High Frequency Monitoring of cyanoHABs Dynamics

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Prediction of cyanoHAB/toxin events

Questions

- Which biotic/abiotic factors drive cyanobacterial communities and cyanotoxin production?
- Are there environmental or molecular measures which can indicate impending blooms and cyanotoxin production?
- How does sampling frequency impact the picture provided by monitoring?
- What are the challenges and opportunities of reservoir hydrology in HAB dynamics and management?
- Goal

Reactive->Proactive Risk Management

Study Approach

- Leverage a variety of monitoring parameters
- Collect data/samples at a frequency which can capture variability of the system
- Develop relationships between observed parameters and bloom status
- Provide near-term predictive capabilities to focus cyanotoxin monitoring

HAB monitoring tools

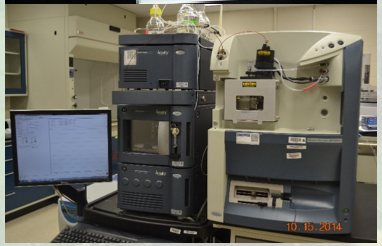
HF Physico-chemical
- Water Quality
  - Temp
  - pH
  - ORP
  - Sp Cond
  - Turbidity
  - Dis Oxygen
  - TOC
  - DOC
  - NO_3-N
  - UV-Vis spectra
- PAR
- Weather

Wet Chemistry
- Total Nitrogen
- NO_2-NO_3
- NO_2
- Total NH_4
- Total Phosphorous
- Total Reactive Phosphorous

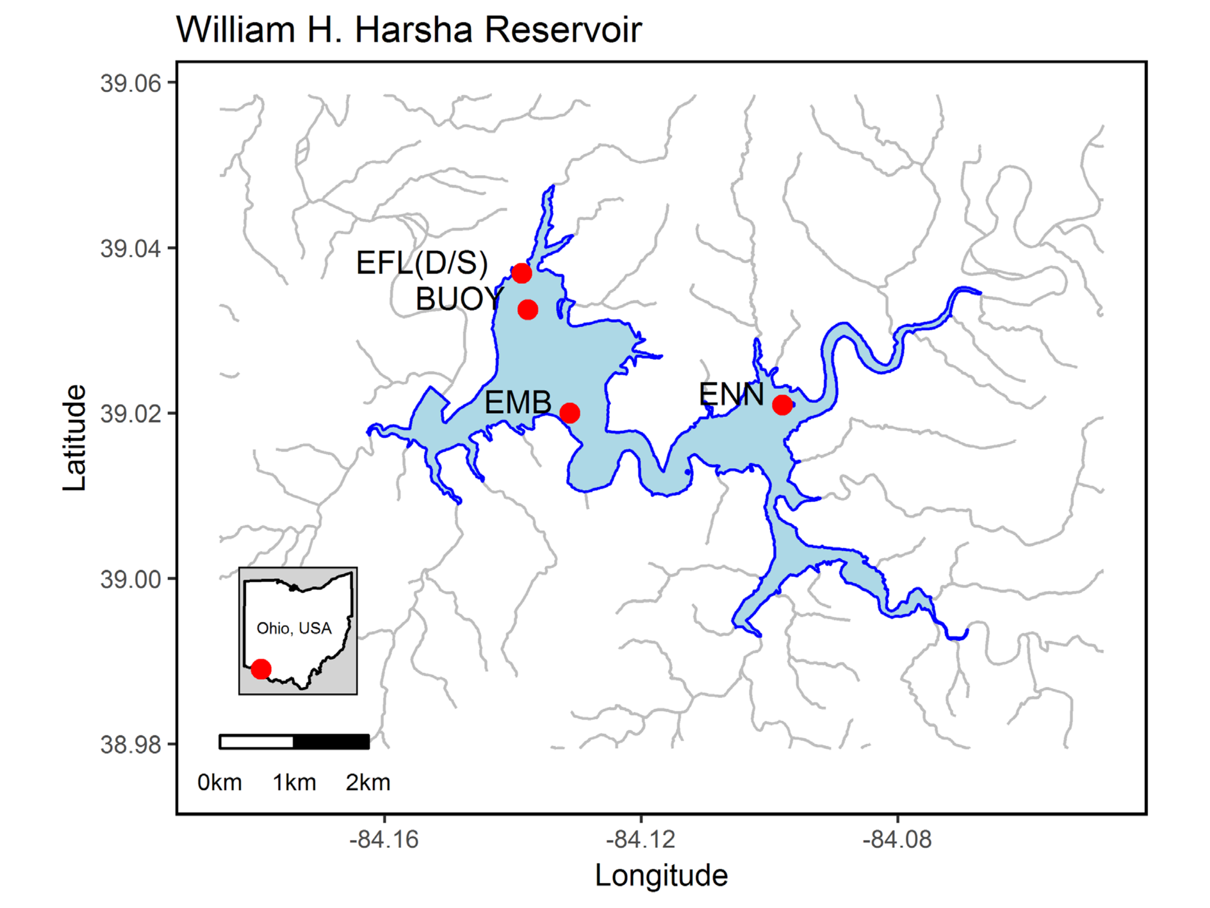
Phototroph Dynamics
- *In-vivo* Fluorescence
  - Phycocyanin
  - Chlorophyll
  - Other pigments
    - Diatoms
    - Cryptophyta
- Microscopic enumeration

Molecular Markers
- Next Gen Sequencing
  - 16S rRNA gene
  - 18S rRNA gene
  - Cytochrome oxidase
  - Metagenome
  - Metatranscriptome
- qPCR/RT-qPCR assays
  - Toxin specific gene assays

Cyanotoxin Analysis
- ELISA
  - MC-ADDA
- LC-MSMS
  - MC congeners
  - Cylindrospermopsin
  - Anatoxin-a
  - MMPB

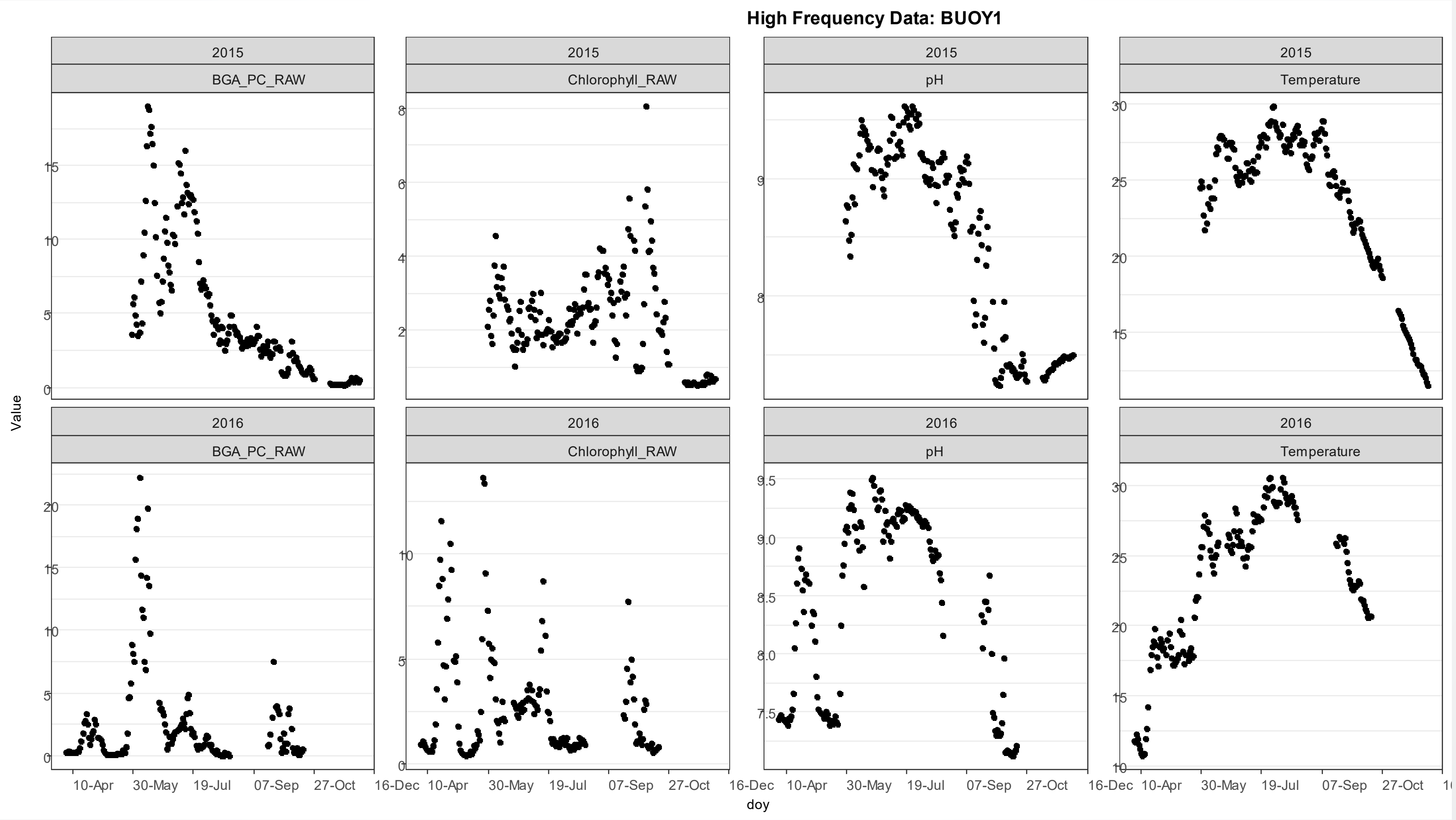


Lake Harsha, Clermont County, OH



- Watershed Area
  - 342 miles^2
- Summer Pool Elevation
  - 733 ft
- Summer Pool Area
  - 2000 acres
- Water Quality Data since 2012 at 3 week intervals

High frequency parameters



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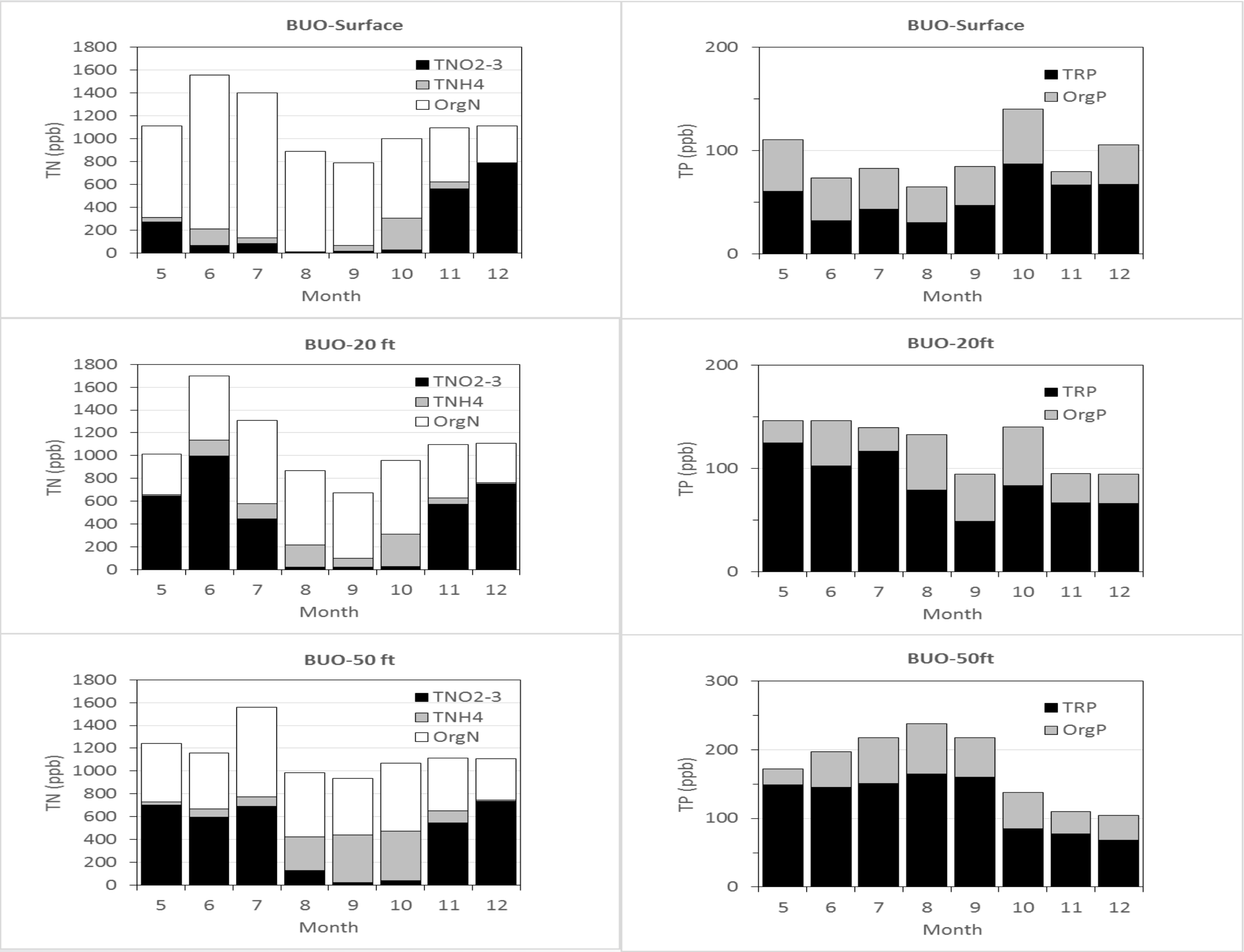
Nutrients



- Interior plateau ecoregion Targets
  - TN = 688 ppb
  - TP = 34 ppb
- Lake Harsha lake is well above these levels most of the time especially for TP.
- Depth profiles among sampling sites suggest the hypolimnion as a source of NH_4^+ and TRP
  - Concentrations increase until fall turn over
- Inorganic nutrients deplete in the surface waters by early summer, while organic fractions tend to dominate, presumably as live algae.

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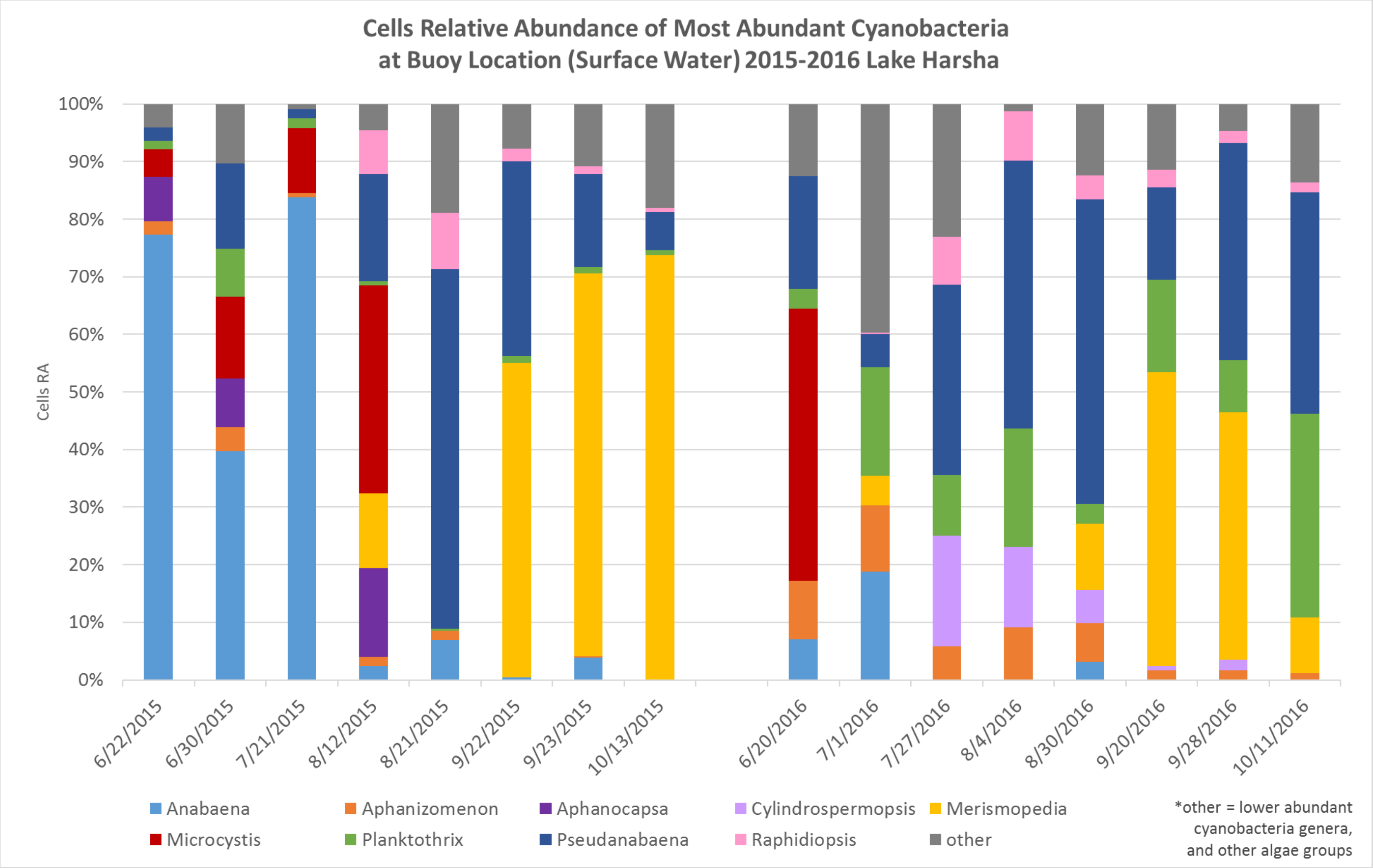
Phytoplankton dynamics



- 2015 and 2016 summer cyanobacteria relative abundances
- Cyanobacteria community is diverse and changes as season progresses
- Inter-annual differences are significant

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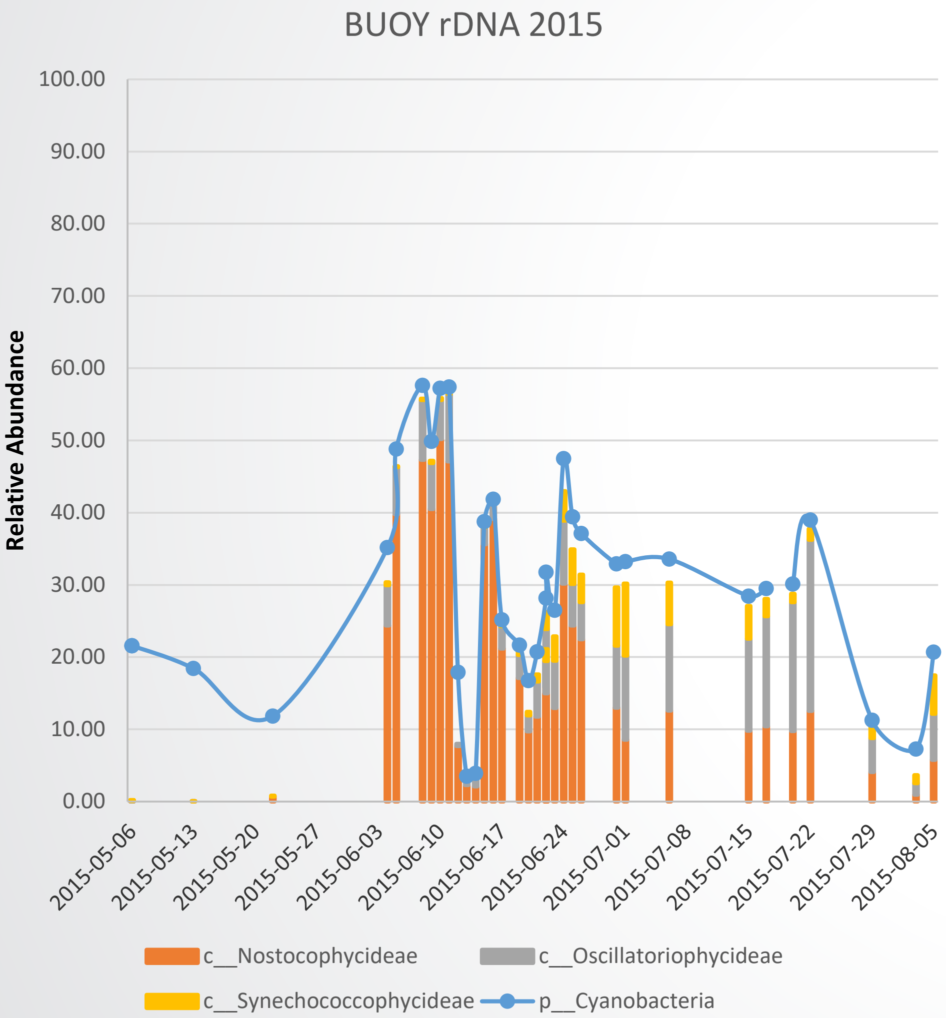
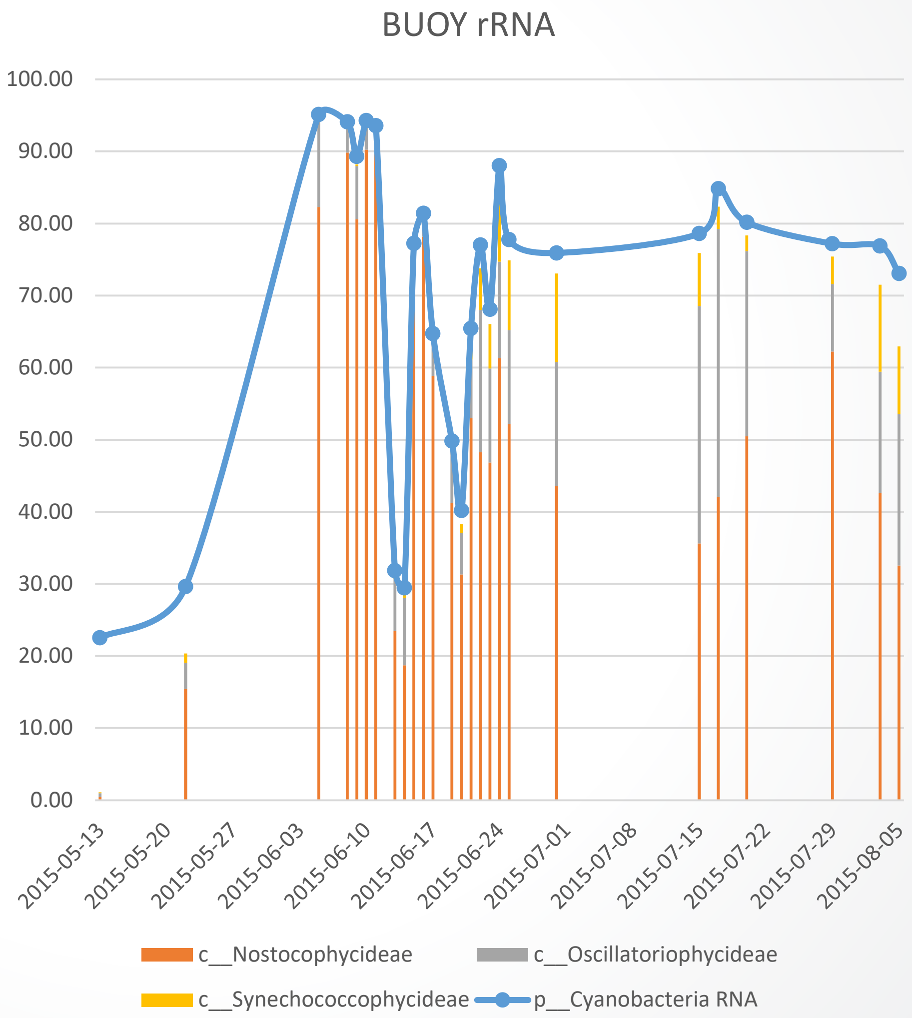
16S rDNA and rRNA sequencing





- k__Bacteria
- p__Cyanobacteria
- c__Chloroplast
  - o__Chlorophyta
  - f__Chlamydomonadaceae
  - o__Stramenopiles
  - o__Cryptophyta
  - o__Euglenozoa
  - o__Haptophyceae
  - o__Streptophyta
- c__Nostocophycideae
  - g__Aphanizomenon
  - g__Cylindrospermopsis
  - g__Dolichospermum
  - g__Trichormus
  - g__Anabaena
- c__Oscillatoriophycideae
  - g__Microcystis
  - g__Phormidium
  - g__Planktothrix
  - g__Snowella
- c__Synechococcophycideae
  - g__Pseudanabaena
  - g__Synechococcus

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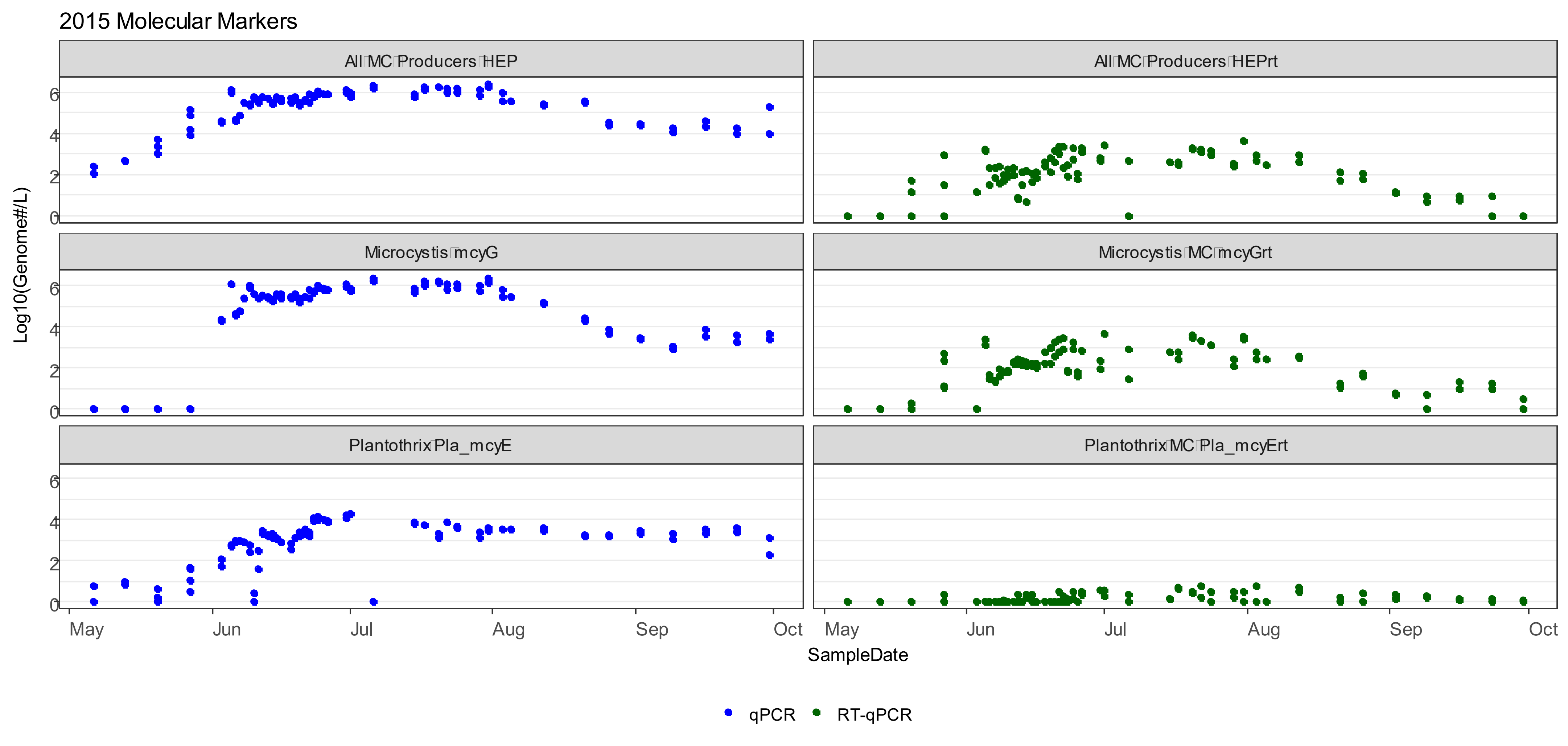
qPCR and RT-qPCR



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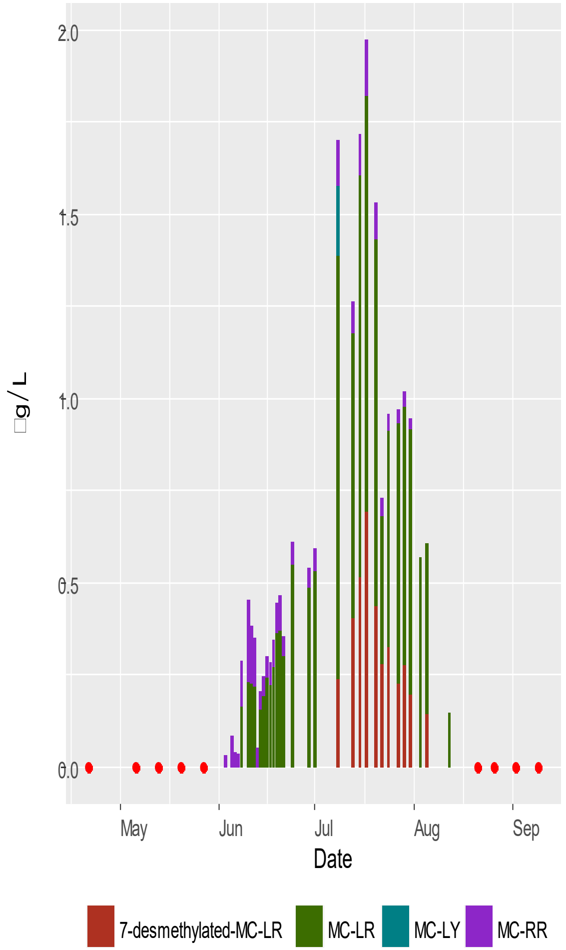
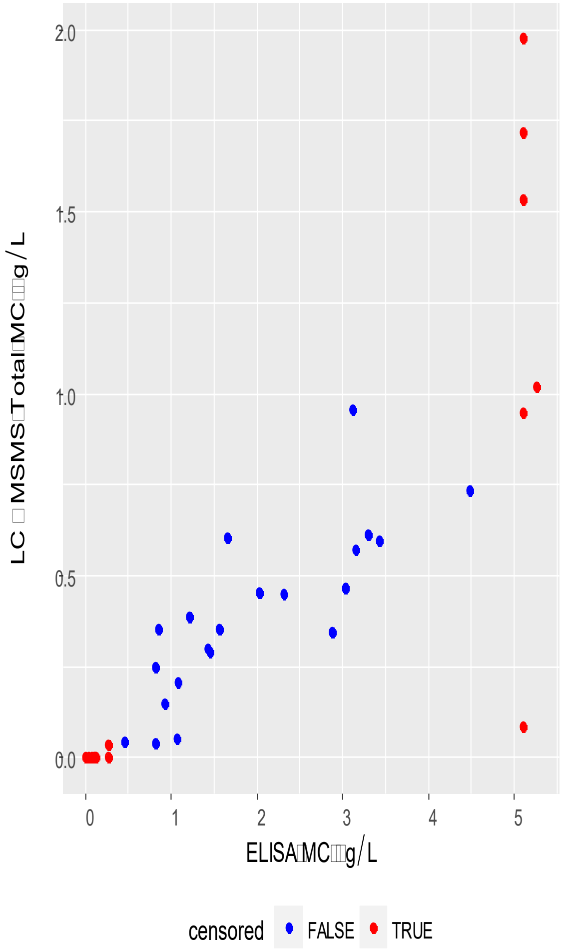
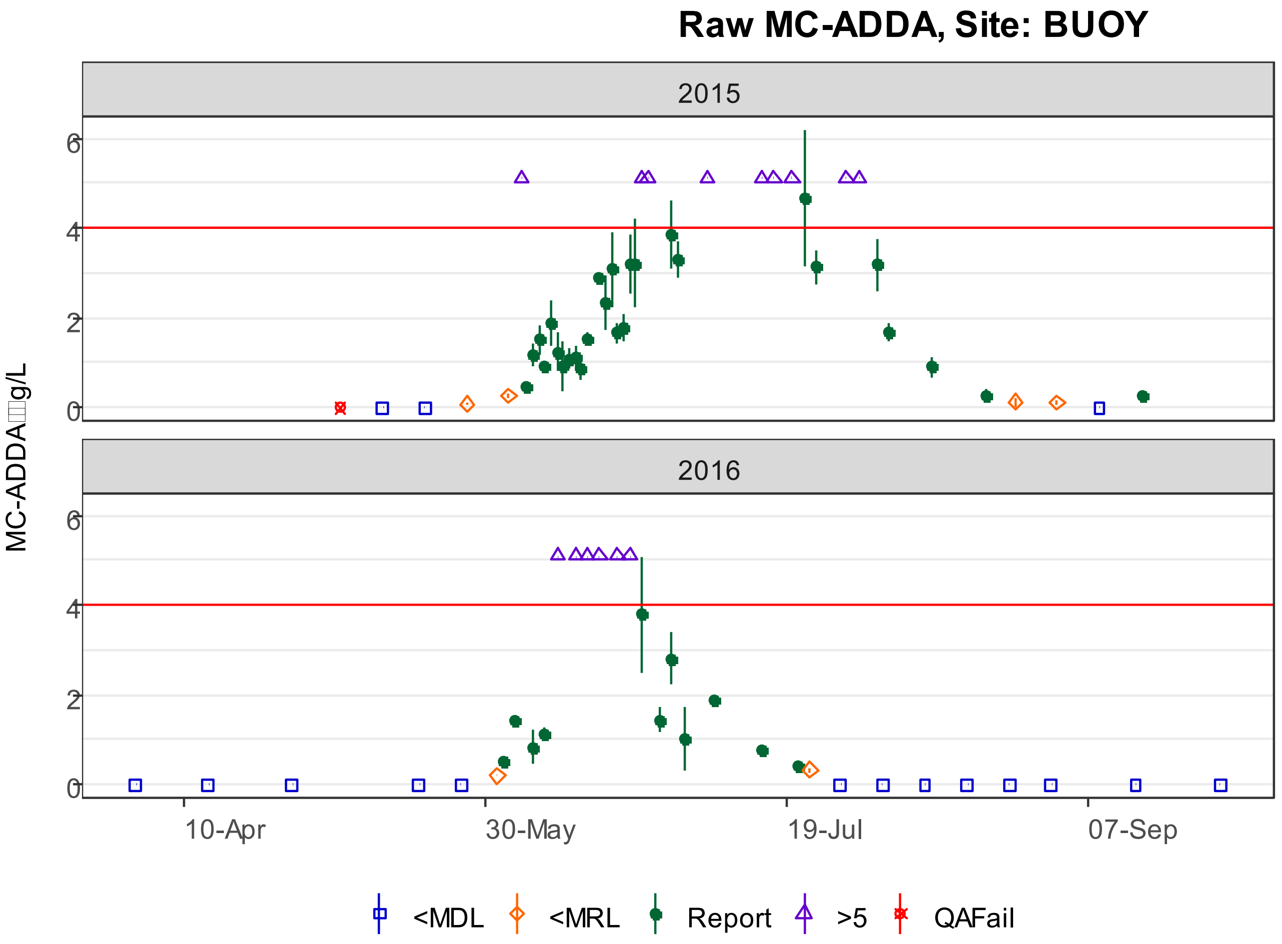
Cyanotoxin analysis







Nodularin, MC-YR, MC-HtyR, MC-RR, 3-desmethylated-MC-RR, MC-LR, MC-WR, 7-desmethylated-MC-LR, MC-HilR,3-desmethylated-MC-LR, MC-LA, MC-LY, MC-LW, MC-LF

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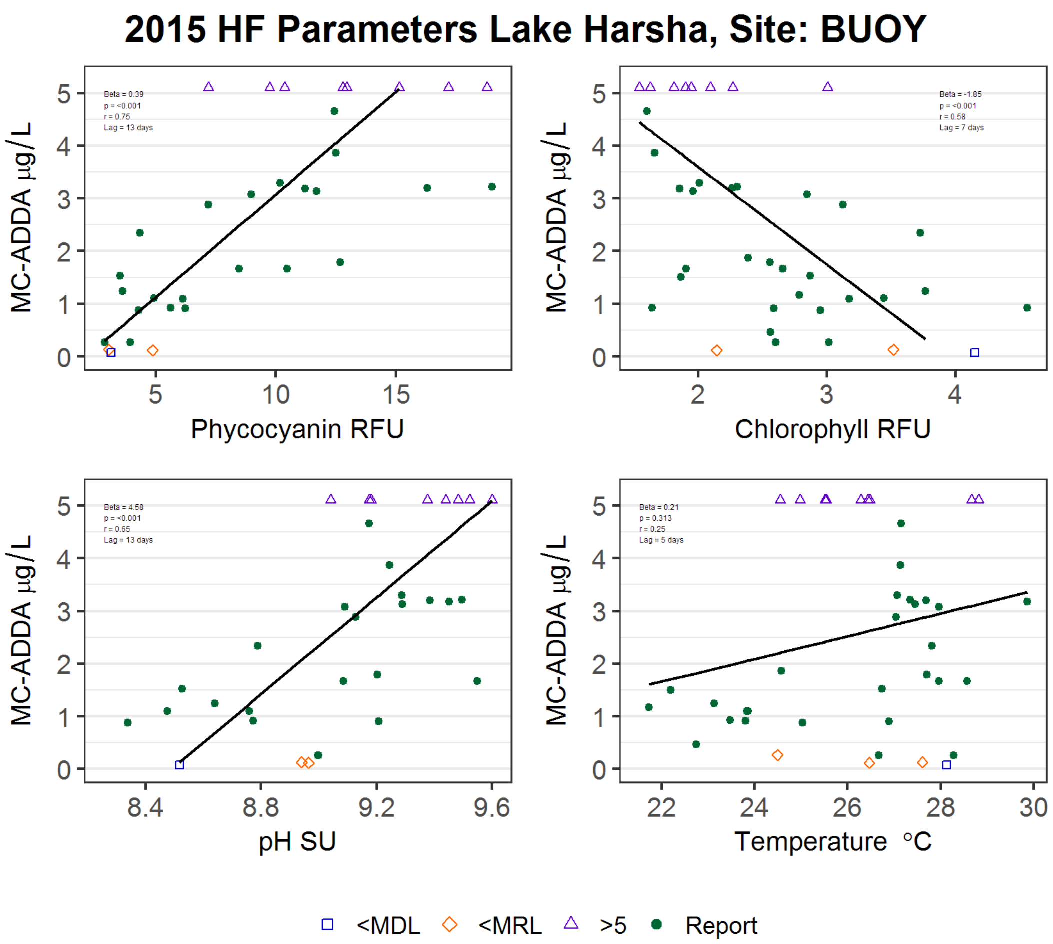
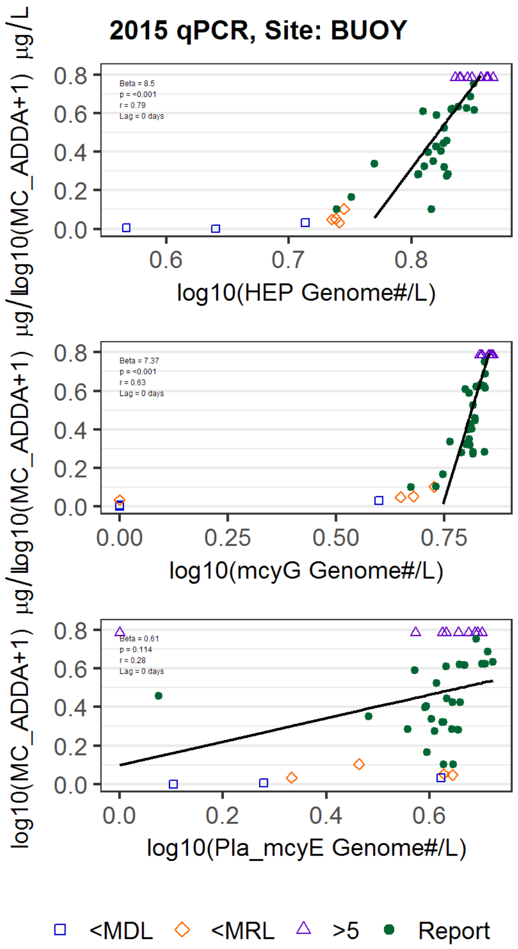
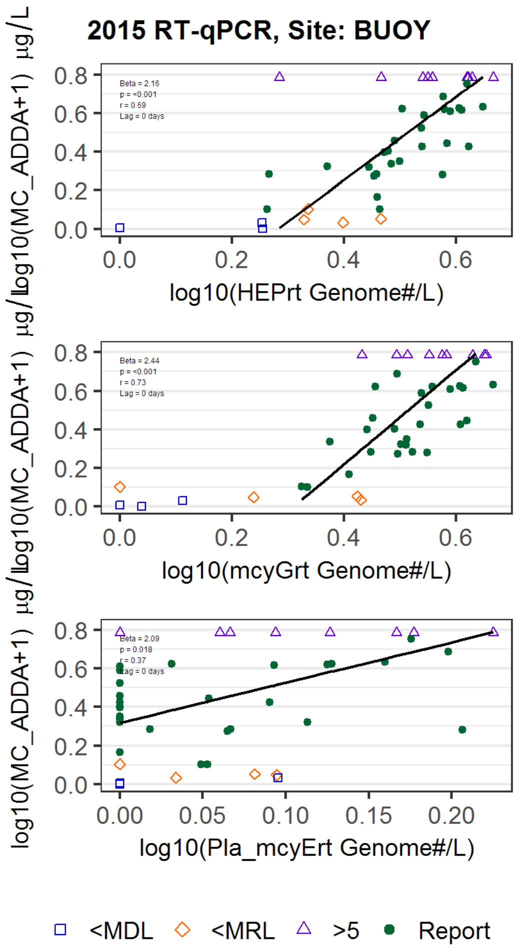
Relationships







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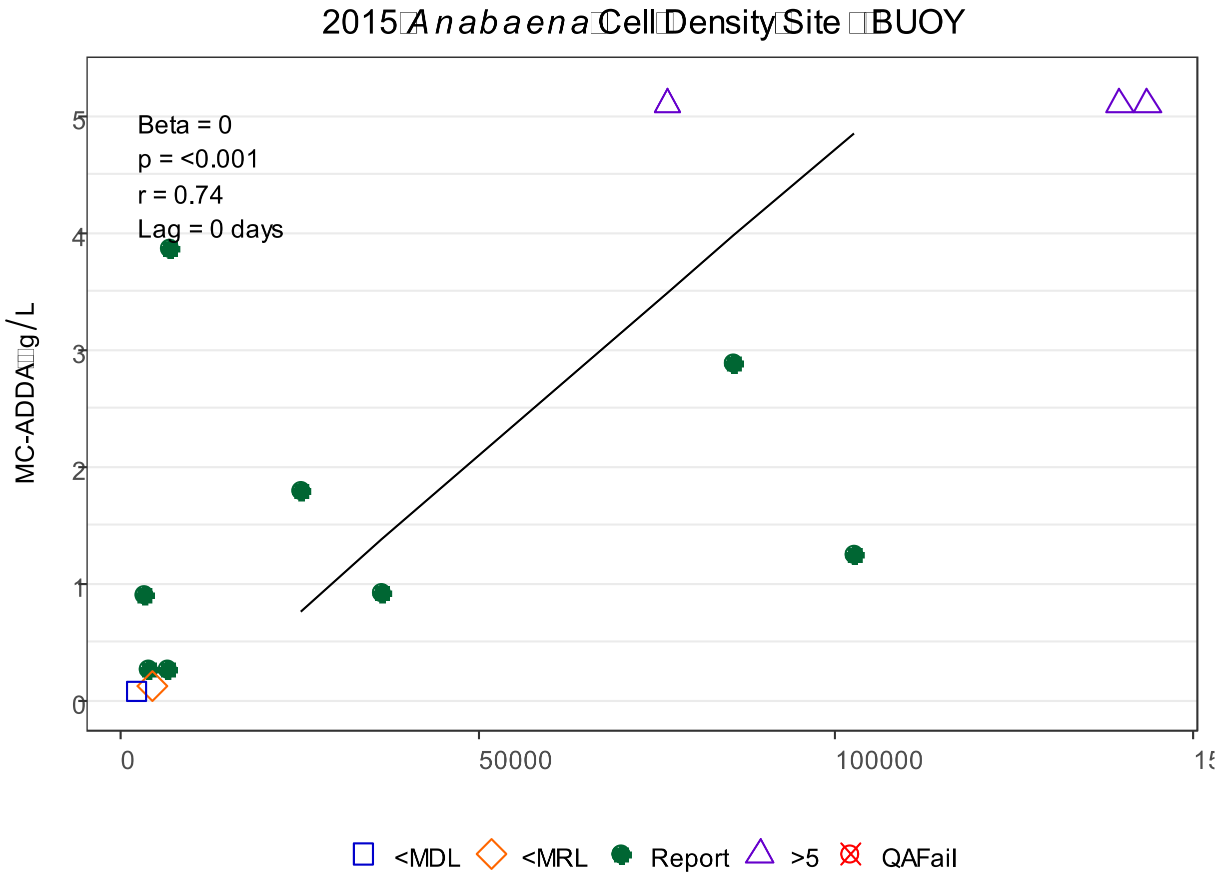

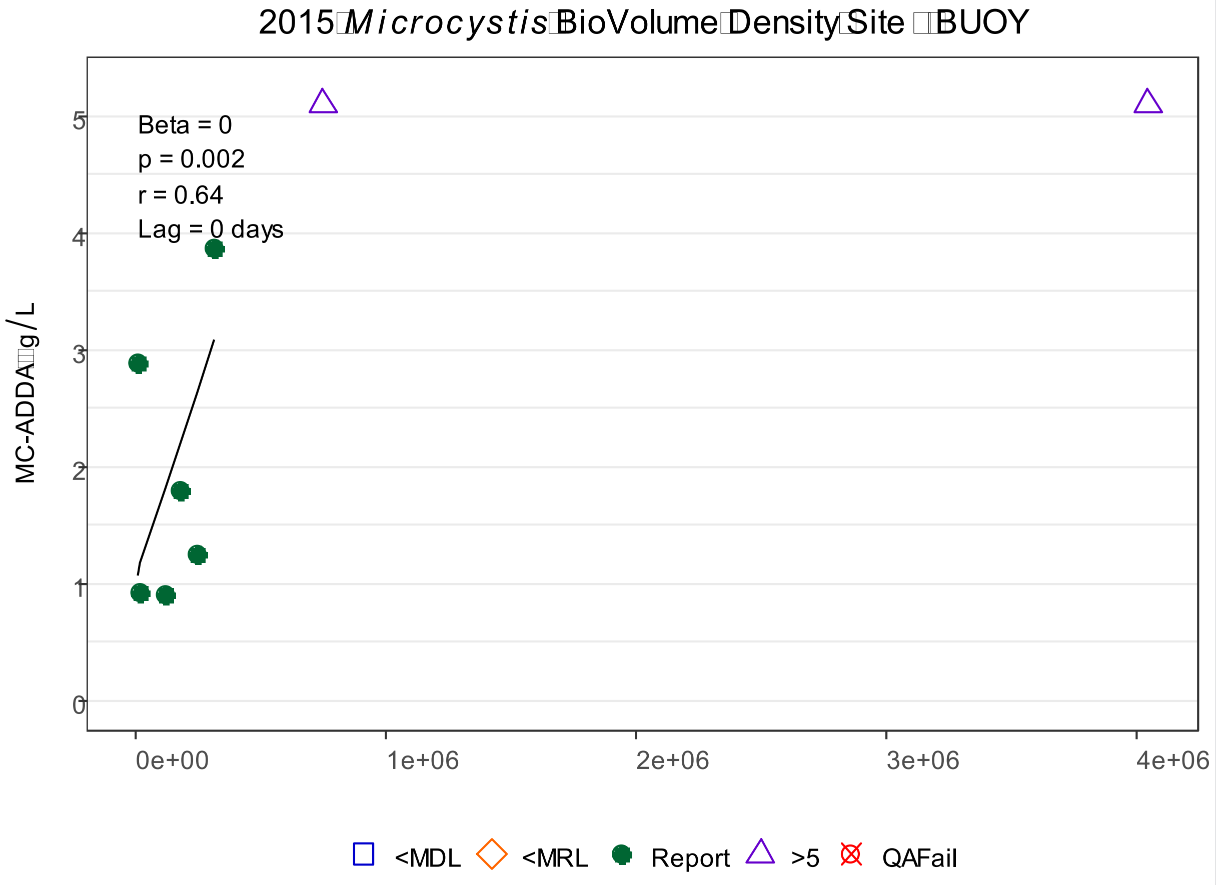

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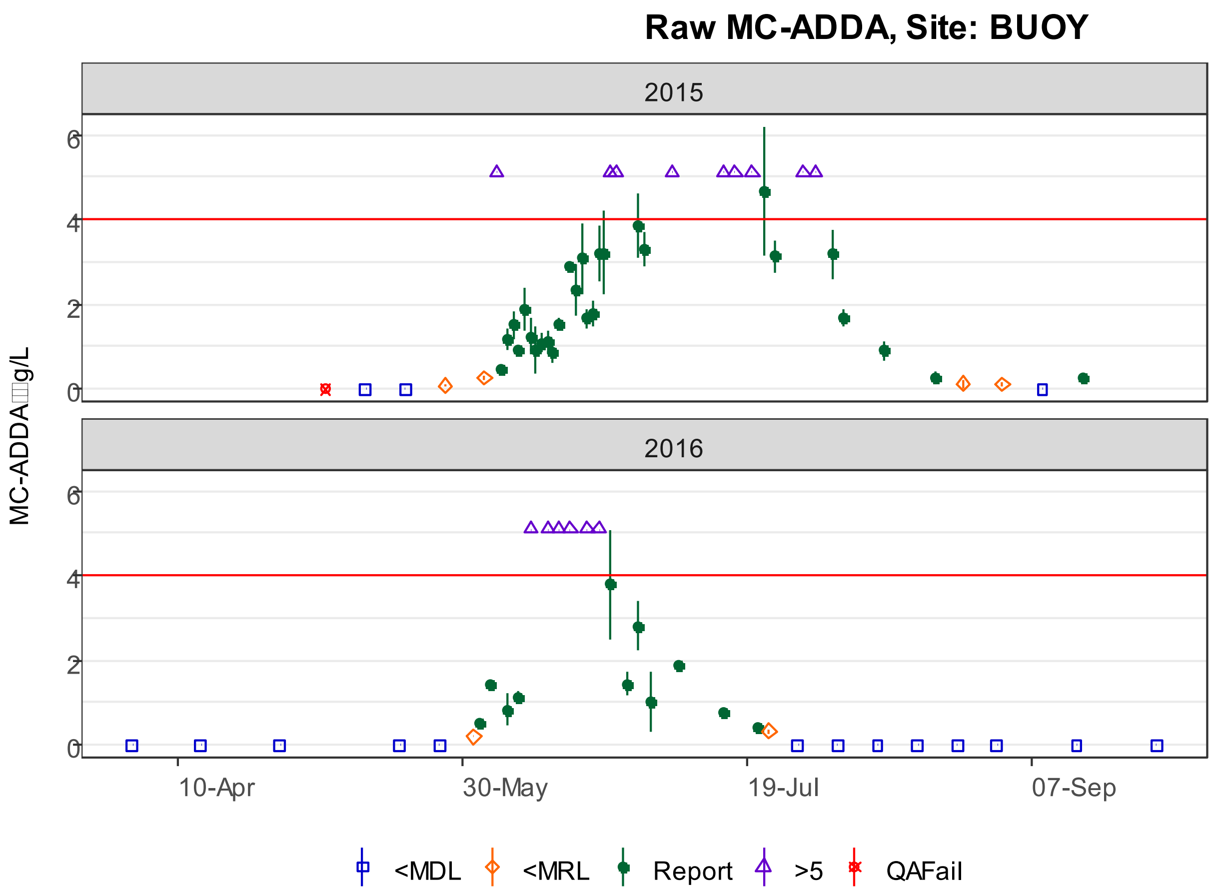

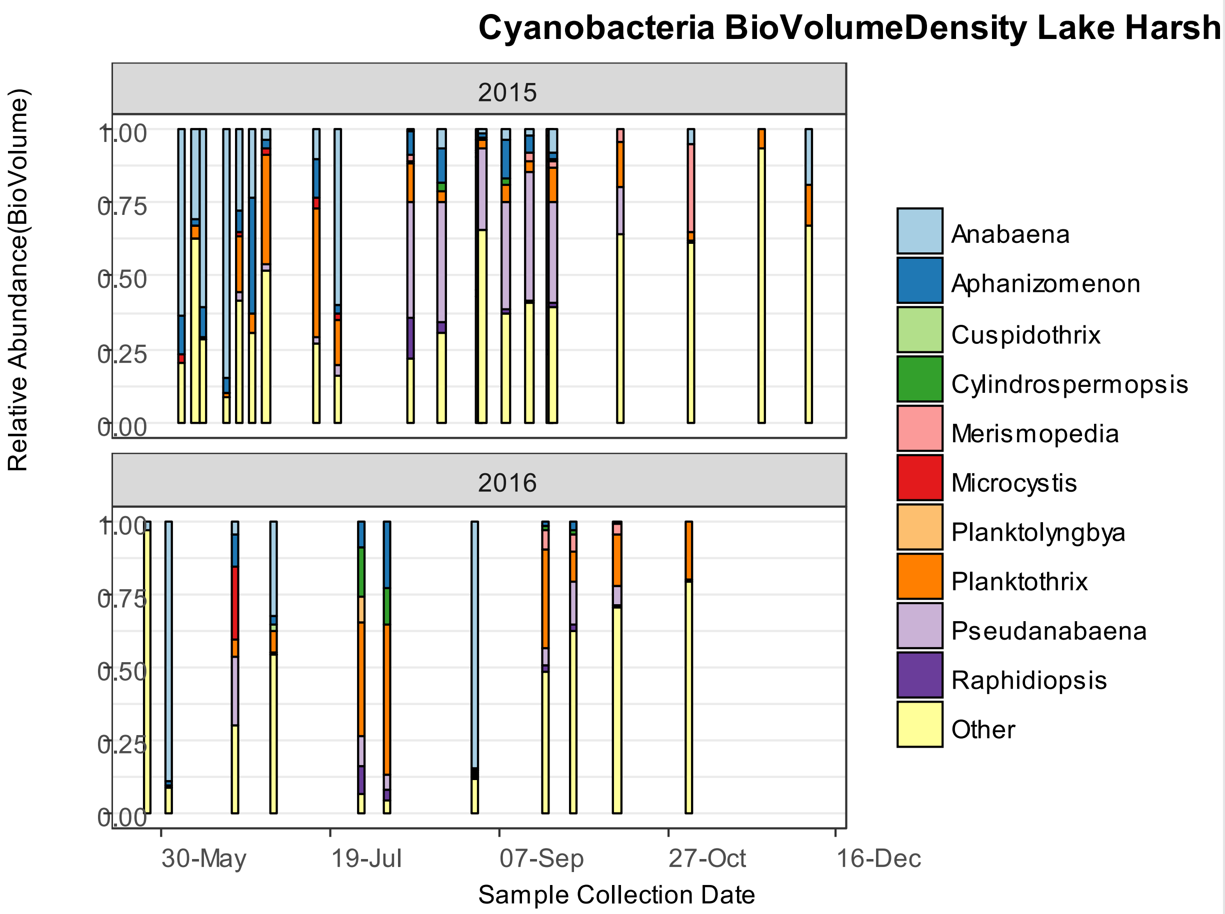

Summary

- Lake Harsha is a eutrophic inland reservoir located in the interior plateau ecoregion
- A variety of tools were used to characterize the cyanobacterial community and environmental factors during the cyanoHAB events of 2014-16
- High resolution sampling has given insight into the relationship between indicator parameters of bloom status and cyanotoxin production
  - Taxa trends show Lake Harsha is a diverse system with multiple cyanotoxin producing groups
  - Cyanotoxin analytical techniques confirmed the presence of cyanotoxins over the course of the season
    - ELISA may be better for magnitude
    - LC-MSMS demonstrates diversity of MC congeners present
  - *in-vivo* fluorescence can provide useful information regarding HAB status
  - Molecular techniques indicate the occurrence of genes involved in cyanotoxin production and correlate well with cyanotoxin water column concentrations
- Evidence suggests *Microcystis* is the greatest contributor to microcystin prodution