Vermont EPSCoR

Experimental Program to Stimulate Competitive Research

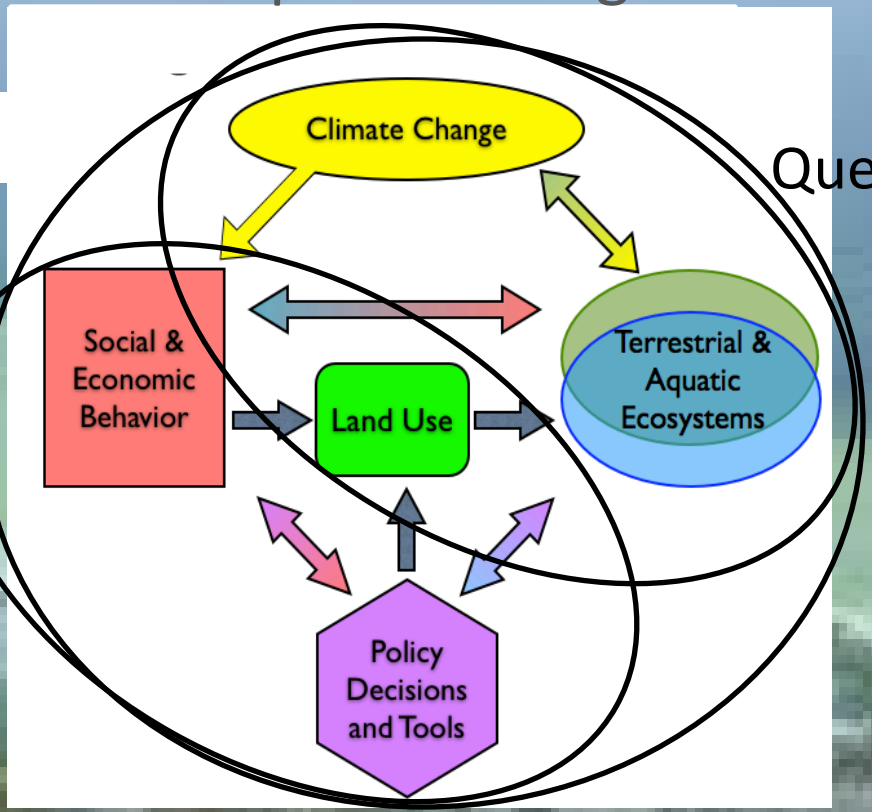
Research on **A**daptation to **C**limate **C**hange

Question 1

The Overarching RACC Question

How will the interactions of climate change and land use alter hydrological processes and nutrient transport from the landscape, internal processing and eutrophic state within Lake Champlain, and what are the implications for adaptive management strategies?

Integrated Assessment Model (IAM)



Questions 1 and 2

Question 3

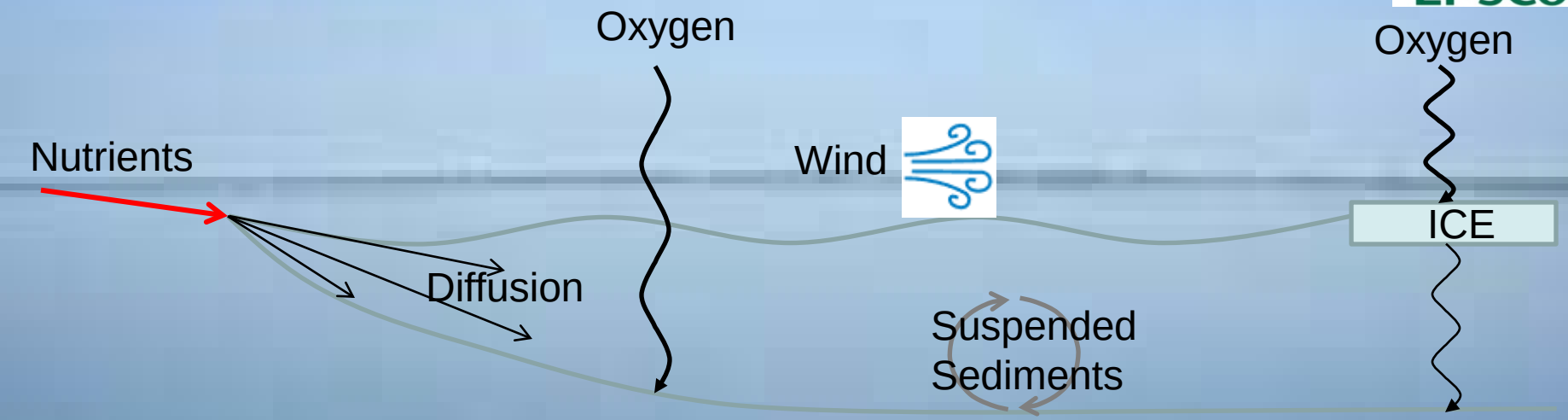
Question 1

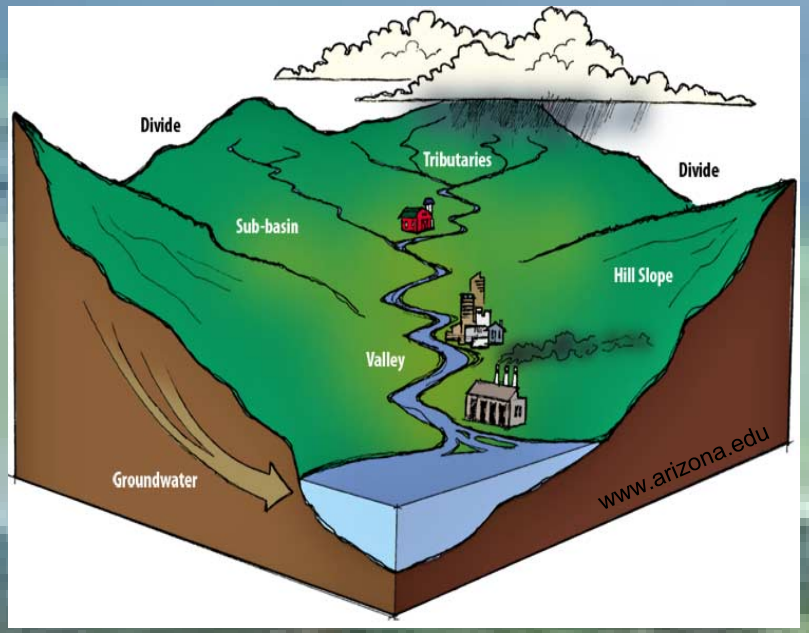
- Q1: What is the relative importance of endogenous (in-lake) processes versus exogenous (to-lake) processes to eutrophication and harmful algal blooms?

Internal

External

Approach to Question 1





- What are the important sources of nutrients & sediment to the lake?
- How do land use and climate affect the nature and strength of these sources?
- How are nutrients and sediments transformed in transport to the lake and within the lake?
- How do the loadings of these materials affect lake processes?

The Recipe for an Algae Soup in Lake Champlain

Algae Cocktail

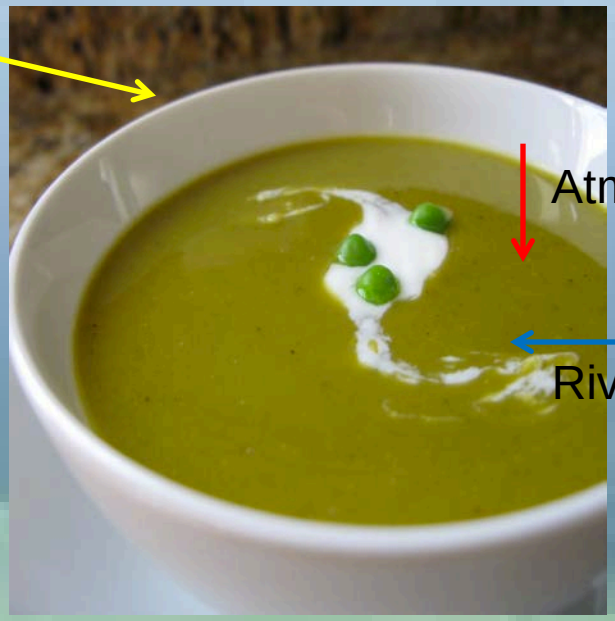
Light

Algae Cocktail

Light
Water Temperature (~ 20ºC)

Algae Cocktail

Light
Water Temperature (~ 20ºC)



Atm

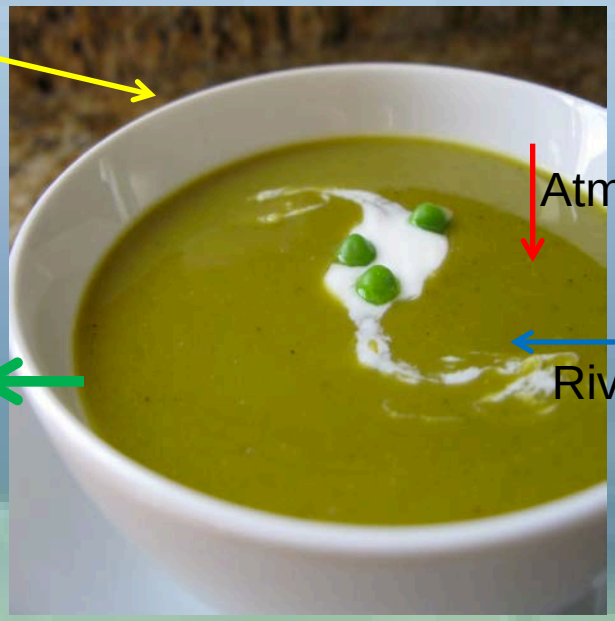
Rivers

Sediments

Nutrients – P, N

Algae Cocktail

Light
Water Temperature



Atm

Rivers

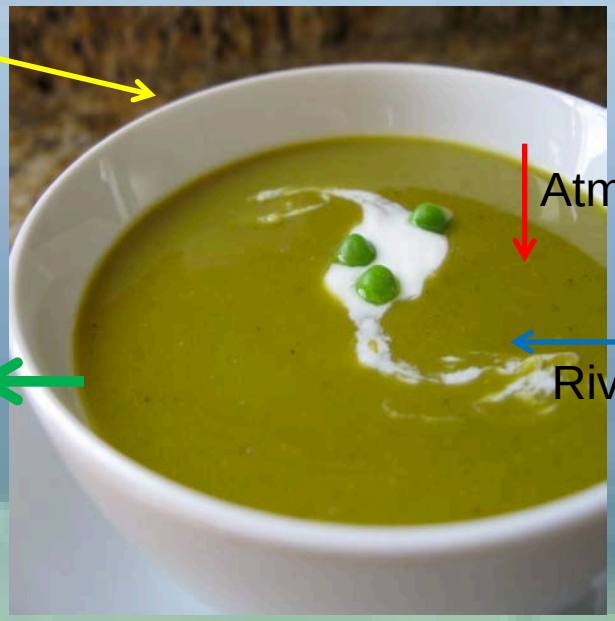
Sediments

Nutrients – P, N

High Phytoplankton Primary Productivity Cocktail

P input is the most manageable ingredient of the cocktail!

Light
Water Temperature



Atm

Rivers

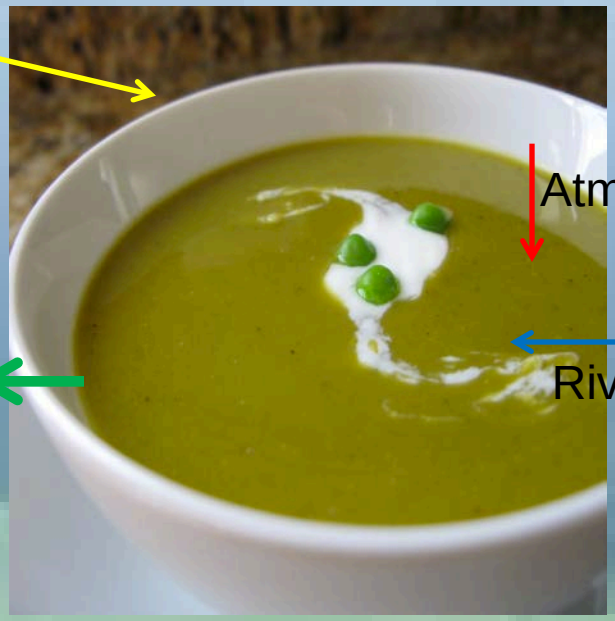
Nutrients – P, N

Sediments

How Will Climate Change Affect the Primary Productivity Cocktail

Timing of when we reach the recipe?
For how long and at what level?
Does the recipe remain the same?

Light
Water Temperature



Atm

Rivers

Nutrients – P, N

Sediments

Example Climate Change Effects on Lake Champlain System

External Changes

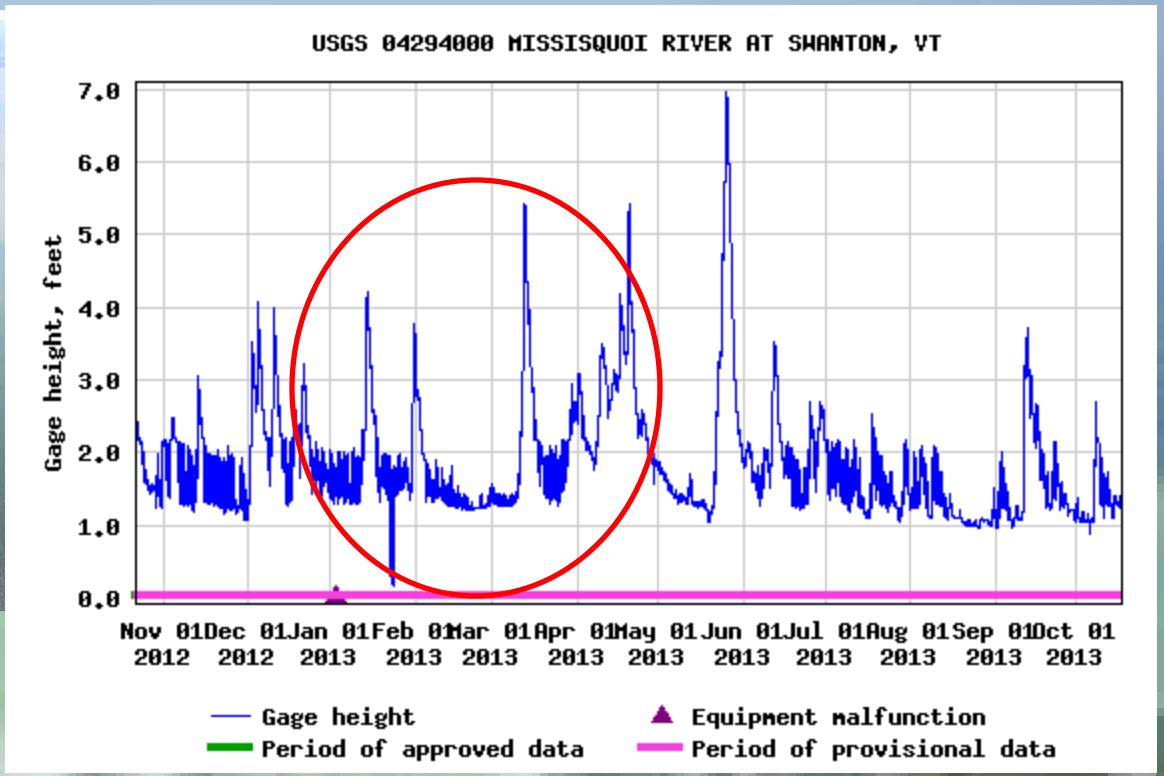
- More frequent storms
- Longer growing season on land

Internal Changes

- Less ice cover
- Warmer water temperatures for more of the year

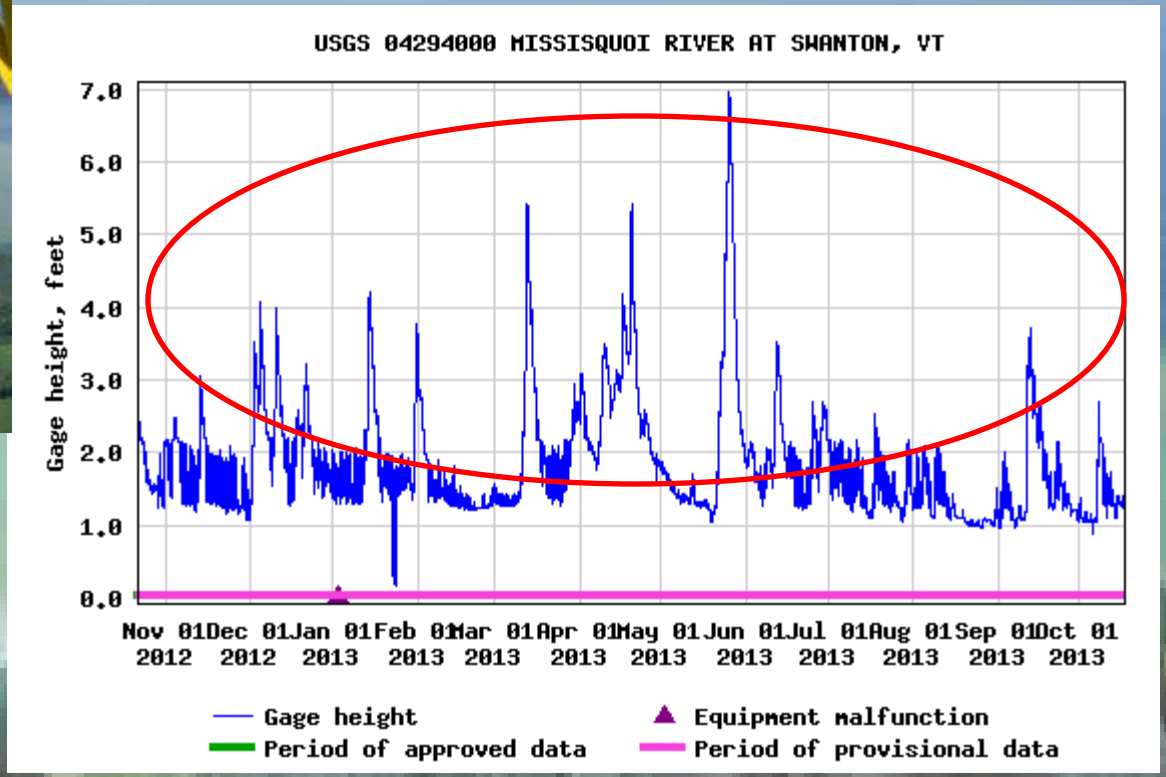
Where in the watershed does the Phosphorous come from? Most comes from high flow events

- Snowmelt



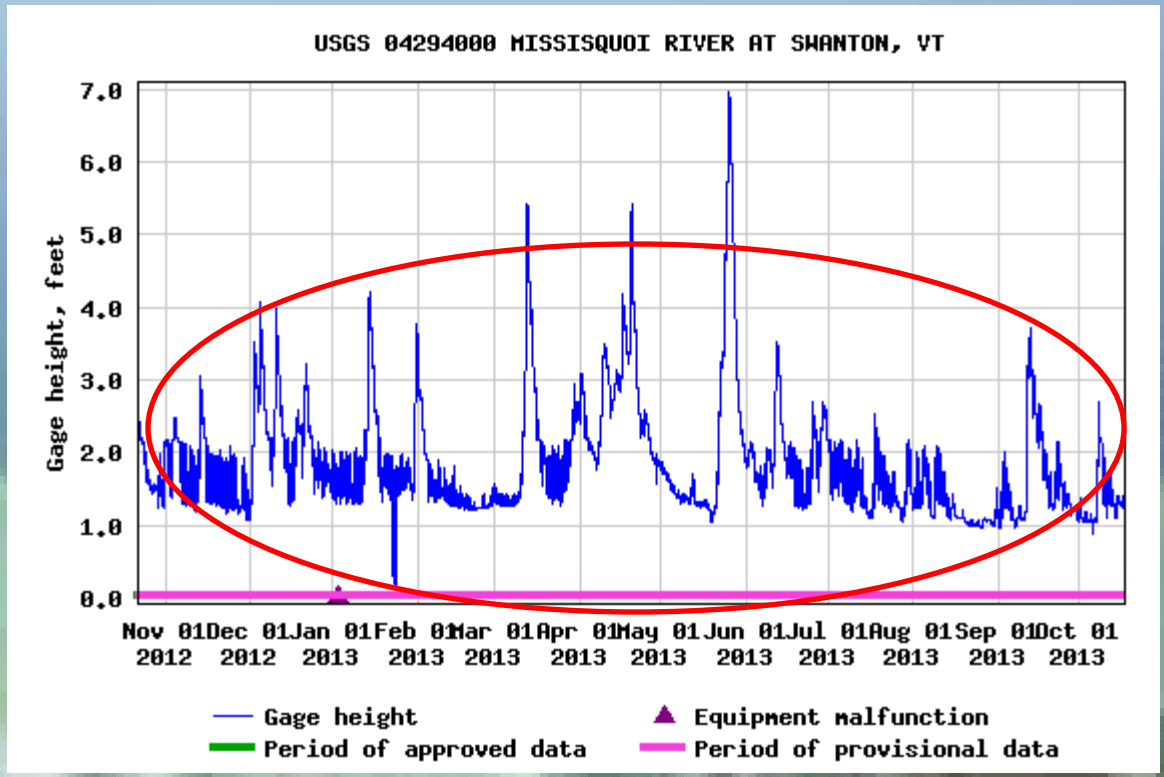
Watershed P Sources-High Flow Events

- Agricultural runoff during storms and flooding



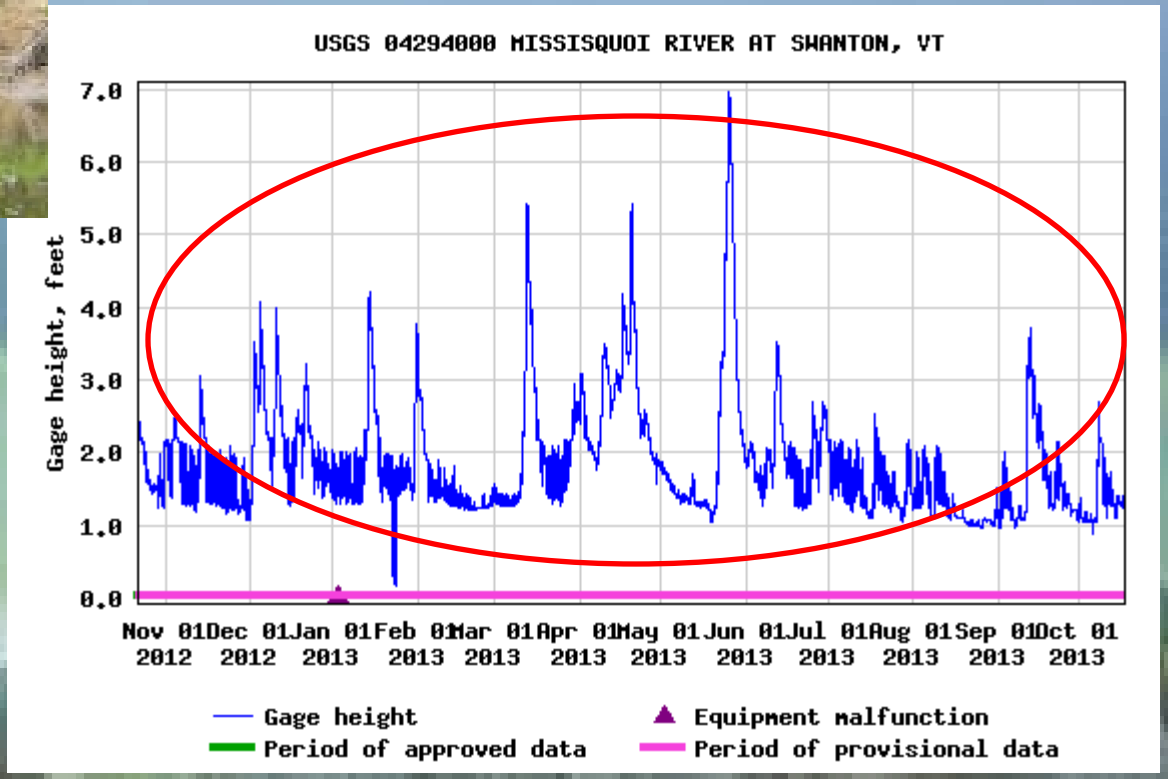
Watershed P Sources-High Flow Events

- Urban runoff during storms



Watershed P Sources-High Flow Events

- Stream bank and road erosion



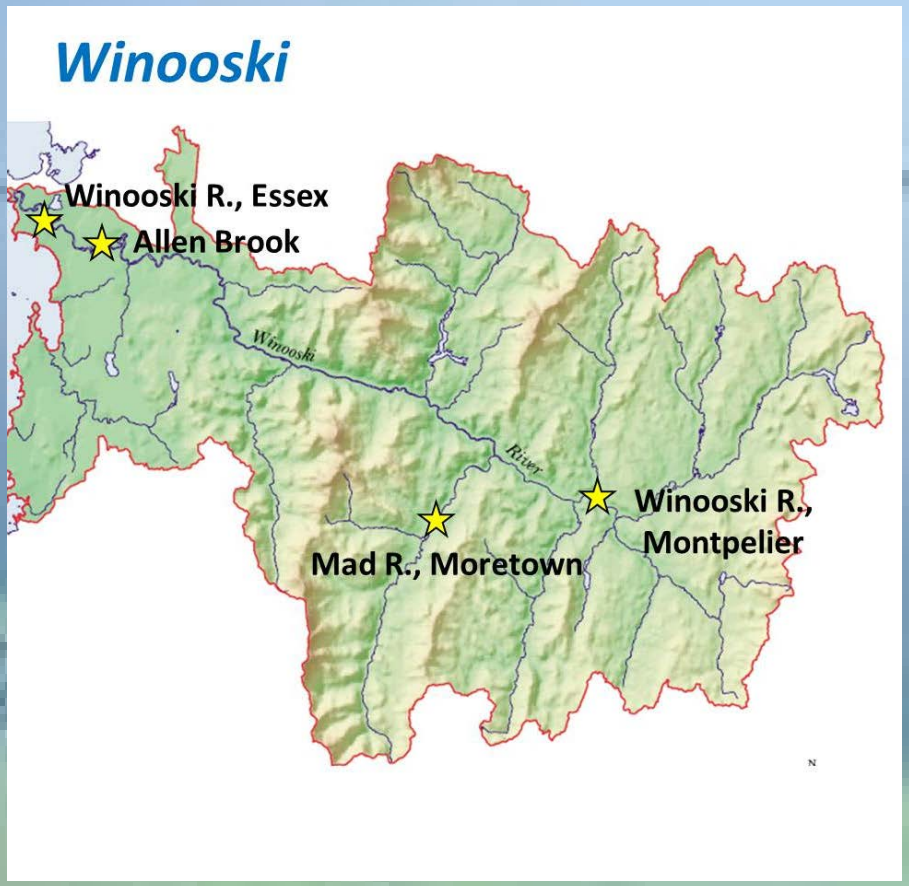
Focus Watersheds

Agriculture: runoff, groundwater, soils, stream bank erosion

Forested: soils, groundwater, roads, channel migration, erosion

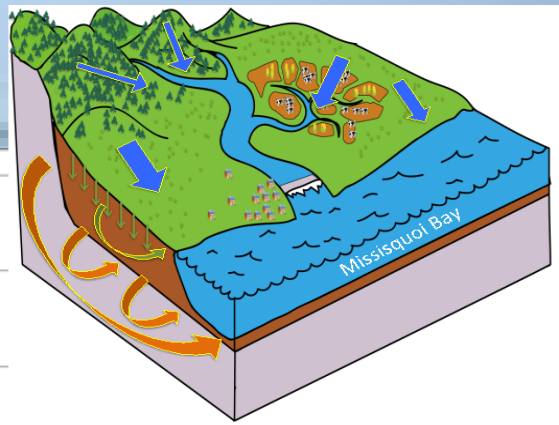
Urban: stormwater runoff, wastewater, stream erosion

RACC Watershed Monitoring Sites



Automated storm sampling coupled with baseflow grab sampling
Measurements: TP, SRP, TN, N species, metals TSS, Discharge(USGS)

Capture Storm Event Biogeochemical Evolution with Automated Sampling



Question 1

- Q1: What is the relative importance of endogenous (in-lake) processes versus exogenous (to-lake) processes to eutrophication and harmful algal blooms?

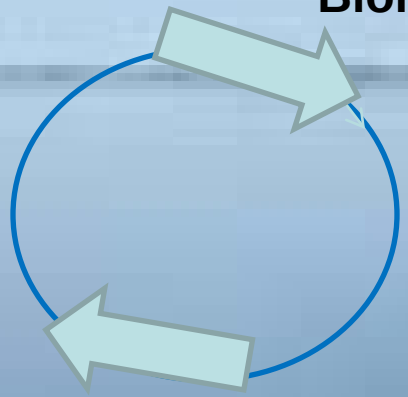
Internal

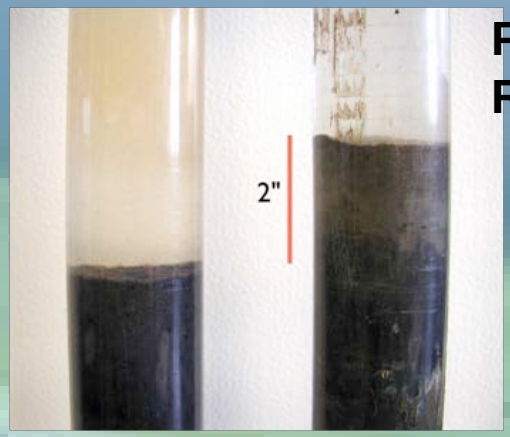
External

Lake sediment source of nutrients to the system

Poorly understood feedback loop between water column processes and sediment in shallow lake systems

Biological Productivity



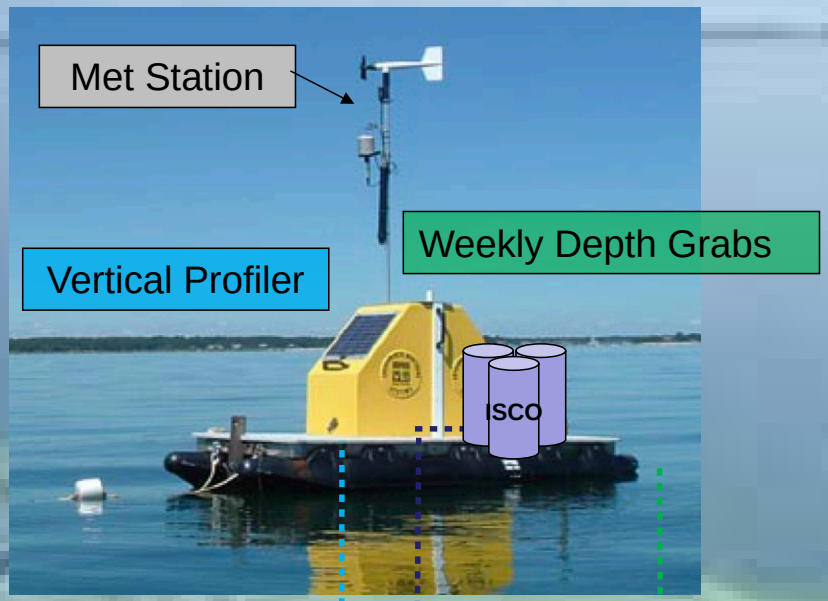


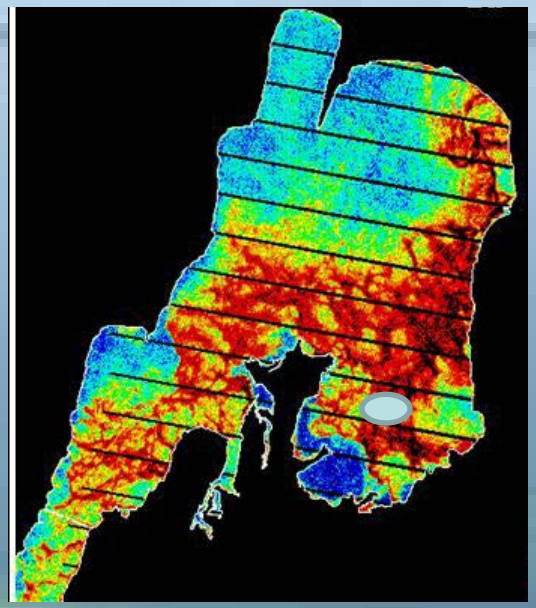
Fe/Mn minerals dissolve at SWI
Release P

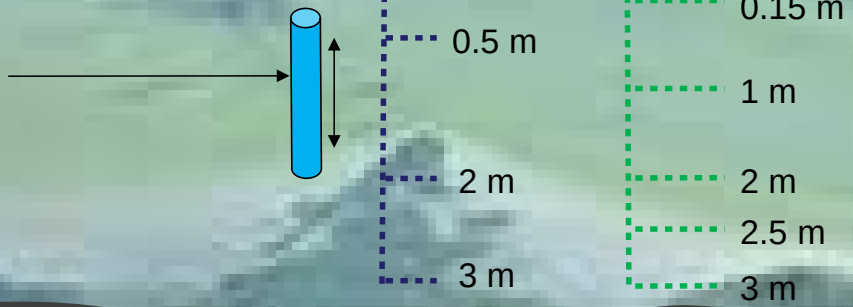
Biological productivity drives P release from sediment which drives more productivity!

Missisquoi Bay Advanced Environmental Monitoring Systems: Main Site

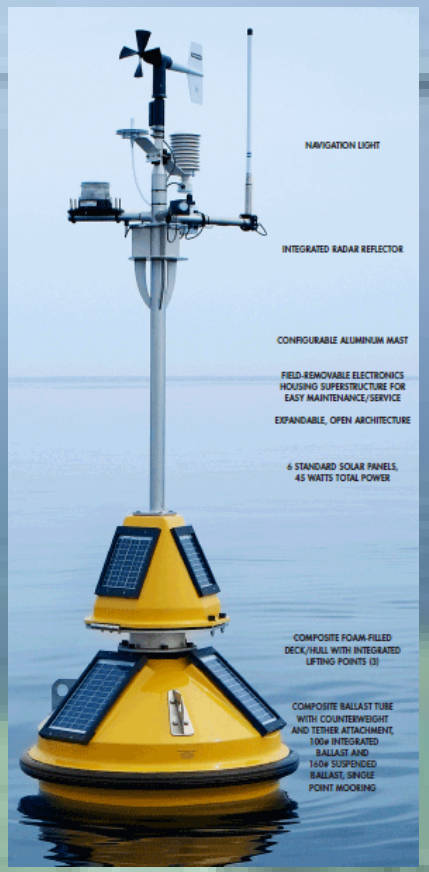
UVM Biogeochemical Station





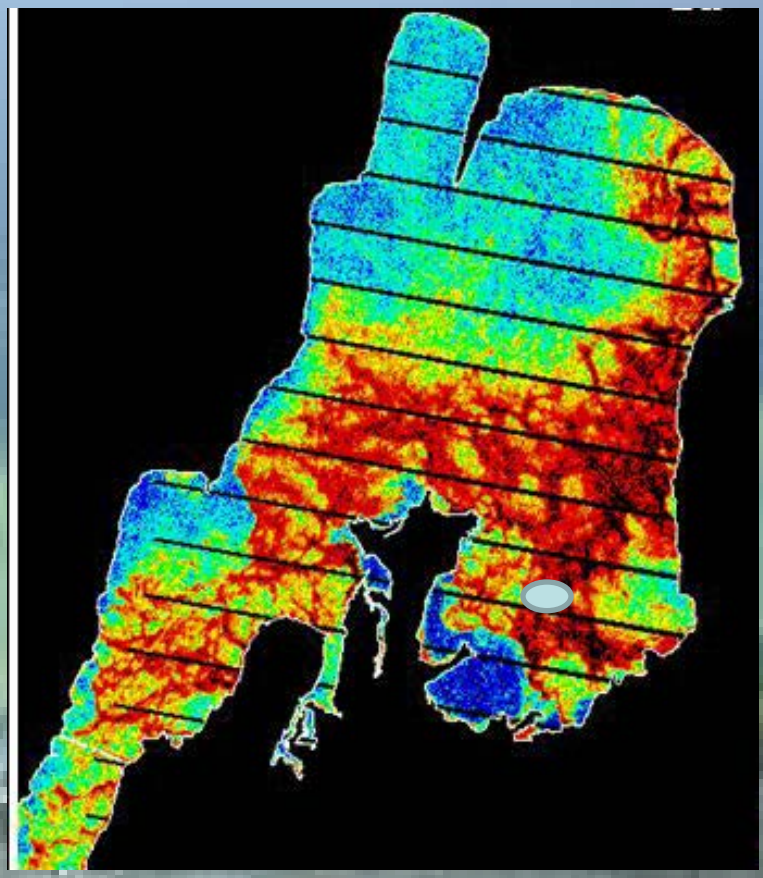


Middlebury Hydrodynamics



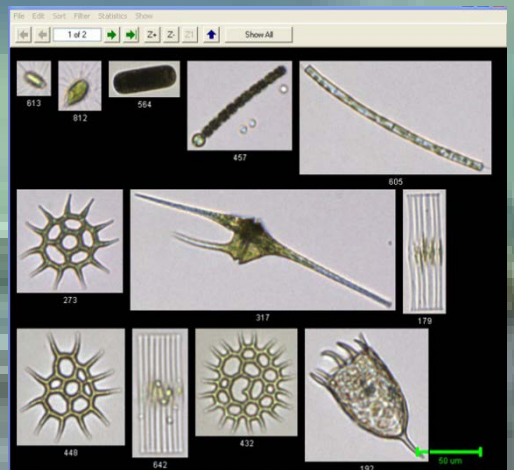
UVM Biogeochemical High-Frequency Sampling Strategy: Sample Site

- Water depth ~ 3-4 m
- SE portion of bay insulated from S, E, W winds
- Site of the most intense BGA blooms

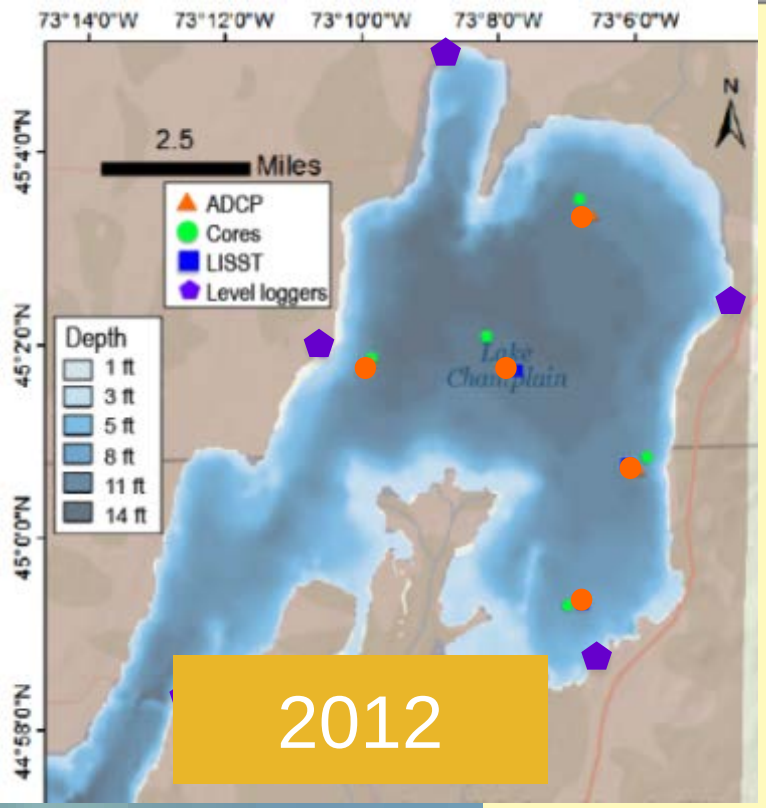


High-Frequency Sampling Strategy: Measurements

- Hourly:
  - Sonde measurements (DO, pH, turbidity, temp, phycocyanin, chlorophyll *a*) (5 depths)
  - Weather, river variables (temp, wind, discharge, water level)
- Every 8 hours (5am, 1pm, 9pm)
  - Total nitrogen, total phosphorus, total metals (3 depths)
- Weekly
  - SRP, TDP, NO_3^-, NH_4^+, dissolved metals, colloidal metals, DOC, phytoplankton species, zooplankton species, TSS, sediment cores(forms of metals and P, Biweekly)



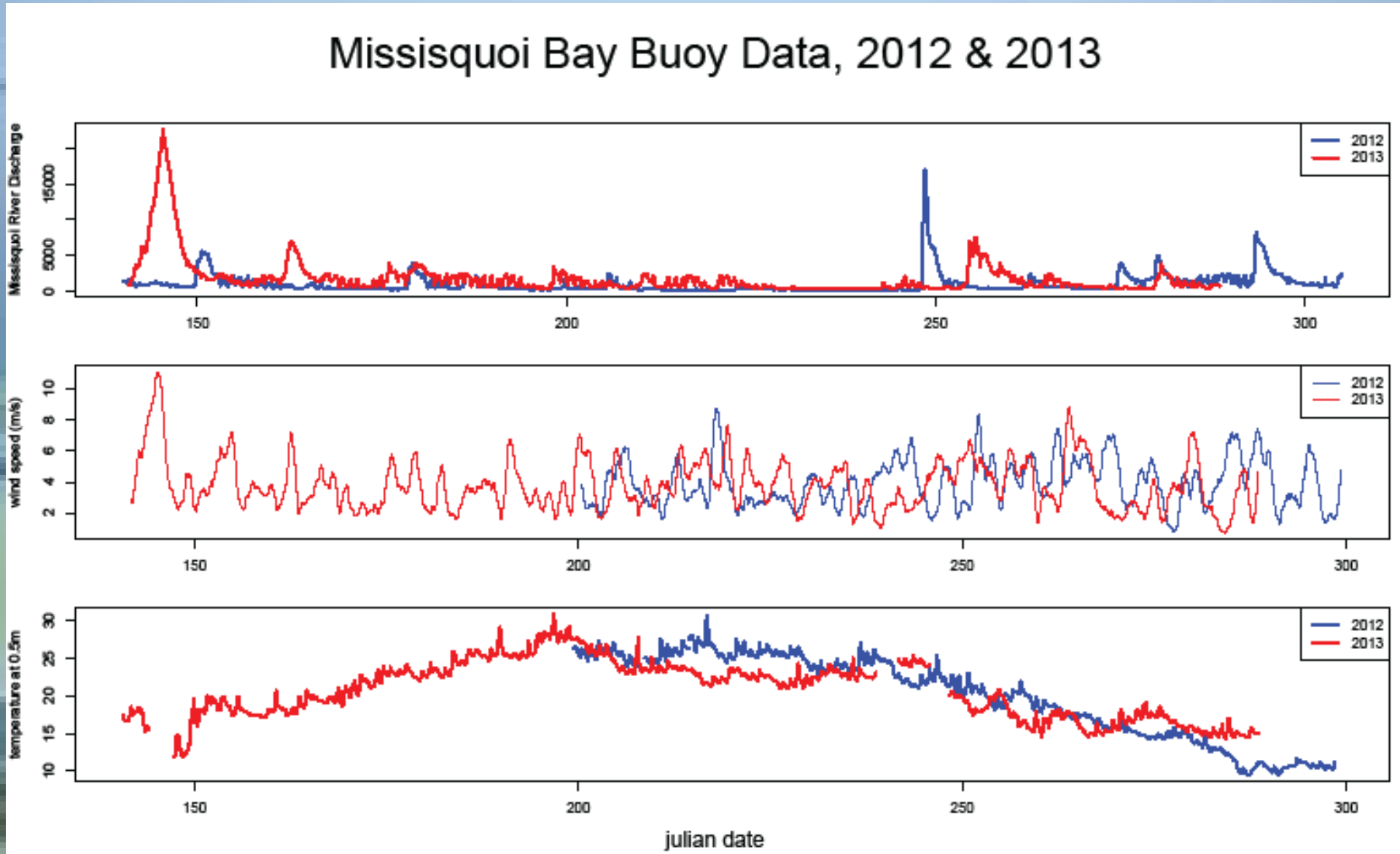
Middlebury Hydrodynamics Array



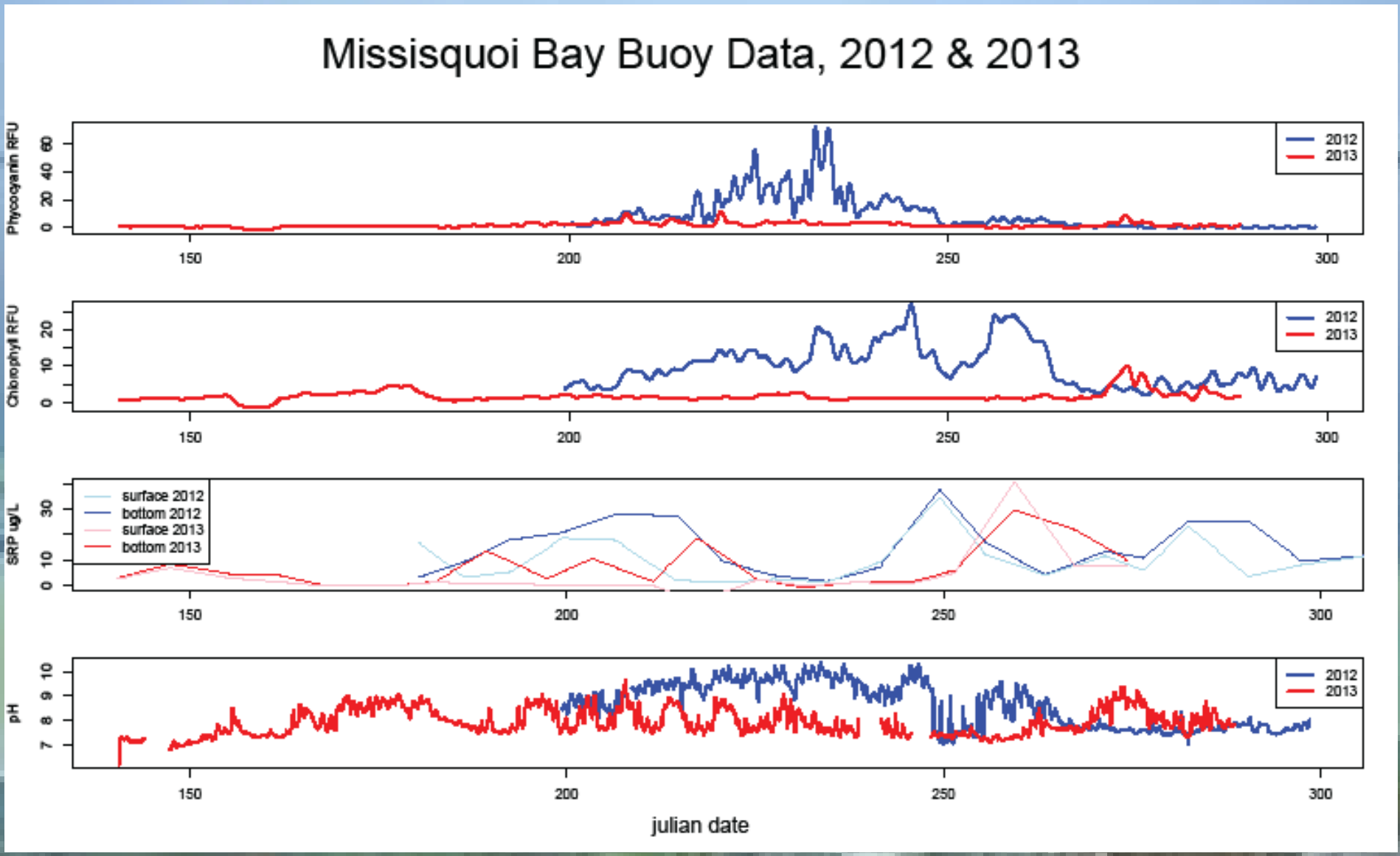
2013
10 ADCPs

Sampling Freq = 30 min
5 water level loggers
5 Particle size analyzers
10 ADCPs
S2 Met Buoy

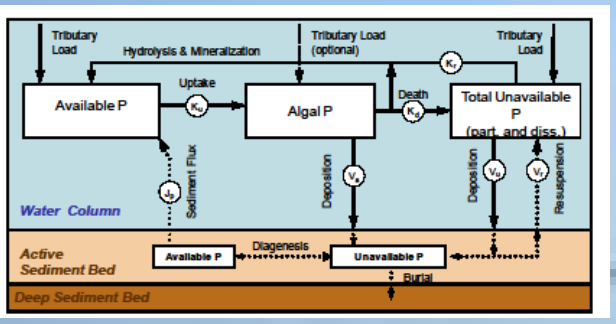
Environmental Conditions: 2012 and 2013



Biology and Water Chemistry: 2012 and 2013



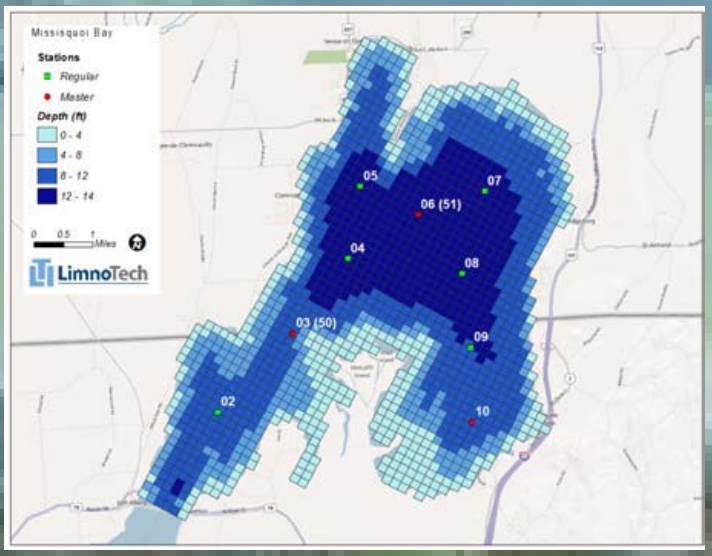
Process-Based Modeling



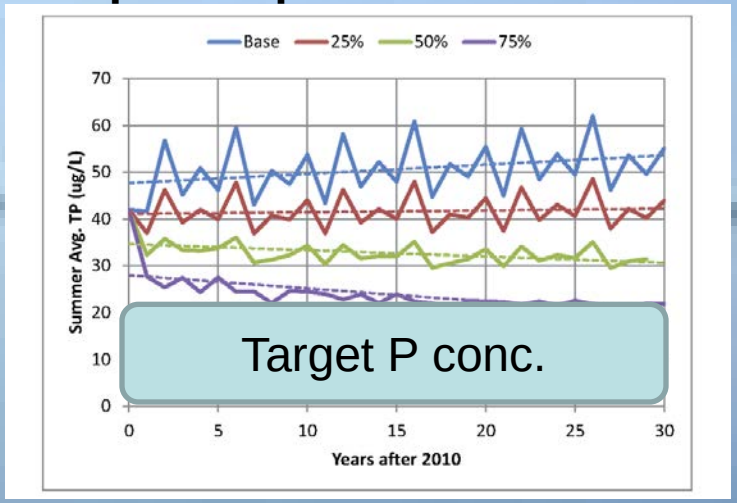
Model Scenarios

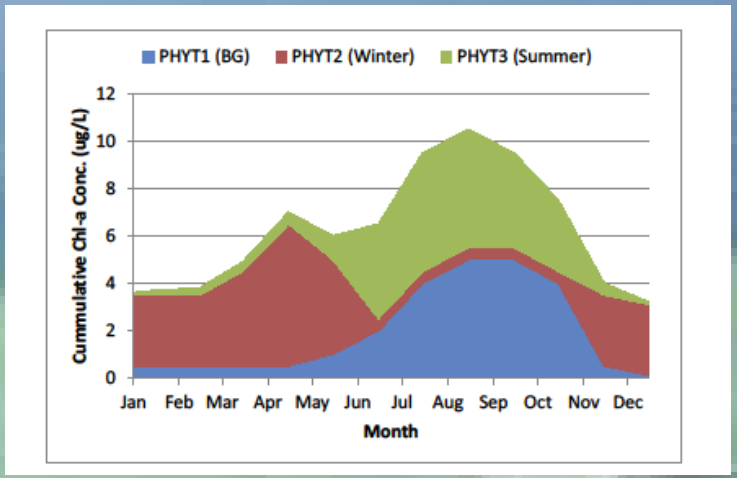
Climate Change

Human Management Decisions



Example Output from Scenarios

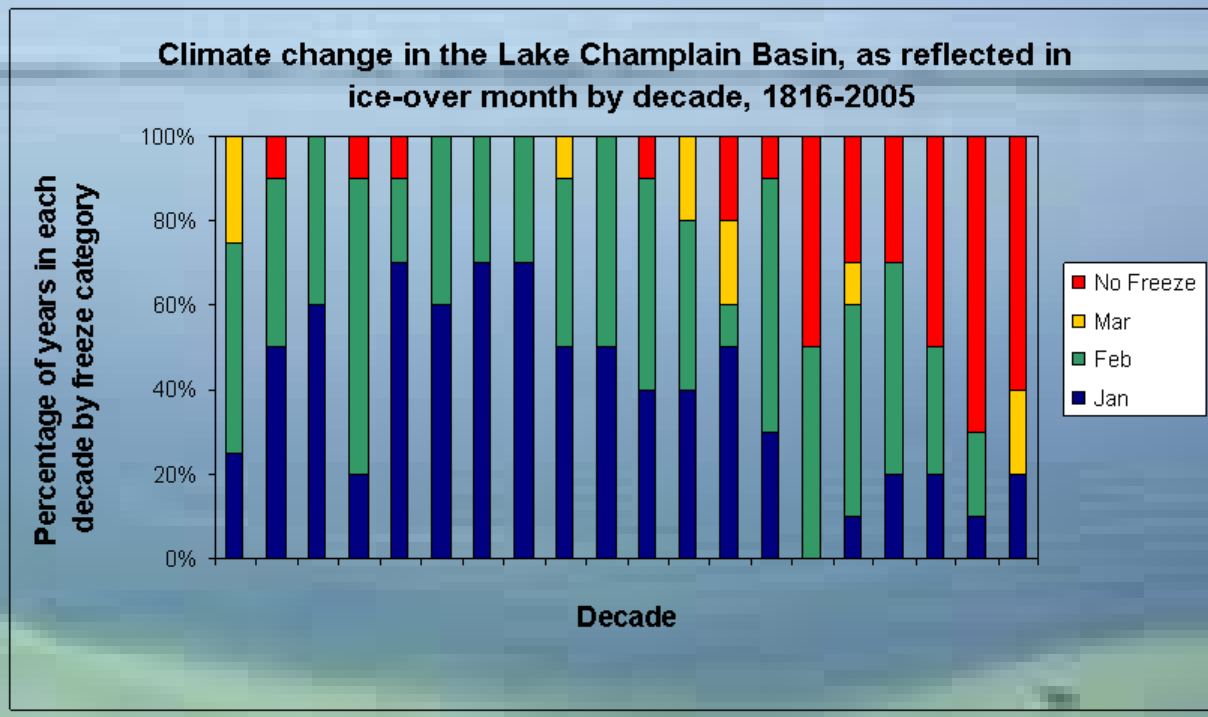


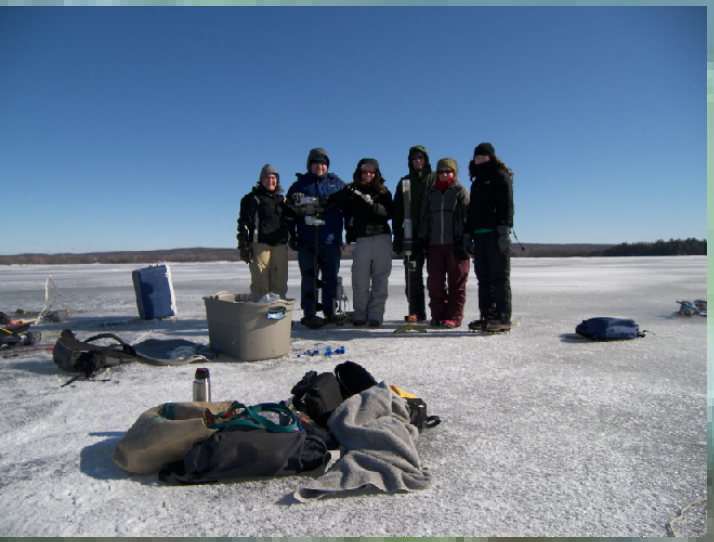


What have we accomplished?

Winter Through Ice Sampling

Duration and extent of ice cover is decreasing!



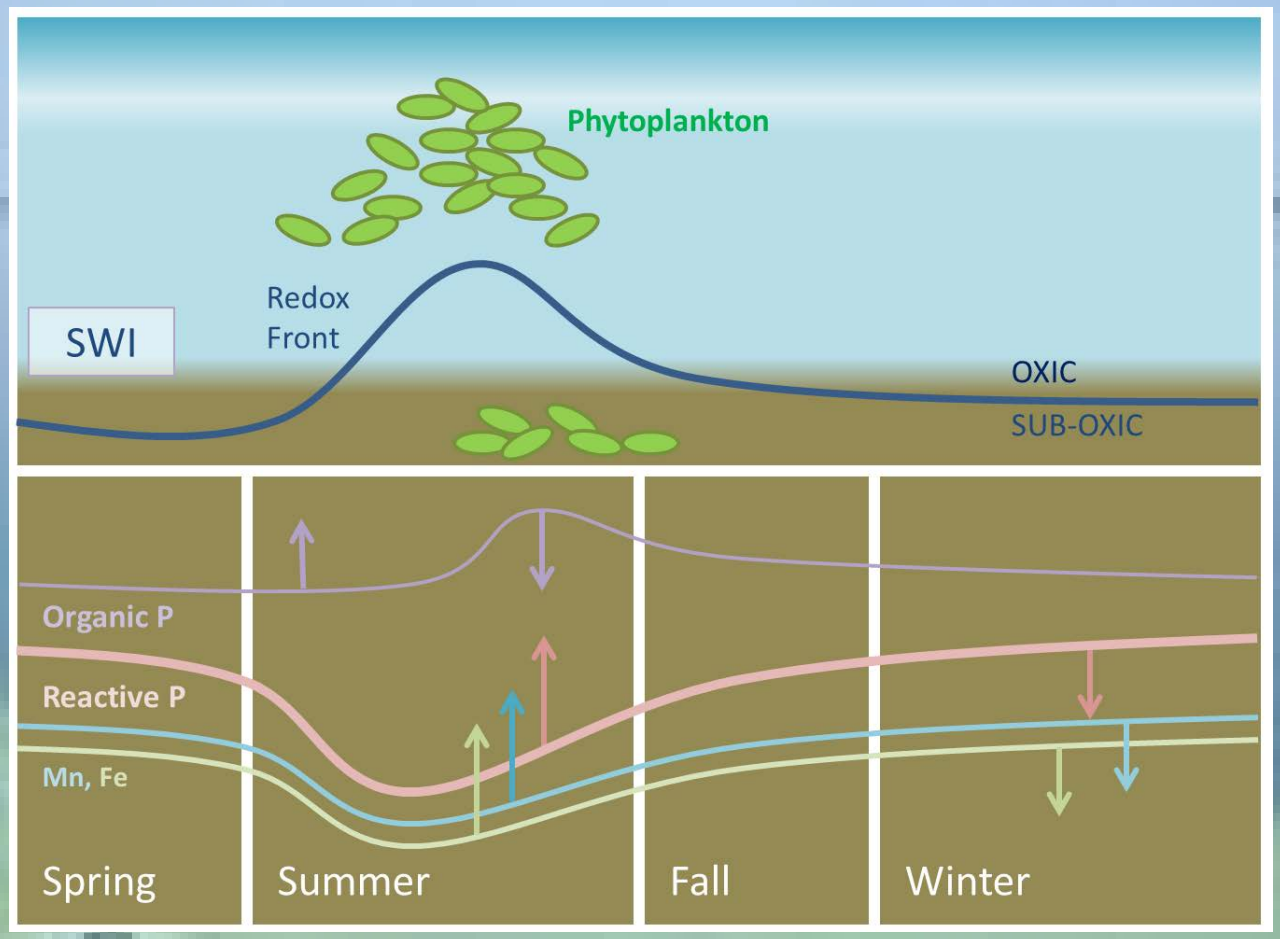


How does ice cover affect lake biology, physics and chemistry?

Winter grab sampling of water profile chemistry/biology and sediment cores

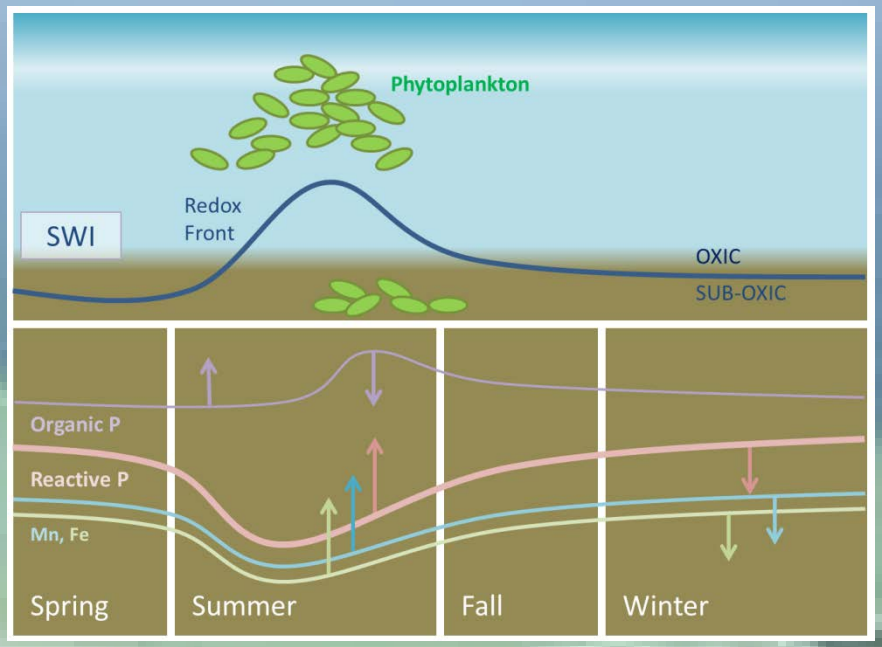
Hydrodynamic array under ice

Conceptual Model: Basic Function of the System



Objective 1: Use high-frequency seasonal multiyear data collected by RACC to better understand the biogeochemical and hydrodynamic mechanistic function of this system across the seasons and in space

Conceptual Model: External Drivers and Climate Change



Objective 2: Use high-frequency seasonal multi-year data collected by RACC to develop a conceptual understanding and process-based model of how external drivers associated with climate change affect both inputs (external) and internal processes (hydrodynamics and biogeochemistry)