Jefferson Project at Chautauqua Lake: Lake Management and HABs

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Agenda

Introduction

HABs Overview

- Algae
- Mechanisms
- Stream intrusion
- High-frequency measurements
- Cyberinfrastructure and computer modeling

Advances in genomic research

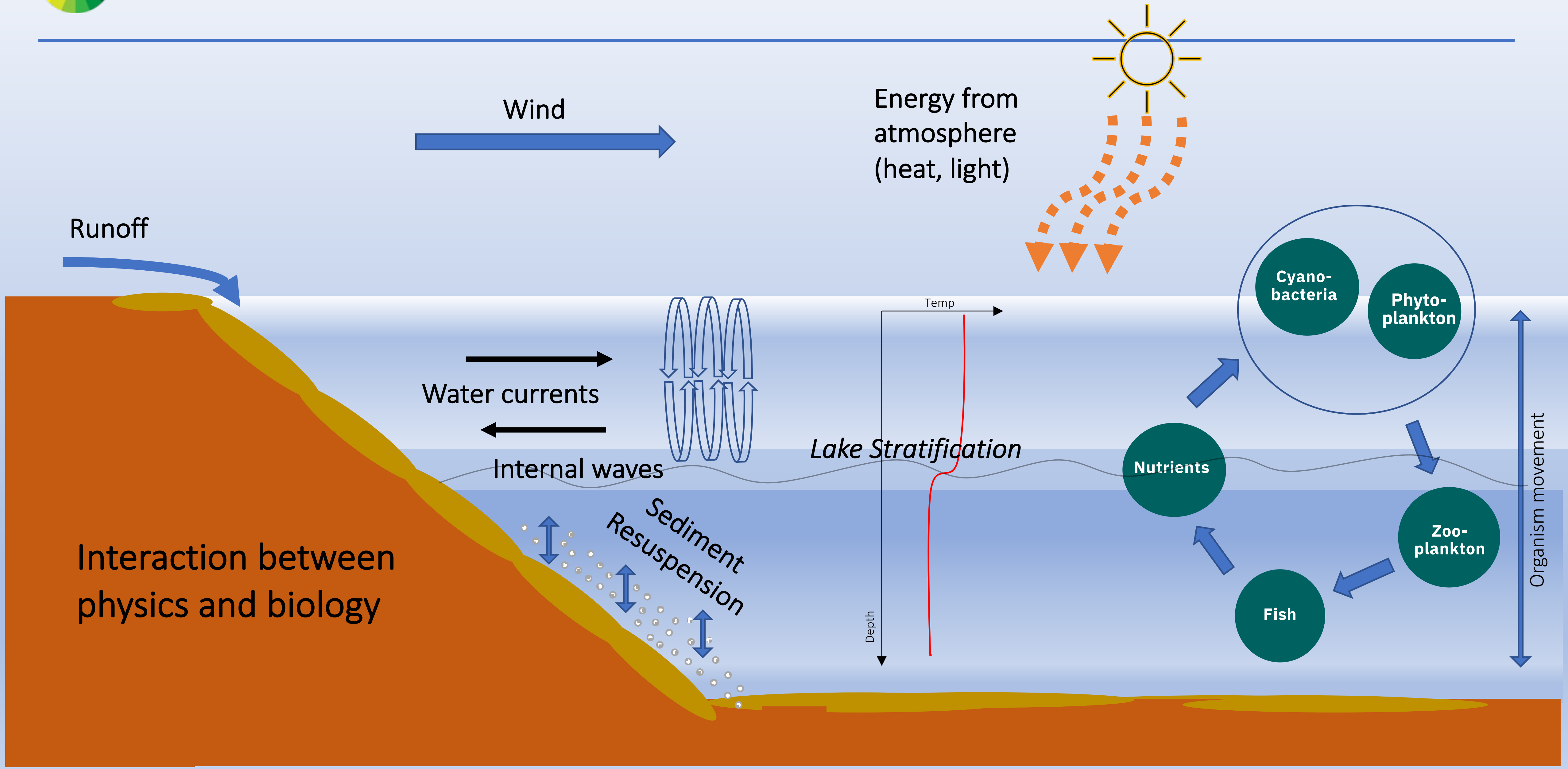
Plans and the view forward

Harmful Algal Bloom (HAB) common thinking

Nutrients + Warm Temperatures/Sun = [Surface] HAB

It's not that simple…

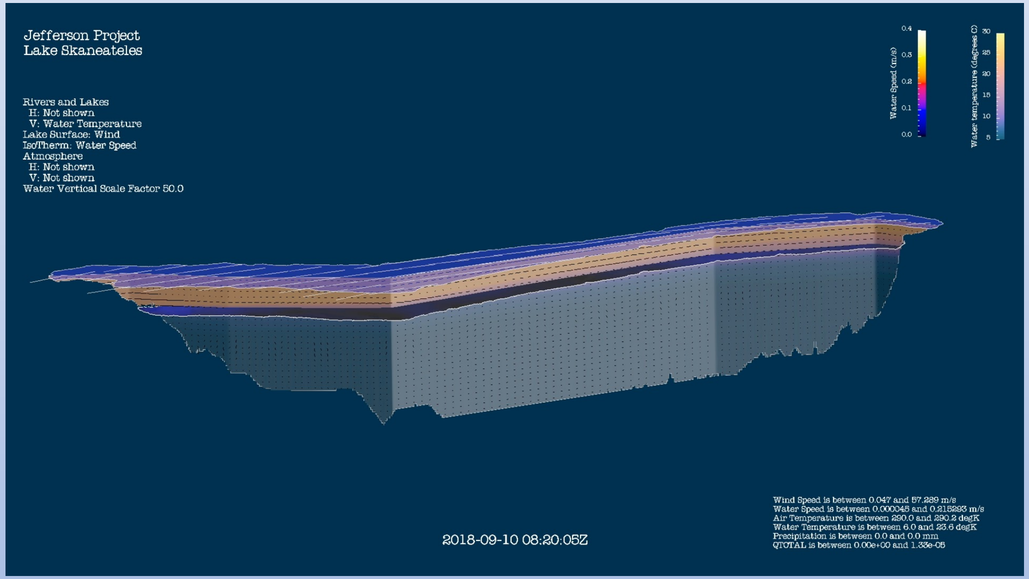
The lake is a complex environment comprised of a "systems of systems"



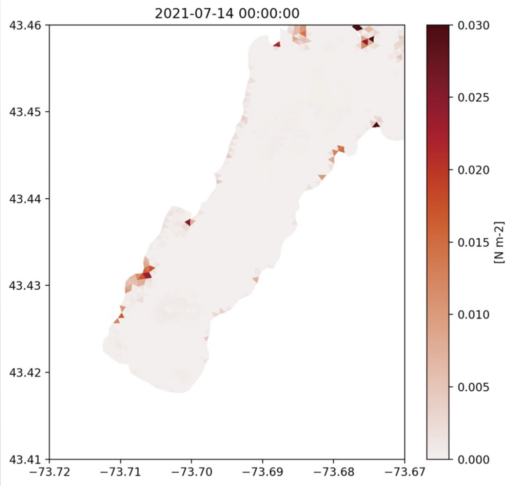
Mechanisms

HABs germination and recruitment

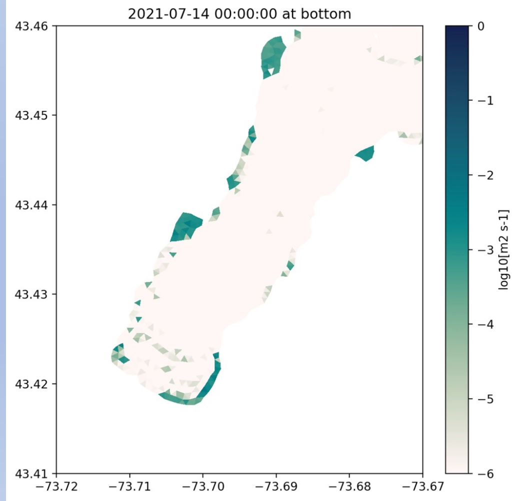
Internal waves



Lake bottom Interactions

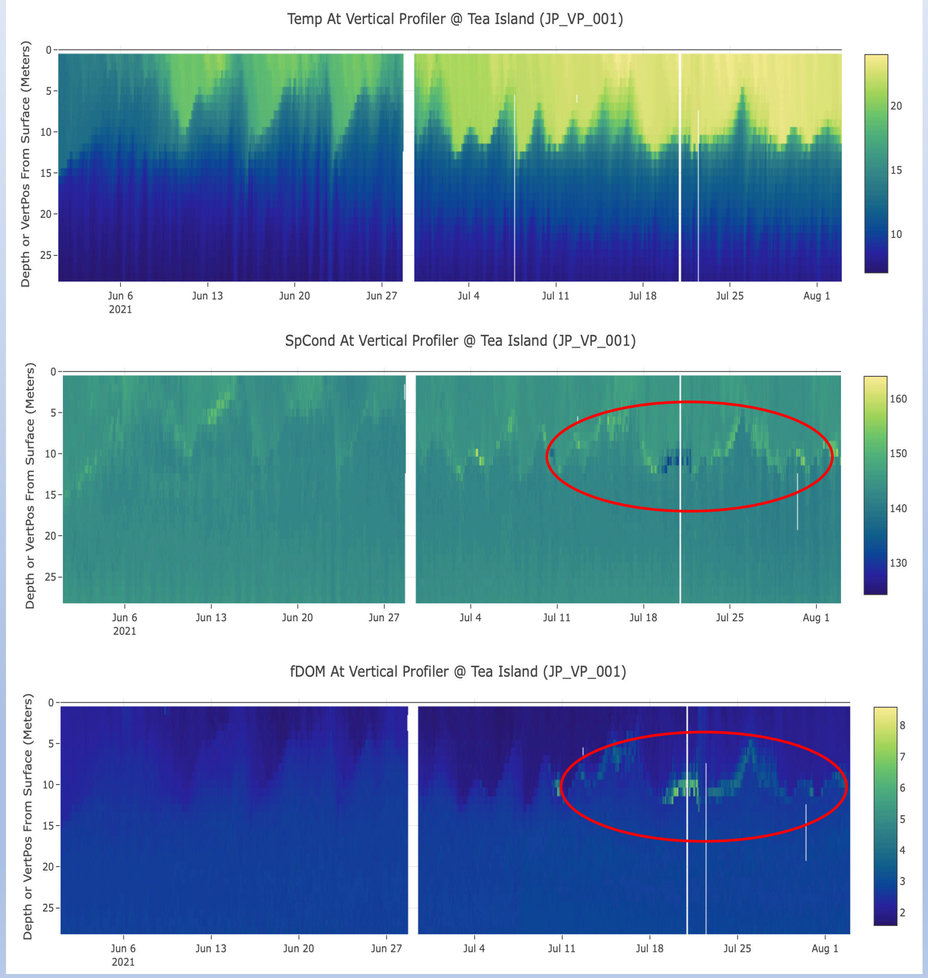


Shear stress



Turbulent diffusion rate

Stream intrusion and contaminants

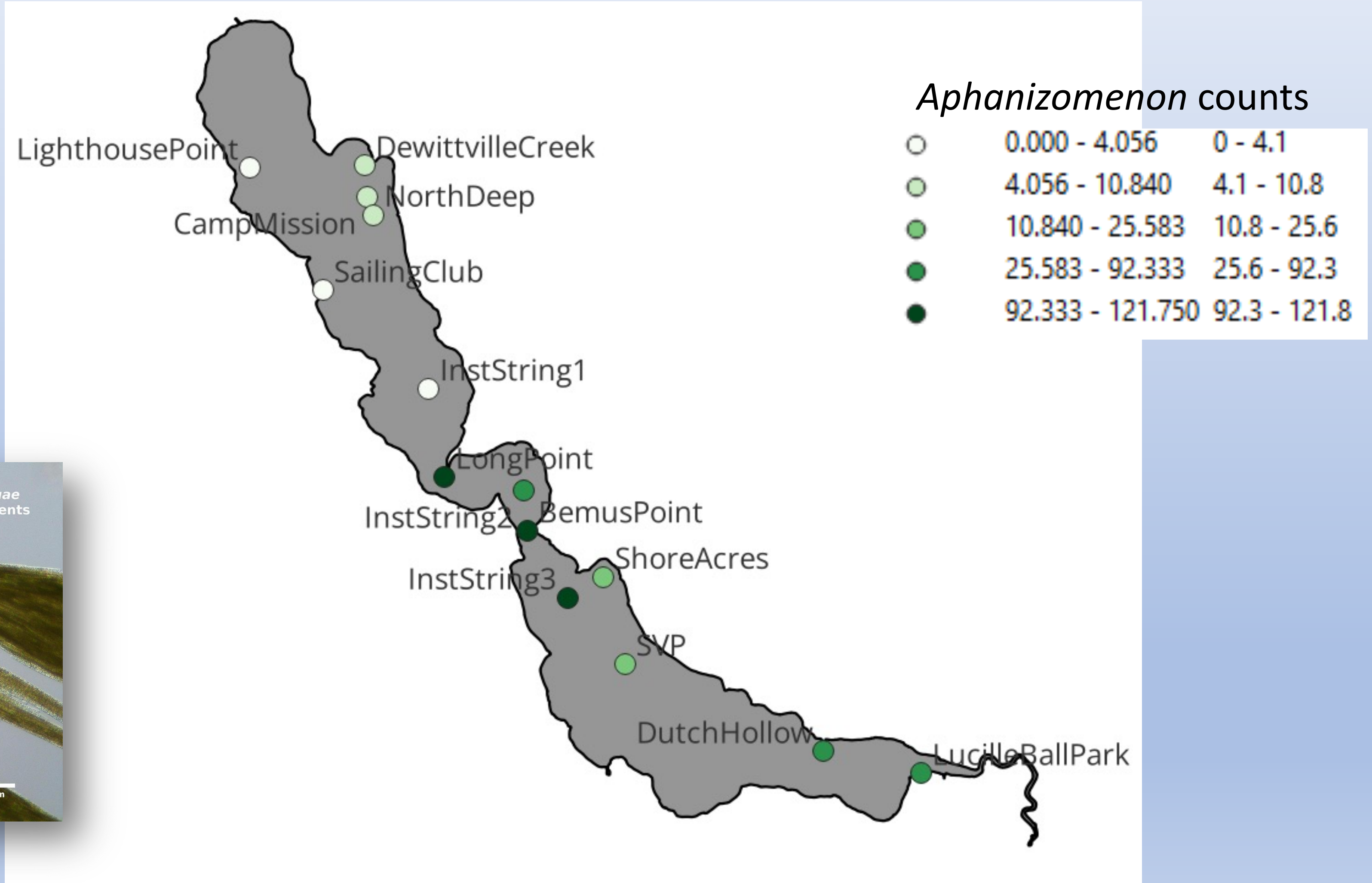


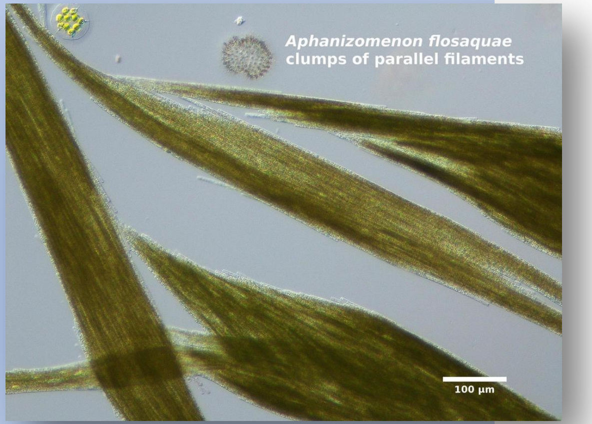
Sampling program

Sampling is underway!

- Bi-weekly sampling at 18 lake stations
- Algal tile survey at 11 dock sites
- Cyanobacteria sensor from a dock in Celoron
- Vertical profilers and phosphorus sensors to be launched soon

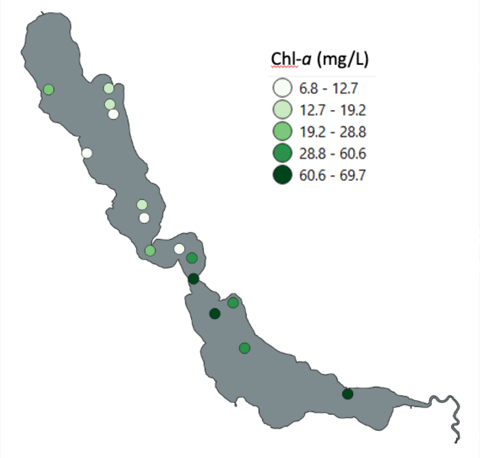
Cyanobacteria - more abundant in the southern and central parts of the lake

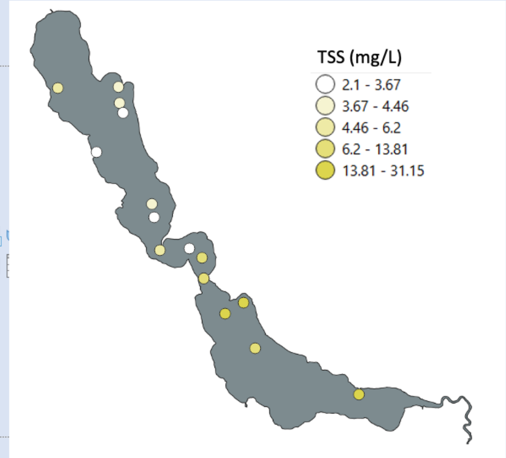




Select sampling survey early results - 2022

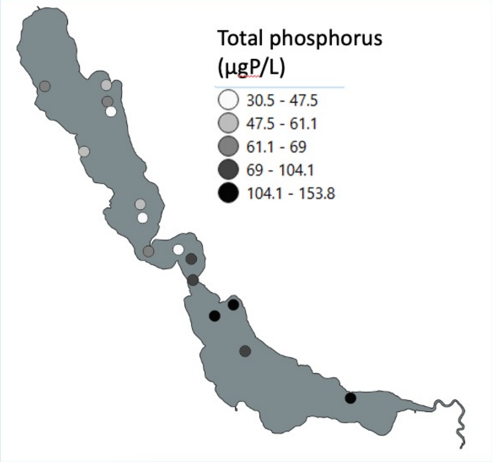
High chlorophyll-*a* and total suspended solids

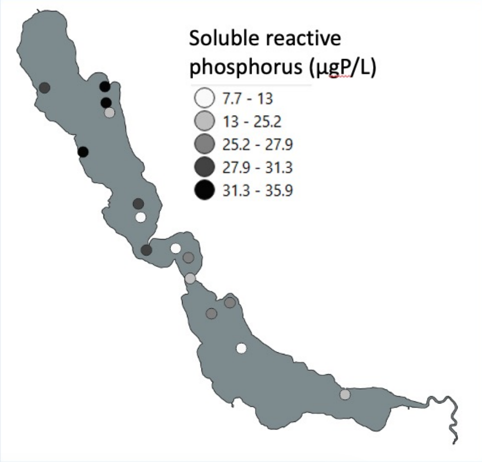




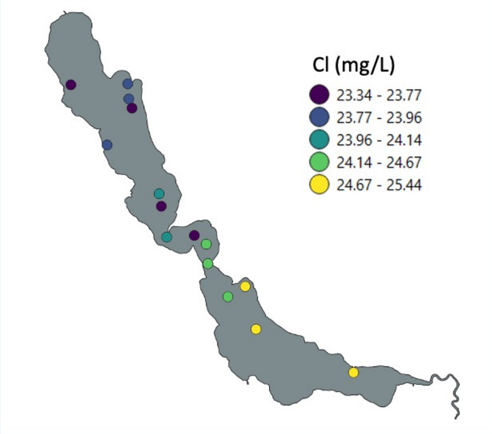
All values are epilimnetic means from 2021-2022

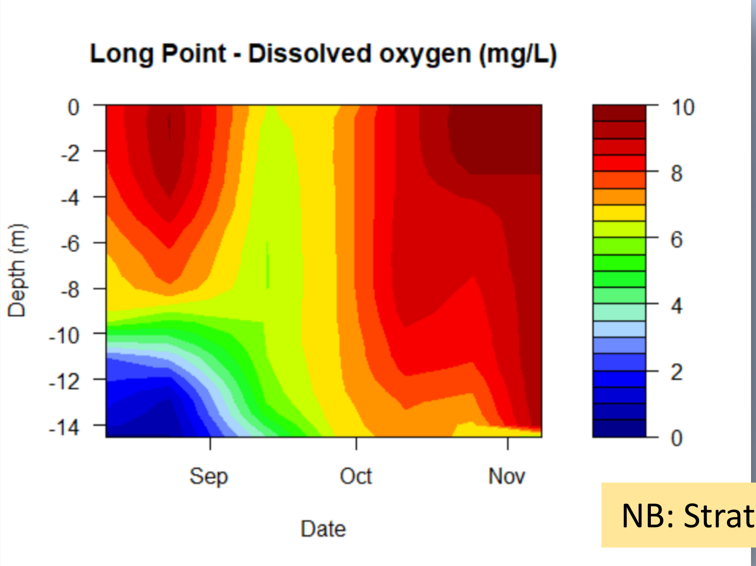
Potential SRP uptake in South Basin





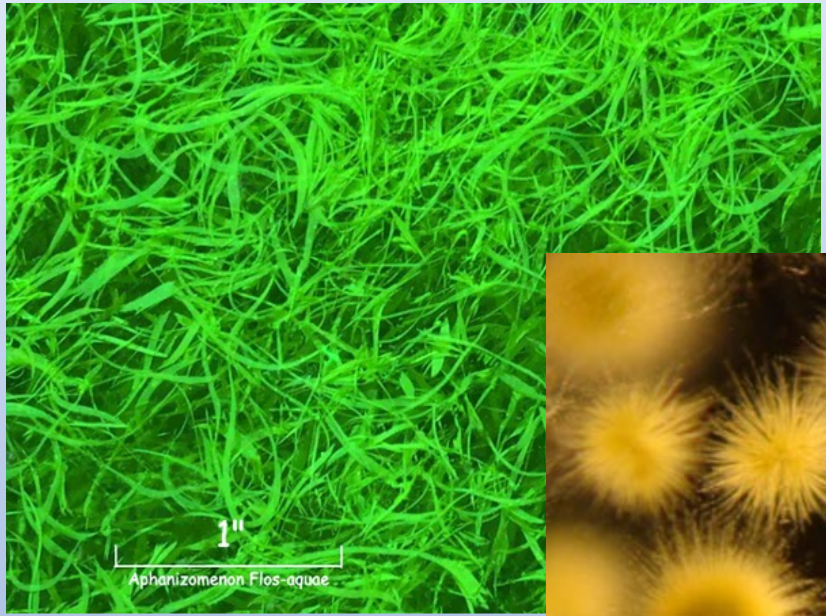
Chloride is higher in the south basin

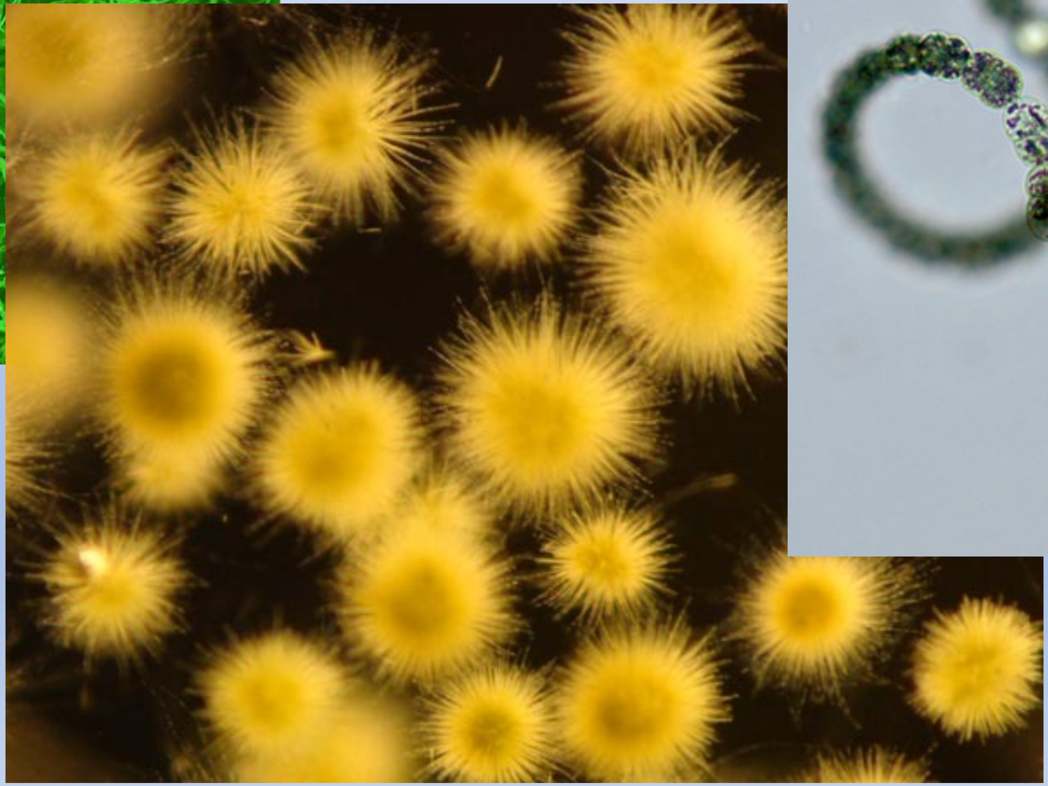




NB: Stratification @ 11m

Nitrogen-fixing cyanobacteria are common





Images: UNH PhycoKey

Summary of 2022 sampling findings

- Different conditions in 2021 vs. 2022
  - SRP, nitrate, and perhaps ammonium were much higher later in the season in 2022
  - Higher chlorophyll in 2022

- Chloride dynamics are not unexpected (road salt incursion) and may be worth further investigation

- Evidence of nitrogen limitation

Advanced technology and supporting cyberinfrastructure

JP technologies have been essential tools to better understand HABs

YSI 6951

- Standard sensor payload with limited sensor expandability and integration
- Coarse spatial profiling
- 135 W solar capacity
- 200 Ah battery capacity
- No water current monitoring capability

RPI CATS V1

- Enhanced sensor payload
- High frequency profiling with precise depth acquisition
- 300 W solar capacity
- 300 Ah battery capacity
- Single water current sensor (ADCP)

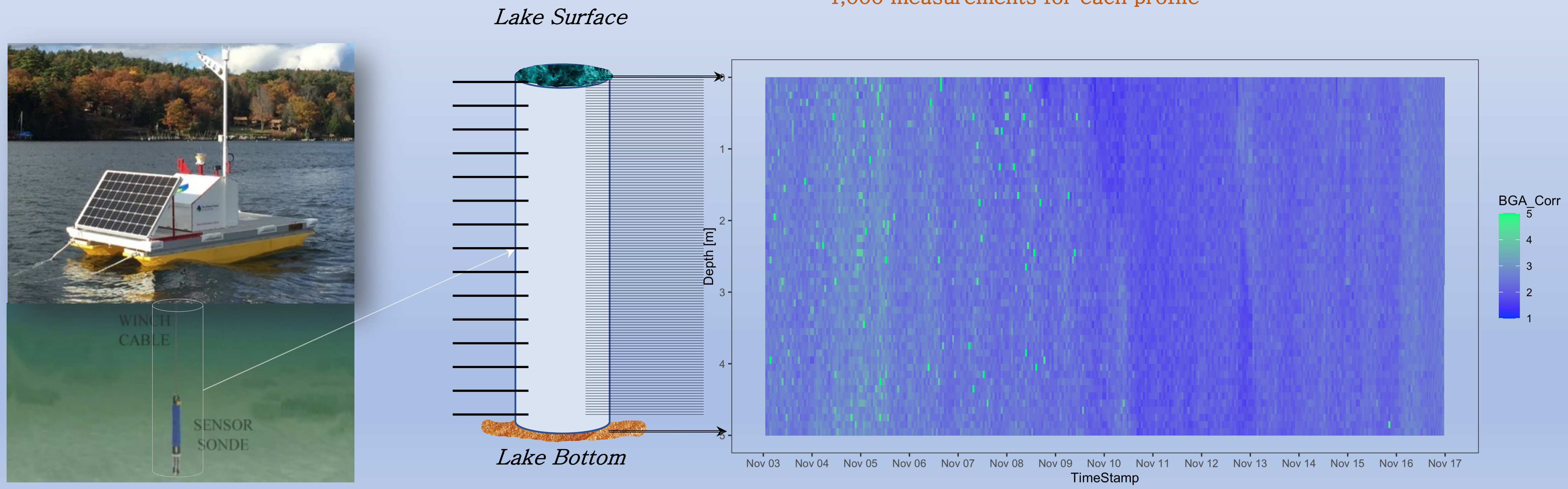
RPI CATS V2

- Enhanced sensor payload
- High frequency profiling with precise depth acquisition
- Integrated triple ADCP and surface WQ sensor mounts
- Larger, more stable platform
- 300 W solar capacity
- 400 Ah battery capacity
- Improved visibility and safety
- Increased flotation and deck space

HABs are more than a surface phenomenon

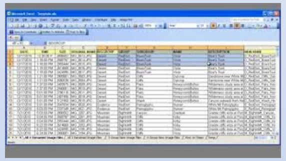
Jefferson Project Advanced Technology
Detecting Blue-Green Algae (BGA) in the water column via high-resolution measurements

30 minutes to profile surface to bottom
4,000 measurements for each profile



Lake George

A coupled observatory and modeling System at Lake George



~39 years of historical water quality data

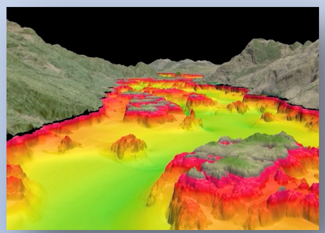
Analytics Platform

- Visualization
- Scenario Engine
- Analytics
- Data & Semantics

Operational Model Forecasting Platform

- Chemistry/Biology
- Circulation/Ice/Particle
- Runoff/Pollutants
- Weather/Land Surface

Bathymetric& topographic survey data



IoT Edge Nodes (Sensors with real time, autonomous edge analytics and AI)

Vertical Profilers

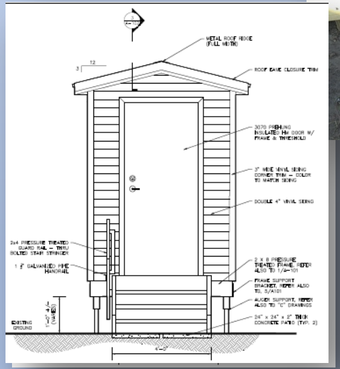
Weather Stations

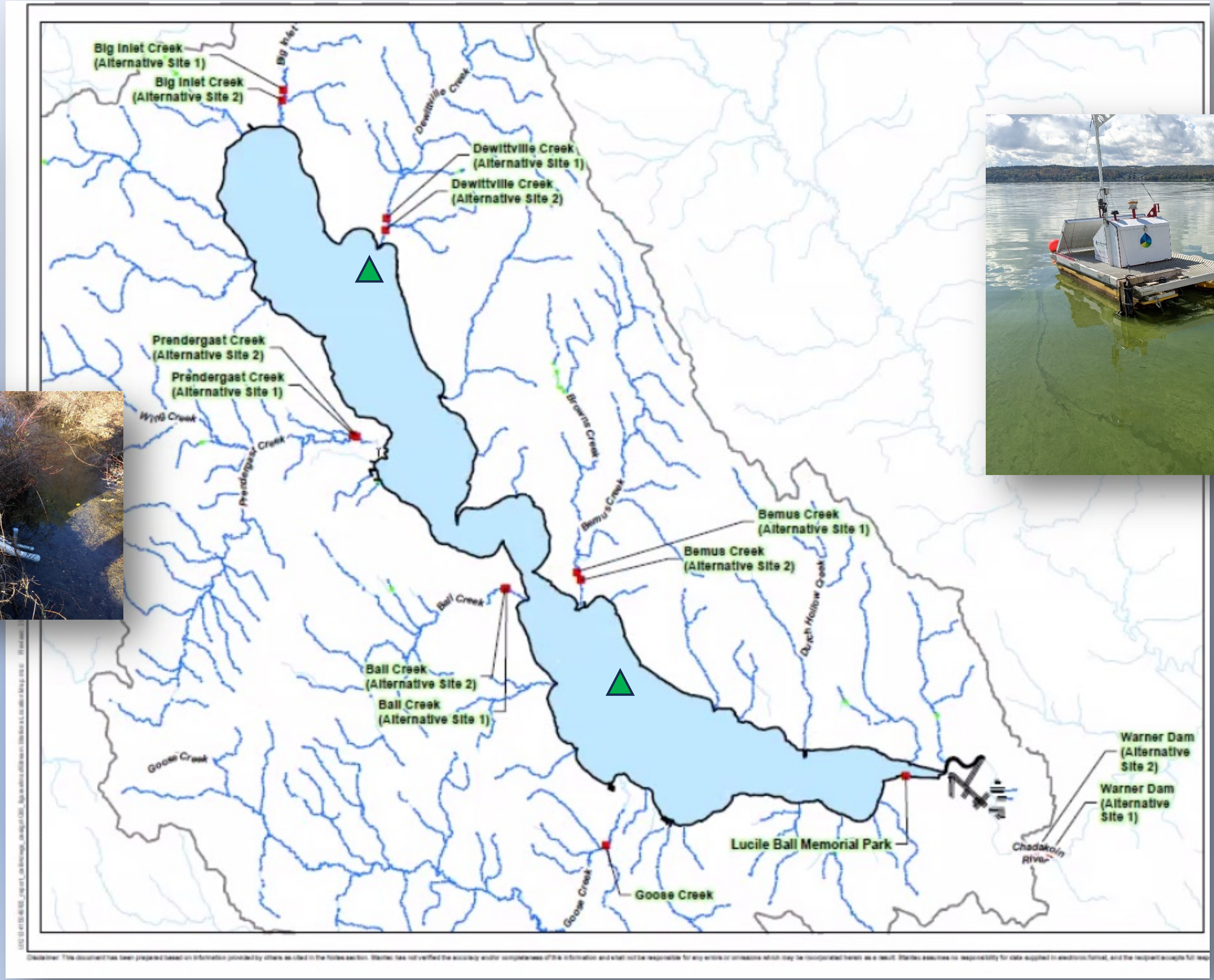
Stream Stations

ADCPs

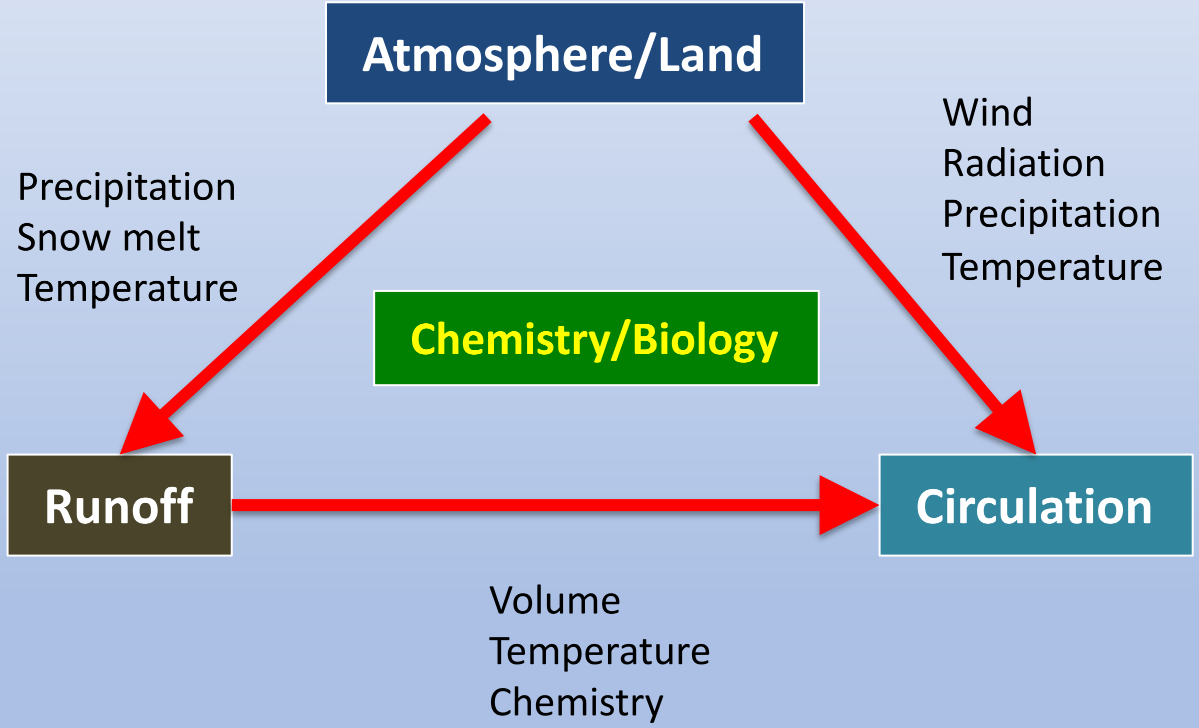
~50 sensor platforms, 500 sensors, 1.3 B observations

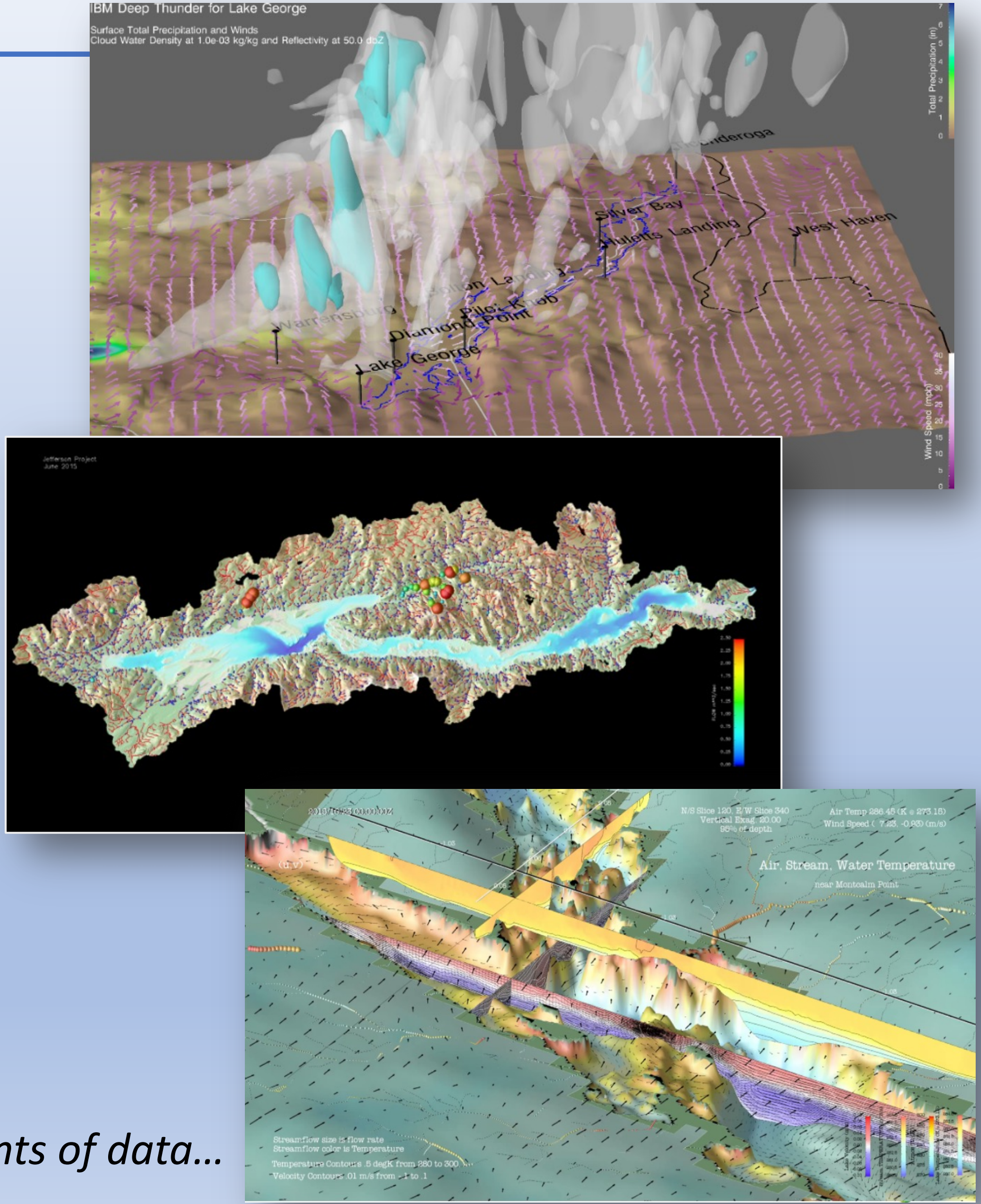
Vertical profiler deployments and tributary monitoring station rollout





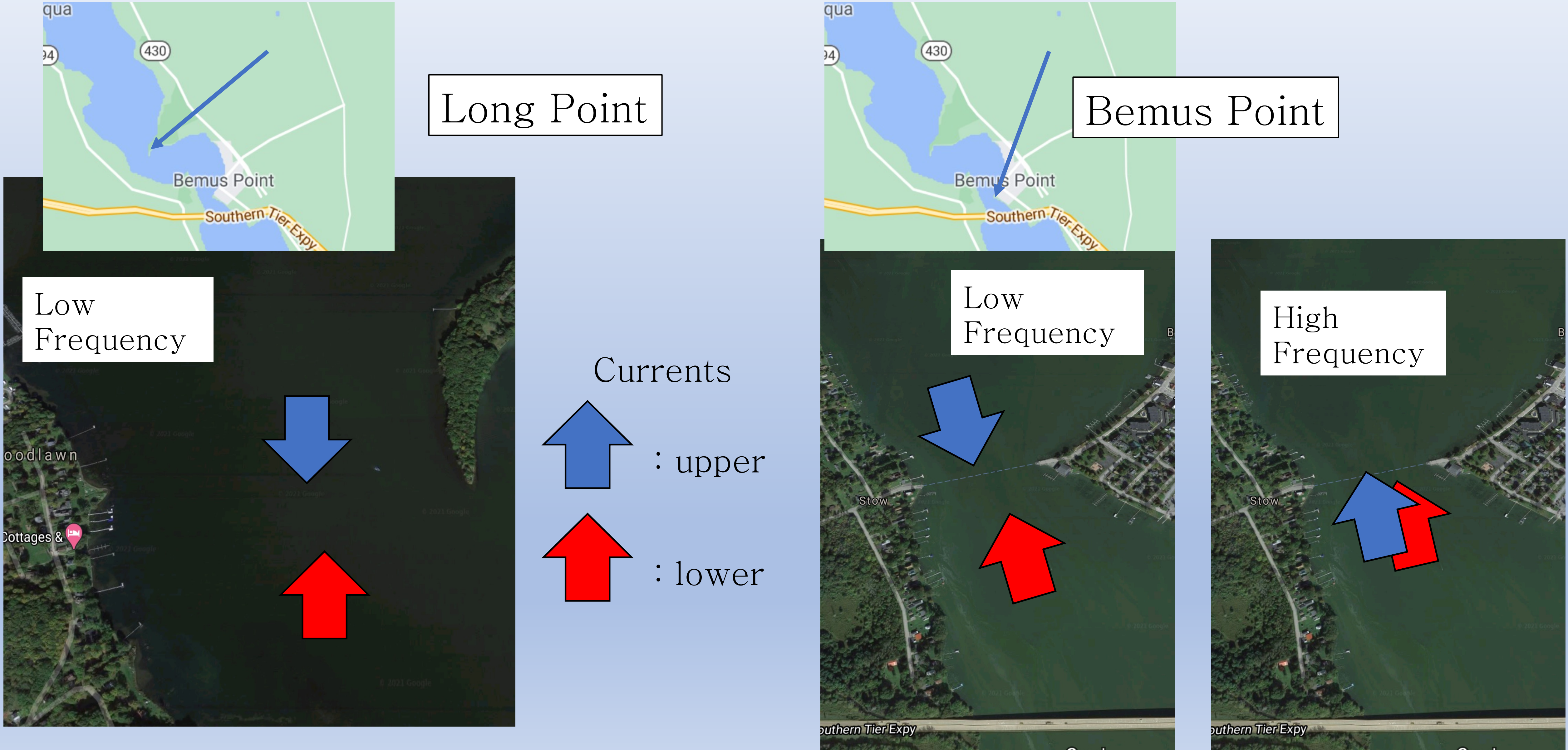
Coupled computer models provide the foundation for prediction





These models are "operational," running daily and generating huge amounts of data…

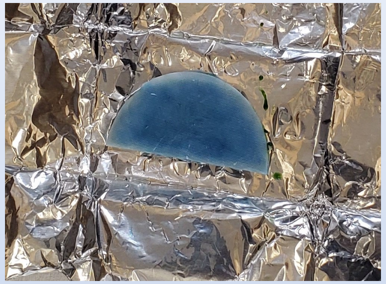
Chautauqua Lake circulation studies 2022



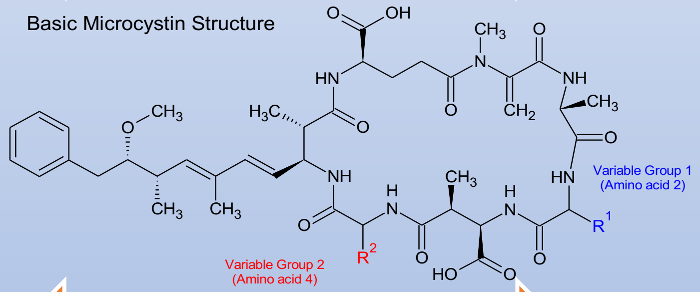
Genomics

Linking the mesoscale to the microscale: The physics-chemistry-biology axis

Sampling

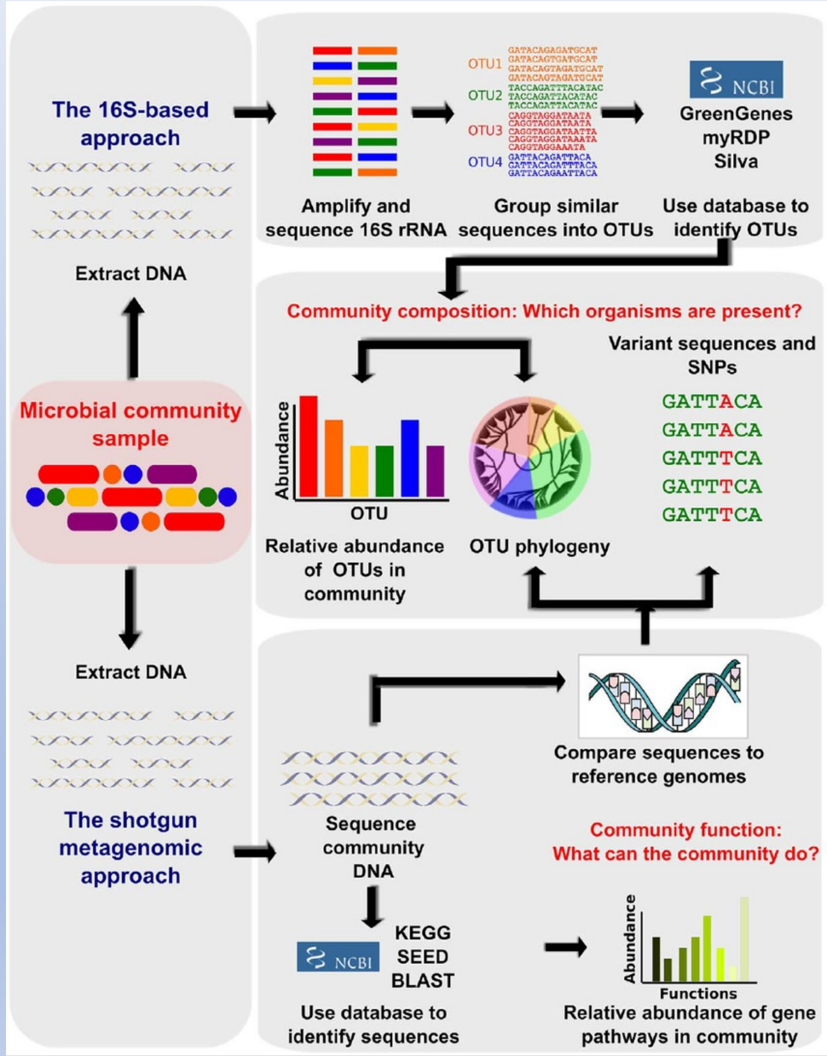


Sensing

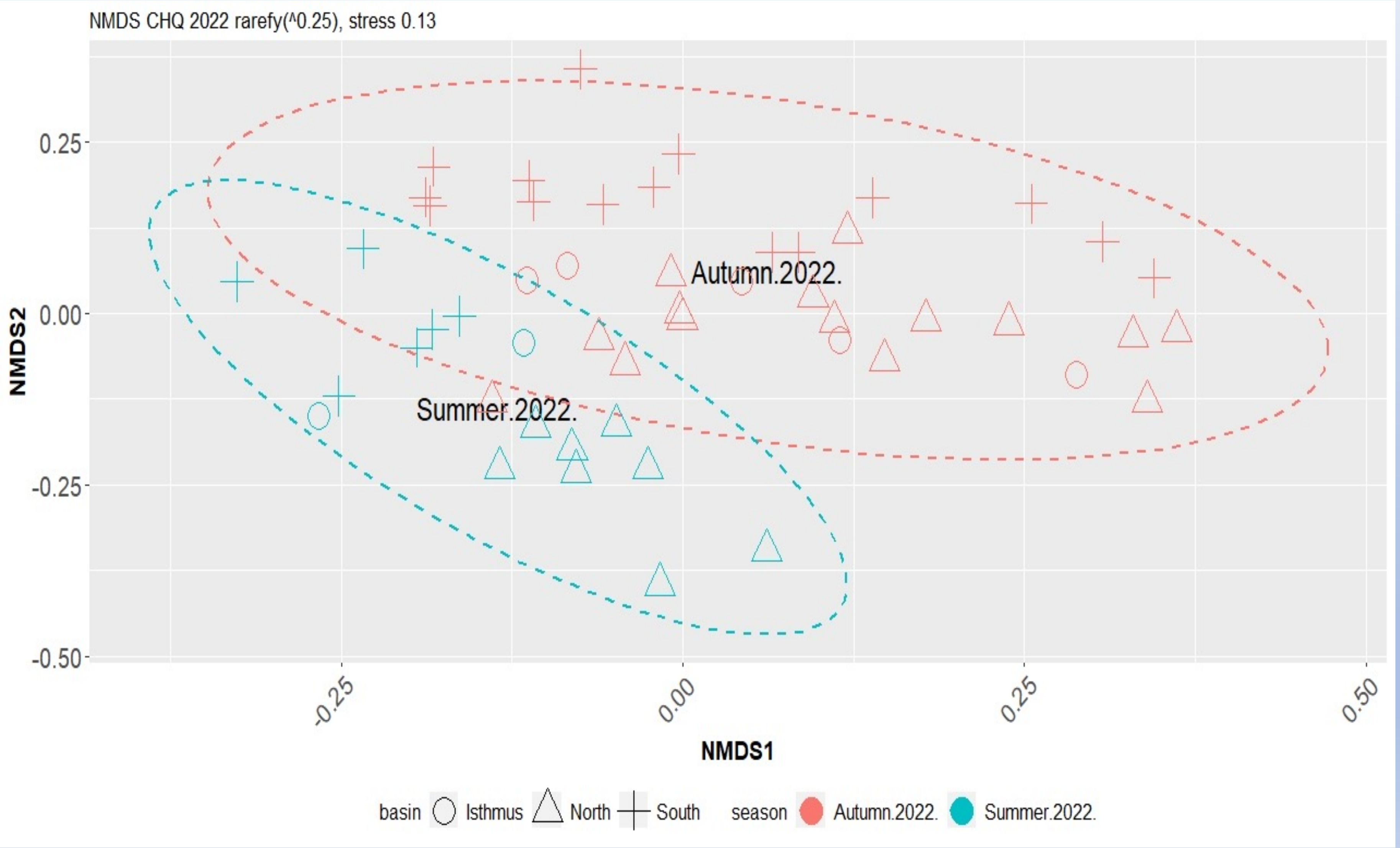


Data Analytics

Lake Metagenomics

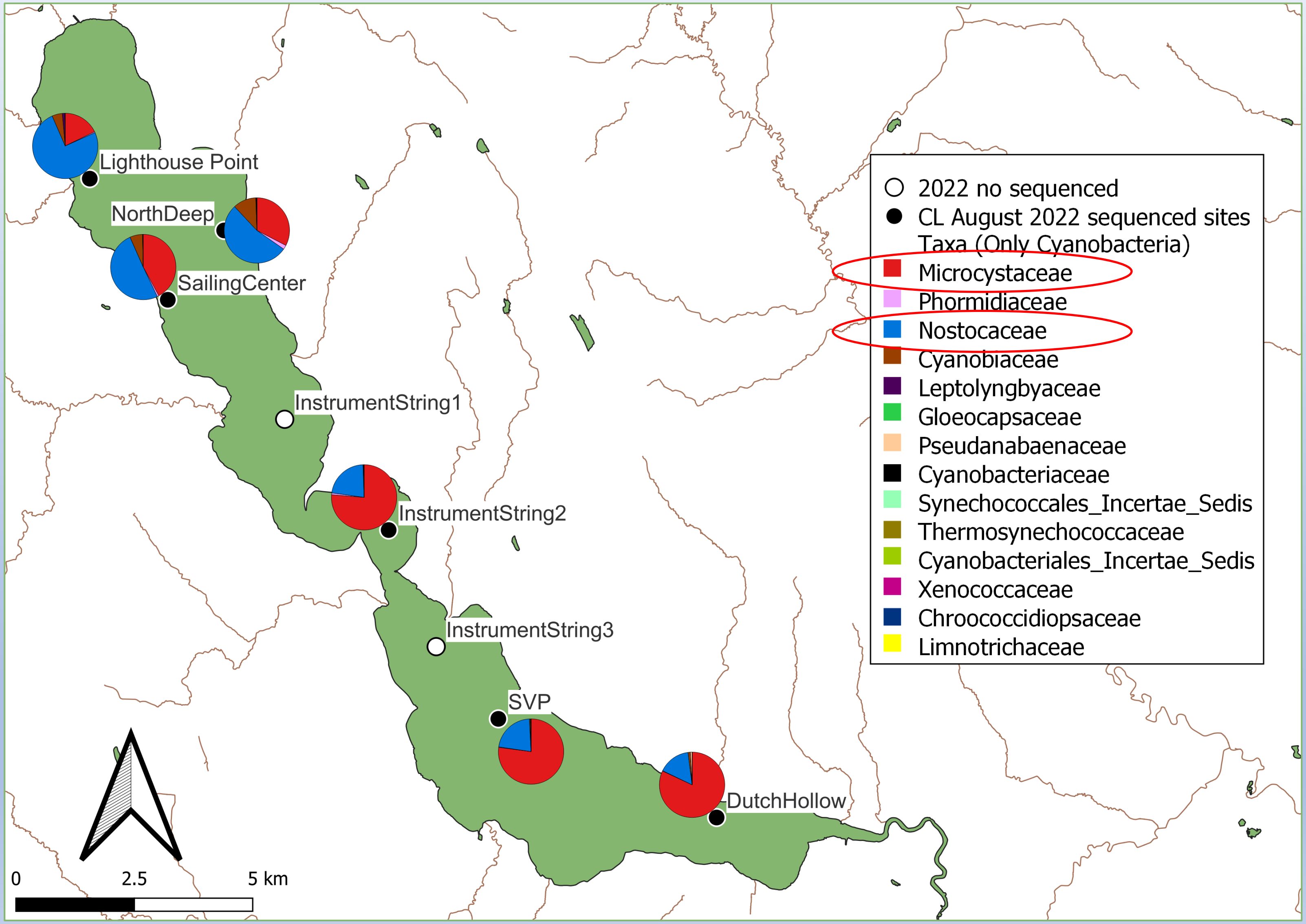


Microbial community structure – Chautauqua Lake



At a large time scale (entire season) the community structure is separated by season and basin, most likely explained by the many differences between basins

Spatial distribution of 16S cyanobacteria abundances in Chautauqua Lake blooms (Aug. 2022)



- Cyanobacteria in Chautauqua Lake are represented by a few families.
- Most abundant: Microcystaceae (red) & Nostocaceae (blue).
- Very different bloom composition than Lake George.
- Cyanobiaceae (brown) (*Synechoccus*) is more abundant in the less eutrophic Northern basin.

What is next?

- Continue to obtain samples and obtain high-quality sequences
- Perform transcriptomics (RT-PCR) of cyanobacteria focusing on known toxin pathway genes. Correlate bloom vs. no bloom and toxin formation vs. no toxin formation.
- Perform mass spectrometry analysis to identify and quantify toxin production from lake samples.
- Develop models that link the physical and chemical features of the lakes with the microbial populations.

Goal: Curate the data and develop predictive machine learning models.

(Optionally: Perform highly controlled mesocosm studies to test models)

2023 Plans: the way forward

Sampling

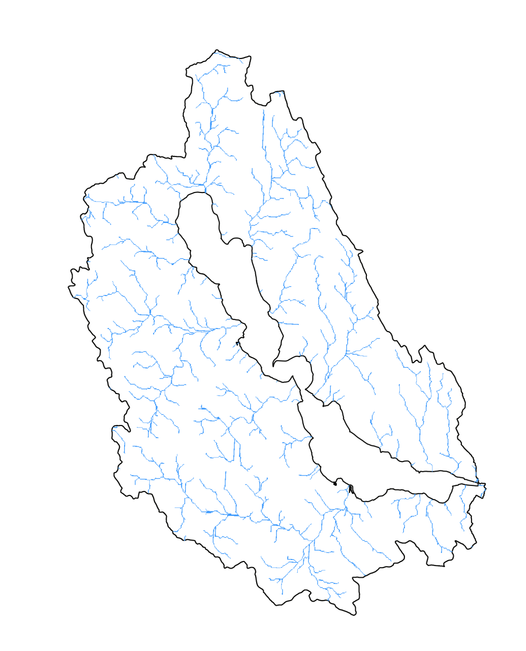
- Continue biweekly lake sampling program
    - Focus on toxins via transcriptomics

Observations/measurements

- Redeploy next generation vertical profilers in N and S basins
- Complete the tributary station and outlet (Chadakoin River) rollout

Modeling

- Validate and refine the hydrological (runoff) model
- Characterize stream runoff effects
- Determine water residency times for Bemus Bay
    - water from the north basin
    - water from the south basin
    - during both stratified and unstratified seasons
- Continue building the lake nutrient model



Summary

- We continue to make significant progress in the understanding of the multiple components contributing to the development of HABs. These include physical, chemical, and biological elements.
- The investment in research and technology development in conjunction with research spanning multiple lakes has been instrumental to this progress.
- Our recent advances in the application of genomics have shown great promise and suggest important findings for the near future.
- Due to the complexities of the possible multiple mechanisms involved with HABs, our near-term focus is on characterization, detection, and prediction.
- HABs remediation/prevention is likely to be complicated and expensive. Nutrient reduction will be very important and actions on this front should remain a priority.