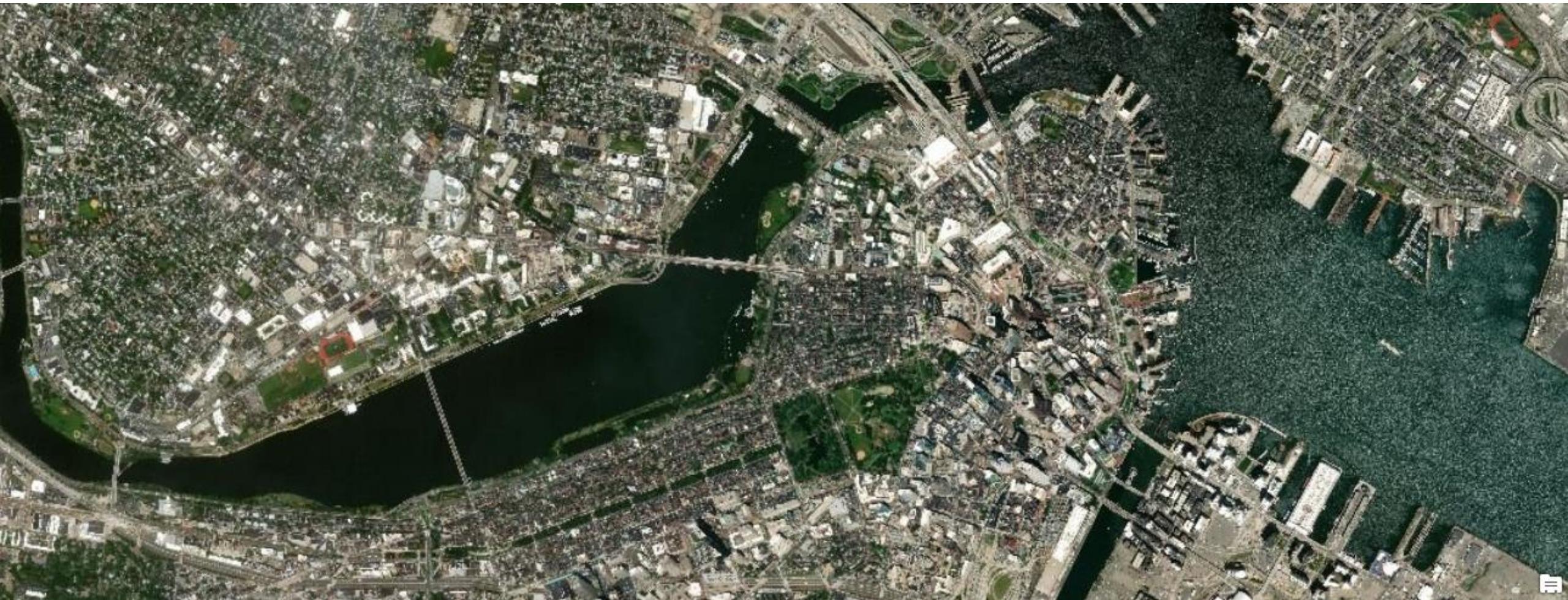


# Eutrophication, Cyanobacteria, and Floating Wetlands

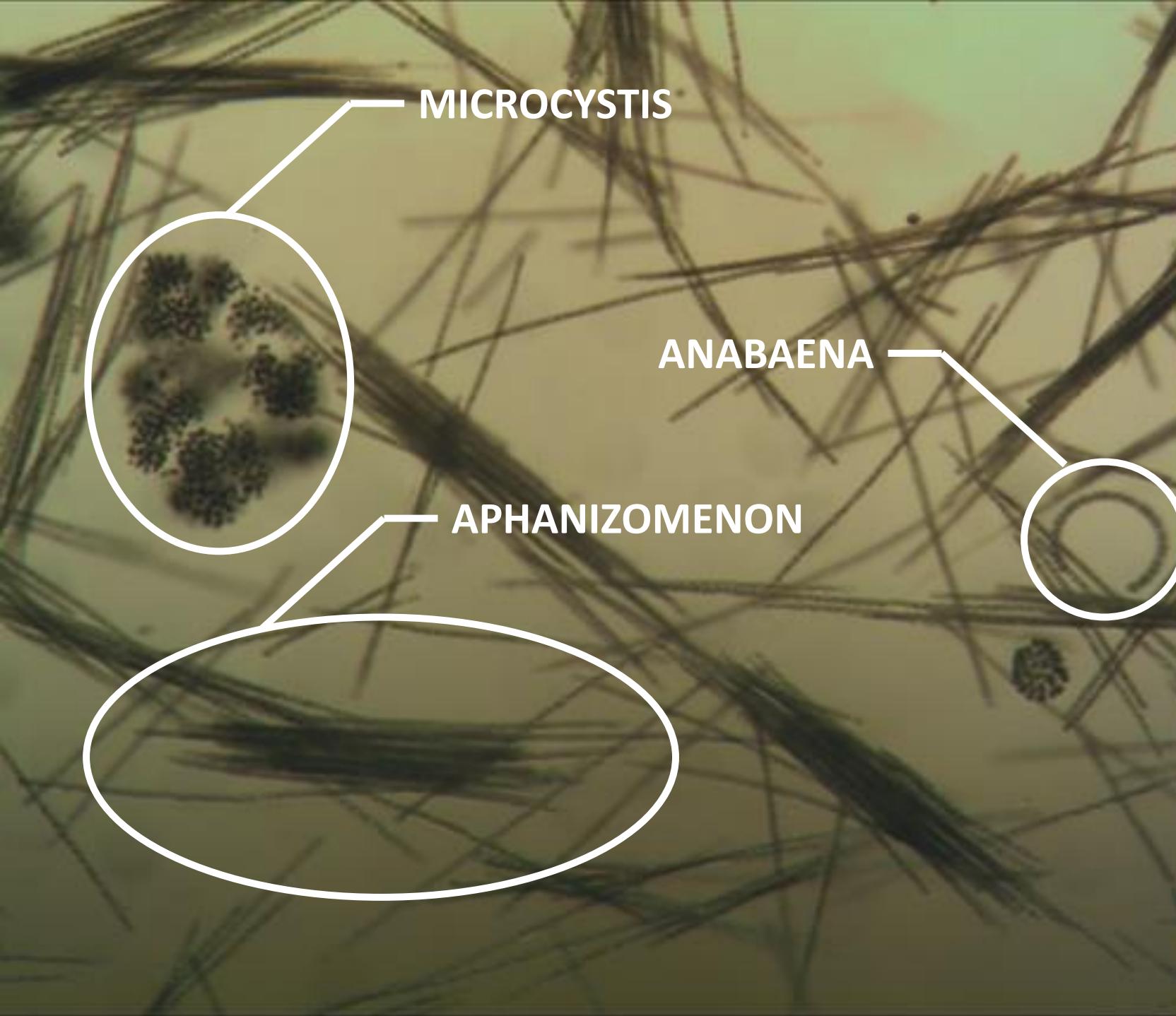
## Quantification and remediation



Presentation for: MA COLAP  
4.12.19

Max Rome | [rome.m@husky.neu.edu](mailto:rome.m@husky.neu.edu)  
Ph.D. Candidate, Northeastern University  
Ed Beighley Research Group  
4/12/2019







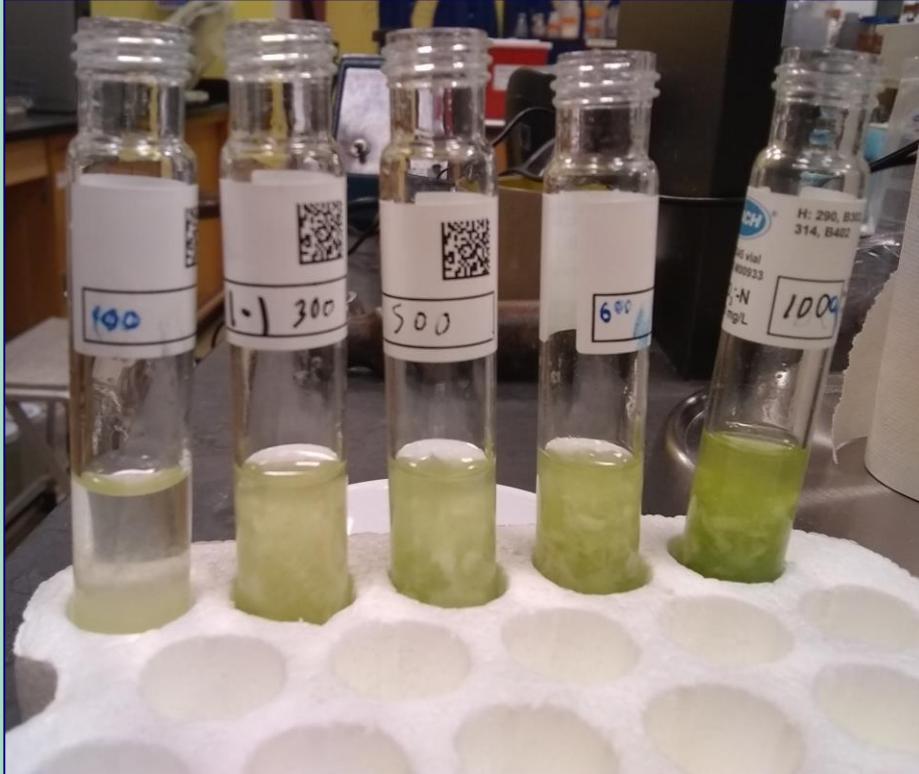
### Global rise of cyanobacterial blooms

Although cyanobacterial blooms have been known since ancient times (BOX 1), several studies indicate that they are currently increasing globally. For example, analysis of cyanobacterial pigments in sediment cores from over 100 lakes in North America and Europe shows that cyanobacteria have increased substantially in almost 60% of the lakes since the industrial revolution, that cyanobacterial abundance has increased disproportionately relative to other phytoplankton and that this increase has accelerated since 1945 (REF.<sup>26</sup>). This trend is likely to continue in the next decades. A recent study used climate change projections from five global circulation models as input for a coupled water quantity and quality model of the USA<sup>28</sup>. The model predicts that, in the USA, the mean number of days with harmful cyanobacterial blooms will increase from about 7 days per year per waterbody under current conditions to 18–39 days in 2090. The expansion of cyanobacterial blooms and their economic and societal

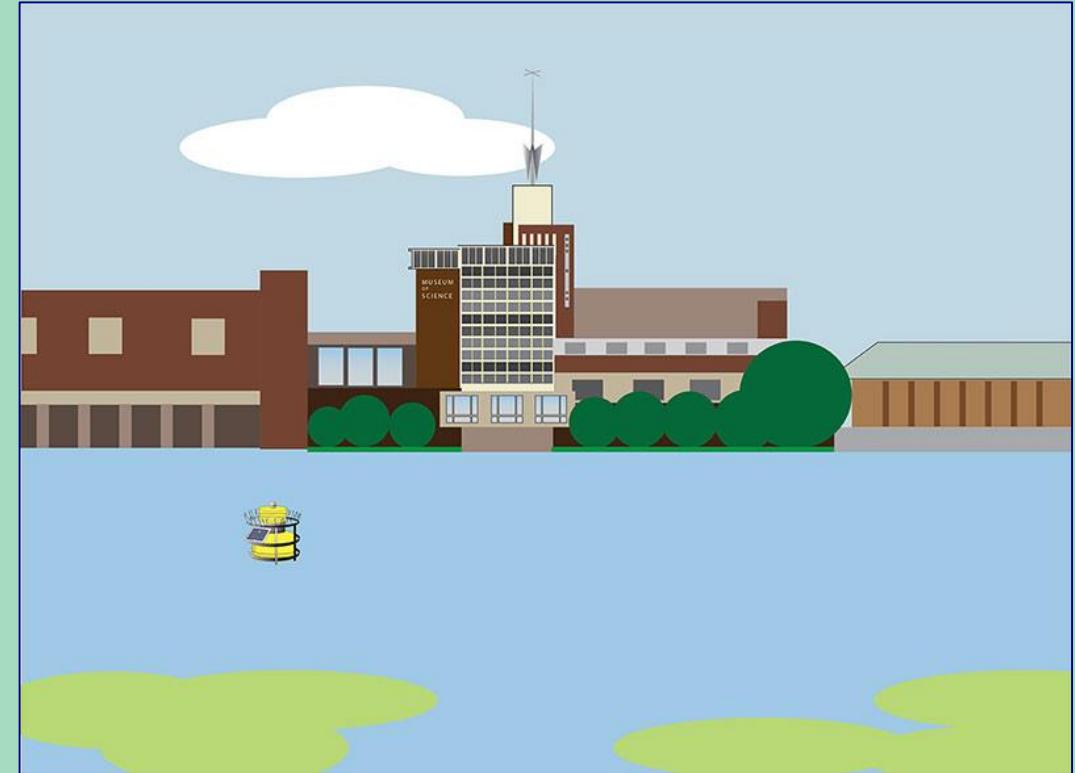
Huisman et al. 2018

# Bloom Quantification

## What to measure and how to measure it



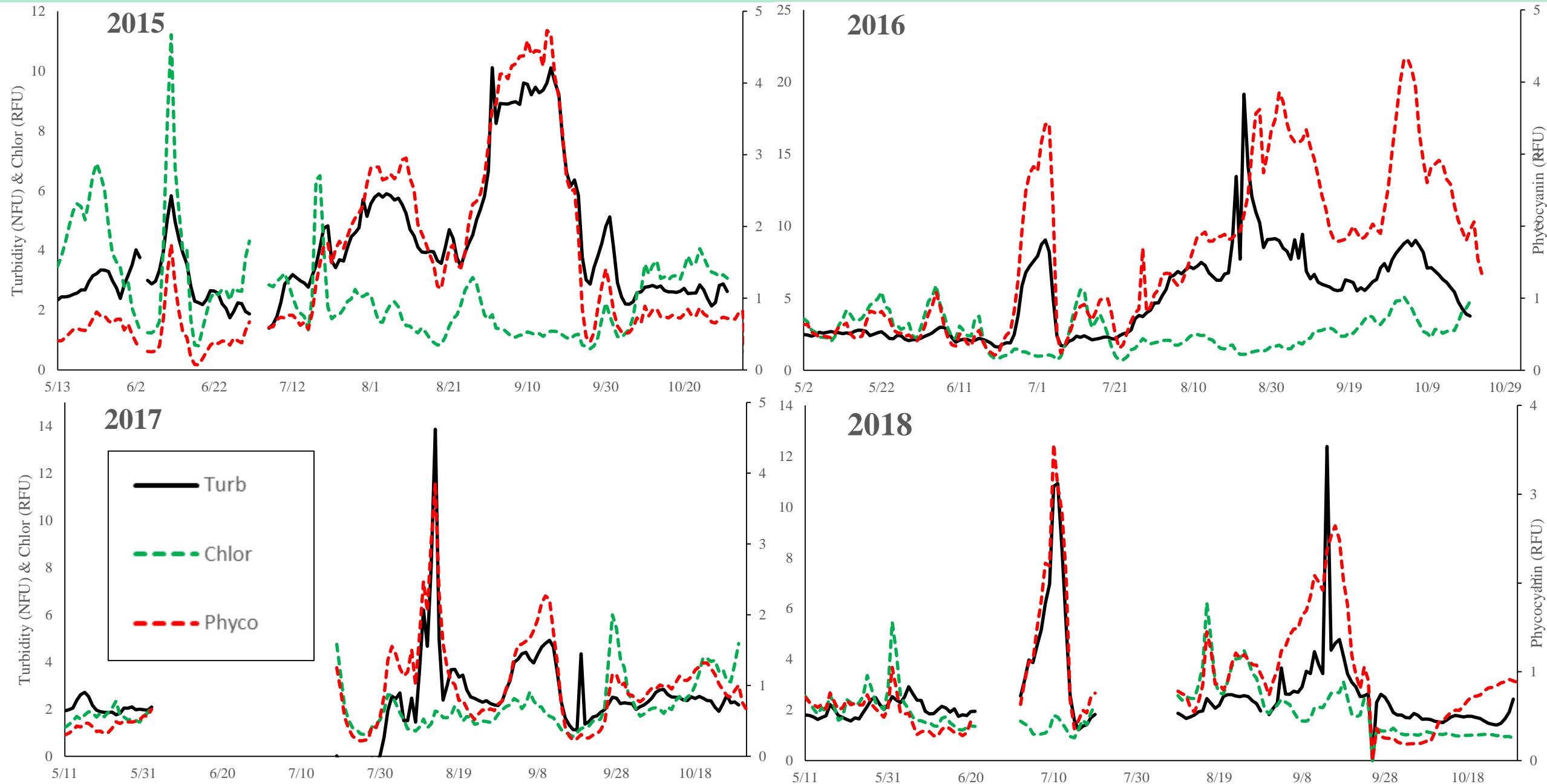
Sampling and Laboratory



EPA Buoy: Summer 2015-Present

# EPA Buoy in-vivo fluorescence

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# Methods

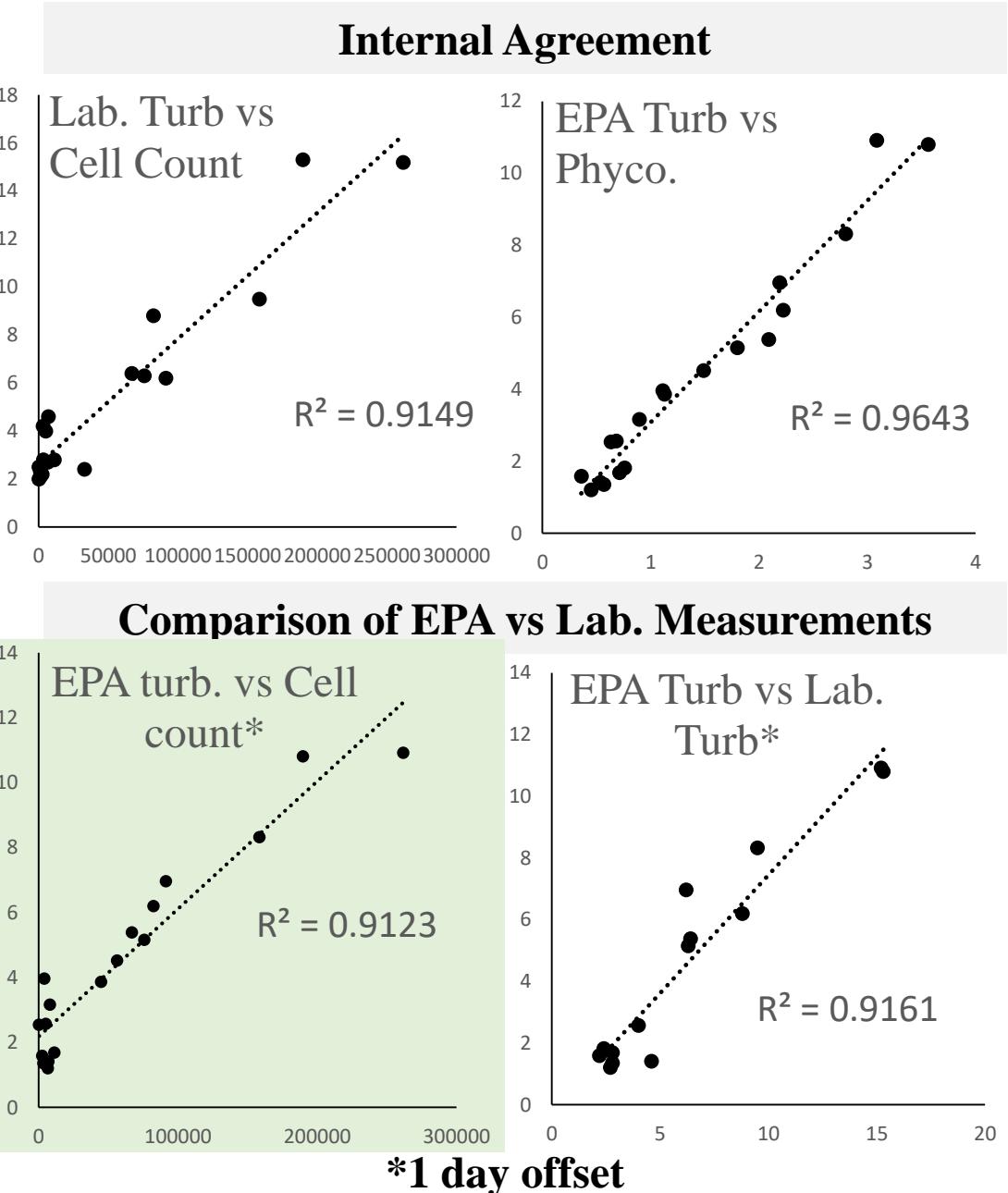
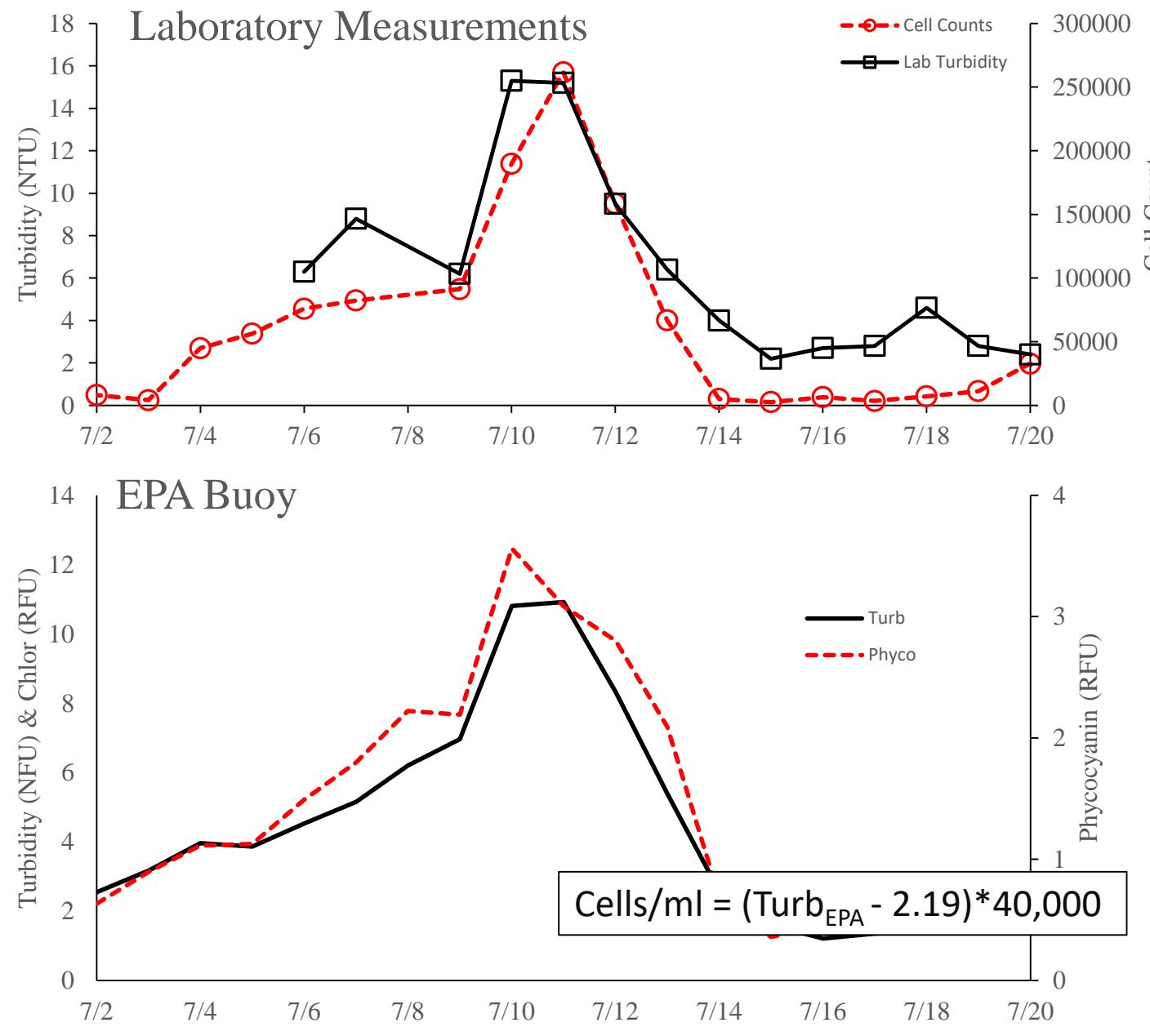


Cyanobacteria (Cells / mL)

Abundance Estimation Using Sedgewick Rafter Counting  
Chamber (Catherine et al. SOP 1. 3.3)

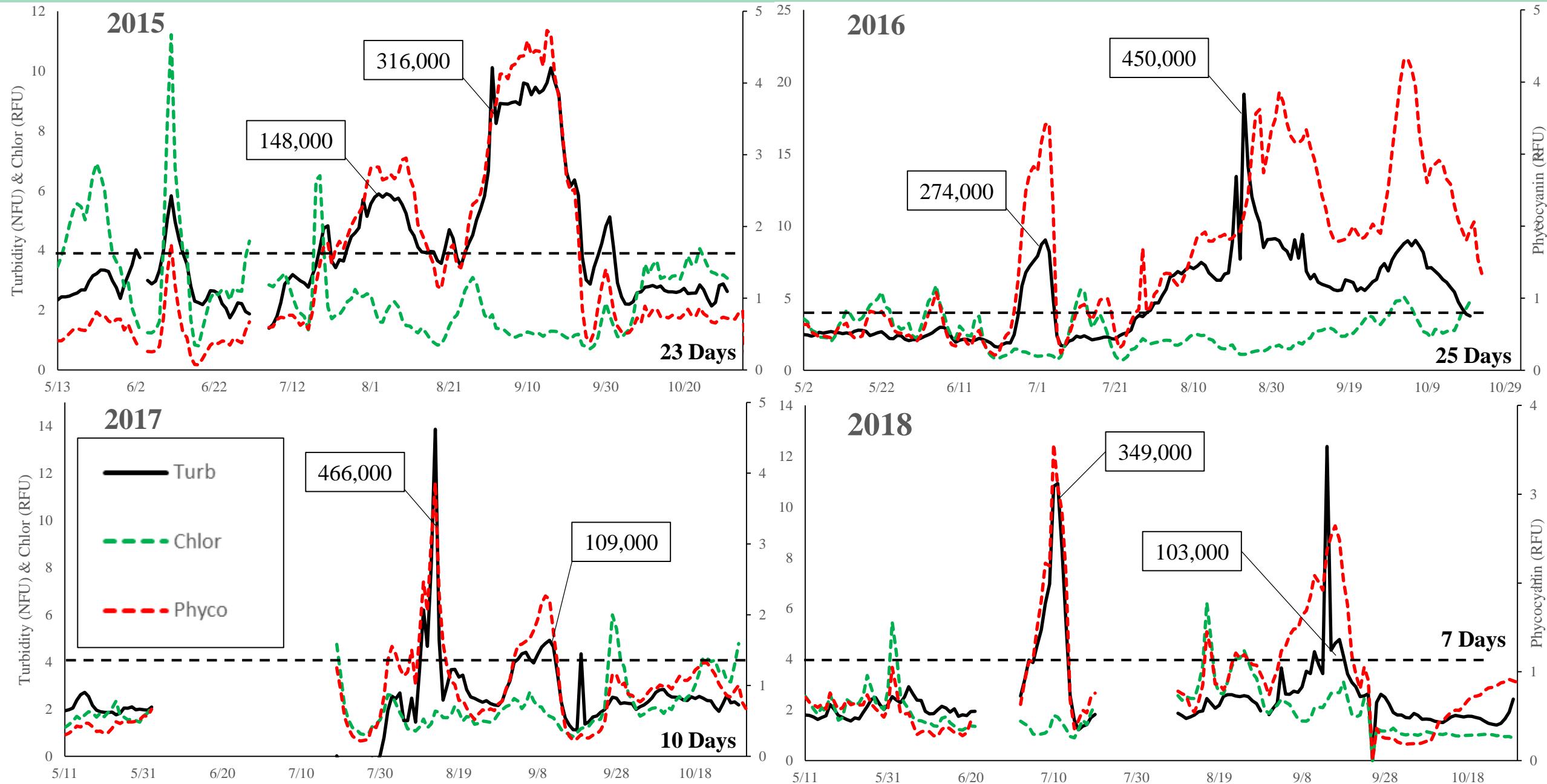


# Can we trust turbidity?



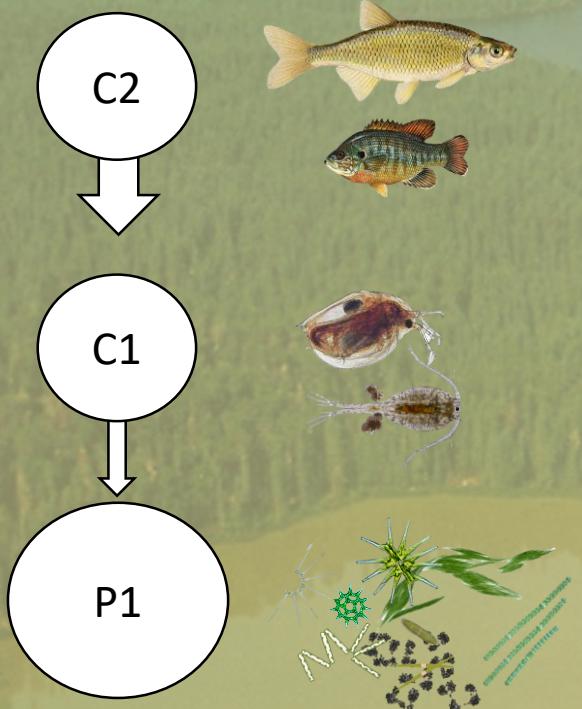
# EPA buoy - revisited

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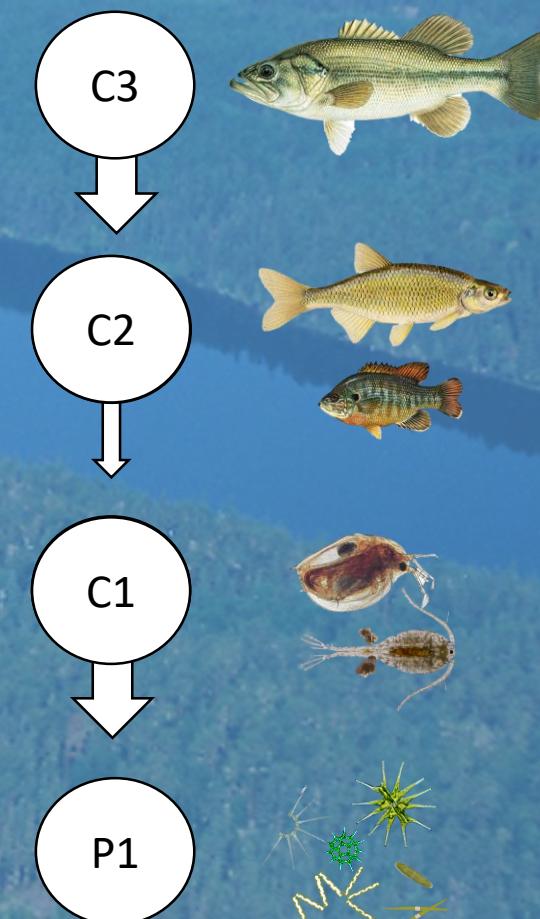


# Theory

## Bottom-up Control



## Top-down Control



Oligotrophic  
State I  
Clear with  
Submerged  
vegetation

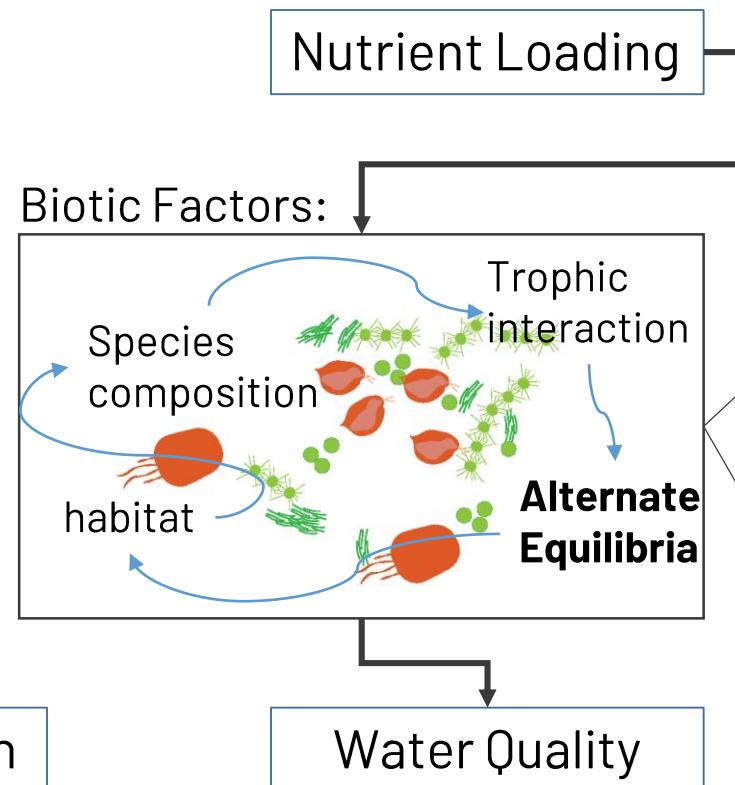
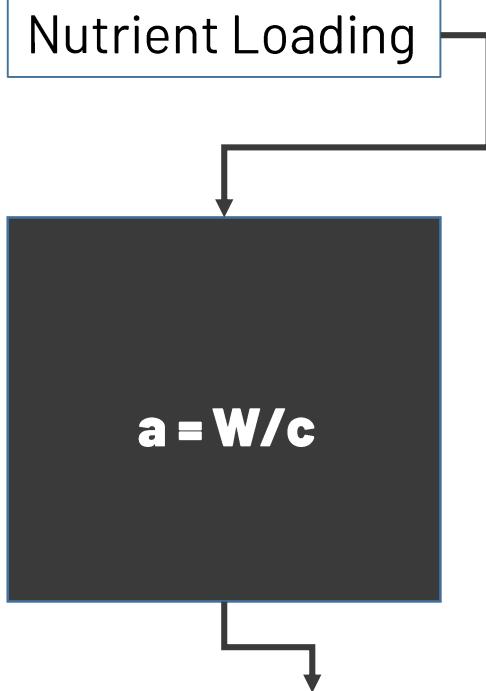
Top-down control

Bottom up  
control

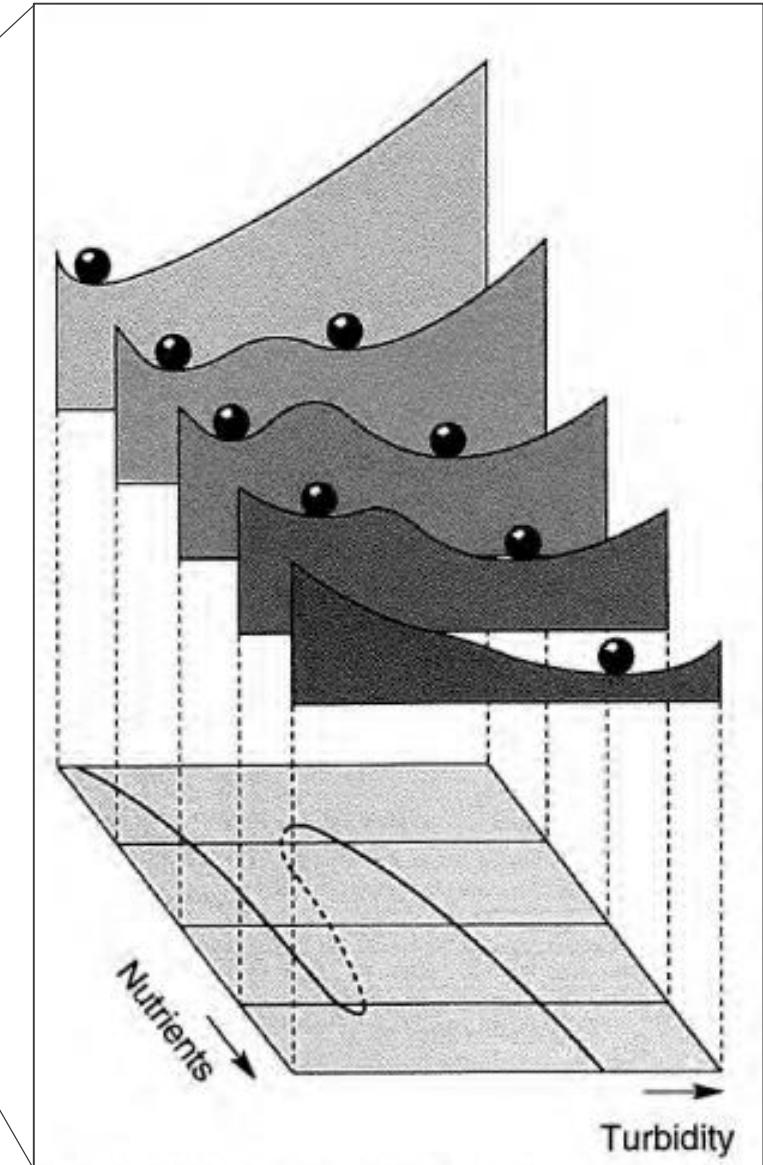
Eutrophic  
State II  
Turbid with algal  
growth

# Assimilative Factor and Alternative Equilibria

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Long Lake Michigan, from: Trophic Downgrading of Planet Earth  
Estes et al. (2011)



Alternate Equilibria in Shallow Lakes  
Scheffer et al. (1993)

## Reducing Phosphorus to Curb Lake Eutrophication is a Success

David W. Schindler,<sup>\*†</sup> Stephen R. Carpenter,<sup>‡</sup> Steven C. Chapra,<sup>§</sup> Robert E. Hecky,<sup>||</sup> and Diane M. Orihel<sup>⊥</sup>

<sup>†</sup>Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9, Canada

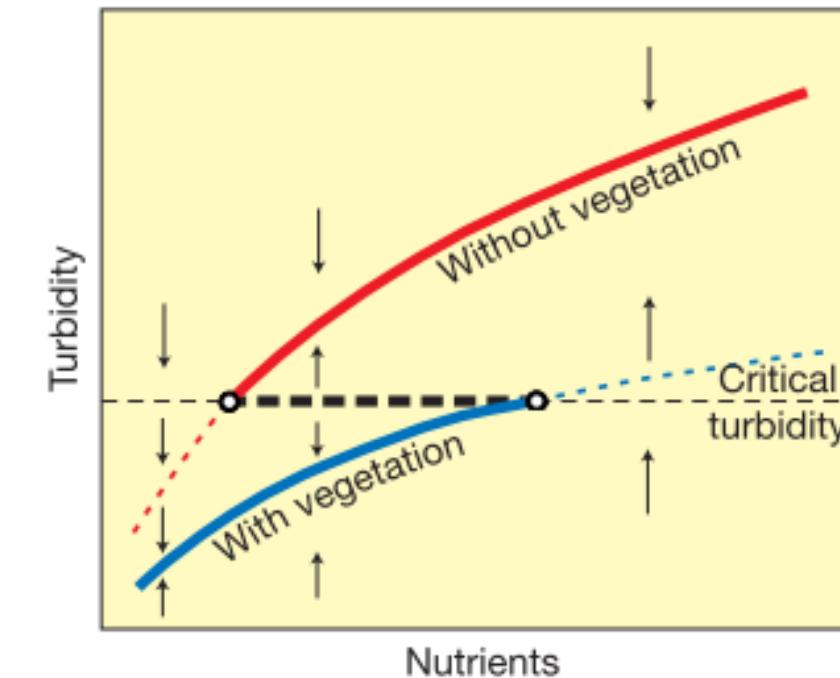
<sup>‡</sup>Center for Limnology, University of Wisconsin-Madison, Madison, Wisconsin 53706, United States

<sup>§</sup>Civil and Environmental Engineering Department, Tufts University, Medford, Massachusetts 02155, United States

<sup>||</sup>Large Lakes Observatory, University of Minnesota-Duluth, Duluth, Minnesota 55812, United States

<sup>⊥</sup>Department of Biology, University of Ottawa, 30 Marie Curie, Ottawa Ontario K1N 6N5 Canada, Canada

**ABSTRACT:** As human populations increase and land-use intensifies, toxic and unsightly nuisance blooms of algae are becoming larger and more frequent in freshwater lakes. In most cases, the blooms are predominantly blue-green algae (Cyanobacteria), which are favored by low ratios of nitrogen to phosphorus. In the past half century, aquatic scientists have devoted much effort to understanding the causes of such blooms and how they can be prevented or reduced. Here we review the evidence, finding that numerous long-term studies of lake ecosystems in Europe and North America show that controlling algal blooms and other symptoms of eutrophication depends on reducing inputs of a single nutrient: phosphorus. In contrast, small-scale experiments of short duration, where nutrients are added rather than removed, often give spurious and confusing results that bear little relevance to solving the problem of cyanobacteria blooms in lakes.



**Scheffer, carpenter 2001**

**Ecological Thresholds: The Key to Successful Environmental Management or an Important Concept with No Practical Application?**

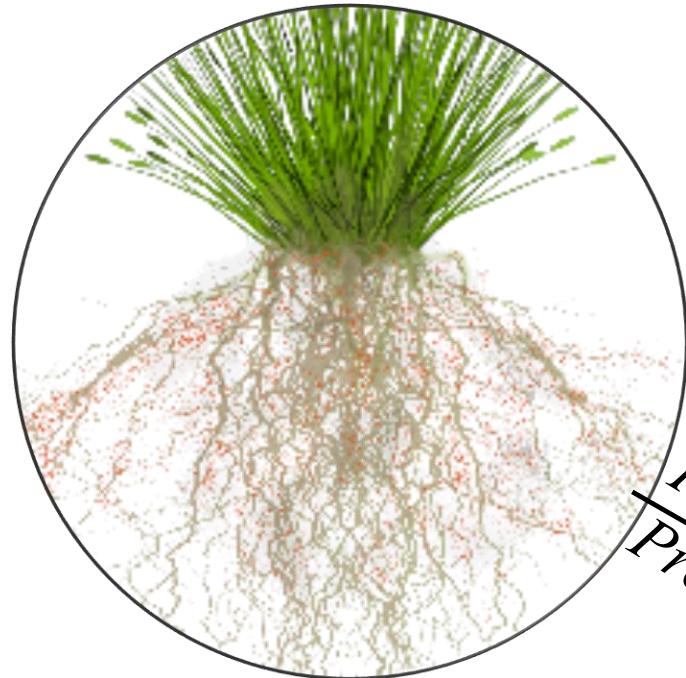
**Table 1 Characteristics of some major ecosystem state shifts and their causes**

Ecosystem	State I	State II	Events inducing shift from I to II	Events inducing shift from II to I
Lakes	Clear with submerged vegetation	Turbid with phytoplankton	Killing of plants by herbicide Killing of Daphnia by pesticide	Killing of fish Low water level

Peter M. Groffman,<sup>1\*</sup> Jill S. Baron,<sup>2</sup> Tamara Blett,<sup>3</sup> Arthur J. Gold,<sup>4</sup> Iris Goodman,<sup>5</sup> Lance H. Gunderson,<sup>6</sup> Barbara M. Levinson,<sup>5</sup> Margaret A. Palmer,<sup>7</sup> Hans W. Paerl,<sup>8</sup> Garry D. Peterson,<sup>9</sup> N. LeRoy Poff,<sup>10</sup> David W. Rejeski,<sup>11</sup> James F. Reynolds,<sup>12</sup> Monica G. Turner,<sup>13</sup> Kathleen C. Weathers,<sup>1</sup> and John Wiens<sup>14</sup>

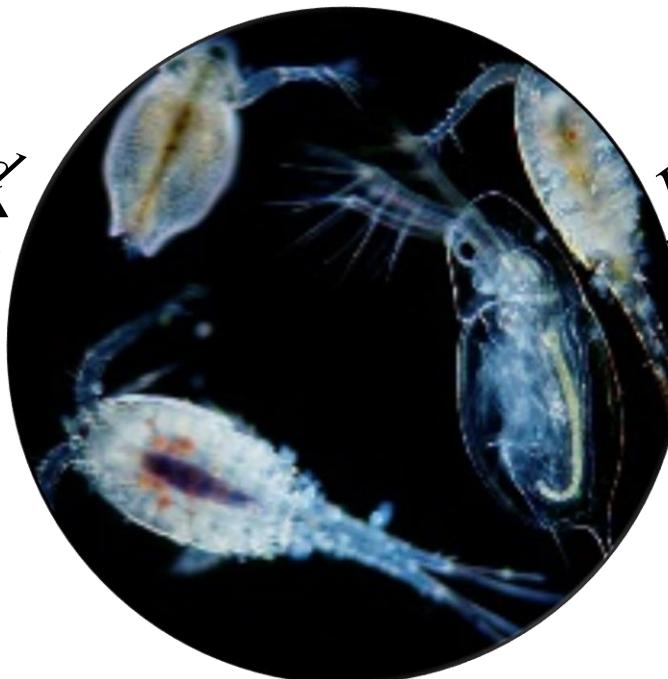


# Hypothesis



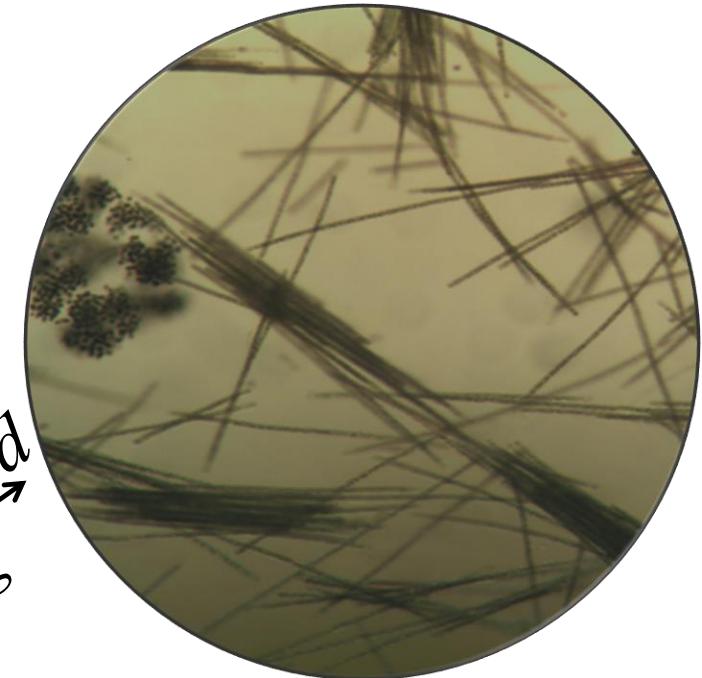
↑ Refugia  
(plant roots)

Reduced  
Predation



Large Bodied  
Zooplankton

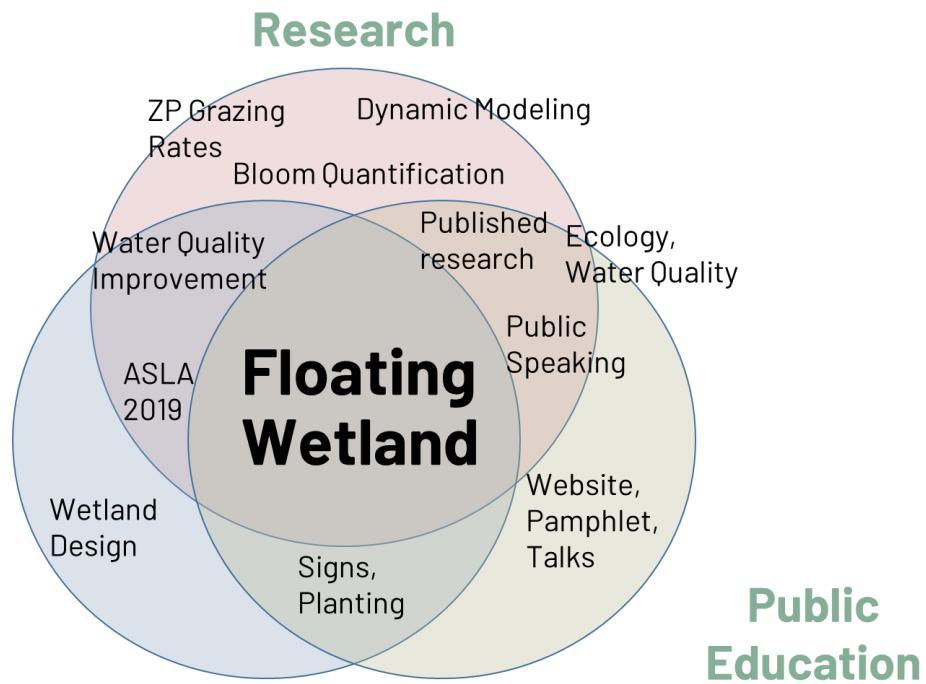
Enhanced  
Grazing



↓ Cyanobacteria  
(HAB)

# Wetland Design

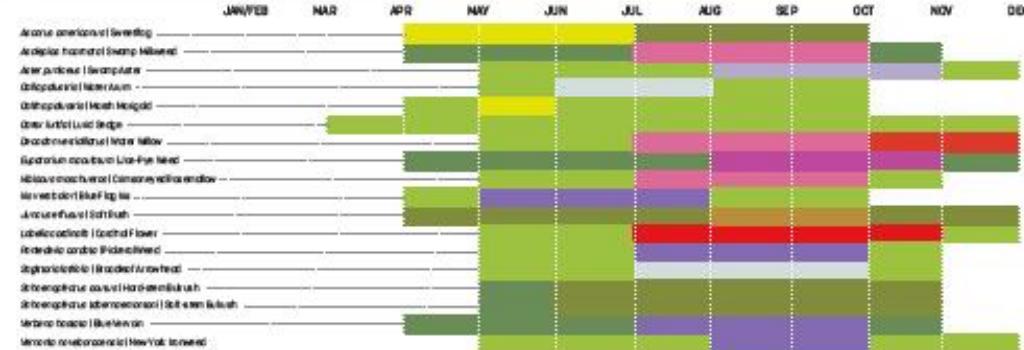
## Place Making



## Public Education

## PLANTING STRATEGY

GOALS for plant selection include (a) maximizing roots for habitat, (b) creating a visually captivating design, and (c) selecting varieties appropriate for the growing conditions.



## WHY?



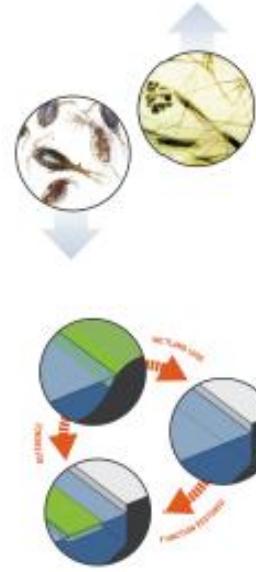
### History

Before urban development, the Charles River was a free-flowing tidal estuary. A complex habitat of wetlands and mud-flats surrounded the main channel and supported a diversity of species including shellfish, migratory birds, and anadromous fish.



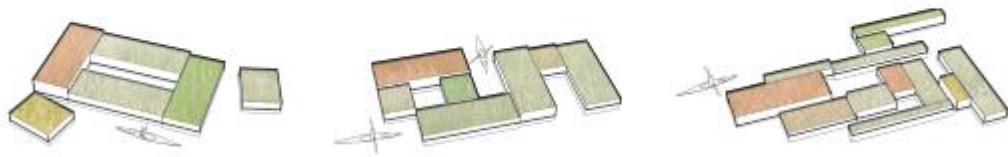
### Urban Condition

Today, the Charles' lower basin is a typical urban waterbody. Dams maintain a near-constant water level and hardscape covers much of the watershed. Wetlands and littoral vegetation are largely absent.



## SCENARIOS

MULTIPLE CONFIGURATIONS of wetlands are possible building from 600sf of material in rectangular blocks or custom organic shapes



## Challenges

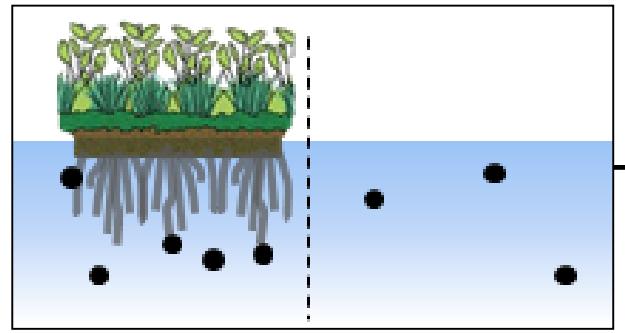
Nutrients, carried by rainwater running off the city streets, act as fertilizers fueling the growth of algae. Ecological feedback loops exacerbated by the lack of wetland vegetation result in frequent algal blooms and depleted zooplankton populations.

## Intervention

Floating wetland roots reintroduce plant habitat, providing zooplankton refuge from predation. This process can locally increase zooplankton populations to aid in the control of algal blooms and help restore ecological balance.

# Proposed Research and Anticipated Results

## Field Experiment



## Data Collection

### Zooplankton

1. Species Abundance
2. Species mean body size
3. Total Herbivore Biomass

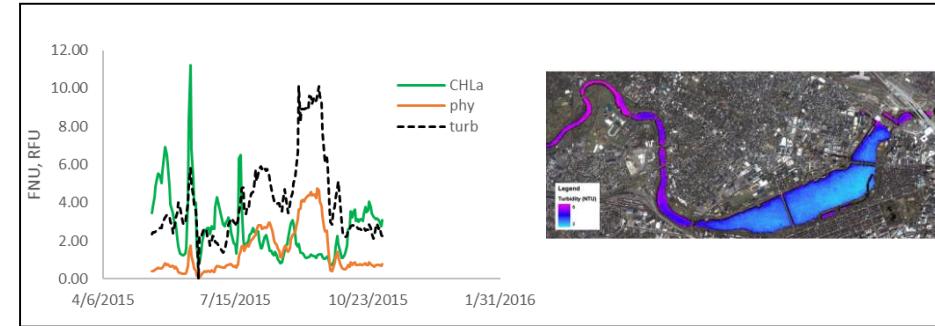
### Bloom Quantification

1. Cell Counts
2. Chlor extraction (?)
3. Phycocyanin extraction (?)

### Floating Wetland

1. E. coli
2. Plant growth and survival

## Public Data Sets & Remote Sensing



## Literature



## Calculation

1. Algal Growth Rates
2. Peak Algal Biomass
3. Community Grazing Rates
4. Substrate specific grazing rates

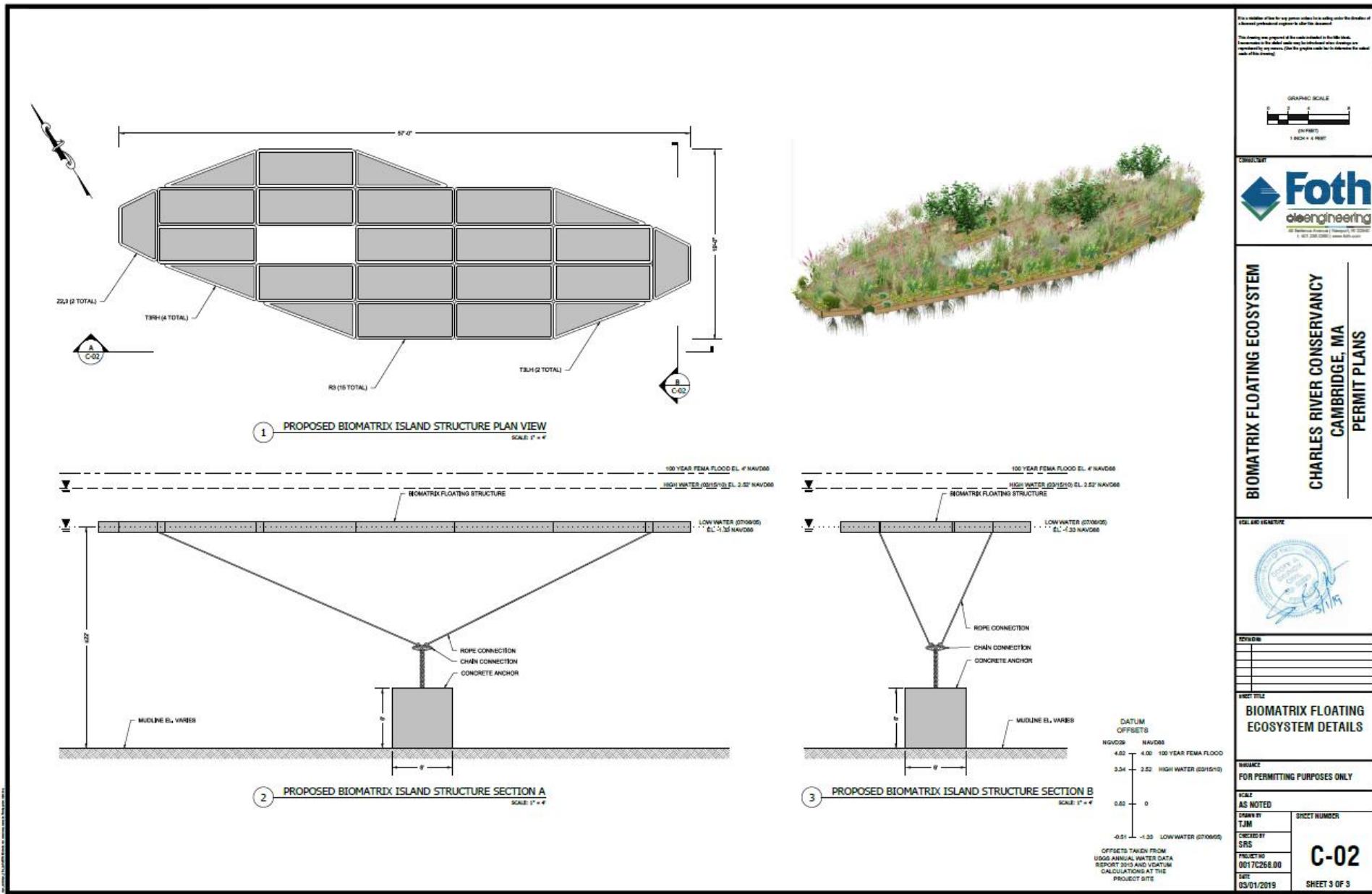
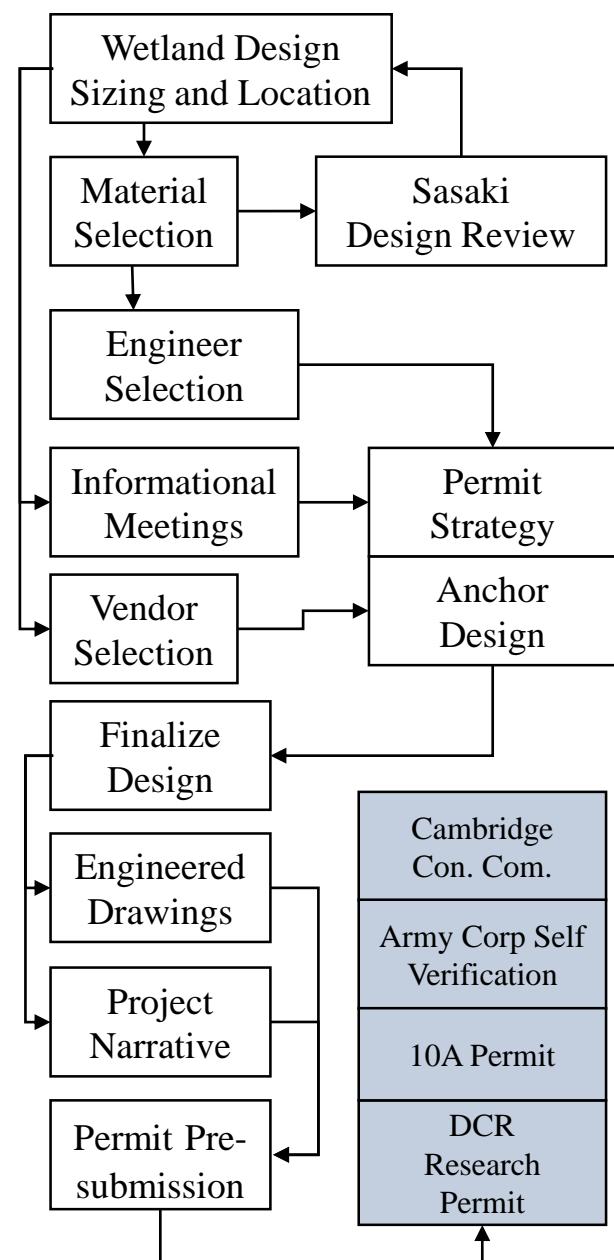
## Modeling

1. Predation and Competition
2. Critical Grazing Rate
3. Nutrient Concentration and Turbidity

## Results

1. Wetland sizing criteria for water quality improvement
2. Improved bloom alert system
3. Improved long-term monitoring

# Permitting and Progress



A scenic landscape featuring a winding river or stream flowing through a dense field of tall grasses, likely reeds. The grasses are a mix of green and yellowish-brown, suggesting a seasonal transition. The water is calm, reflecting the surrounding vegetation and the clear blue sky above. The overall scene is peaceful and natural.

Thank You!

**Cyanobacteria and eutrophication:**(Shapiro, 1980)(Coakley & Baker, 2014; Gragnani, Scheffer, & Rinaldi, 1999; Jeppesen et al., 1997; Scheffer & Van Nes, 2007; Smith, 2003)

**Nutrients and Eutrophication:**(Schindler, Carpenter, Chapra, Hecky, & Orihel, 2016)

**Alternative Equilibrium:**(Bond et al., 2015; Scheffer & Carpenter, 2003; Scheffer, Hosper, Meijer, Moss, & Jeppesen, 1993; Yu et al., 2016)

**Floating Wetlands:**(Location & Island, 2005; McAndrew & Ahn, 2017; Power, Matthews, & Stewart, 2017; Shapiro, 1980; Urrutia-Cordero, Ekval, & Hansson, 2015)

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