Vermont EPSCoR

Experimental Program to Stimulate Competitive Research

Understanding Drivers of Water Quality and Eutrophication in the Lake Champlain Basin: RACC and NEWRnet Progress and BREE Context

Andrew Schroth

Talk Outline

Research Introduction

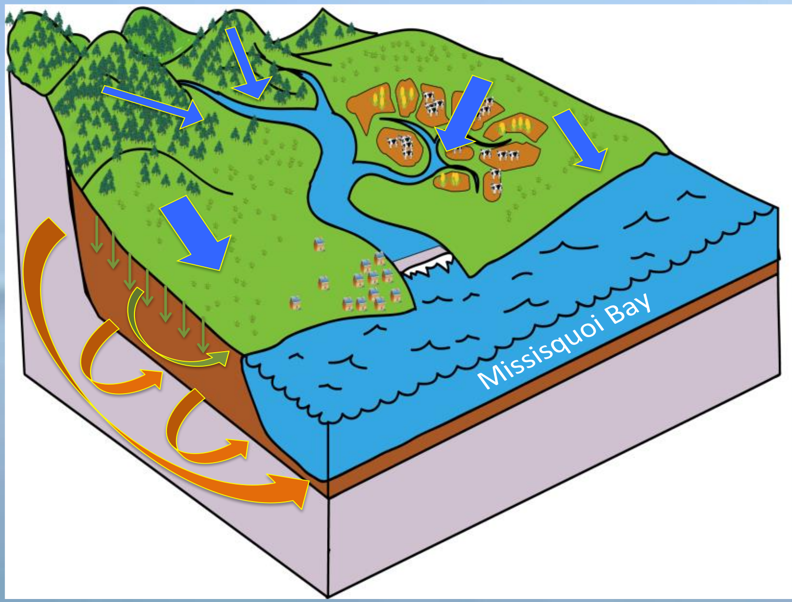
Environmental Monitoring Infrastructure Development

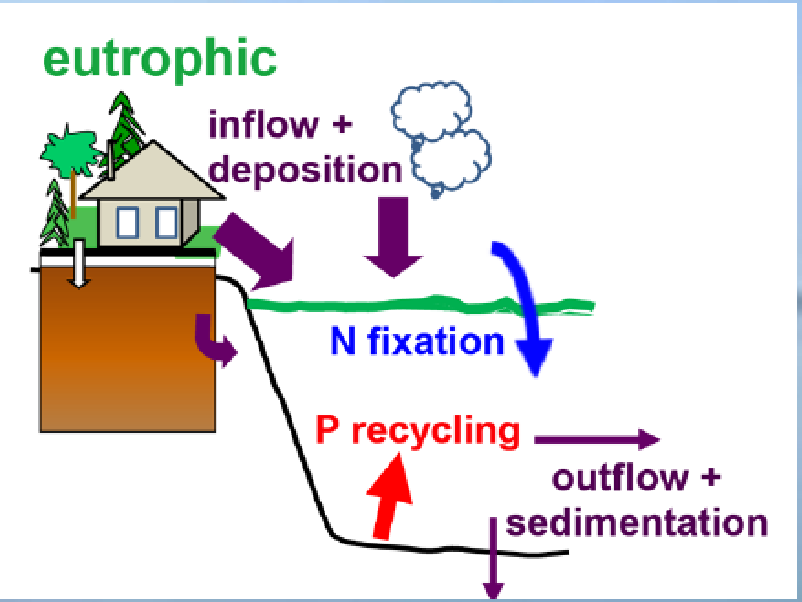
Missisquoi Bay Studies

Lake Champlain-Wide Studies

BREE Introduction to Ecological Work

Integrated Research Approach



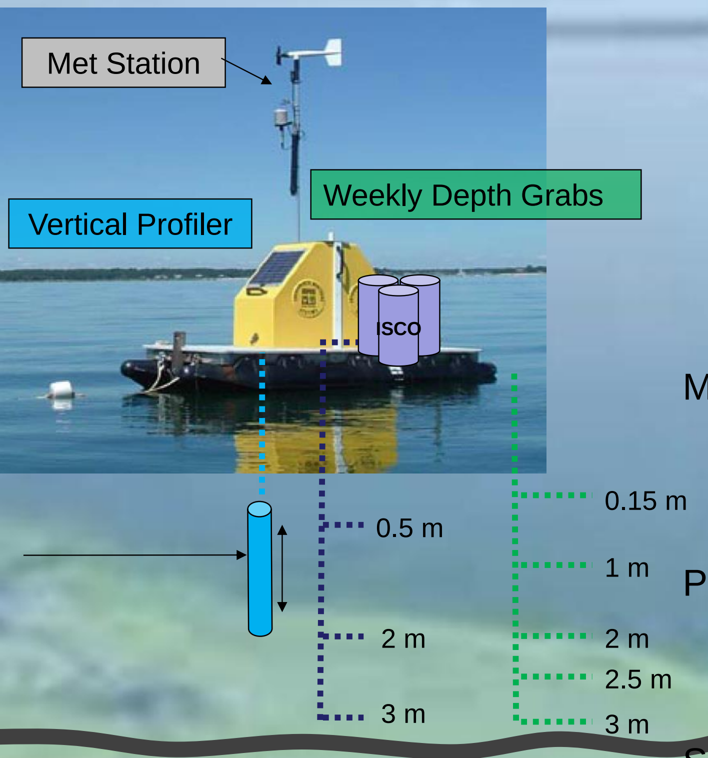


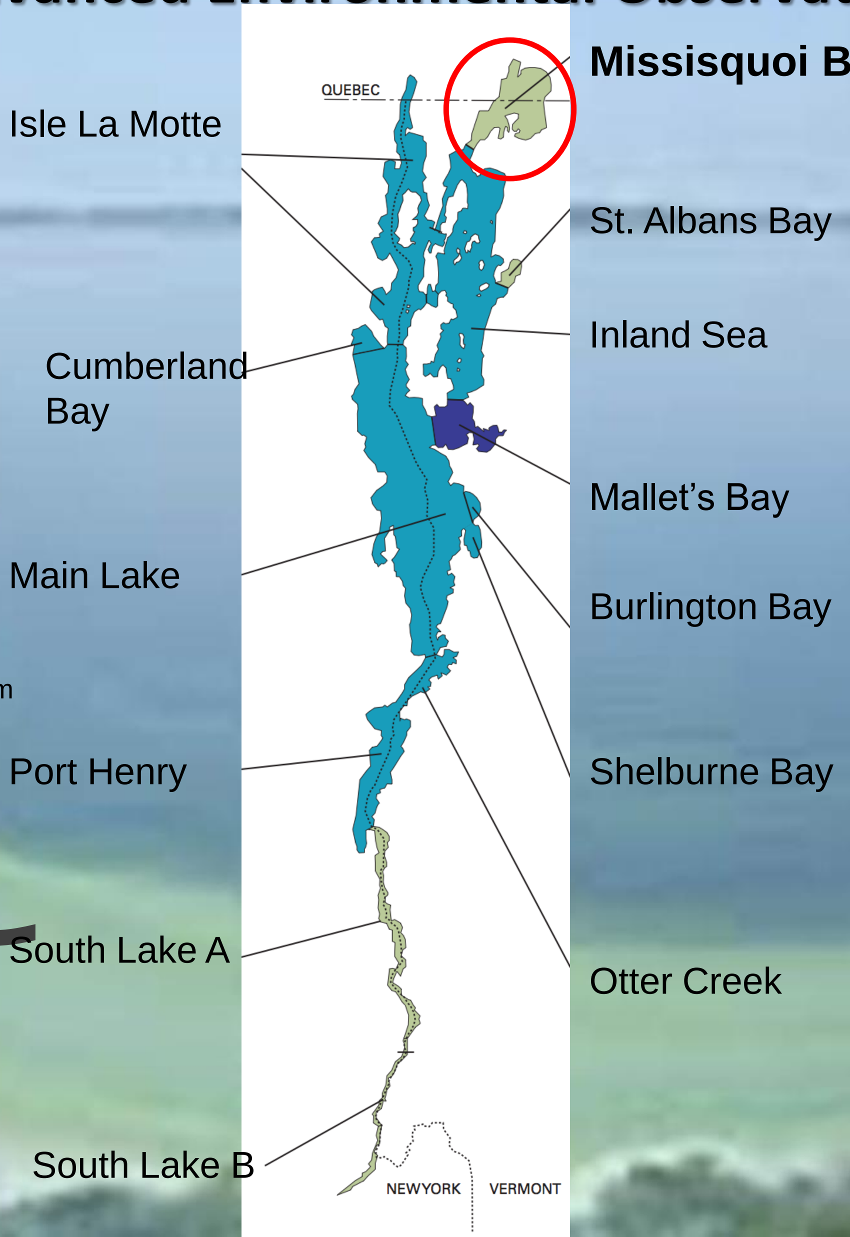
- What are the important sources of nutrients & sediment to the lake?
- How do land use, seasonality and climate affect the nature and strength of these sources?
- How are nutrients and sediments transformed and cycled within the lake over time and space?
- How do the loadings of these materials and hydrodynamics affect lake processes and ecosystems?

What we have accomplished?

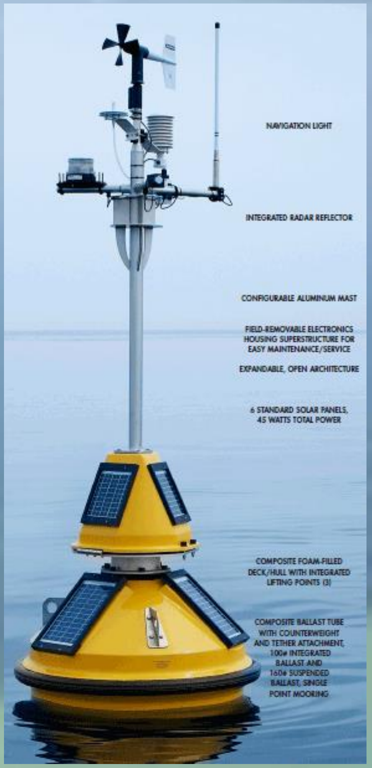
Missisquoi Bay Advanced Environmental Observatory

UVM Biogeochemical Station





Middlebury Hydrodynamics



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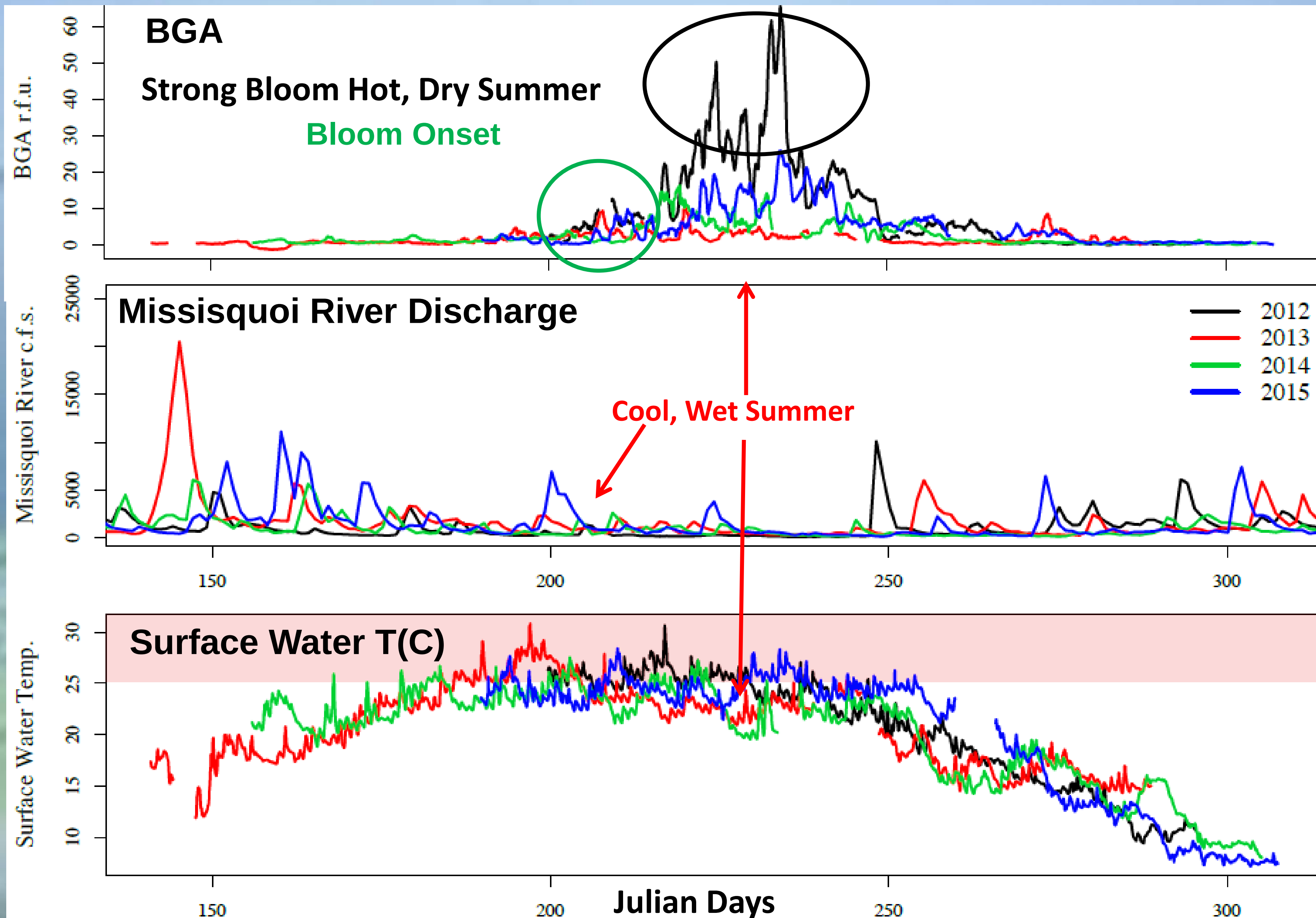
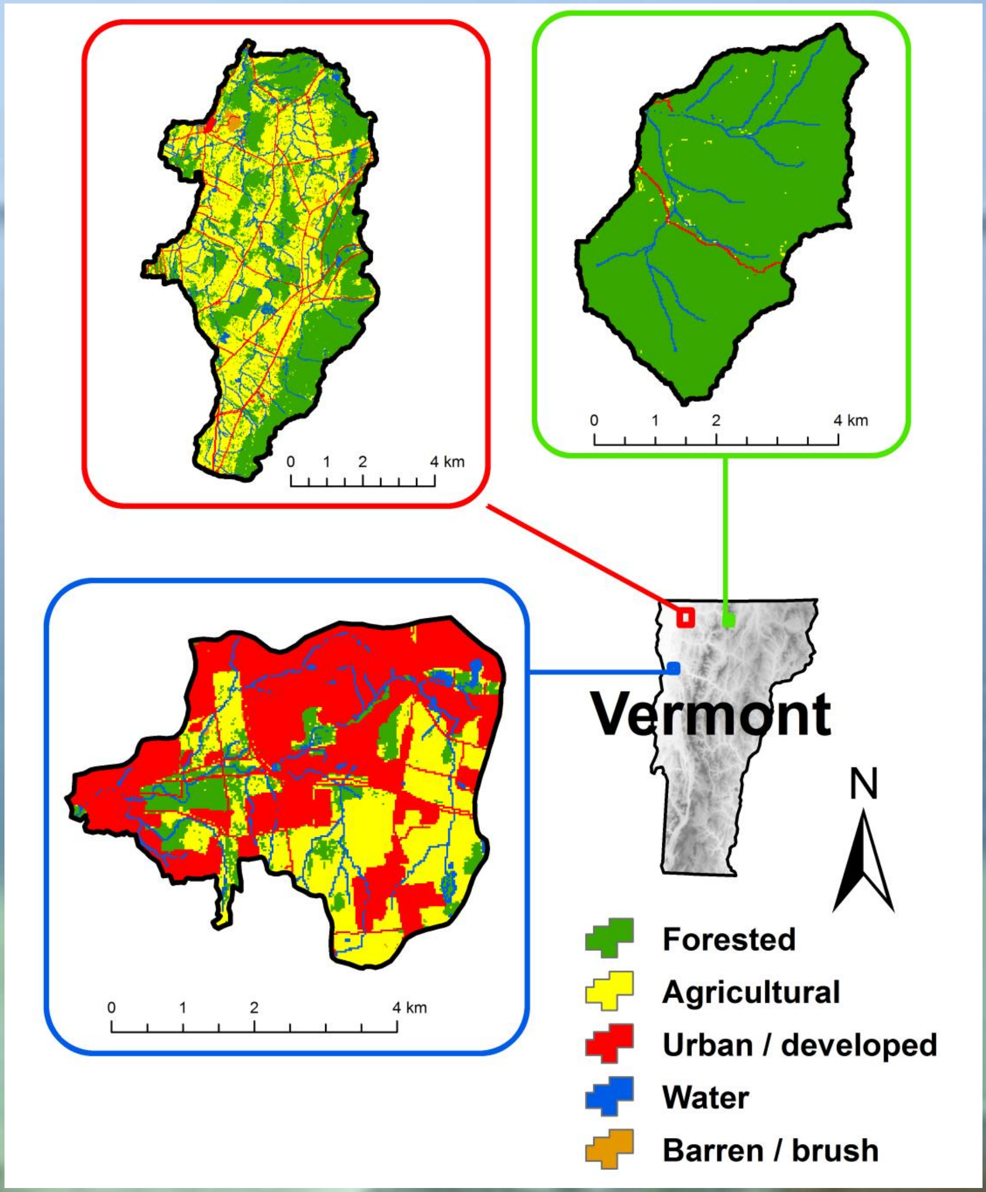
Continuous Monitoring Since 2012

New high-frequency data reveals dramatic inter-annual variability in internal/external drivers and ecosystem response



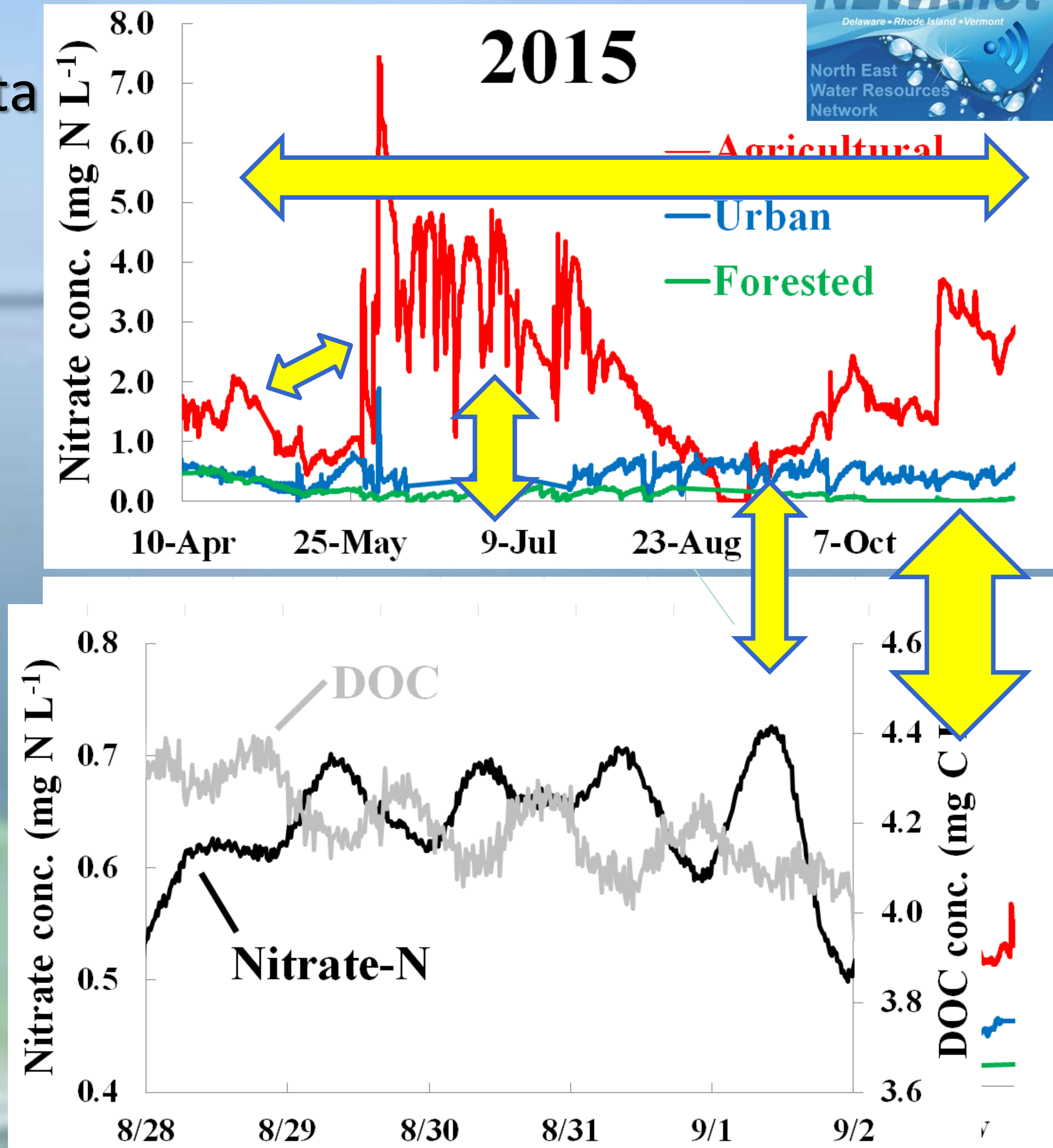
In-stream Biogeochemical and Hydrologic Observatories (NEWRnet)



Example NEWRnet In-Stream Sensor Data

Study:

- Landcover Effects
- Seasonal Dynamics
- Event Variability
- Inter-Annual Variability (in all of the above)
- Diurnal Cycling



Research Highlights and Next Steps

Journal of Great Lakes Research 41 (2015) 818–829
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ELSEVIER
IAGLR

Dynamic internal drivers of a historically severe cyanobacteria bloom in Lake Champlain revealed through comprehensive monitoring

CrossMark

Peter D.F. Isles [a,b,*], Courtney D. Giles [b], Trevor A. Gearhart [b,c], Yaoyang Xu [b], Greg K. Druschel [b,d], Andrew W. Schroth [b,e]

Journal of Environmental Quality TECHNICAL REPORTS
SURFACE WATER QUALITY

Characterization of Organic Phosphorus Form and Bioavailability in Lake Sediments using ^{31}P Nuclear Magnetic Resonance and Enzymatic Hydrolysis

Courtney D. Giles,* Lydia G. Lee, Barbara J. Cade-Menun, Jane E. Hill, Peter D. F. Isles, Andrew W. Schroth, and Gregory K. Druschel

LIMNOLOGY and OCEANOGRAPHY
ASLO
Limnol. Oceanogr. 00, 2017, 00–00

doi: 10.1002/lno.10521

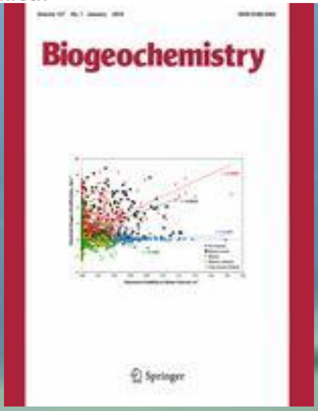
Winter weather and lake-watershed physical configuration drive phosphorus, iron, and manganese dynamics in water and sediment of ice-covered lakes

DongJoo Joung,[1]* Meagan Leduc,[2,7] Benjamin Ramcharitar,[3] Yaoyang Xu,[1] Peter D. F. Isles,[1,4] Jason D. Stockwell,[4] Gregory K. Druschel,[5] Tom Manley,[6] Andrew W. Schroth[1,7]

Freshwater Biology
Freshwater Biology (2015) doi:10.1111/fwb.12615

Quantile regression improves models of lake eutrophication with implications for ecosystem-specific management

YAOYANG XU*, ANDREW W. SCHROTH*,†, PETER D. F. ISLES*,‡ AND DONNA M. RIZZO*,§



Environmental Science & Technology
Article
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1 Dynamic Coupling of Iron, Manganese, and Phosphorus Behavior in
2 Water and Sediment of Shallow Ice-Covered Eutrophic Lakes

3 Andrew W. Schroth,*,†,‡ Courtney D. Giles,‡ Peter D.F. Isles,‡,§ Yaoyang Xu,‡ Zachary Perzan,‖
4 and Gregory K. Druschel⊥

LIMNOLOGY and OCEANOGRAPHY: METHODS
ASLO
Limnol. Oceanogr.: Methods 13, 2015, 237–249

doi: 10.1002/lom3.10021

Developing a 21st Century framework for lake-specific eutrophication assessment using quantile regression

Yaoyang Xu,*[1] Andrew W. Schroth,[2] Donna M. Rizzo[3]

ELSEVIER
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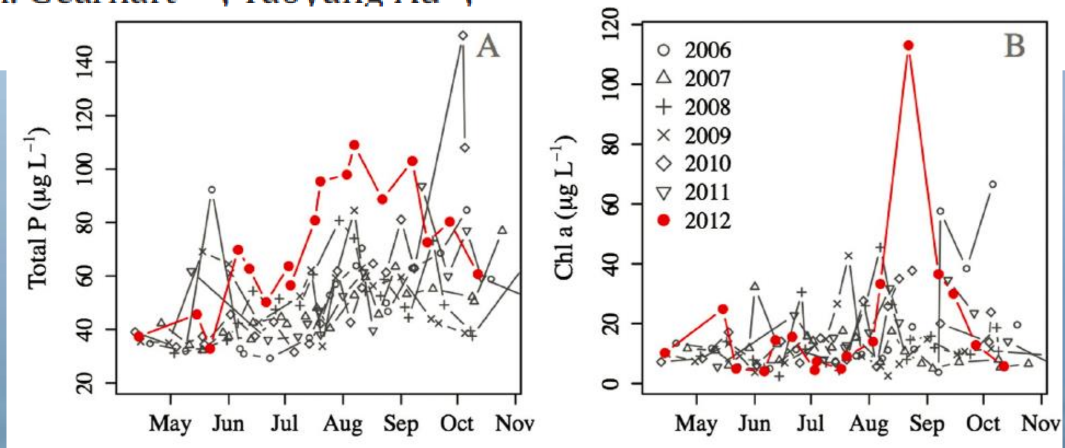
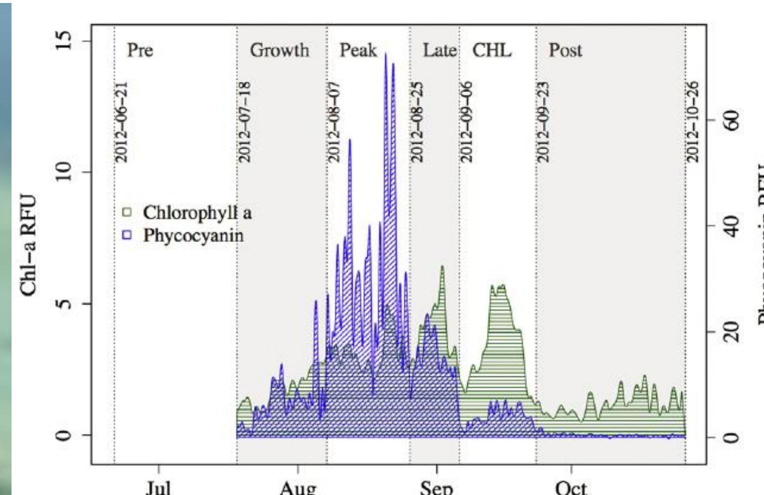


Key Points:

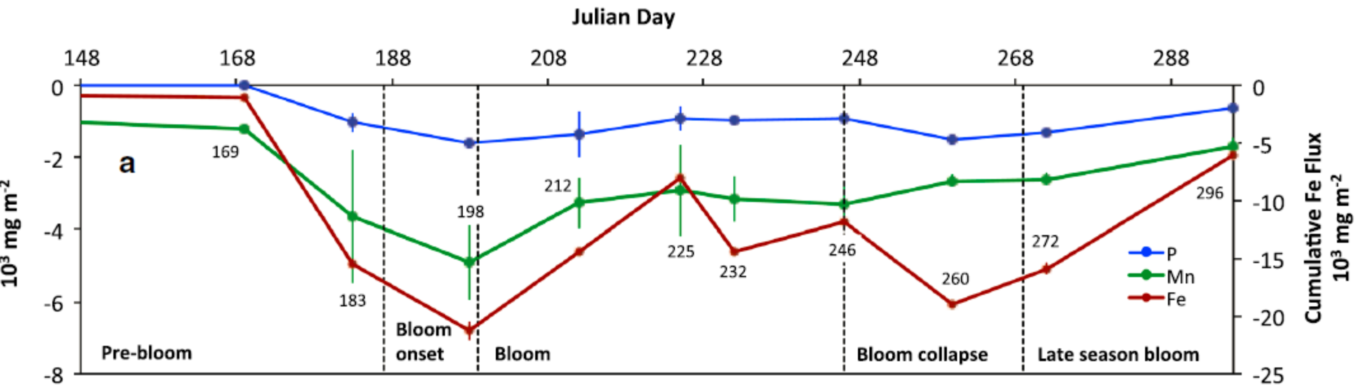
2012 was a historically severe bloom year due to sustained warmth and water column stability.

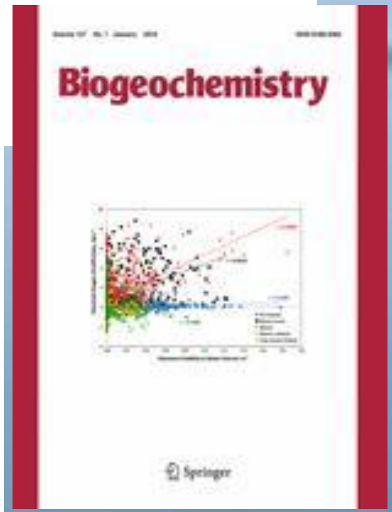
Limiting resources vary in systematic progression over time and promote cyanobacterial dominance until system changes due to a storm event.



The mobility of phosphorus, iron, and manganese through the sediment–water continuum of a shallow eutrophic freshwater lake under stratified and mixed water-column conditions

Courtney D. Giles · Peter D. F. Isles · Tom Manley ·
Yaoyang Xu · Gregory K. Druschel · Andrew W. Schroth



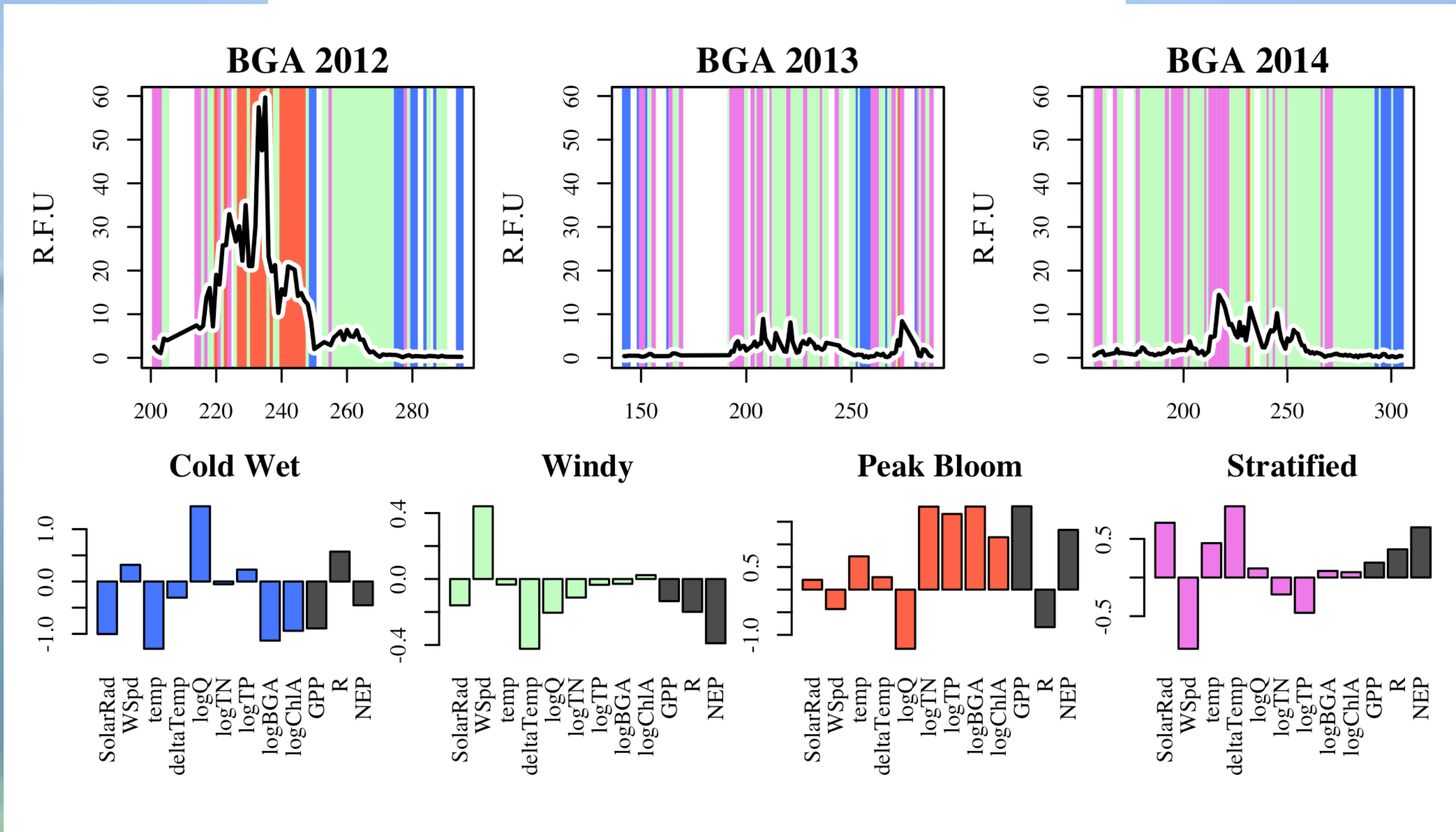


Key Points: Water column stability, as controlled by wind and diurnal thermal stratification, is the critical driver of internal release of P, Mn and Fe

Fluctuations in WCS impact the onset, severity and duration of the bloom in 2013 by controlling internal P loading.

Next Steps(BREE): Comparable analysis of this relationship across years where bloom severity and weather differ. Comparison with St. Albans Bay that is not impacted by a large river, but also driven by internal loading.

Analyses of Entire RACC Time Series: SOM Multiple Parameters



Key Points: Coupled analysis of physical and chemical drivers using more advanced clustering approaches can help to tease out interactive effects and critical thresholds within complex systems

Next Steps: Comparative studies with concurrent data sets across space. Do a suite of non extreme conditions generate an extreme event in lake water quality (e.g. 2012)

Environmental Science & Technology

Article

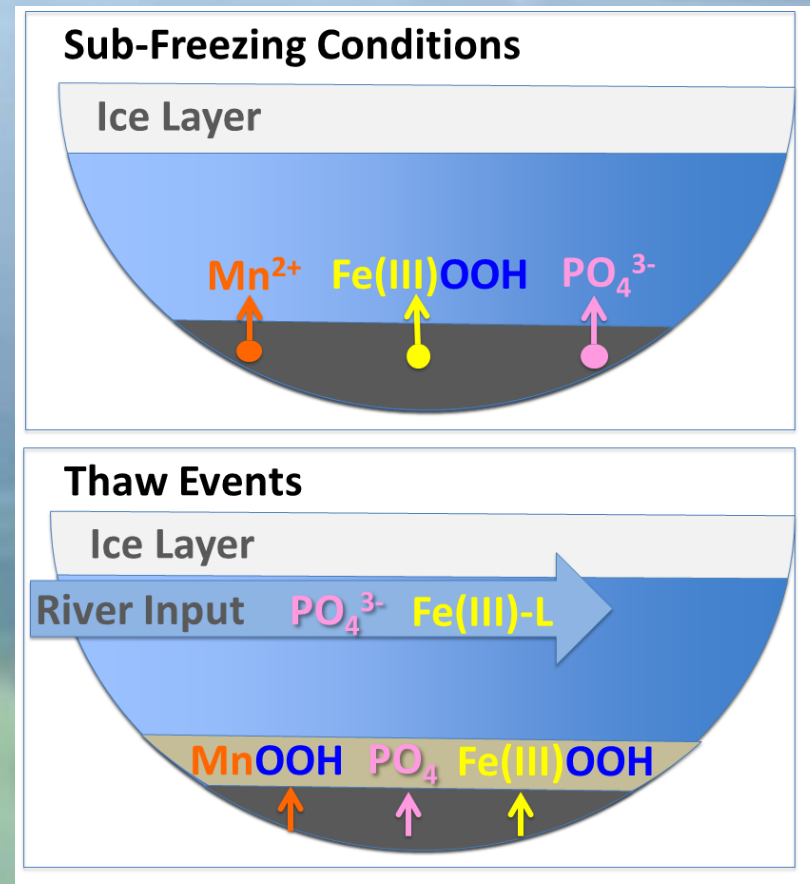
pubs.acs.org/est

Dynamic Coupling of Iron, Manganese, and Phosphorus Behavior in Water and Sediment of Shallow Ice-Covered Eutrophic Lakes

Andrew W. Schroth,[*,†,‡] Courtney D. Giles,[‡] Peter D.F. Isles,[‡,§] Yaoyang Xu,[‡] Zachary Perzan,[||] and Gregory K. Druschel[⊥]

Key Points: Under ice period concentrates reactive Fe, Mn, and P in bottom water and near surface sediments. Promotes internal loading and reactive species concentration around the SWI

Thaw events have unique chemical signature and impact



LIMNOLOGY and OCEANOGRAPHY

ASLO

Limnol. Oceanogr. 00, 2017, 00–00

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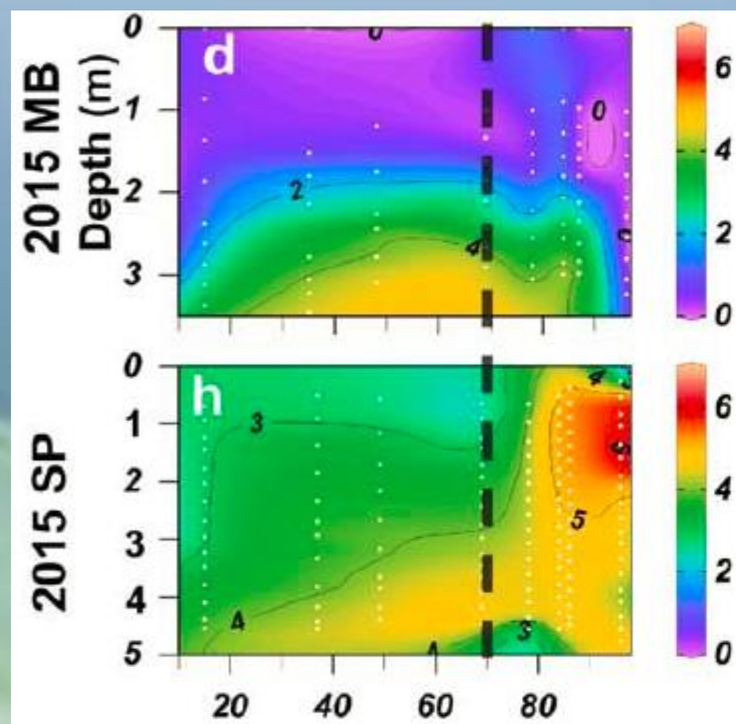
Winter weather and lake-watershed physical configuration drive phosphorus, iron, and manganese dynamics in water and sediment of ice-covered lakes

DongJoo Joung,[1*] Meagan Leduc,[2,7] Benjamin Ramcharitar,[3] Yaoyang Xu,[1] Peter D. F. Isles,[1,4] Jason D. Stockwell,[4] Gregory K. Druschel,[5] Tom Manley,[6] Andrew W. Schroth[1,7]

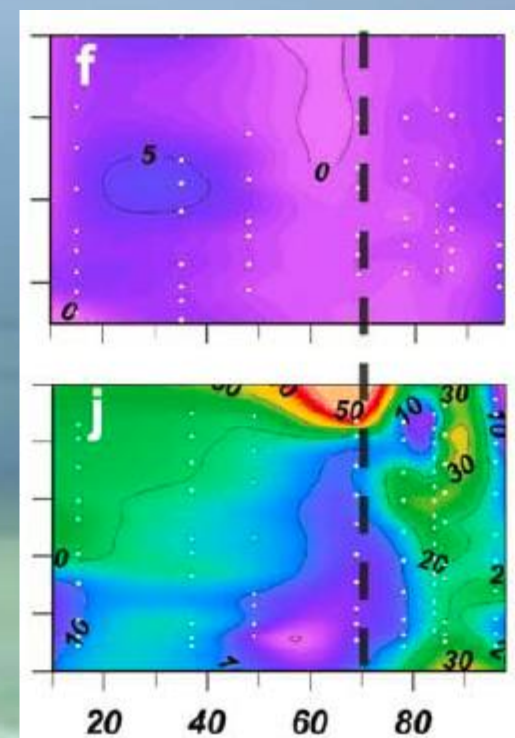
Key Points: Under ice chemistry, biology and response to 'events' dramatically differs between MB and SP (while exposed to the same weather) due to physical configuration

Next Steps: Under the ice in SAB compares to these systems and varies inter-annual to diff. winter conditions

T (ºC) Thaws



Chl-A



LIMNOLOGY and OCEANOGRAPHY: METHODS

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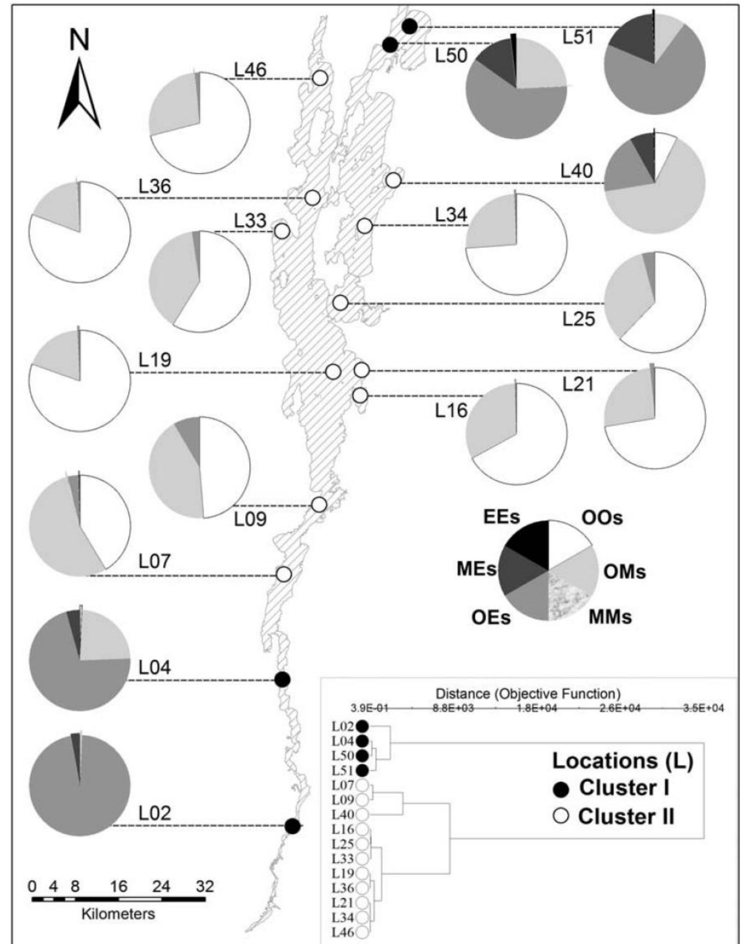
Developing a 21st Century framework for lake-specific eutrophication assessment using quantile regression

Yaoyang Xu,*[1] Andrew W. Schroth,[2] Donna M. Rizzo[3]

Key Points: Develop water quality and ecological metrics that are useful for management and detecting impacts of climate/landuse change across diverse environments of LC.

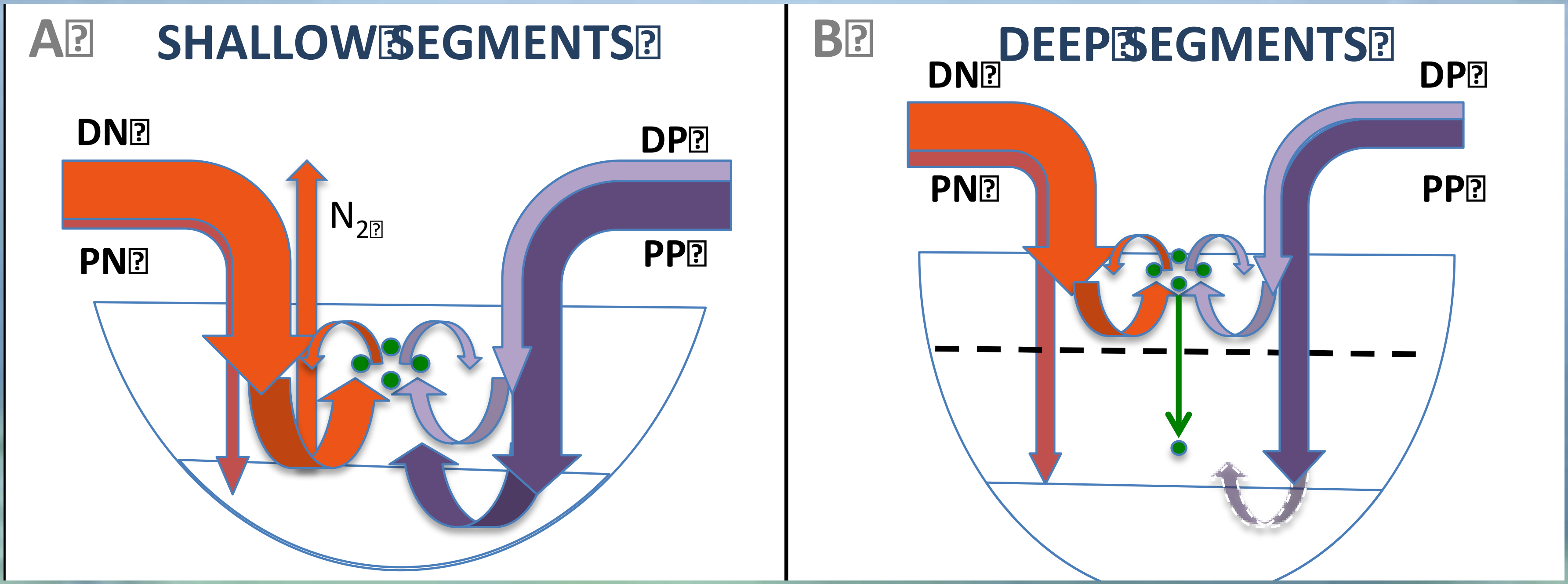
Focus on using 'big' environmental data to develop ecosystem specific metrics and management targets.

Next Steps: These metrics can then be used to project water quality impacts of climate change in the IAM (Asim's talk). Additional insight from long-term monitoring lake/trib data?



Climate-driven changes in energy and mass inputs systematically alter nutrient concentration and stoichiometry in deep and shallow regions of Lake Champlain

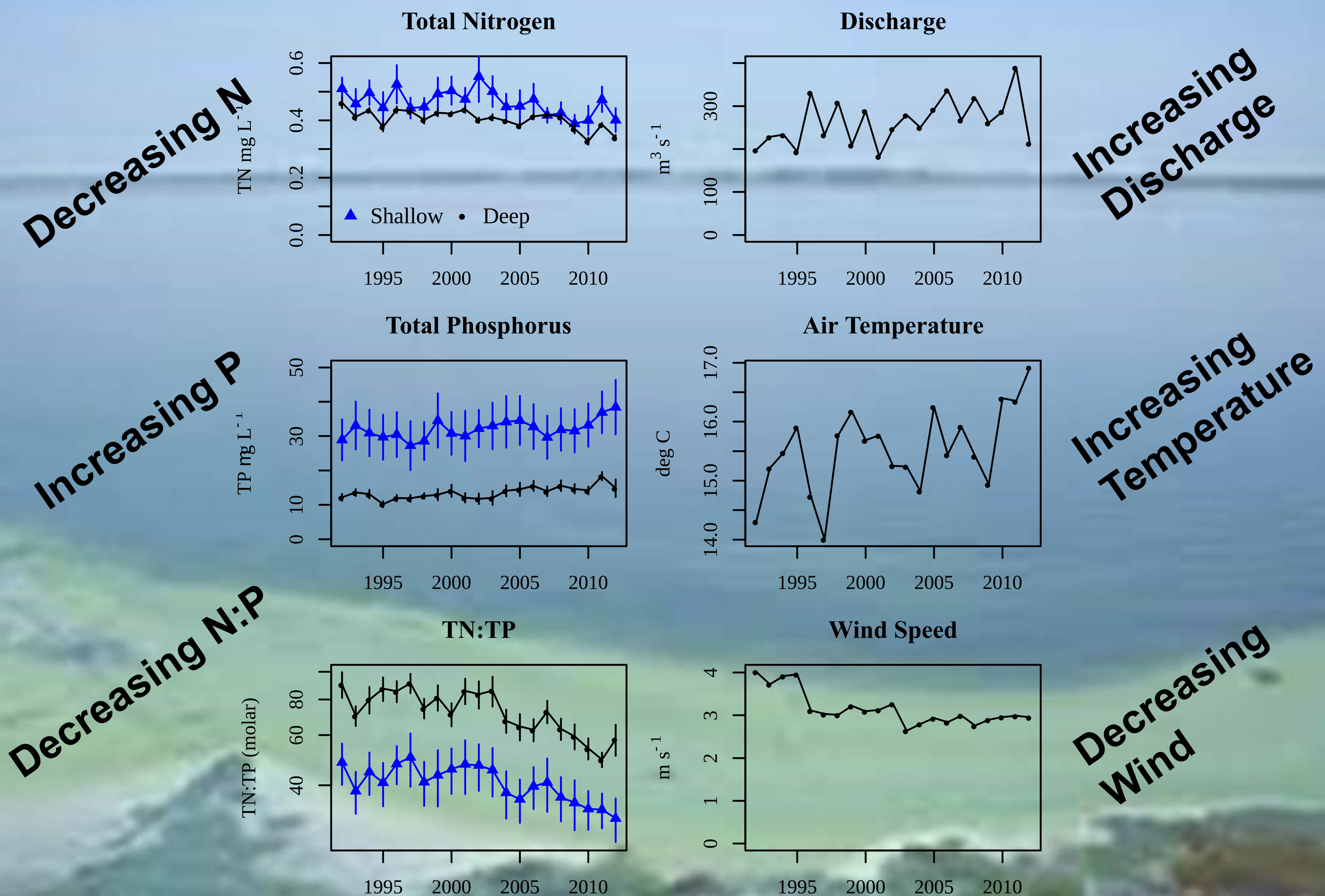
Peter D. F. Isles · Yaoyang Xu · Jason D. Stockwell · Andrew W. Schroth



- Dissolved nutrients available immediately (in spring)
- Particulate nutrients available when Temp, O_2 conditions allow

- Dissolved nutrients efficiently recycled
- Particulate nutrients mostly lost to the sediments

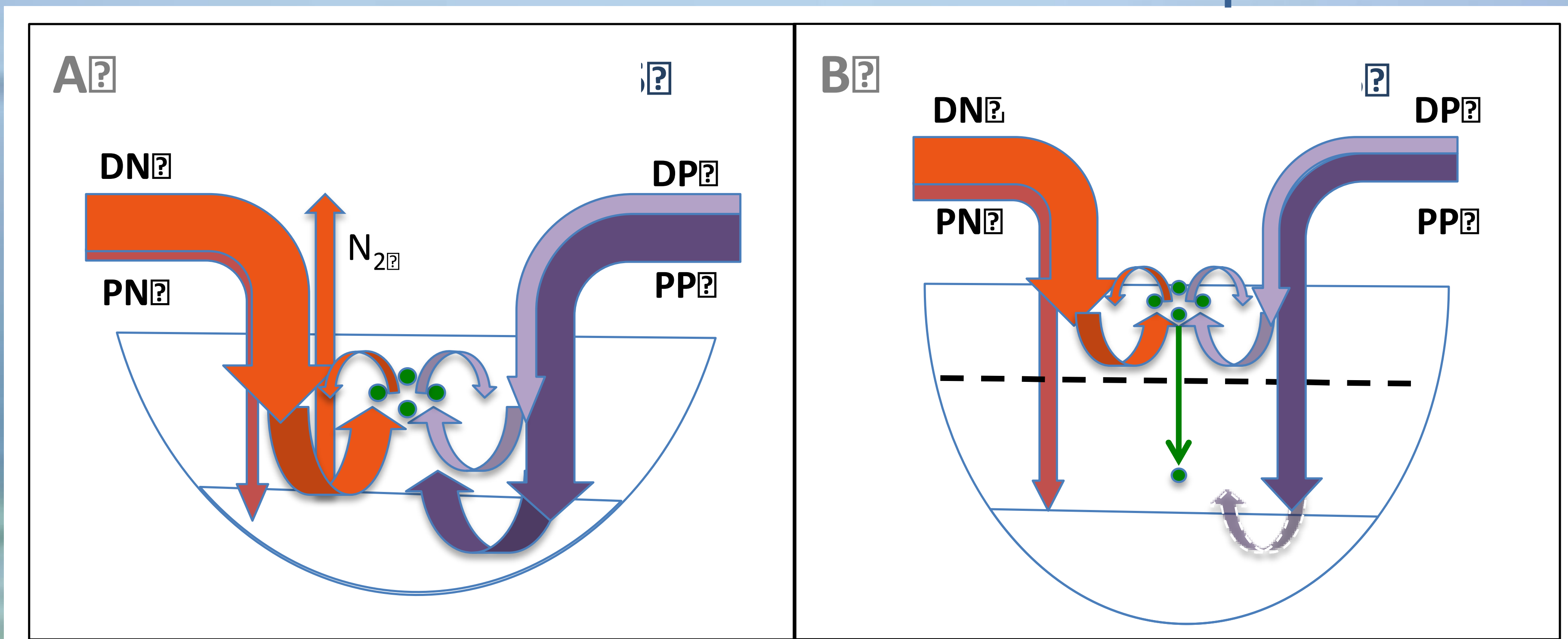
Long-Term Lake Champlain Trends



Conceptual Model: TN:TP Sensitivity to Env. Change

Shallow

Deep



- Most sensitive to changes in

Take Home Point: Climate change will promote cyanobacteria dominance across LC via multiple mechanisms, but potentially fruitful targeted management interventions exist

as changes in timing of nutrient delivery

lead to increased role of late season internal loading

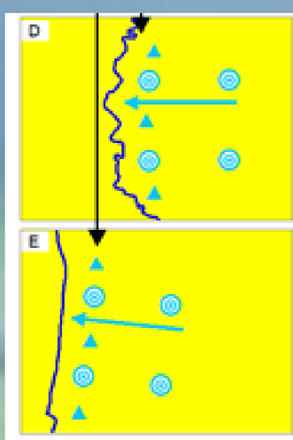
Where are we going?

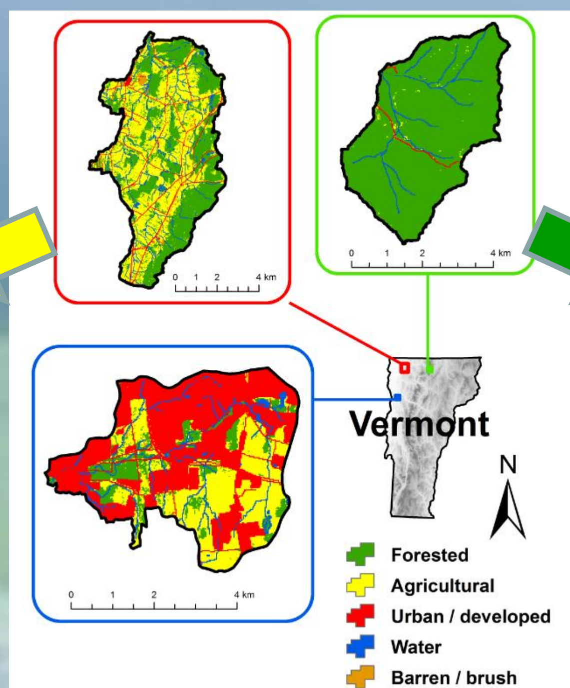
Overarching Hypothesis:

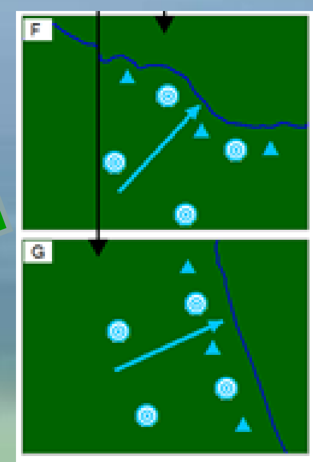
Hypotheses: 1) Certain land uses (agricultural practices, stormwater drainage) will increase the connectivity of the ecological system's terrestrial-aquatic boundaries (flow from land to streams, rivers and receiving waters of the Lake) and reduce system resilience to extreme weather events (by bypassing, removing, or creating less effective riparian "filters"). 2) Watersheds and lakes that have biophysical structures and/or antecedent conditions that suppresses connectivity require a more severe or persistent extreme event to degrade water quality; conversely systems with well-connected interfaces will be more susceptible to extreme event-induced degradation of water quality.

Wet

Dry

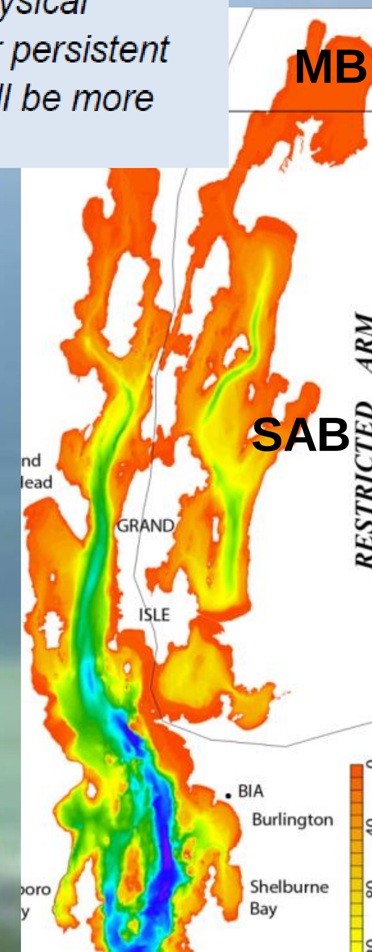




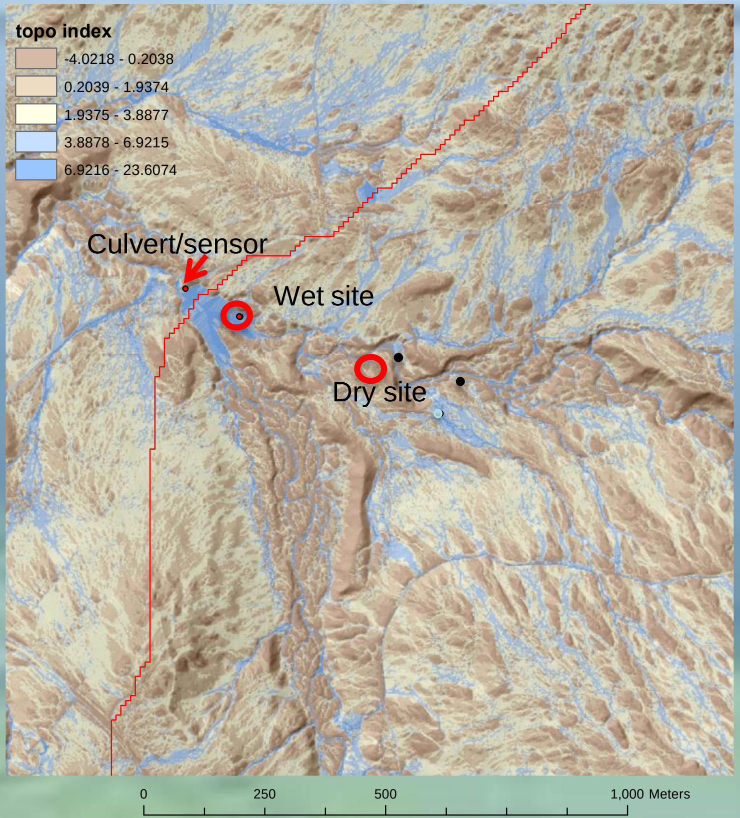


Wet

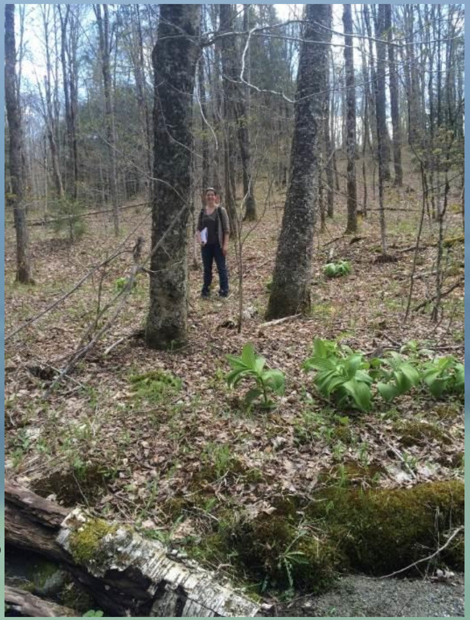
Dry



Wade Brook Watershed: Site Selection



Wet site



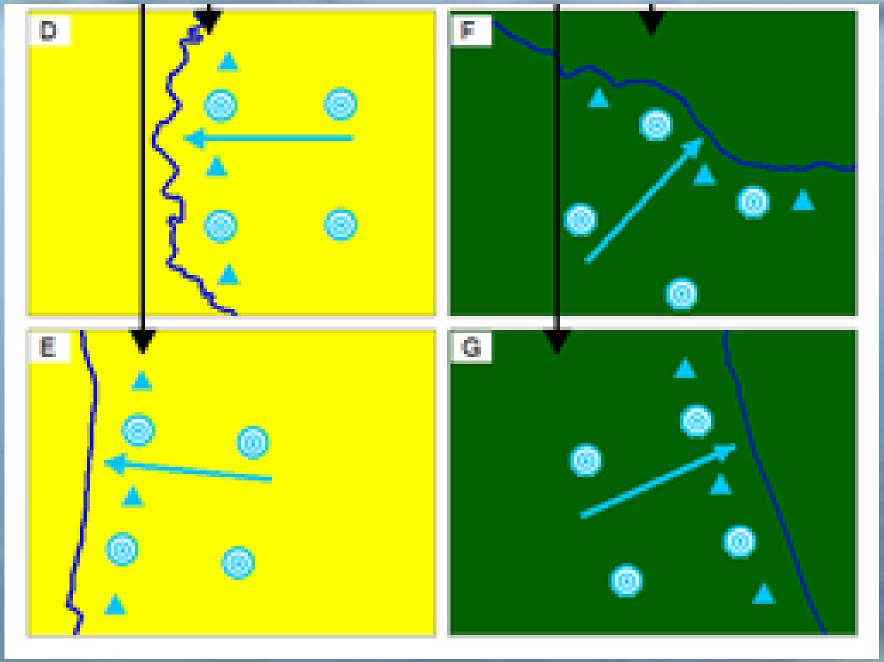
Dry s

Riparian Monitoring: Site Installation

- Wetland site

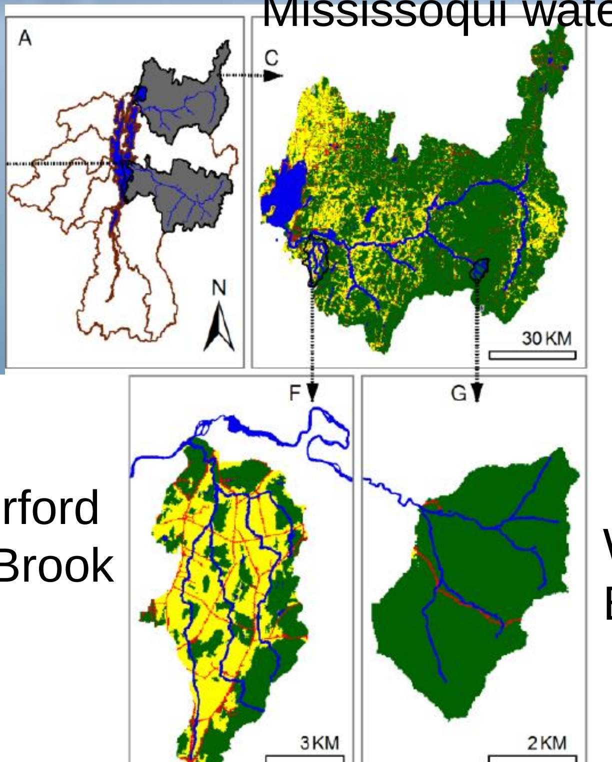
Riparian Monitoring: General Layout & Tools

- Physical (circles):
  - Soil T, moisture, electric conductivity
  - Lysimeter & shallow monitoring well
    - Both: Nutrients, DOC, metals
    - Monitoring wells: DO
- Gases, redox (triangles):
  - Redox, CO_2, O_2
- Met stations
- Phenocams
- Shallow well transects



Hungerford Brook: site selection

Mississoqui watershed



ungerford
Brook

Wade
Brook

Journal of Environmental Quality | TECHNICAL REPORTS
SURFACE WATER QUALITY

Characterization of Organic Phosphorus Form and Bioavailability in Lake Sediments using ^{31}P Nuclear Magnetic Resonance and Enzymatic Hydrolysis

Courtney D. Giles,* Lydia G. Lee, Barbara J. Cade-Menun, Jane E. Hill, Peter D. F. Isles, Andrew W. Schroth, and Gregory K. Druschel

Key Points:

Organic P speciation and bioavailability in sediment differs under bloom vs non-bloom water column.

Suggests a poorly-constrained feedback between blooms and internal P loading.

Next Steps (Courtney):

Relate Organic P speciation and bioavailibility to water column biology, chemistr and hydrodynamics

Alteration of essential fatty acids in secondary consumers across a gradient of cyanobacteria

Trevor A. Gearhart[1], Katie Ritchie[2,5], Evan Nathan[3,6], Jason D. Stockwell[4], and Jana Kraft[2]

Hydrobiologia (Under Review)

Key Points:

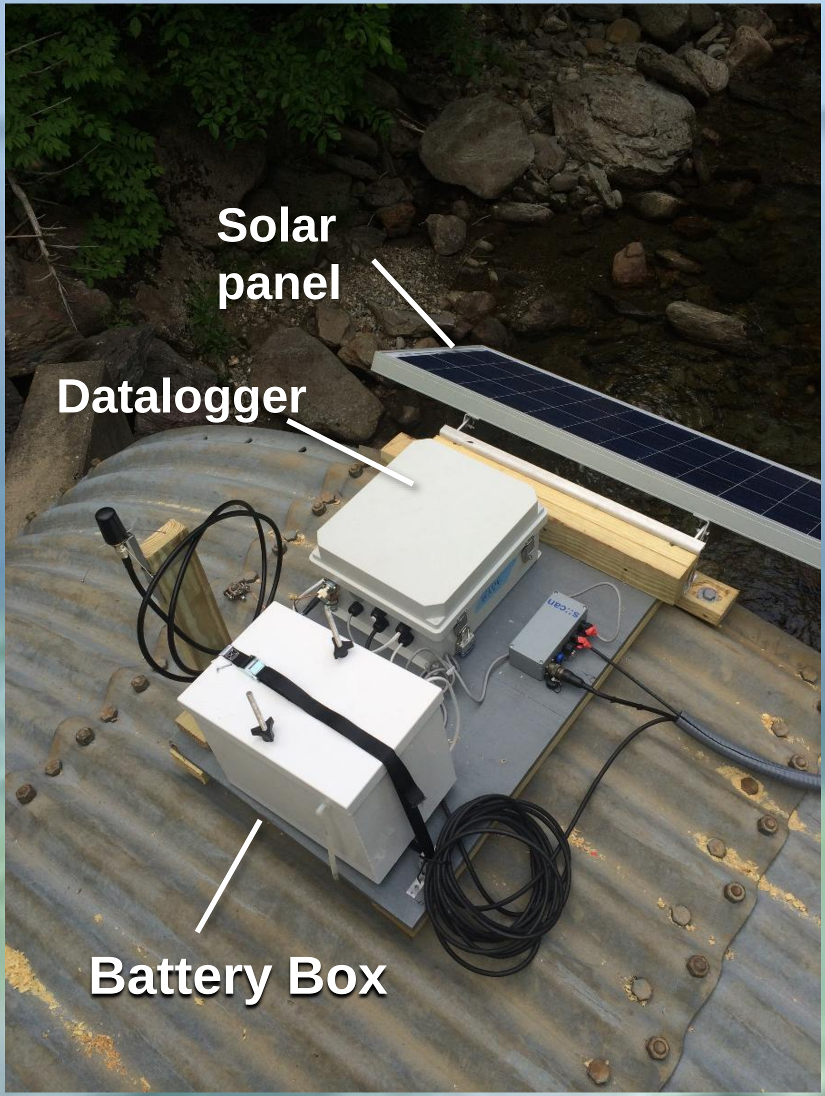
Fish in eutrophic systems show depressed levels of nutritious fatty acids.

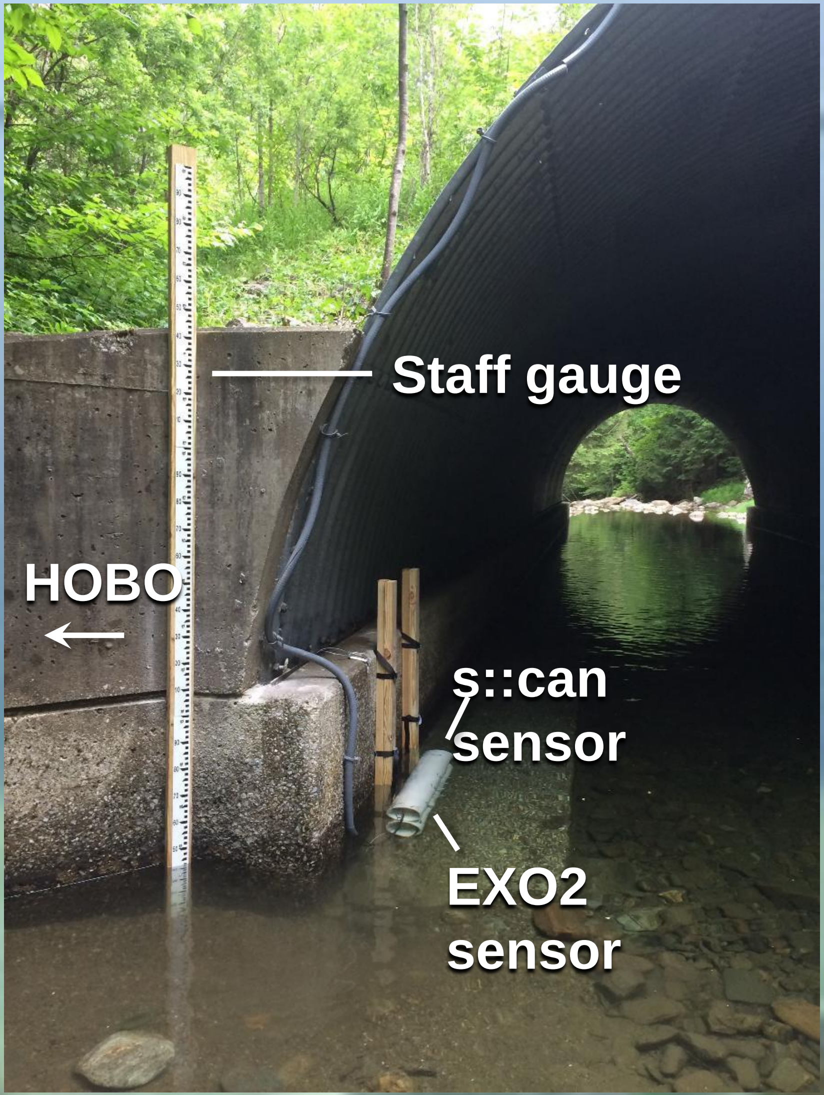
These shifts in FA composition present potential health and reproductive consequences.

Next Steps:

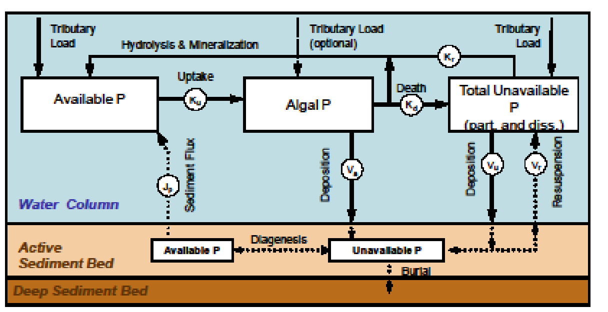
Determine threshold levels for duration and extent of essential fatty acid deficiency and extent of physiological consequences

NEWRnet Field Installations

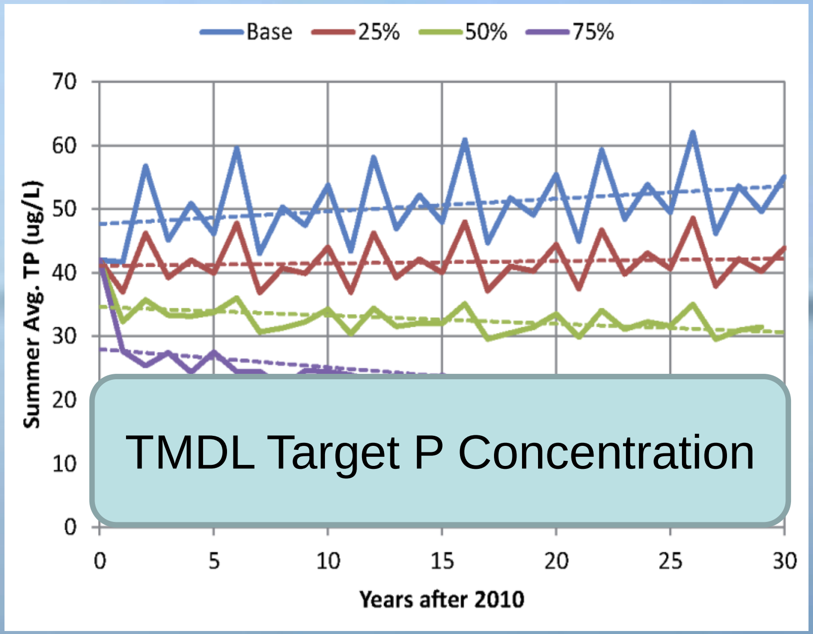




Data Drives Process-Based Modeling



Pete's IAM talk



Model Scenarios

Climate Change

Human Management Decisions