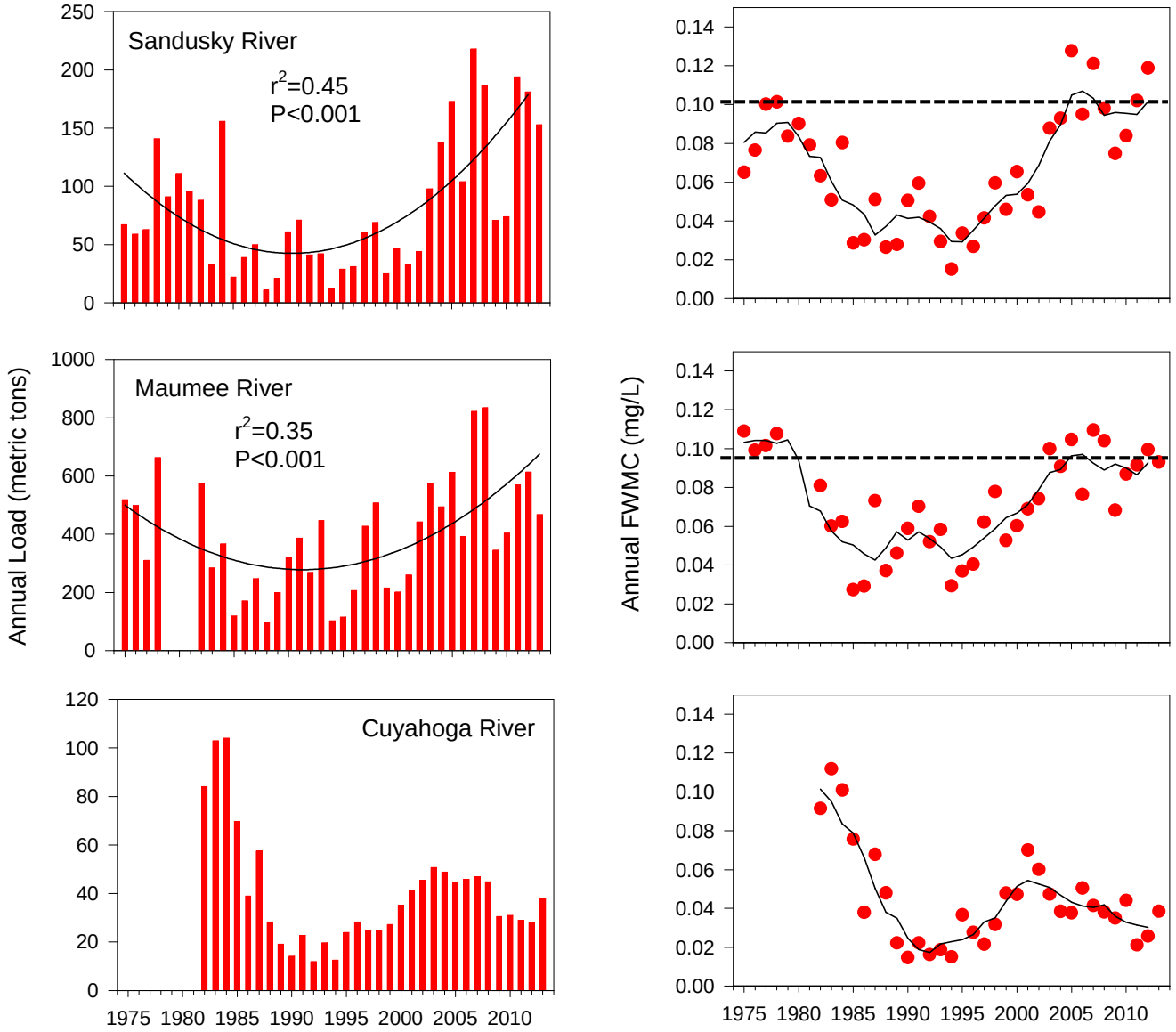
$r^2 = 0.04$
$P = 0.29$



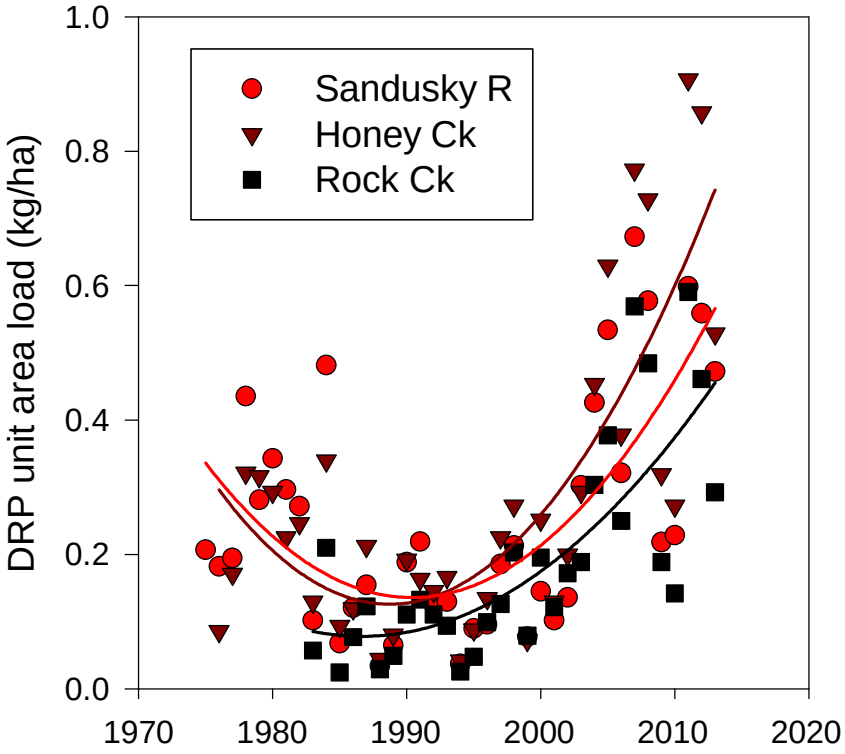


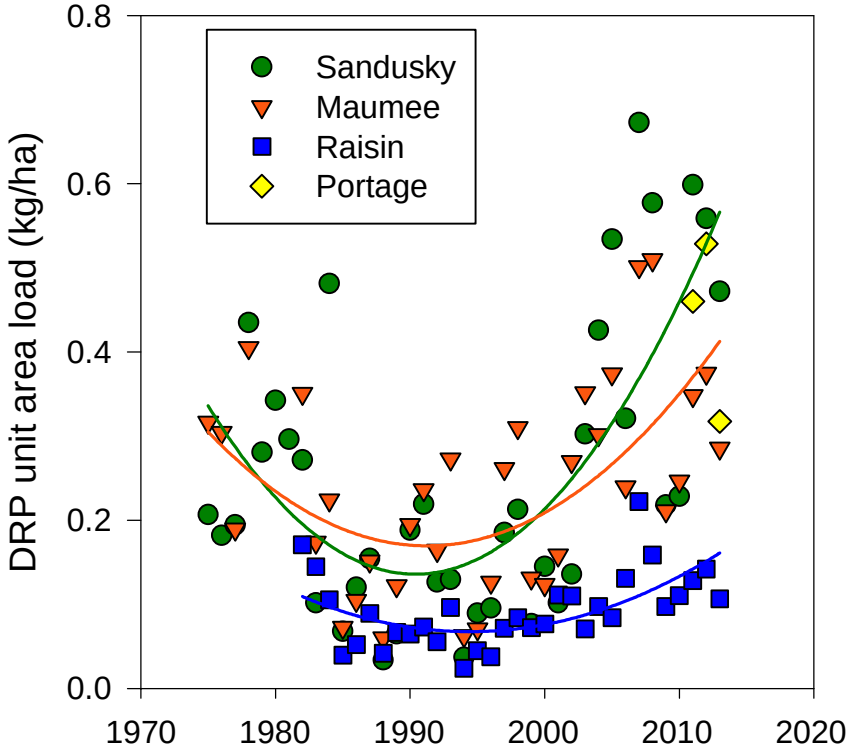
$r^2 = 0.20$
$P = 0.01$

Annual dissolved reactive P loads and FWMCs have been increasing in agricultural watersheds since the mid-1990s



Annual dissolved reactive P unit area loads are increasing in subwatersheds of the Sandusky as well as other agricultural rivers





- River Raisin is less flashy than other agricultural watersheds
  - only 50% agriculture
  - drains sandier soils

2011 vs. 2012

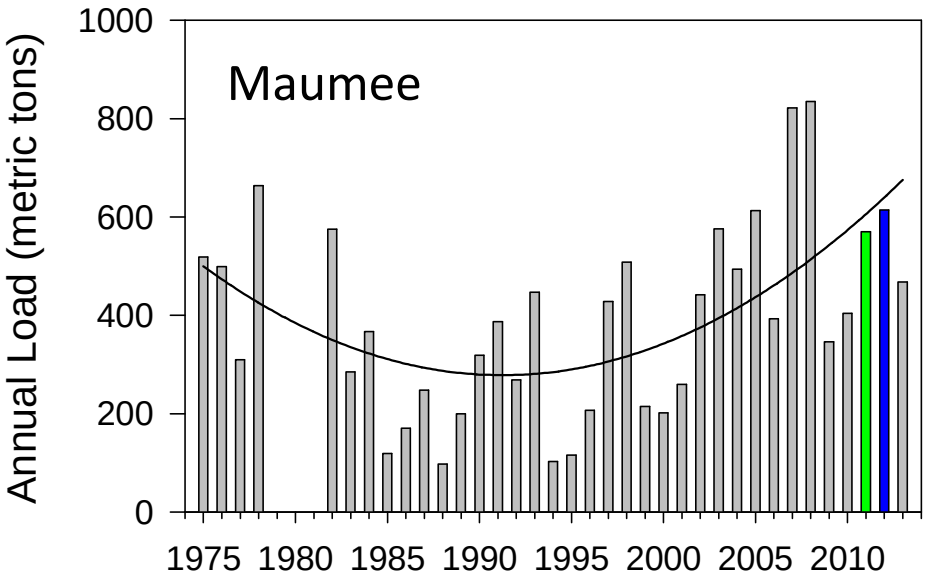
2011 vs 2012

09/03/2011 (DOY=246)

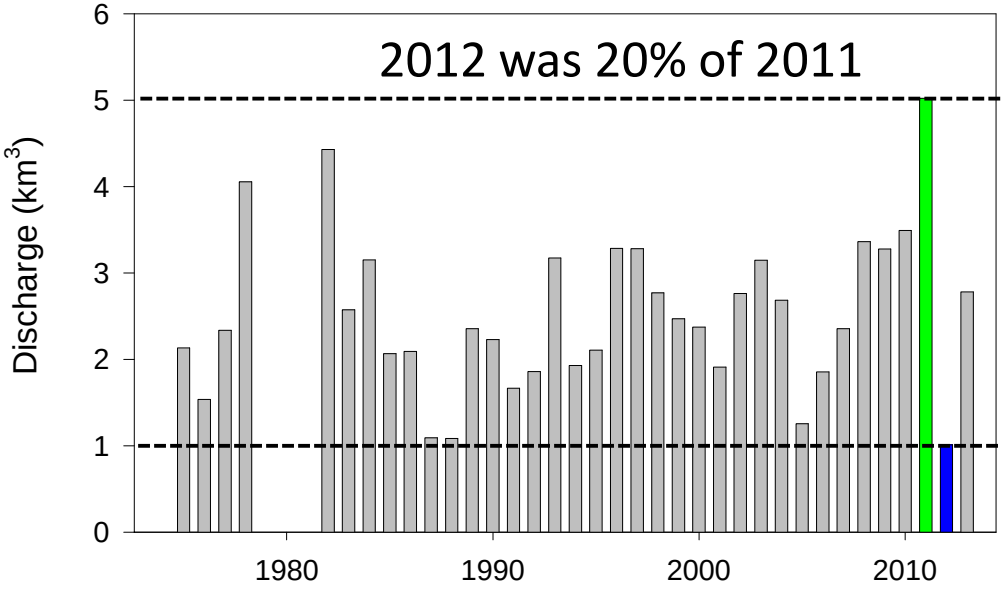
Big Contrast!

08/30/2012 (DOY=243)

Maumee River DRP loads
October-September

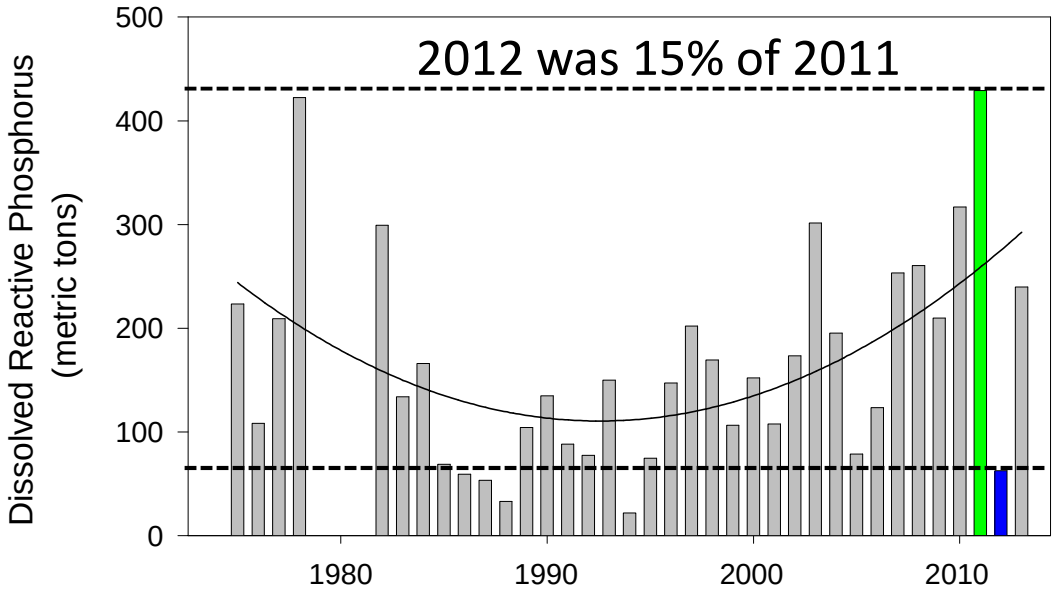


Annual loads were very similar between 2011 and 2012



Maumee River in spring *March-June*

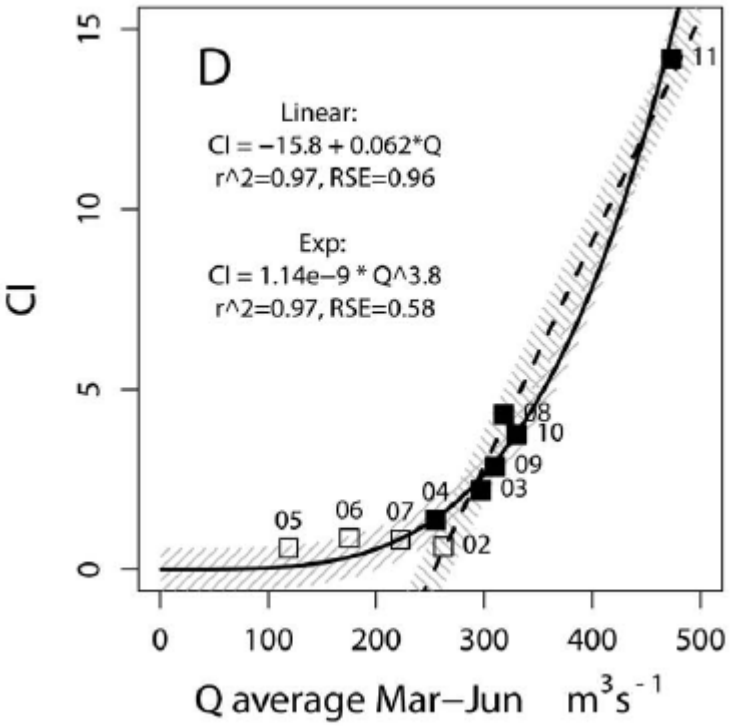
- Spring loading appears to better describe algal blooms

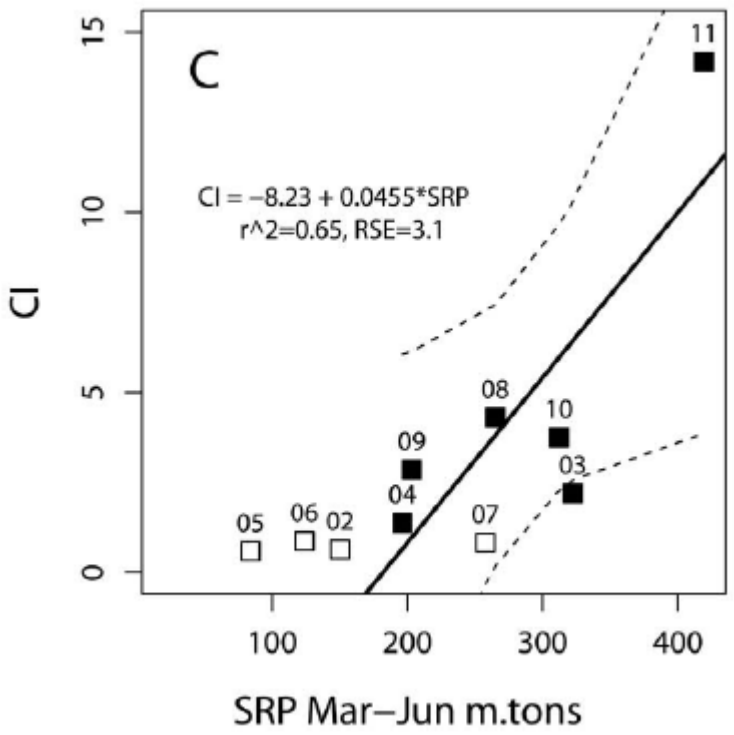


- Lake Erie is responsive to reduced phosphorus in a short timeframe

Relationship between Maumee spring loads and cyanobacterial index

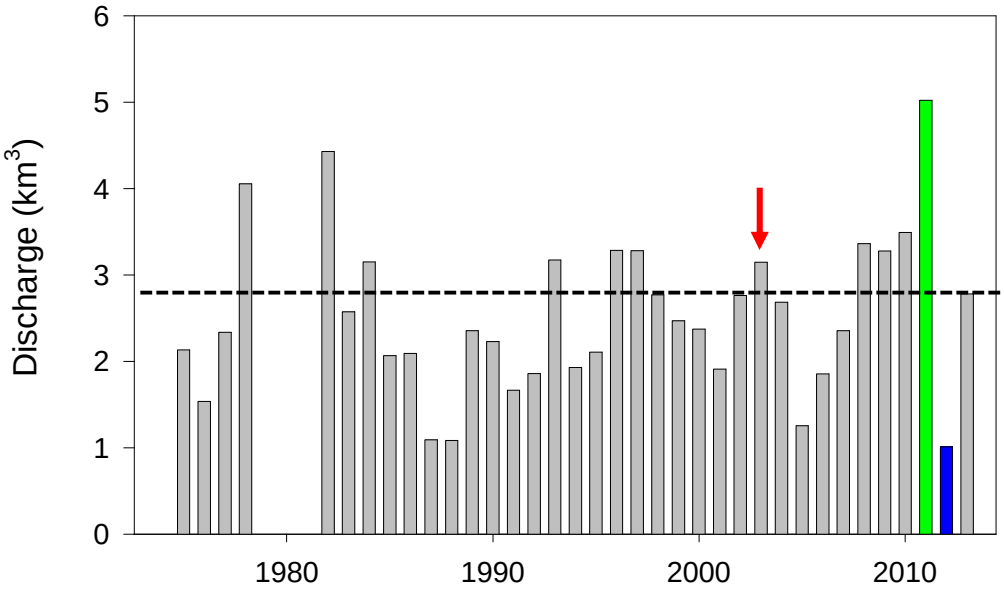
Stumpf et al. 2012, PLoS ONE

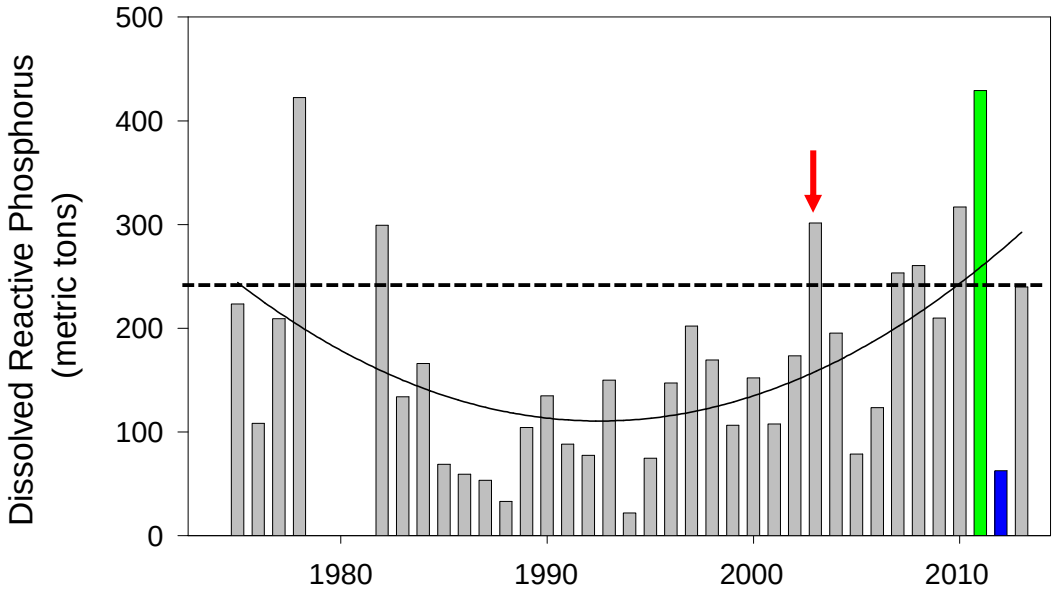




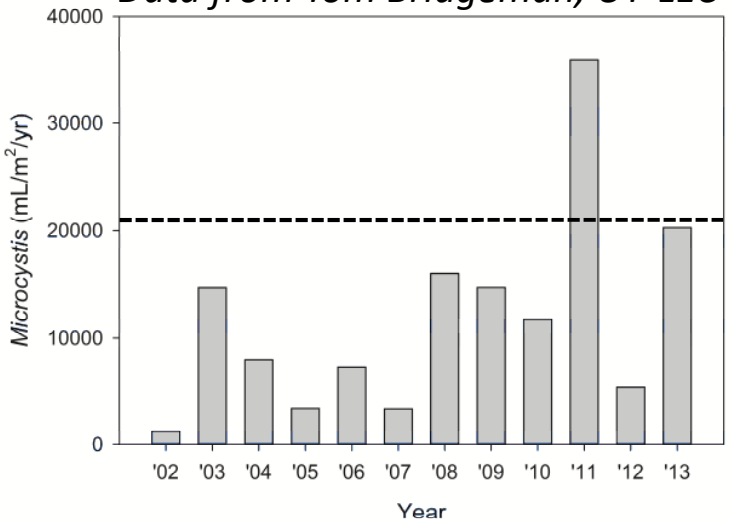
- Strongly related to spring discharge
- Less related to DRP loads

Maumee River in spring *March-June*

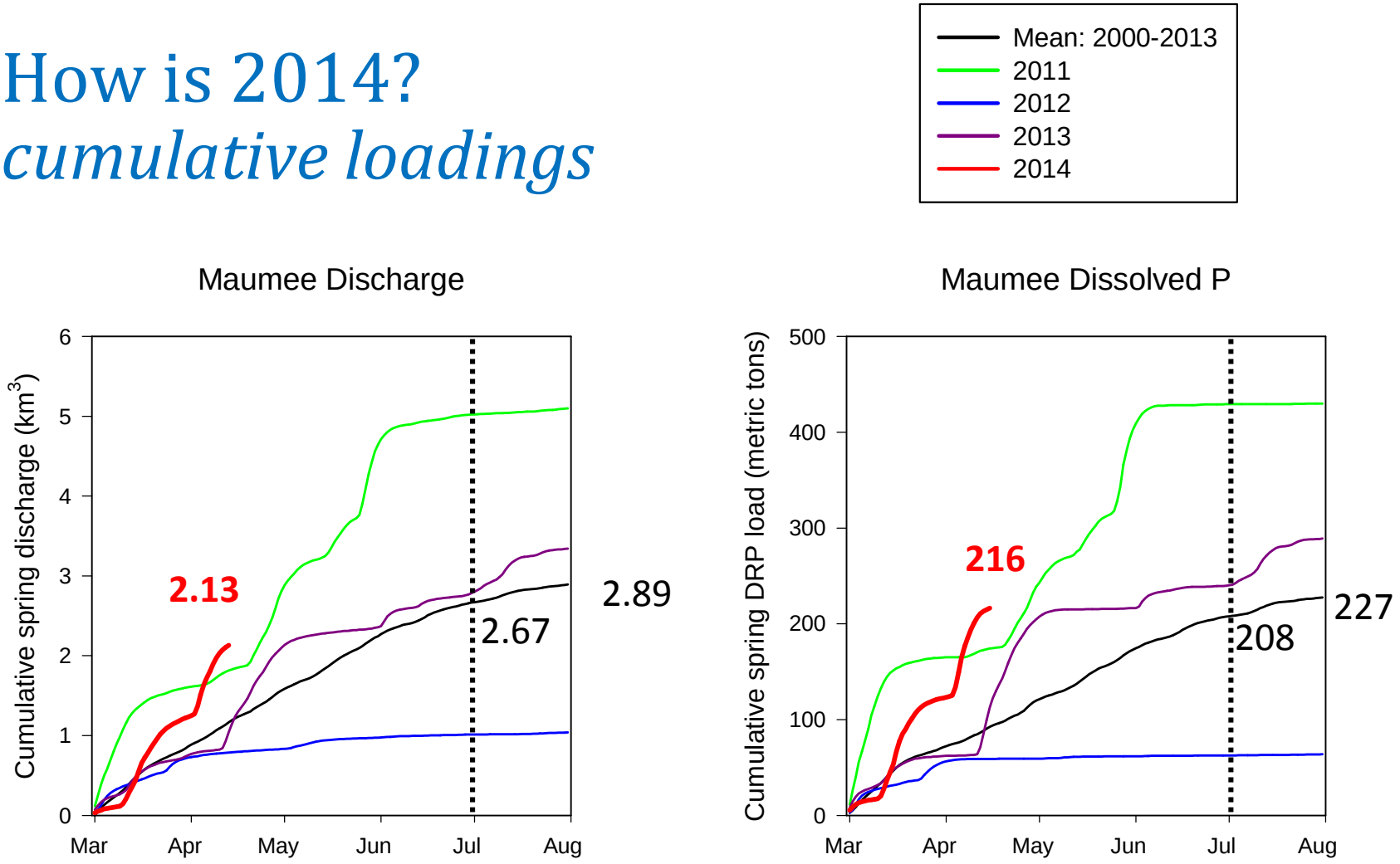




Data from Tom Bridgeman, UT-LEC



How is 2014?
cumulative loadings



- HAB forecast for 2014 planned for July 10th

Summary

- Although TP loads to Lake Erie reached the target in 1981, algal blooms have returned and have been increasing over the past decade
- Over this time, dissolved reactive P has increased drastically from agricultural rivers
- It appears spring loading (March-June) best predicts the extent of algal blooms in the western basin
- Our inability to accurately predict the magnitude of 2013 indicates we still have more to learn!

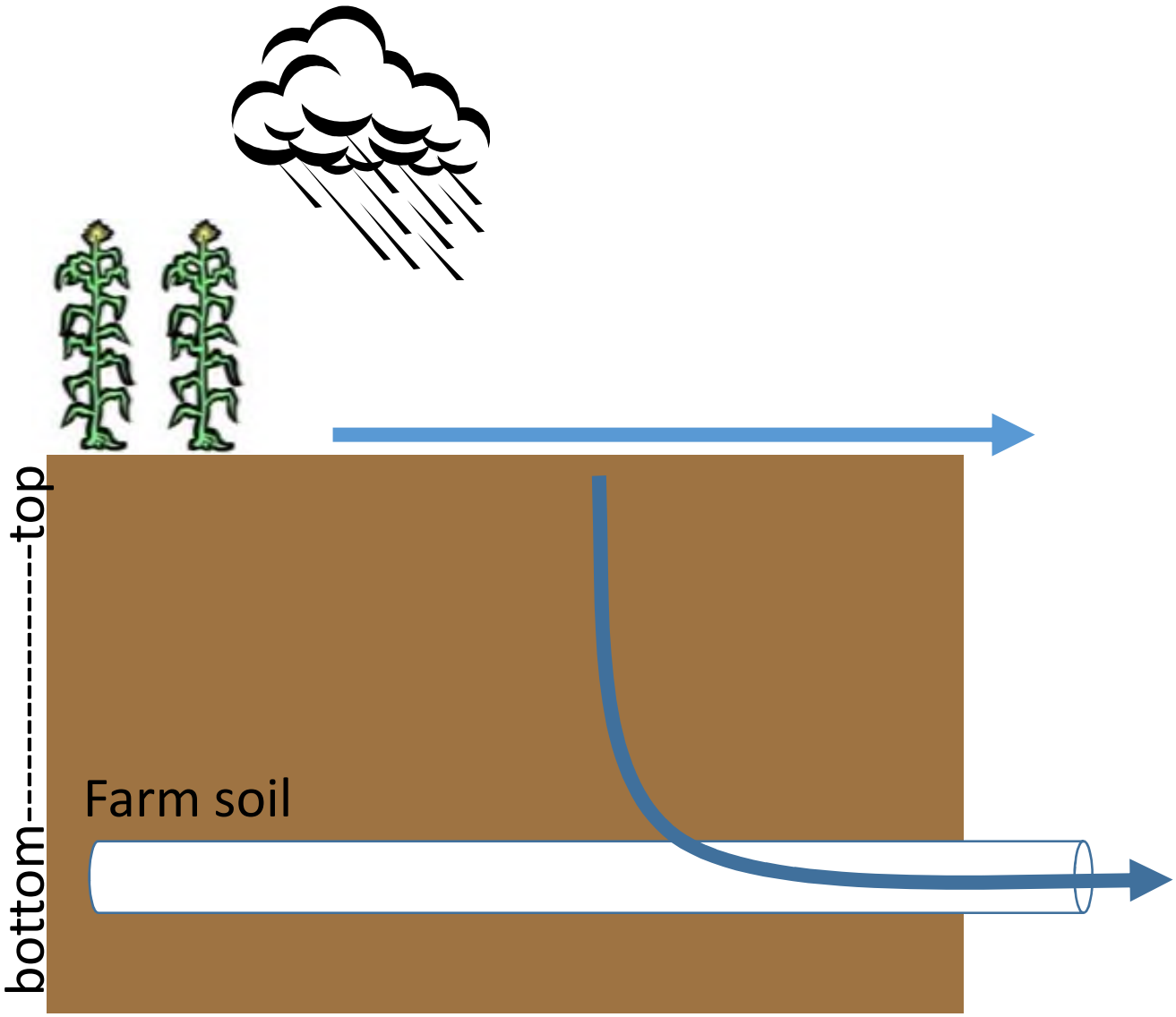
For more information visit:

http://www.heidelberg.edu/NCWQR

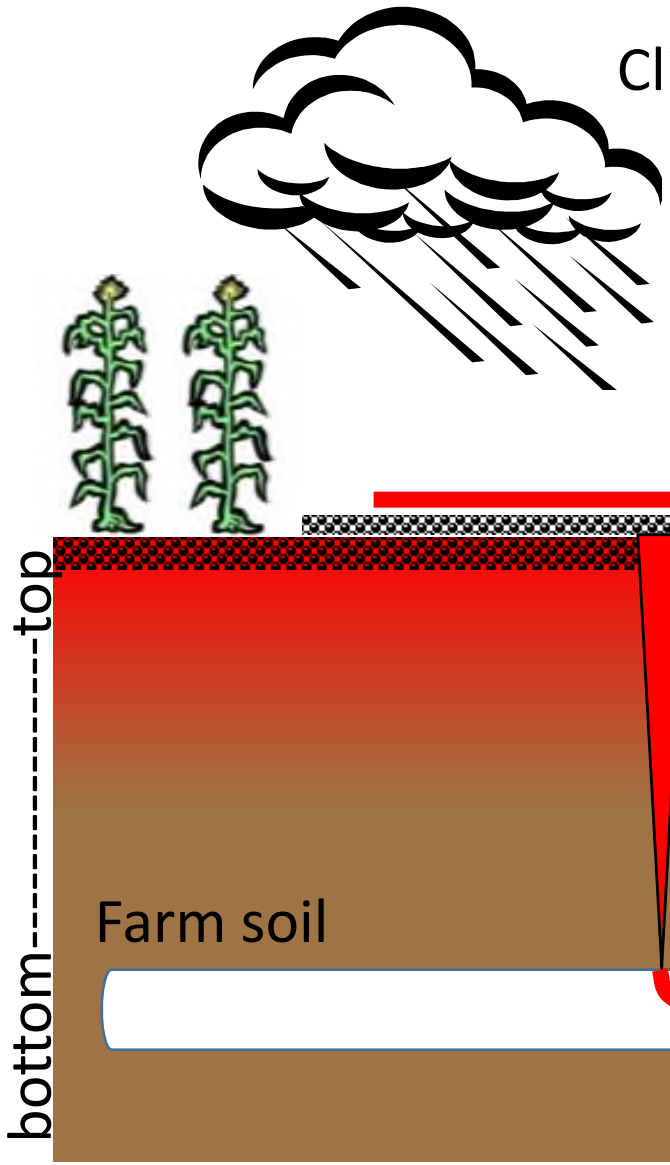
Or contact me at ljohnso1@heidelberg.edu

http://www.facebook.com/NCWQR

Why is dissolved P increasing?



Why is dissolved P increasing?



Surface application of P fertilizers

Application on frozen ground or shortly before precipitation

P stratification

Tile drain intensity

Tile delivery from macropores

Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

12 September 2013; Bulletin 19

The area of most intense bloom remains in the far western part of Lake Erie and Maumee Bay. Scum may be seen in pockets in the western basin near Maumee Bay.

Slight south-eastern transport is forecasted for the next few days. Winds tomorrow could exceed >15 knots, possibly mixing the bloom. Low winds (<8 knots) are expected over the weekend which could cause the bloom to intensify at the surface and produce patchy areas of scum.

- Dupuy, Stumpf

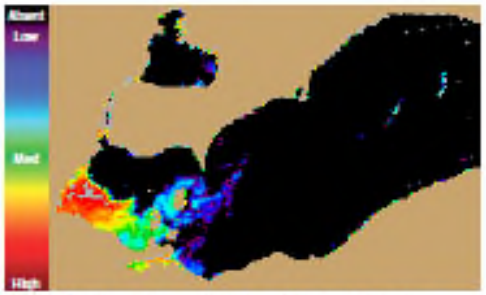


Figure 1. MODIS Cyanobacterial Index from 10 September 2013. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 35,000 cells/mL.

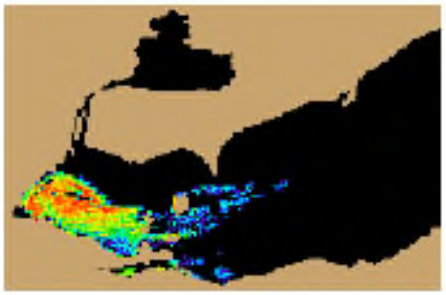


Figure 2. Nowcast position of bloom for 12 September 2013 using GLCFS modeled currents to move the bloom from the 10 September 2013 image.

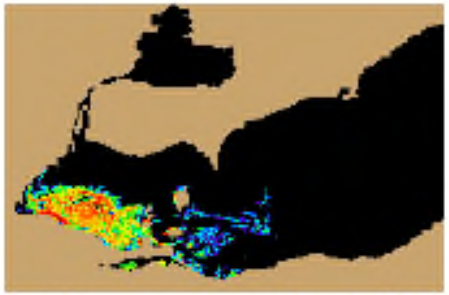
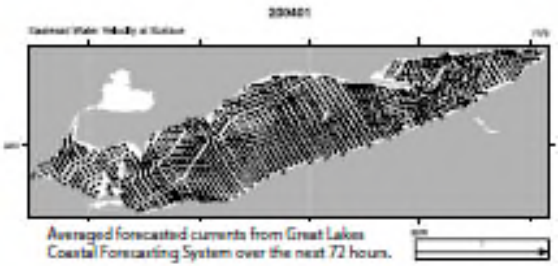
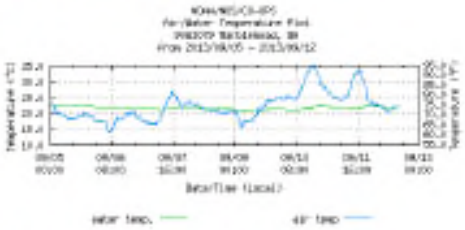


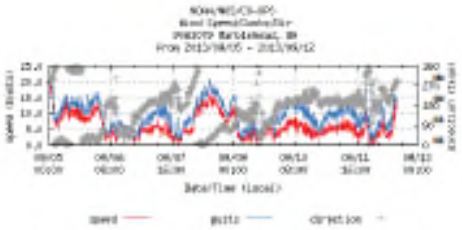
Figure 3. Forecast position of bloom for 15 September 2013 using GLCFS modeled currents to move the bloom from the 10 September 2013 image.



Averaged forecasted currents from Great Lakes Coastal Forecasting System over the next 72 hours.



Air and Water Temperature from Marblehead, OH. From: NOAA/Center for Operational Oceanographic Products and Services (CO-OPS).



Wind Speed, Gusts and Direction from Marblehead, OH. From: NOAA/Center for Operational Oceanographic Products and Services (CO-OPS). Note: 1 knot = 0.51444 m/s. Blooms mix through the water column at wind speeds greater than 7.7 m/sec (~ 15 knots).

For more information and to subscribe to this bulletin go to:
http://www.glerl.noaa.gov/res/Centers/HABS/lake_erie_hab/lake_erie_hab.html

- Weekly bulletin produced throughout season
- Google “Lake Erie HAB bulletin”