An update on Harmful Algal Blooms in Lake Erie

Thomas Bridgeman and Justin Chaffin
University of Toledo
October 30, 2013

Outline

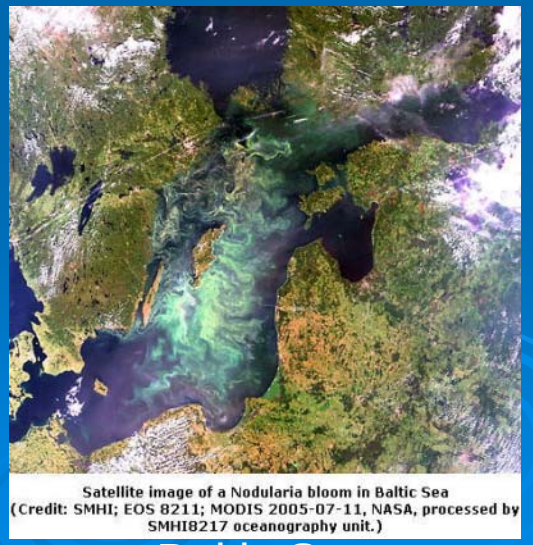
- Introduction and L. Erie HABs 2002-2013
- HAB forecast and early warning tools
- HAB sources and nutrient limitation

1
Introduction and Lake Erie HABs 2002-2013

Harmful algal blooms are increasing worldwide

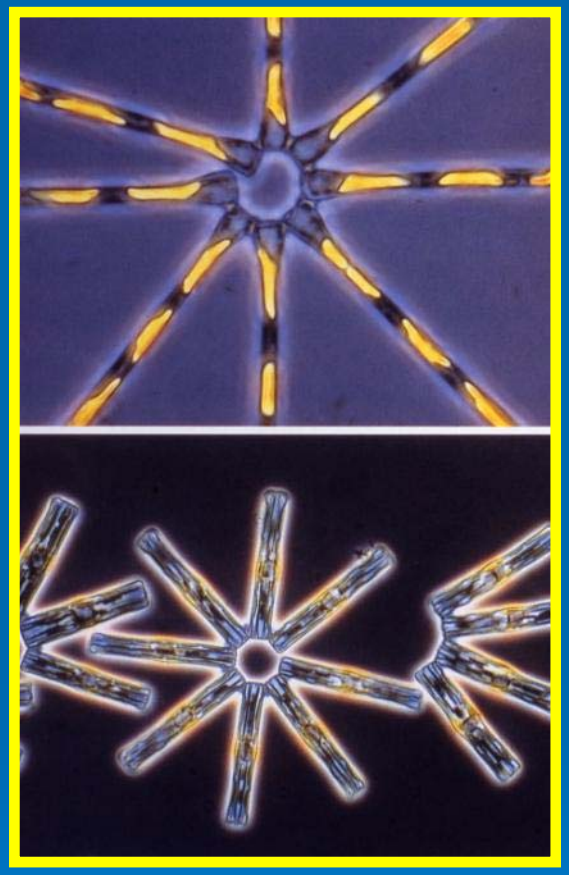
Lake Taihu, China

Lake Winnipeg

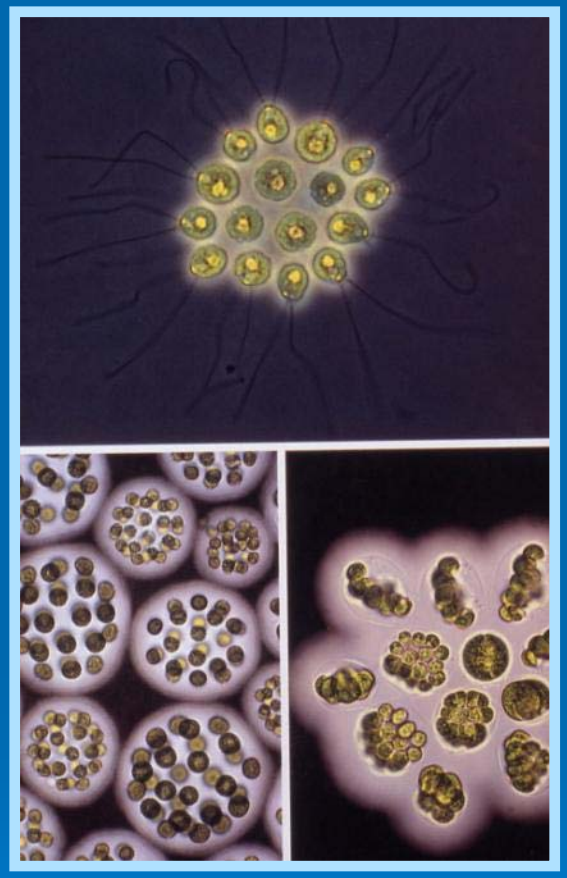


Baltic Sea

Major groups in Lake Erie



Diatoms



Greens

Blue-greens
(Cyanobacteria)

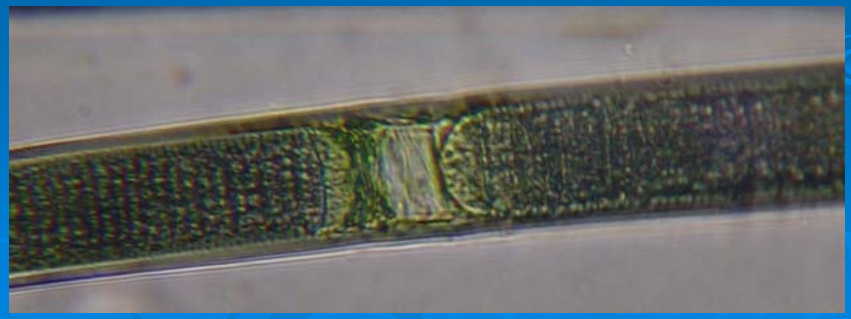
Common Harmful “Algae” (Cyanobacteria)

Anabaena

Aphanizomenon

Microcystis

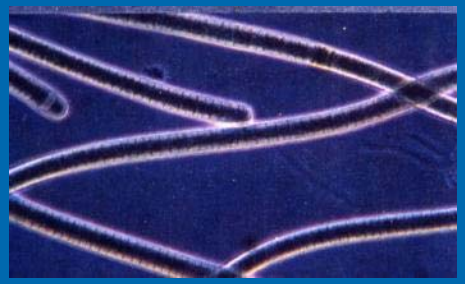
Planktothrix



Lyngbya

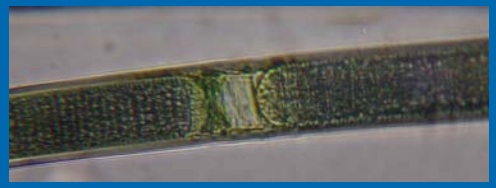
Why are harmful algae harmful?

Microcystis toxins
Microcystin



Planktothrix toxins
Anatoxin
Lyngbyatoxin
Aplysiatoxin

Anabaena toxins
Microcystin
Cylindrospermopsin
Anatoxin
Saxitoxin



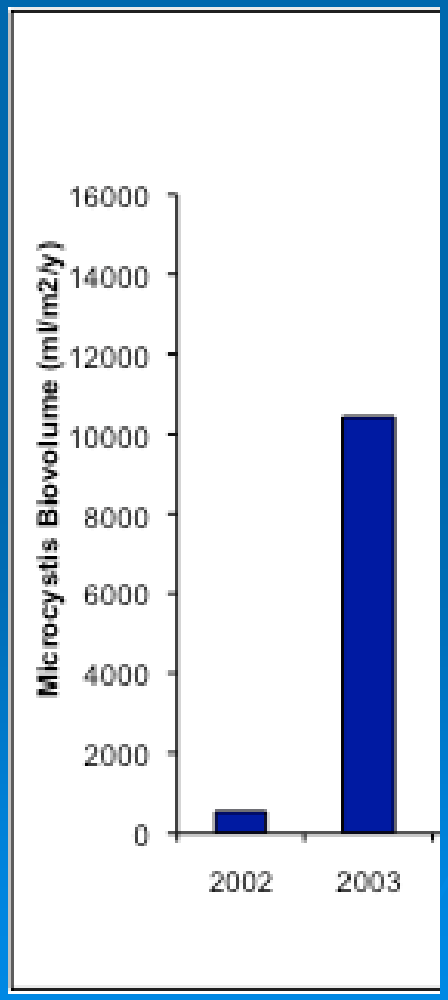
Lyngbya toxins
Saxitoxin
Lyngbyatoxin
Aplysiatoxin

Aphanizomenon toxins
Cylindrospermopsin
Anatoxin
Saxitoxin

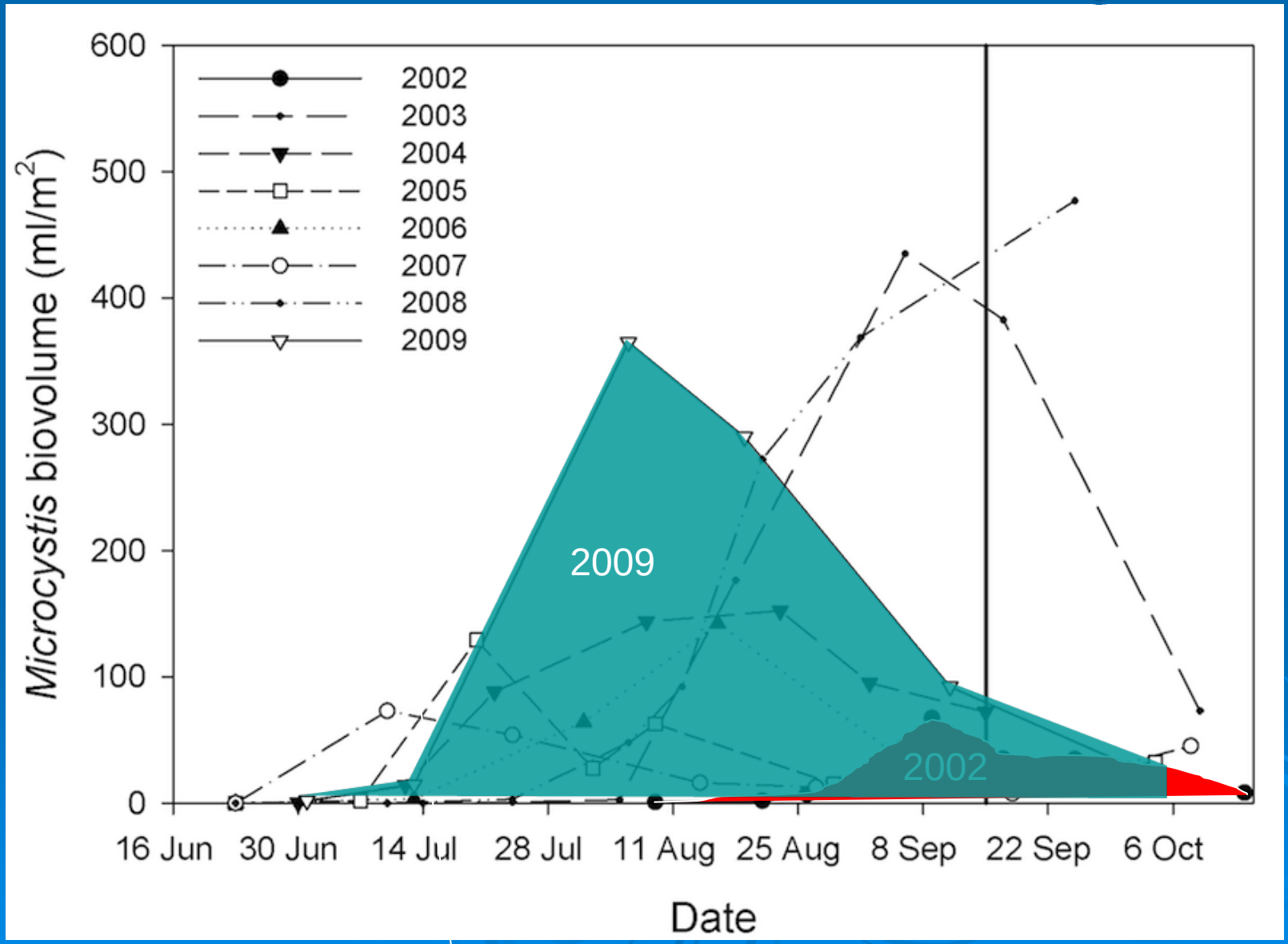
Microcystis bloom August 2003

landsat

2002-present: *Microcystis* in Lake Erie

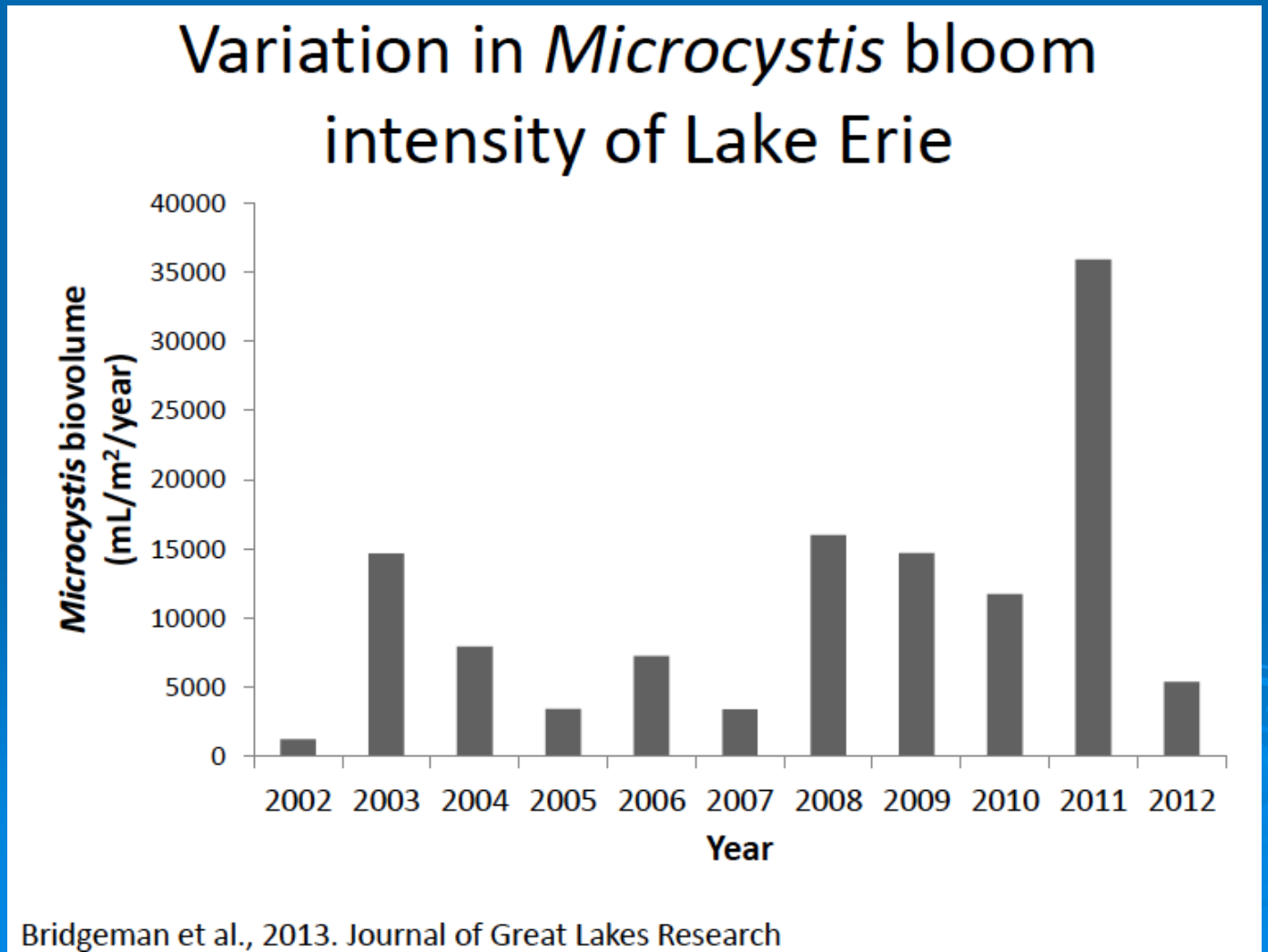


Annual estimate of *Microcystis*



Microcystis in Lake Erie

All years following 2002 have had moderate to intense *Microcystis* blooms. The bloom of 2011 was the largest bloom ever recorded.



Bridgeman et al., 2013. Journal of Great Lakes Research

2011 bloom from the Space Station

Michalak et al. 2013

Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions

Anna M. Michalak[a,1], Eric J. Anderson[b], Dmitry Beletsky[c], Steven Boland[d], Nathan S. Bosch[e], Thomas B. Bridgeman[f], Justin D. Chaffin[f], Kyunghwa Cho[g,2], Rem Confesor[h], Irem Daloğlu[g], Joseph V. DePinto[i], Mary Anne Evans[g,3], Gary L. Fahnenstiel[j], Lingli He[k], Jeff C. Ho[l], Liza Jenkins[g,j], Thomas H. Johengen[c], Kevin C. Kuo[d,m], Elizabeth LaPorte[n], Xiaojian Liu[d], Michael R. McWilliams[o], Michael R. Moore[g], Derek J. Posselt[d], R. Peter Richards[h], Donald Scavia[g], Allison L. Steiner[d], Ed Verhamme[i], David M. Wright[d], and Melissa A. Zagorski[d]

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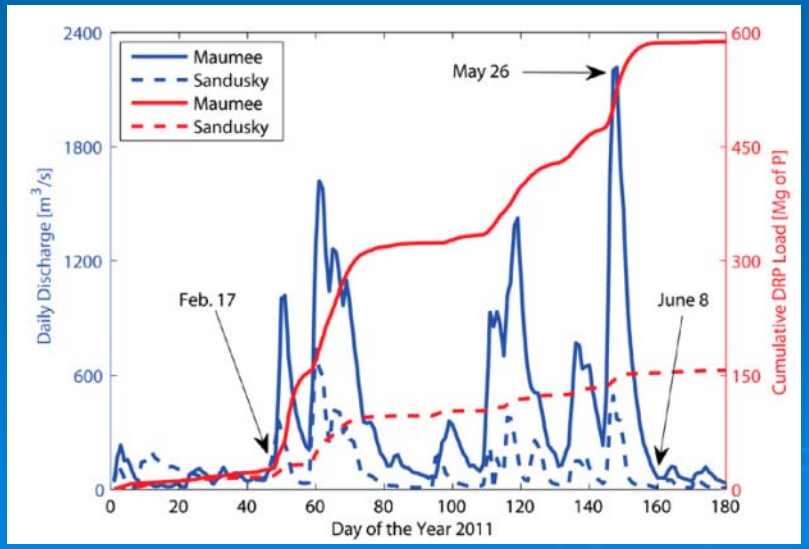
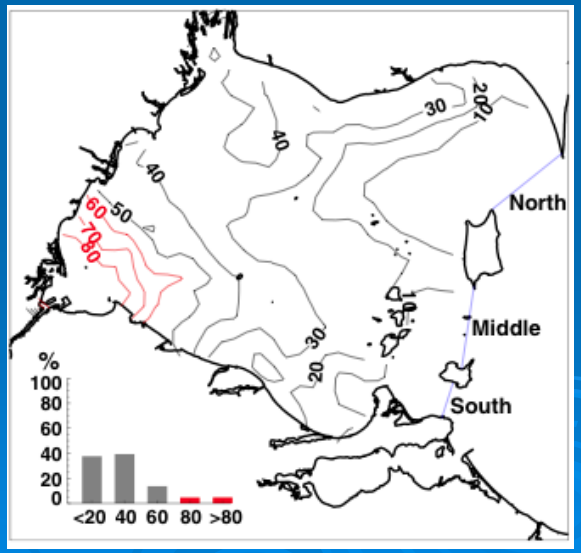
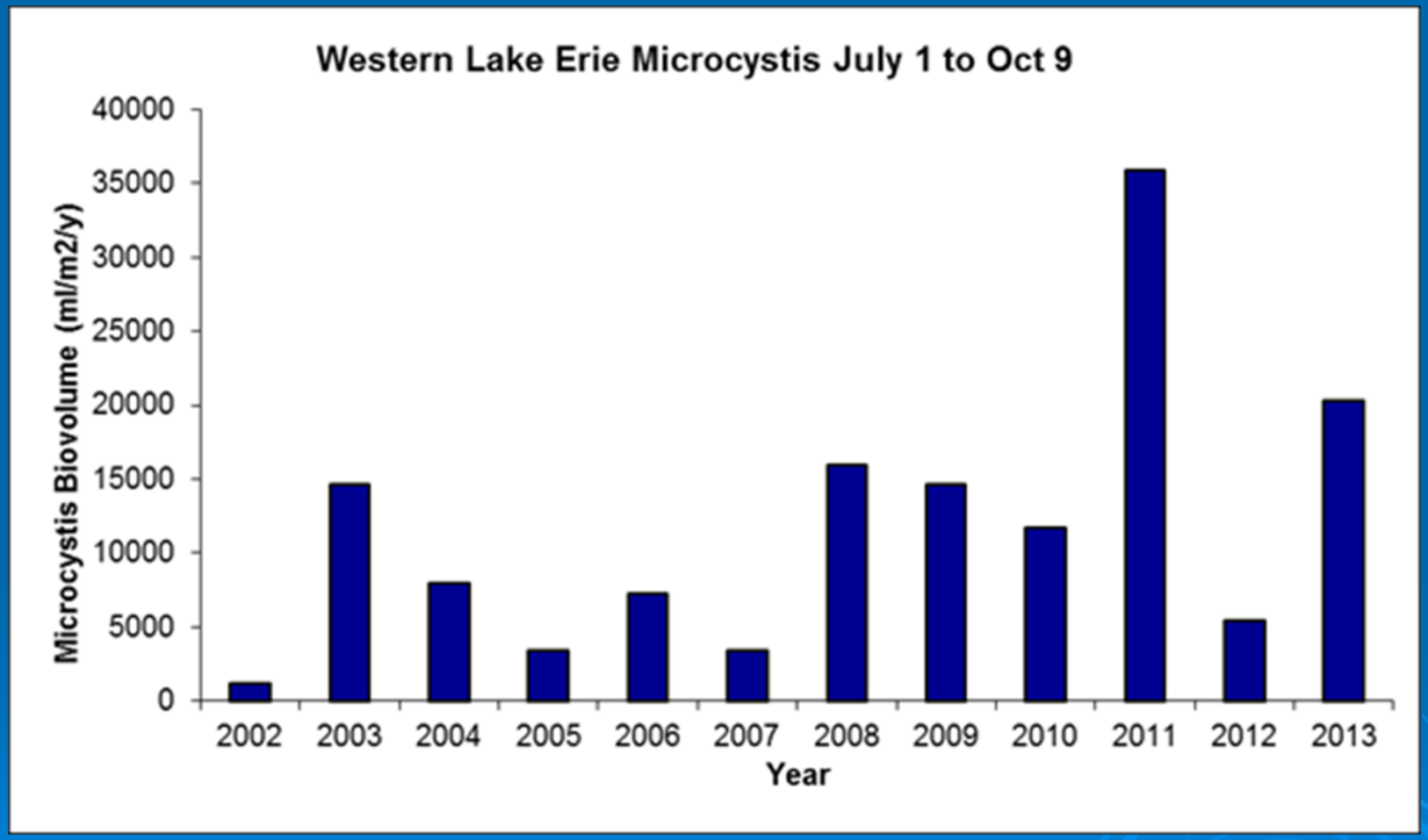


High spring P loads



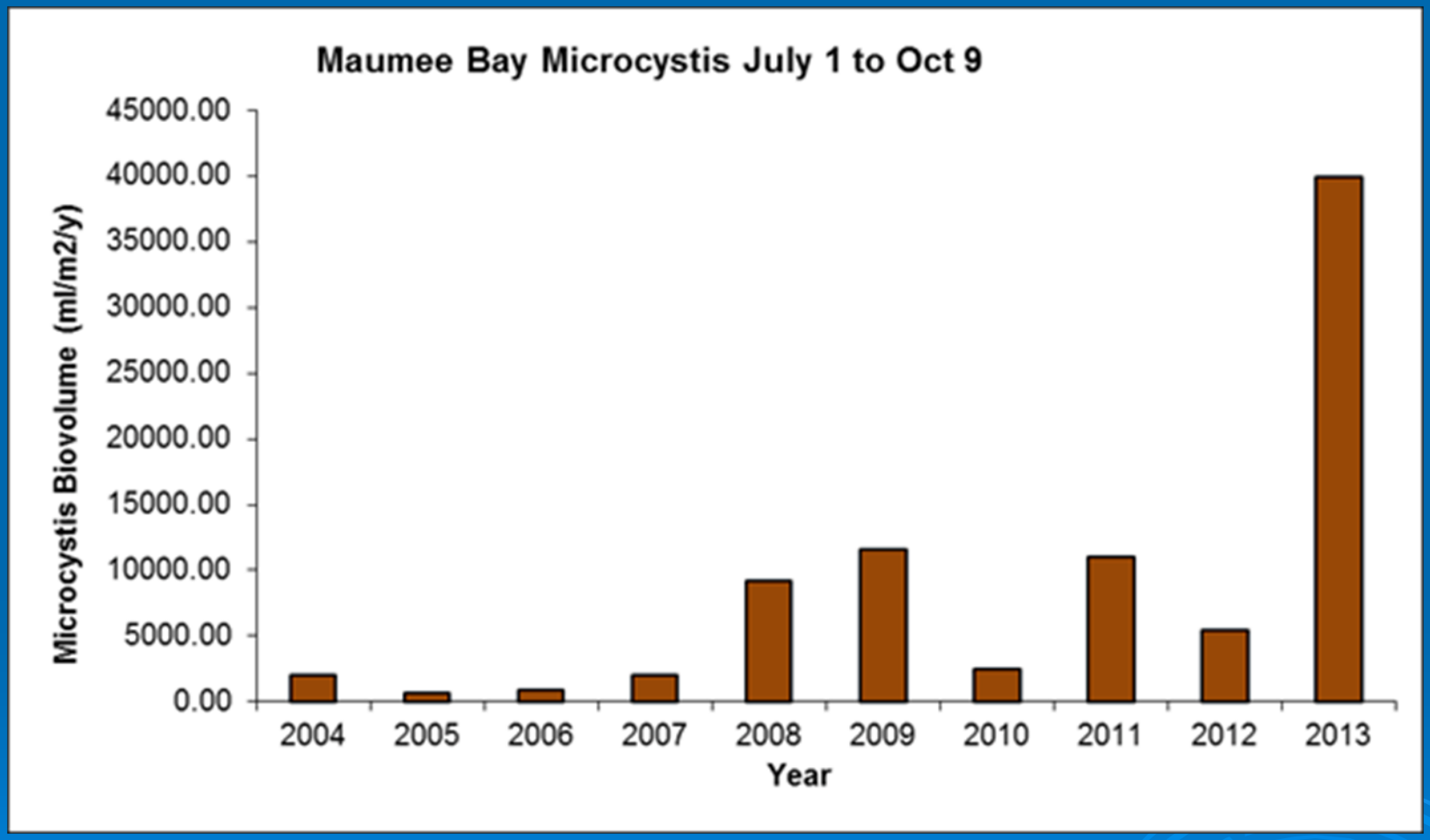
Long water residence time

2013 *Microcystis* open water bloom



2013 open water bloom was second only to 2011 over last 12 years

2013 *Microcystis* Maumee Bay



More *Microcystis* in bay and south shore areas in 2013

September 14, 2013

Effects of 2013 Bloom

Toxins overwhelm Carroll Township water plant

Ottawa Co. treatment facility offline while remedy made

BY TOM HENRY
BLADE STAFF WRITER

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OAK HARBOR, Ohio — The chief toxin produced by western Lake Erie's 2013 algae bloom spiked such extreme levels along the Ottawa County shoreline this week that it knocked the water-treatment pl serving 2,000 Carroll Township residents offline.

Poisonous microcystin, the toxin in Lake Erie's most prevalent harmful blue-green algae, microcystis, w found at levels of 3.56 parts per billion in samples drawn from the Carroll Township facility, Heidi Griesmer, Ohio Environmental Protection Agency spokesman, said Friday.

Toxin to cost Toledo another $1M

Council hikes budget, OKs $6.4M for sewer work, water lines

BY IGNAZIO MESSINA
BLADE STAFF WRITER

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A sign alerts swimmers to the danger of algae this summer.
THE BLADE/JEFFREY SMITH

Toledo City Council unanimously agreed Tuesday to open the city's wallet and pay $1 million to neutralize a potentially lethal toxin from algae in western Lake Erie that found its way into the city's water supply.

Council also agreed to spend $6.4 million toward sewer work and water lines for the Lucas Metropolitan Housing Authority's Collingwood Green Senior Community.

The Bell administration told council last week the city had no choice regarding the extra money to keep tap water safe to drink.

Toxic algae spur warning at Lake Erie beach near Toledo

By Spencer Hunt
The Columbus Dispatch · Wednesday August 14, 2013 5:42 AM

Comments: 2 Recommend 77 Tweet 24

Satellites and sensors give SURFACE cyanobacteria concentration

However, HABs mixed downward may cause more problems for utilities

Mixed plankton

After 1 Hour

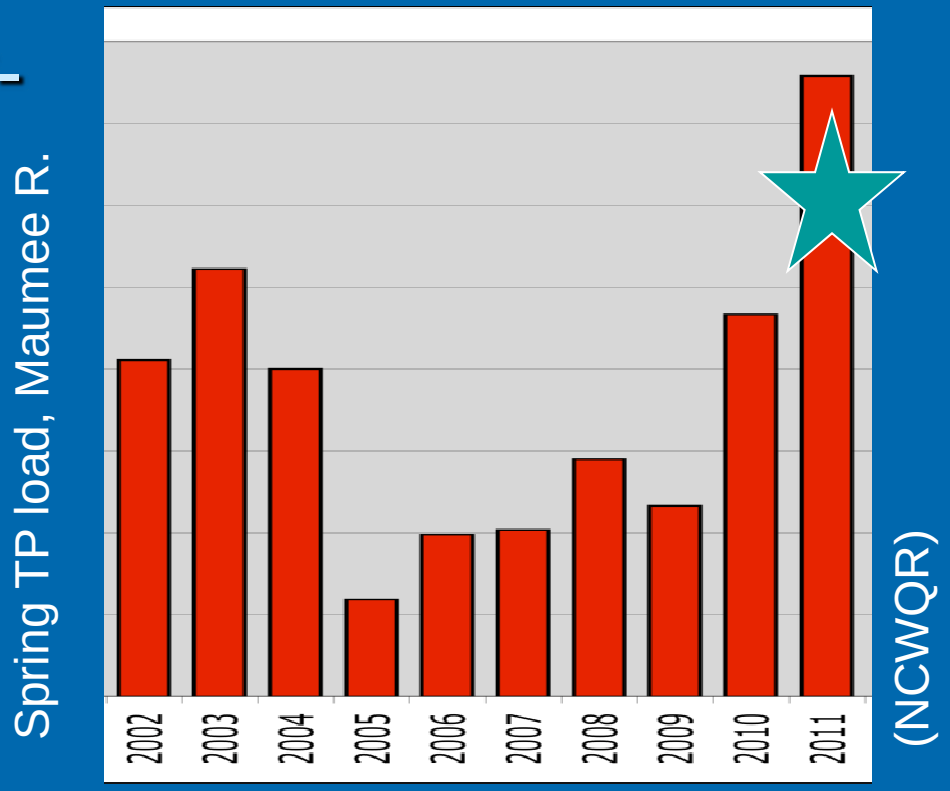
After 1 Day

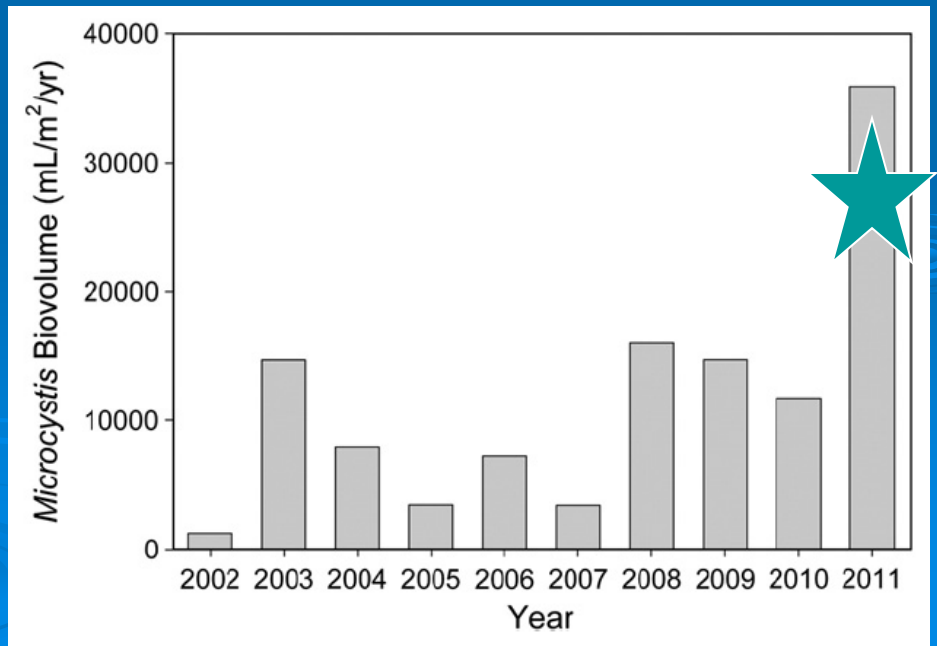
2
HAB Forecast and Early-Warning Tools

HAB Forecast and Early-Warning Tools

Springtime (March-June) TP load is the best predictor of summer blooms

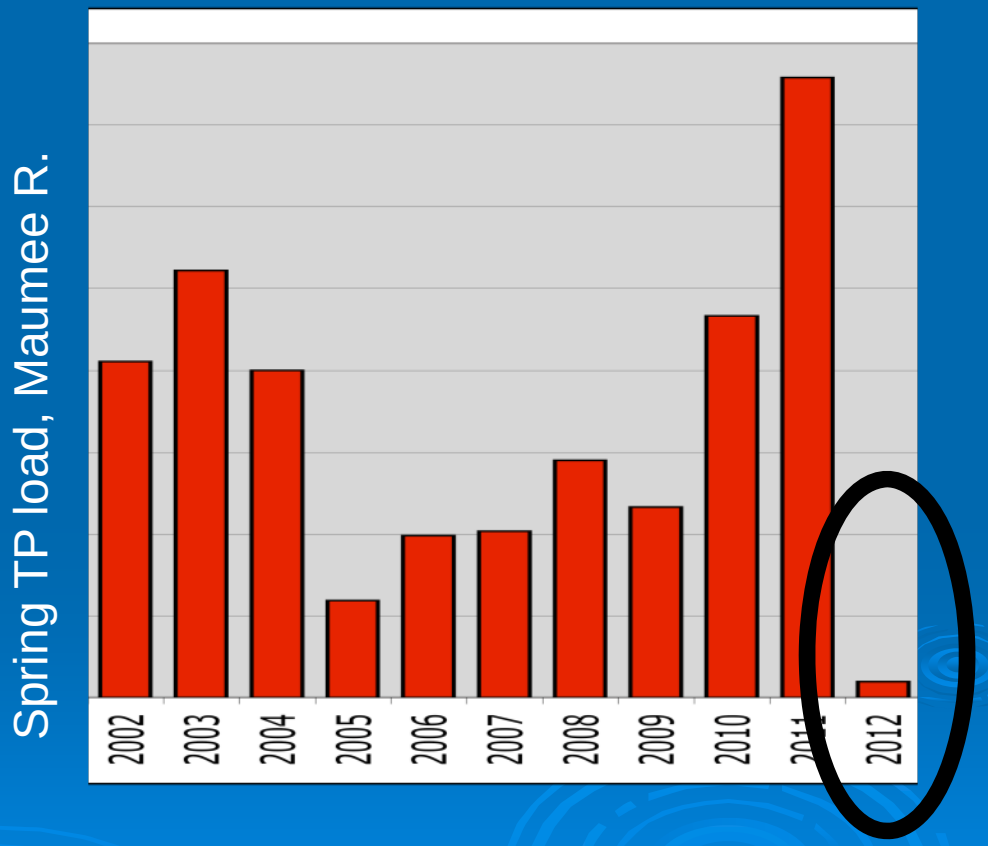
TP loading during March-June 2011 was the highest on record, resulting in greatest bloom on record





2012

TP loading during March-June 2012 was one of the lowest on record.



(NCWQR)

HAB Forecast and Early-Warning Tools

NOAA annual forecast (July 5, 2012)

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

NOAA, partners predict mild harmful algal blooms for western Lake Erie this year

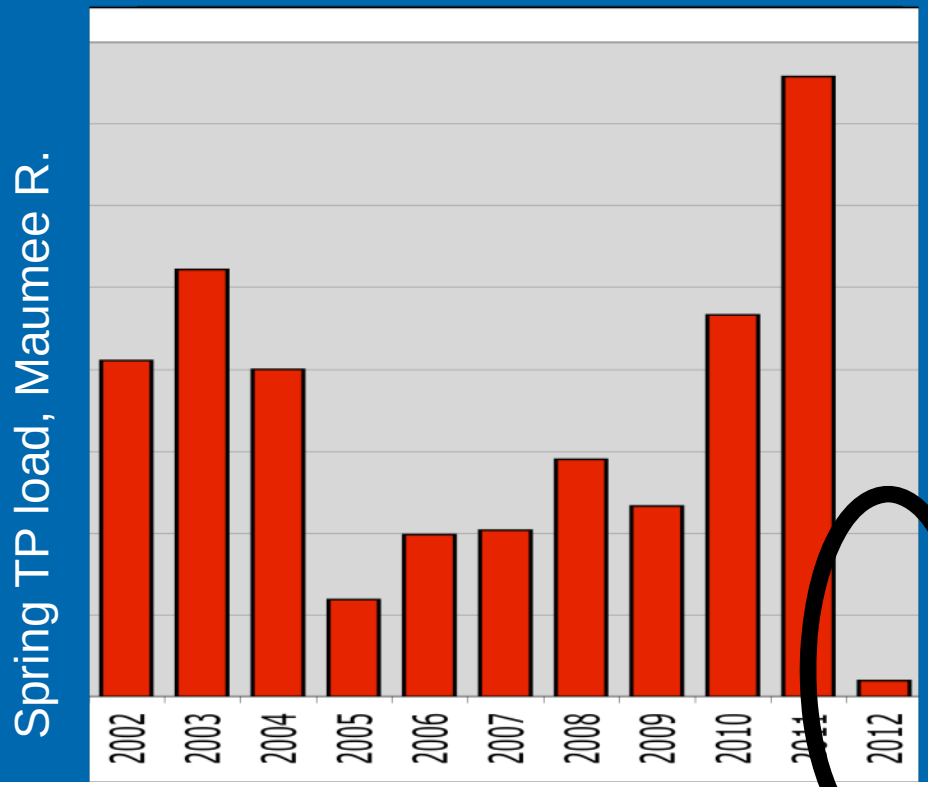
July 5, 2012

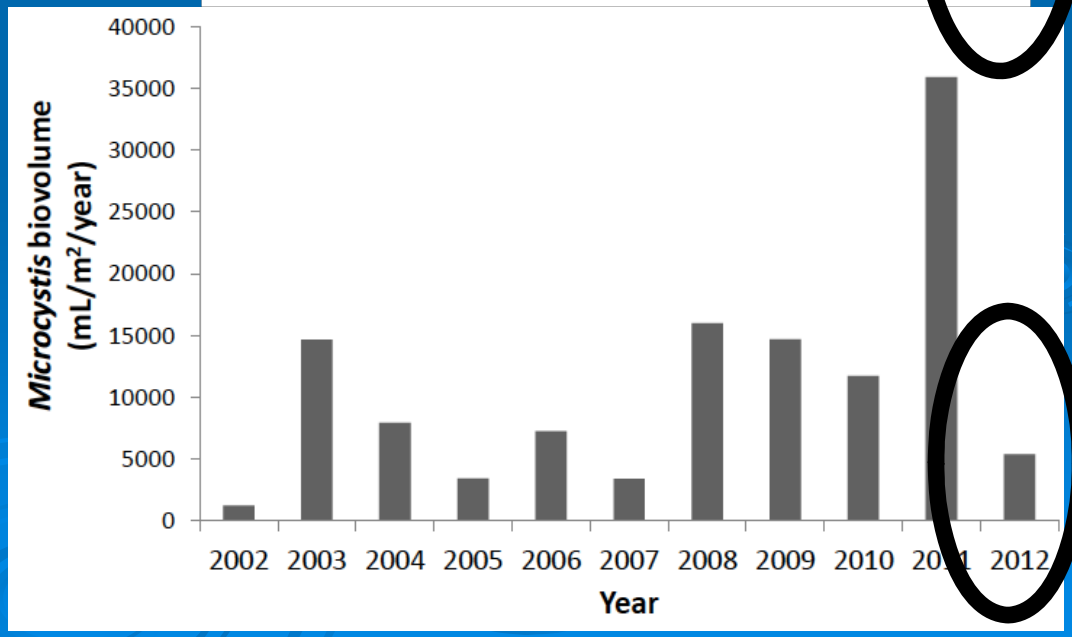
In its first-ever seasonal harmful algal bloom forecast for Lake Erie, NOAA researchers are predicting that western Lake Erie will have a mild bloom this summer, equivalent to conditions last seen in 2007.

Lake Erie has been plagued by a steady increase of harmful algal blooms (HABs) over the past decade. HABs can cause the death of fish, foul coastlines, and harm both aquatic and human life. NOAA has issued weekly bulletins for HABs in Lake Erie since 2008, and will continue to do so.

2012

NOAA HAB forecast for 2012 was on target.





HAB Forecast and Early-Warning Tools

2013 Forecast

Toxic algae could hit third of W. Lake Erie

NOAA says bloom to be heavy, but smaller than 2011's dense growth

BY TOM HENRY
BLADE STAFF WRITER

GIBRALTAR ISLAND, Ohio — Western Lake Erie is headed for another heavy bloom of toxic blue-green algae this summer that will damage the Great Lakes region's recreation and tourism industries, threaten public health, and cost Toledo, Monroe, Port Clinton, and other area shoreline municipalities more to treat lake water for home and business use.

The western third of the lake can expect a "significant bloom" starting in early August. It likely will peak by mid-September, according to a new type of forecasting being developed by the National Oceanic and Atmospheric Administration.

But the mass likely will amount to only about 20 percent of what it was in 2011, when dense mats of algae covered more of Lake Erie than it had in decades.

Dr. Rick Stumpf, of NOAA, demonstrates how to measure water samples with a fluorometer while on a boat in Lake Erie at Stone Laboratory on Put-in-Bay.
THE BLADE/LORI KING **Enlarge | Buy This Photo**

HAB Early-Warning Tools

Experimental Lake Erie Harmful Algal Bloom Bulletin

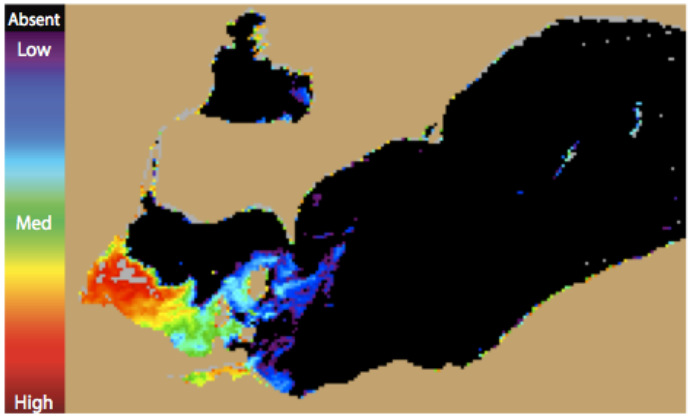


Figure 1. MODIS Cyanobacterial Index from 10 September 2013. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow)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

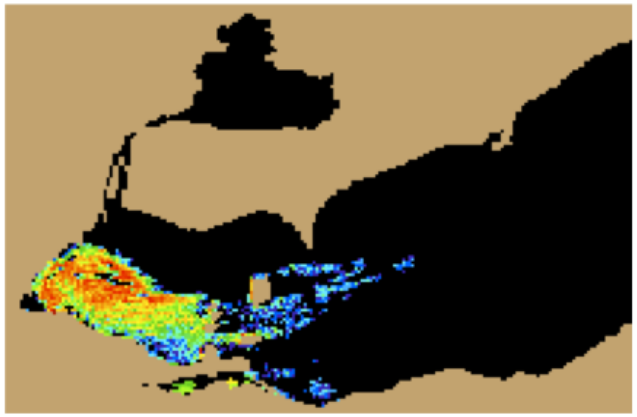


Figure 2. Nowcast position of bloom for 12 September 2013 using GLCFS modeled currents to move the bloom from the 10 September 2013 image.

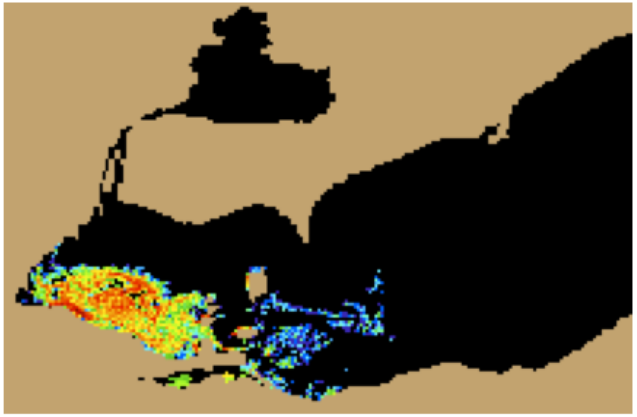
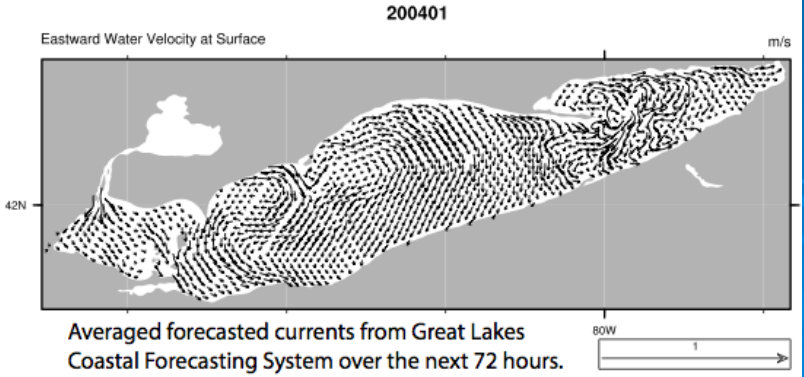


Figure 3. Forecast position of bloom for 15 September 2013 using GLCFS modeled currents to move the bloom from the 10 September 2013 image.



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

http://www2.nccos.noaa.gov/coast/lakeerie/bulletin/bulletin_current.pdf

October 12, 2013

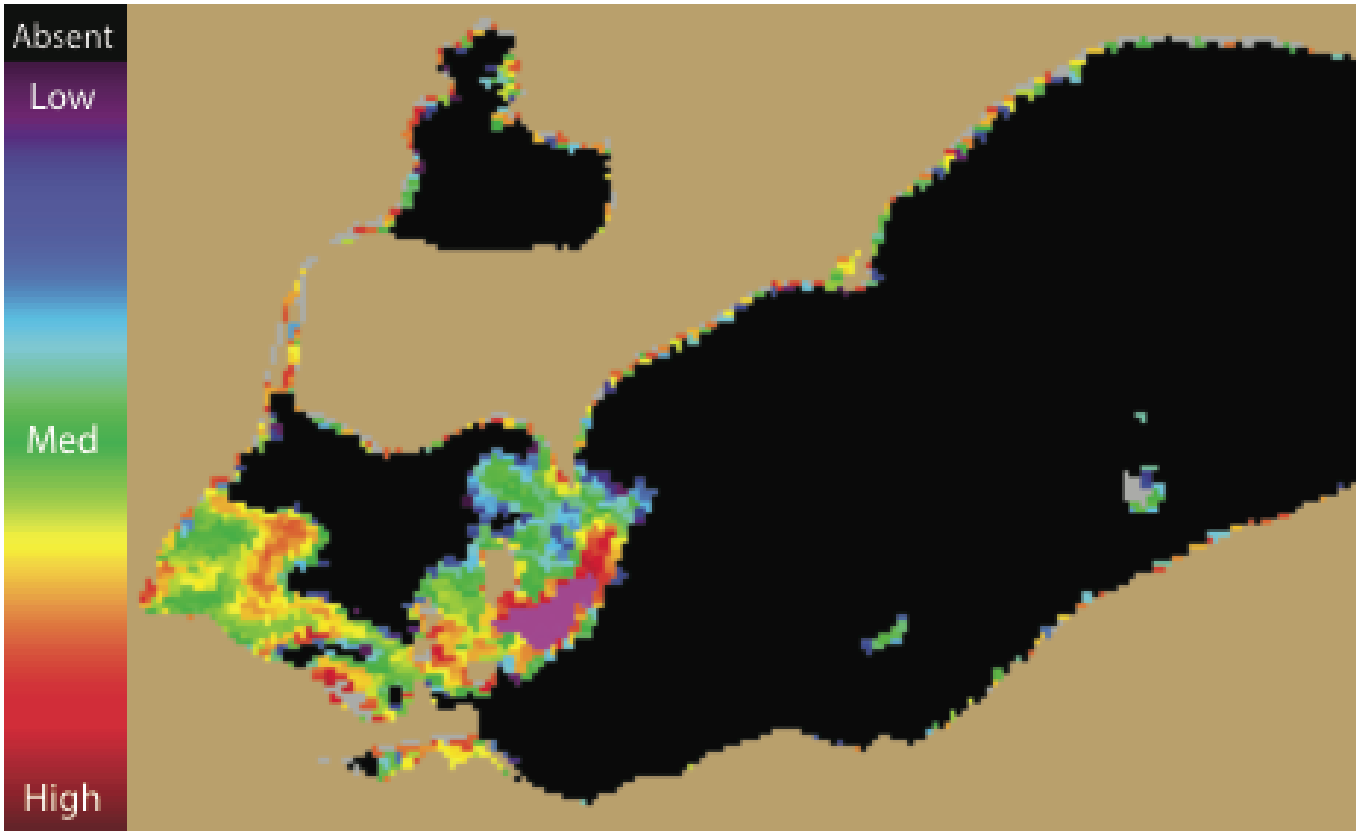


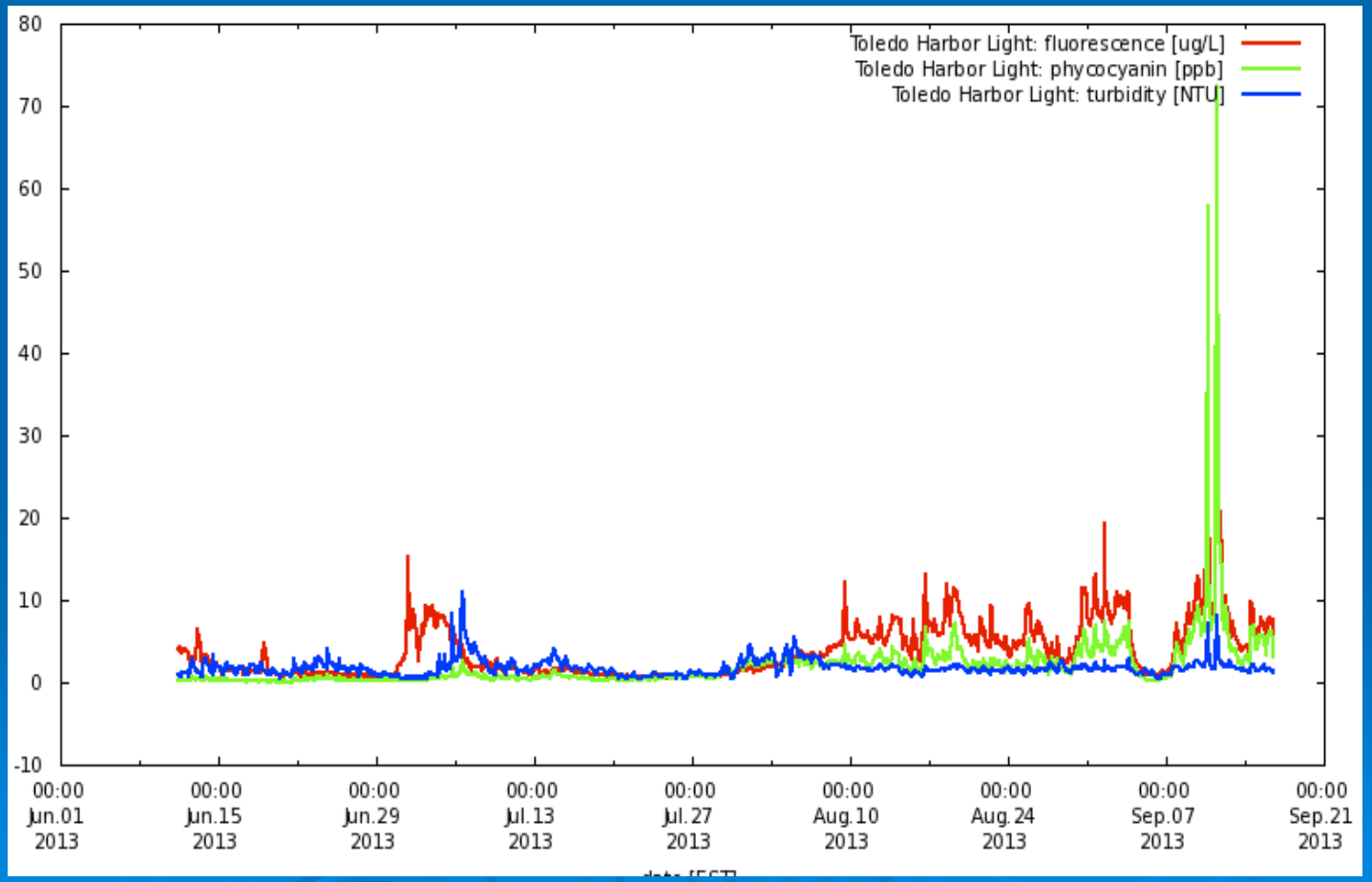
Figure 2. MODIS Cyanobacterial Index from 12 October 2013.

R. Stumpf, NOAA National Center for Coastal Ocean Science

HAB Early-Warning Tools

LOBO Land/Ocean Biogeochemical Observatory

Battery Voltage	13.5	V
CDOM	7.90	QSDE
Conductivity	0.02	mmho/cm
Fluorescence	5.97	µg/L
Oxygen	6.50	ml/l
Oxygen Saturation	6.28	ml/l
Oxygen % Saturation	103.48	%
Phosphate Concentration	-0.03	µM
Phycocyanin	3.16	ppb
Pressure	0.312	dBar
Salinity	0.11	PSU
Temperature	20.50	°C
Turbidity	1.29	NTU
Turbidity raw	152	count



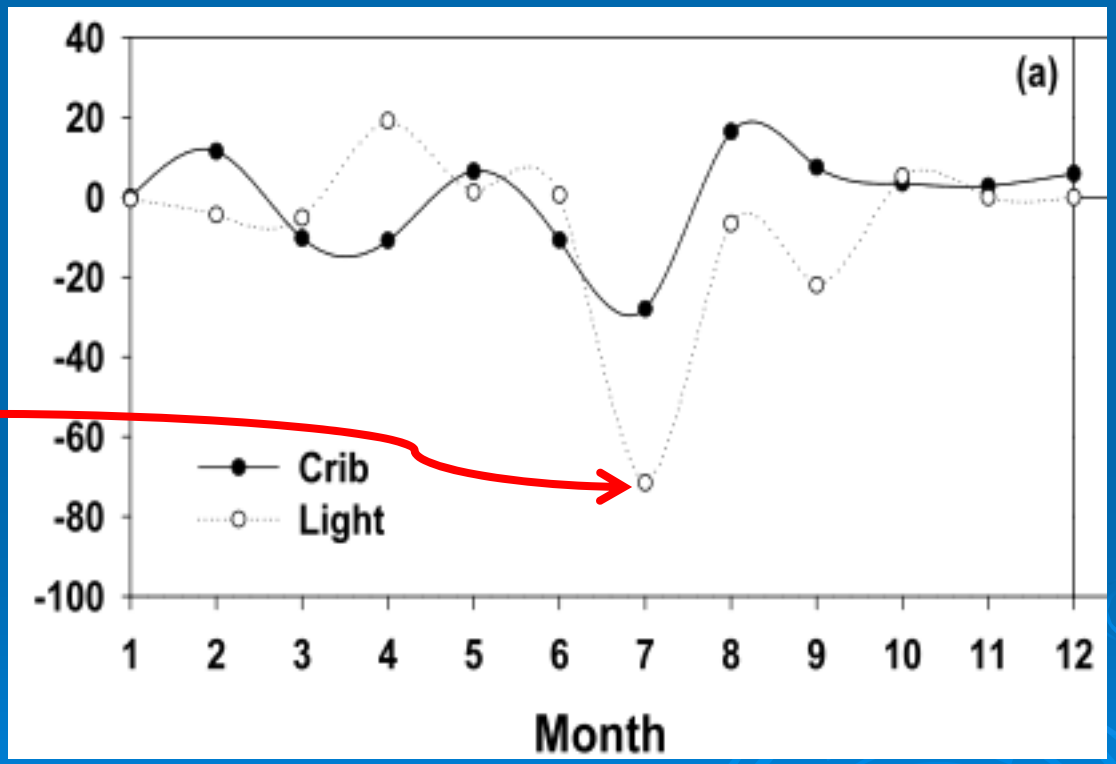
http://algae.loboviz.com/

Carbon Gas Flux into / out of lake

Carbon out of lake

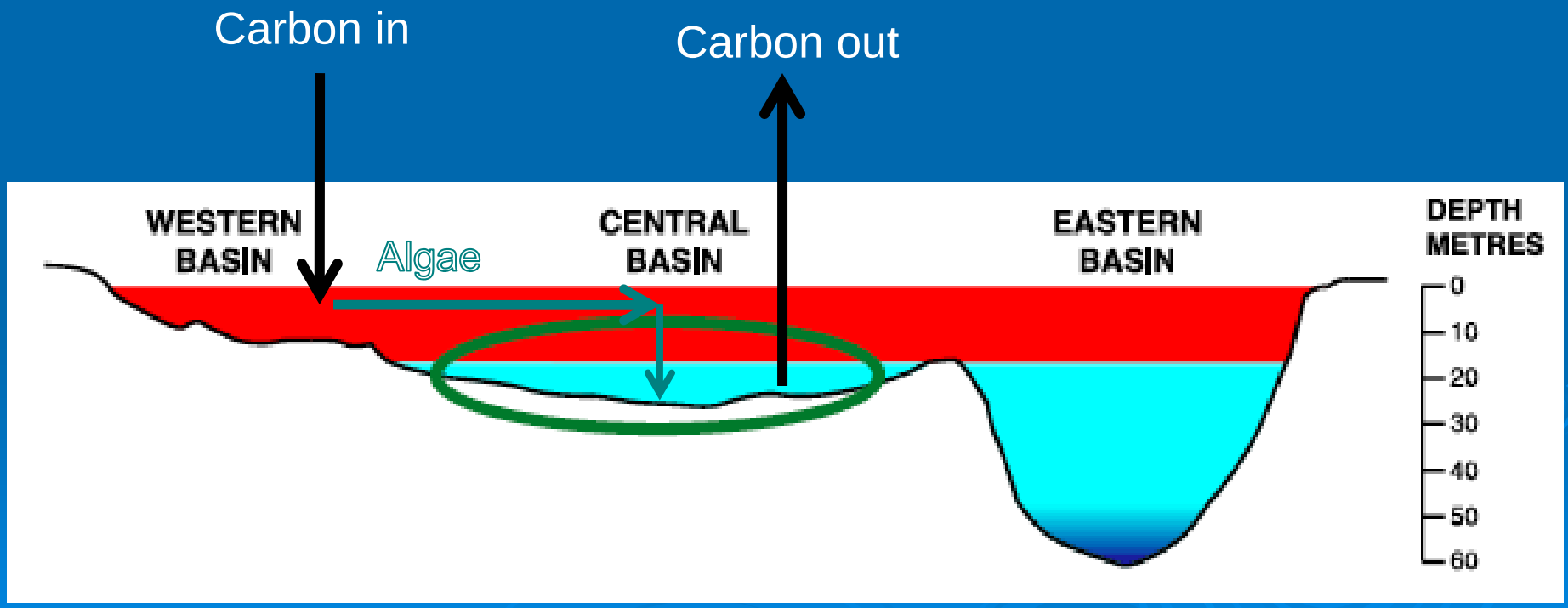
0= Carbon neutral

Carbon into lake



J. Chen, C Shao – U. Toledo

Carbon Flux suggests possible transport of algae out of western basin



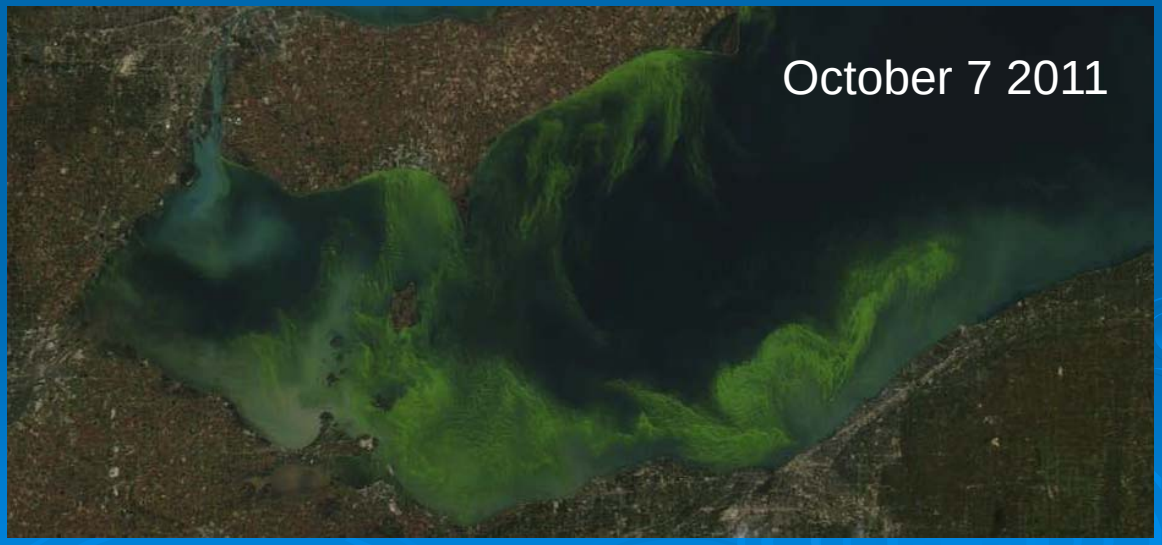
D. Scavia

3
HAB sources and nutrient limitation

Sources of HABs

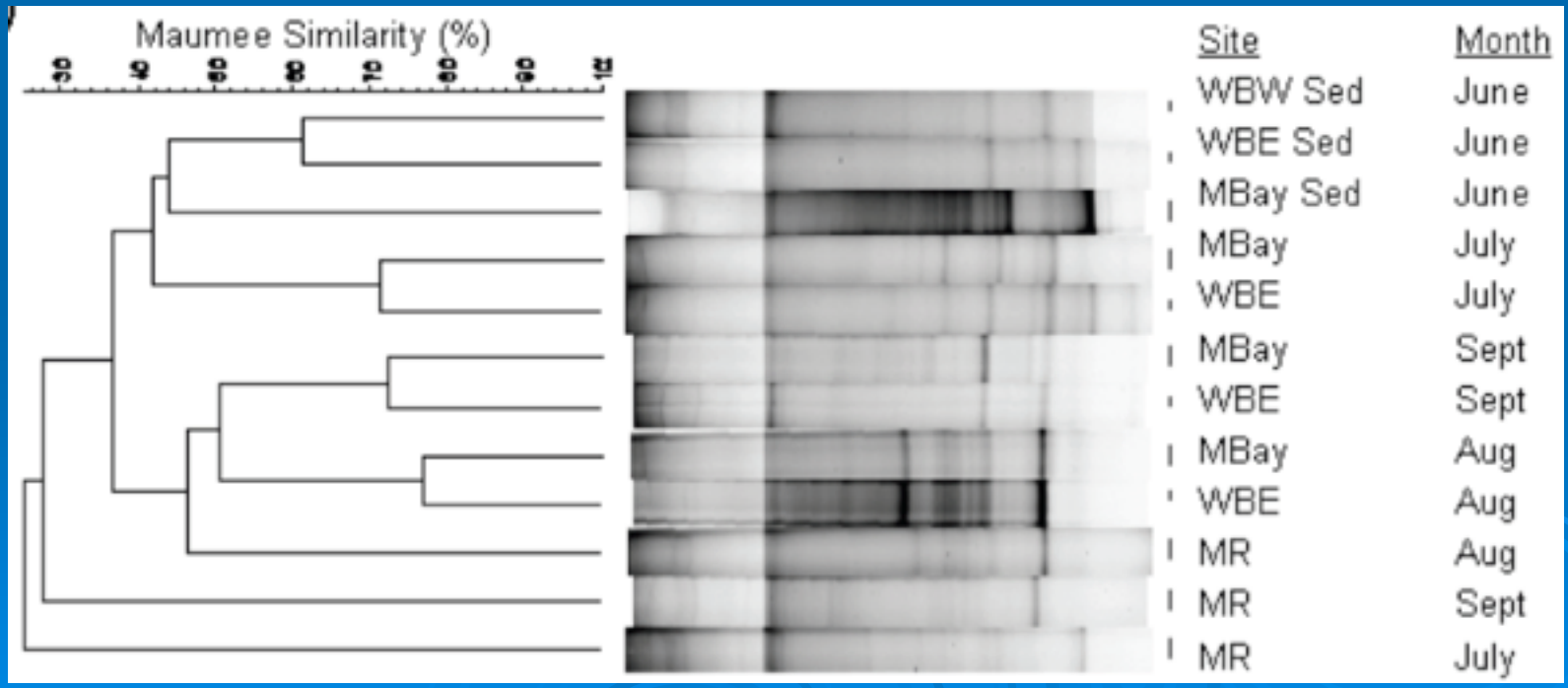
- Were these different blooms or a continuation of the same bloom?

- How important are tributary sources of *Microcystis* vs. lake sediments?



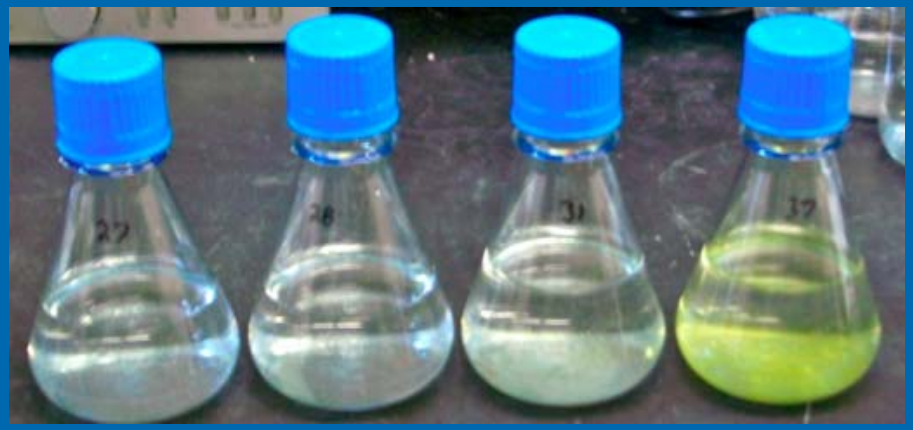
Source of HABs

- Genetic studies indicate that *Microcystis* in Lake Erie is most similar to *Microcystis* in Lake sediments than tribs.
- Suggests that L. Erie blooms grow from cells overwintering in lake sediments (J. Chaffin)



J. Chaffin, Ph.D. Dissertation

Nutrient Limitation

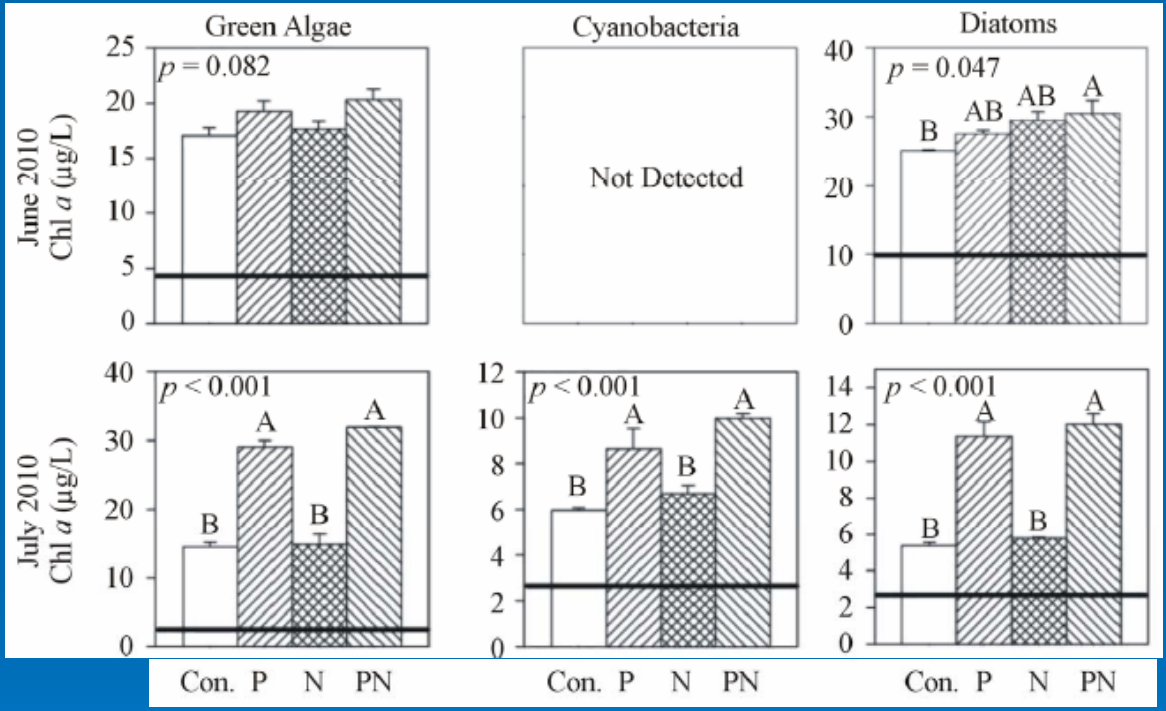


- General Pattern for Maumee Bay
  - June:No nutrient limitation ➔Juy:P-limitation ➔ August: N-limitation
- General Pattern for offshore western basin
  - June: P-limitation ➔ July: P-limitation ➔ August: N-limitation

J. Chaffin et al. 2013

Nutrient Limitation

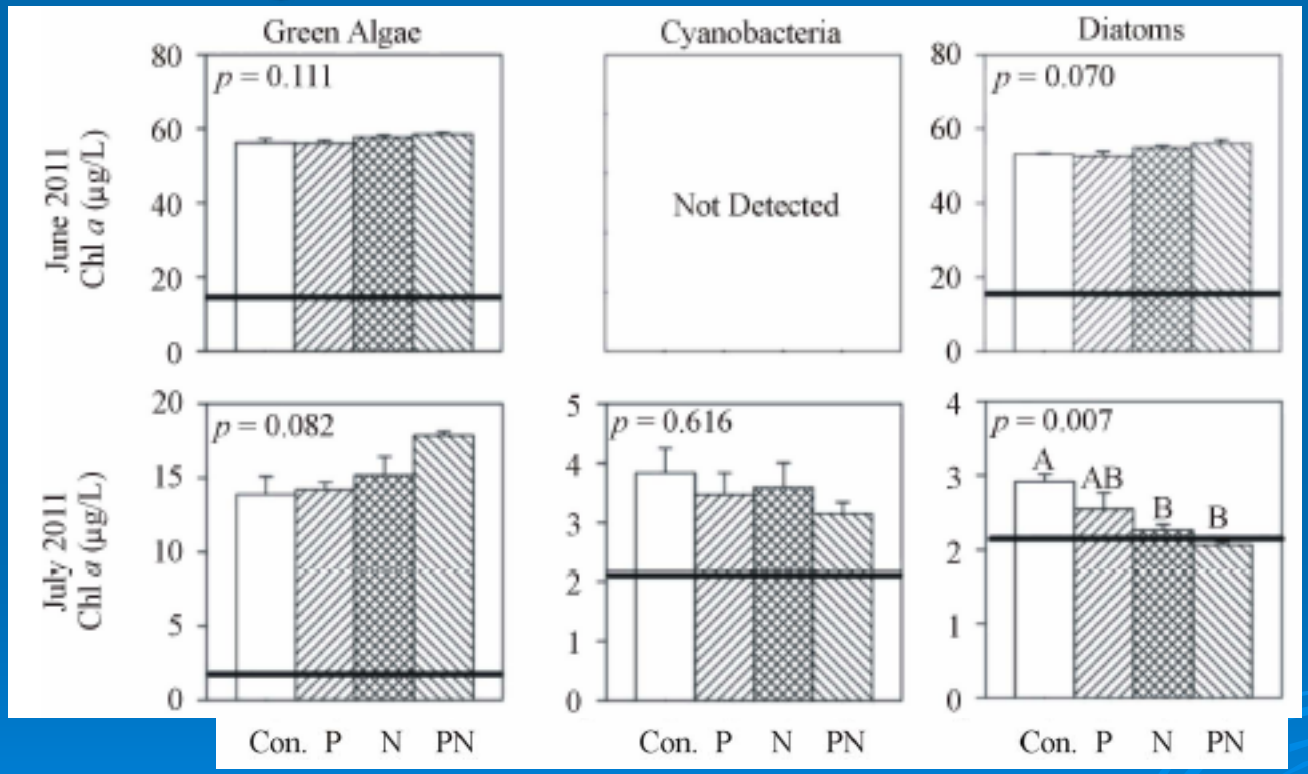
- Maumee Bay 2010: Bioassays show NO nutrient limitation until July.



J. Chaffin et al. 2013

Nutrient Limitation

- Maumee Bay 2011: Bioassays show NO nutrient limitation until August. Therefore had a longer period of unlimited growth.



J. Chaffin et al. 2013

Summary

- HABs in Lake Erie are linked to spring TP loading and seem to be getting even larger in recent years.
- There are a variety of forecasting and early warning tools available.
- HABs may become larger due to unconstrained growth early in the summer. This period is followed by a period of P-limitation and finally N-limitation.