Using advanced detection methods to understand the drivers of growth and toxicity of cyanoHABs in western Lake Erie

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NOAA

GLERL
Great Lakes Environmental Research Laboratory

Co-authors & Funding

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- **Duane Gossiaux, Steve Ruberg** – NOAA-GLERL
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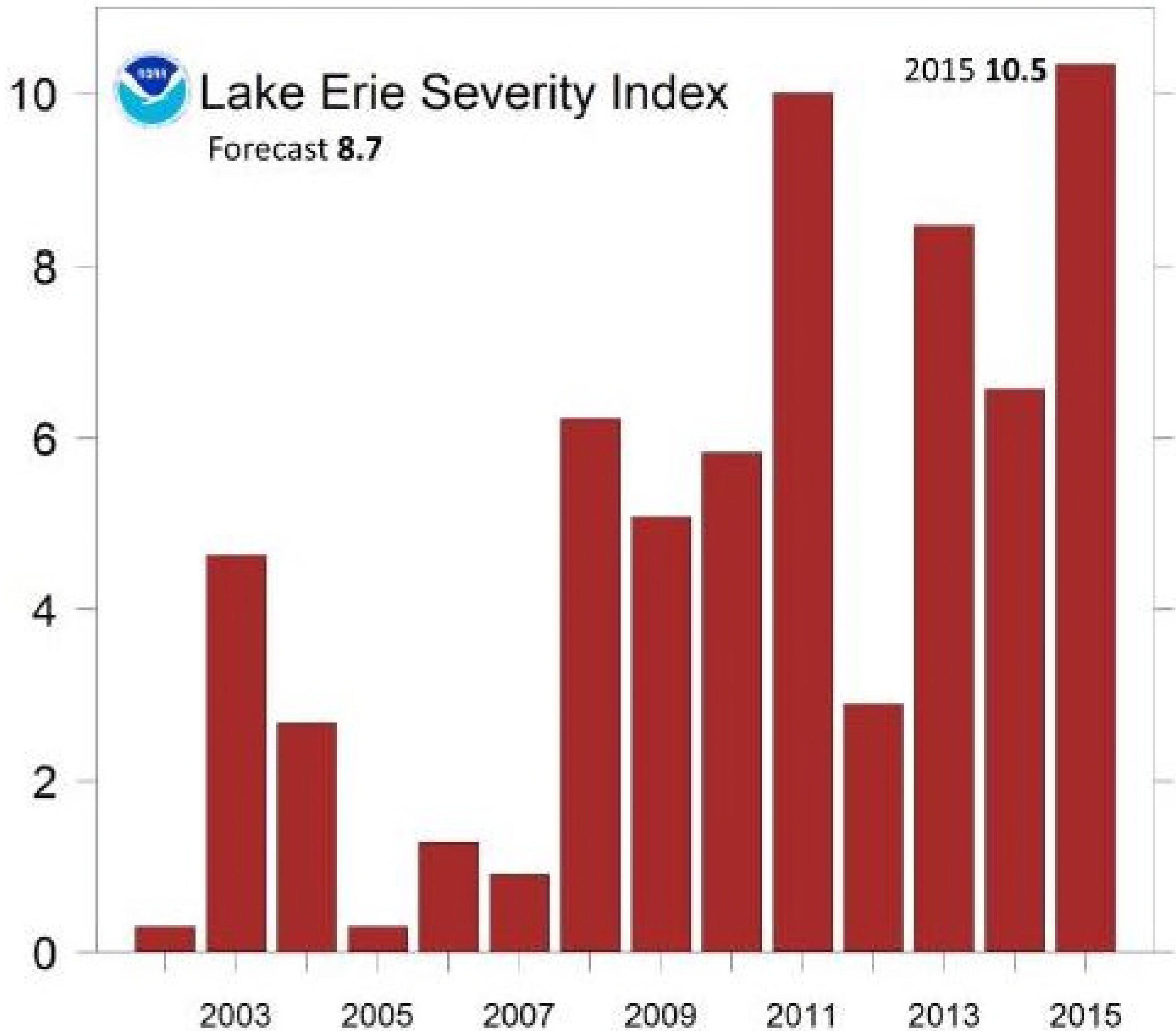
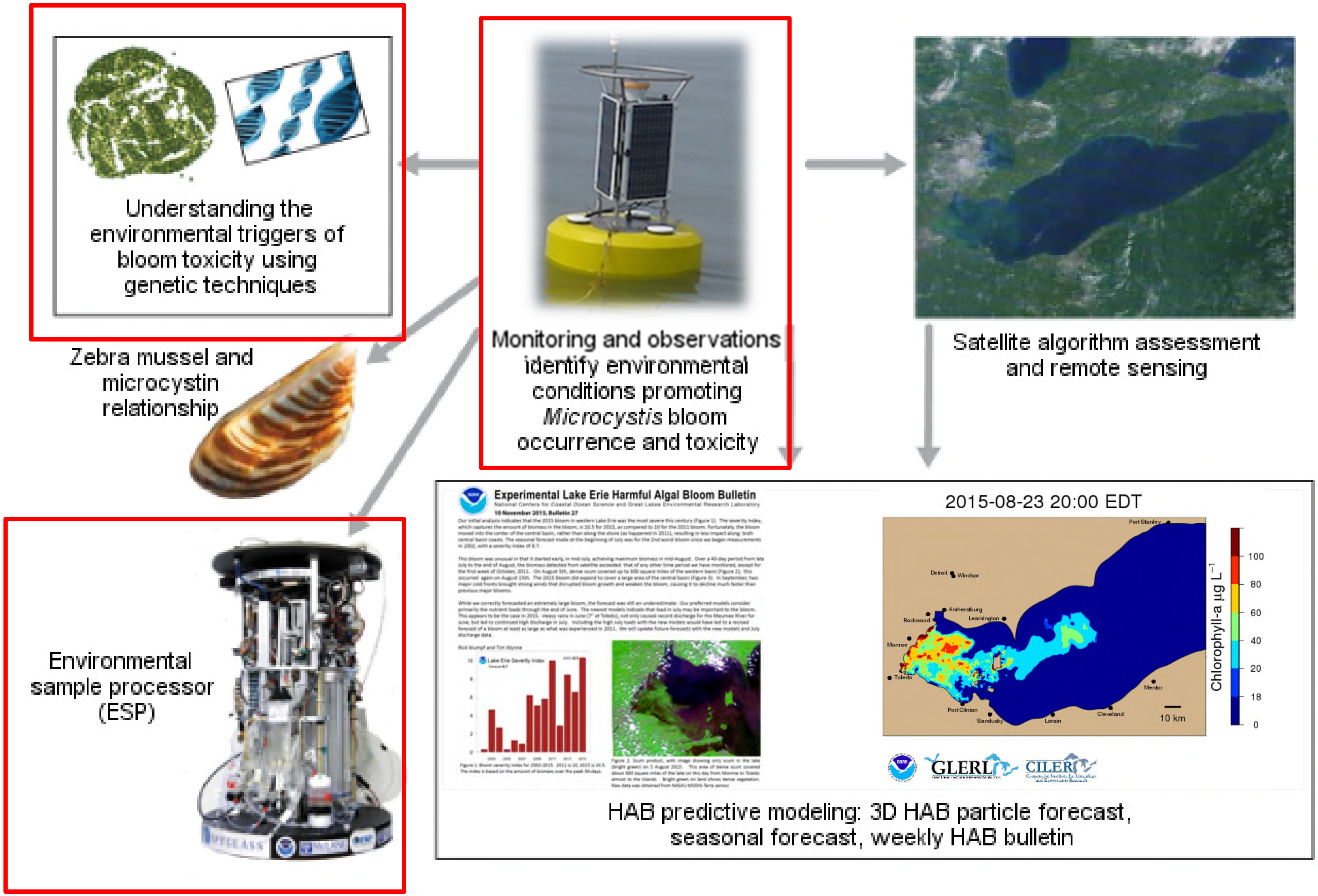
Lake Erie CHABs are increasing in severity



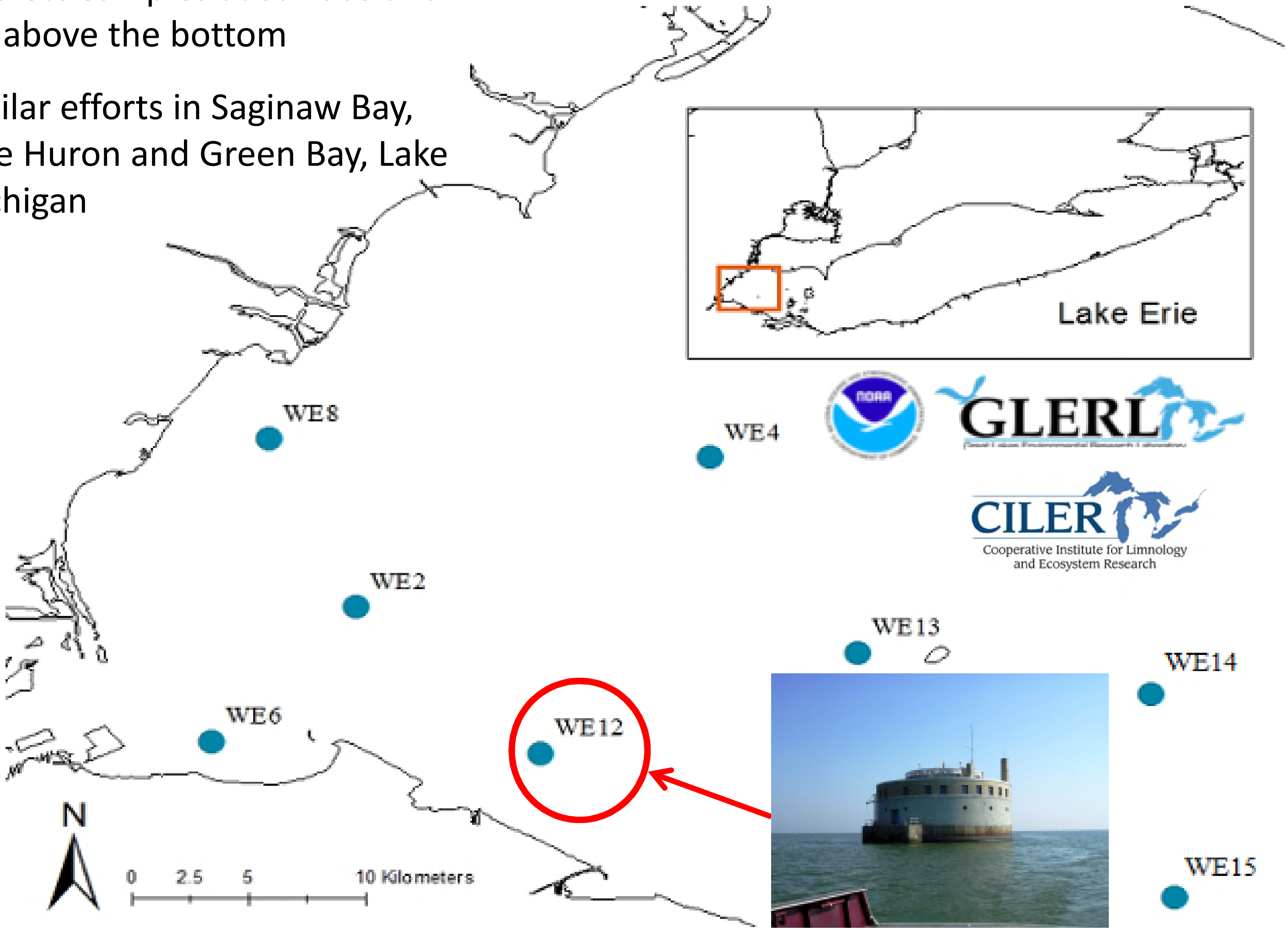
Richard Stumpf, Timothy Wynne, et al.

NOAA uses an integrated approach to study HABs



Western Lake Erie HAB monitoring

- Since 2009 (June – October)
- Discrete samples at surface and 1m above the bottom
- Similar efforts in Saginaw Bay, Lake Huron and Green Bay, Lake Michigan



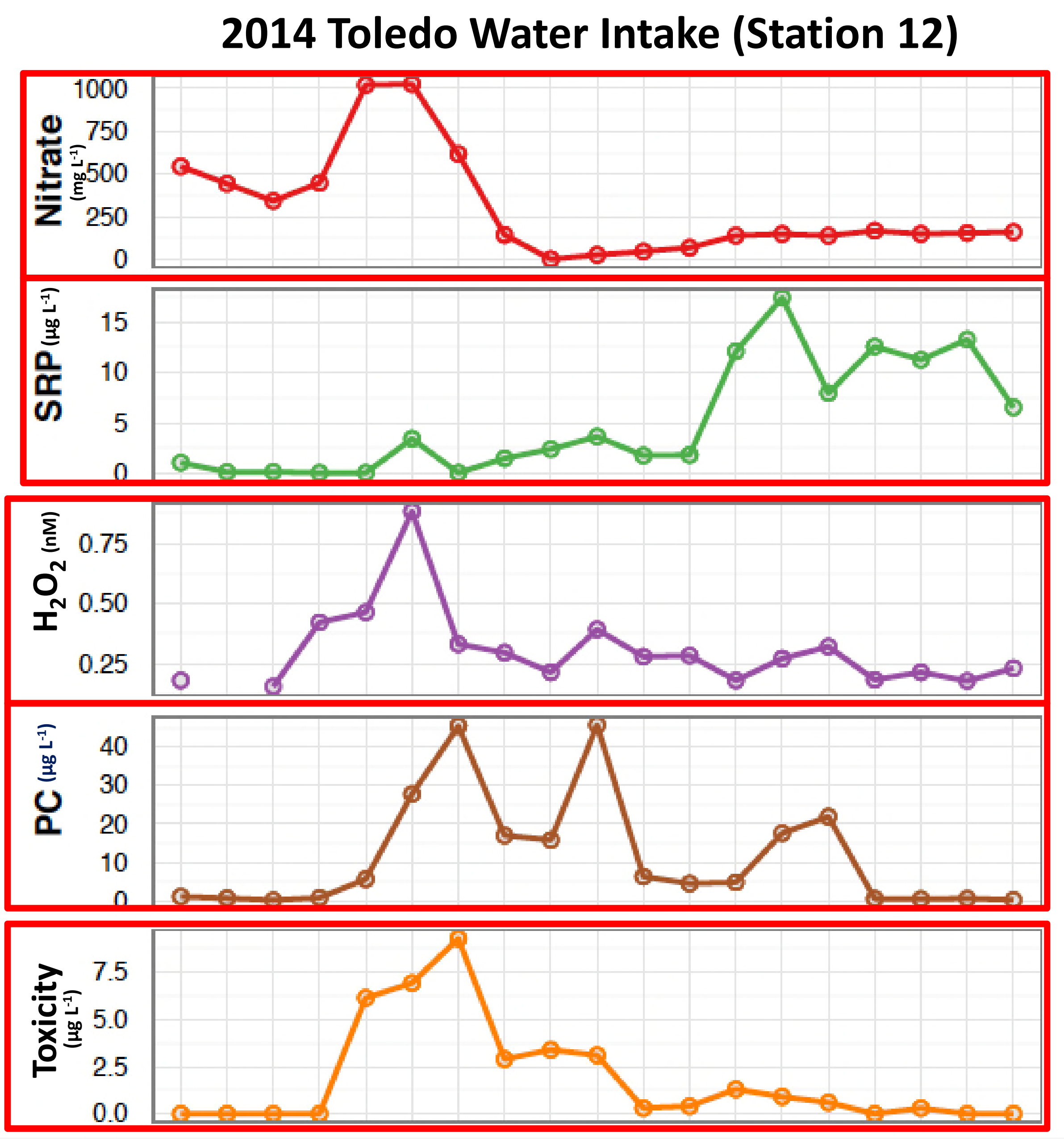
Weekly sampling reveals important trends that highlight potential environmental drivers and inform future experiments

- Toxicity changes throughout the bloom

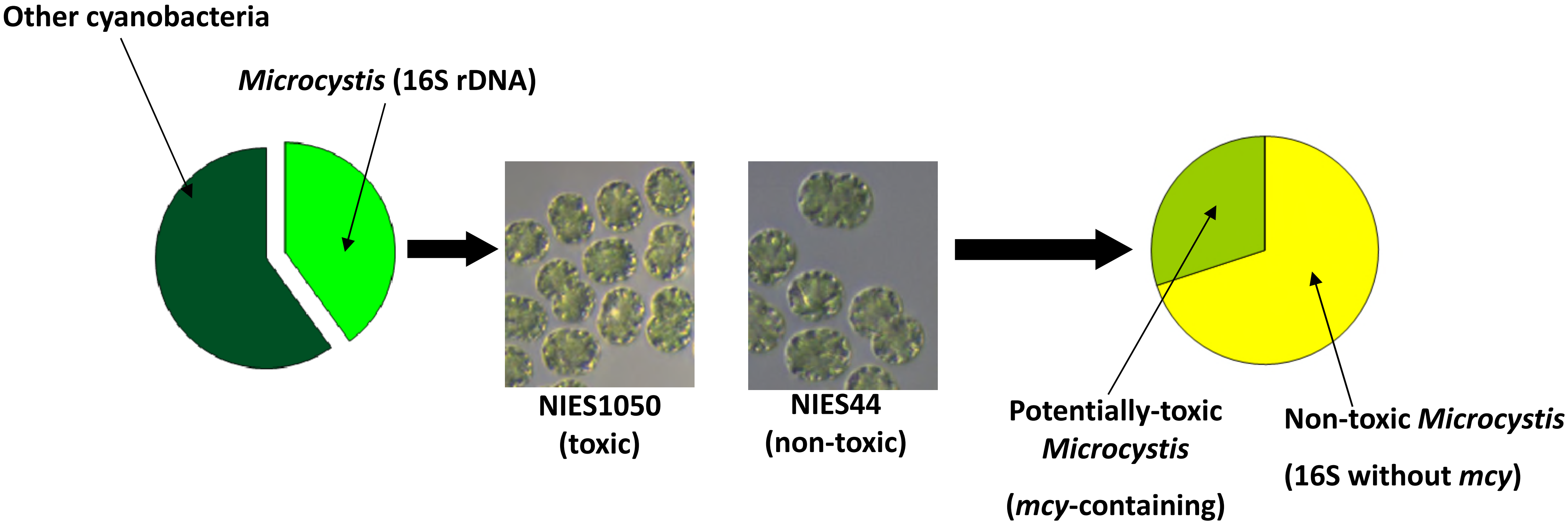
- Relationship between nitrogen and toxicity

- *Microcystis* blooms occur even when phosphorus concentrations are low

- Other factors beyond nutrients may be important in driving bloom structure and function



Analysis of *Microcystis* subpopulations:



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

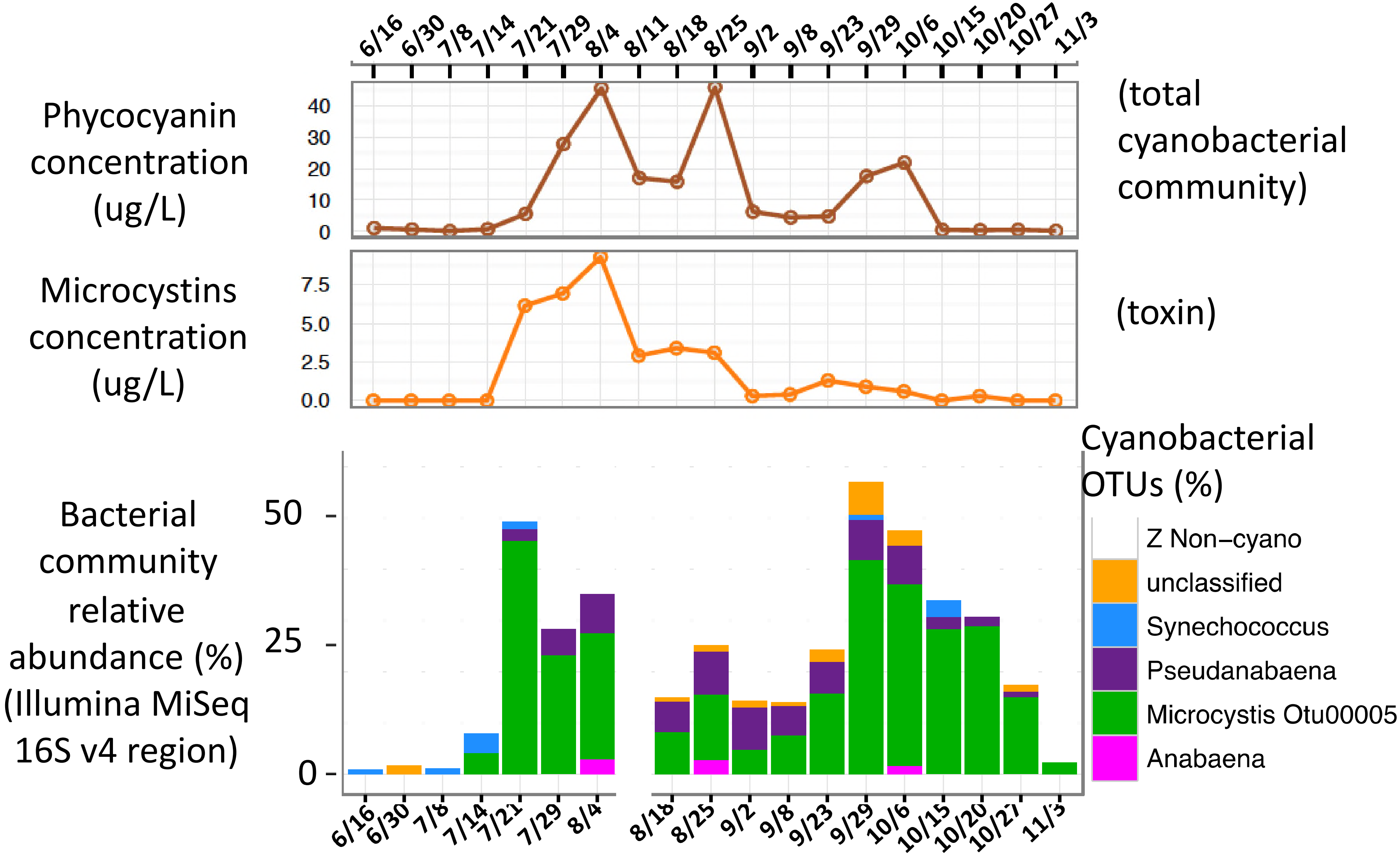
Determined by (1) qPCR and (2) metagenomics

What is omics?

biomolecule:	**DNA**	→	**mRNA**	→	**protein**
cellular function:	encodes genes and stores hereditary information		an intermediate of genes and proteins		structural (e.g., cell wall) and catalytic (mediates biochemical reactions)
omics approach:	genomics		transcriptomics		proteomics

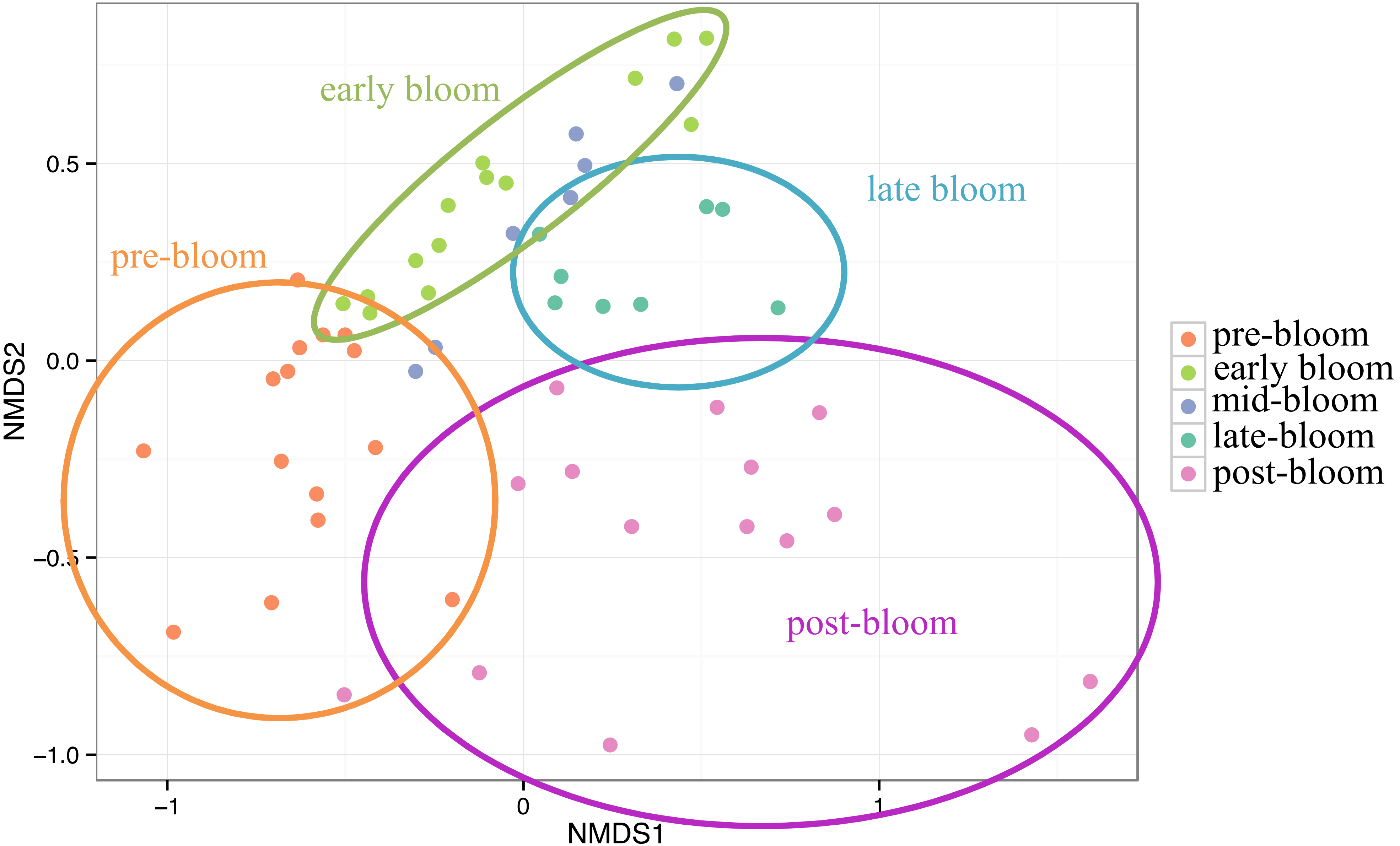
Dick and Lam, *Elements Magazine*, in review

The same *Microcystis* OTU dominates throughout the season



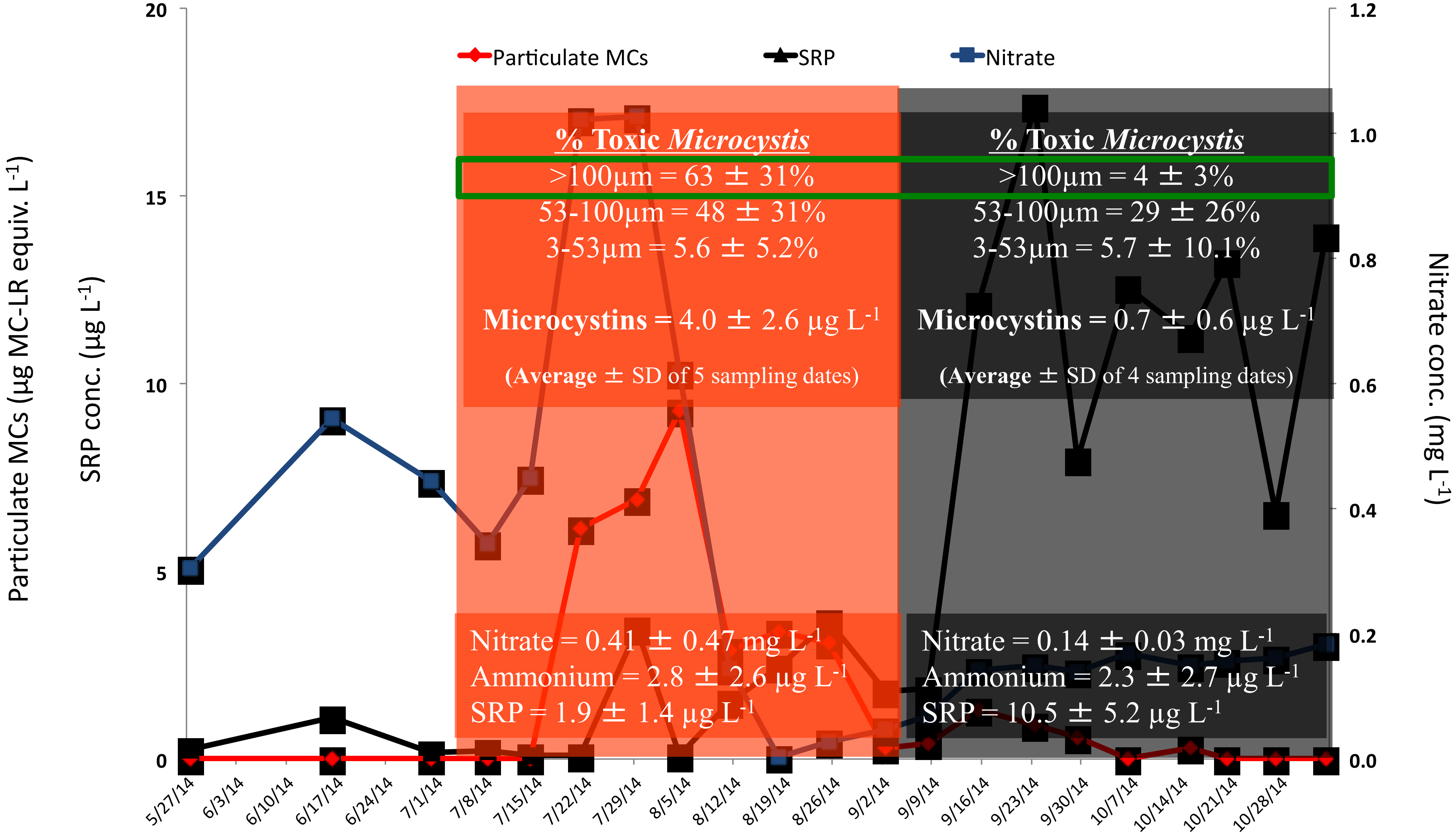
Berry, White, **Davis** et al., *submitted* to ISME J

Community shifts correlate with (1) seasonal parameters (e.g., temp) (2) the bloom (pH)

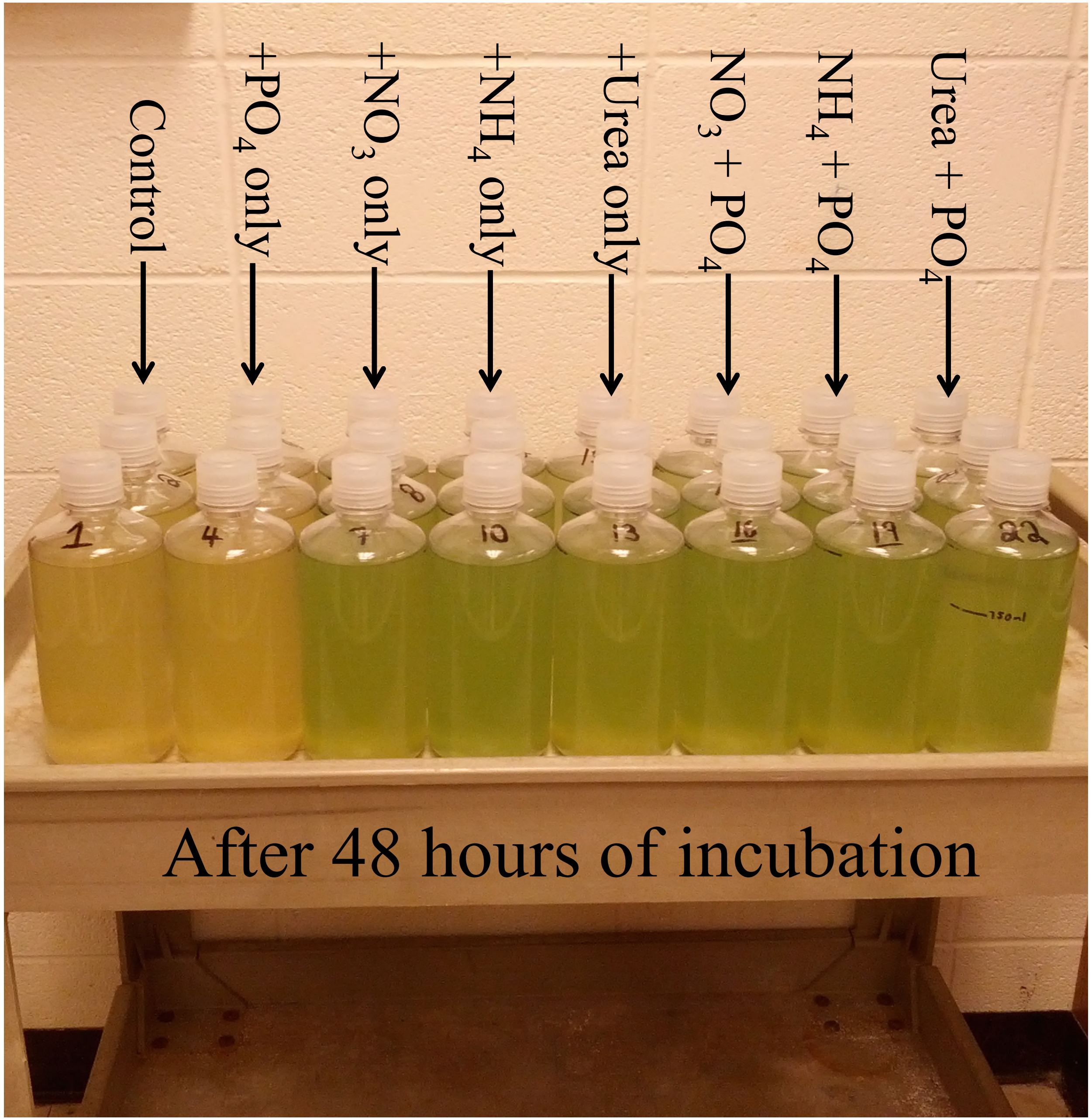


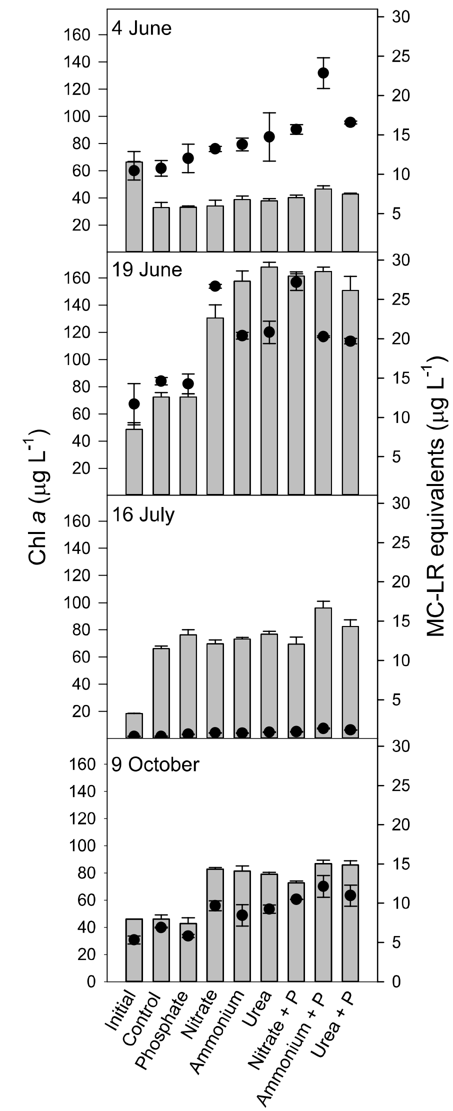
Berry, Cory, **Davis** et al., *submitted* to Environmental Microbiology

Toxic strains decline with lower nitrate concentrations



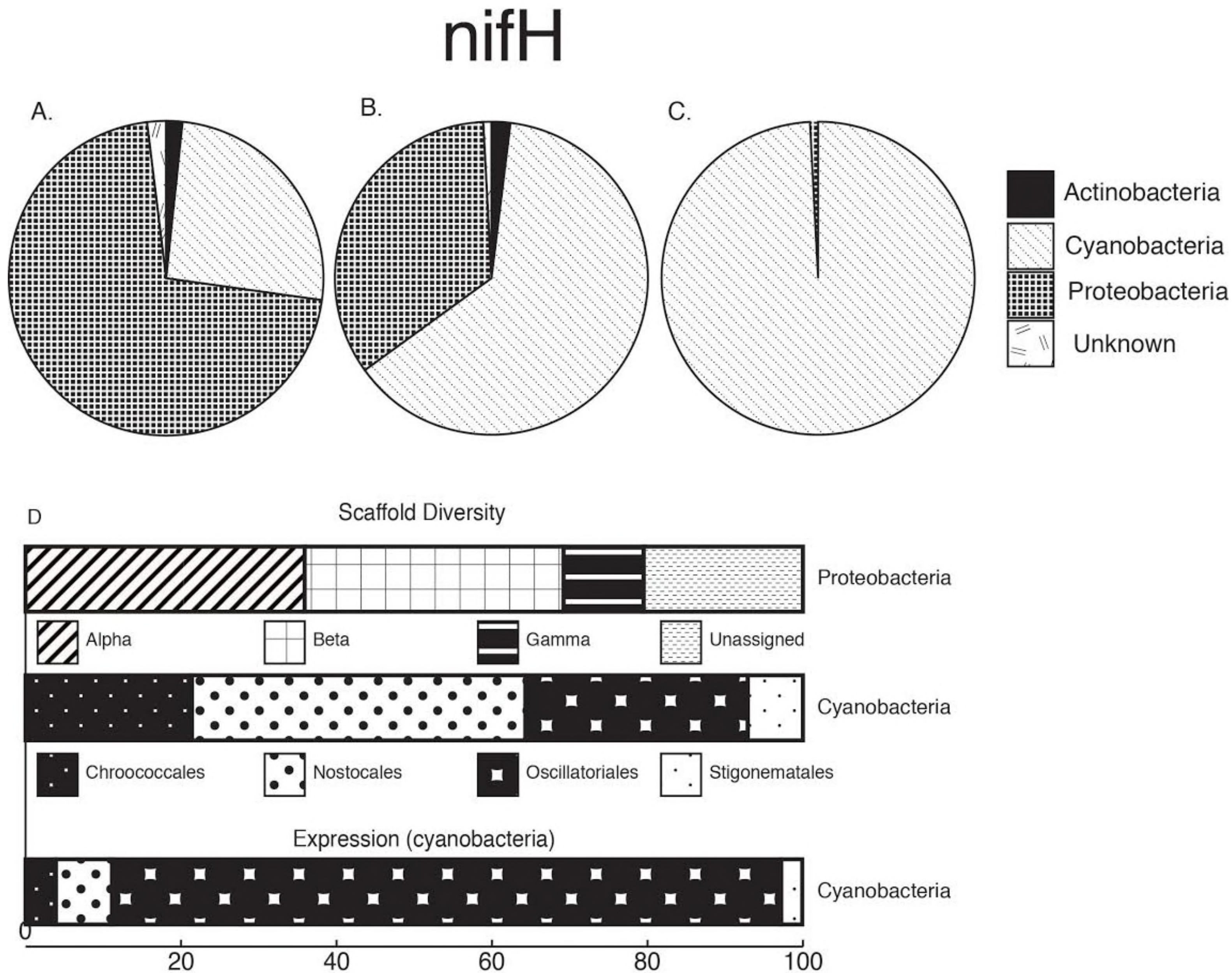
Nitrogen constrains growth and toxicity of *Planktothrix* in Sandusky Bay





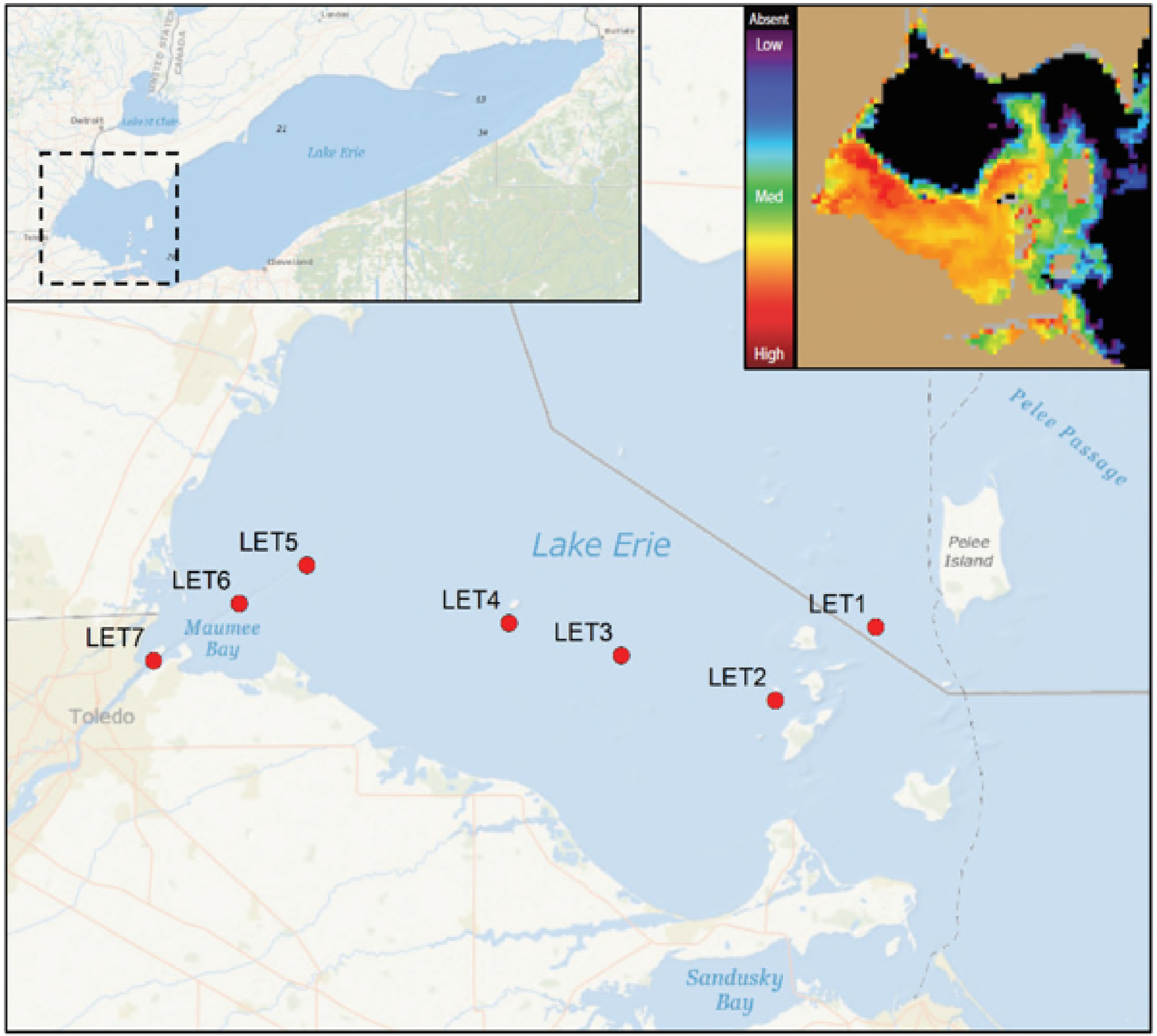
Davis et al., 2015 ES&T

Proteobacteria and *Cyanobacteria* dominate but cyanos are doing the work



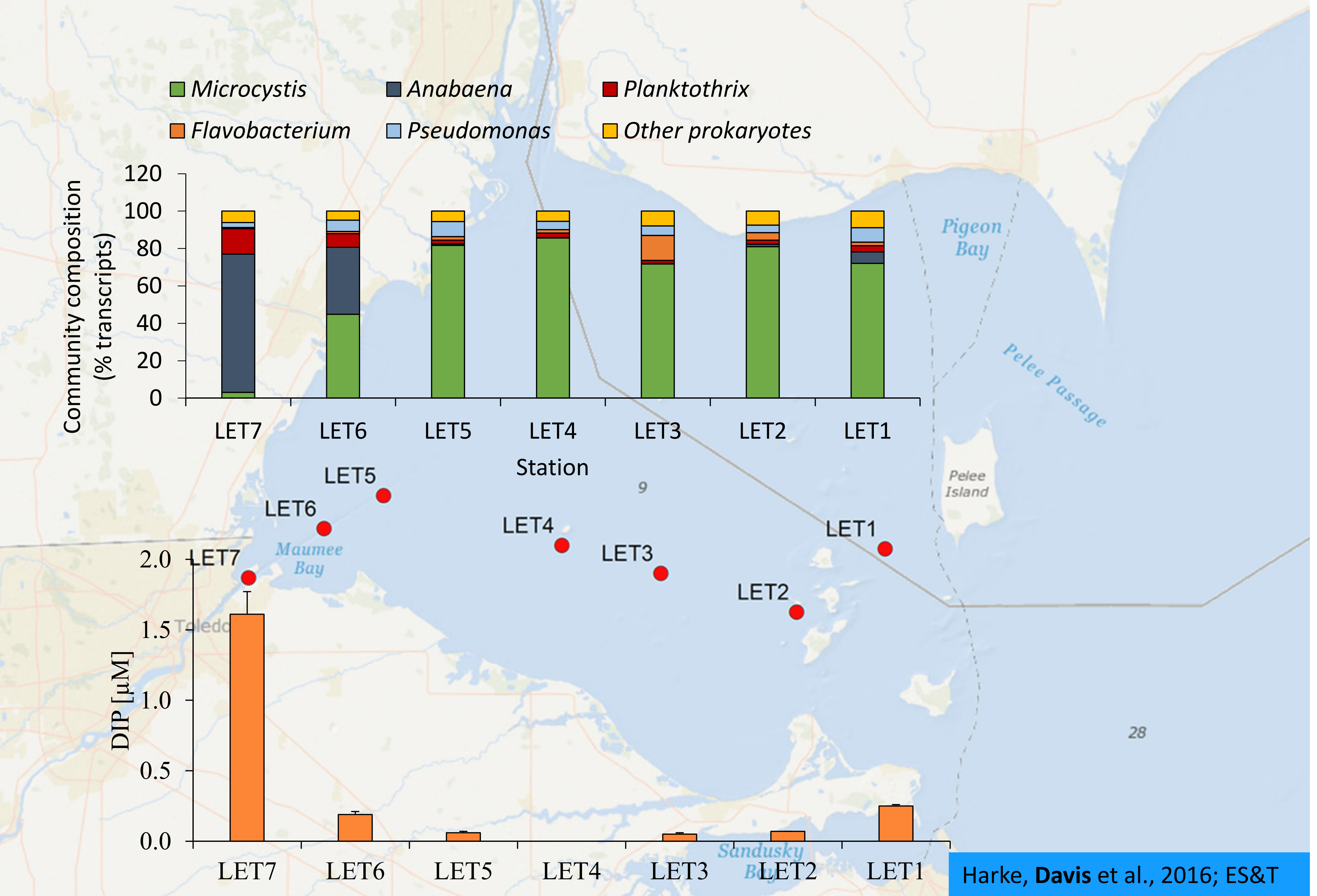
A. Scaffolds containing nifH (n = 55). B. Abundance of nifH-containing bacteria based on scaffold depth. C. nifH expression (read count of 36 expressed scaffolds) D. Assigned taxonomy for scaffolds of Proteobacteria and Cyanobacteria.

Eco-transcriptomic surveys of LE CHABs



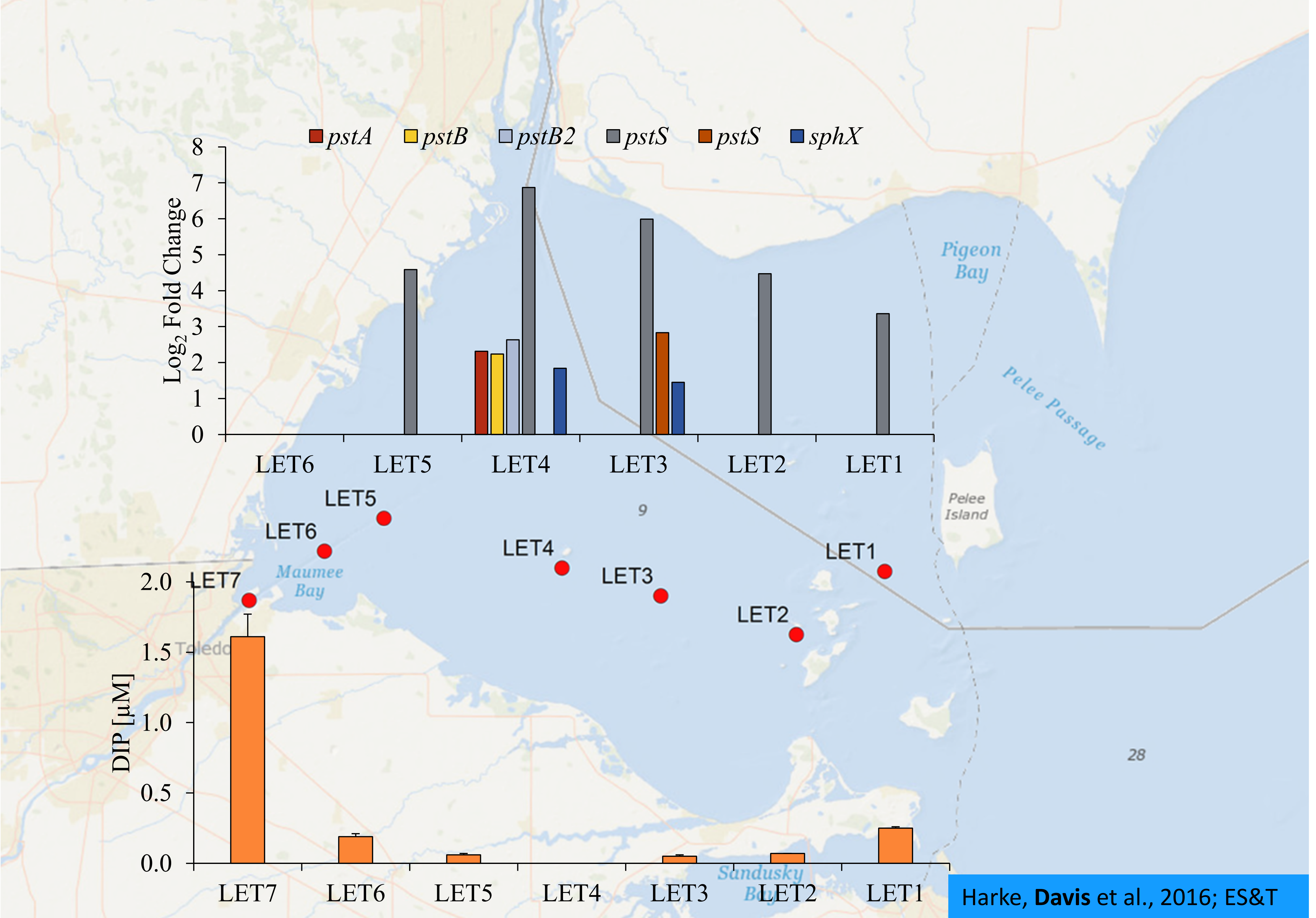
Harke, **Davis** et al., 2016; ES&T

Niche differentiation among cyanobacterial populations

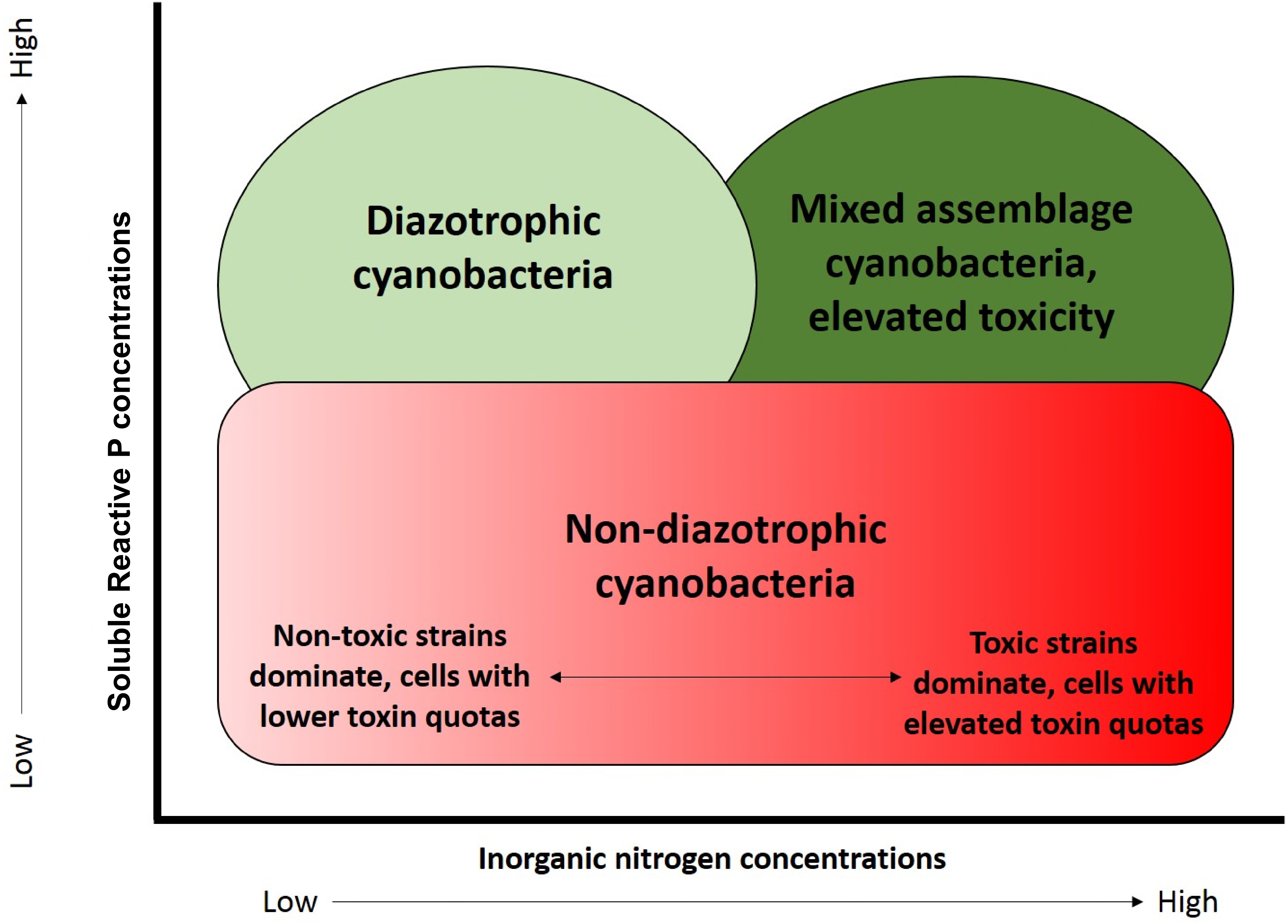


Harke, **Davis** et al., 2016; ES&T

Microcystis is an excellent P scavenger



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

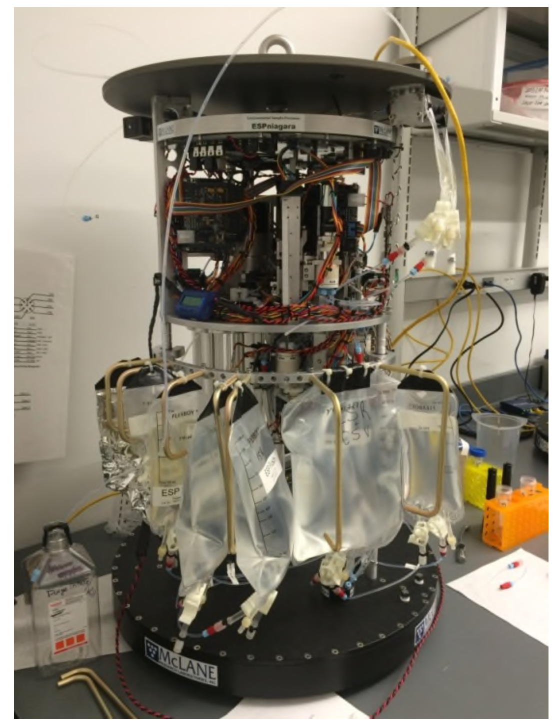


From: Gobler, Burkholder, **Davis**, et al., 2016, Harmful Algae

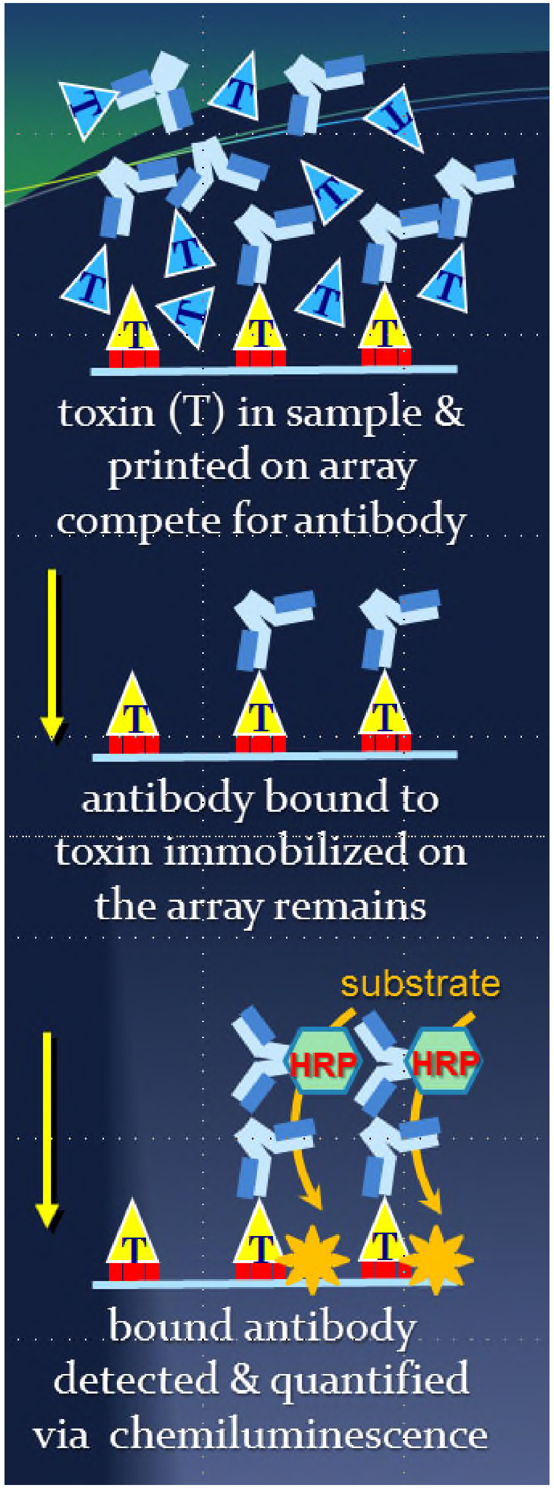
Environmental Sample Processor

- Autonomous, *in-situ*, electromechanical robotic instrument
- Acquires, processes, and analyzes samples for molecular-based detection and measurement of organisms and their metabolites
- Allows for near real-time detection of HABs and their toxins (including cyanotoxins)
- Will be valuable in developing toxicity forecasting models

Arial image of HAB in Lake Erie



ESP*niagara*

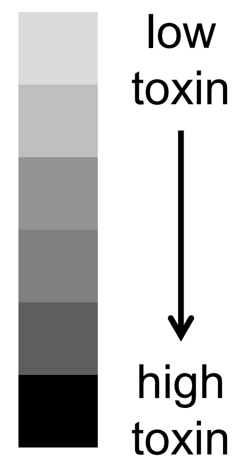


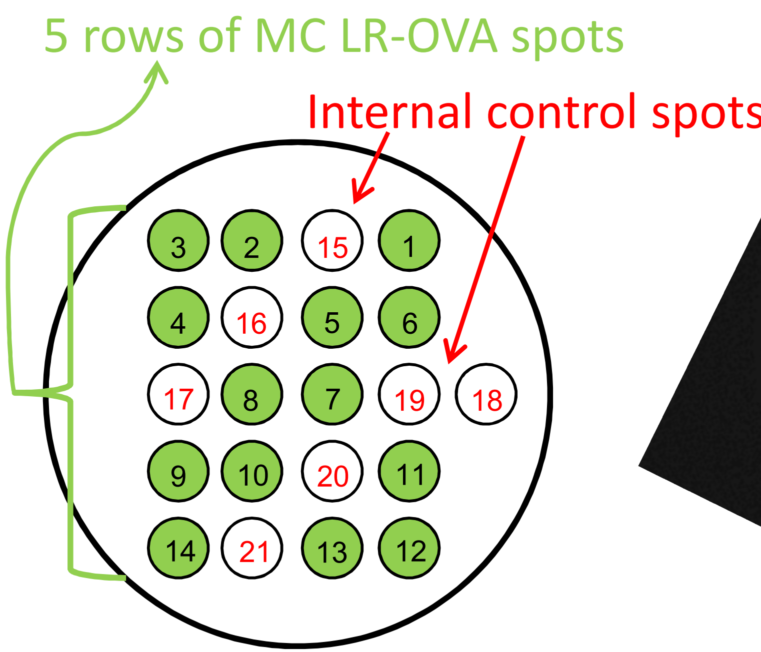
Toxin extraction

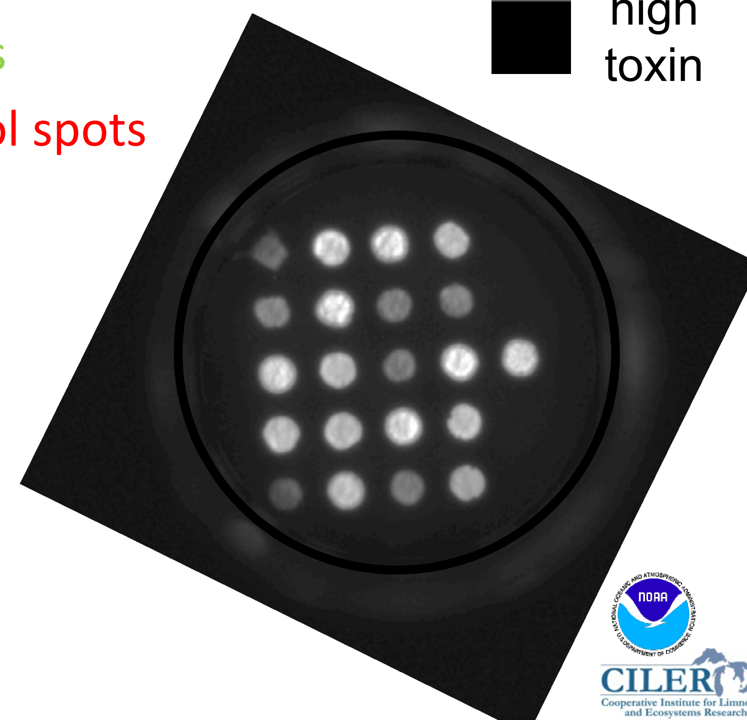
- Utilizes ZyGEM©+ Heat + Pressure
- Recover rate ≥ 95%

MC cELISA Development

- Formatted as a competitive immunoassay
- Incorporates an 'ADDA specific' monoclonal antibody
- Employs membrane-based toxin arrays
- Range of Quantification ~1 order of magnitude: 2.9-27.3ng/mL







Deployment of ESP*niagara*

Bolted lifting assembly

Pressure housing for ESP – Rated to 48 m depth

3-way sample valve

Sampling manifold

ESP battery assemblies (and opposite)

Each hold 200 D cell batteries

Tagline attachment points

- 5’6” tall
- 5ft x 5ft footprint
- < PSI pressure on footprint
- Deck weight ~ 1800 lbs
- In-water weight ~ 750lbs

June ‘16

Test of communication system and general operations

July

Science testing at Ohio State University Stone Laboratory on South Bass/Gibraltar Islands

Sept/Oct

Full Mission Deployment

- Microcystin sampling every other day
- Archived samples for future DNA sequencing

Questions?