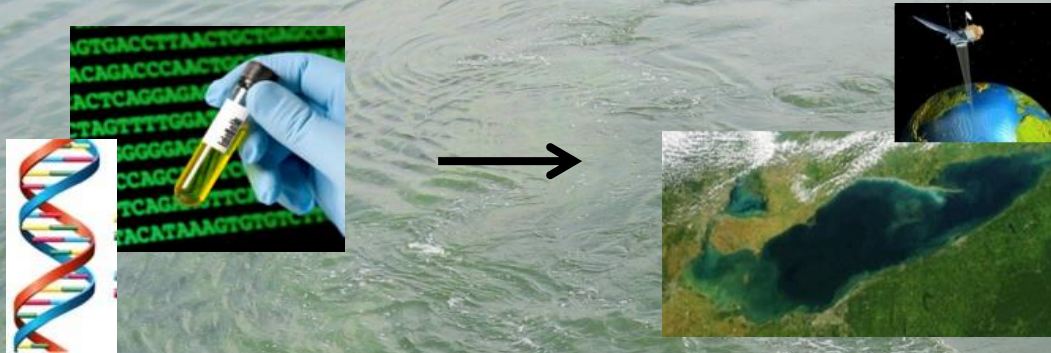


Understanding Harmful Algal Blooms in Lake Erie

Evidence from Genomes to Satellites



Tom Johengen
Michigan Sea Grant and
Cooperative Inst for Great Lakes Research
University of Michigan

MSU Great Lakes Conference
March 3, 2020

Algae are important!

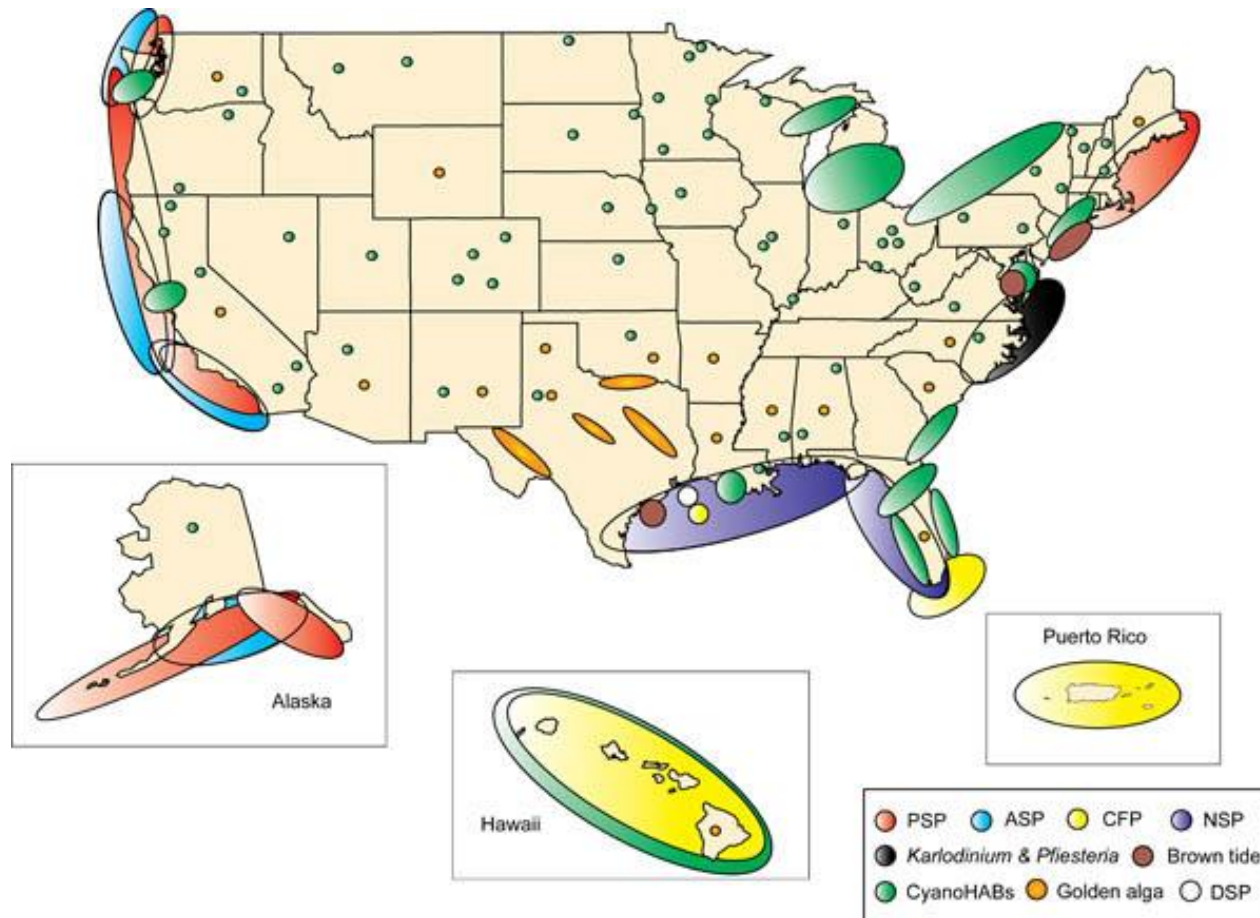
(but too much of a good thing can lead to bad things.....)

- Although only comprising ~ 1% of all plant biomass they produce ~50% of the oxygen we breathe
- Are the base of most aquatic food webs
- Help fight rising CO₂ concentrations in the atmosphere (i.e. the biological pump)



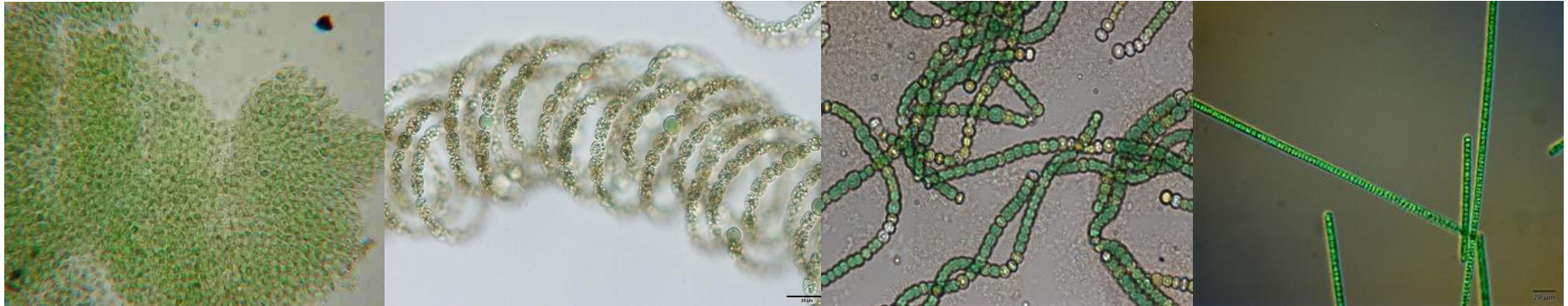
Harmful algal bloom (HAB)

- Photosynthetic organisms that accumulate to levels that are harmful to the ecosystem.
- Include species that grow to nuisance levels (visual, taste and odor, block light, reduce oxygen)
- Include species that produce **toxins** that are harmful to humans, aquatic organisms, or wildlife.
- Of the thousands of known phytoplankton species, about 100 are known to be harmful to aquatic ecosystems.

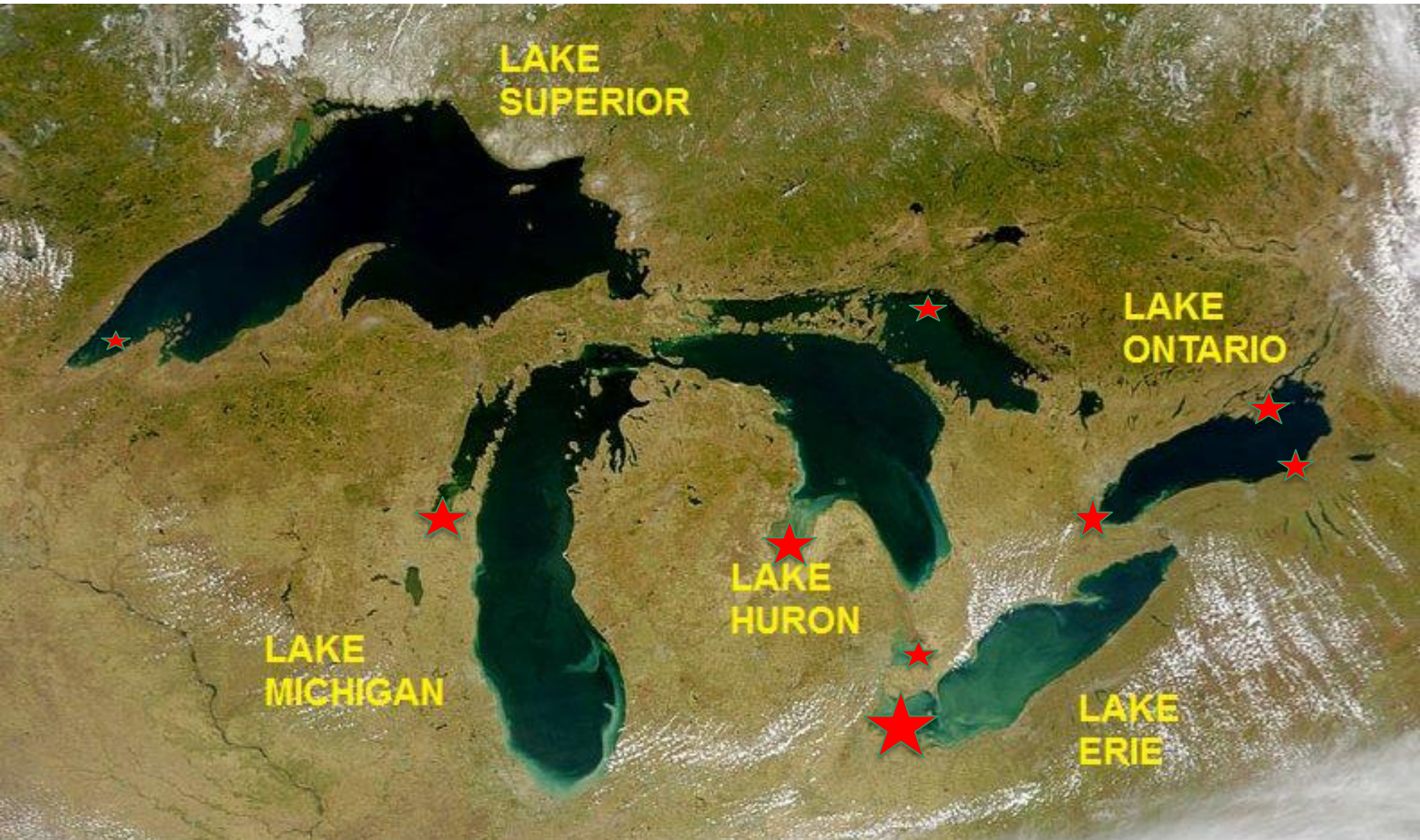


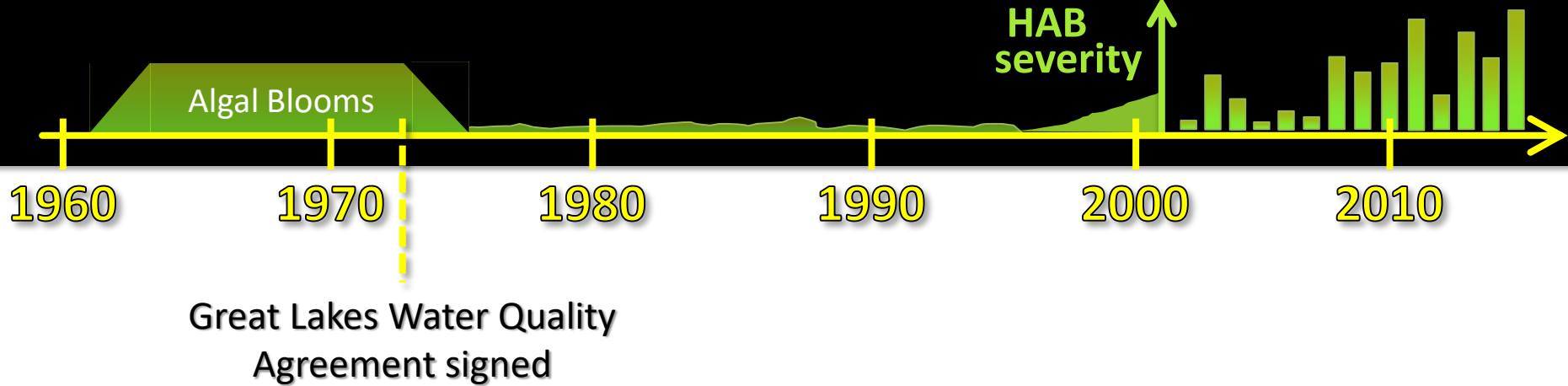
Freshwater HABs

- Most common form is Cyanobacteria or Blue-green algae
 - Photosynthetic bacteria
- Several different species including:
 - *Microcystis*, *Dolichospermum*, *Aphanizomenon*, *Cylindrospermopsis*, *Nodularia*, *Planktothrix*, *Anabena*, *Woronichinia*
- The most common toxin they produce is **microcystin**.
- Potential Health effects of microcystin include: destructive to liver, kidney, and reproductive system and potential carcinogen



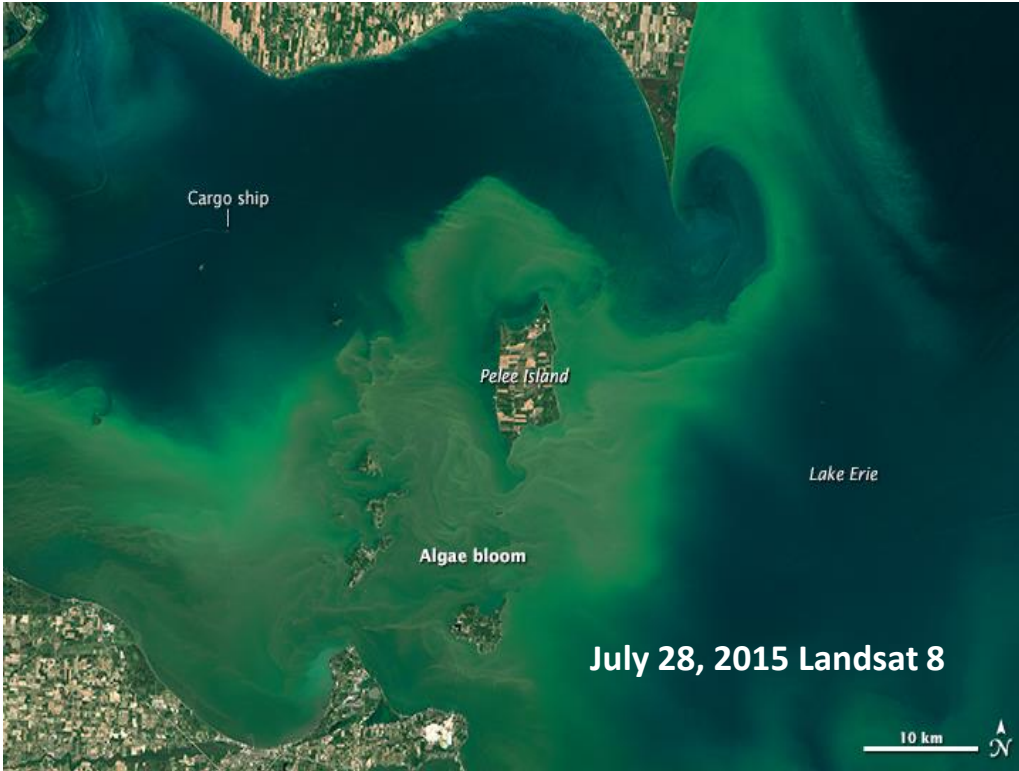
HABs occur throughout the Great Lakes basin



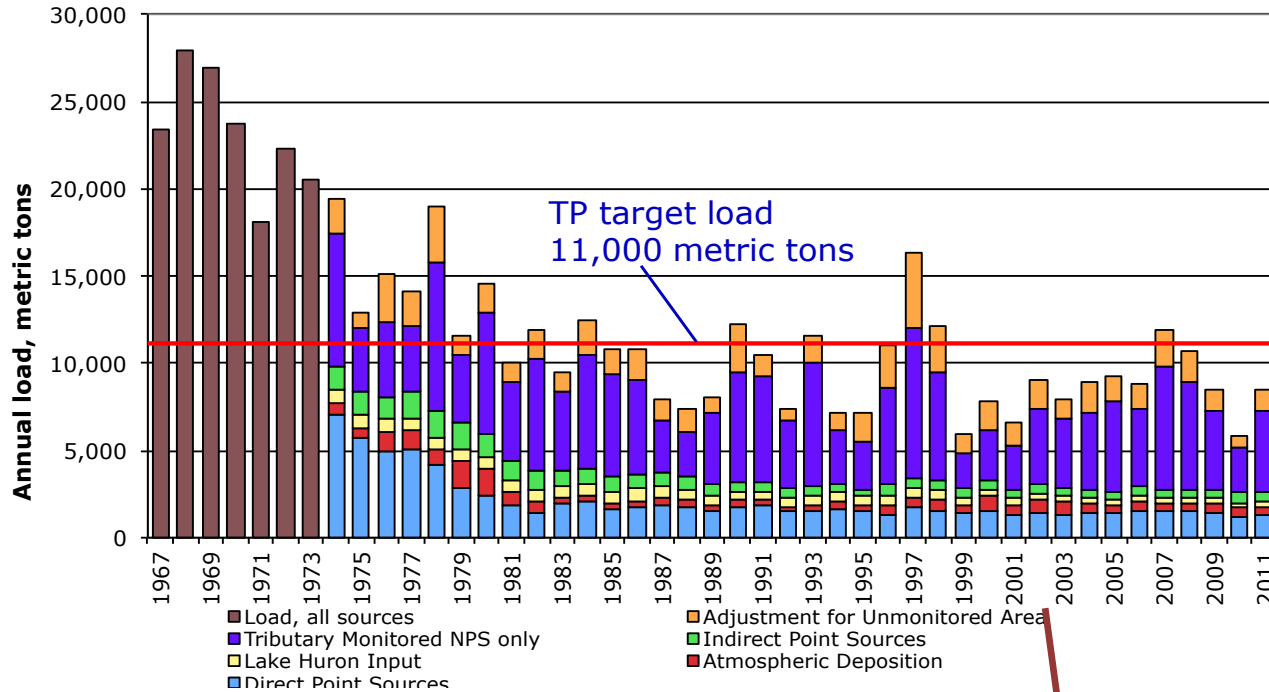


Great Lakes Water Quality Agreement signed

1. Since 1960's Lake Erie has experience HABs
2. Recovery with phosphorous controls from the 1970's-1990's
3. 2003 increased prevalence of HABs in Lake Erie
4. 2014 shut down of Toledo water intake



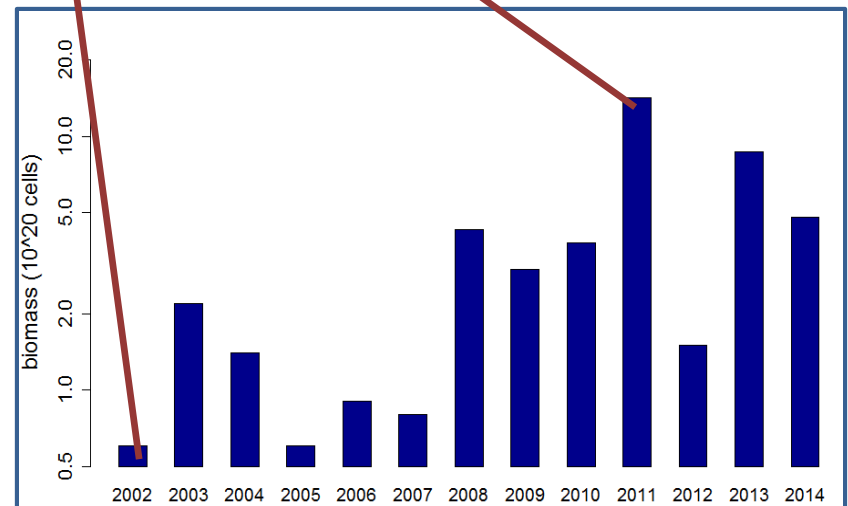
Lake Erie Total Phosphorus Loading, 1967-2011 (D. Dolan, U. WI Green Bay)



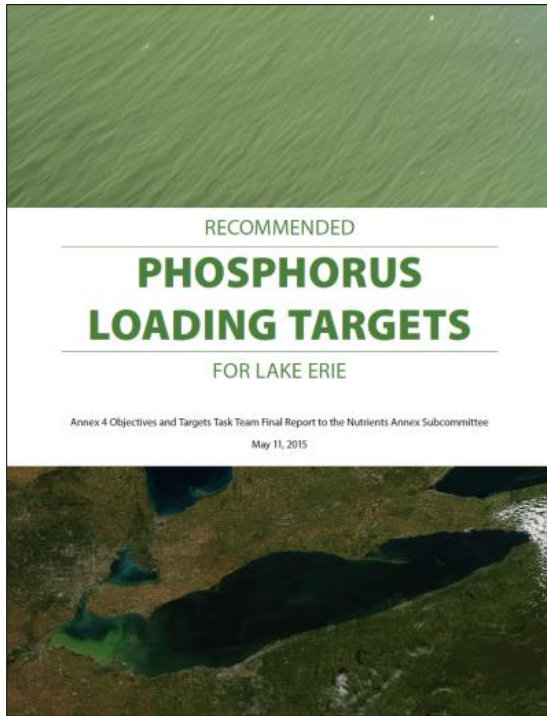
Target Loads of the GLWQA generally met since 1990s;

Yet, significant increase in western basin HABs

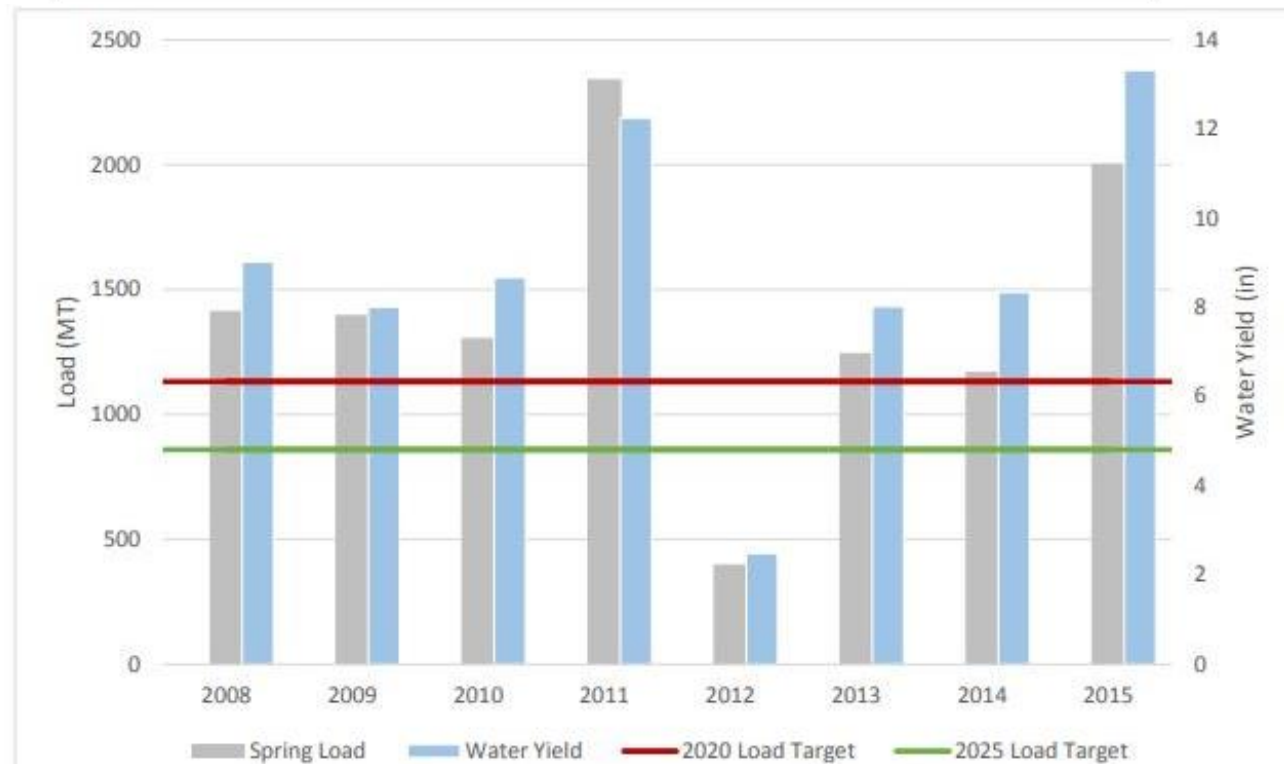
- Increase in proportion of bioavailable P
- Mussel selectivity and nutrient cycling
- Overwintering seed stocks



2012 GLWQA: Annex 4: Phosphorus Loading Targets Report - May 2015



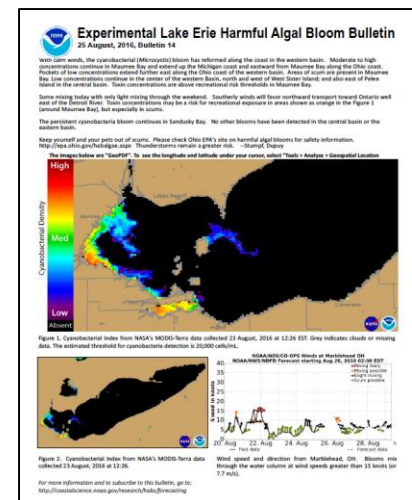
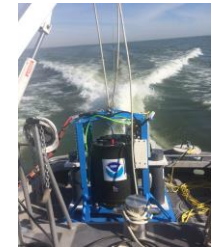
Priority Tributary	Spring (March 1-July 31) Values				
	2008 Baseline			Targets under 40% Reduction by 2025	
	Discharge (km ³)	Load metric tons	FWMC mg/L	Load Metric tons	FWMC mg/L
Maumee River	3.76	1,414 TP 302 DRP	0.38 TP 0.08 DRP	860 TP 186 DRP	0.23 TP 0.05 DRP
Portage River	NA	NA	NA	TBD	TBD
Sandusky River	0.963	367 TP 69.1 DRP	0.38 TP 0.07 DRP	230 TP 43 DRP	0.23 TP 0.05 DRP



Loading targets were established from an ensemble of nine water quality models

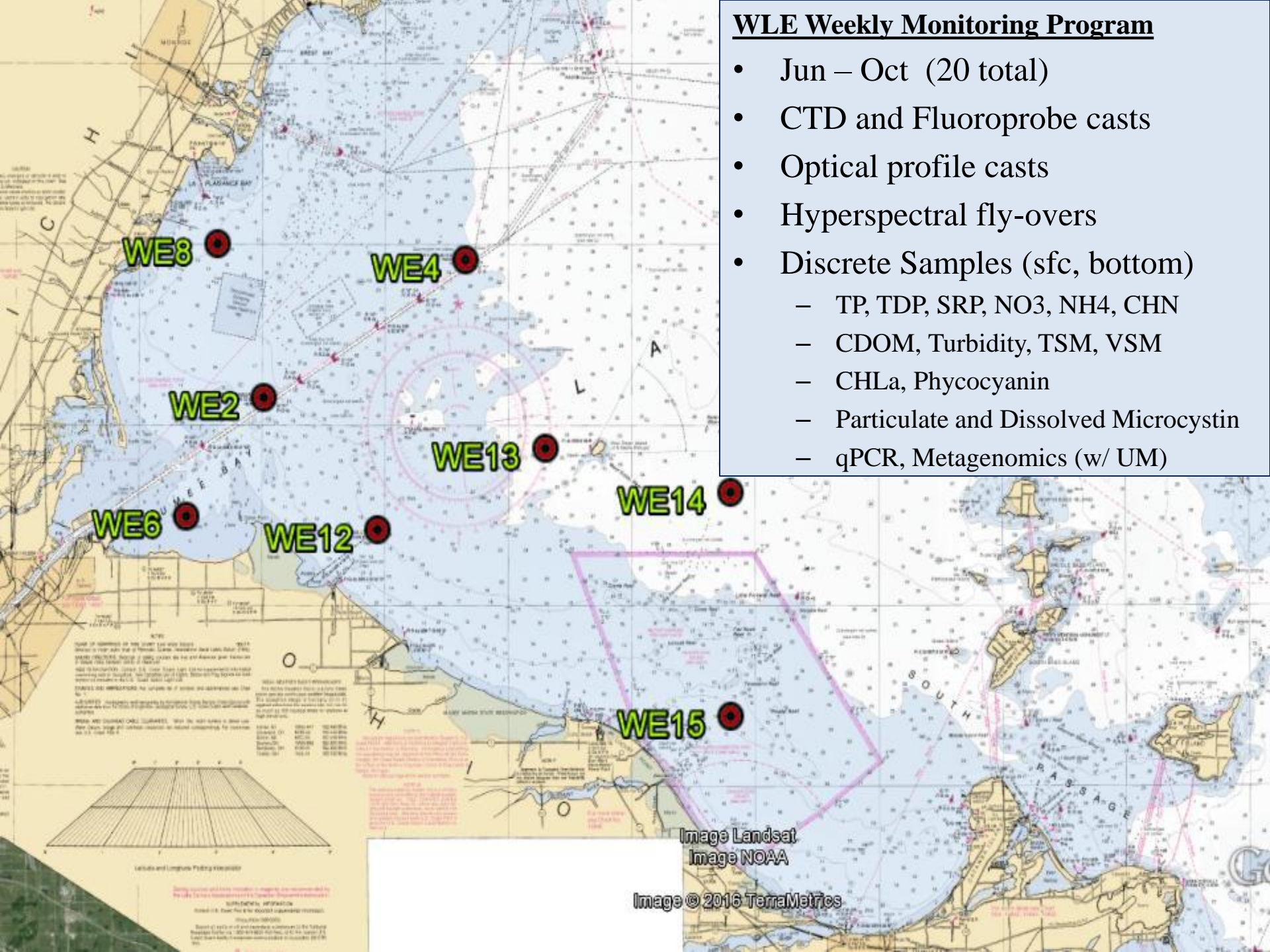
What we are doing at NOAA-CIGLR to study HABs

- Weekly Monitoring
- Real-time Buoys
- Remote Sensing
- Advanced Technologies
 - 2G_ESP; 3G_LRAVU; MBIO; Hyperspectral
- Forecasting Models
 - Seasonal, HAB Bulletin, HAB Tracker
 - Biophysical Model
 - Statistical Model

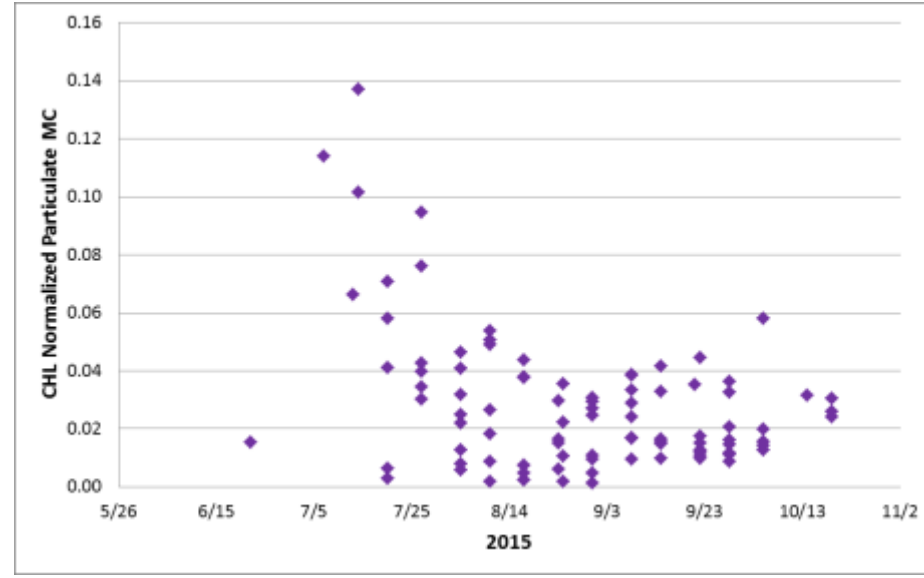
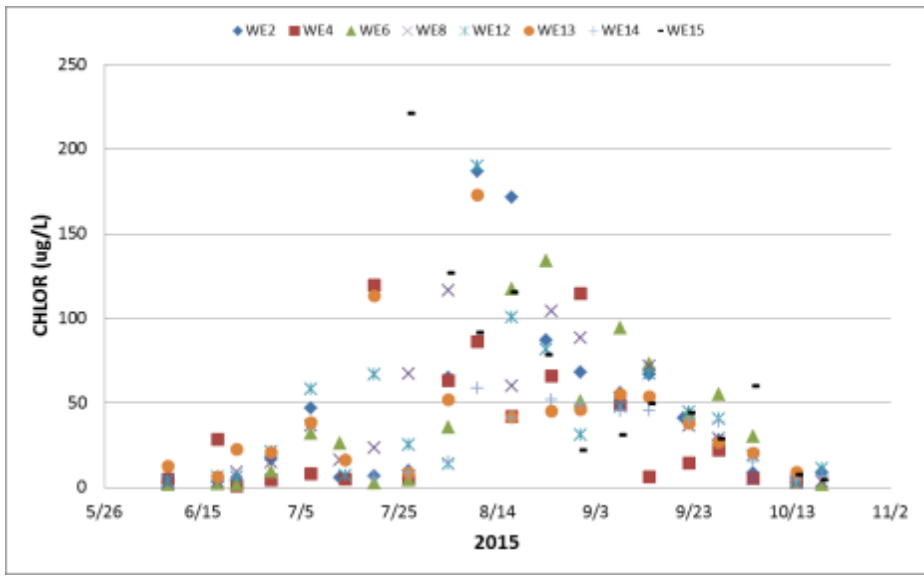
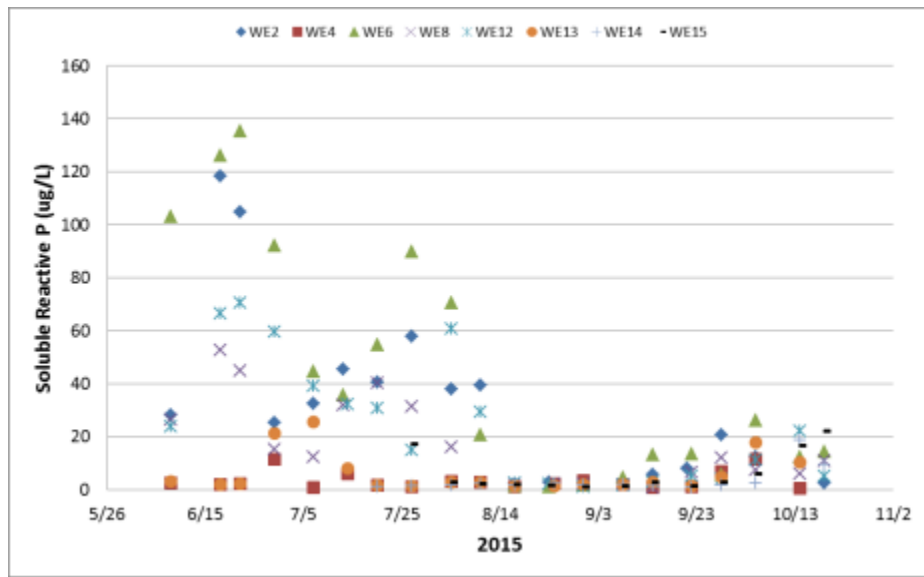
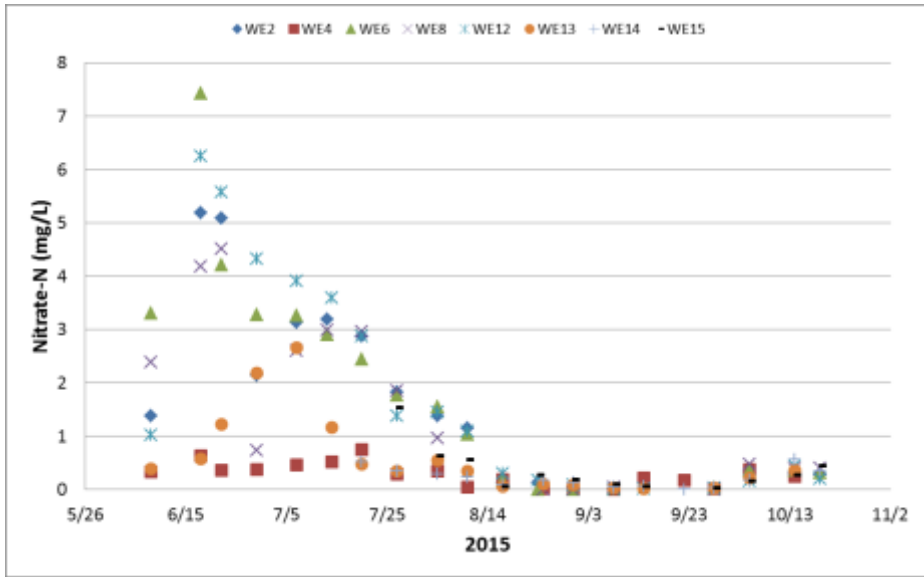


WLE Weekly Monitoring Program

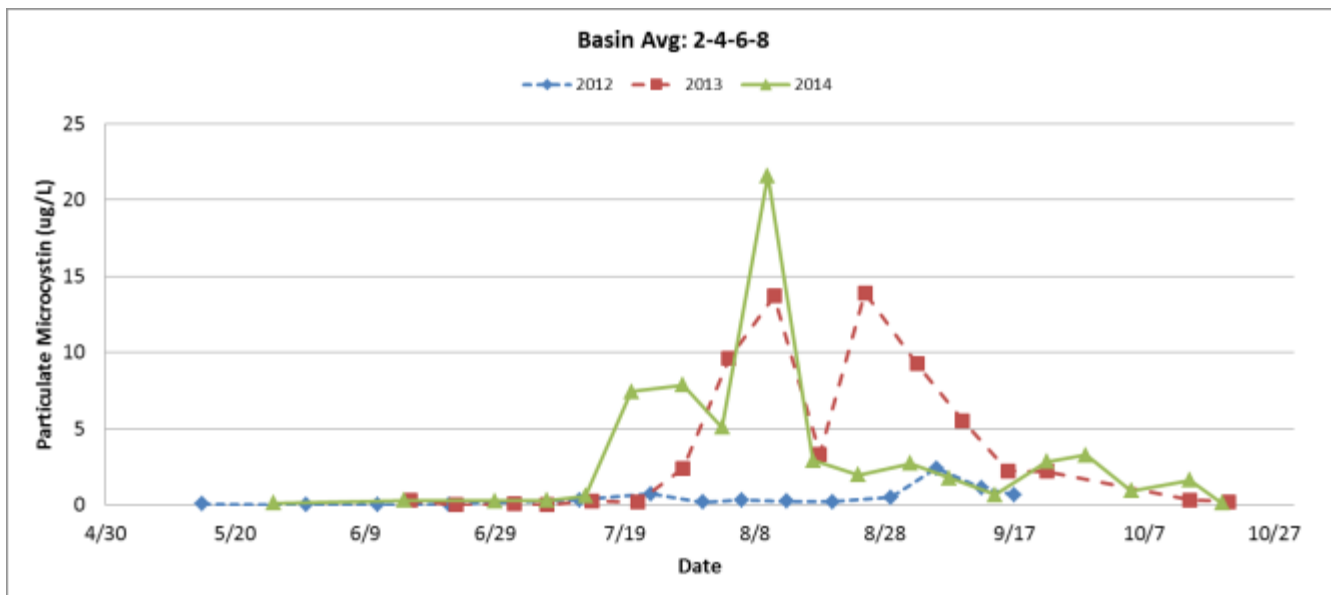
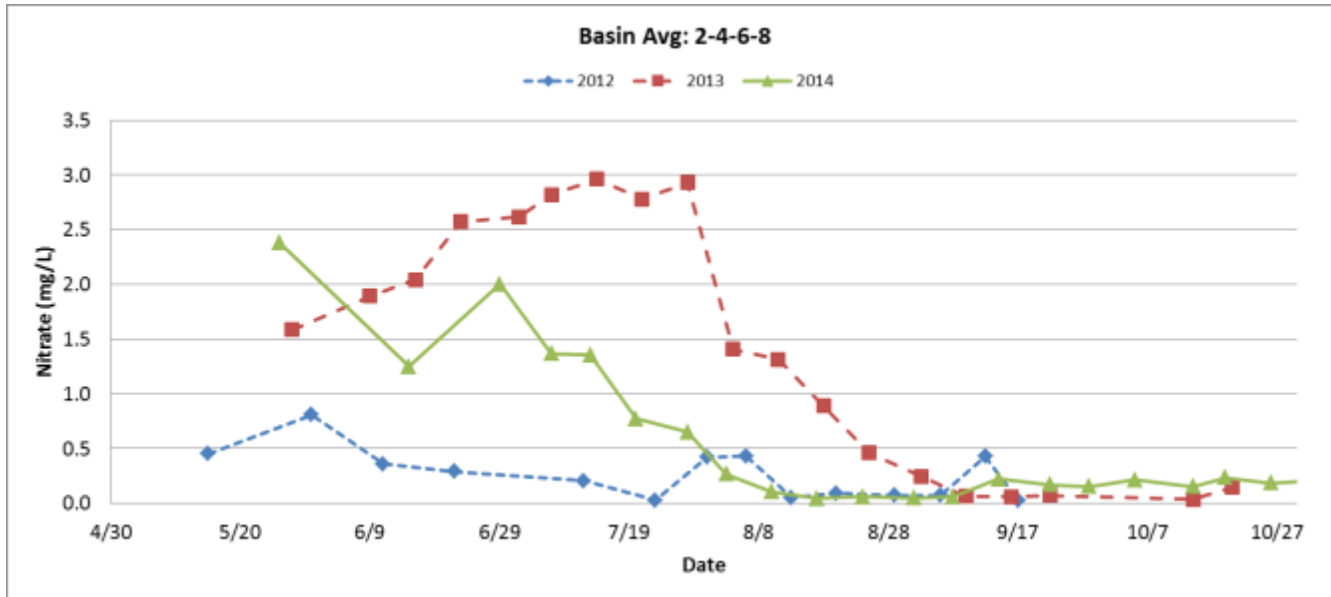
- Jun – Oct (20 total)
- CTD and Fluoroprobe casts
- Optical profile casts
- Hyperspectral fly-overs
- Discrete Samples (sfc, bottom)
 - TP, TDP, SRP, NO₃, NH₄, CHN
 - CDOM, Turbidity, TSM, VSM
 - CHLa, Phycocyanin
 - Particulate and Dissolved Microcystin
 - qPCR, Metagenomics (w/ UM)



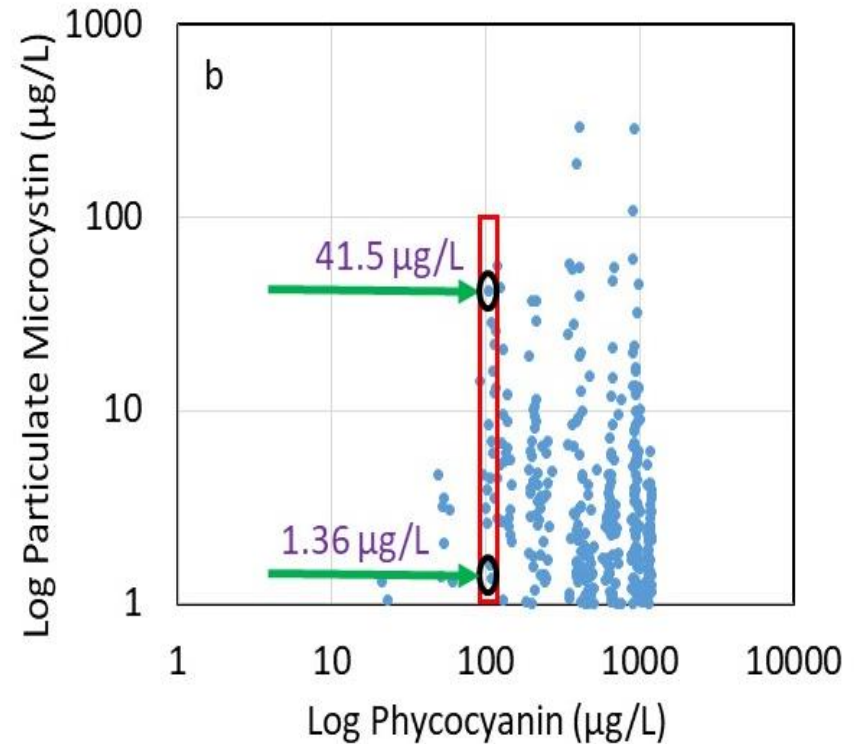
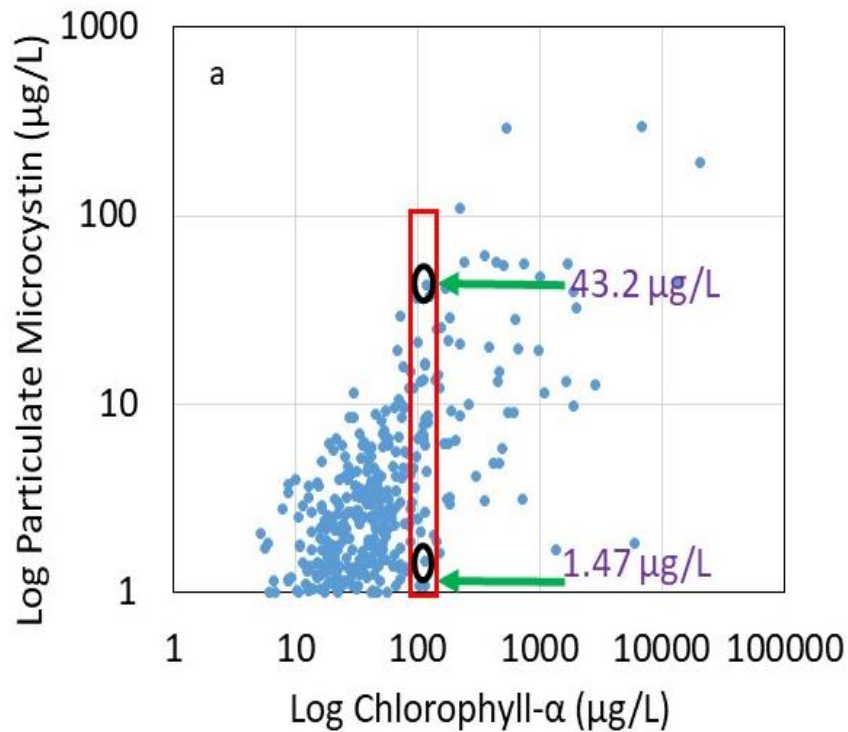
Spatial and Seasonal Dynamics in Nutrient Availability and Bloom Response



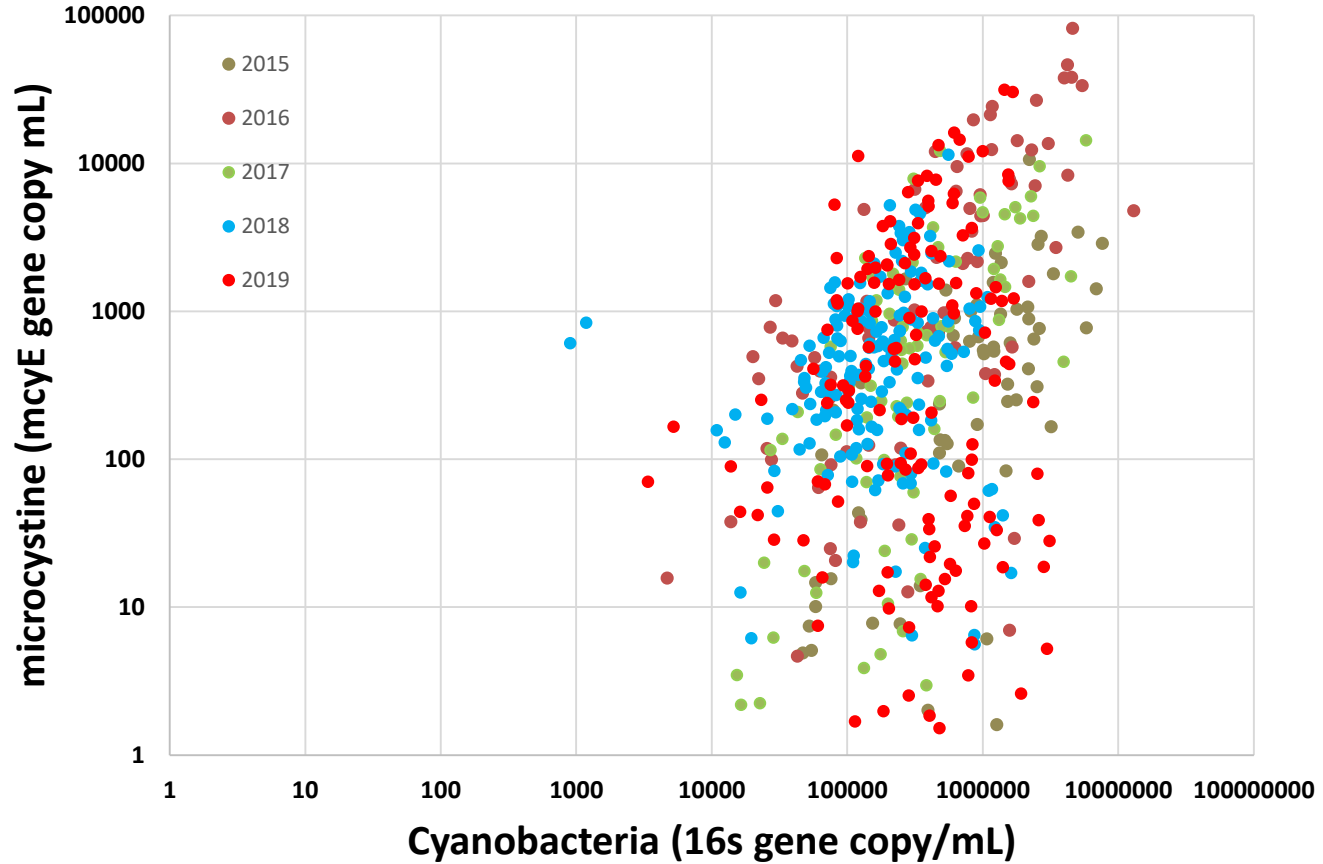
Inter-annual differences in Lake Response



Toxin concentrations vs bloom intensity



Total Cyanobacteria vs Microcystine



How to improve the prediction of HABs

- Identify the toxin vs non toxin producing strains
- Monitoring the toxin producing strains
- Identify the conditions that trigger the toxin production

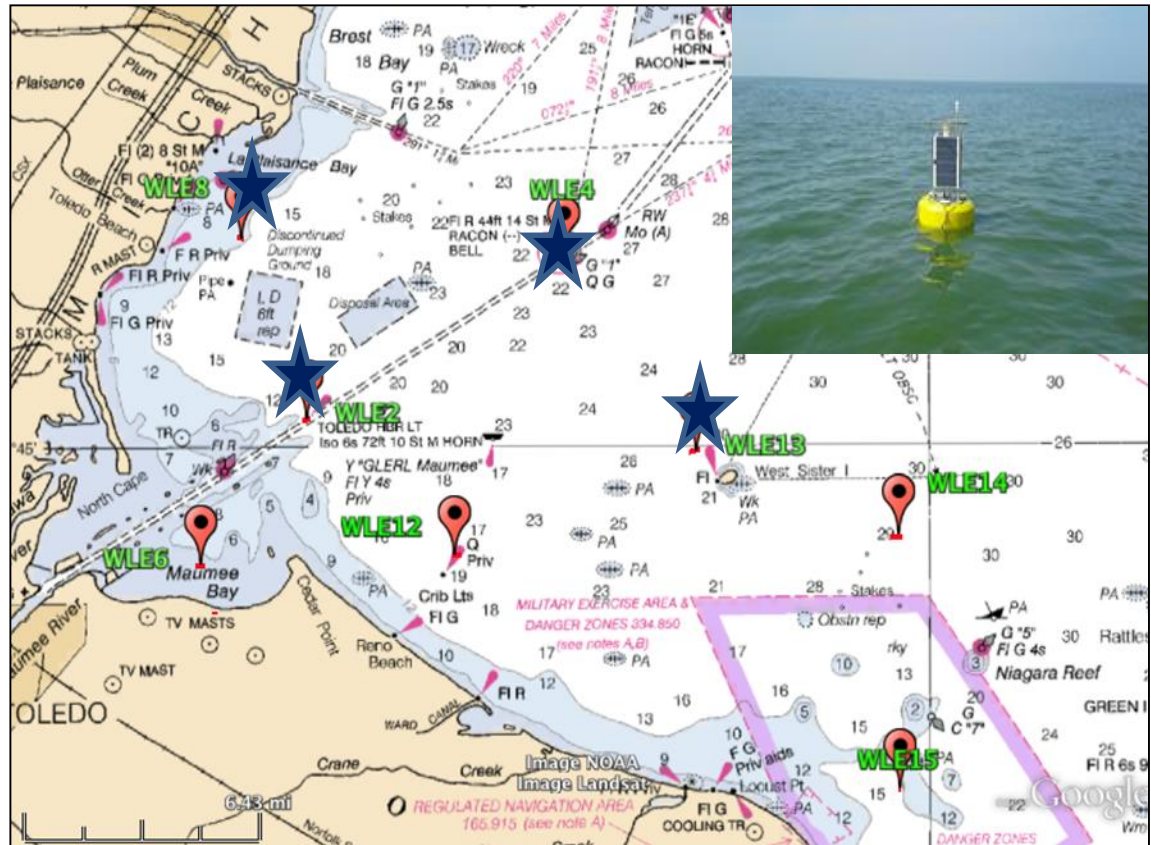
WLE Continuous Real-time Monitoring Network

- Provide real-time water quality obs every 15 min
- Evaluate lake response to Nutrients Loads (and proposed mitigation)
- Evaluate internal nutrient dynamics
- Provide finer temporal resolution of bloom dynamics for biophysical model
- Examine relationships between nutrient availability and toxicity

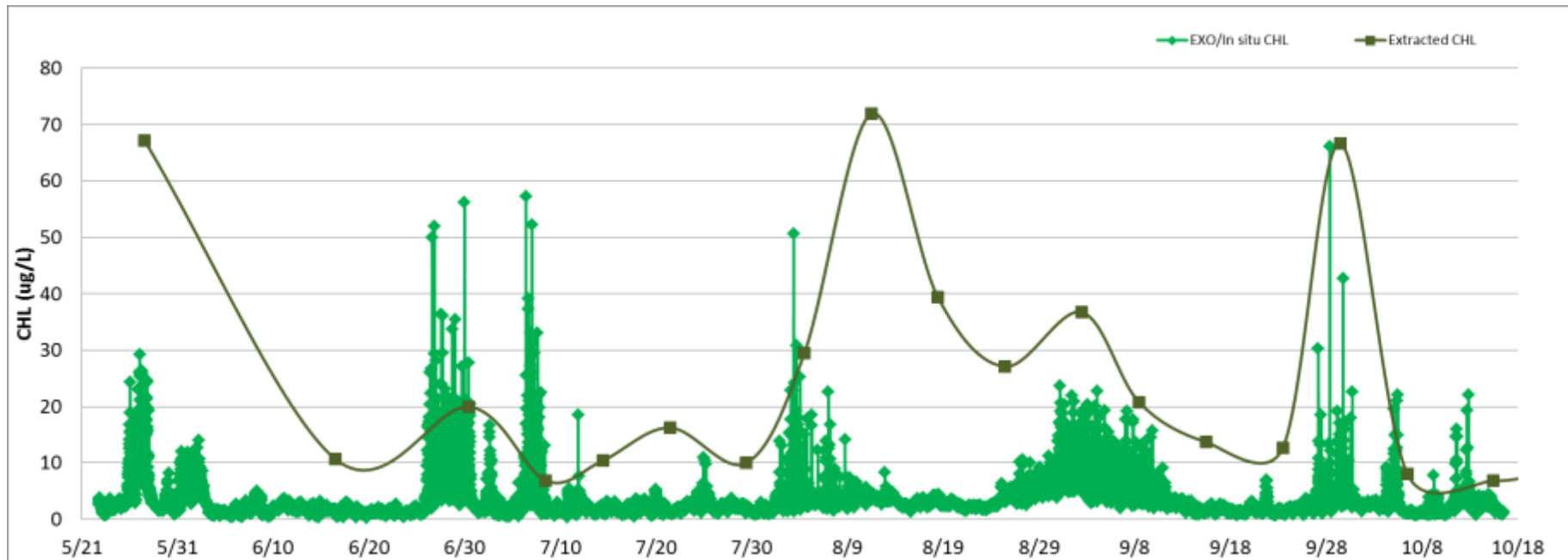
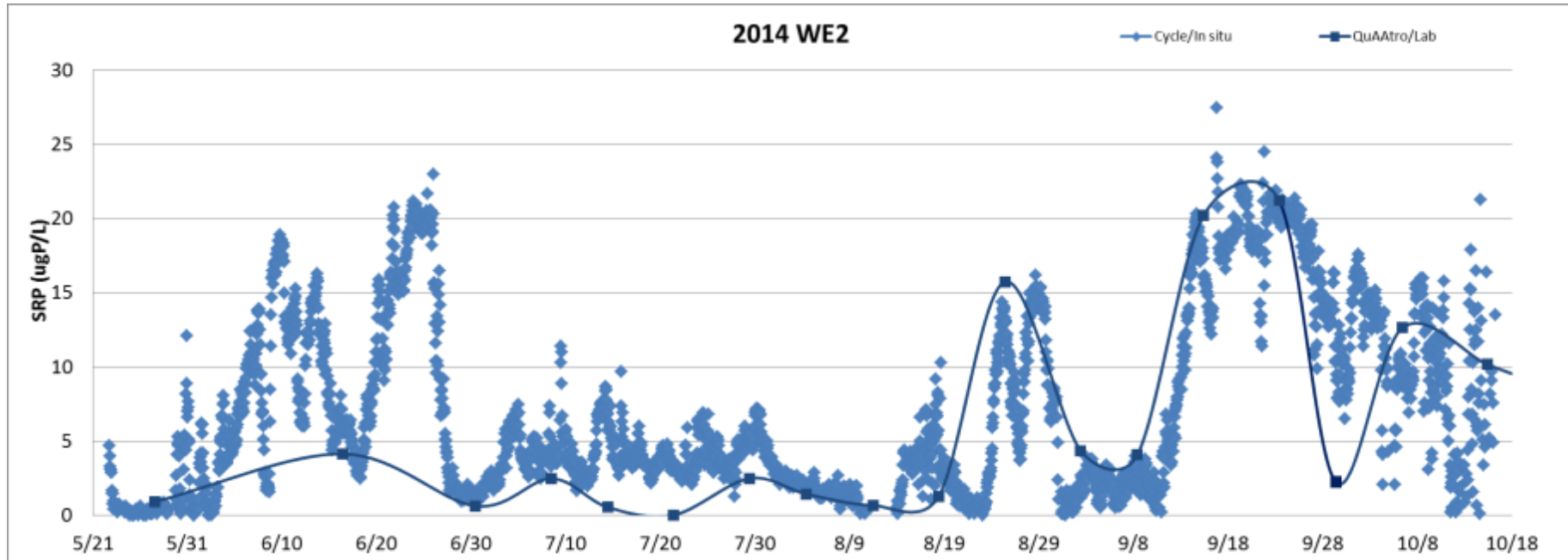


Parameters:

- MET and Waves (new in 2019)
- EXO2: chl, bga, fdom, pH, C/T, DO
- Satlantic SUNA (NO3)
- SeaBird Cycle P (SRP)



2014 Continuous Time Series: WE2



Environmental Sample Processor - ESP



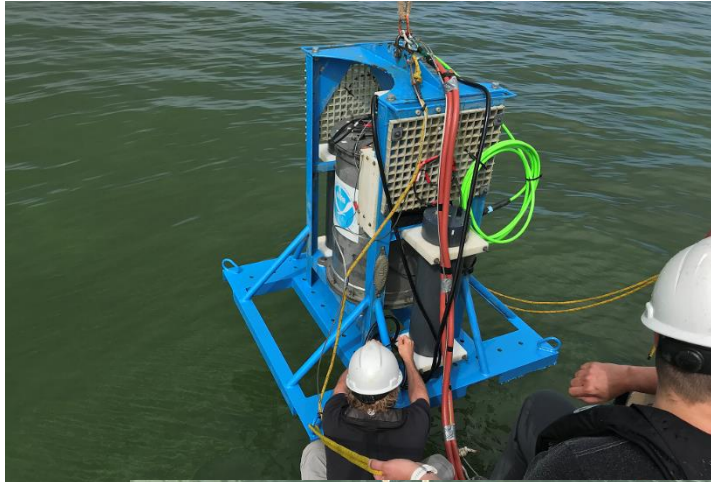
Danna Palladino & Tina Mikulski

- Developed by MBARI, available through McLANE
- In situ collection and analysis → microcystin
- Near real-time
- Immunosorbent assay (ELISA)
- Approximately 40 field samples per deployment

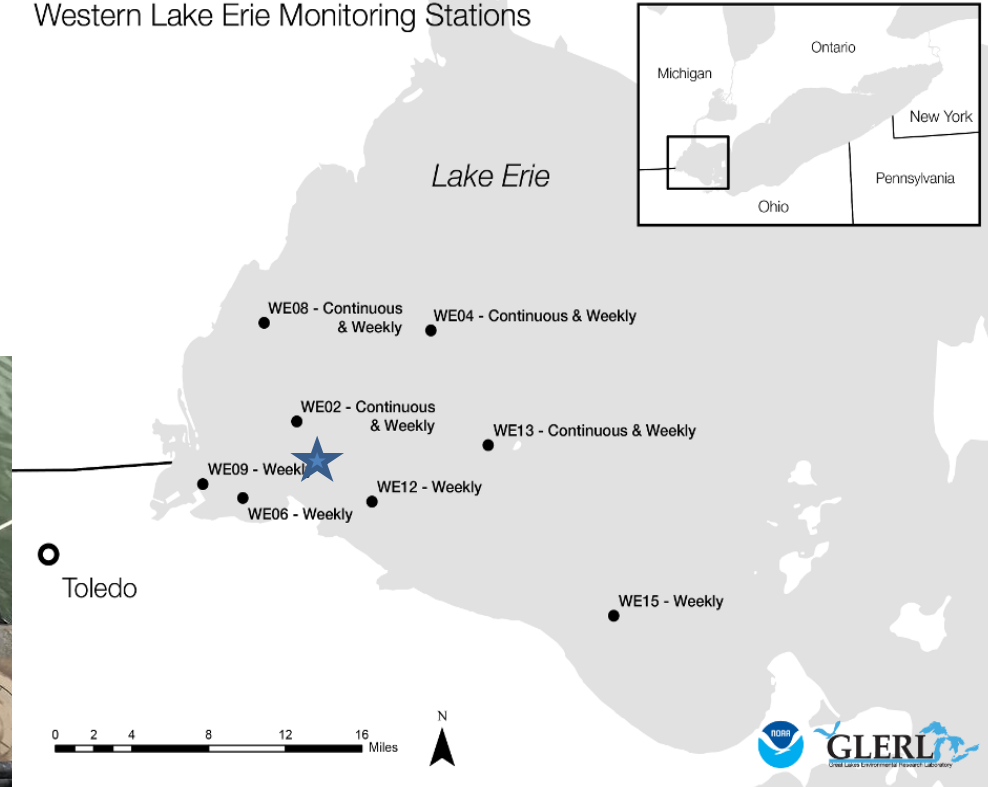
At GLERL:

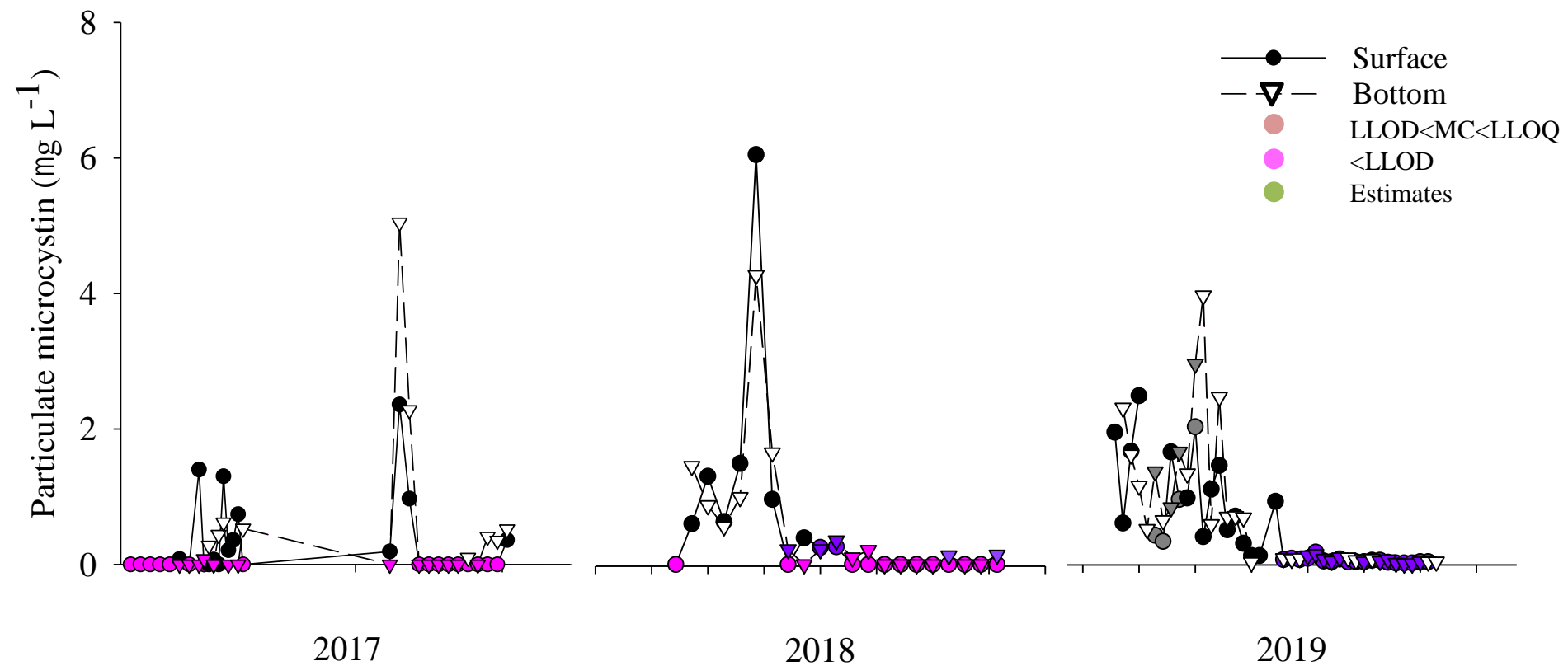
ESPniagara deployed starting 2017,
Added *ESPnessie* and *ESPrush* in 2019

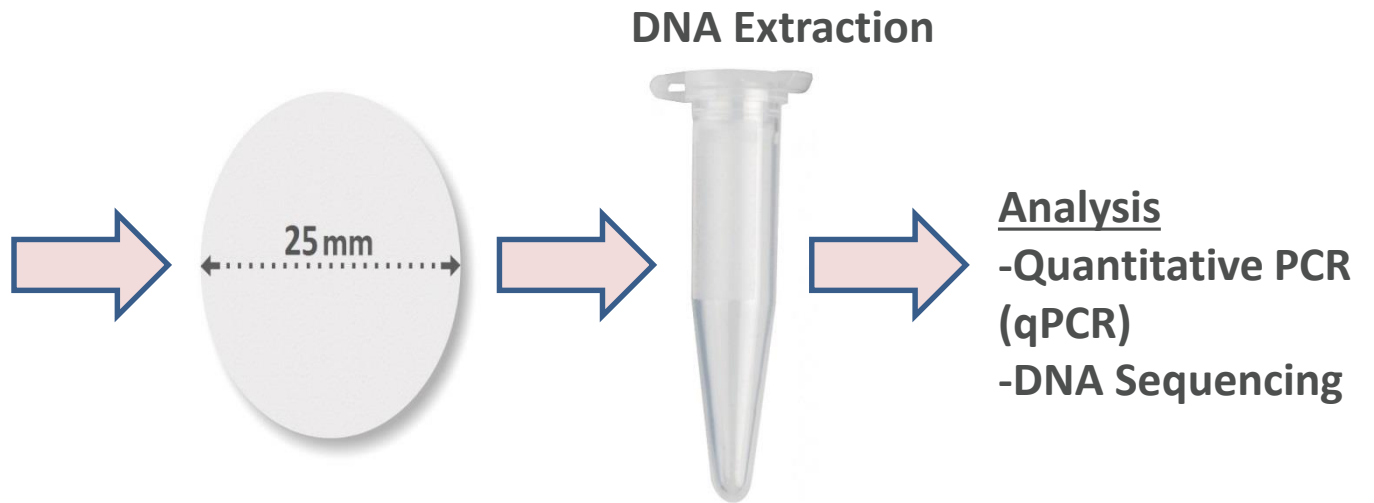
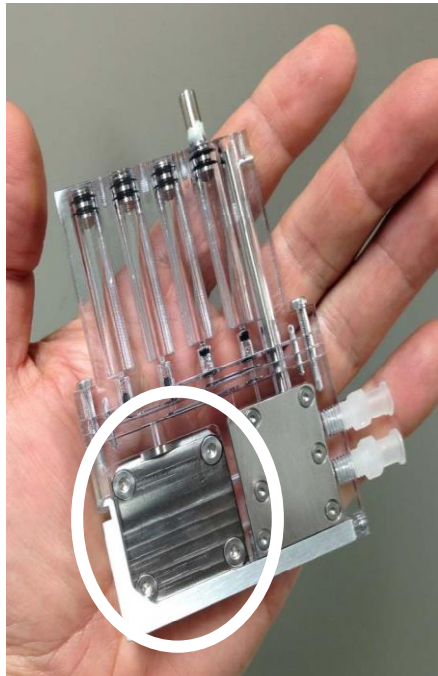
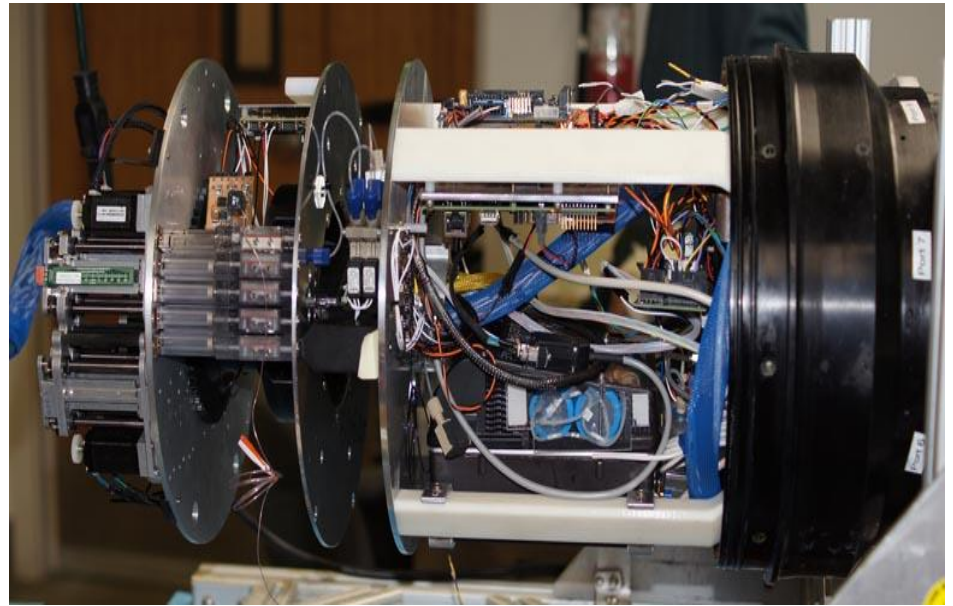
ESPniagara



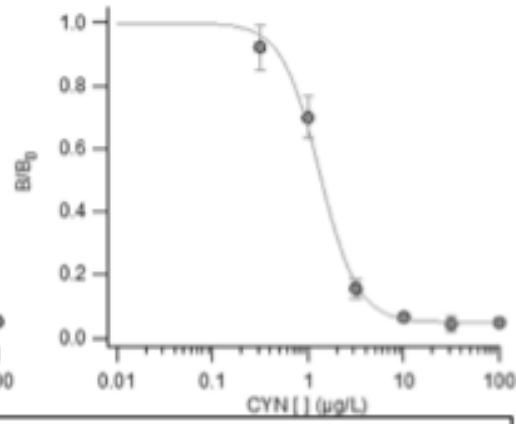
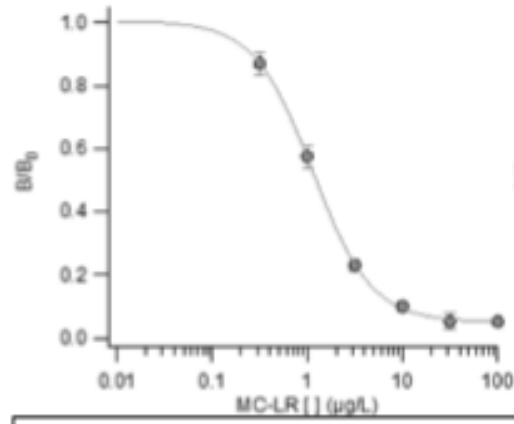
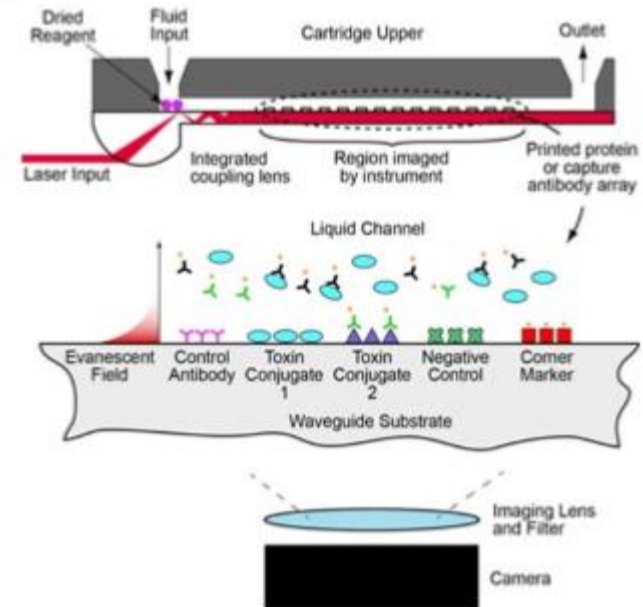
Western Lake Erie Monitoring Stations







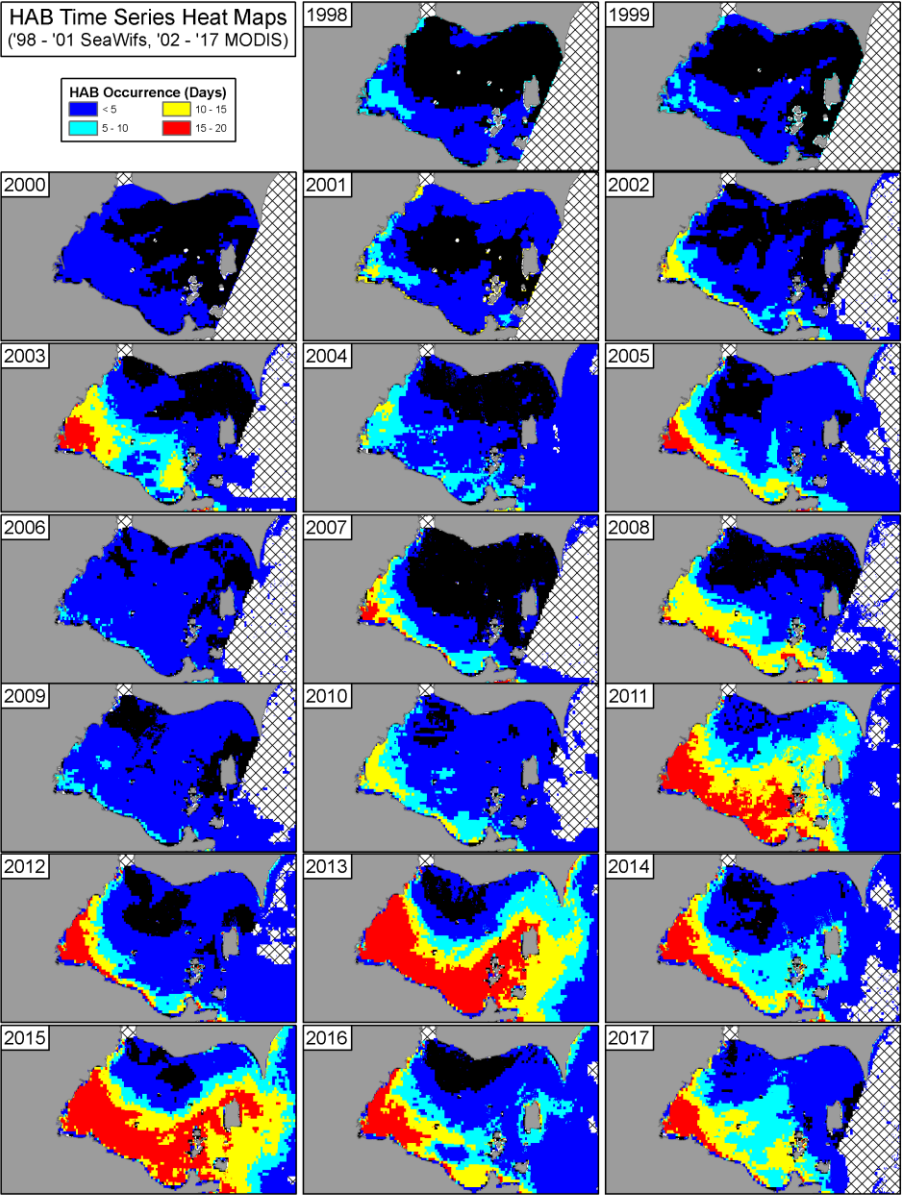
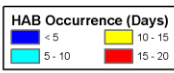
MBio: A Field Portable, User Friendly, Inexpensive Toxin Detection Kit



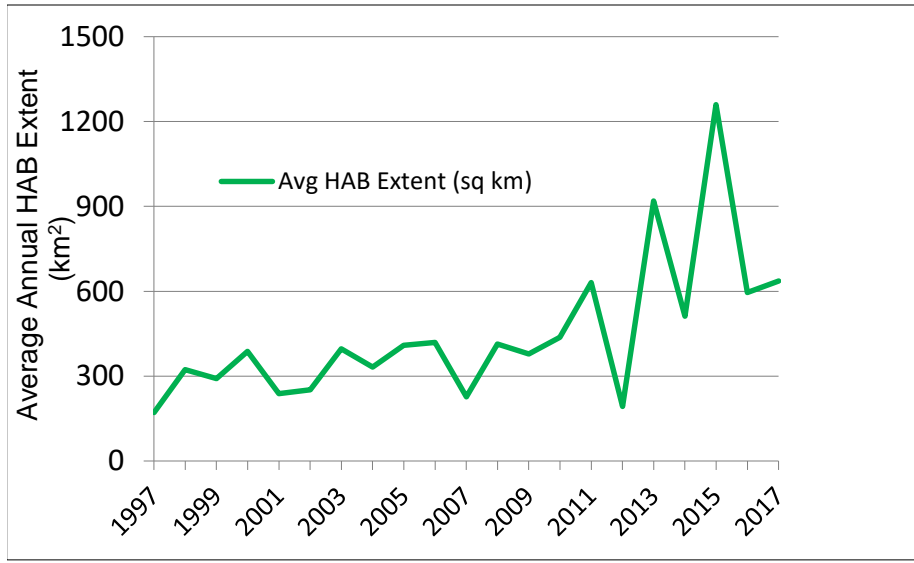
Satellite Remote Sensing



HAB Time Series Heat Maps ('98 - '01 SeaWifs, '02 - '17 MODIS)



MODIS Satellite Western Lake Erie HAB Trends



Airborne Hyperspectral Detection of Cyanobacteria:



240 spectral bands

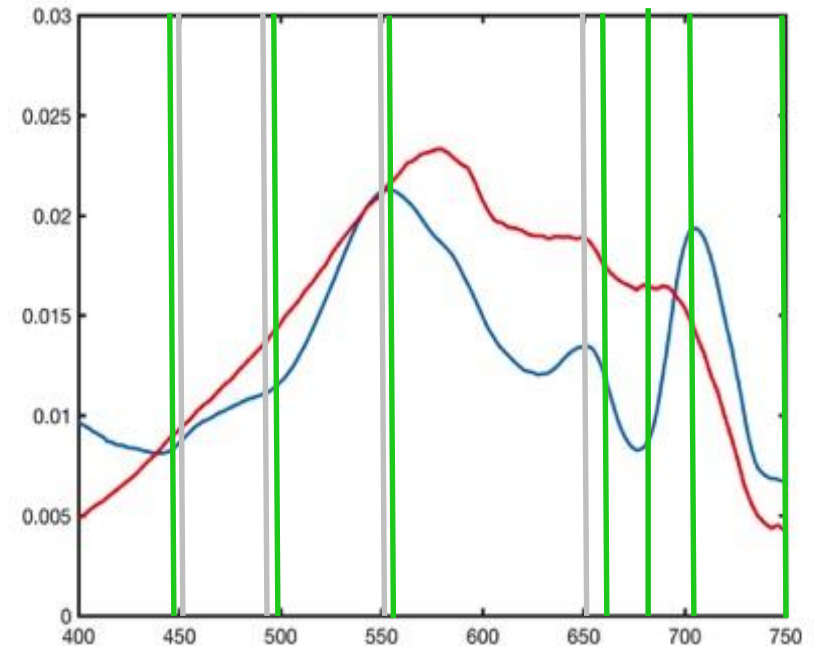
1.1 m spatial resolution

400-900 nm

17.6 degree FOV



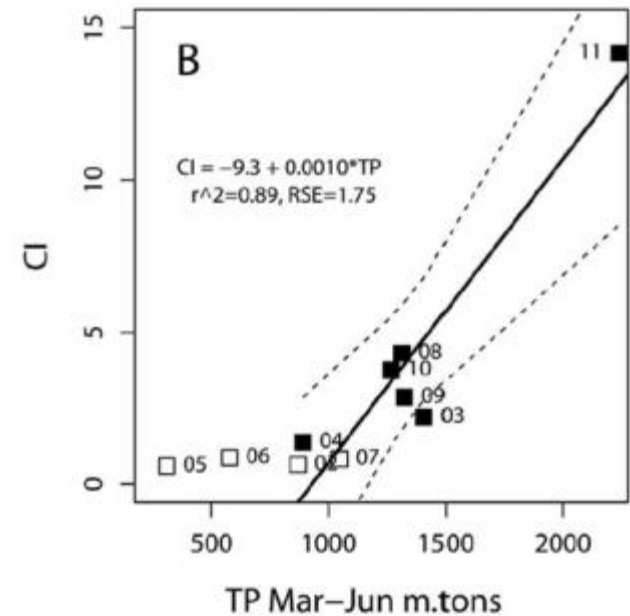
Resonon Pika II



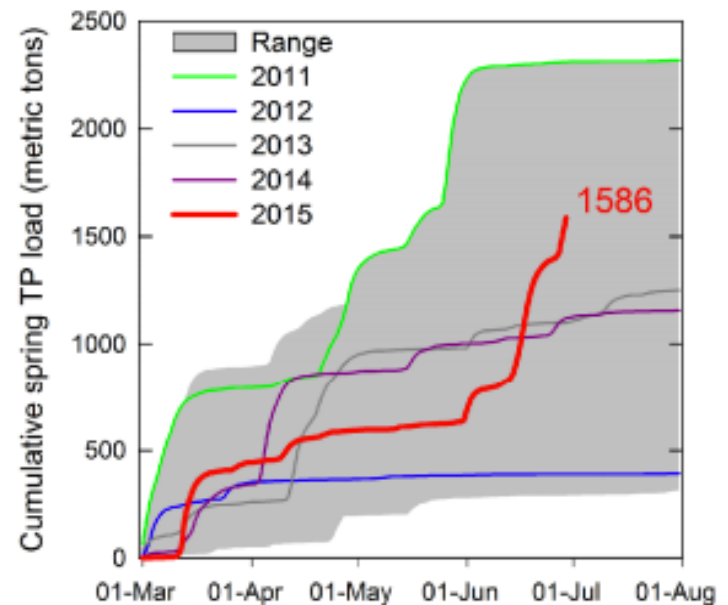
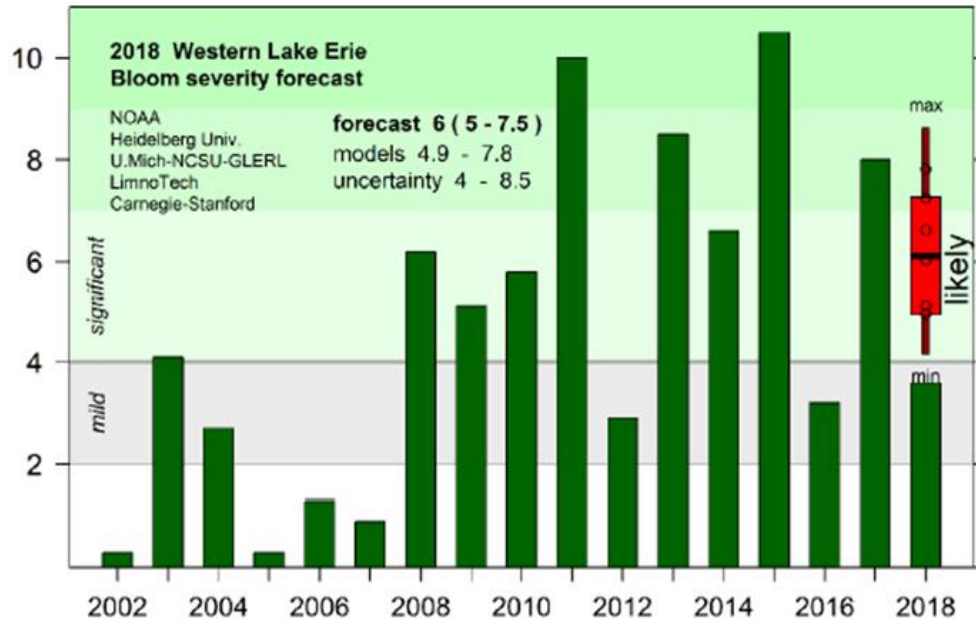
Flyovers of western Lake Erie, Saginaw Bay and Lake St. Clair in US and CA waters

Lake Erie Seasonal HABs Forecast

Statistical Models between P-Loading (Heidelberg University) and HAB Intensity were developed by NOAA-NCCOS, University of Michigan and Limno Tech to create a seasonal bloom forecast.



Stumpf et al. 2012





Lake Erie Harmful Algal Bloom Bulletin

06 August, 2018, Bulletin 14

Analysis

The *Microcystis* cyanobacteria bloom continues in the western basin. Recent satellite imagery (8/6) indicates the bloom is present in Maumee Bay, extending north along the Michigan coast to Brest Bay, east to touch Pelee Island, and along the Ohio coast 8 miles east of Sandusky Bay. Observed winds (8/3-5) reduced mixing and may have lead to scum formation. Measured toxin concentrations have been detected as far east as Kelleys Island, but are still below the recreational threshold throughout the bloom extent. *Keep pets and yourself out of the water in areas where scum is forming.* The persistent cyanobacteria bloom in Sandusky Bay continues.

Forecasts

Winds forecast (5-9 kn) today through Thursday (8/6-9) may lead to scum formation in areas of high *Microcystis* concentrations, save a short period of elevated winds (8/8) that could cause slight mixing. Eastward transport of surface *Microcystis* concentrations is predicted. Clouds will likely obscure the lake Tuesday and Wednesday (8/7-8). --Keeney, Ludema

Additional Resources

To find a safe place for recreation, visit the Ohio DOH "BeachGuard" site: <http://publicapps.odh.ohio.gov/beachguardpublic/>

Ohio EPA's site on harmful algal blooms: <http://epa.ohio.gov/HAB-Algae>

NOAA's GLERL provides additional HAB data here: http://www.glerl.noaa.gov/res/HABs_and_Hypoxia

The images below are "GeoPDF". Please visit <https://go.usa.gov/xReTC> for instructions on viewing longitude and latitude.

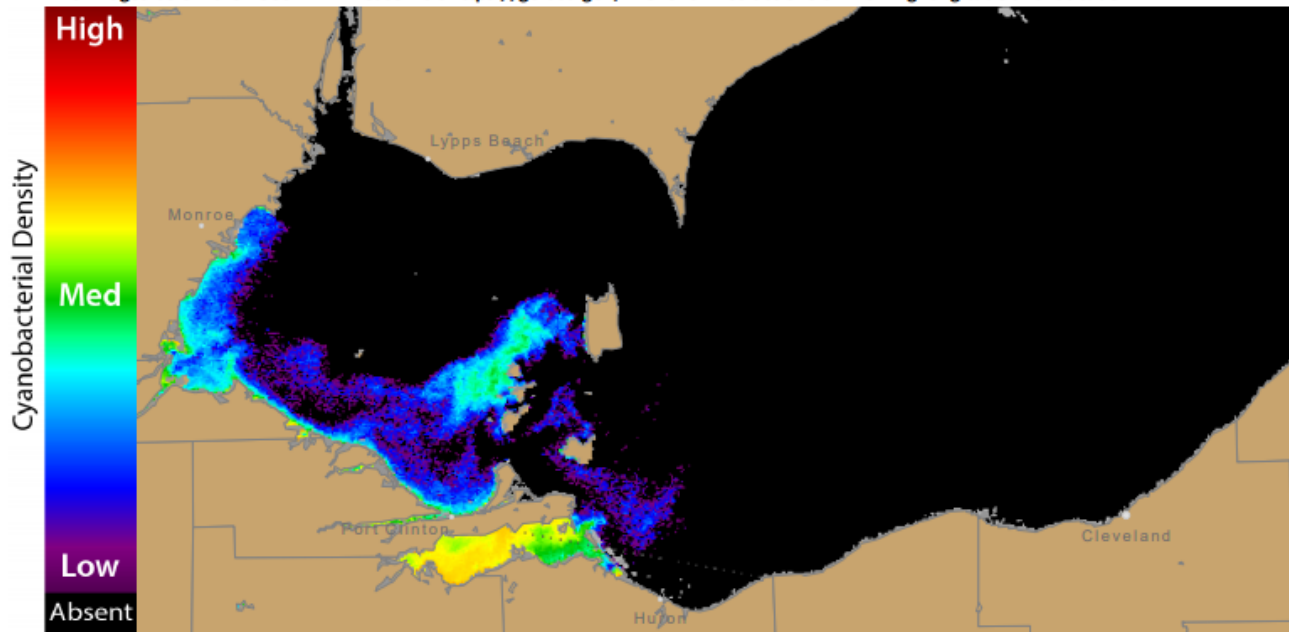
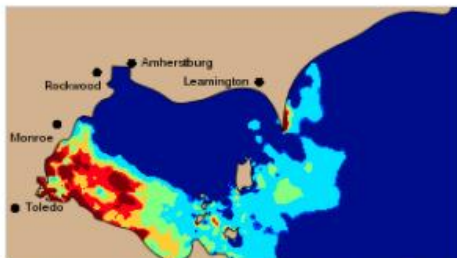


Figure 1. Cyanobacterial Index from modified Copernicus Sentinel 3 data collected 05 August, 2018 at 11:38 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 ce^{10}/m^3

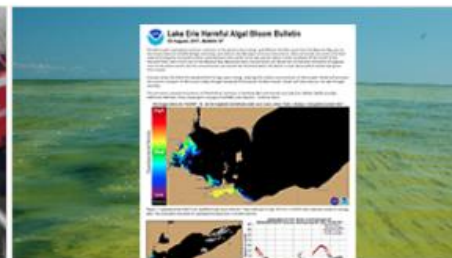
Great Lakes Harmful Algal Blooms (HABs) and Hypoxia



Experimental Lake Erie HAB Tracker



Environmental Sample Processor



Lake Erie HAB Bulletin



Water Quality and Monitoring Data



Hyperspectral Image Data



Lake Erie Hypoxia Warning System



Frequently Asked Questions



HABs and Hypoxia Publications



Flickr HAB Photo Gallery

The Do's and Don'ts of HABs

- **Do** avoid contact with water where algae are visible (e.g. pea soup, floating mats, scum layers, etc), or where water is discolored.
- **Do** rinse yourself and/or your pet off after swimming in any ponds, lakes or streams, regardless of the presence of a visible algal blooms.
- **Do** obey posted signs for beach closings.
- **Do** contact your local health department or department of natural resources to report any large blooms.

- **Don't** drink untreated surface water, whether or not blooms are present. Remember, **BOILING THE WATER WILL NOT REMOVE THE TOXINS.**
- **Don't** use algaecides to kill the cyanobacteria– when the cells die, the toxins are directly released into the water.
- **Don't** allow children or pets to play in or drink water where scum is present.
- **Don't** water-ski or jet-ski over algal mats.
- **Don't** irrigate lawns or golf courses with water that looks or smells bad.

Thanks for your attention

