

Use of Satellite Data to Monitor and Evaluate Cyanobacteria Blooms in Lake Erie and Other Lakes

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Put-in Bay, July 24, 2015
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Stone Laboratory, OSU



Issues with cyano blooms

URGENT NOTICE TO RESIDENTS

DO NOT DRINK THE WATER
DO NOT BOIL THE WATER

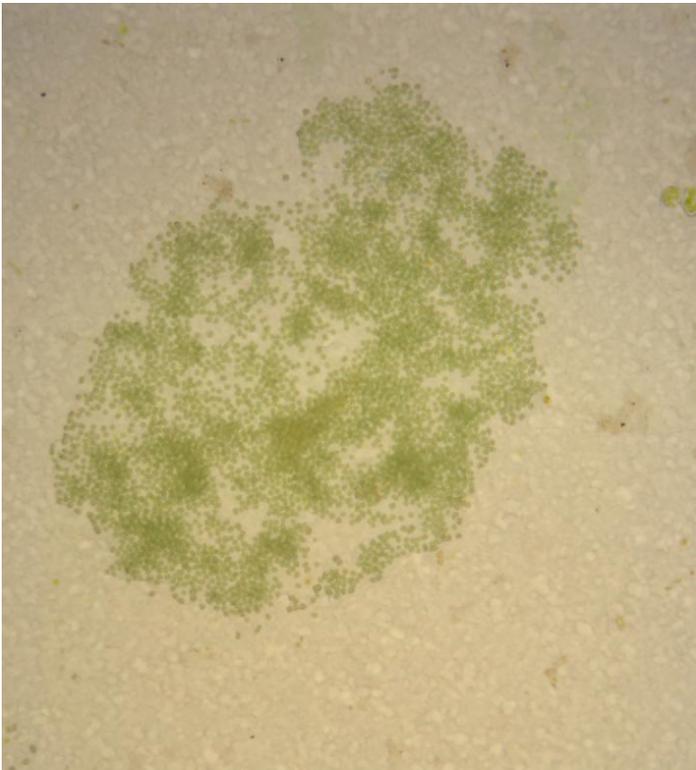
Toledo, safe water, July 2015



Tom Feran, The Plain Dealer, 29 July 2015

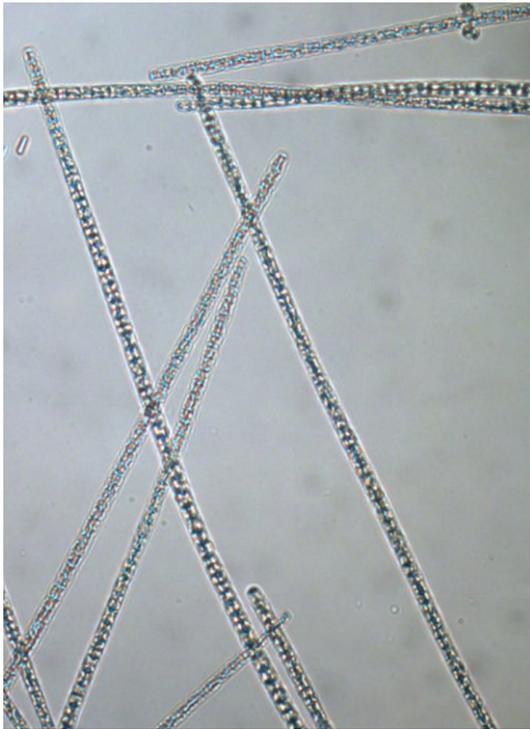
Microcystis example, it rises when it needs to make food

- Aug 2010, Lake Erie



Some stay mixed, *Planktothrix* example

- Sandusky Bay, Ohio, dispersed



Satellite imagery



Lake Erie, MERIS, 05 Oct 2011

Satellite Comparison for cyano applications

Satellite	Spatial	Temporal	Key Spectral
MERIS (2002-12) OLCI Sentinel-3 2015	300 m <i>OK</i>	2 day <i>good</i>	10 (5 on red edge) <i>good</i>
MODIS high res Terra 1999; Aqua 2002	250/500 m <i>OK</i>	1-2 day <i>good</i>	4 (1 red, 1 NIR) <i>marginal</i>
MODIS low res & SeaWiFS	1 km <i>poor</i>	1-2 day <i>good</i>	7-8 (2 in red edge) <i>OK</i>
Landsat	30 m <i>good</i>	8 or 16 day <i>poor</i>	4 (1 red, 1 NIR) <i>marginal</i>
Sentinel-2 (2015)	20 m <i>good</i>	10 day (5 day with 2 nd satellite in 2017) <i>Potential with 2</i>	5 (1 red; 2 NIR, 1 in red edge) <i>potential</i>

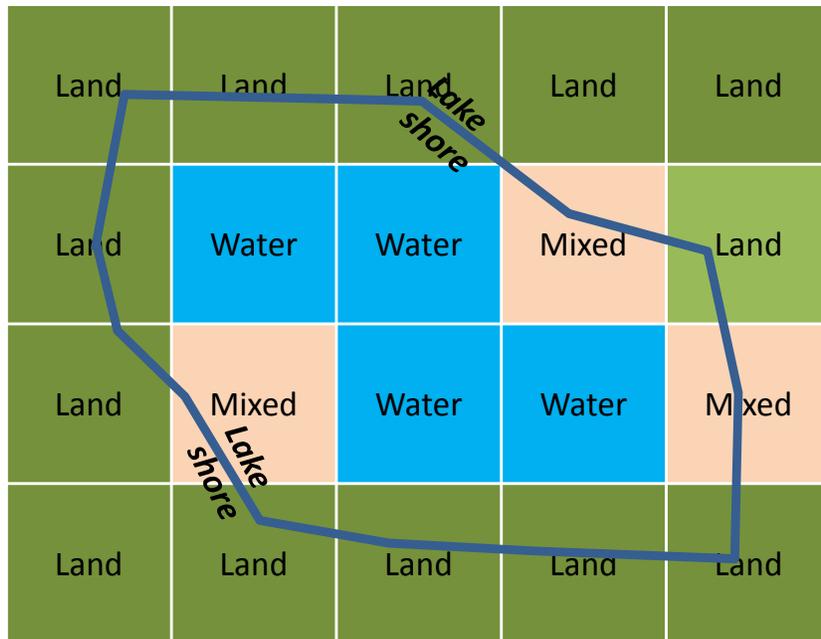
Clouds take out 1/2 to 2/3 of imagery

Some sunglint is not a problem for our algorithms

Minimum resolution, 3 pixels across (2 mixed land/water)

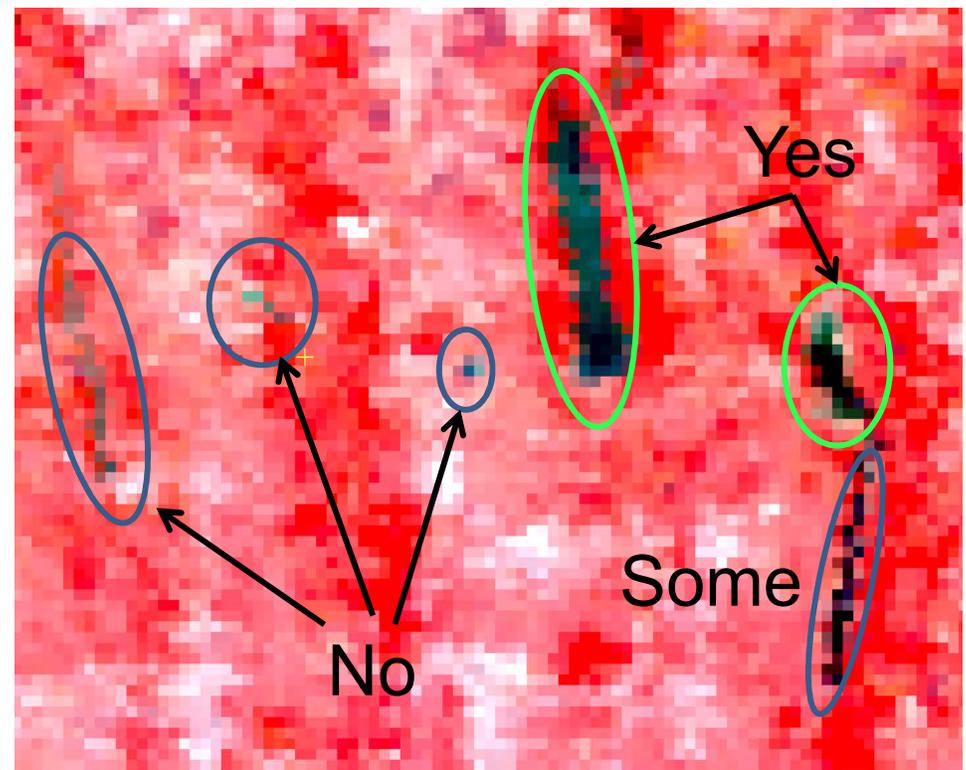


Resolution and water bodies

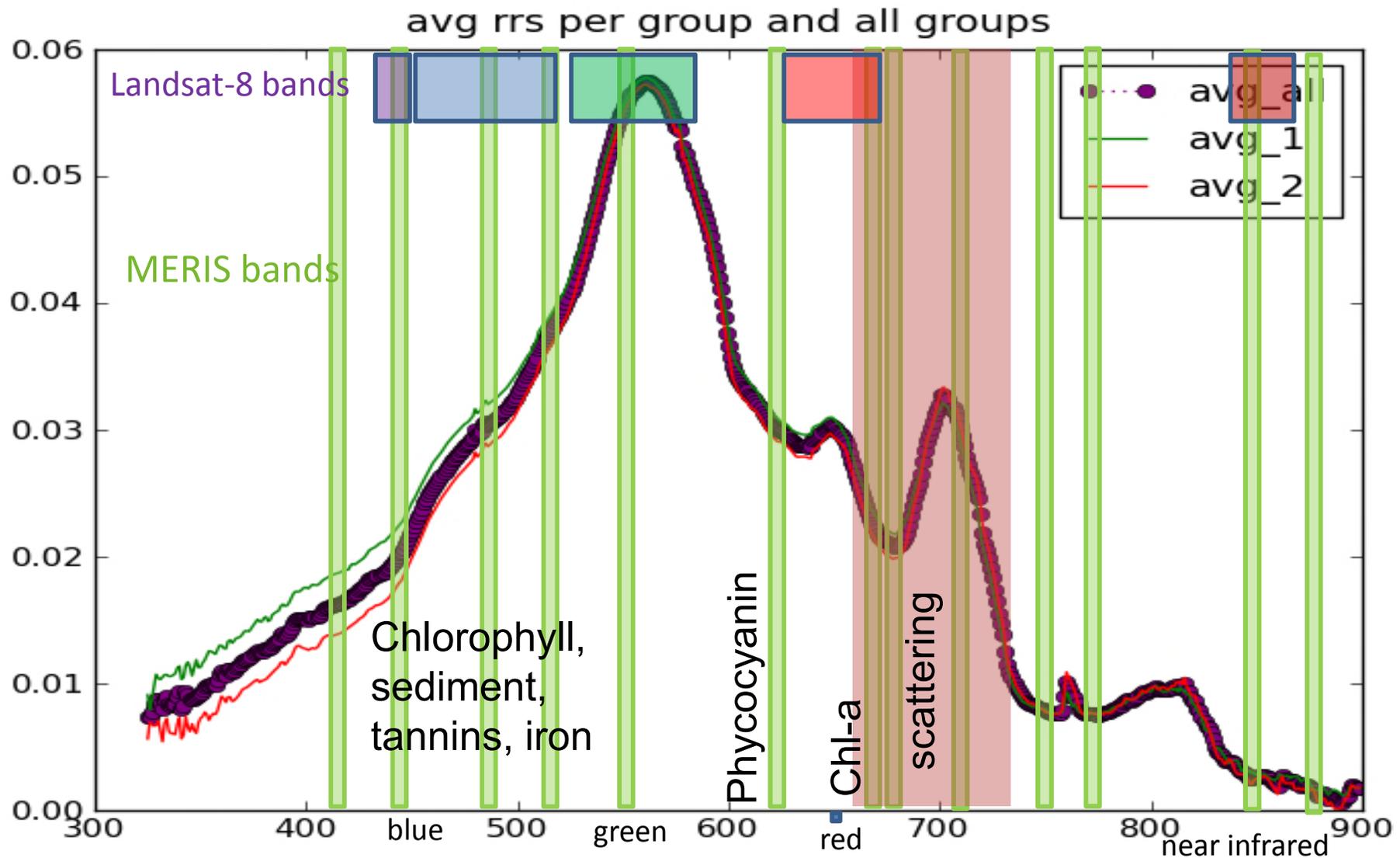


Mixed pixels limit our ability to monitor small water bodies.

Note: false color sharpens distinction between land and water.
Reddish pixels at right include land.



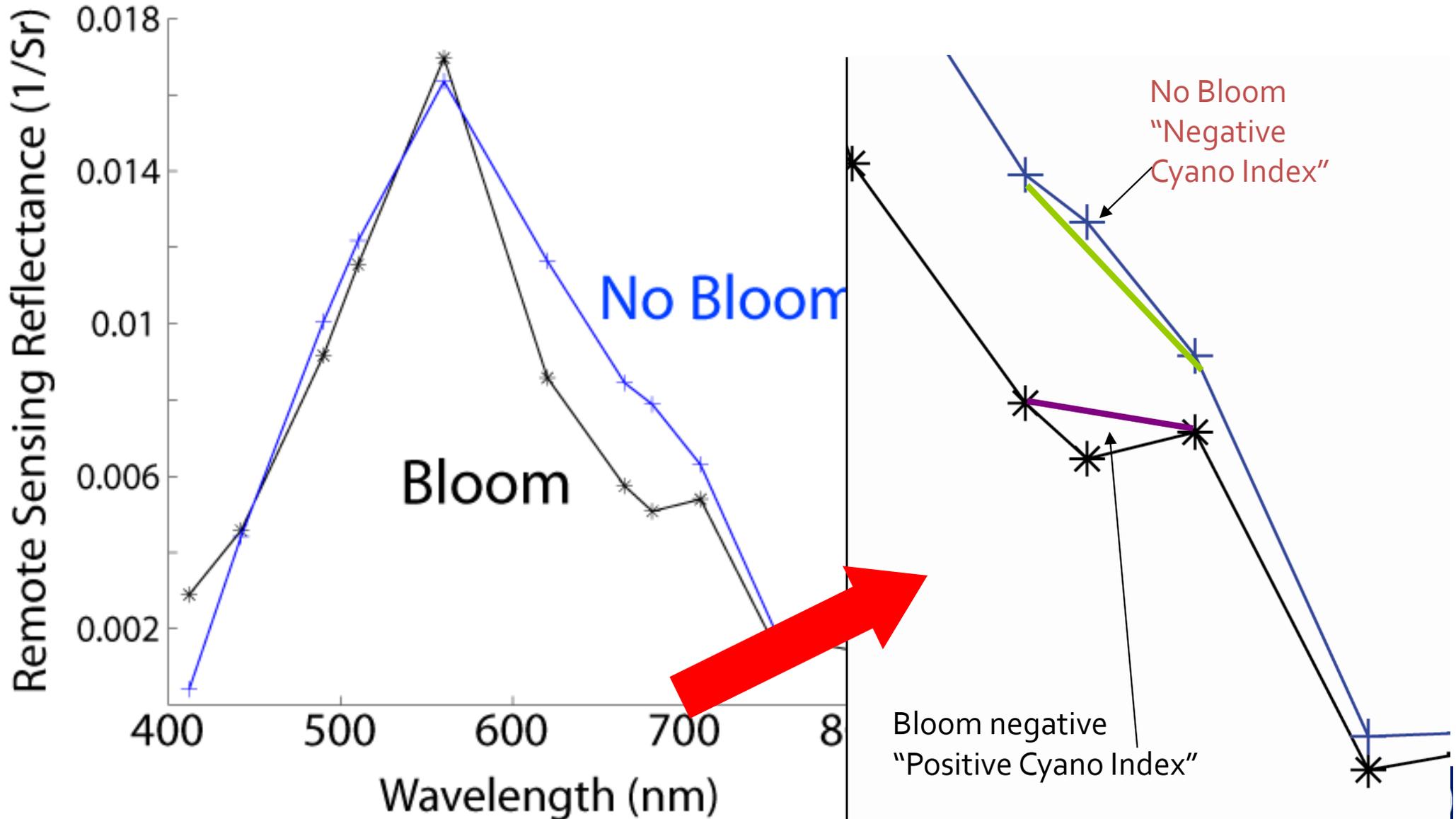
MERIS (and Landsat) Bands on water spectra from *Microcystis*



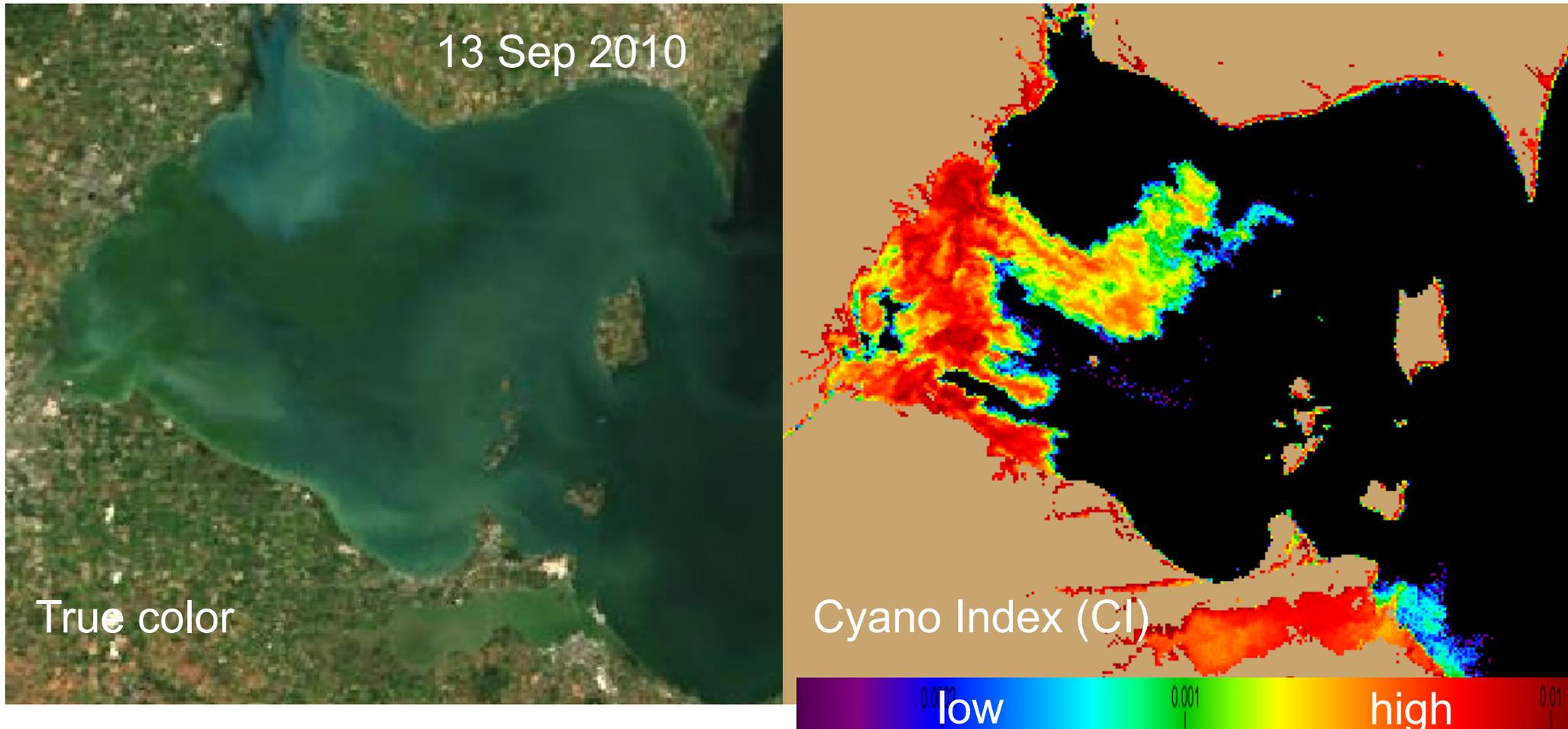
Also have to correct for atmosphere;
Landsat runs out of information content to discriminate everything

Detection Algorithm, curvature (shape) Detects surface concentration

Wynne et al., IJRS, 2008



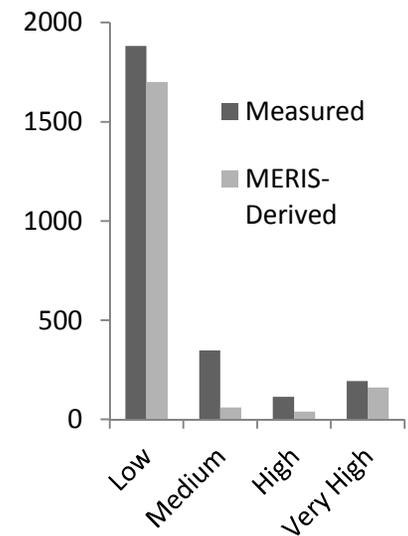
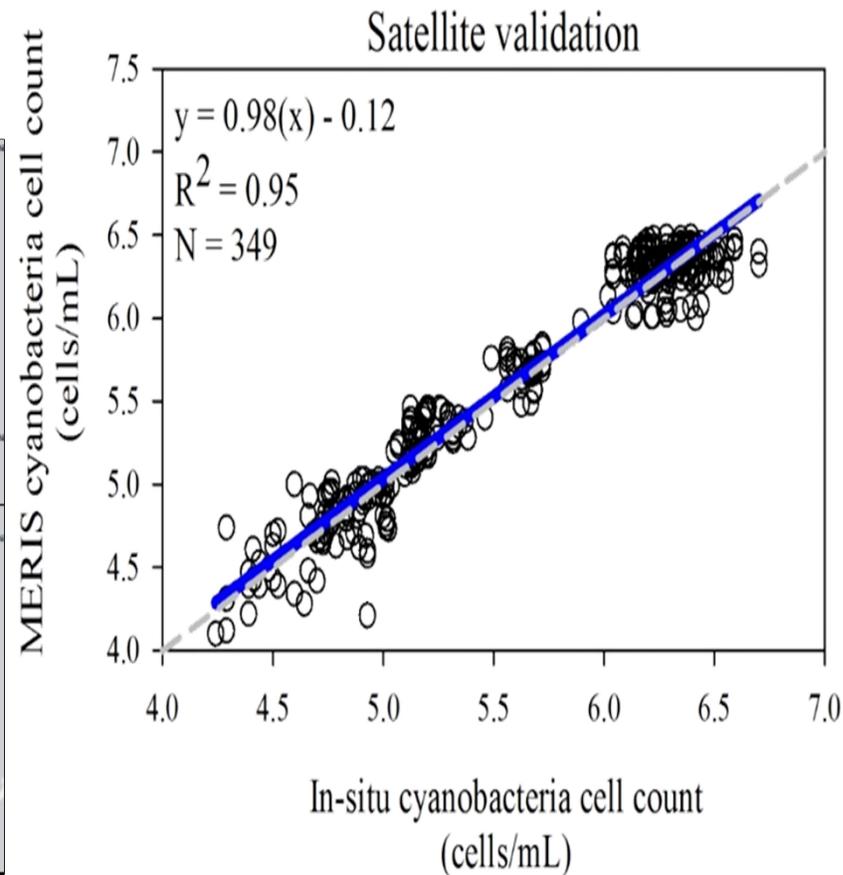
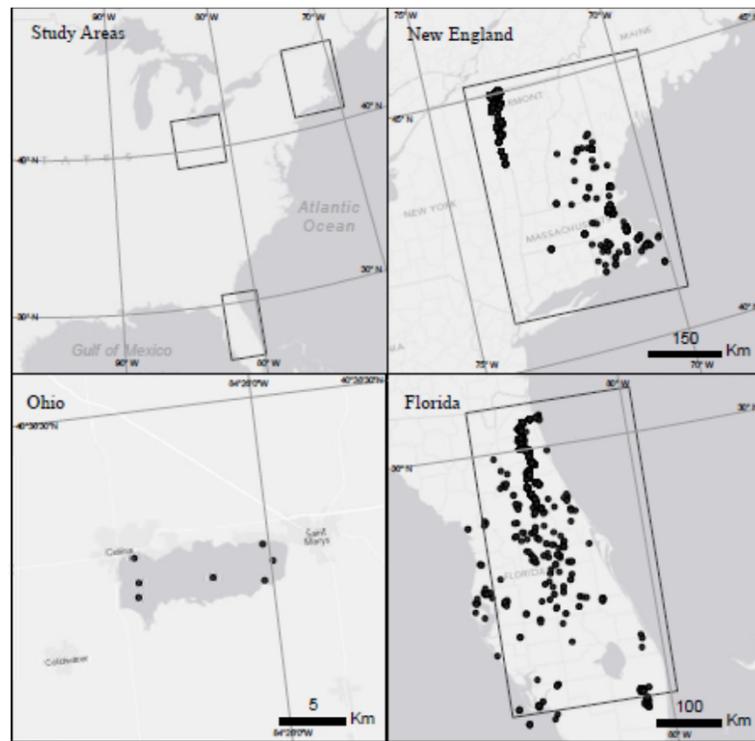
The extra wavelengths give a cyanobacteria index, “CI”, which equates to concentration



Surface concentration (up to 1 m). Not dependent on scum

Validation of Lake Erie algorithm for other areas

- Remote Sensing
 - *Uniform and systematic approach for identifying & quantifying cyanobacteria blooms.*
 - Second derivative spectral shape algorithms (SS; Wynne et al. 2008)



Lunetta, Schaeffer, Stumpf et al. Remote Sensing of Environment

And Between CI and chl-a from Florida (St Johns River WMD)

Direct match of radiometer
(simulate satellite) with water
sample

10% mean uncertainty

$$Est\ chl\ a = 4020 * (CI) + 20\ \mu g/L$$

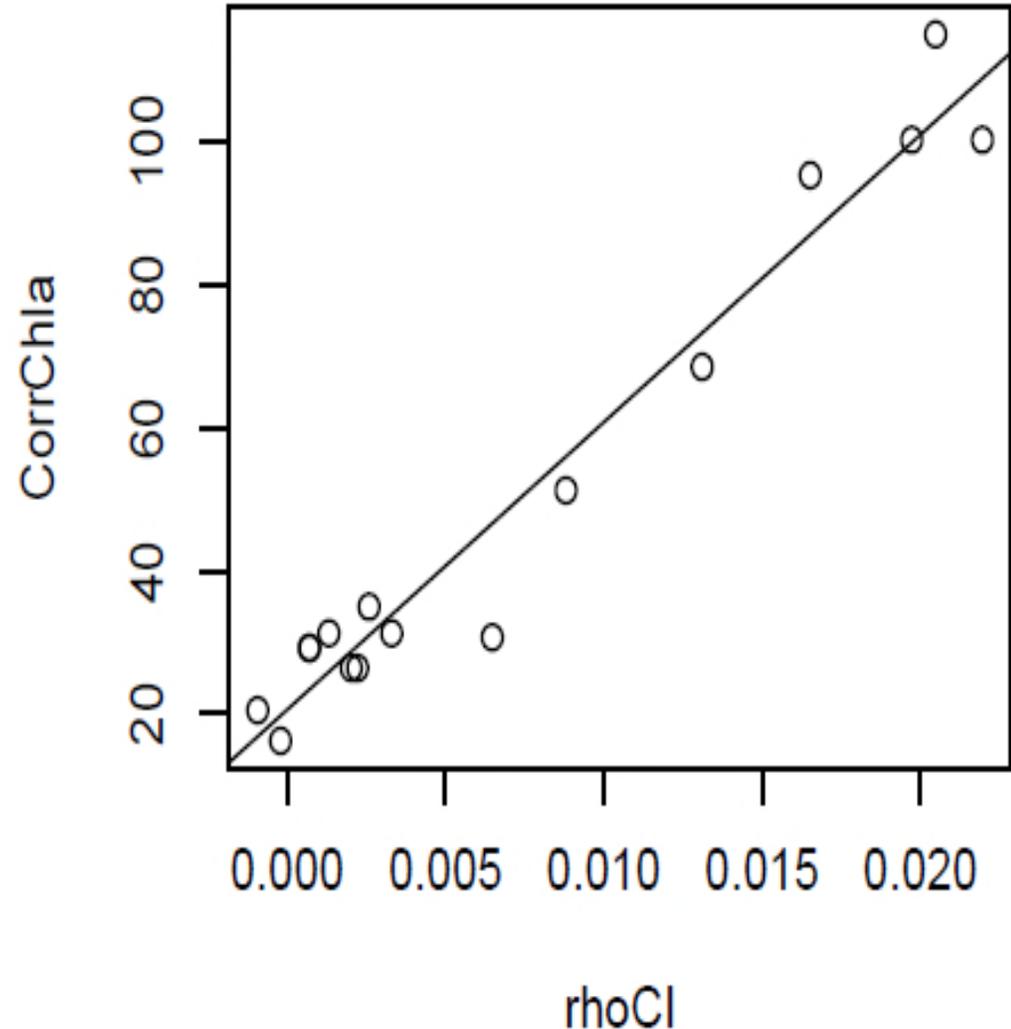
Detection of chlorophyll

> 20 $\mu g/L$

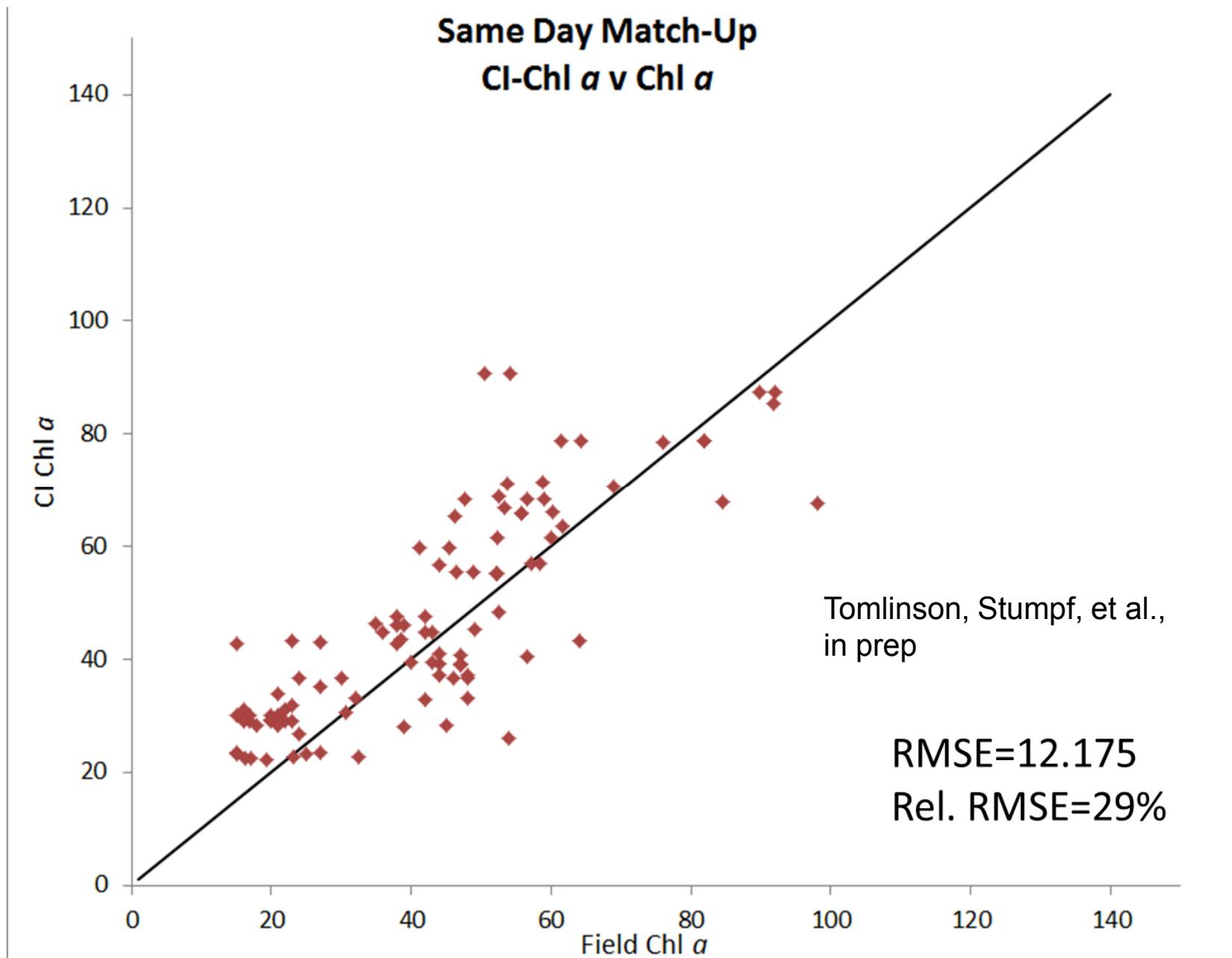
(working on > 10 $\mu g/L$)



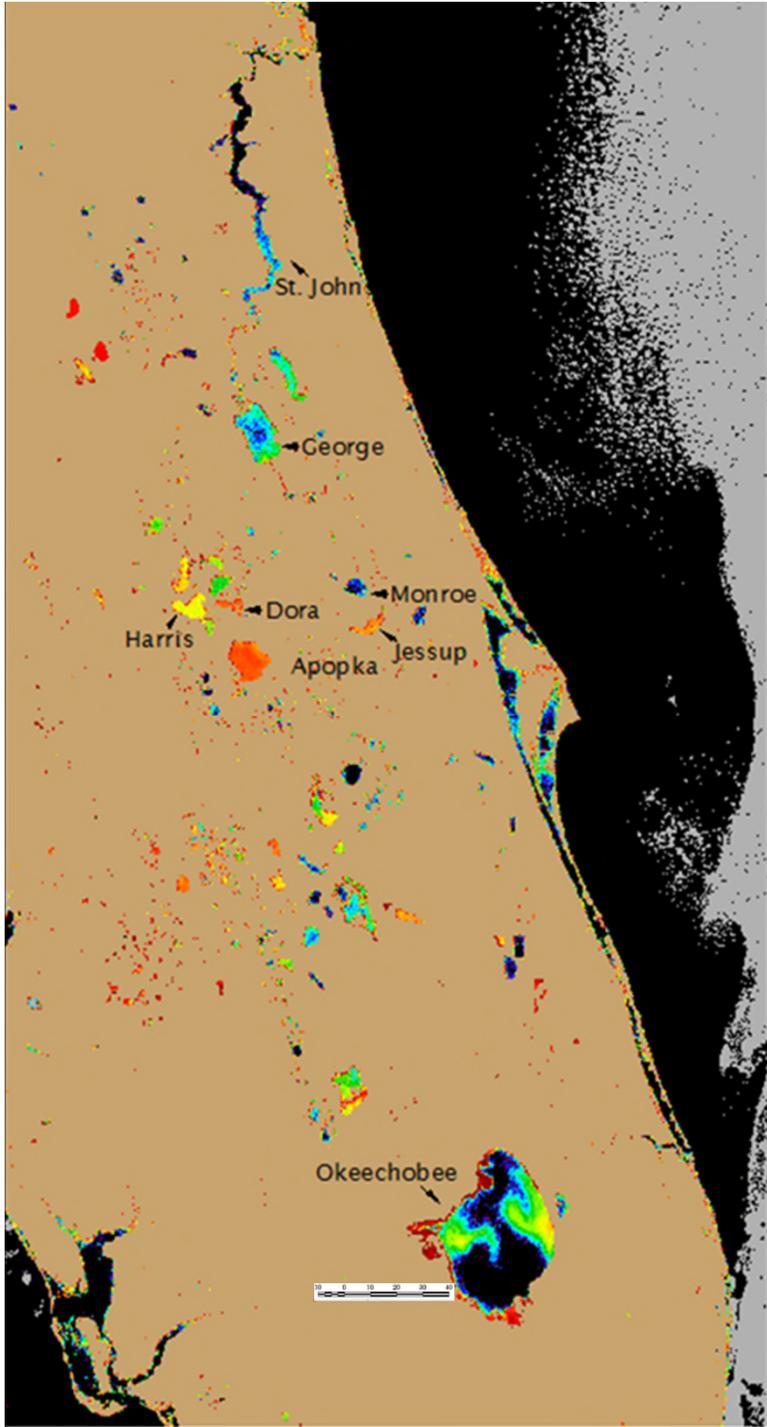
Tomlinson et al., 2015,
Remote Sensing Letters



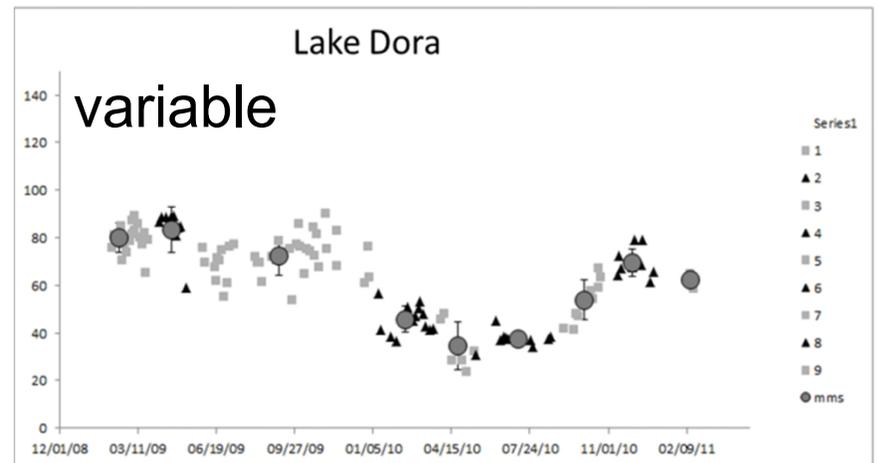
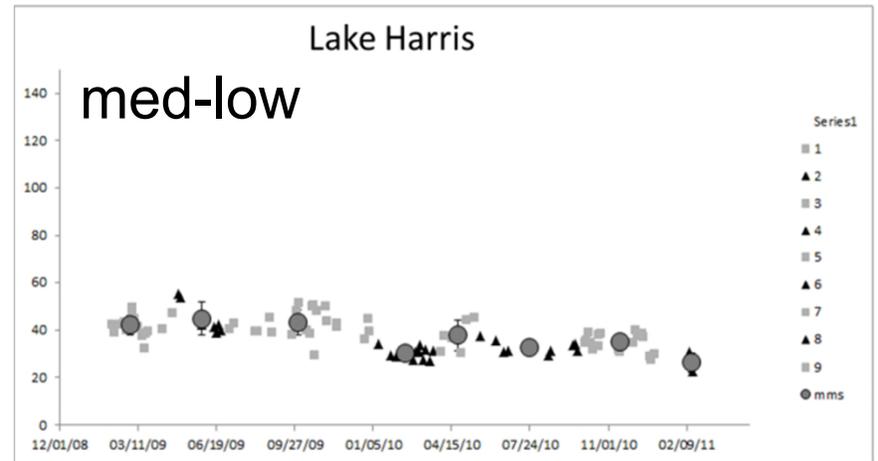
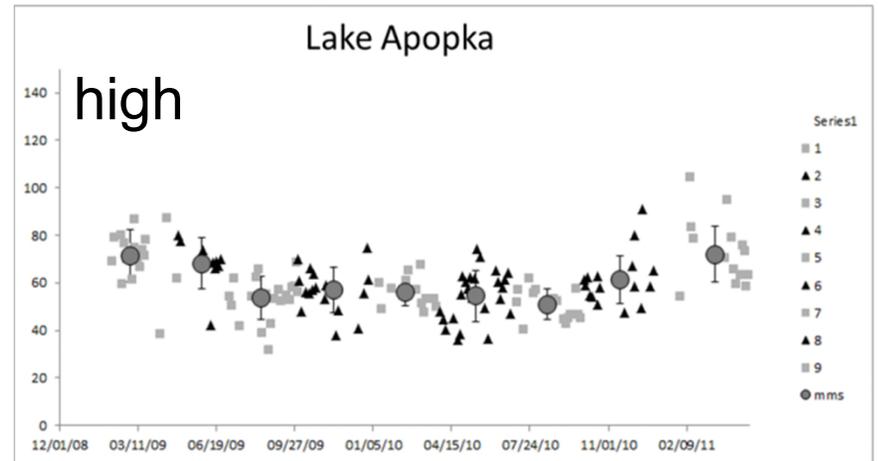
Biomass indicator, Florida Lakes (data from LakeWatch and MERIS)



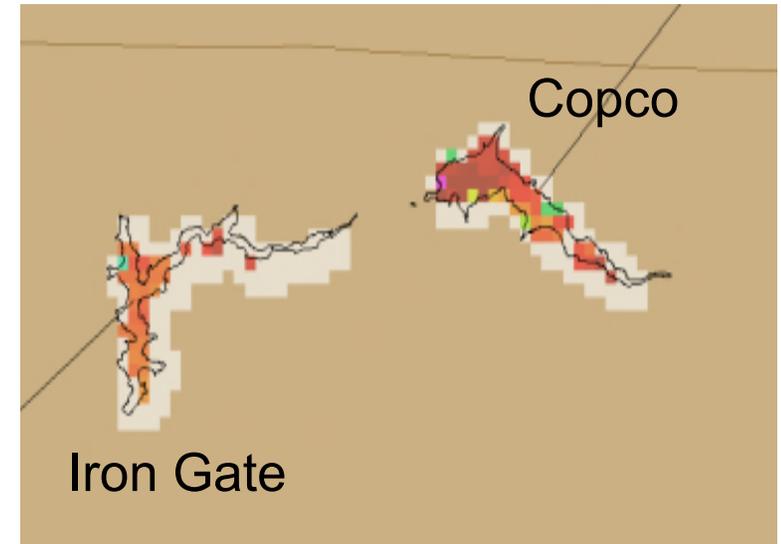
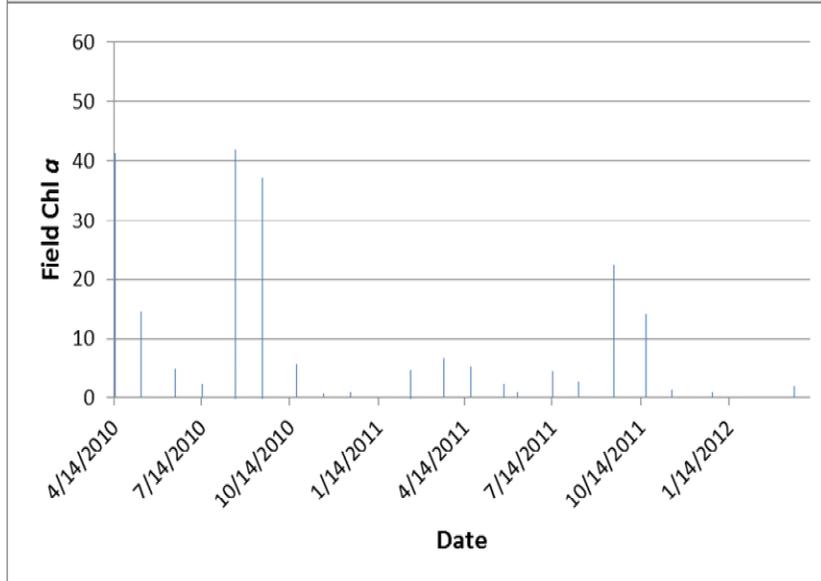
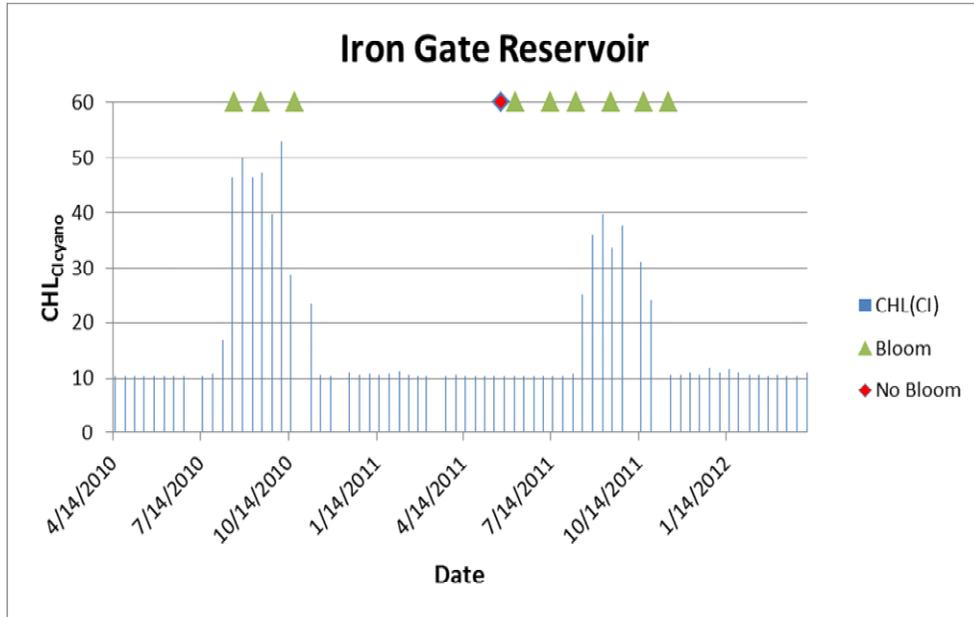
Tracking biomass in Florida



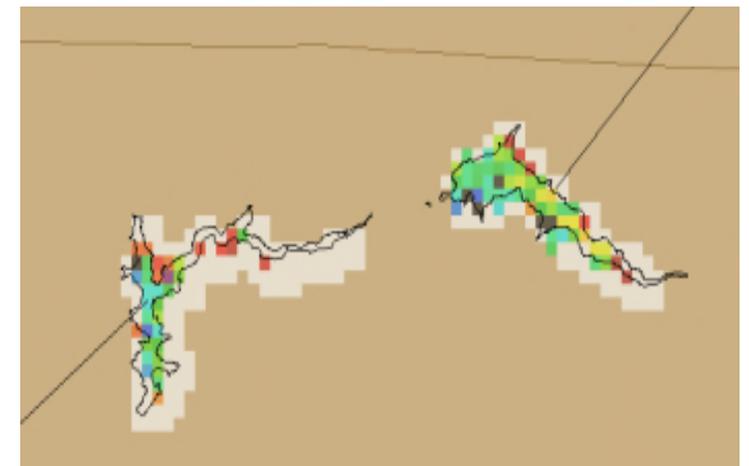
Biomass
over 3
years



Klamath River (California) reservoirs.



MERIS composites
 Aug 11-20, 2010 top
 Feb 1-10, 2011 bottom



2015: 1500 subscribers + media reports

Experimental Lake Erie Harmful Algal Bloom Bulletin

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

The *Microcystis* cyanobacteria bloom continues across a large part of the western basin south of West Sister Island from Michigan to the islands. Dense scums have formed in highest concentration areas, with extensive scums occurring in the red to dark red areas in the western basin. The bloom is found east of the islands, including scum patches away from shore. Moderate concentrations extend as far as Rondeau on the Ontario coast. Microcystin is present in this bloom, and the toxin levels are extremely high in scums.

Light southerly to southwesterly winds will continue today and Tuesday, gradually increasing to Thursday. Least mixing and greatest scum formation earlier in the week, and greatest mixing with passage of a cold front late Wed and Thursday. These winds will cause continued movement of the eastern edge into the central basin and also eastward on the Ontario coast.

The persistent bloom in Sandusky Bay continues. No other blooms are evident in the central and eastern basins.

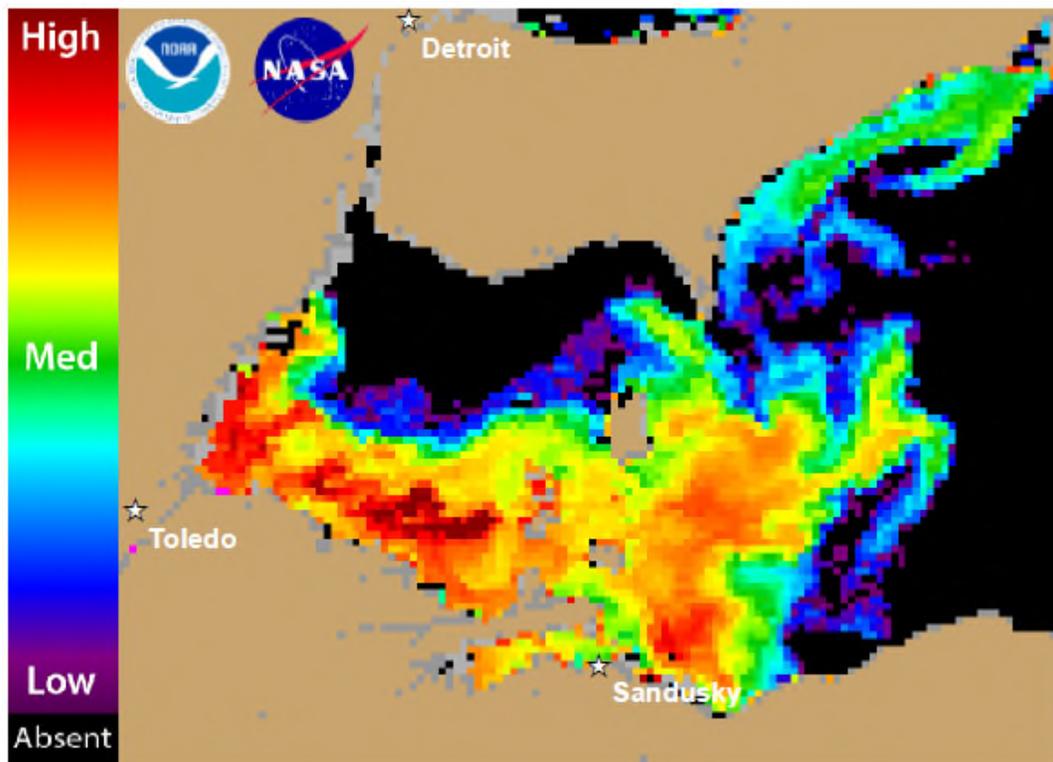


Figure 1. Cyanobacterial Index from NASA's MODIS-Terra data collected 16 August, 2015. Grey indicates clouds or missing data. Black represents

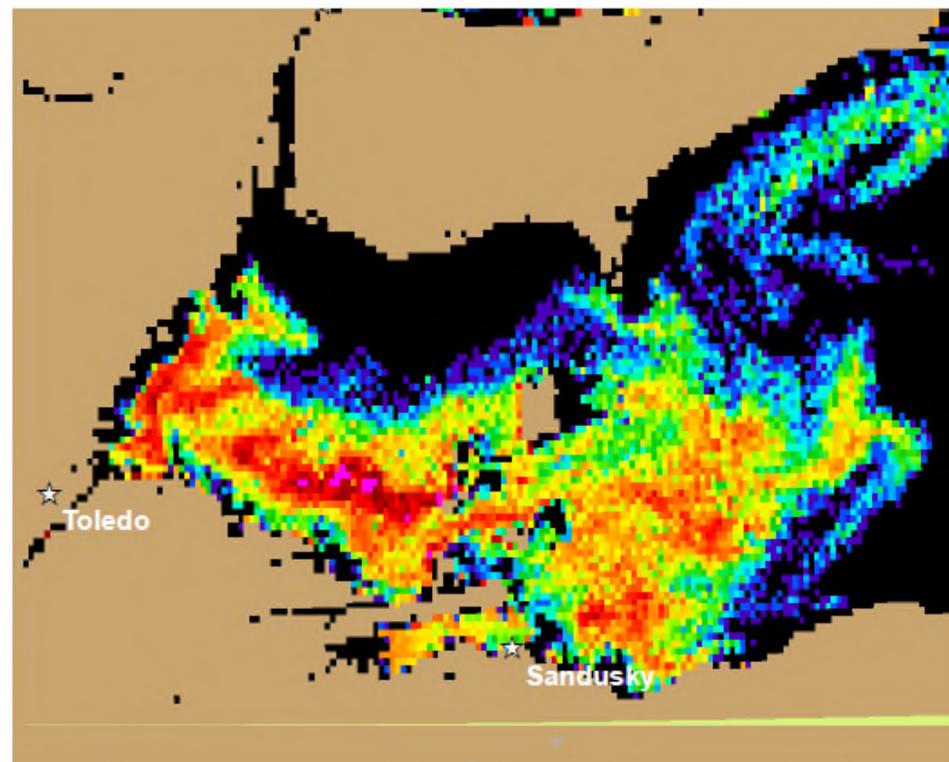
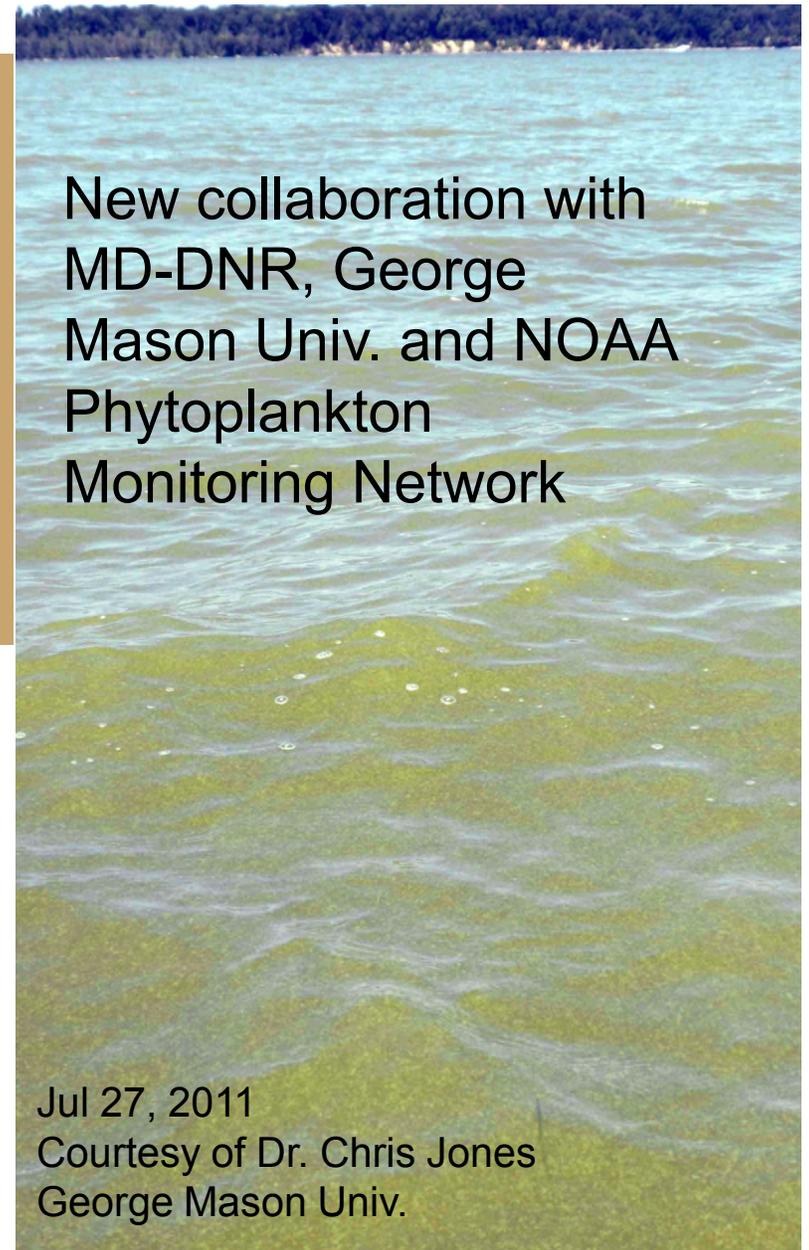
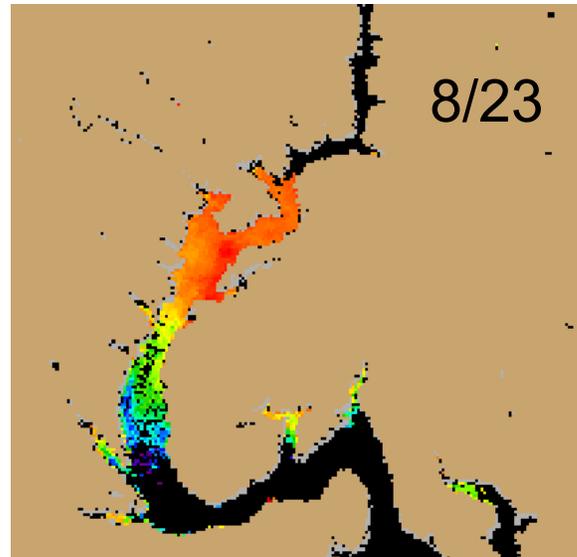
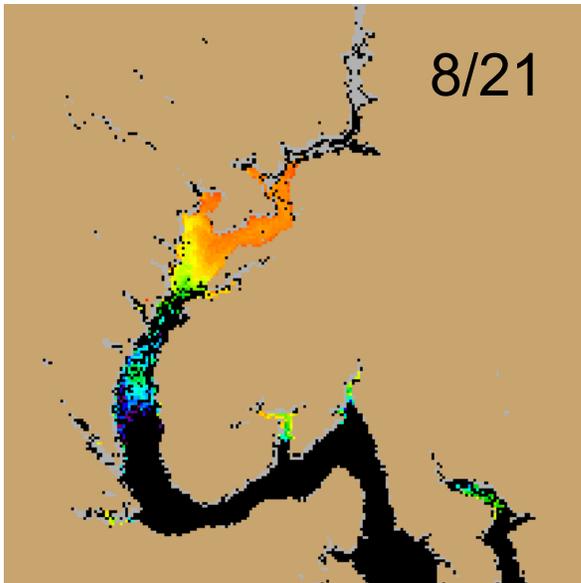
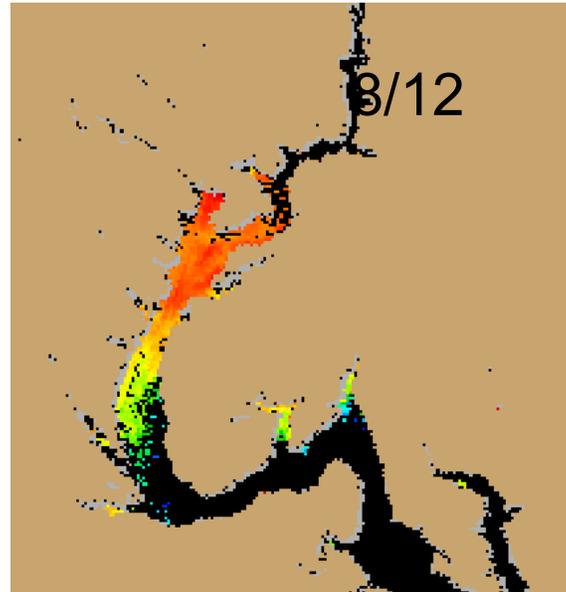
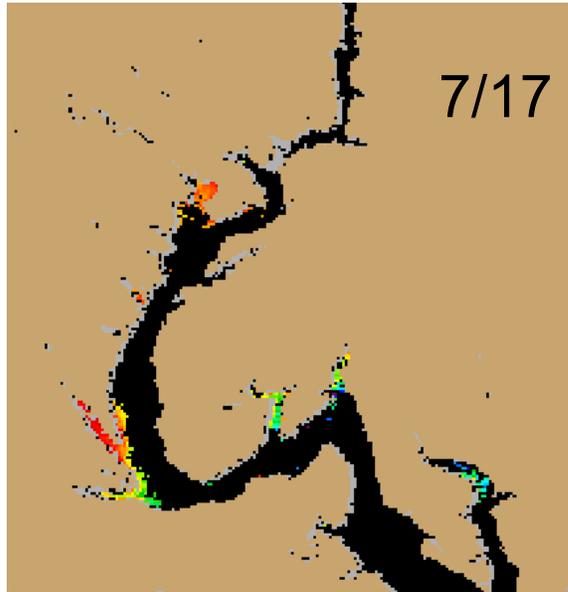


Figure 2. Nowcast position of bloom for 17 August, 2015 using GLCFS modeled currents to move the bloom from the 16 August,



Potomac River *Microcystis* bloom, 2011



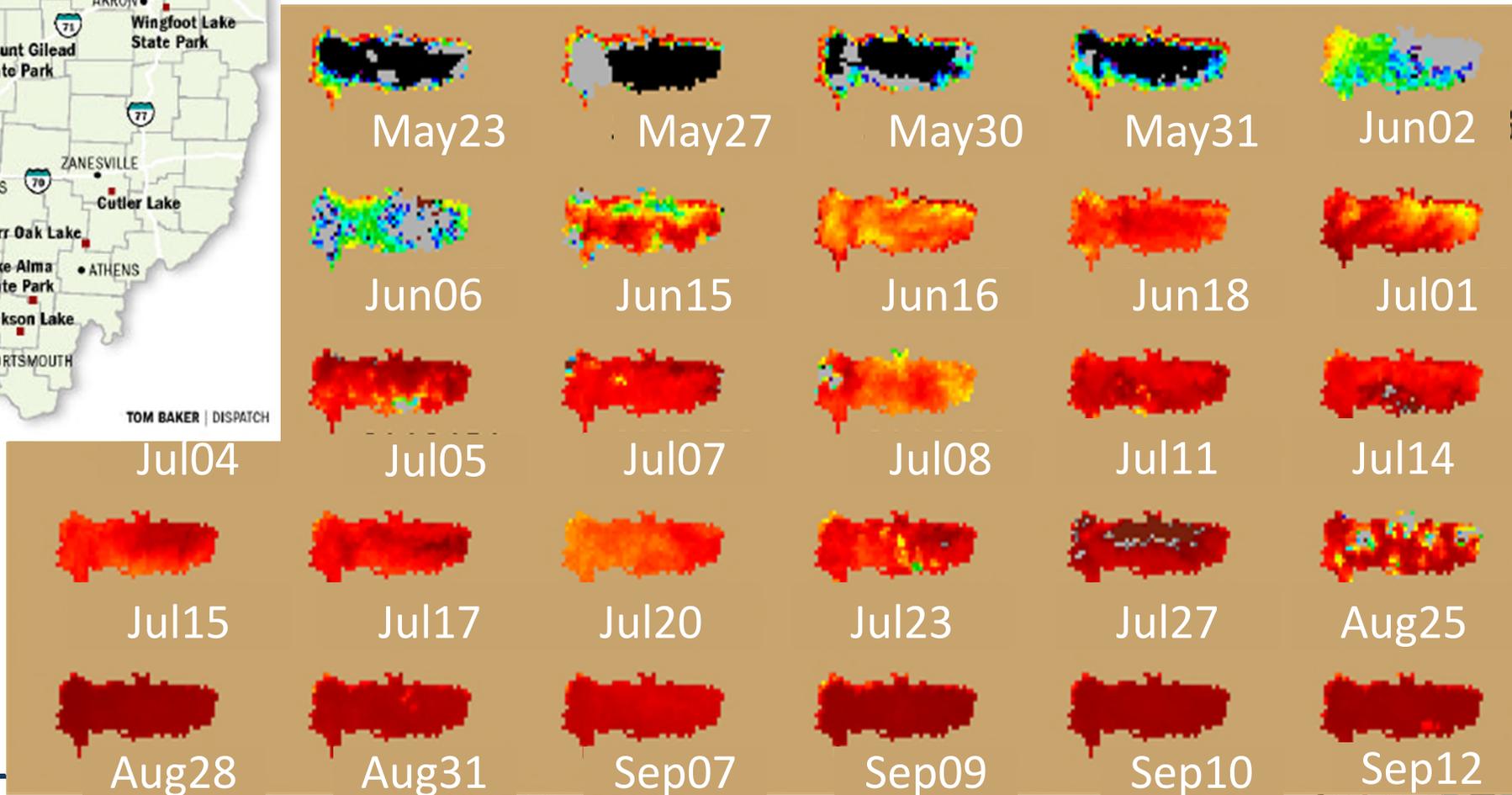
Pinning down start of blooms

Lakes with health warnings

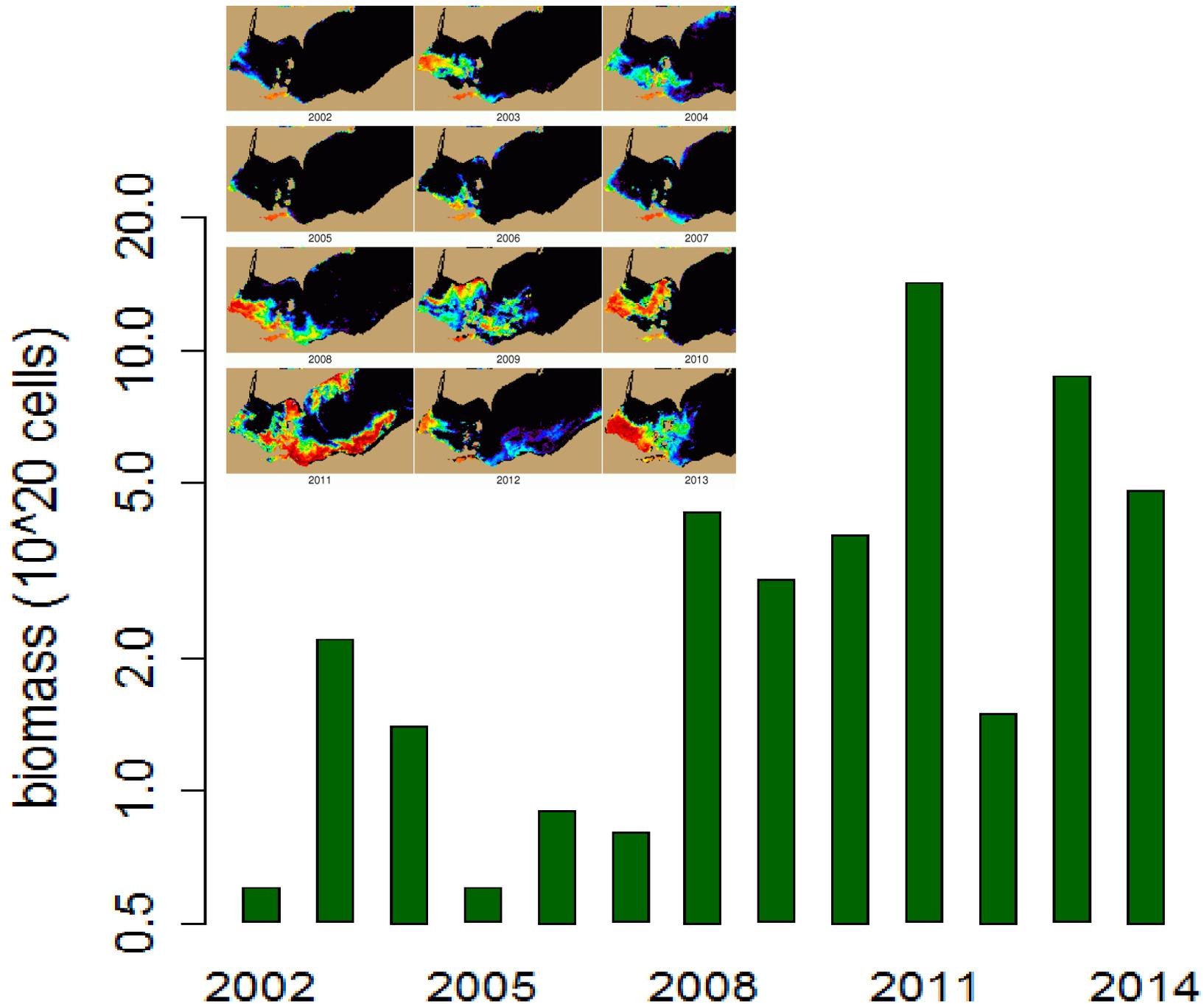
Lakes at Dillon, Lake Hope and Lake Loramie state parks were removed yesterday from the list of lakes that have tested positive for toxic algae. The lake at Mount Gilead State Park was added to the list. There are now 15 lakes and ponds where officials fear that liver and nerve toxins produced by blue-green algae could be a health threat.

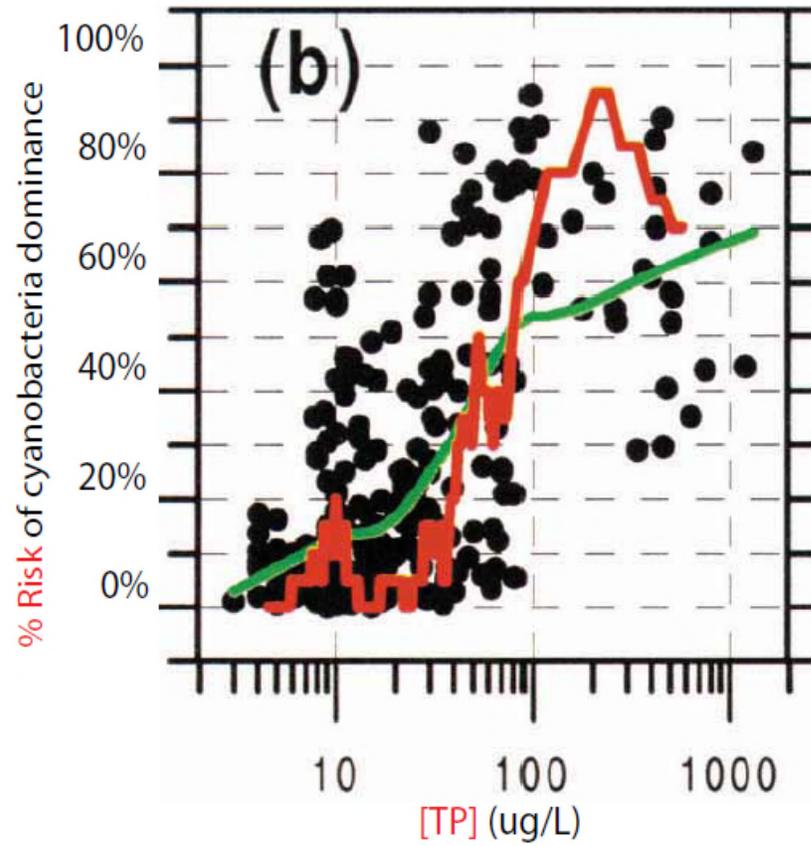


Grand Lake St Marys, Ohio in 2010



Maximum total biomass in western Lake Erie

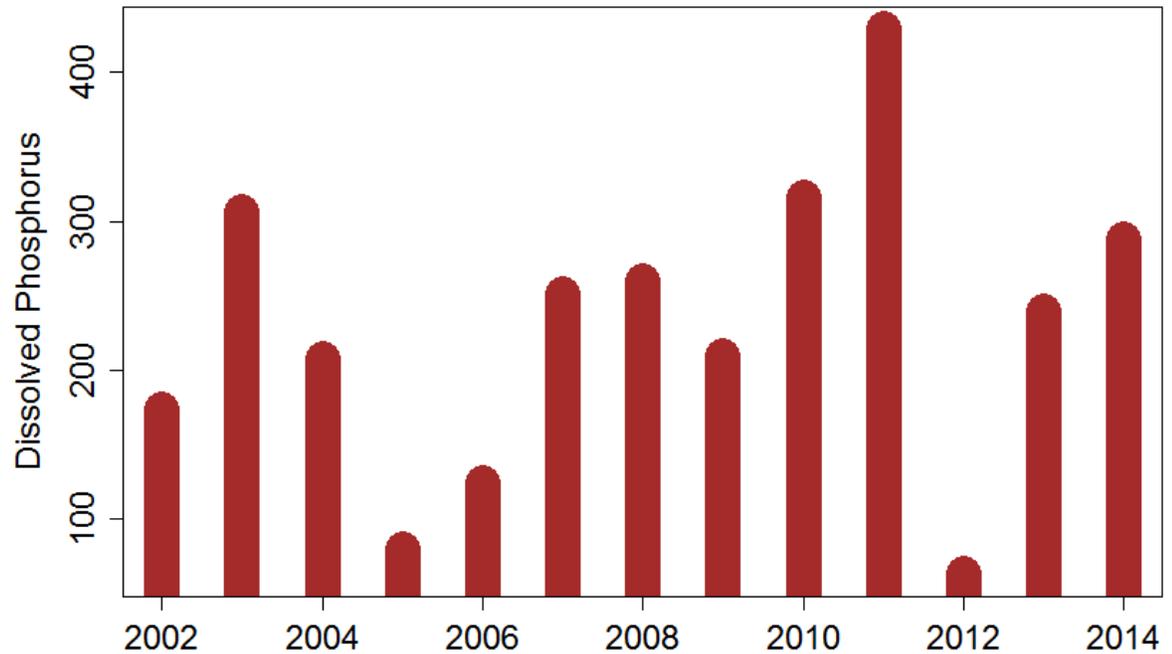




Downing et al., 2001

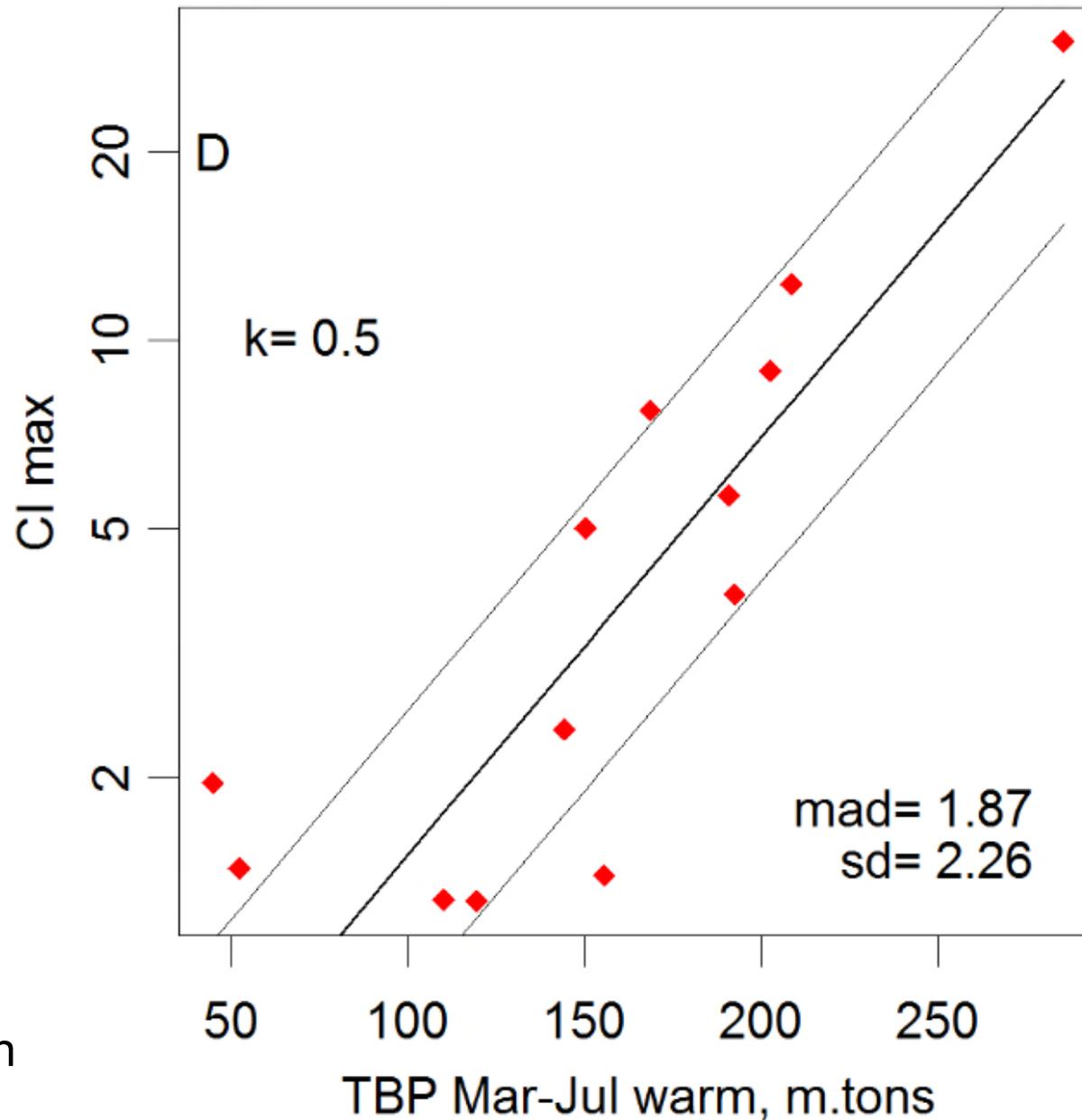
Phosphorus as a driver of cyano blooms in lakes

Lake Erie, spring load from Maumee River



Laura Johnson, NCWQR

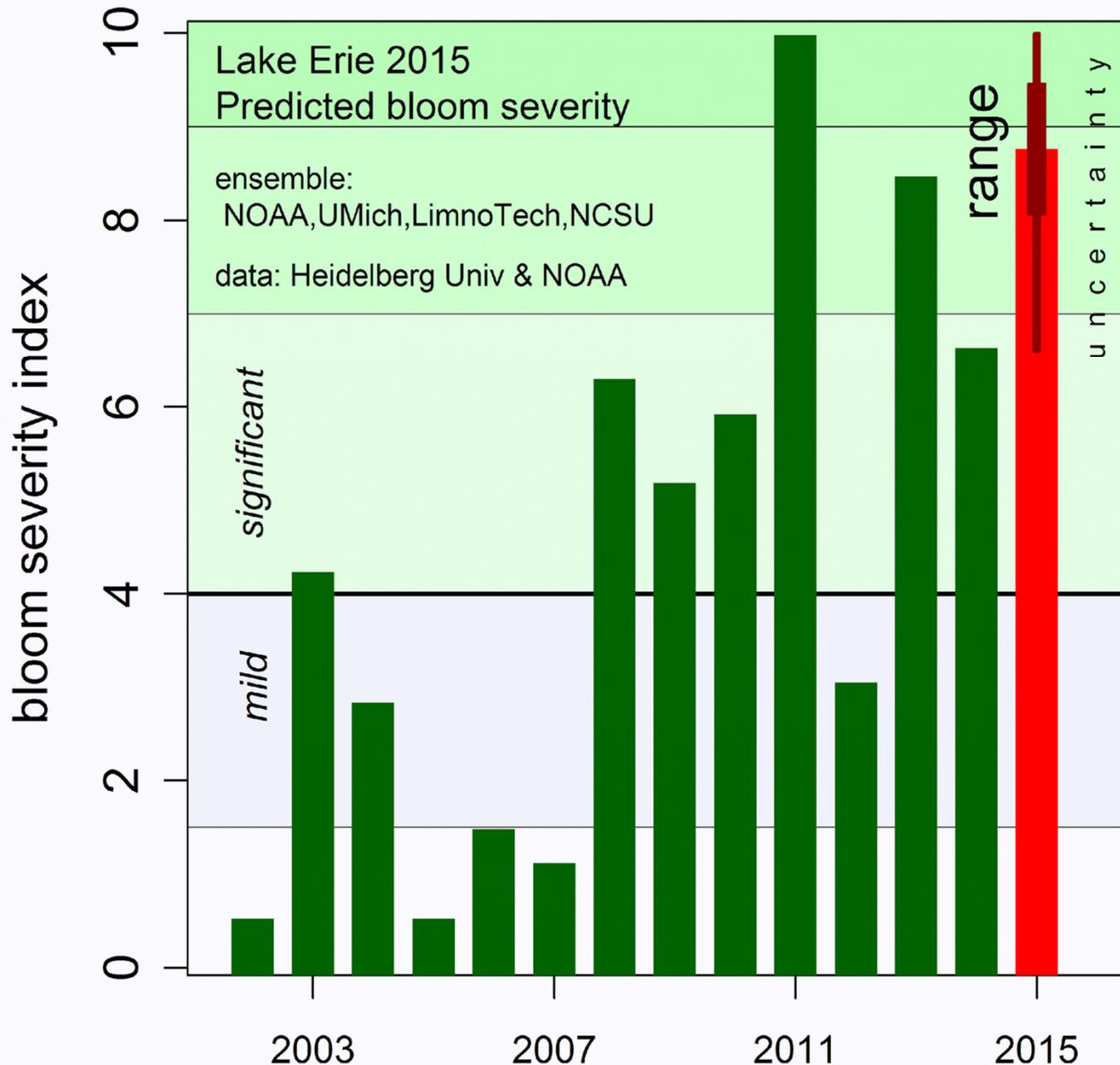
Cyanobacterial biomass related to total bio-available phosphorus (TBP) load from Maumee River, Lake Erie



Stumpf et al., in review



2015 Forecast



Bigger than 2013 and 2014.

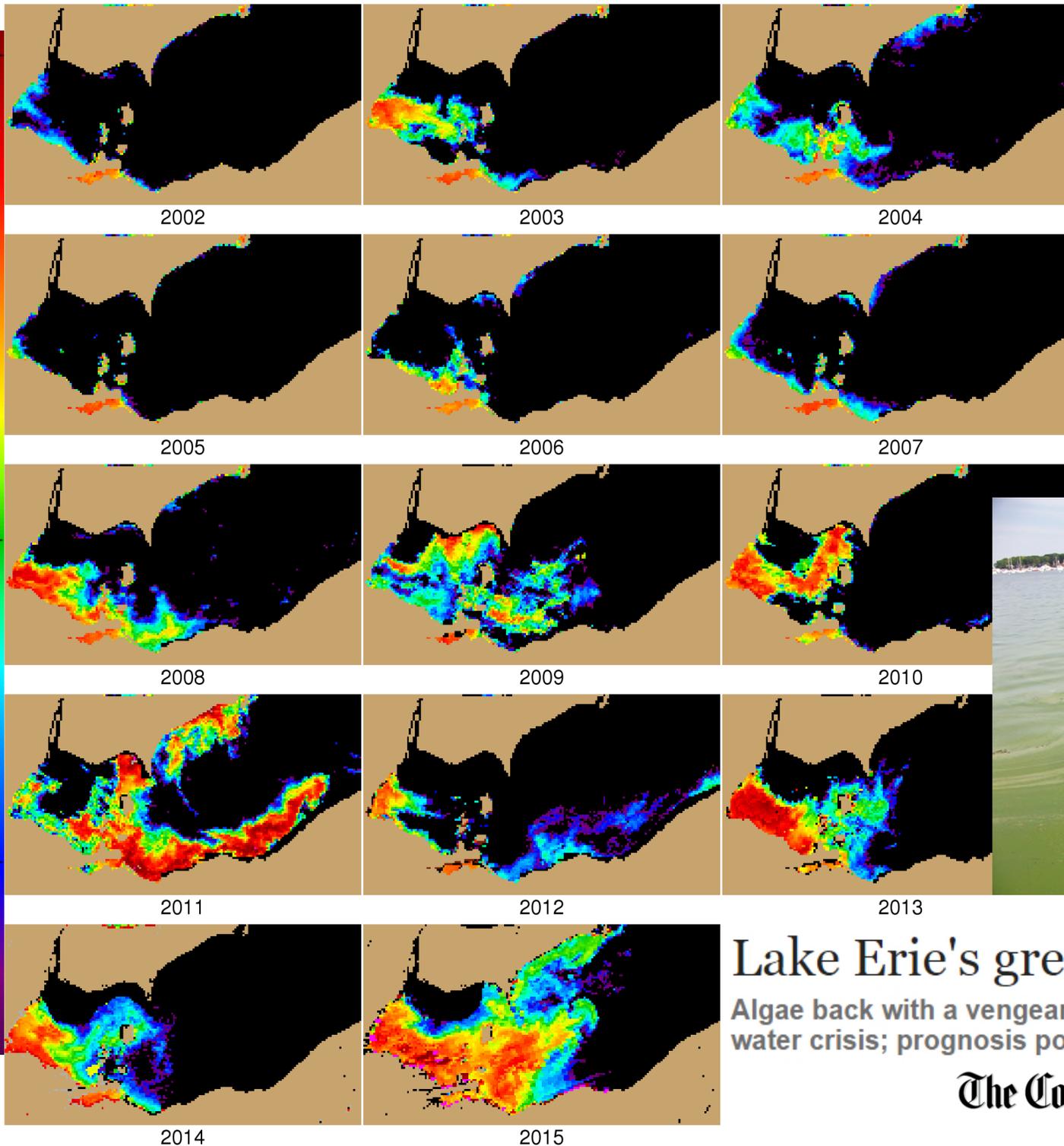
The 2nd biggest Lake Erie has seen

Models emphasis TP and discharge.

However, the warning was out.

Advanced warning reduces risks.

Lake Erie, 2015 was bad



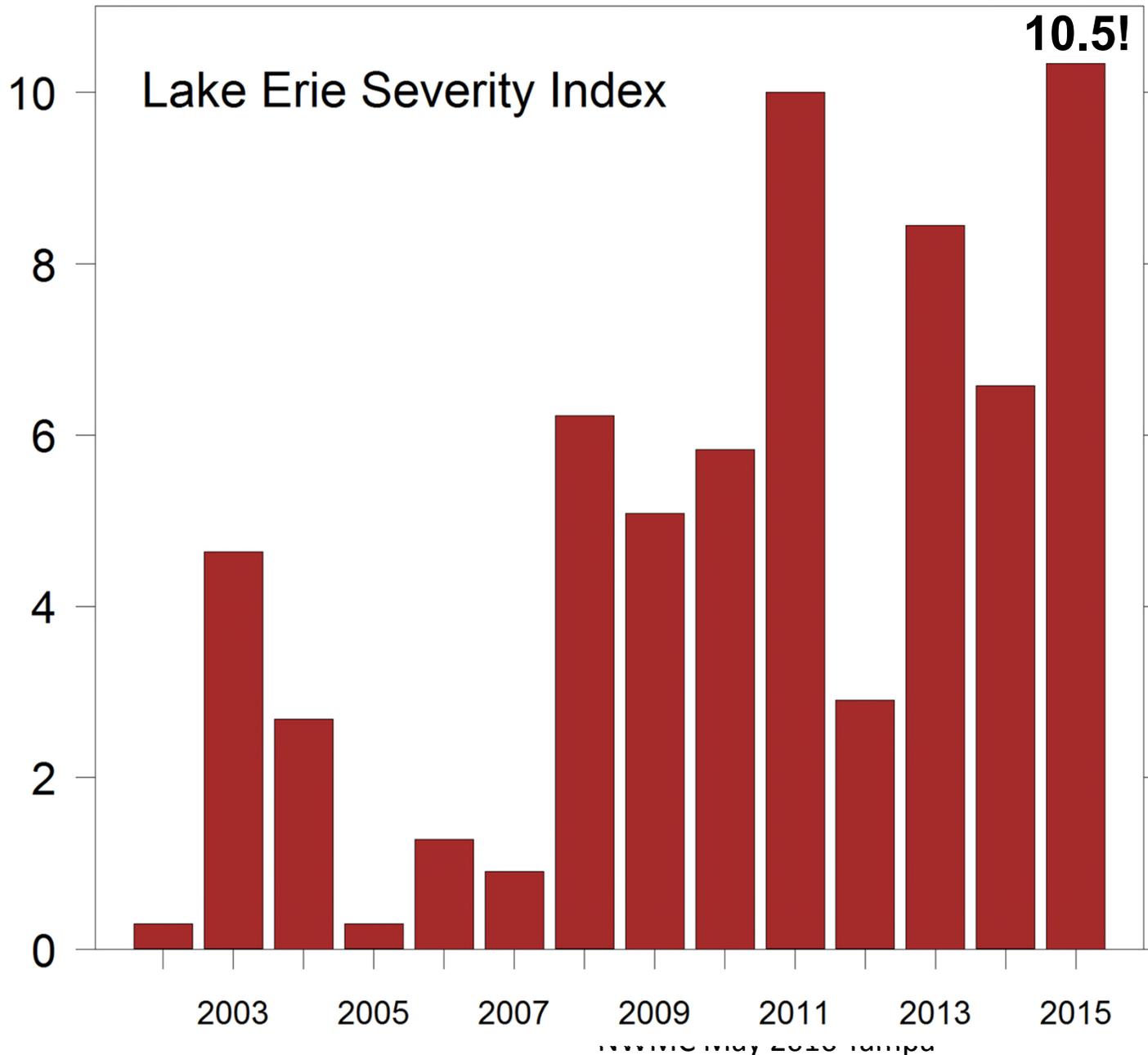
Lake Erie's green monster returns

Algae back with a vengeance in Lake Erie a year after Toledo's water crisis; prognosis poor

The Columbus Dispatch



2015: Lake Erie's most intense bloom



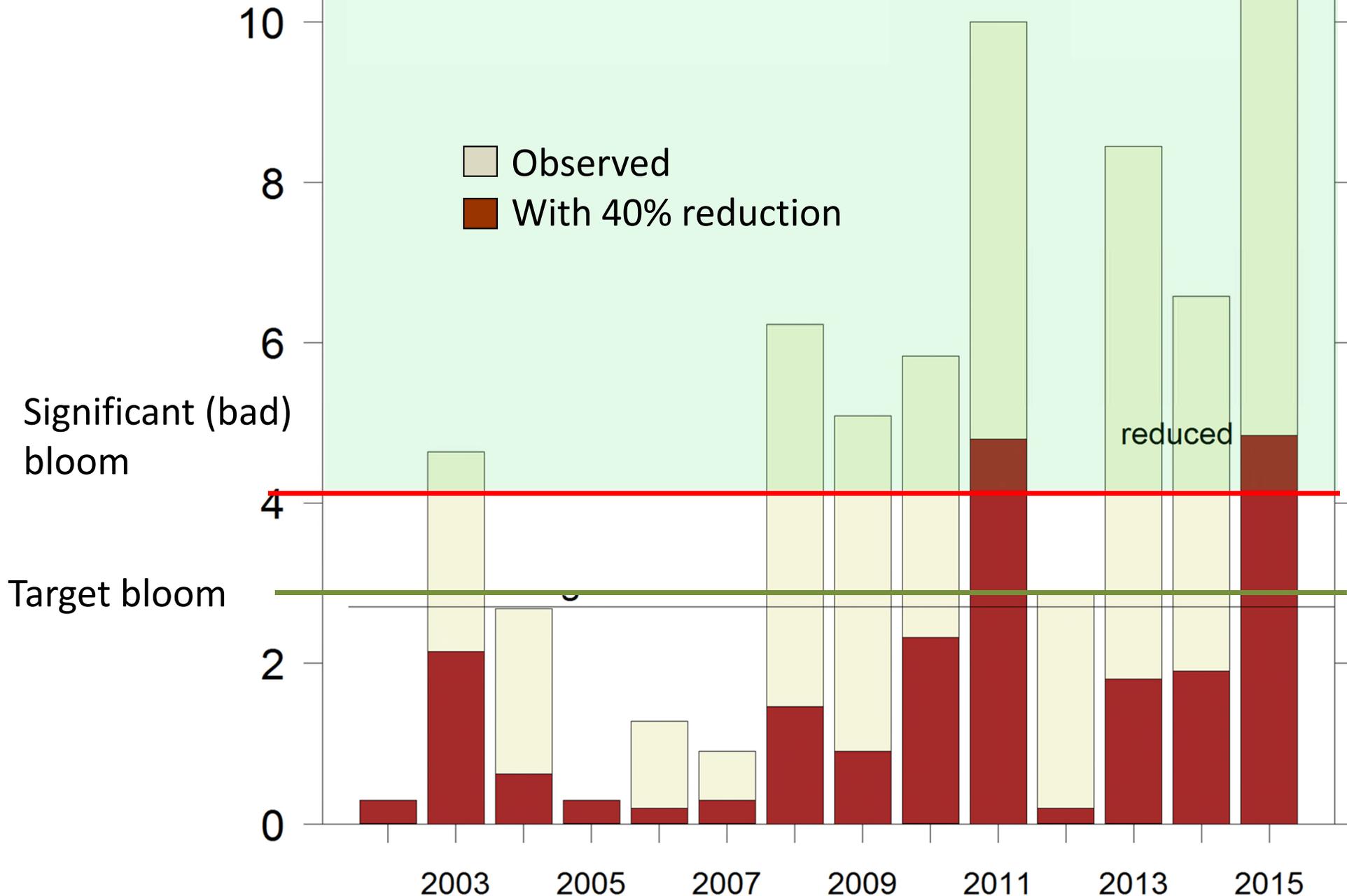
New TBP model predicted this, as did one test version of the LimnoTech WLEEM models.

Models will be examined more closely, and used



Great Lakes Water Quality Agreement

Proposed target reductions in phosphorus



With MERIS (2002-2012))

and OLCI (just launched, stayed tuned)

- Detection of cyanobacterial blooms.
 - Algorithms targets cyano pigment characteristics
- 300 m product, medium to large lakes at 1 km width
 - Potential for monthly assessment at < 900 m
- Estimation of bloom biomass, with consistent algorithm.
 - Does not confuse algae with sediment
 - Consistency in multiple regions
- Retrospective and routine monitoring
 - Up to every 2 days (daily in two years with OLCI/3b)
- Reference for Landsat etc.
- Used in CyAN project, national plan



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