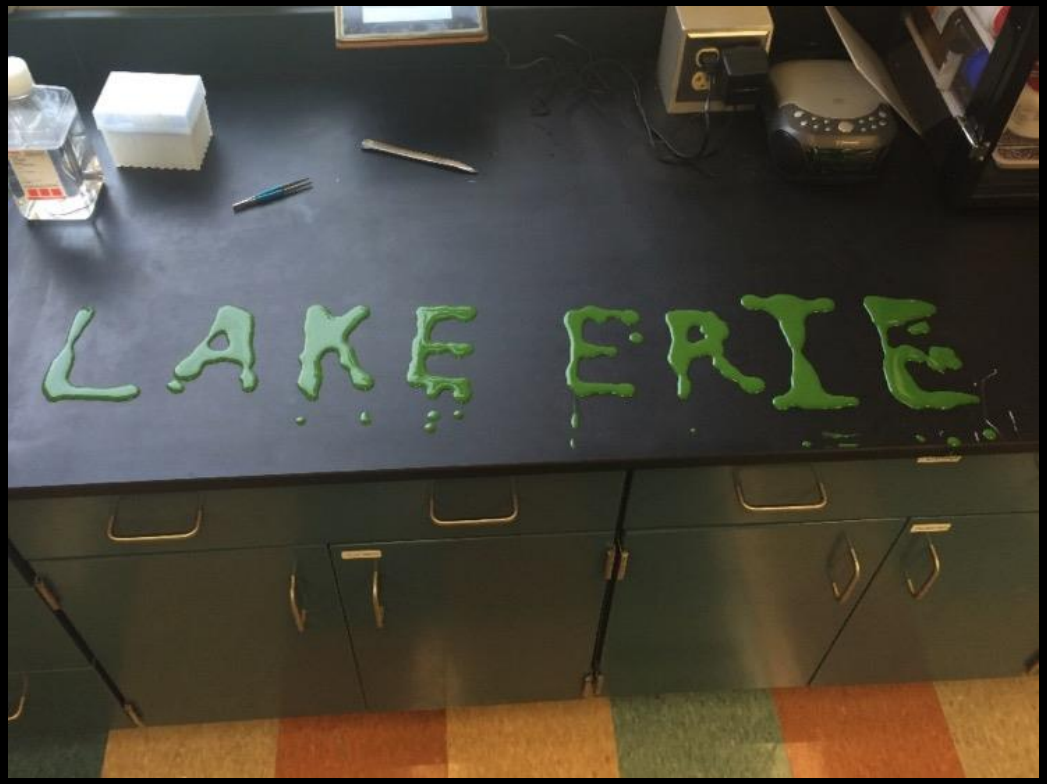
When going green is not the cool thing to do!

Understanding the drivers of Lake Erie's toxic cyanobacterial harmful algal blooms

Timothy Davis



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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 CO_2 concentrations in the atmosphere (i.e. the biological pump)

- Of the thousands of known phytoplankton species, over 100 are known to be <u>harmful</u> to aquatic ecosystems.

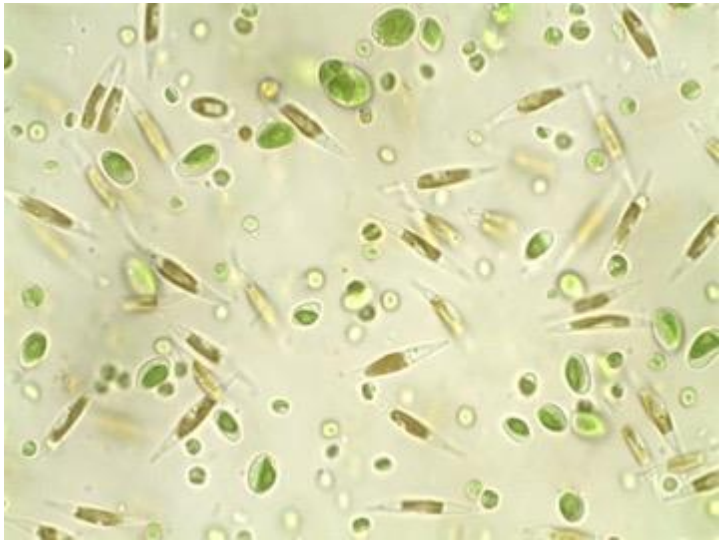
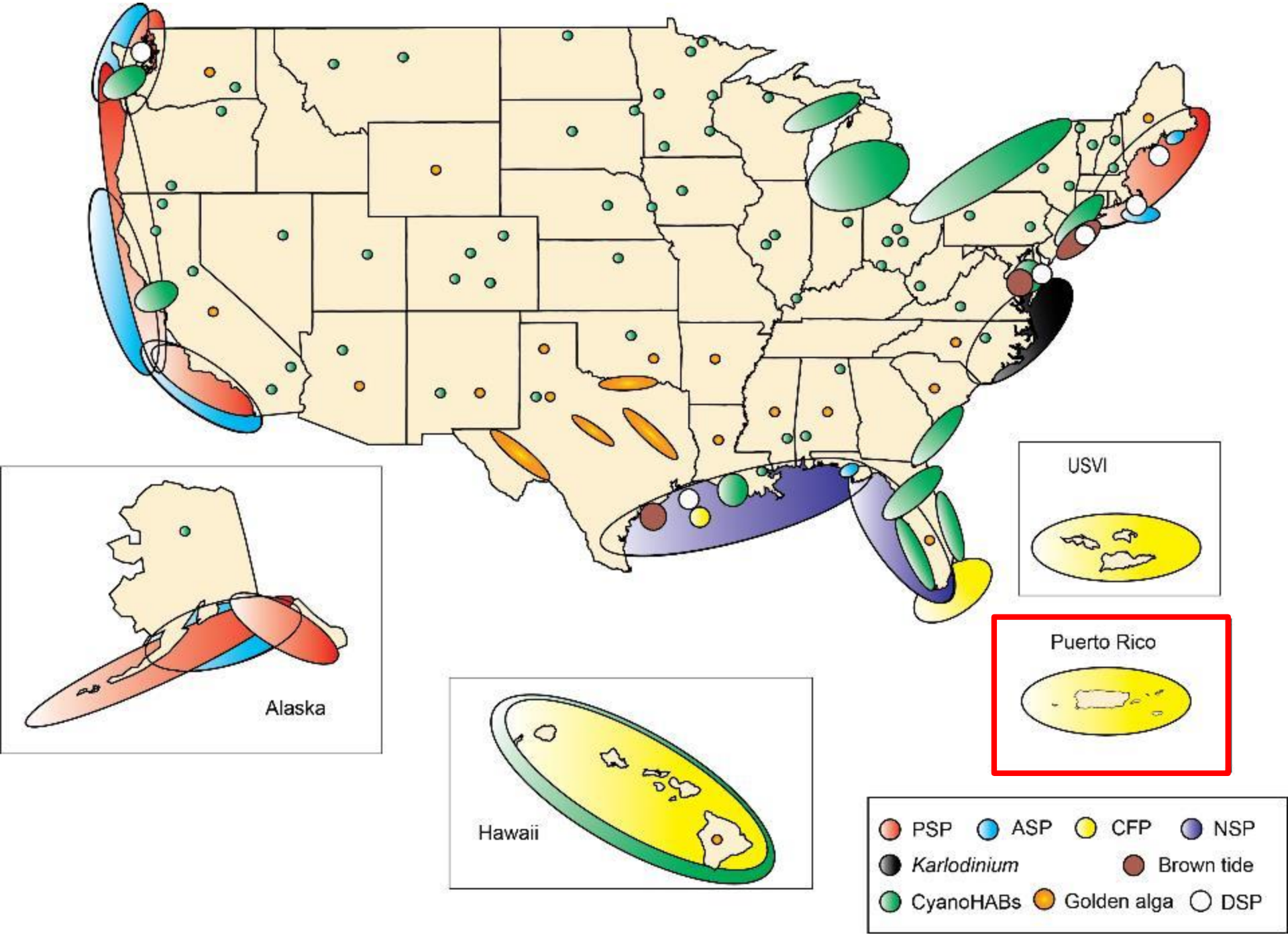
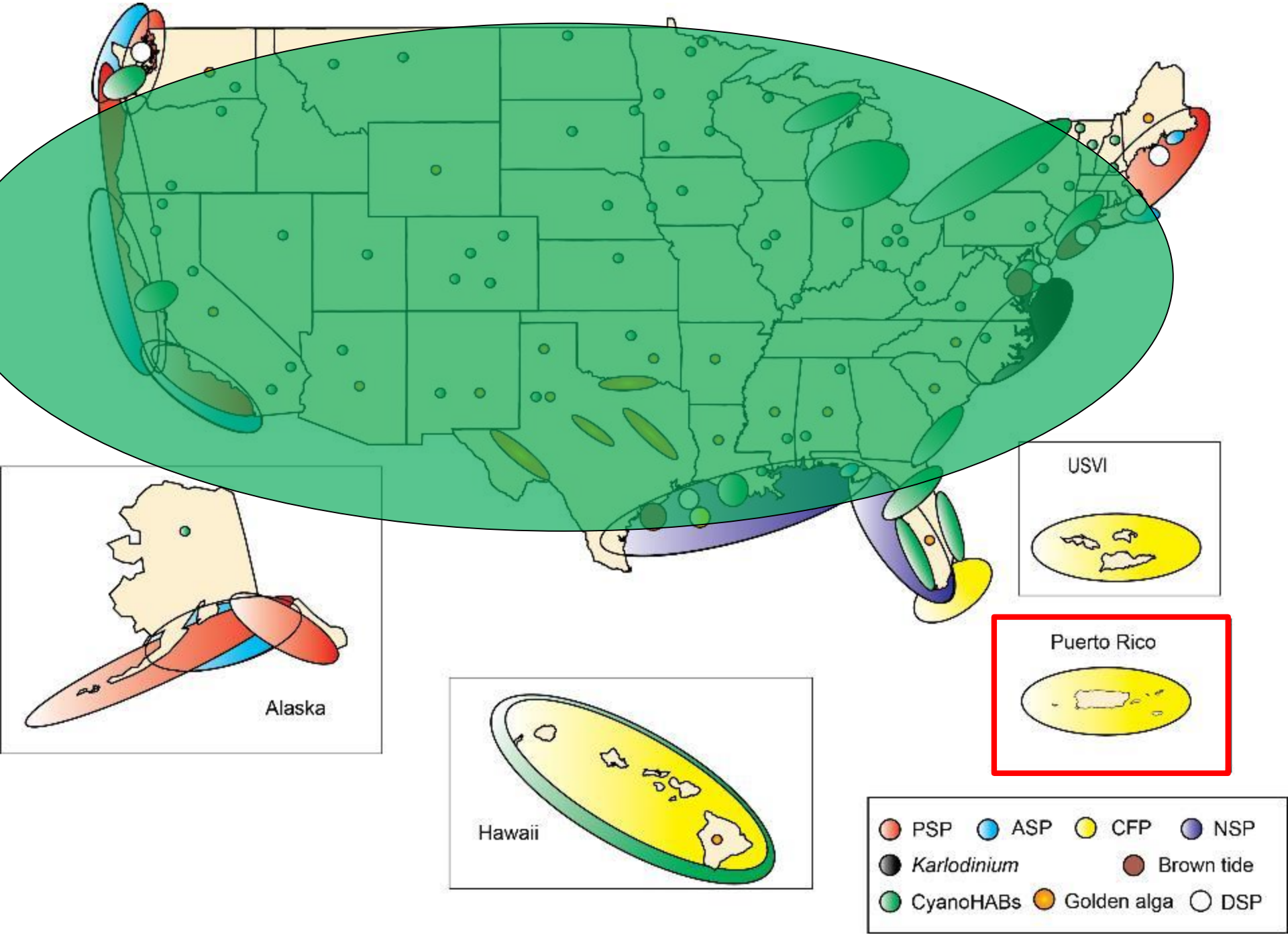


Photo: Innovative Marine Aquaculture Inc.

Photo: Have It Green Magazine


Alaska
USVI
Puerto Rico
Hawaii
PSP
ASP
CFP
NSP
Karlodinium
Brown tide
CyanoHABs
Golden alga
DSP


USVI
Puerto Rico
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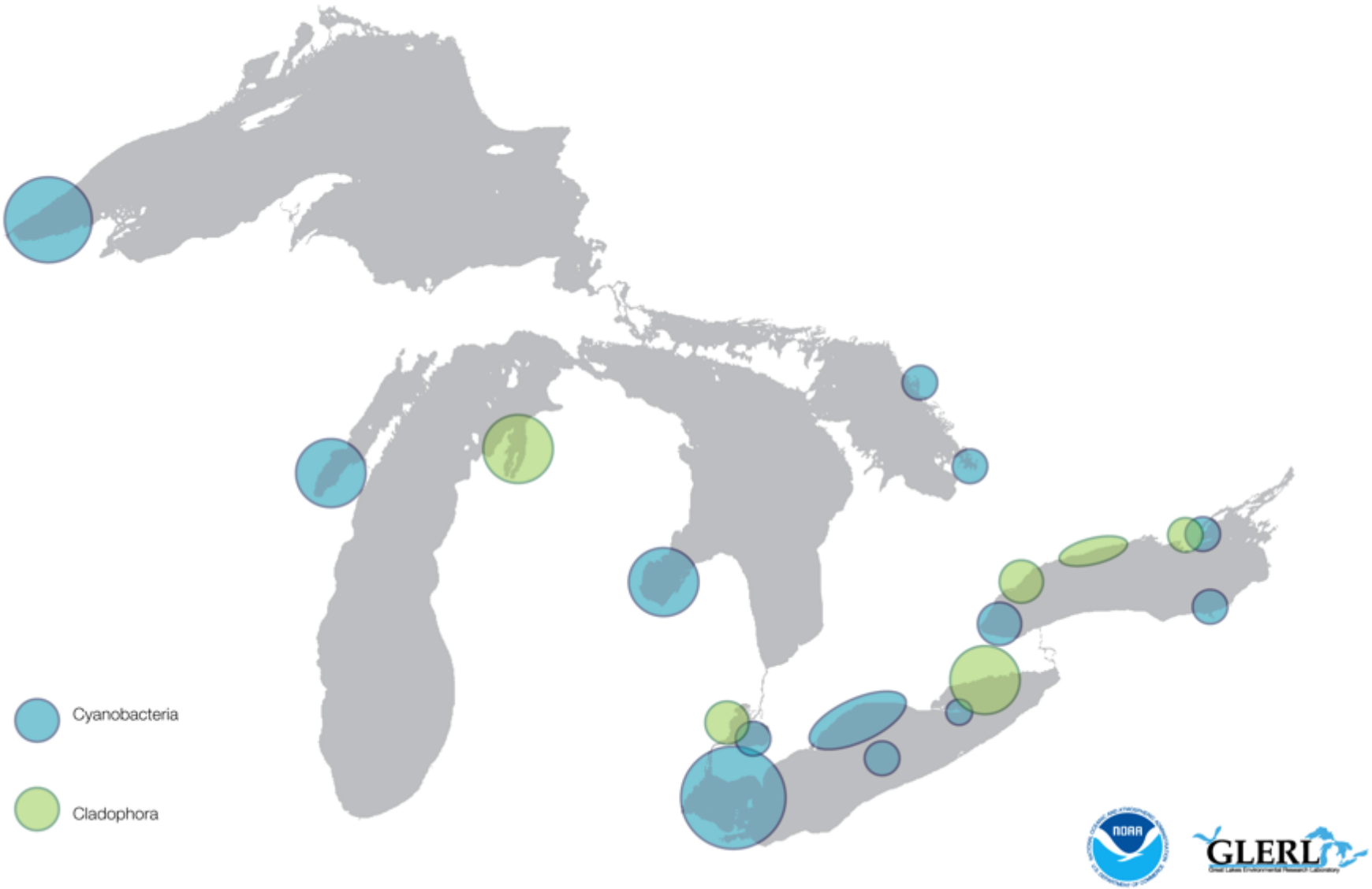
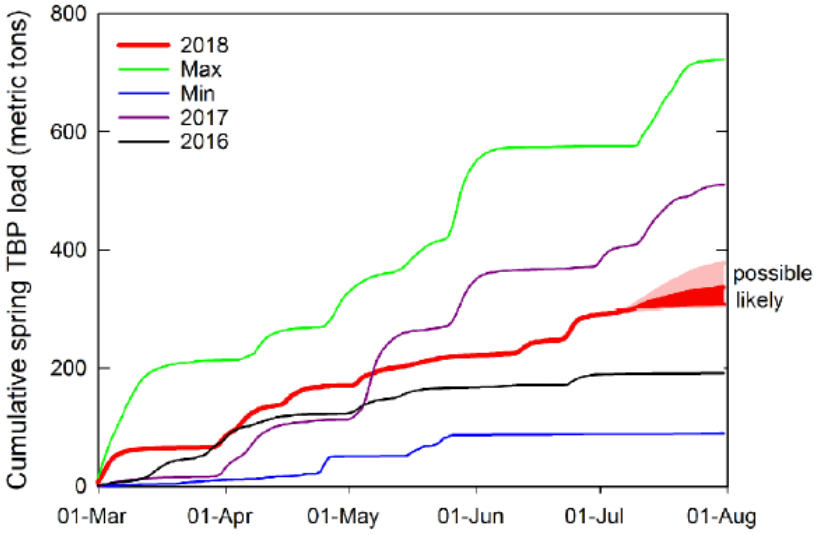
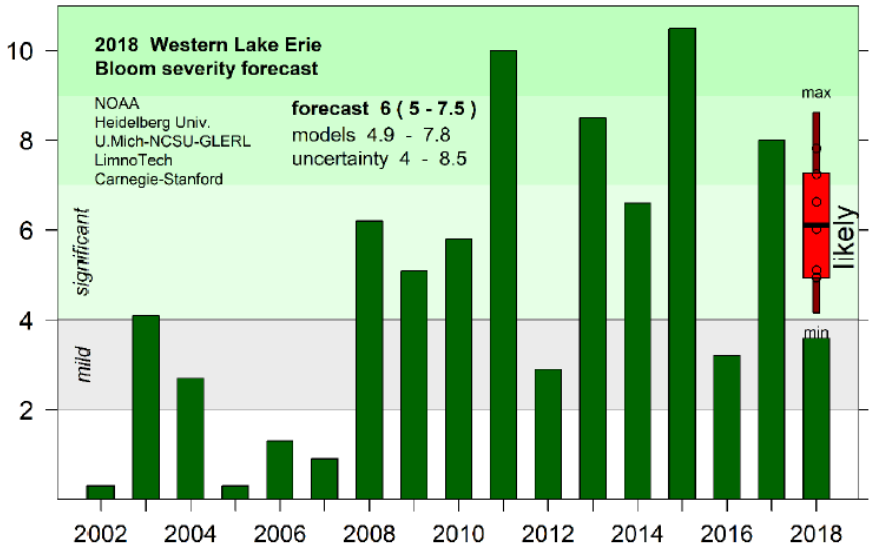
HABs occur throughout the Great Lakes basin



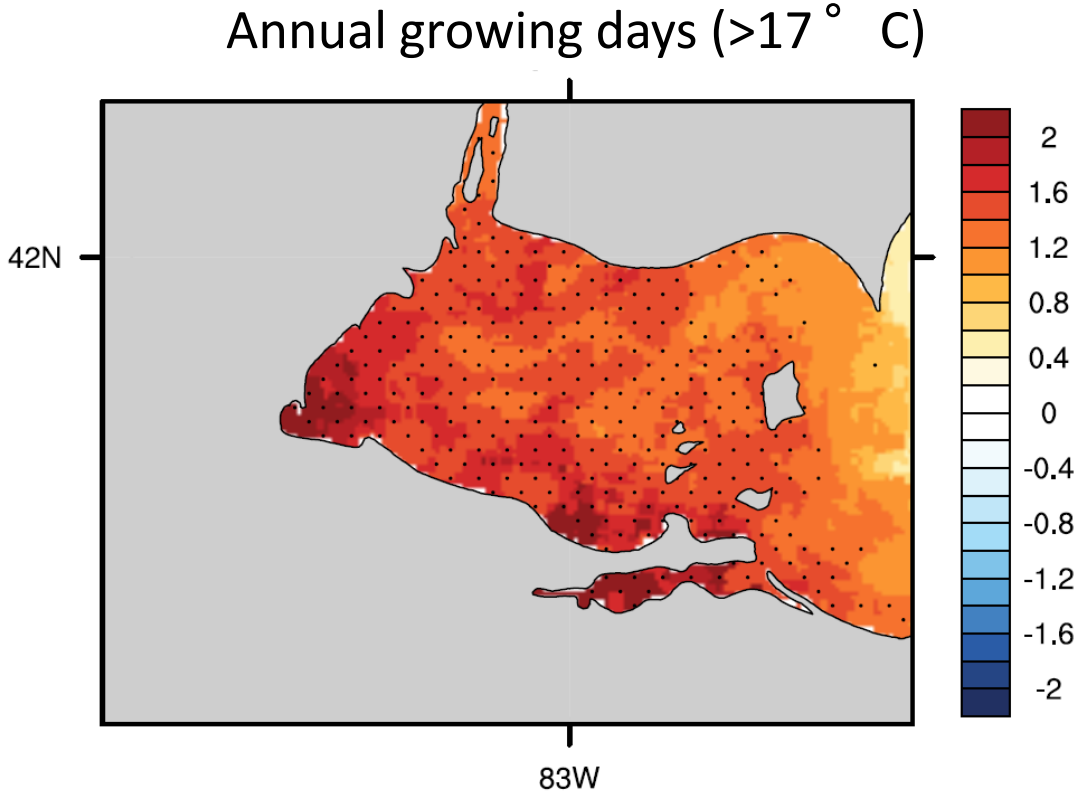
Lake Erie CHABs are increasing in severity

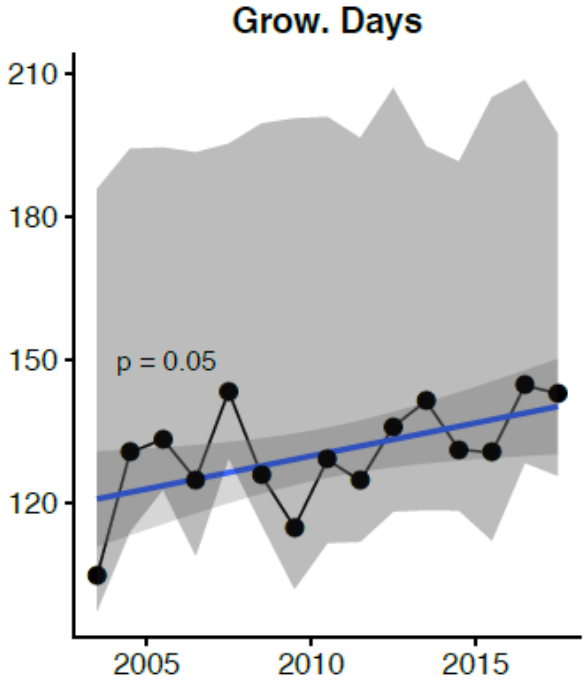




Richard Stumpf, Timothy Wynne, Dupuy

Climate change will lead to blooms that start earlier and end later

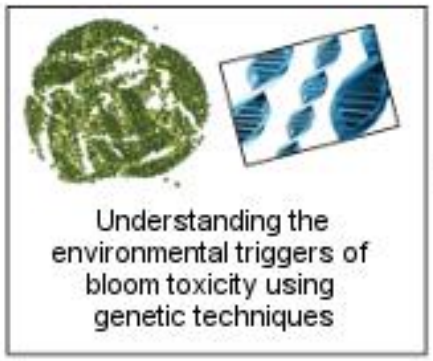




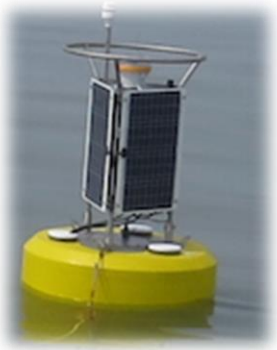
- Black dots represent areas where the trend is significant ($p < 0.05$)

Most of the Western Basin of Lake Erie has experienced an 1-2 day increase in growing days per year since 2002

An integrated approach to studying HABs



Understanding the environmental triggers of bloom toxicity using genetic techniques

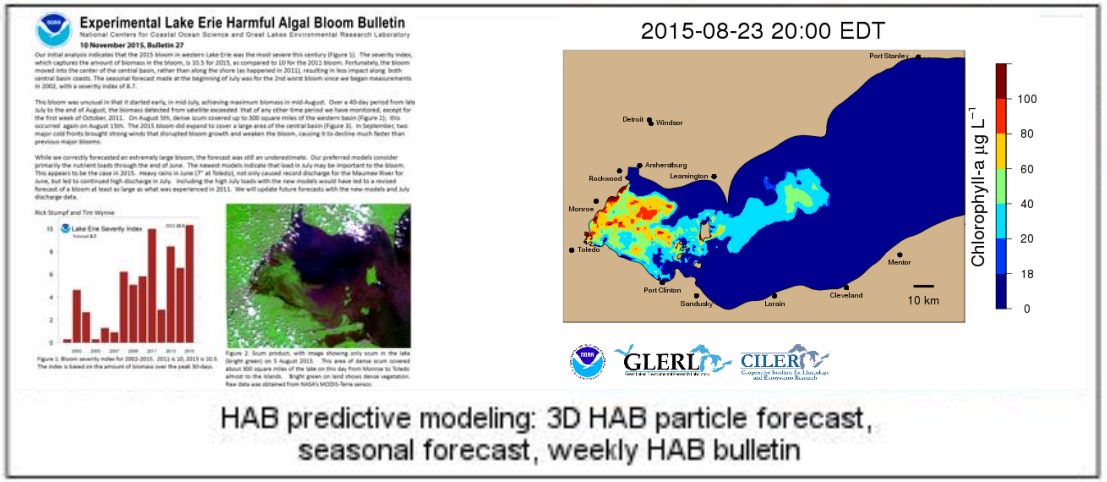


Zebra mussel and microcystin relationship

Monitoring and observations identify environmental conditions promoting *Microcystis* bloom occurrence and toxicity

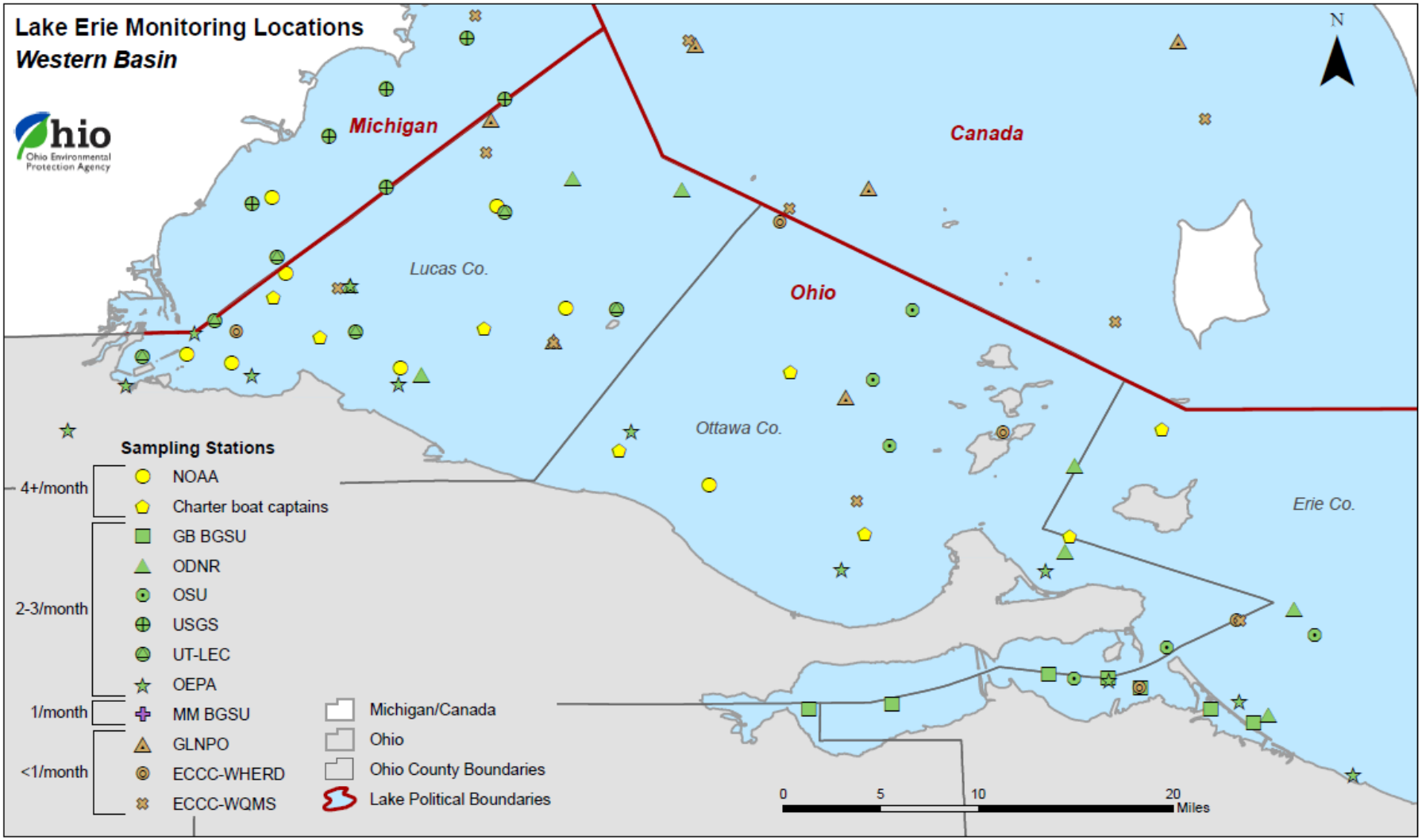
Satellite algorithm assessment and remote sensing

Environmental sample processor (ESP)



HAB predictive modeling: 3D HAB particle forecast, seasonal forecast, weekly HAB bulletin

Partnerships between Federal, State, academic and citizen scientists are critical to monitor HABs



Bloom toxin concentration can vary significantly across the basin

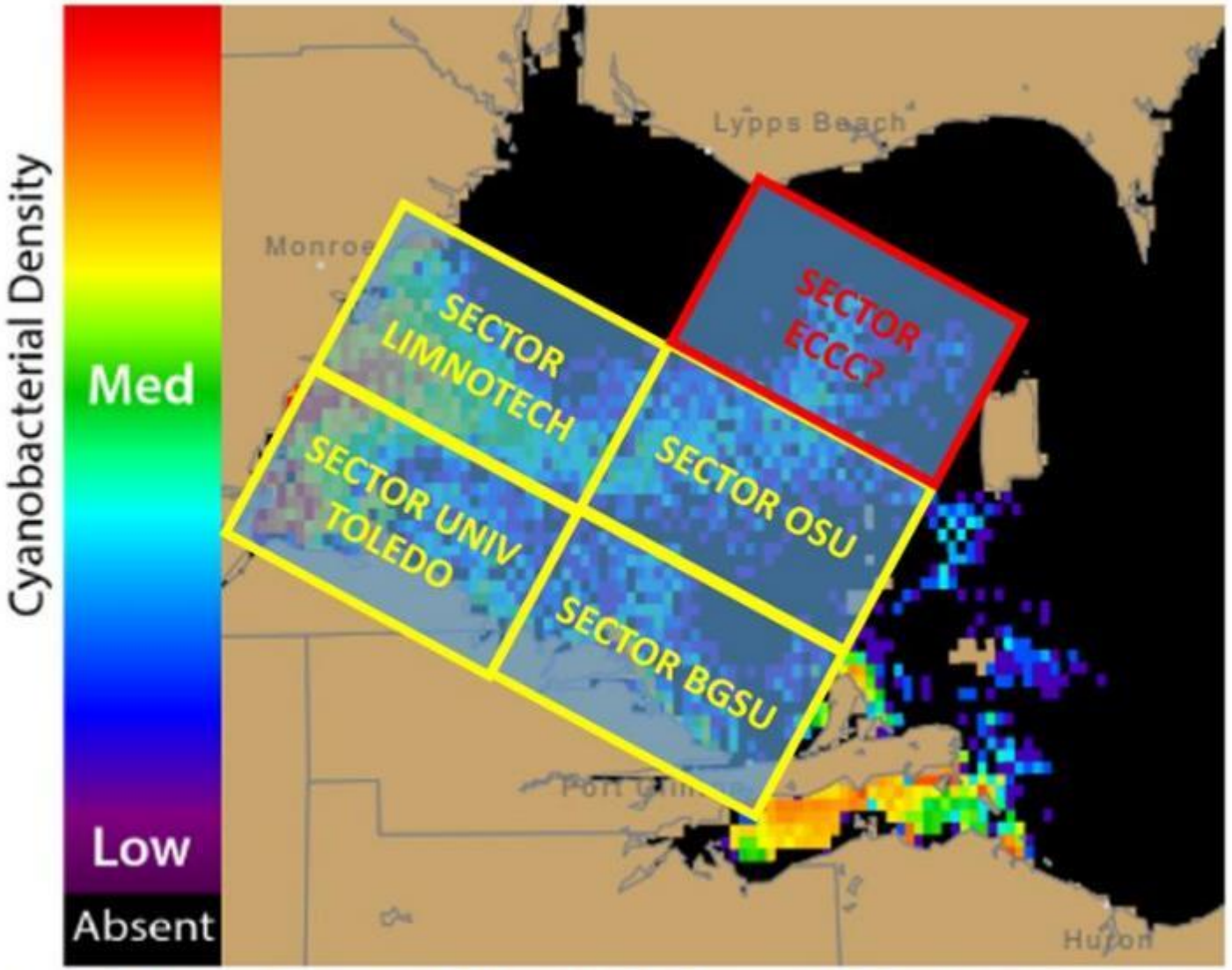
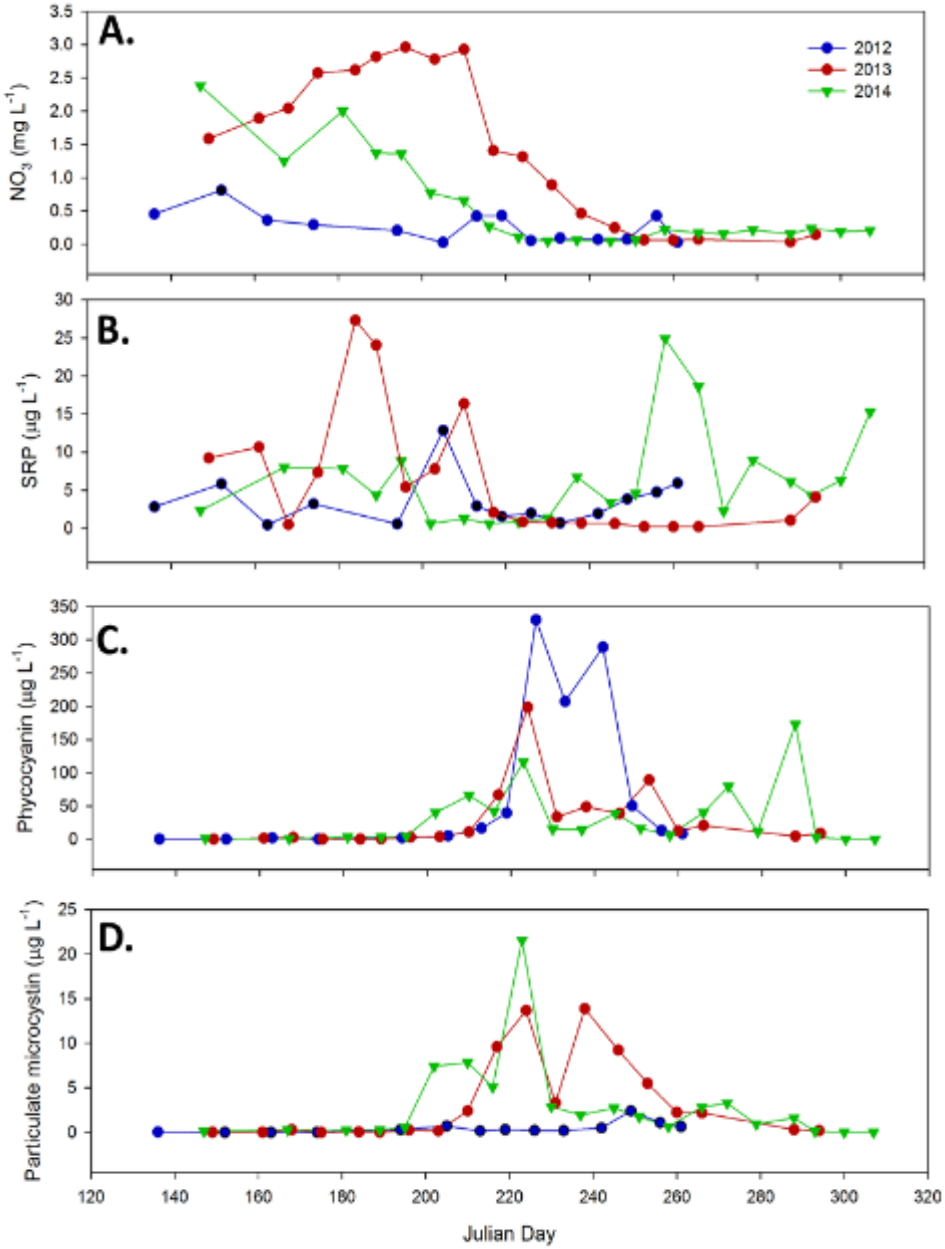


Figure 3. Nowcast position of bloom for 11 August, 2016 using GLFS modelled

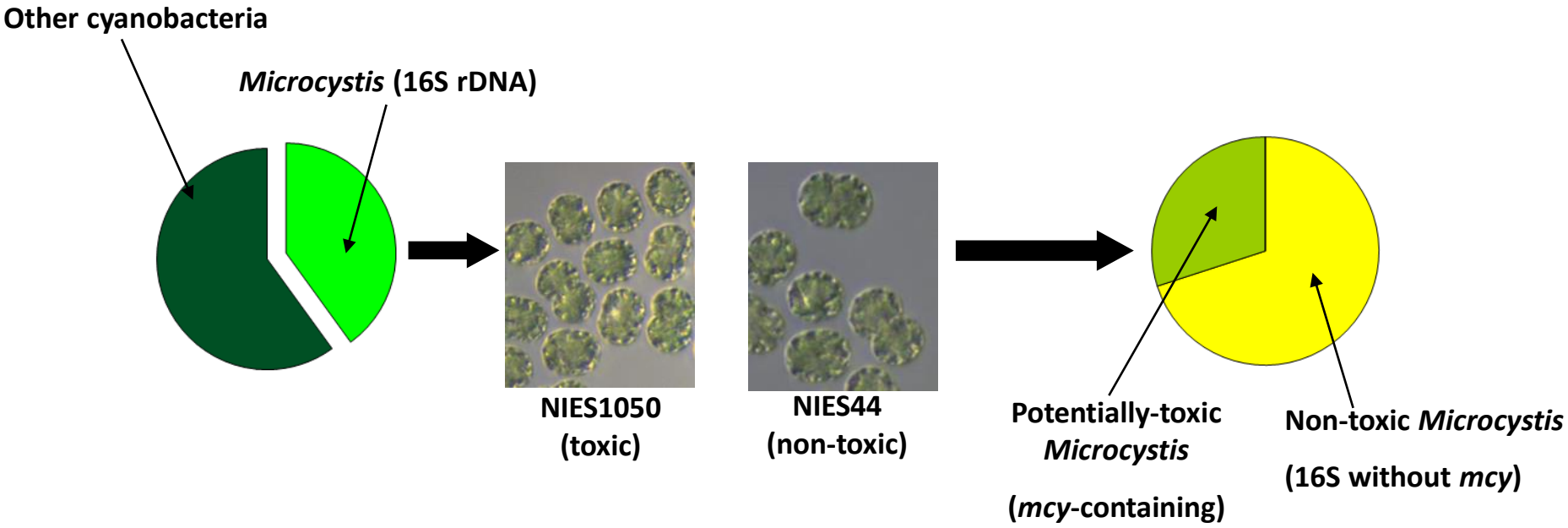
Weekly sampling reveals important trends that highlight potential environmental drivers and inform future experiments



- Toxicity changes throughout the bloom
- Relationship between nitrogen and toxicity
- *Microcystis* blooms occur even when phosphorus concentrations are low
- Other factors beyond nutrients may be important in driving bloom structure and function

From: Gobler, Burkholder, **Davis**, et al., 2016, Harmful Algae

Using molecular tools to monitor CHABs:



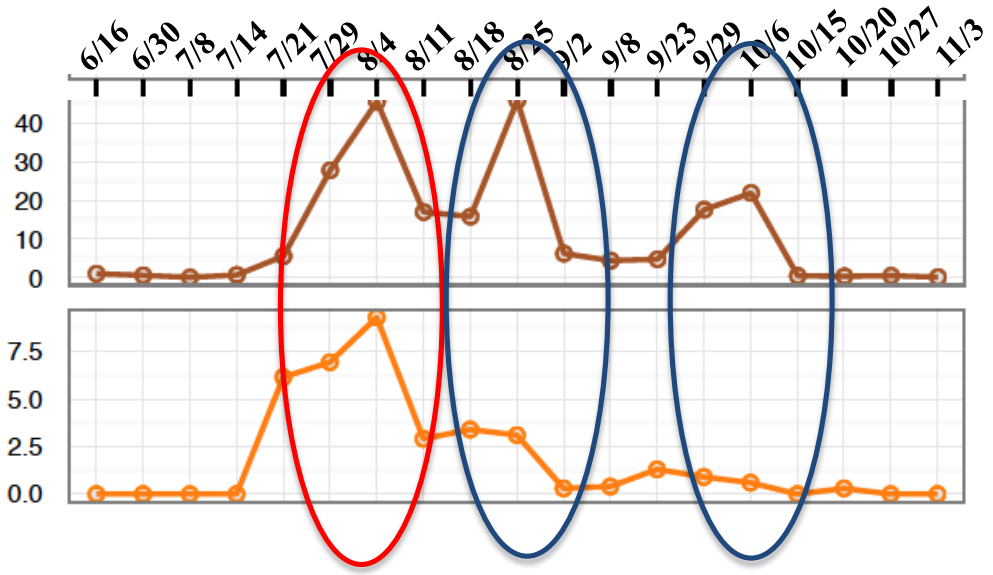
% toxic *Microcystis* = proportion of *Microcystis* cells containing the genetics to produce microcystins (*mcyD* or *E* / 16S x 100)

Determined by (1) qPCR and (2) metagenomics

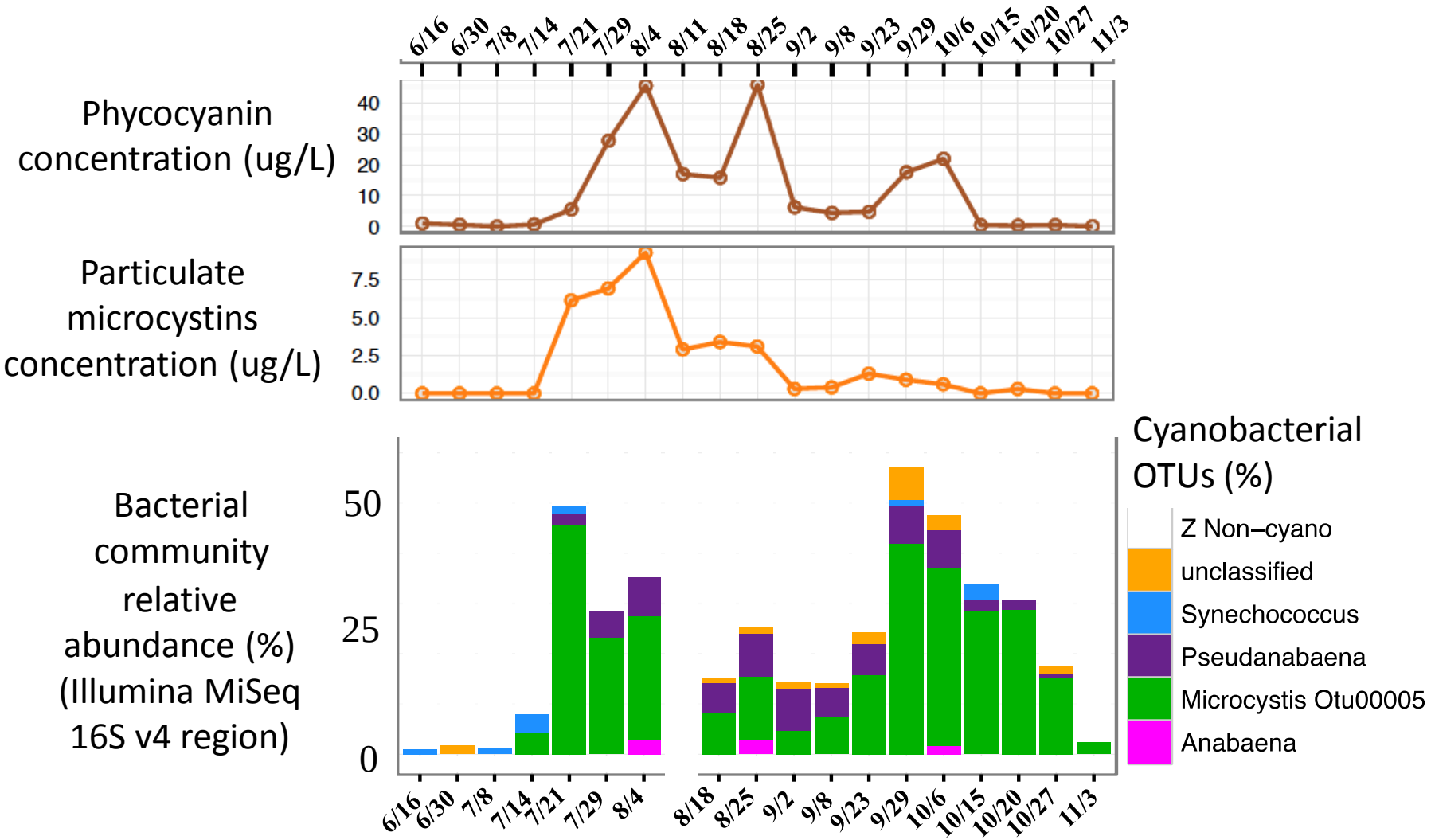
Toxicity decreases as the bloom progresses

Phycocyanin concentration (ug/L)

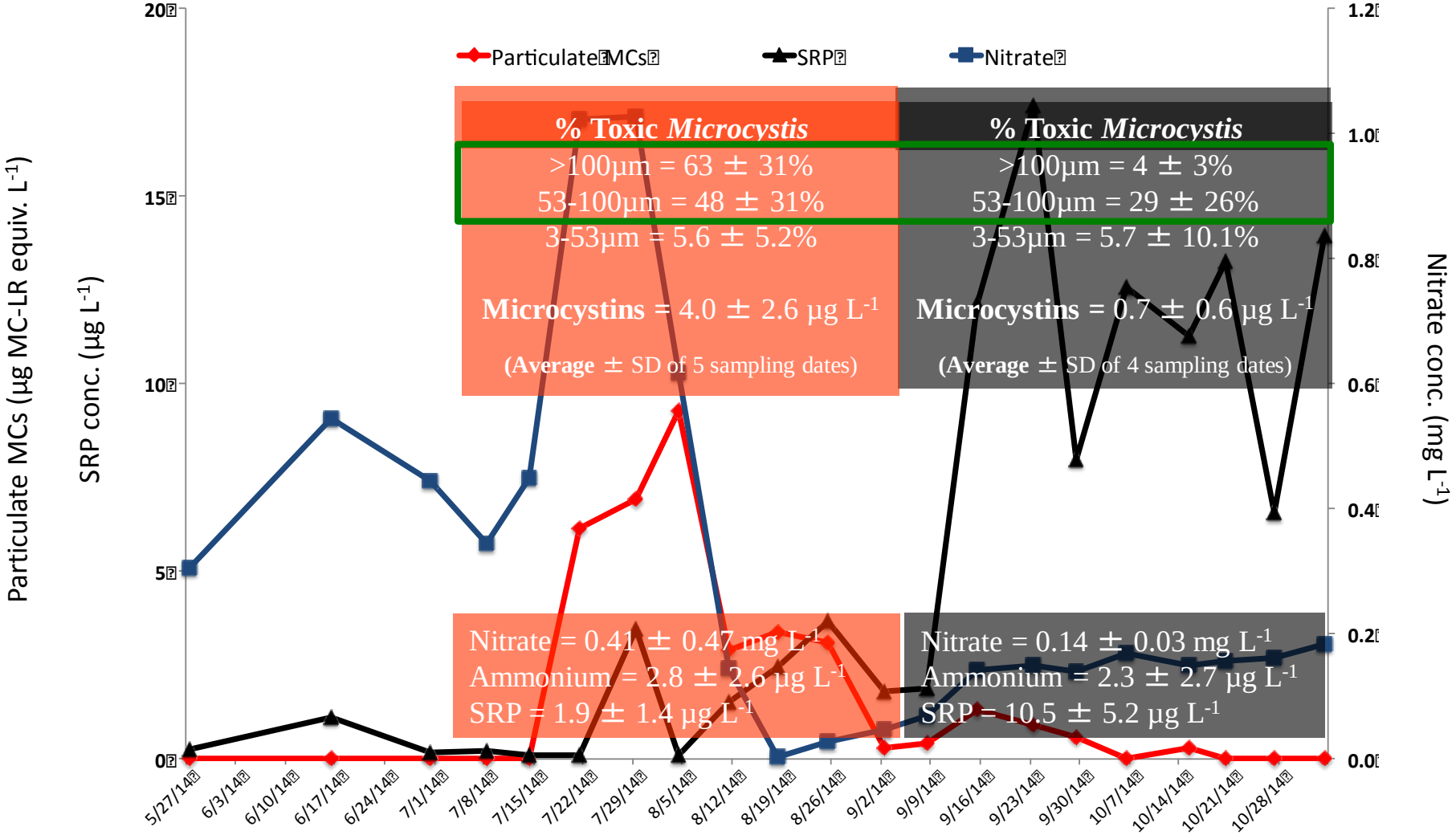
Particulate Microcystins (ug/L)



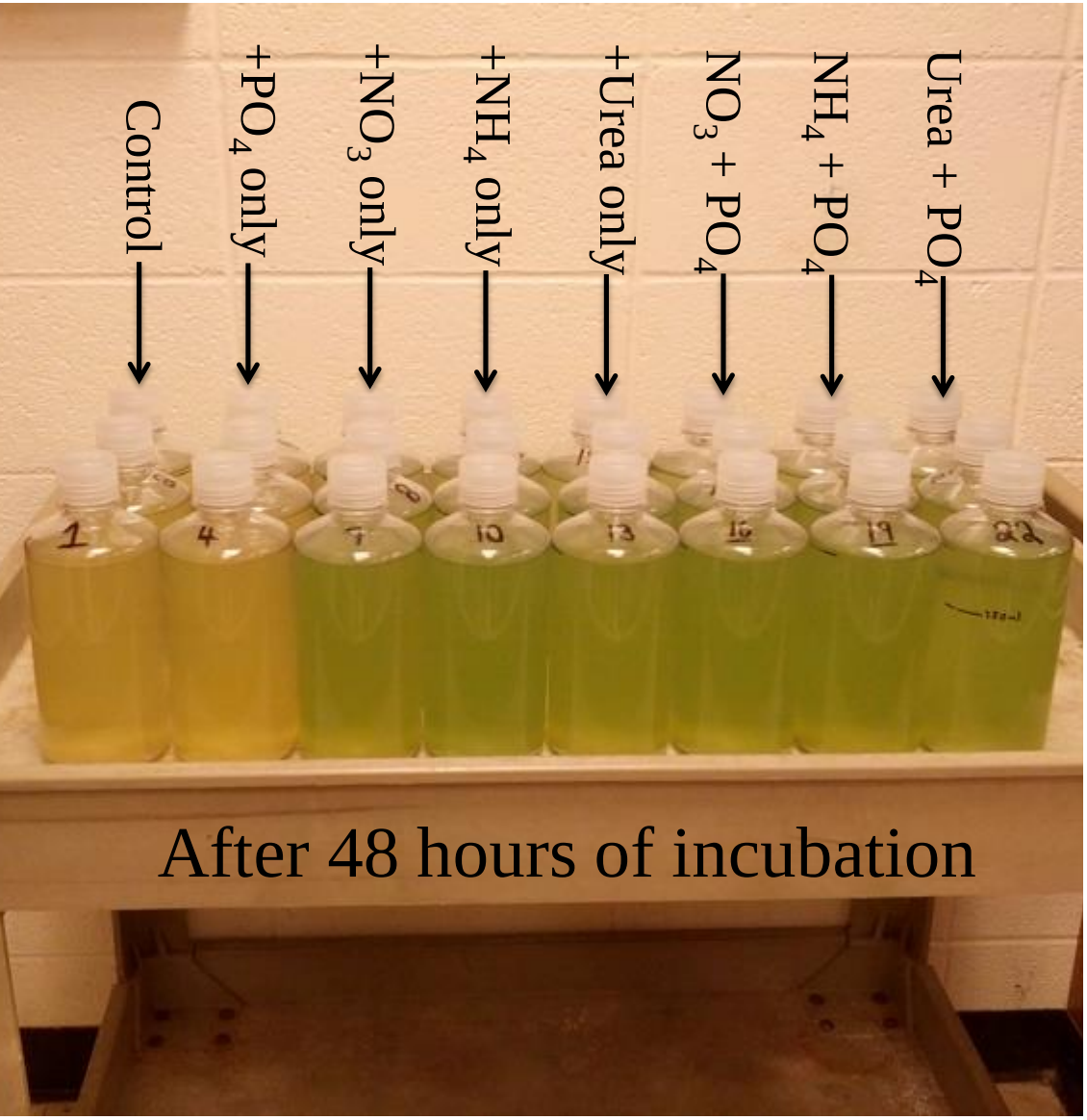
Shift in toxicity not due to changes in cyanoHAB genera

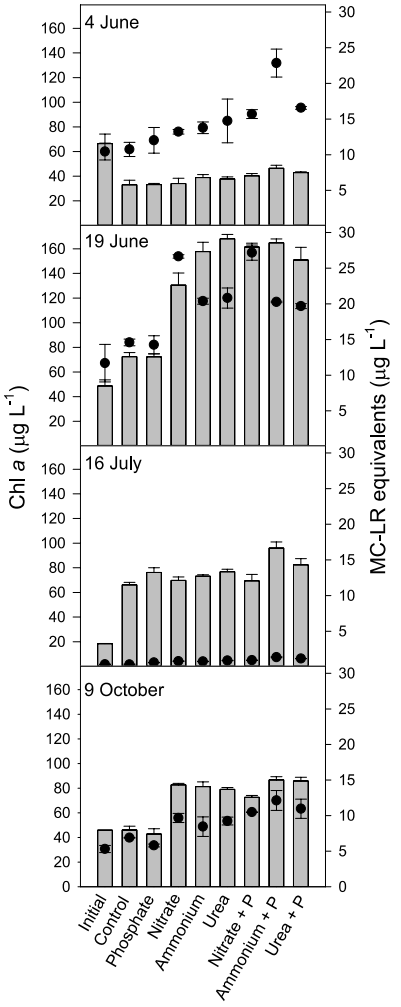


Toxic strains decline with lower nitrate concentrations



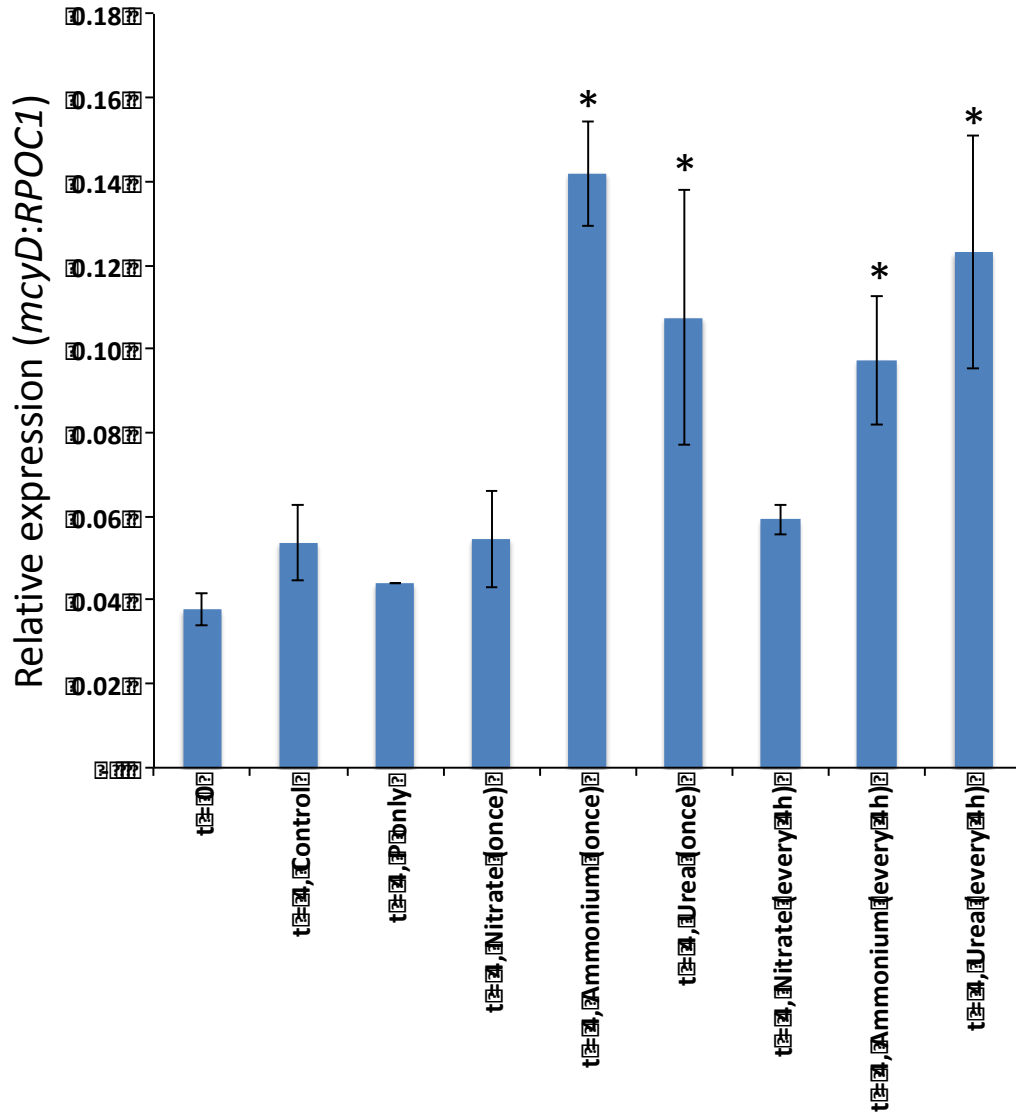
Nitrogen constrains growth and toxicity of *Planktothrix* in Sandusky Bay





Davis et al., 2015 ES&T

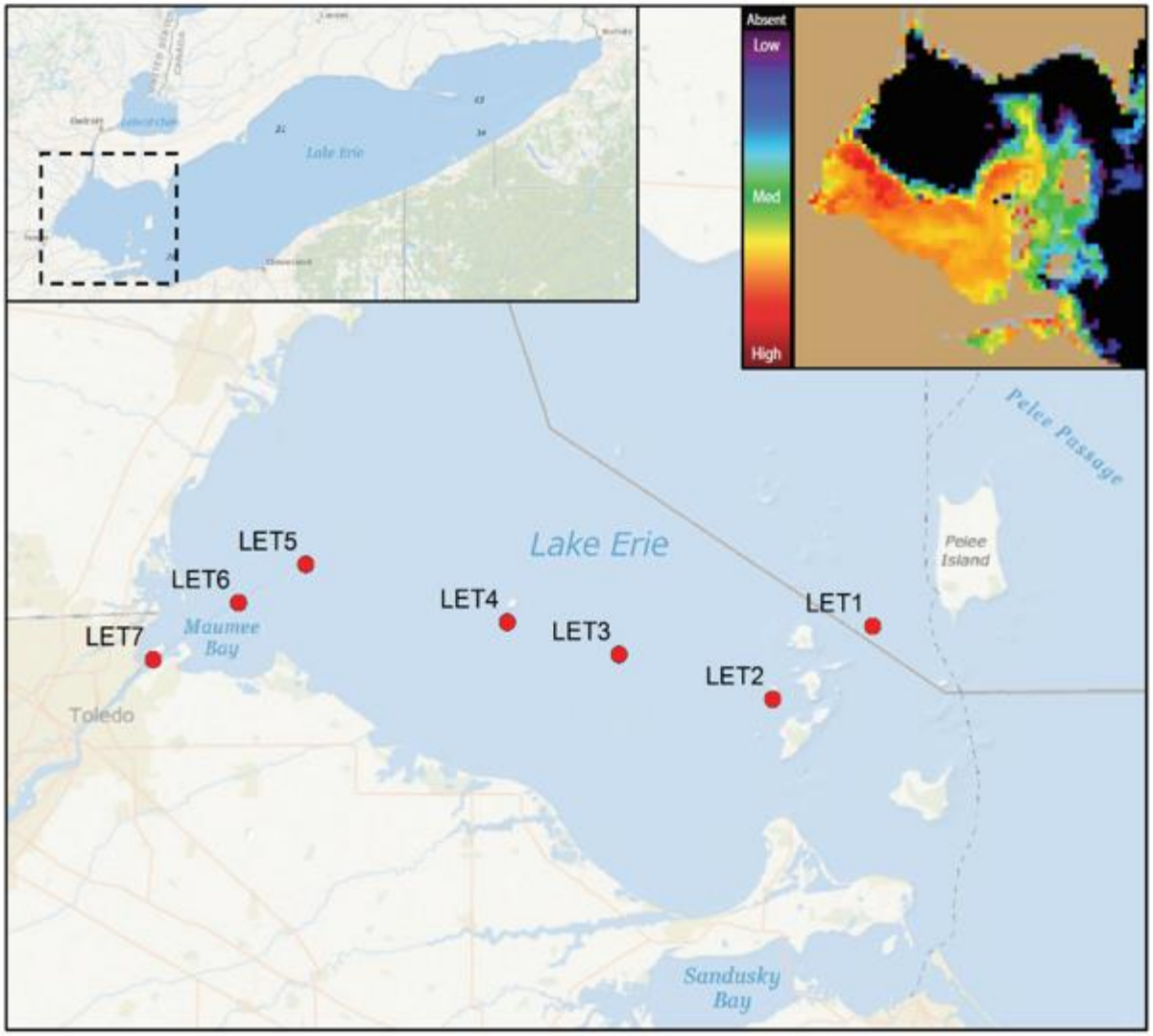
Microcystin synthesis genes up-regulated within 4 hours of exposure to increased N



Bars = Mean ± SE

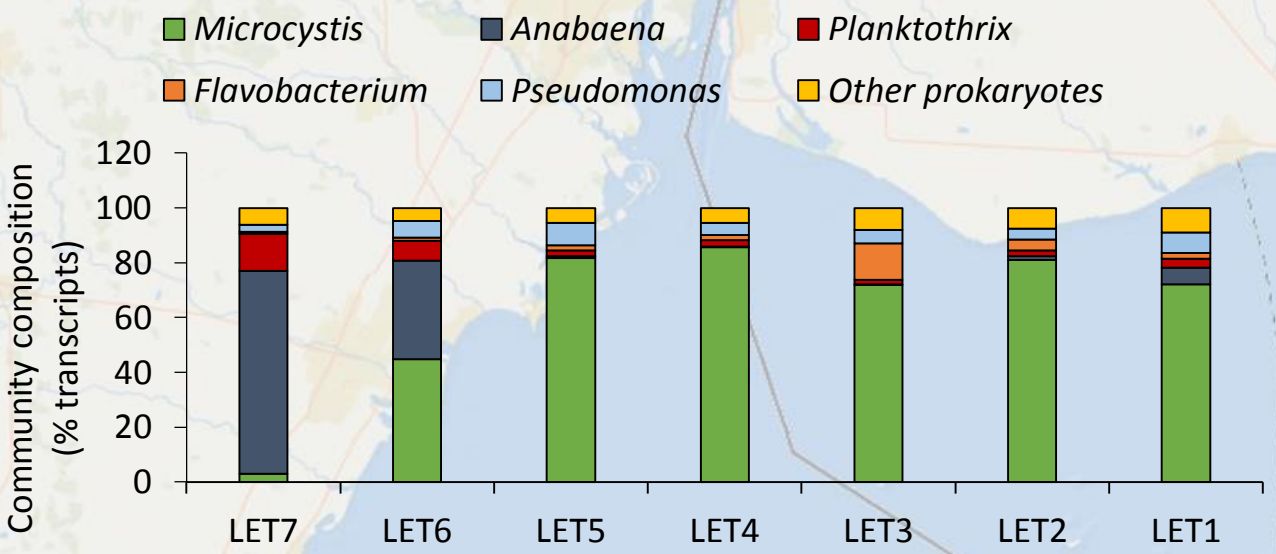
Chaffin, **Davis**, et al, 2018

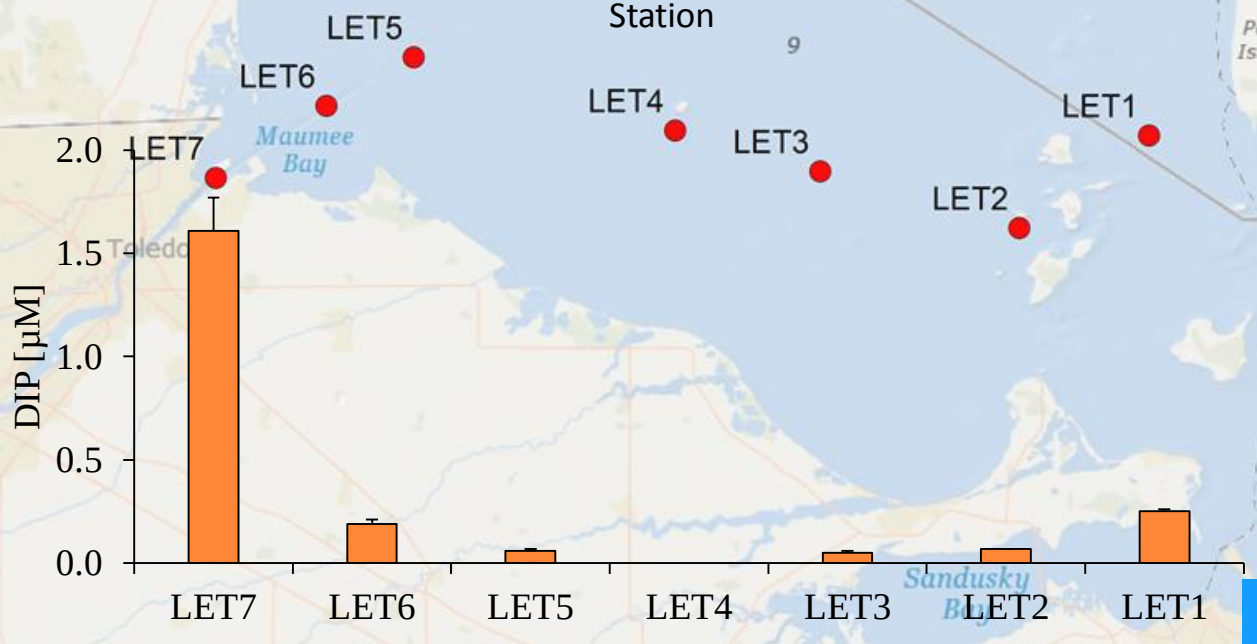
Eco-transcriptomic surveys of LE CHABs



Harke, **Davis** et al., 2016; ES&T

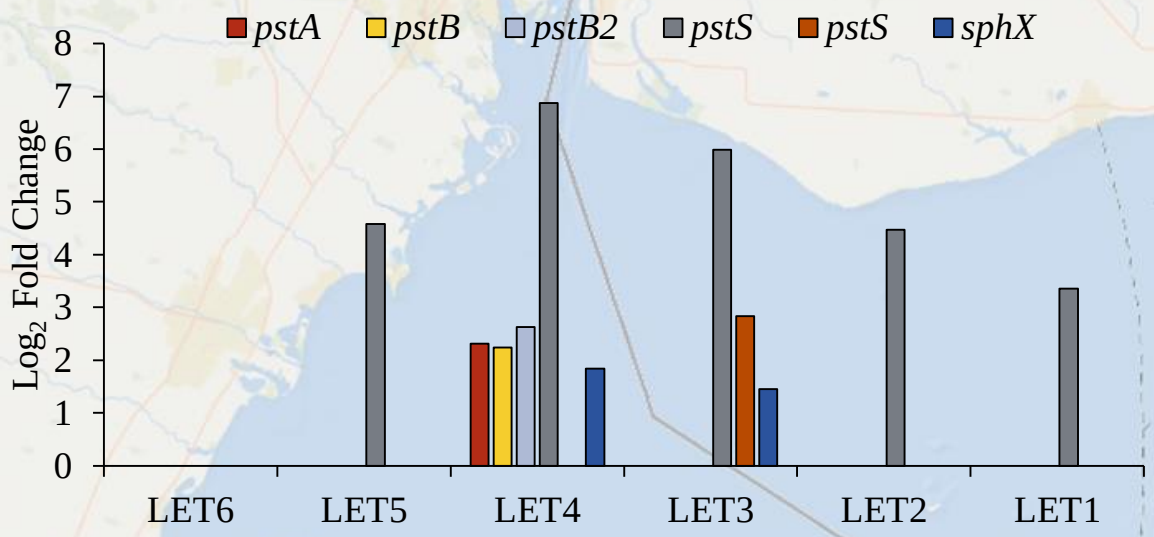
Niche differentiation among cyanobacterial populations



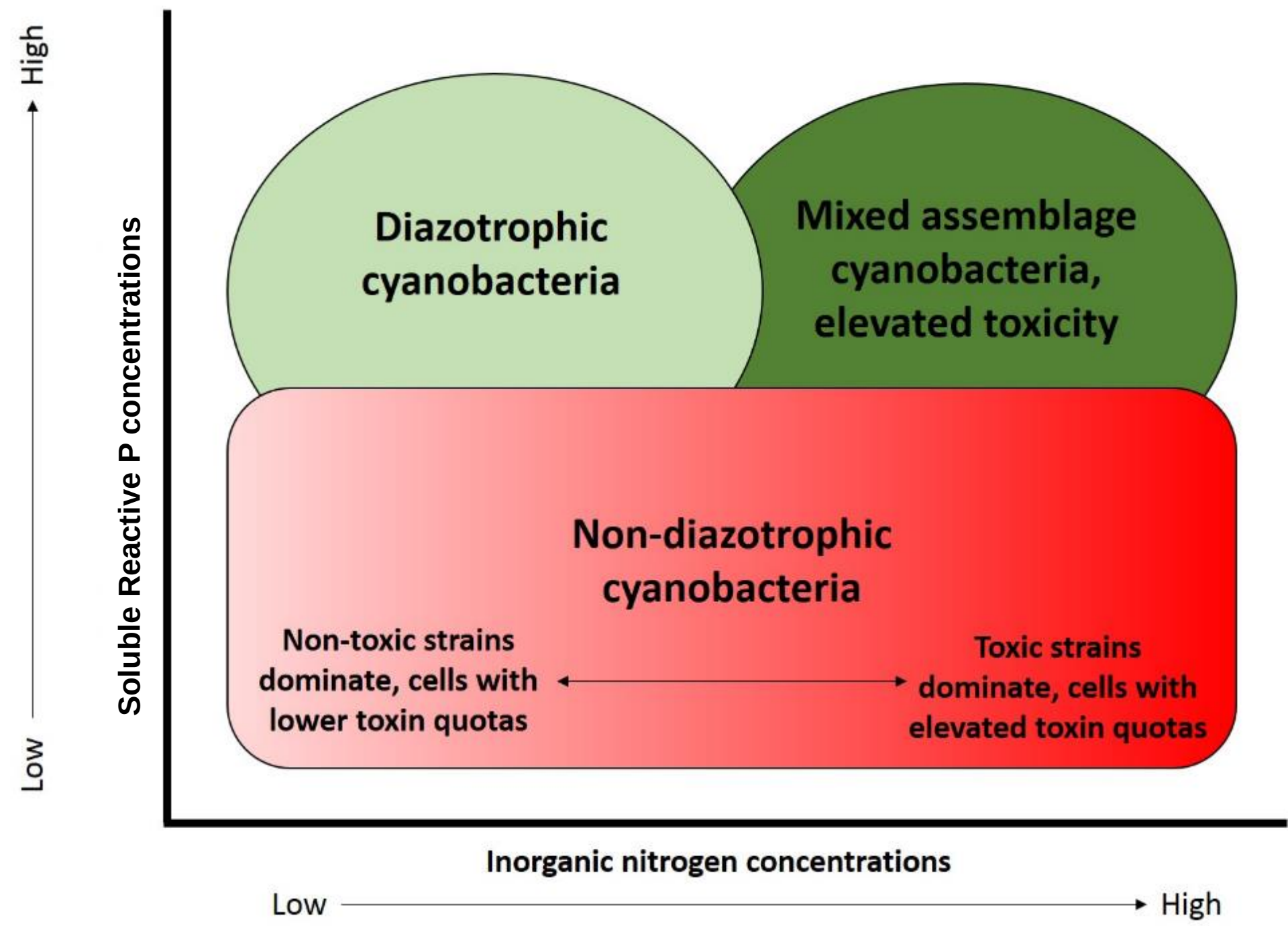


Harke, **Davis** et al., 2016; ES&T

Microcystis is an excellent P scavenger



Harke, **Davis** et al., 2016; ES&T



From: Gobler, Burkholder, **Davis**, et al., 2016, Harmful Algae

Blooms are more than microcystins!

Saxitoxins detected in waters across Ohio

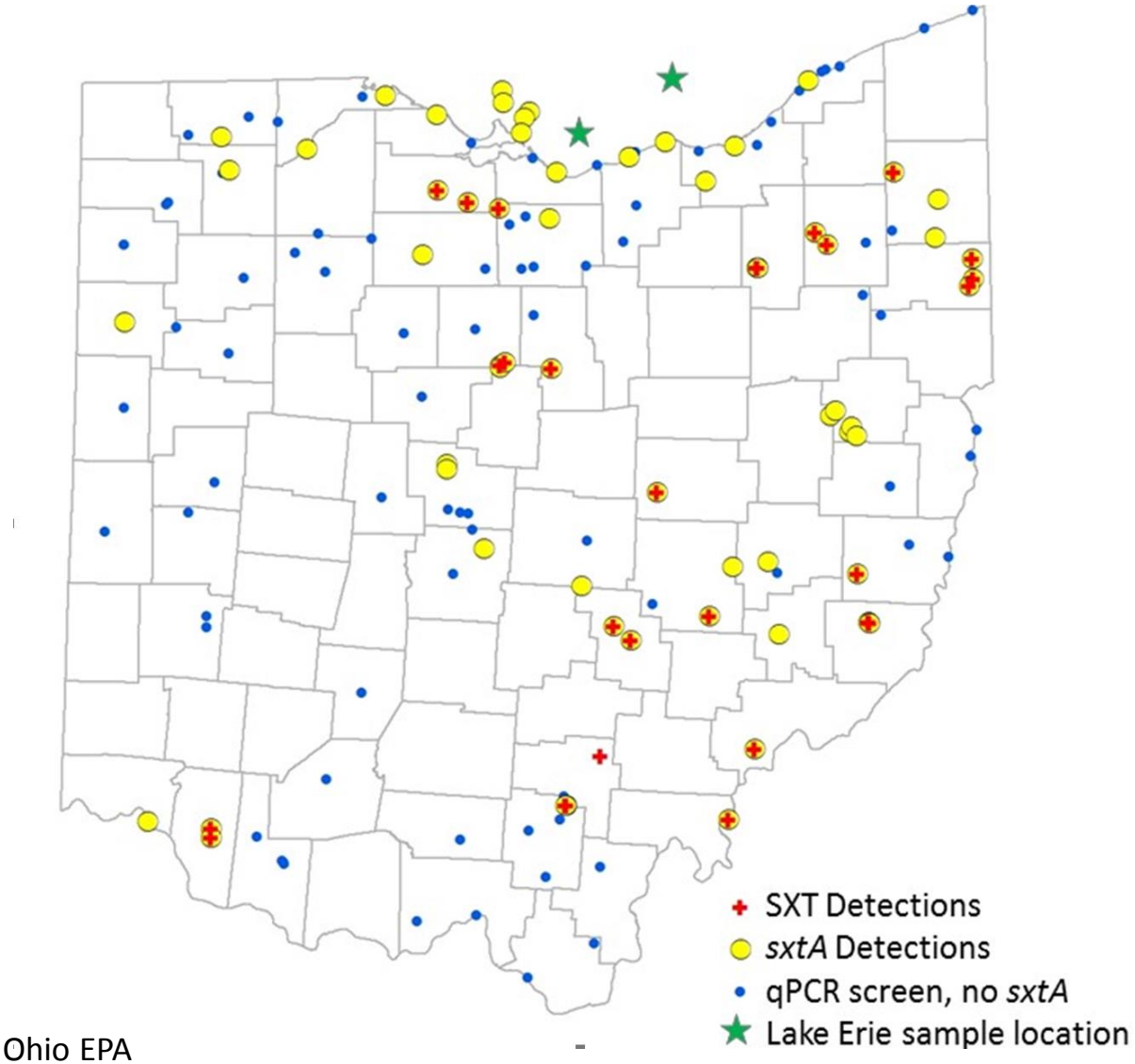
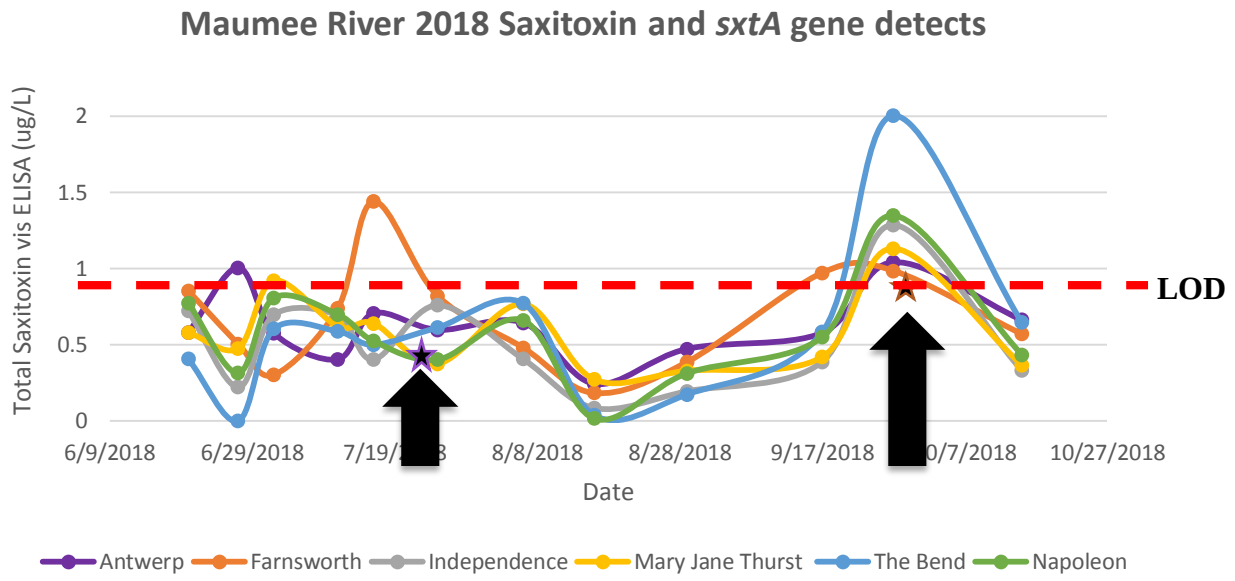


Figure: H. Raymond, Ohio EPA

Saxitoxin and sxtA detected in early and late bloom



- **Disconnect between gene hits and STX detection suggest benthic source**
- **Currently analyzing rock scraps from Maumee River collected in August 2018**

Cyr positive pelagic and benthic samples from Wilmington Reservoir sequenced

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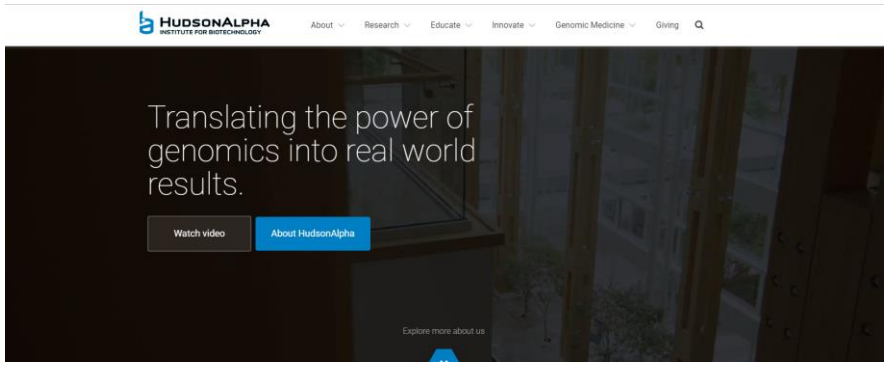
Client Sample ID	Date collected	*mcyE*	*anaC*	*sxtA*	*Cyr*
1-Scioto River Bicentennial Park	28/9/2017 1425	-	-	-	-
2-Evans East inlet Bottom River	12/9/2017 1340	-	-	-	-
3-Evan Dam Gottom Ponar	12/9/2017	-	-	-	-
4-Wimmington Small Res/Rock Scrapings	5/9/2017 1530	-	-	-	+
5-Evans-Struthors Dam Rock Scrape	12/10/2017	-	-	-	-
6-Wilmnington Small Res (1)	5/9/2017 1430	-	-	-	+
7-Evans Inlet bottom Ponar	12/9/2017 1302	-	-	-	-

mcyE = gene involved in microcystin production
anaC = gene involved in anatoxin production
sxtA = gene involved in saxitoxin production
Cyr = gene involved in cylindrospermopsin production



Ongoing temperature gradient experiments

***Each of the 10 temperatures are in triplicate for a total of 30 samples per experiment.**

Current Strains:

- CS-506: ***Cylindrospermopsis raciborskii*** strain from Australia, cylindrospermopsin producer.
- 1033: ***Planktothrix agardhii*** from Lake Erie, microcystin producer.

Future Strains:

- T3: ***Cylindrospermopsis raciborskii*** from Brazil, saxitoxin producer.
- CS-537/02: ***Dolichospermum circinale*** from Australia, saxitoxin producer.
- CS-337/01: ***Dolichospermum circinale*** from Australia, saxitoxin producer.
- CS-1031: ***Dolichospermum circinale*** from Australia, saxitoxin producer.
- CS-541/06: ***Dolichospermum circinale*** from Australia, saxitoxin producer.
- ***Aphanizomenon* sp.** from New Hampshire, saxitoxin producer.
- ***Scytonema* cf. *crispum*** from New Zealand, saxitoxin producer.
- 1025: ***Planktothrix agardhii*** from Lake Erie, microcystin producer.
- SAG 30.87: ***Anabaena flos-aquae*** from Canada, anatoxin producer.

Temperature Gradient Chamber

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Paul Matson
Michelle Neudeck
Emily Beers
Laura Reitz
Matthew Kennedy
Callie Nauman

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