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

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Co-authors & Funding

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Lake Erie CHABs are increasing in severity

NOAA uses an integrated approach to study 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
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:

% **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
What is omics?

Dick and Lam, *Elements Magazine*, in review
The same *Microcystis* OTU dominates throughout the season

Phycocyanin concentration (ug/L)

Microcystins concentration (ug/L)

Bacterial community relative abundance (%) (Illumina MiSeq 16S v4 region)

Cyanobacterial OTUs (%)

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

**Particulate MCs (µg MC-LR equiv. L⁻¹)**

- Nitrate = 0.41 ± 0.47 mg L⁻¹
- Ammonium = 2.8 ± 2.6 µg L⁻¹
- SRP = 1.9 ± 1.4 µg L⁻¹

**SRP conc. (µg L⁻¹)**

- Microcystins = 4.0 ± 2.6 µg L⁻¹
- % Toxic Microcystis
  - >100µm = 63 ± 31%
  - 53-100µm = 48 ± 31%
  - 3-53µm = 5.6 ± 5.2%

**Nitrate**

- Nitrate = 0.14 ± 0.03 mg L⁻¹
- Ammonium = 2.3 ± 2.7 µg L⁻¹
- SRP = 10.5 ± 5.2 µg L⁻¹

**Microcystins**

- Microcystins = 0.7 ± 0.6 µg L⁻¹
- % Toxic Microcystis
  - >100µm = 4 ± 3%
  - 53-100µm = 29 ± 26%
  - 3-53µm = 5.7 ± 10.1%

*(Average ± SD of 4 sampling dates)*
Nitrogen constrains growth and toxicity of *Planktothrix* in Sandusky Bay

After 48 hours of incubation
Proteobacteria and Cyanobacteria dominate but cyanos are doing the work.
Eco-transcriptomic surveys of LE CHABs

Harke, Davis et al., 2016; ES&T
Niche differentiation among cyanobacterial populations

Community composition (% transcripts)

- Microcystis
- Anabaena
- Planktothrix
- Flavobacterium
- Pseudomonas
- Other prokaryotes

Station LET1

Maumee Bay

DIP [μM]

LET7 LET6 LET5 LET4 LET3 LET2 LET1

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
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 ESPniagara

Bolted lifting assembly

Pressure housing for ESP
- Rated to 48 m depth

- 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

ESP battery assemblies (and opposite)
Each hold 200 D cell batteries

3-way sample valve
Sampling manifold
Tagline attachment points
Questions?