Understanding and Modeling Internal Loading of Phosphorus in Missisquoi Bay

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NSF
Vermont EPSCoR
SLAC
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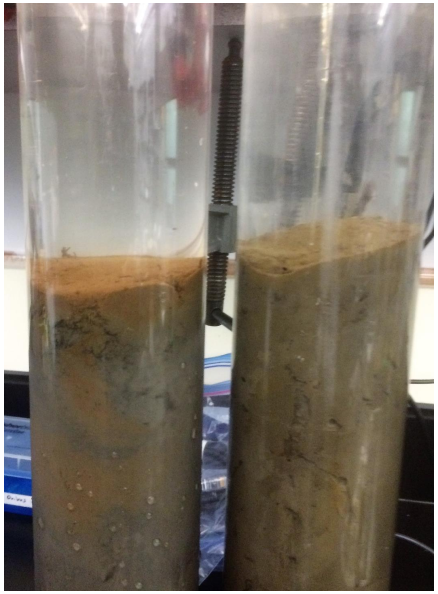
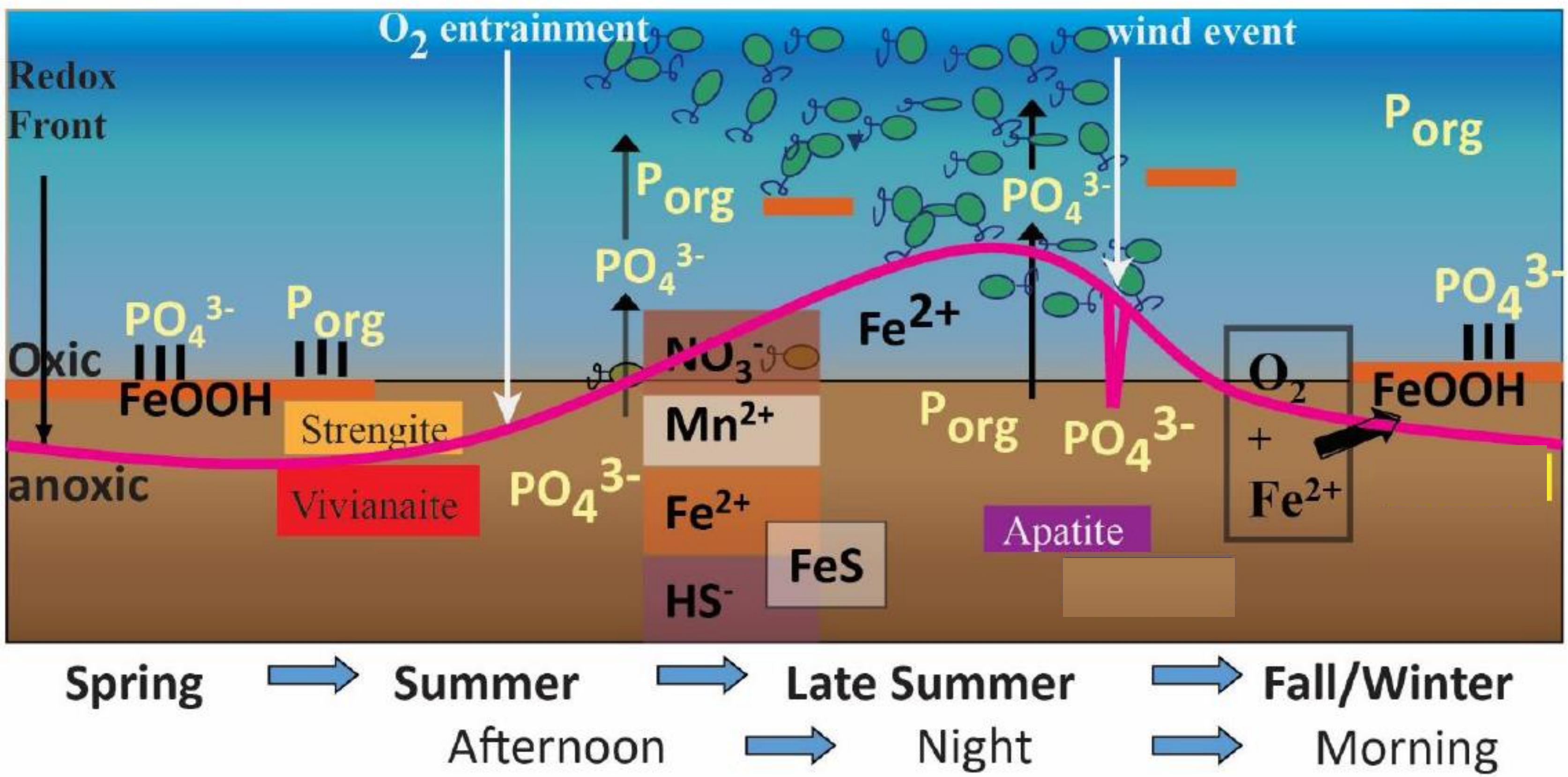


Talk Objectives

- Drivers of internal P loading dynamics in Missisquoi Bay
- Approaches to suppressing internal loading
- Examples of modeling relative impacts of external and internal P load reductions
- Facilitate subsequent discussion and collaboration!

Overarching Theoretical Framework

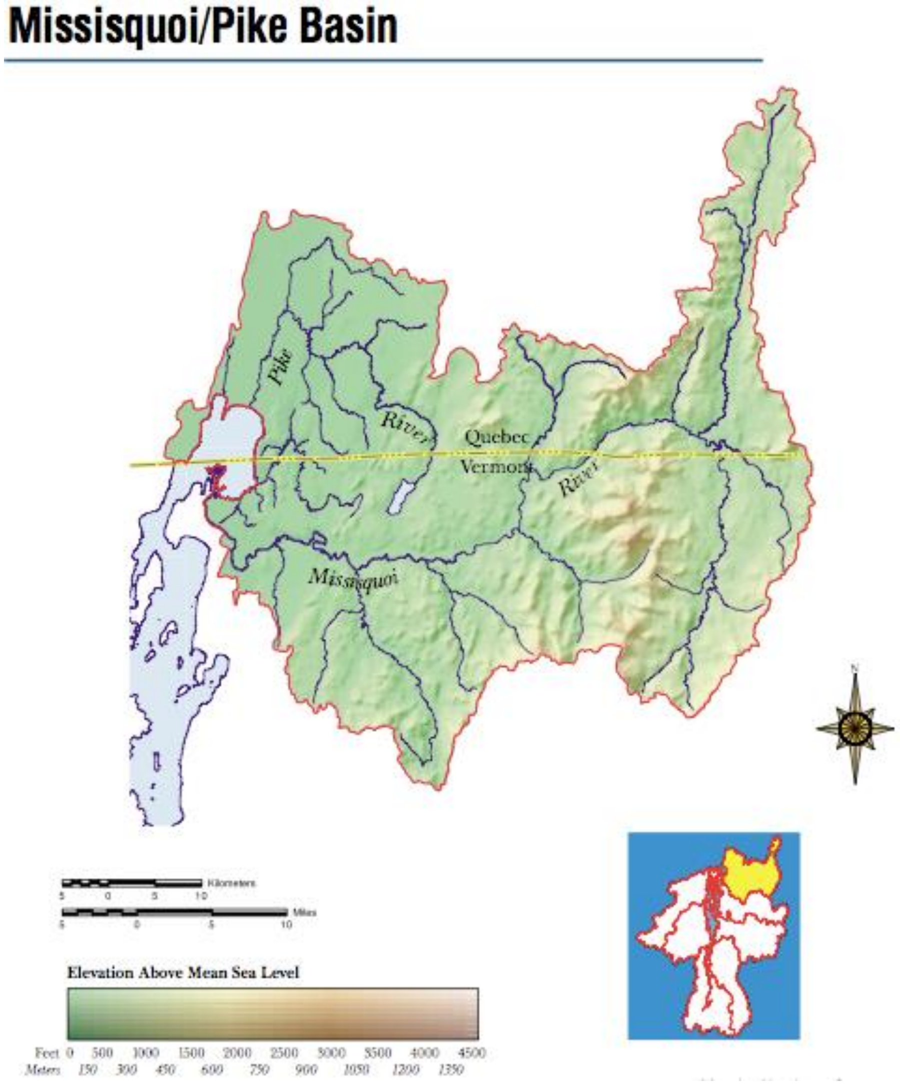
How do environmental drivers of sediment water interface geochemistry (operating at multiple time scales) impact internal benthic phosphorus mobility and chemical partitioning in sediment and water?



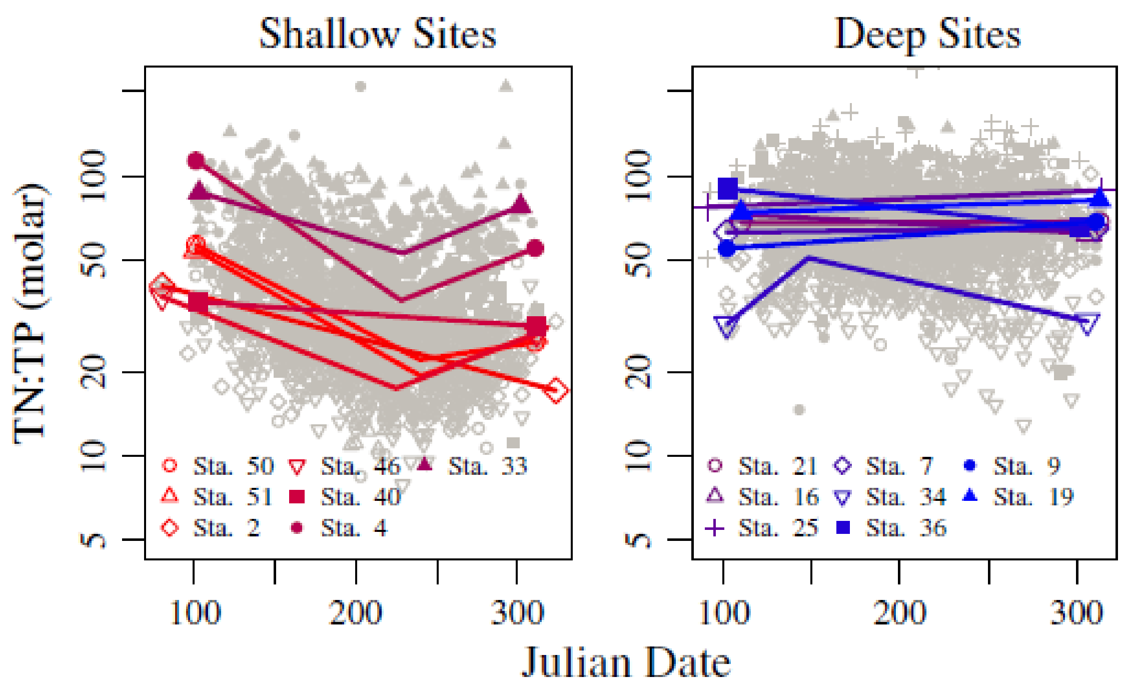
Missisquoi Bay

Key features that drive hydro and biogeochemical dynamics:

- High watershed area to lake area/volume ~40
- Eutrophic (CyanoHABs from ~late July into Sept/Oct)
- Shallow, polymictic (prone to transient stratification and mixing, benthic P can be bioavailable for CyanoHABs)
- Persistent winter ice cover (Dec-April)



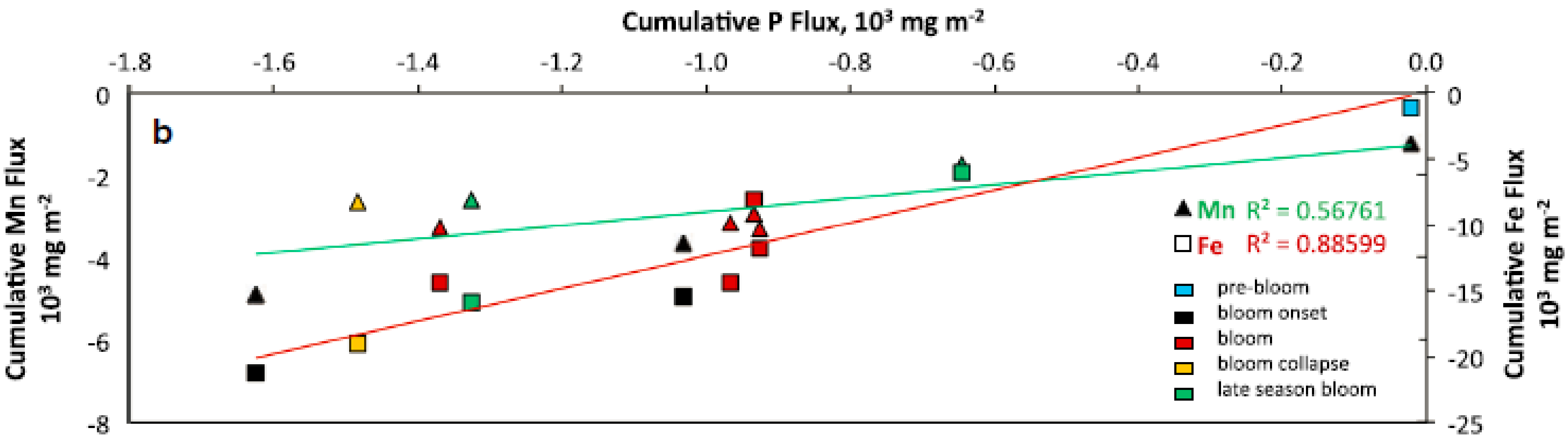
Insight from DEC Long-Term Monitoring Data

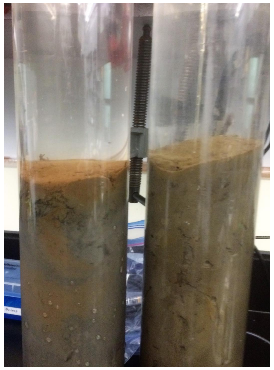


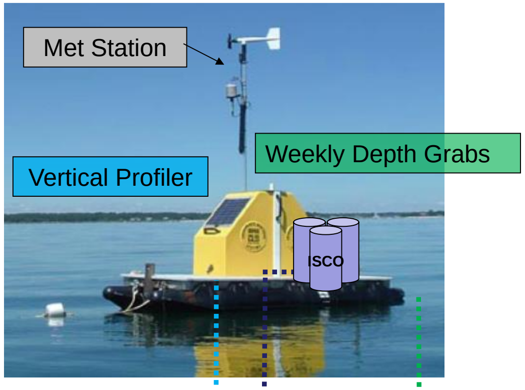
Isles et al. 2017 Biogeochemistry

Linking water column stability to Redox Front Position and Internal Loading (sediment grab sampling coupled with high frequency water column Monitoring)

Giles et al. (2016) Biogeochemistry

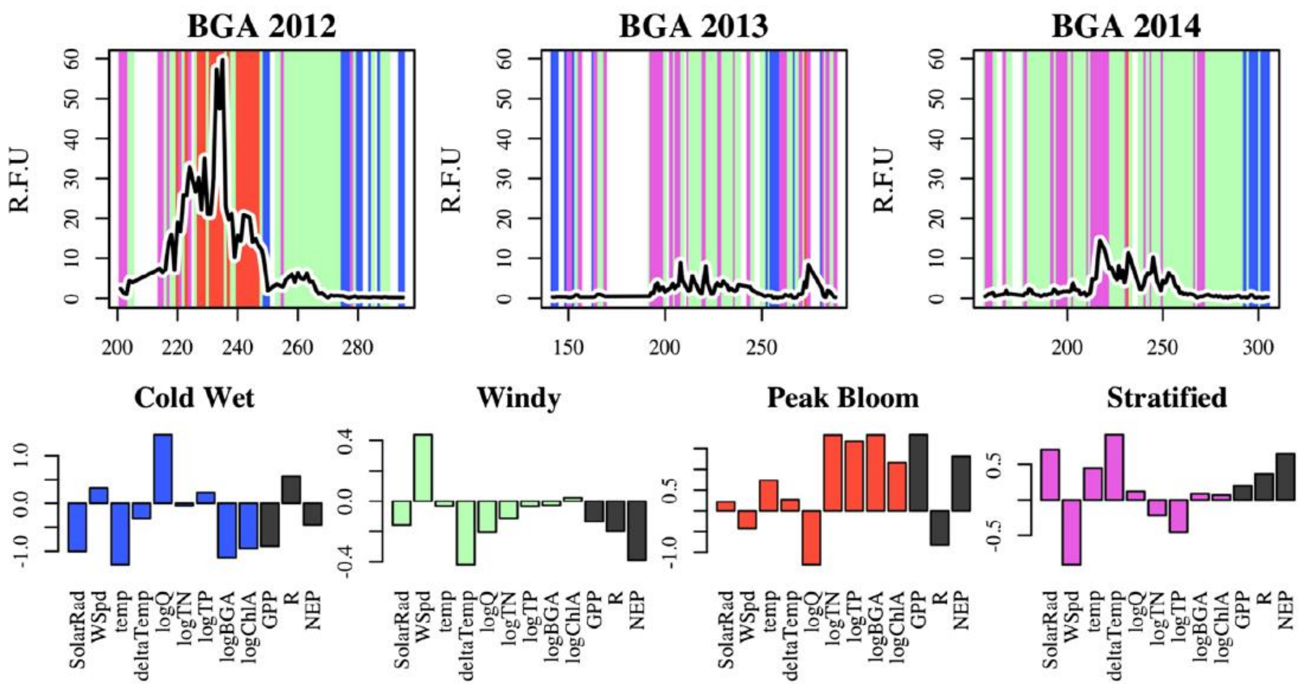


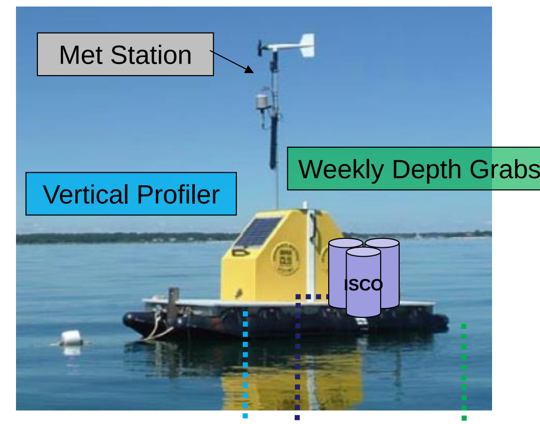




Multi Year High frequency monitoring tells us more about agents and impacts of change

Isles et al. (2017) Inland Waters

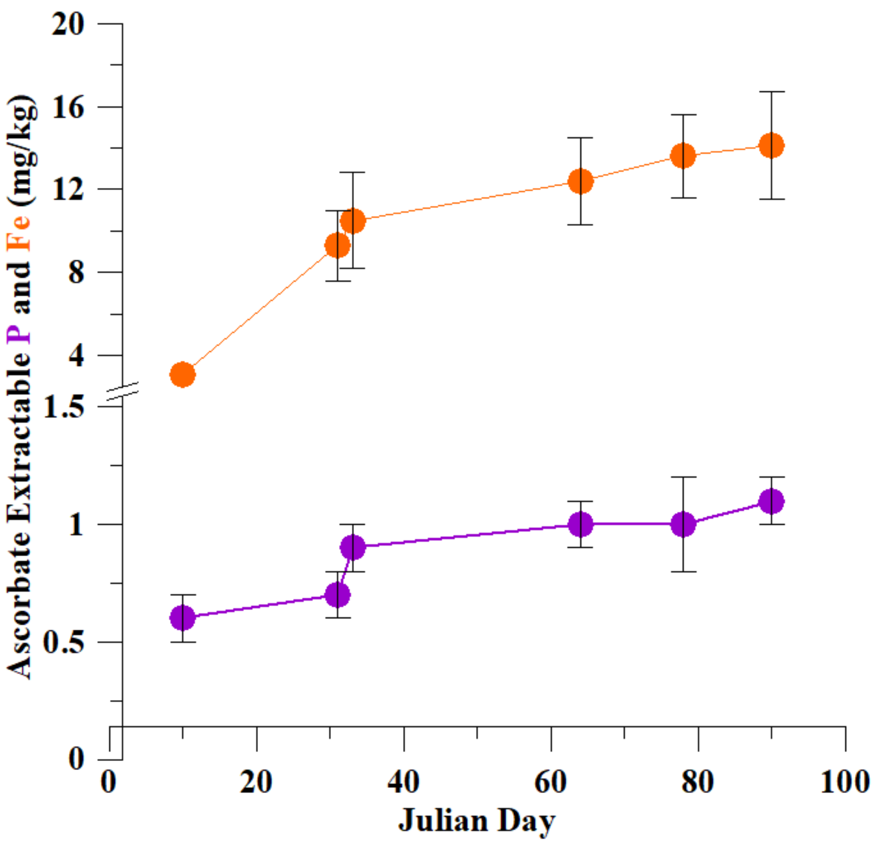


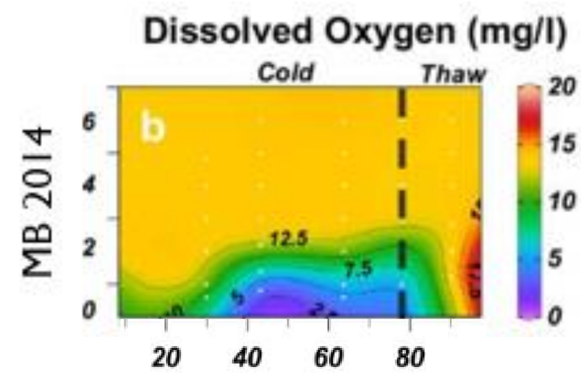


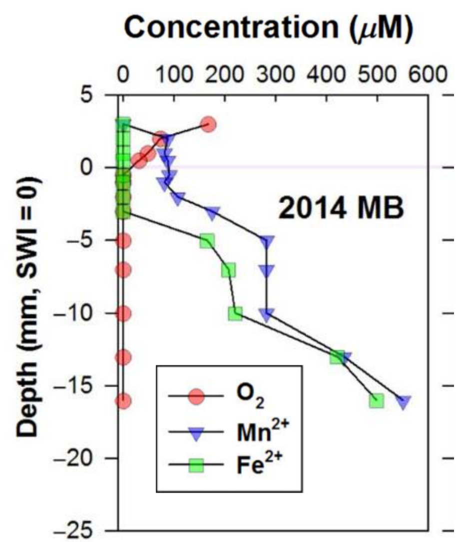
Combinations of biological, physical, and chemical sensors allow us to understand the complex relationship between weather, lake and river flow, chemistry and biology and **drivers of change**

Winter 2014 Redox Front Position Promotes Accumulation of 'Redox Sensitive' P and Fe

Schroth et al. (2015) ES&T

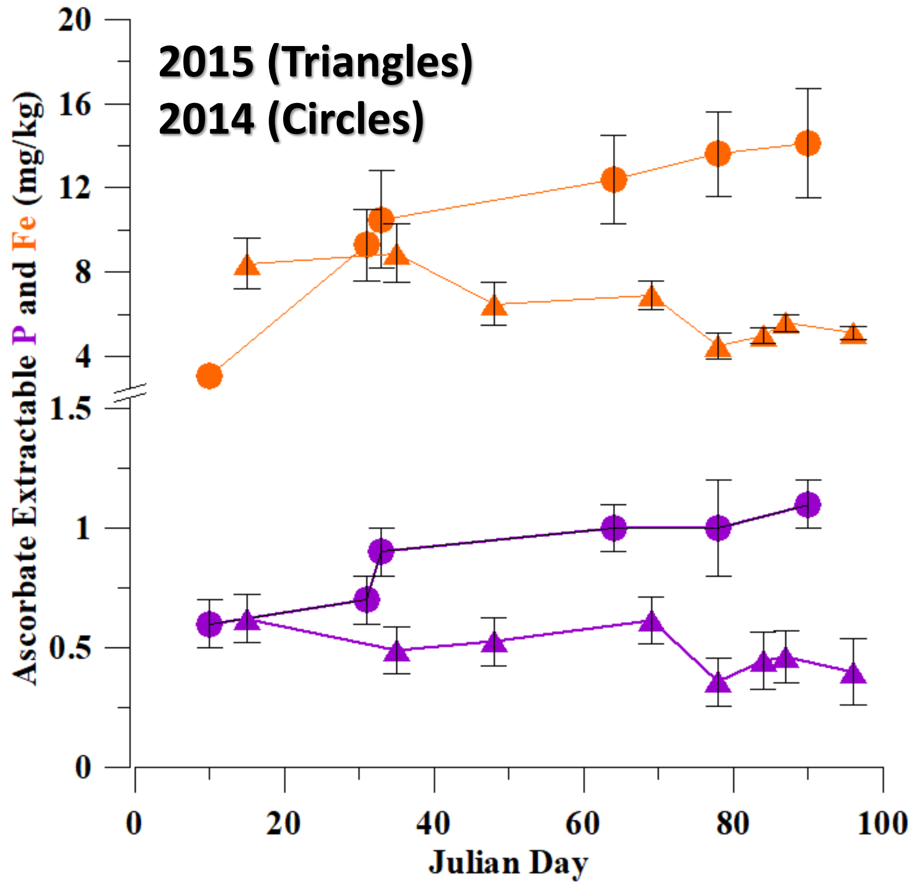


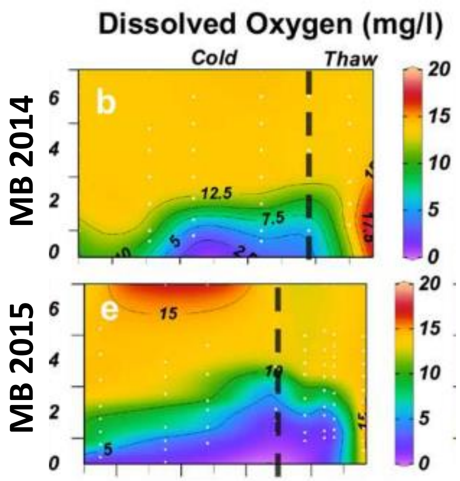


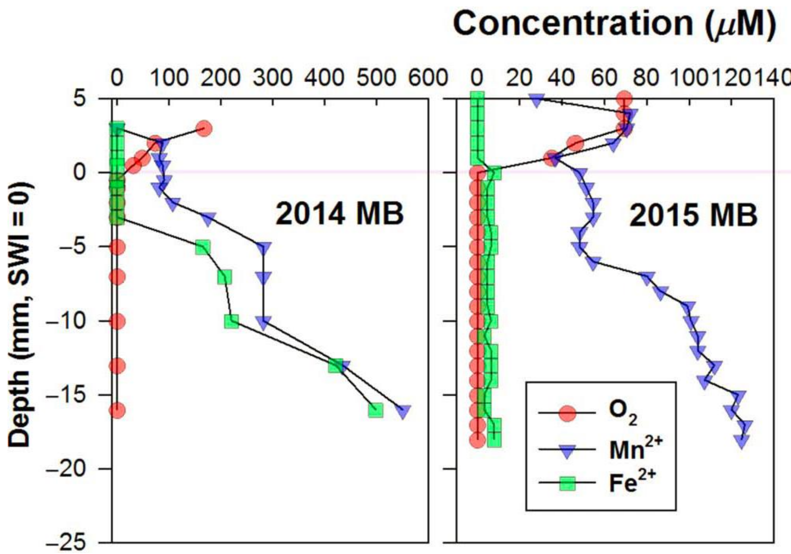


Different Dynamics in 2015

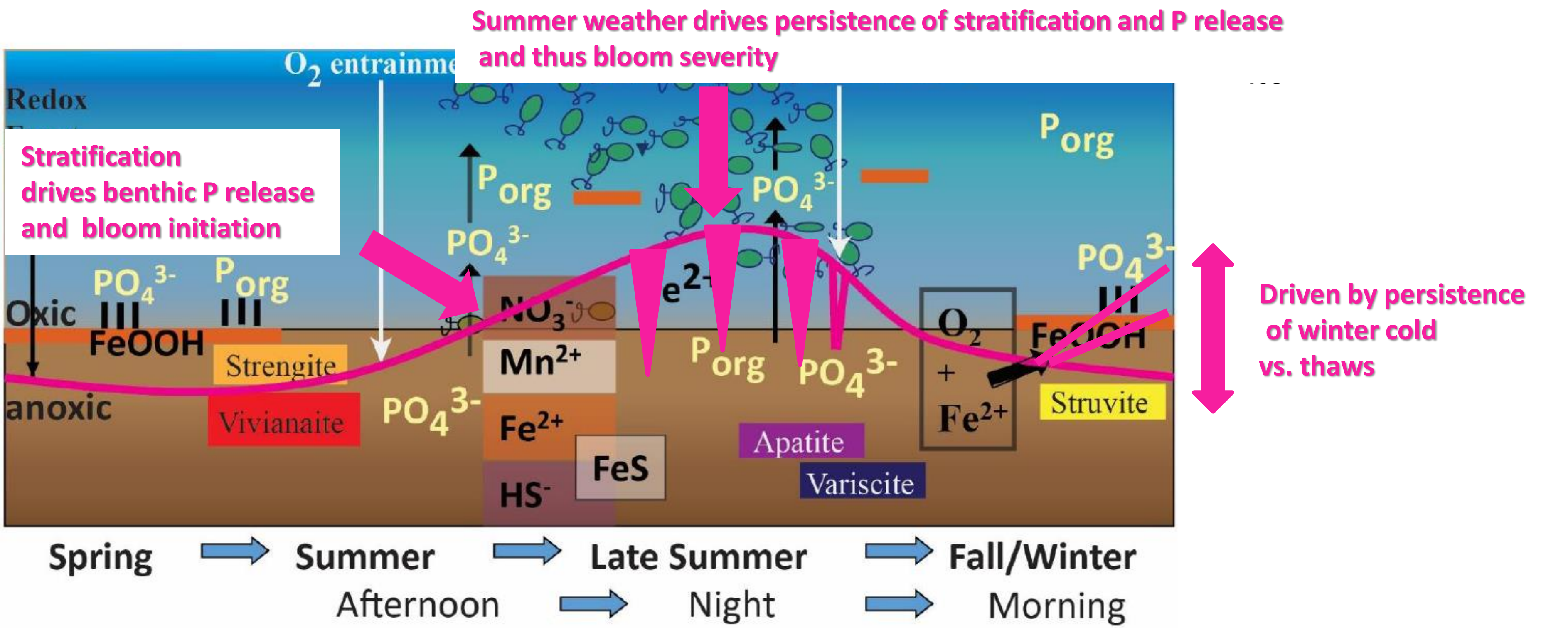
Joung et al. Limnology & Oceanography 2017



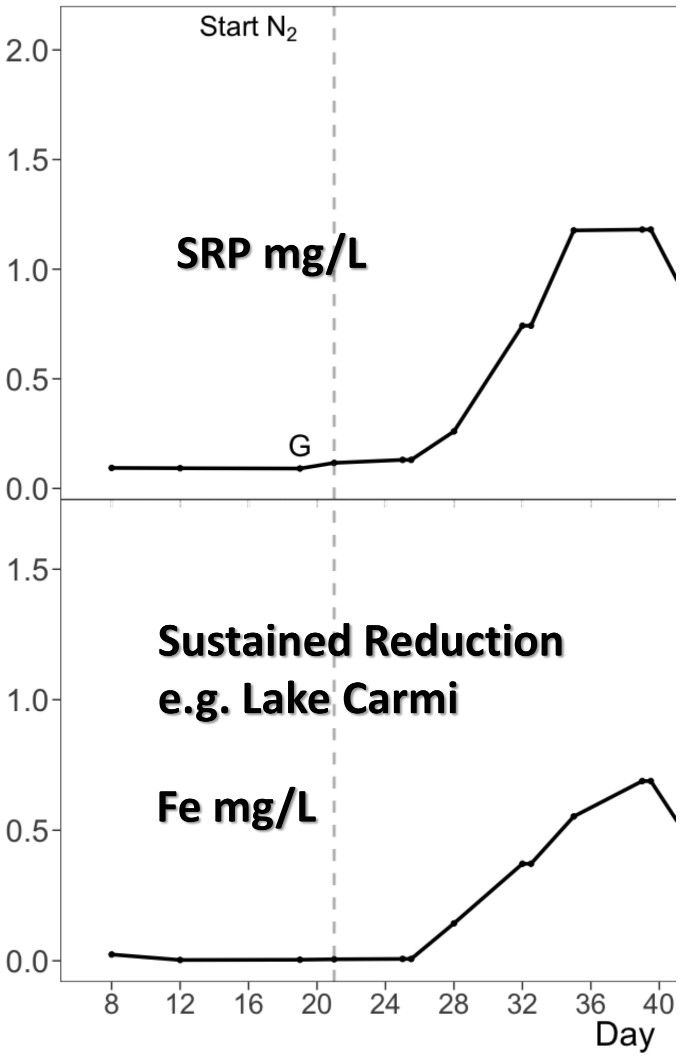


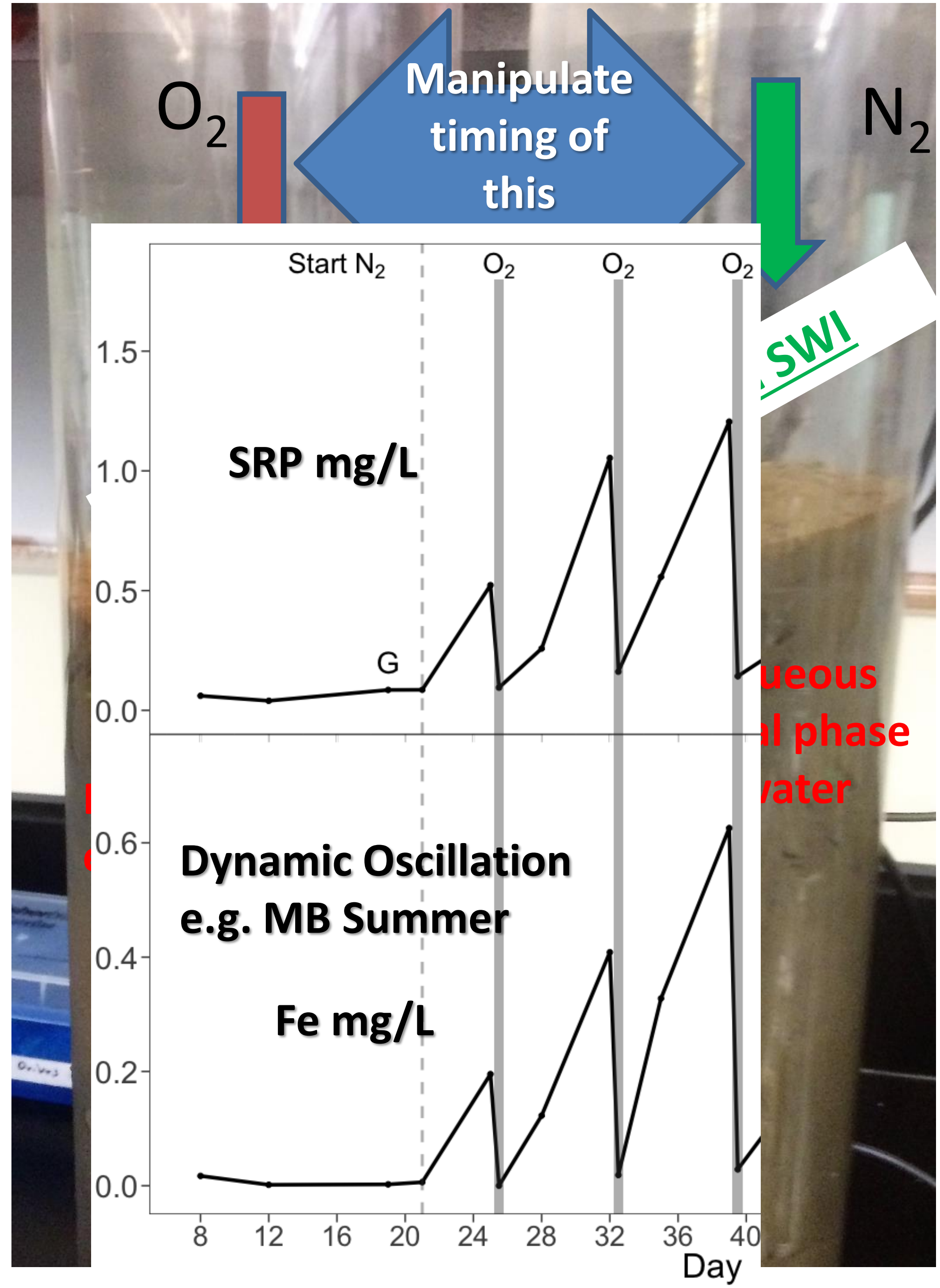


Drivers of Internal P Loading in Missisquoi Bay : Revised Conceptual Model

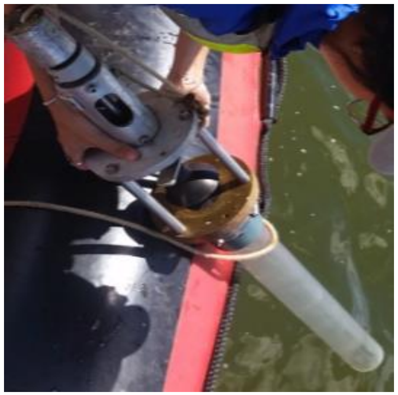


Simulate Internal Loading with Laboratory Experiments

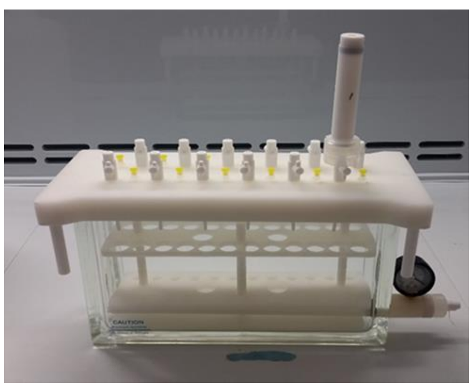


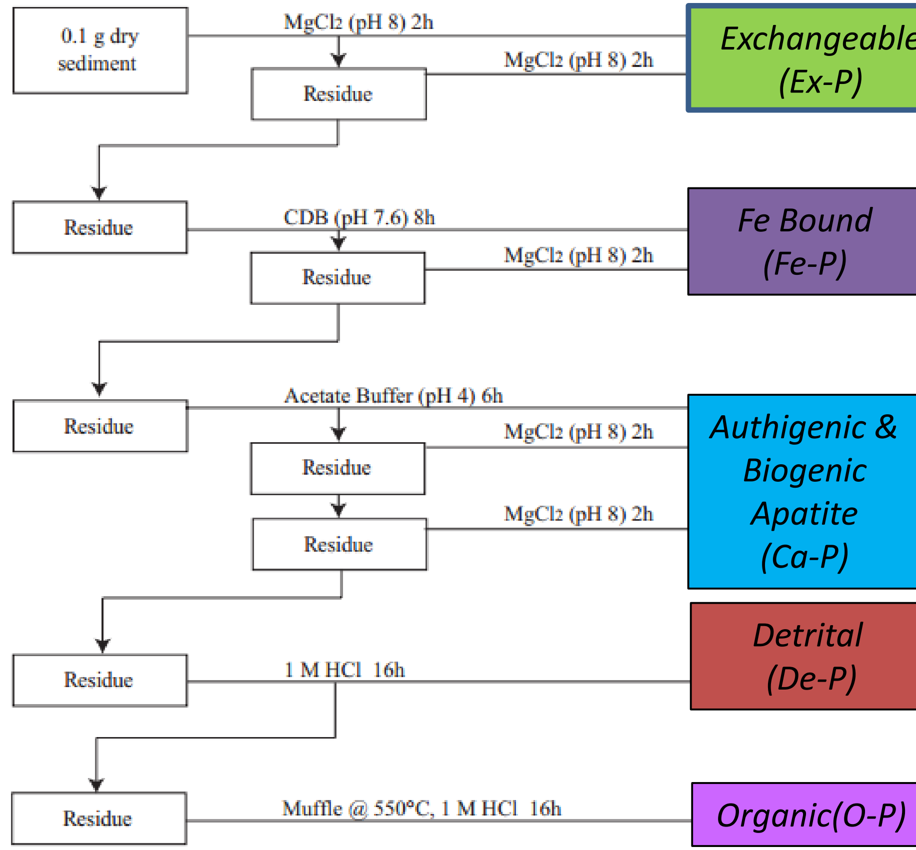


P partitioning in sediment more complex?
Sequential selective extractions(SEDEX scheme)



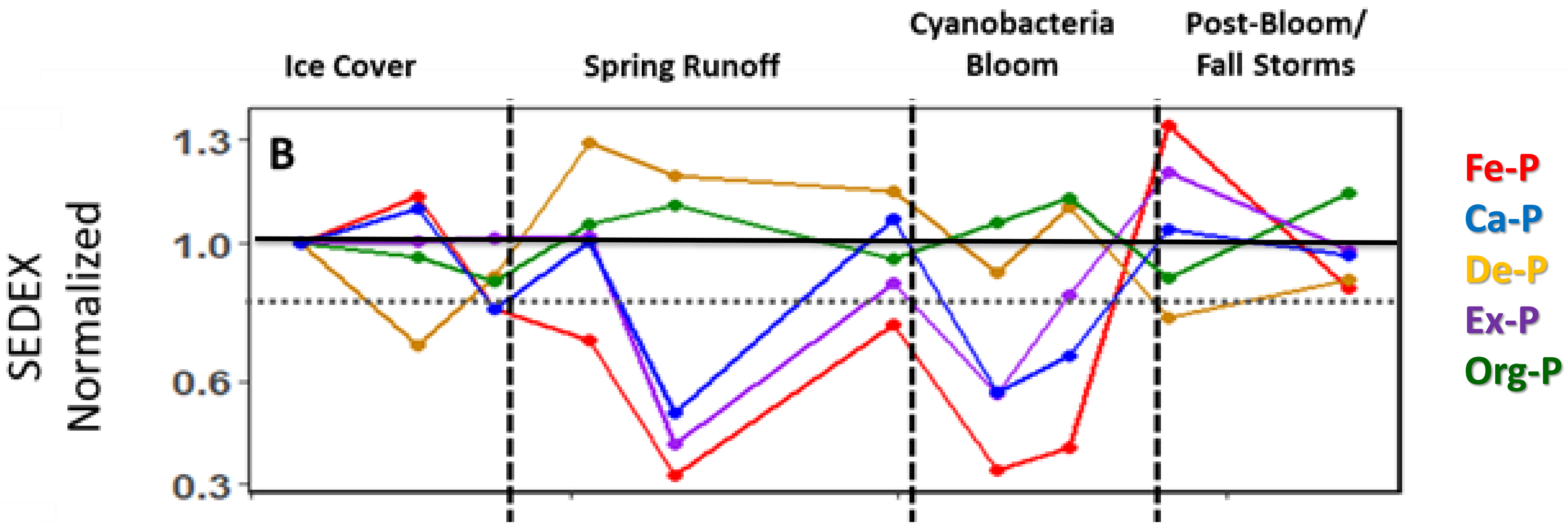
Analyzed 0-1 cm section of cores from Missisquoi Bay 2015 sediment time series



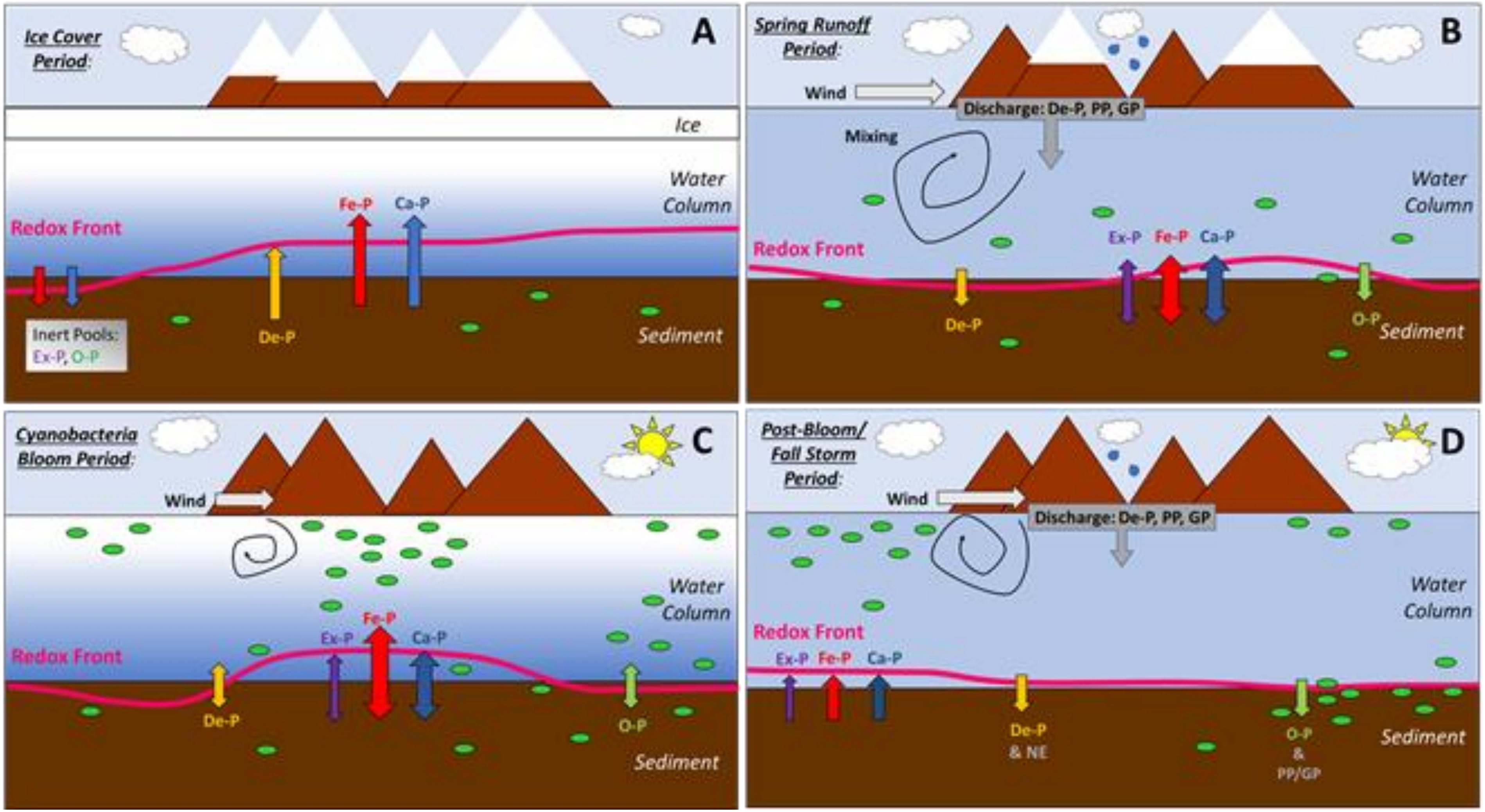


Sequential Extraction (SEDEX) as modified by Ruttenberg et al. 2009

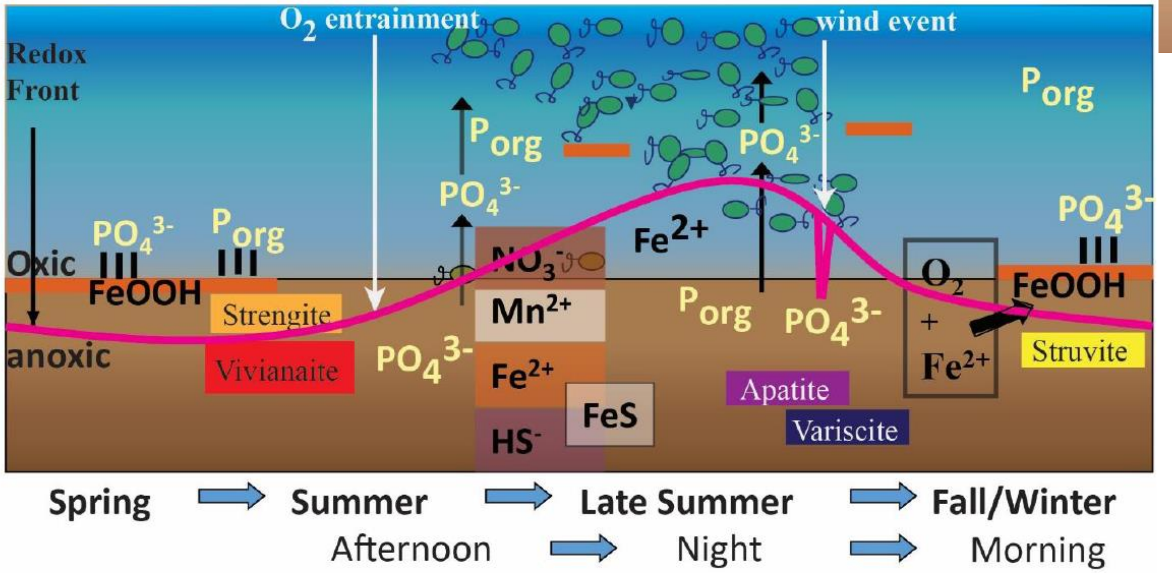
Multiple pools are highly dynamic on the seasonal scale, Fe, Ca, Ex most labile, Hysteretic behavior again on an annual scale!

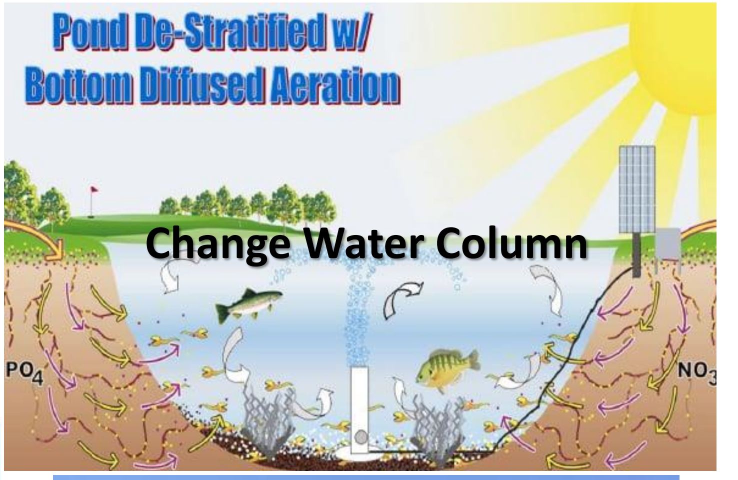


Ongoing Research
Who(P forms) is moving when and why?



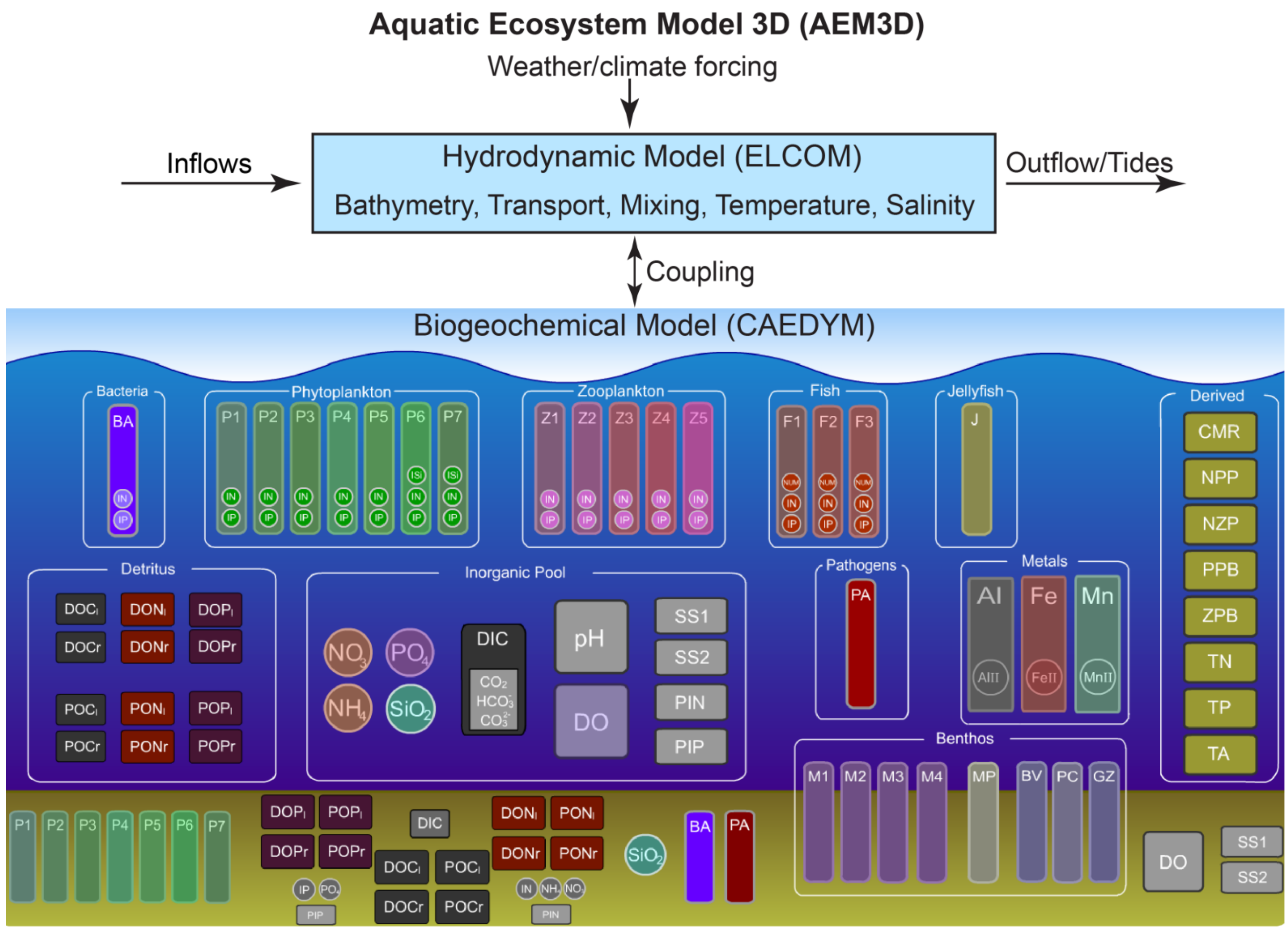
Common Approaches to Suppress Internal P Loading





Balance of internal vs. external P loading reduction to meet water quality goals?
Optimal approach likely site and goal specific

Process-based models are useful tools for answering this question

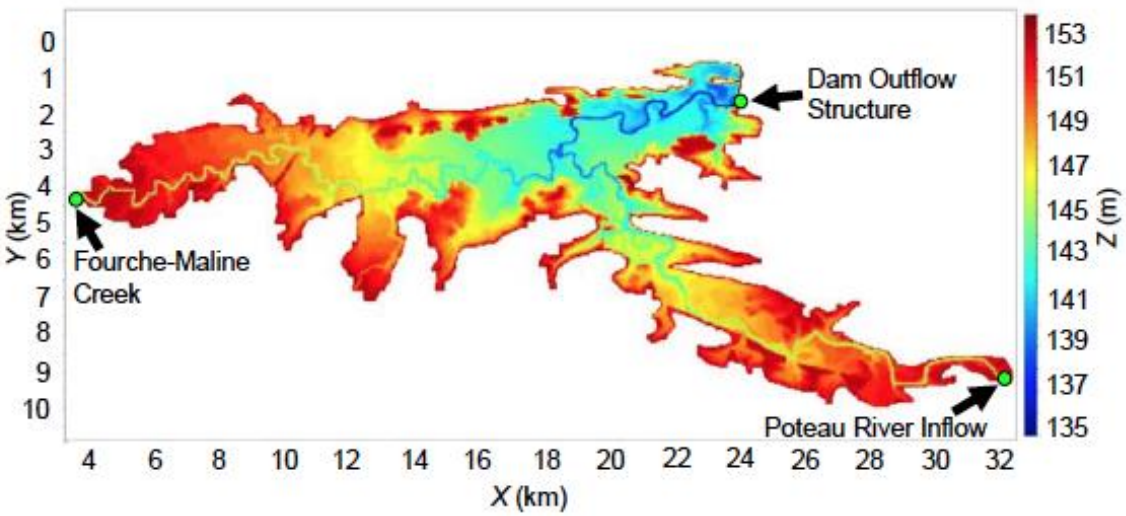


http://www.hydronumerics.com.au/software/aquatic-ecosystem-model-3d

Lake Wister (Oklahoma, USA)

TP and TSS loads reductions to meet the Oklahoma Water Quality Standards

(10 µg/L Chl-a and no more than 10 % of samples exceeding 25 NTU turbidity)



- Internal P loading
- Watershed P loading
- Combined internal and watershed P loading

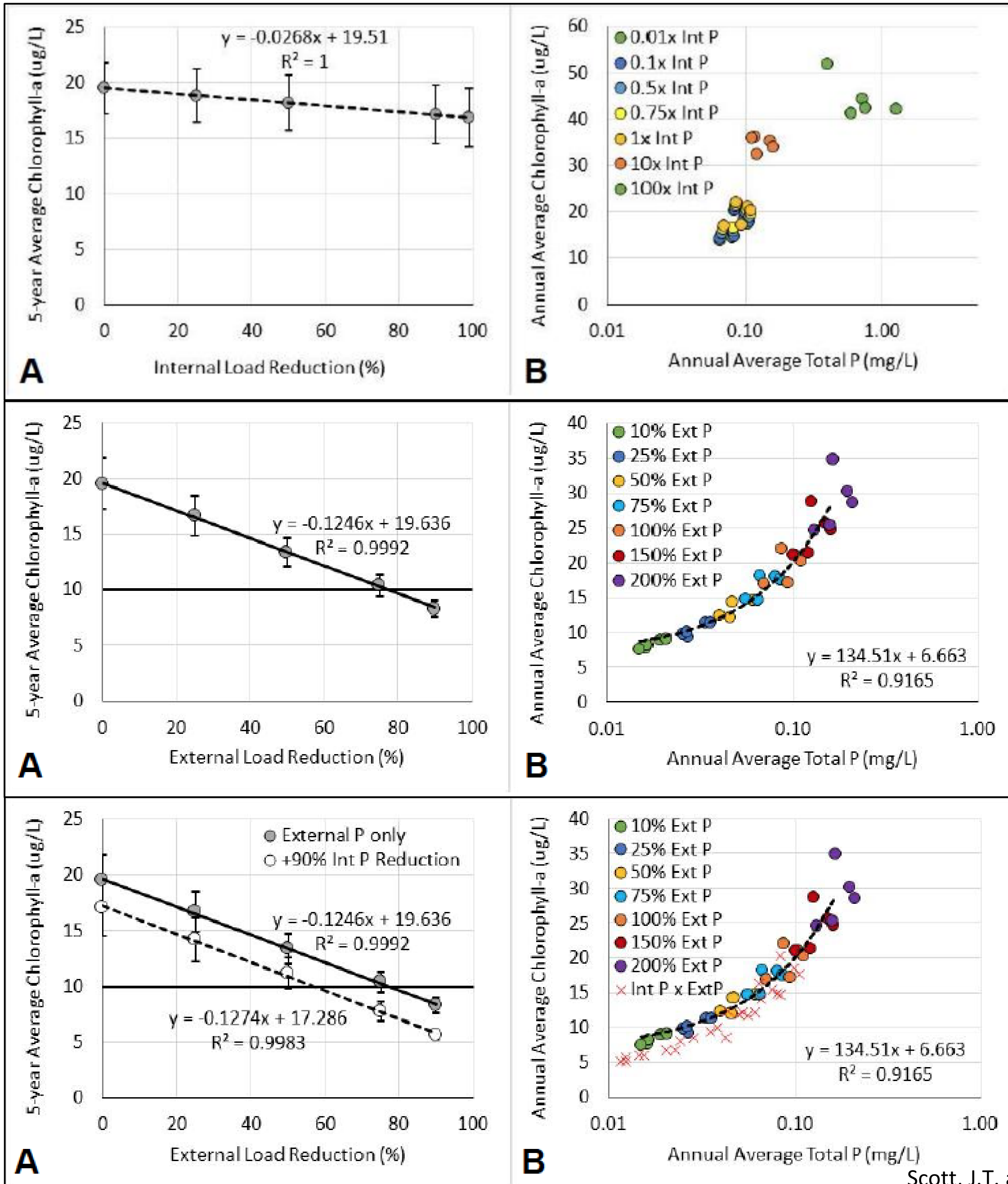
Scott, J.T. and Patterson, S.D. (2018)

Scenario Results

Suppress Internal P loading

Suppress Watershed P loading

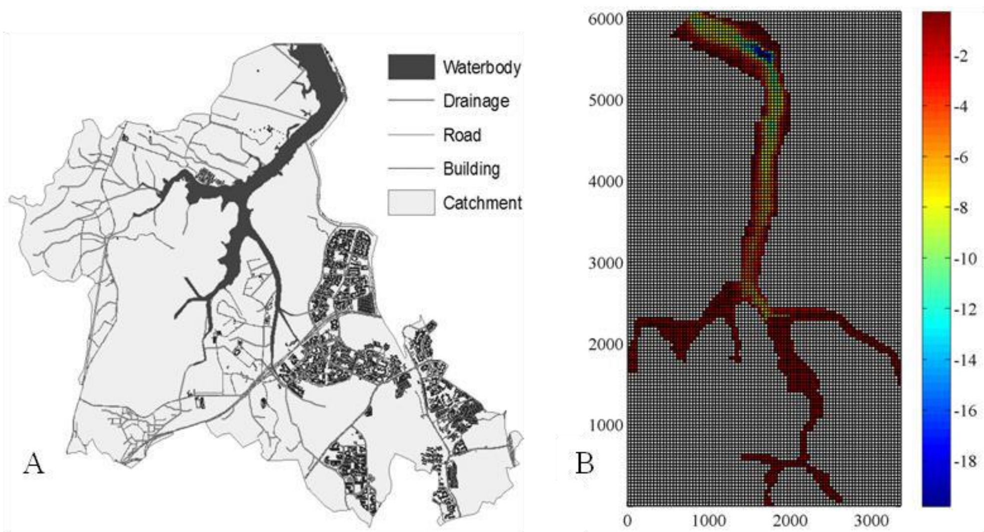
Combined suppression of internal and watershed P loading

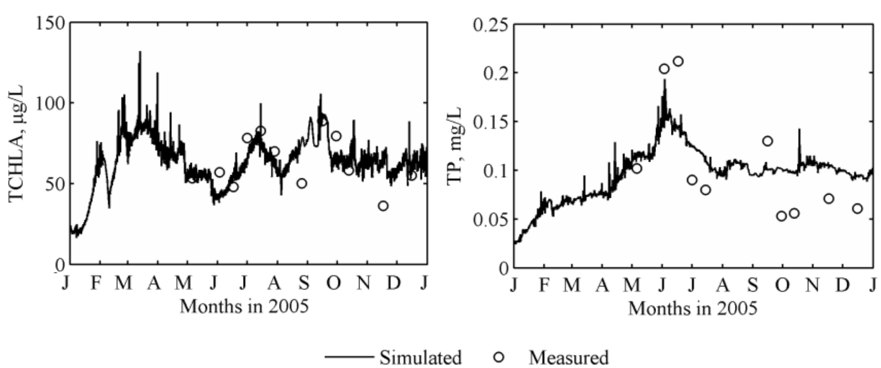


Scott, J.T. and Patterson, S.D. (2018)

Kranji Reservoir (Singapore)

Management scenarios for controlling eutrophication

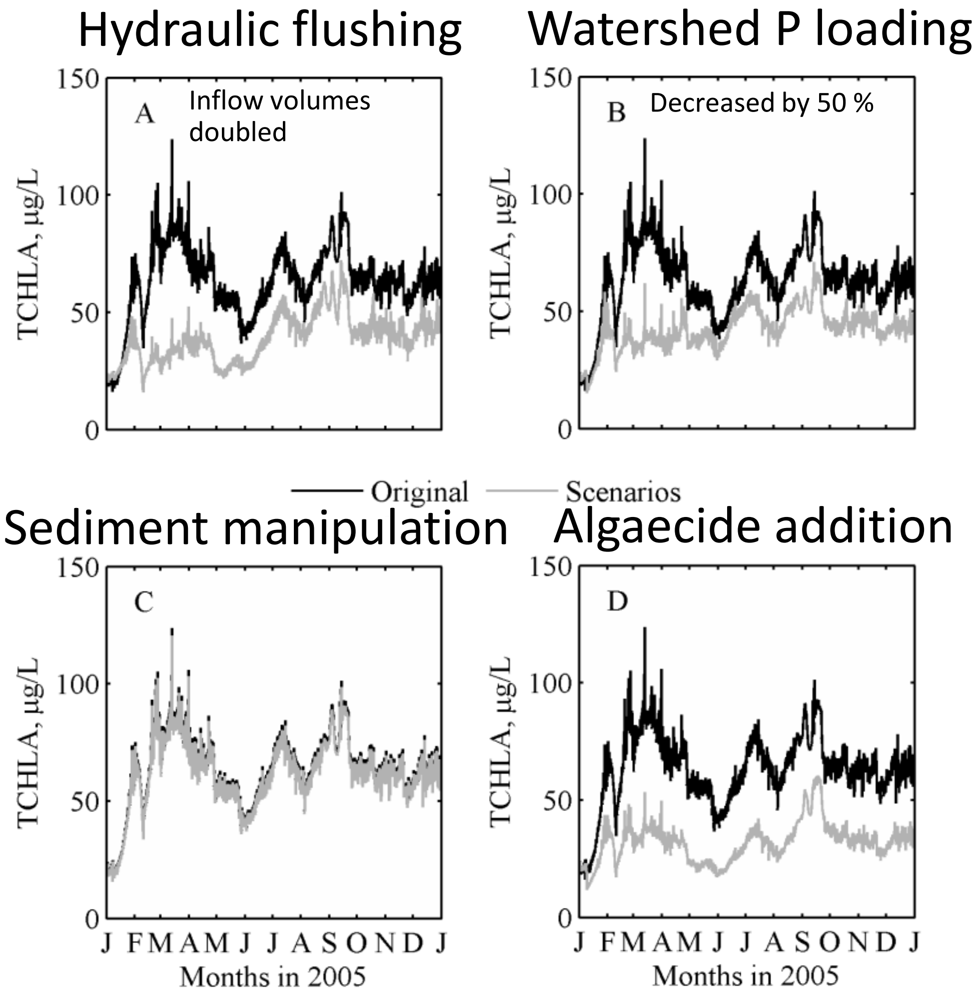


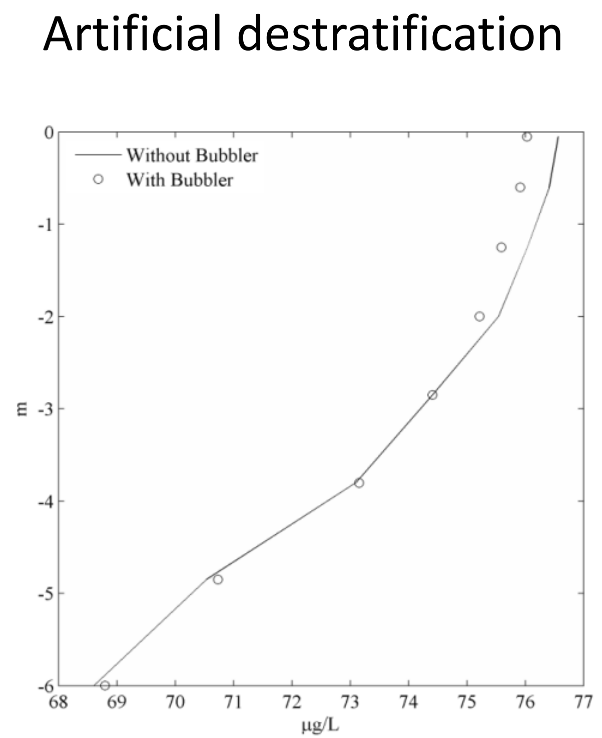


- Watershed nutrient loading
- Hydraulic flushing
- Sediment manipulation
- Artificial destratification
- Algaecide addition

Xing, Z., Chua, L., and Imberger, J. (2014)

Scenario Results





Xing, Z., Chua, L., and Imberger, J. (2014)