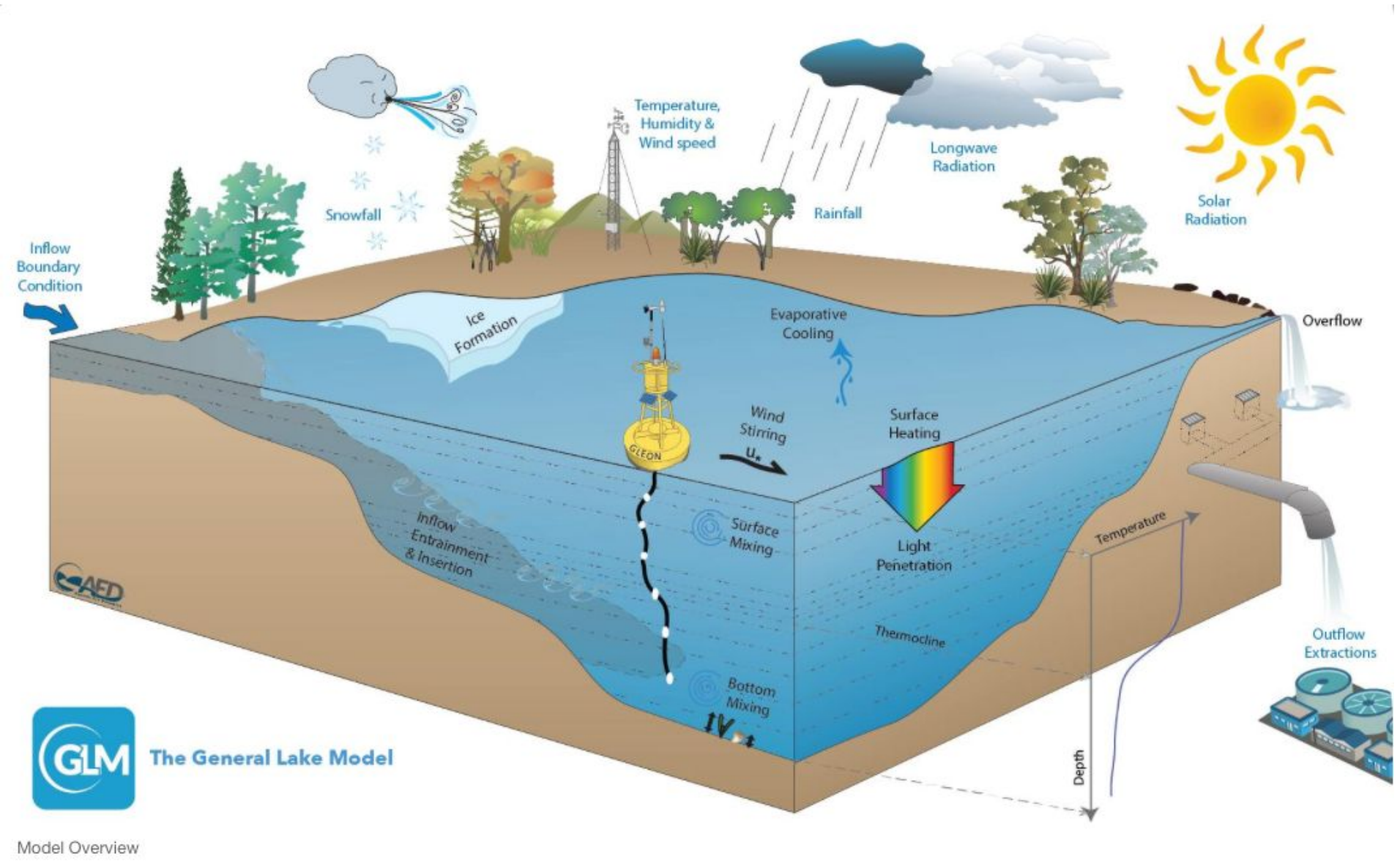
CNH GLM update

GLM team extraordinaire: (listed alphabetically)
Cayelan, Hilary, Julia, Kait, Lars, Nicole, Paul

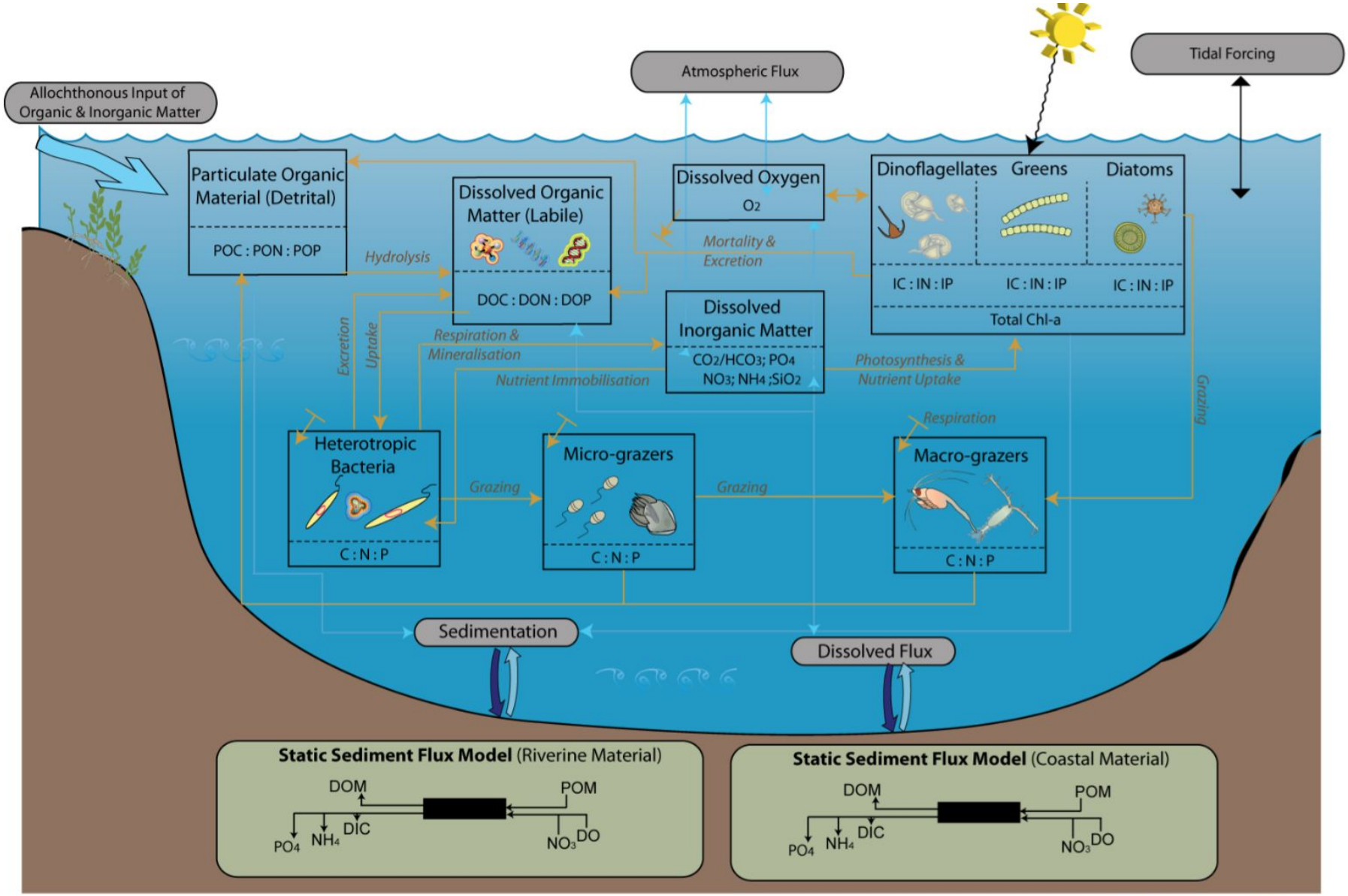
Year in review

- July 2016: Cayelan & Amy presented CNH GLM poster at GLEON
- August 2016: Cayelan, Nicole, and Kak give CNH presentations at LSPA in Sunapee
- September 2016: Cayelan and Nicole visit PSU to coordinate PIHM-->GLM coupling
- September-December 2016: Massive data collation for Sunapee GLM calibration (Nicole, Bethel, Kak, Cayelan)
- January 2017: Cayelan, Paul, Nicole, Julia, Kait, Hilary, and others organize GLM AED water quality calibration workshop in Madison
- Dec-Jan 2017: Nicole spends month in WI to calibrate Sunapee GLM model
- Jan-Feb 2017: Lars spends month in Madison to calibrate Oneida GLM model
- February 2017: Yu provides 14 years of hydrology from PIHM for Mendota
- March-May 2017: Nicole, Kak, and Cayelan meet with LSPA on Sunapee GLM project
- April 2017: Cayelan, Kait, Nicole, and Paul co-organize GLM workshop at PRAGMA conference at University of Florida
- May 2017: Julia successfully defended her MS on Mendota GLM carbon cycling and Kait joins Carey Lab at VT!

GLM-AED overview: open-source hydrodynamics + water quality



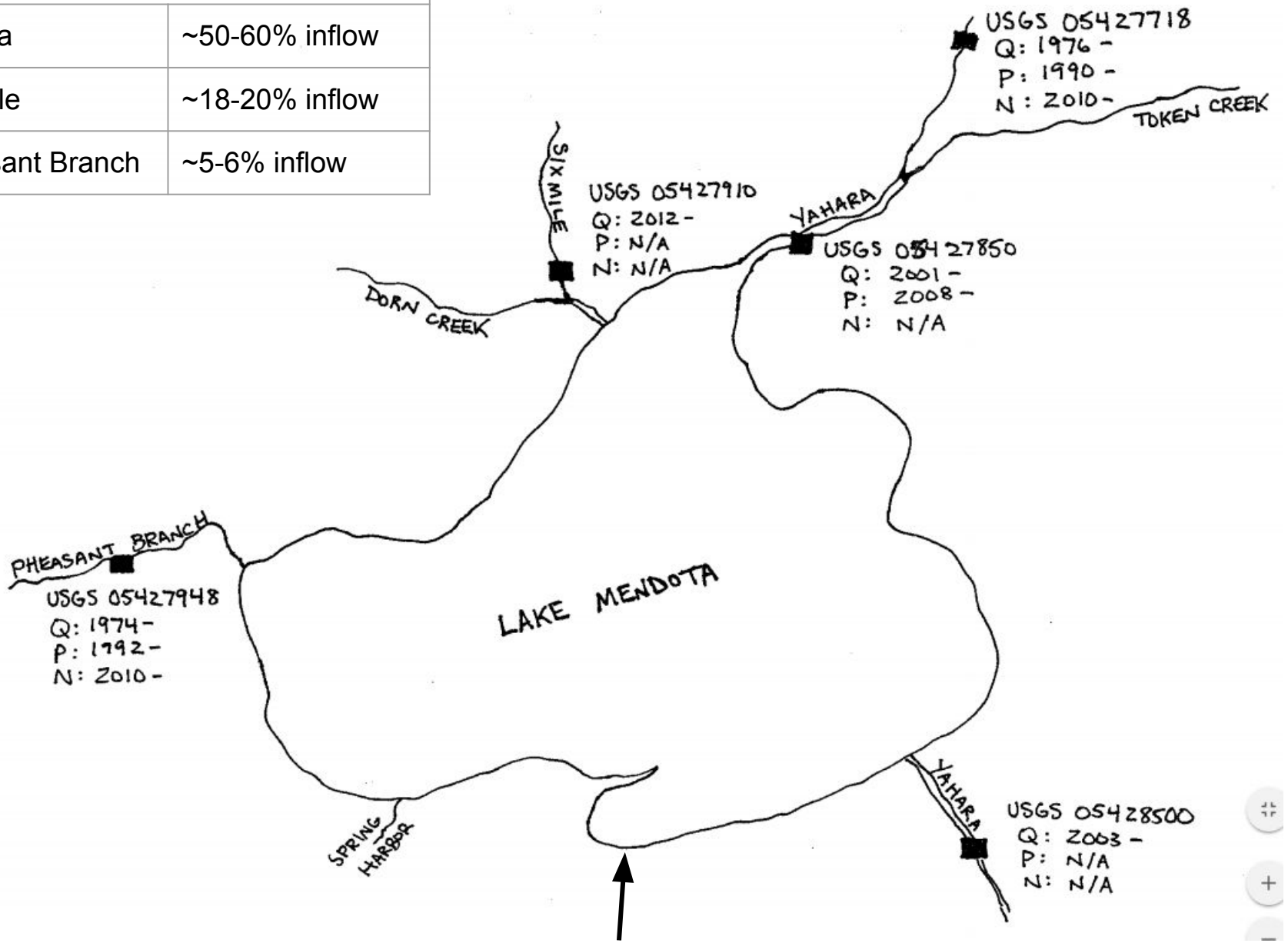
Model Overview



Carbon & Nutrient Flux Pathways

Mendota GLM modeling

Lake Mendota Inflows	
Yahara	~50-60% inflow
Six Mile	~18-20% inflow
Pheasant Branch	~5-6% inflow



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Modeling Lake Mendota inflows

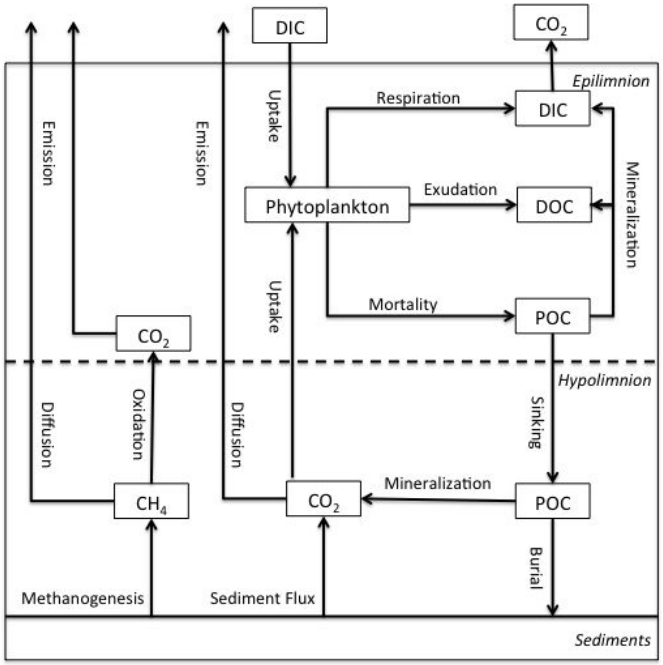
ISSUE: Only have solute concentrations for two inflows (**Yahara, Pheasant Branch**) for <10 years.

SOLUTION: Use USGS hydrology models.
rLOADEST: *Collection of functions to make constituent load estimates. Given a time series of streamflow, additional data variables, and constituent concentration, LOADEST assists the user in developing a regression model for the estimation of constituent load (calibration).*

1	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \epsilon$
2	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln Q^2 + \epsilon$
3	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 DecTime + \epsilon$
4	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 sin(2 * \pi DecTime) + \alpha_3 cos(2 * \pi DecTime) + \epsilon$
5	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln Q^2 + \alpha_3 DecTime + \epsilon$
6	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln Q^2 + \alpha_3 sin(2\pi DecTime) + \alpha_4 cos(2\pi DecTime) + \epsilon$
7	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \sin(2\pi DecTime) + \alpha_3 \cos(2\pi DecTime) + \alpha_4 DecTime + \epsilon$
8	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln Q^2 + \alpha_3 \sin(2\pi DecTime) + \alpha_4 \cos(2\pi DecTime) + \alpha_5 DecTime + \epsilon$
9	$\ln(Load) = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln Q^2 + \alpha_3 \sin(2\pi DecTime) + \alpha_4 \cos(2\pi DecTime) + \alpha_5 DecTime + \alpha_6 DecTime^2 + \epsilon$

Statistical models for Yahara and Pheasant Branch. Extrapolate to other inflows → Six Mile, overland flow

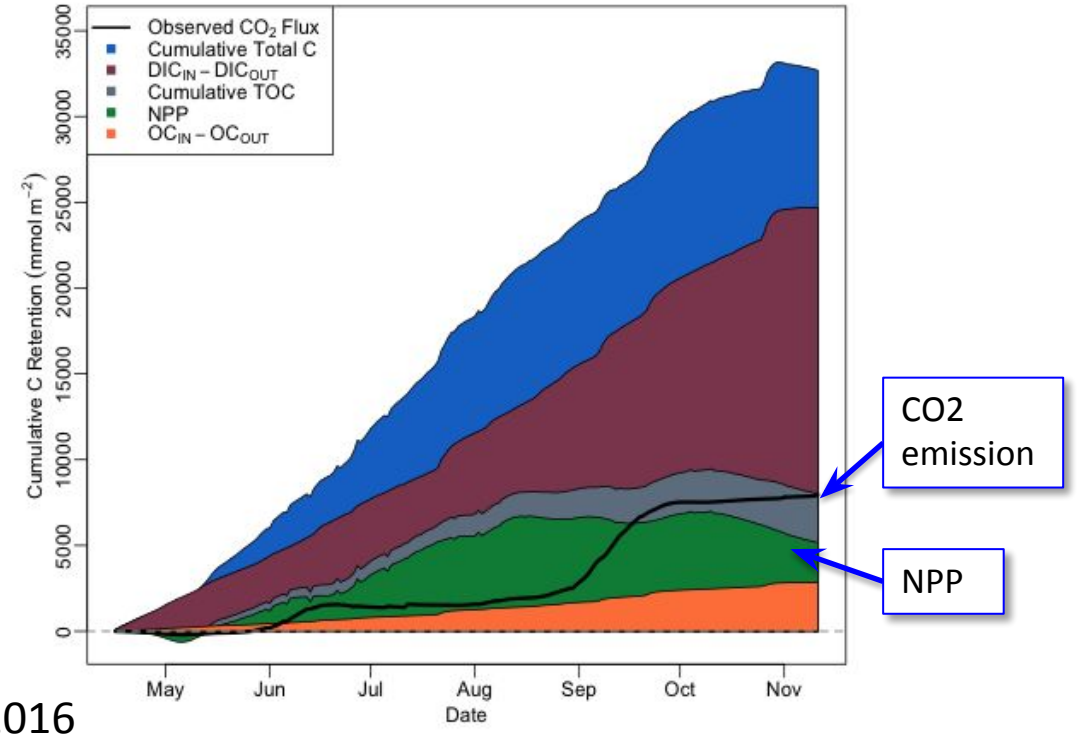
Julia Hart Thesis: OC cycling and GHG fluxes



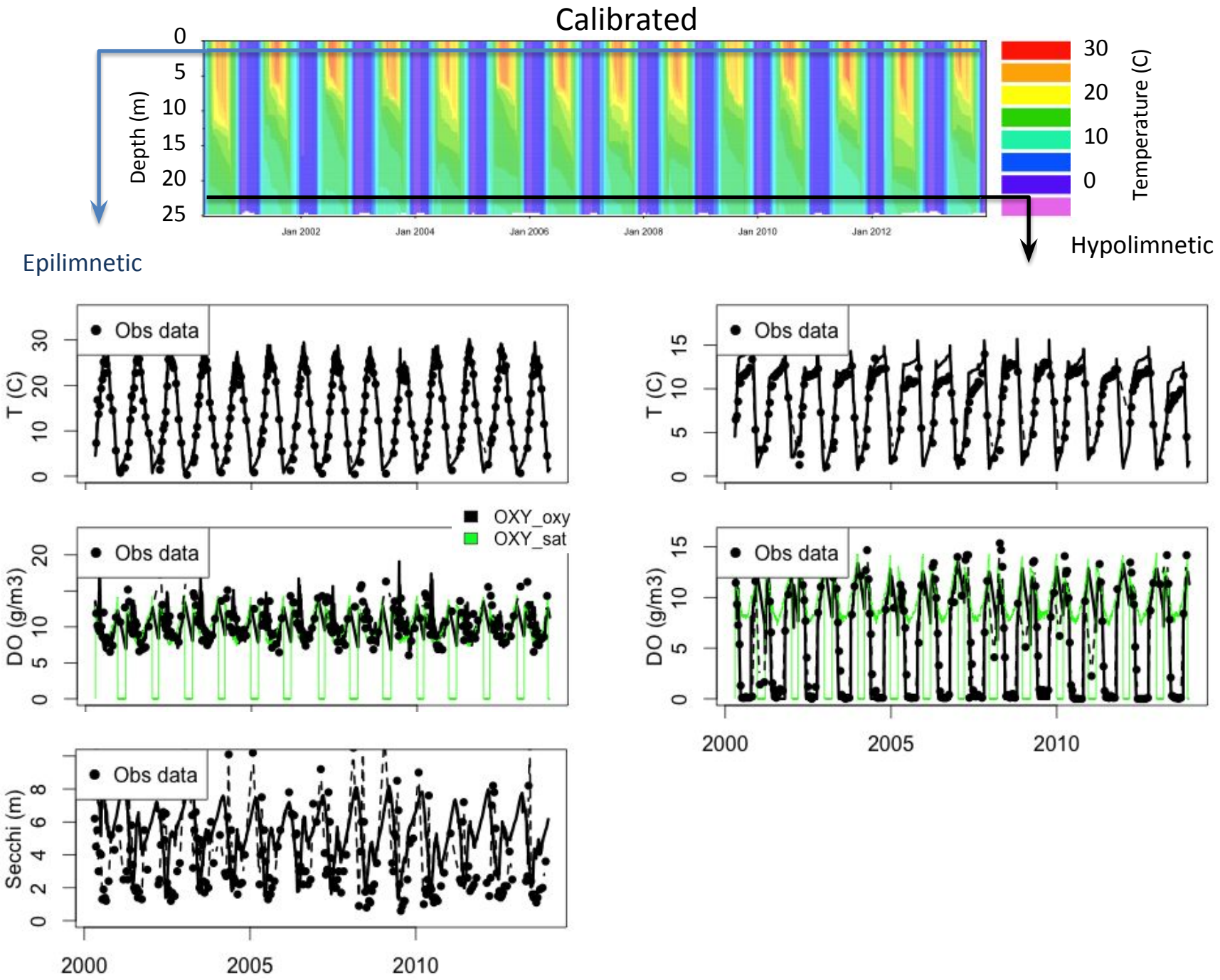
GLM-AED uses carbon as a currency. Hart thesis deals explicitly with particulate organic carbon (phytoplankton in Mendota), an often overlooked C pool.

$$\Delta C\ Storage = OC_{in} - OC_{out} + NPP + IC_{in} - IC_{out} - F_{CO2,Atm} - F_{CH4,Atm} - OC_{Sed} - IC_{Sed}$$

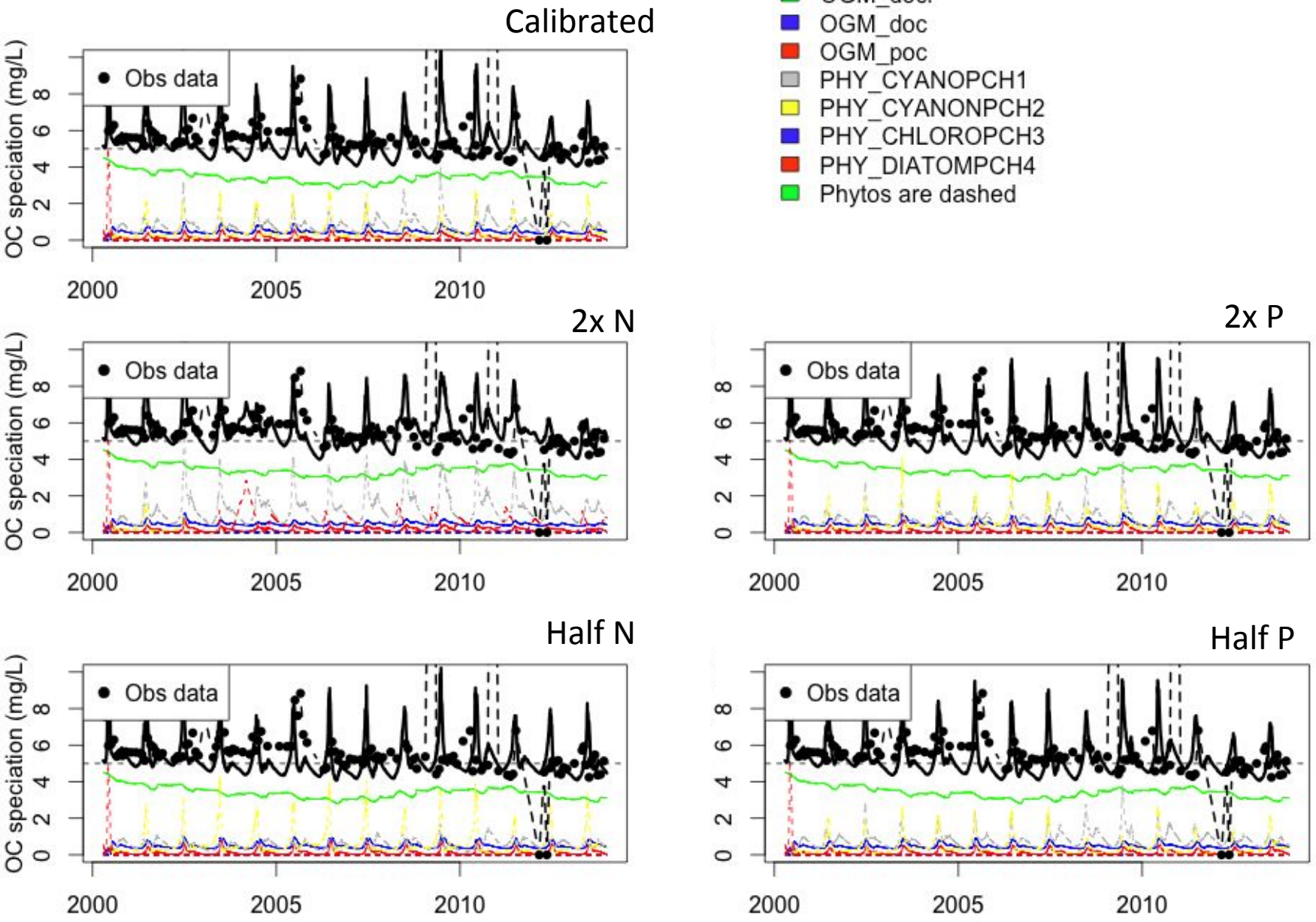
Lake Mendota is a net source of GHG to the atmosphere



2016

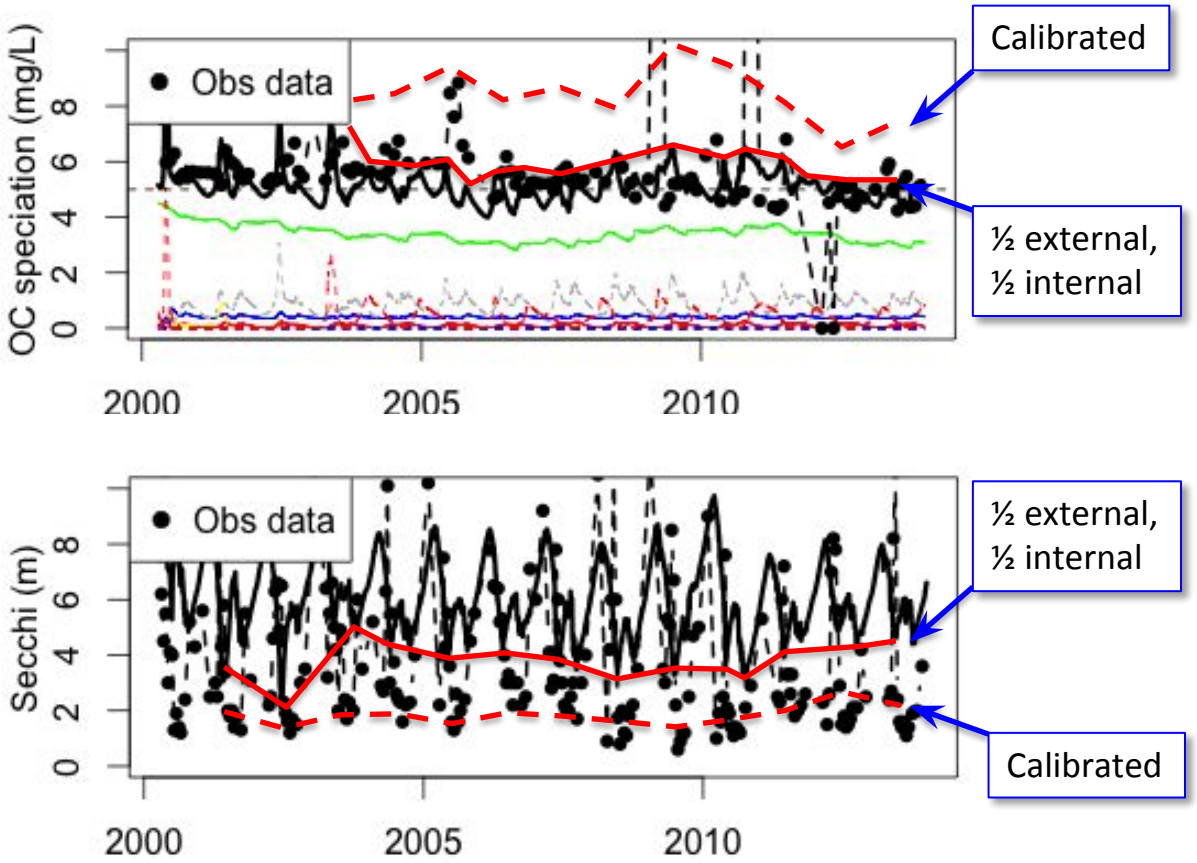


RunOtherPeoplesModels.R



RunOtherPeoplesModels.R

Gain ~2m of clarity (Secchi) under ½ external, ½ internal P loads



RunOtherPeoplesModels.R

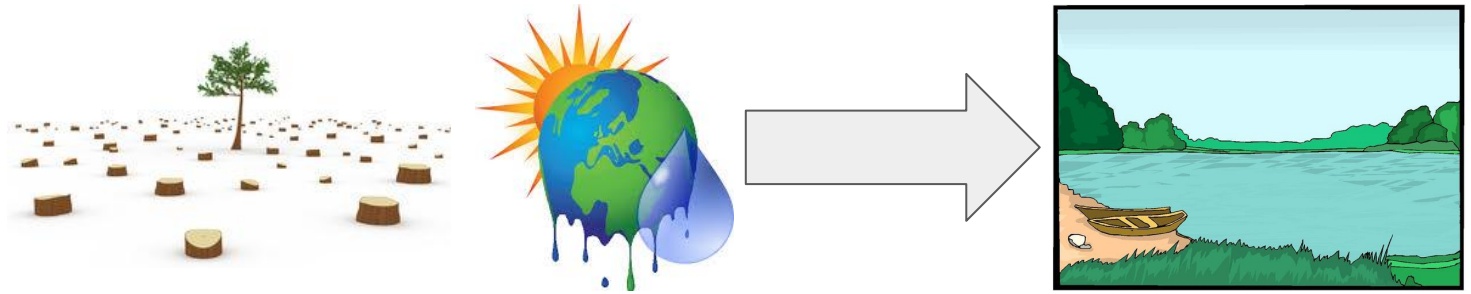
Mendota Summary

- Physics is easy to simulate, biology is hard
- Summer phytoplankton blooms drive annual decreases in water clarity
- Legacy nutrients in the lake sediments cause resilience to changing loads (i.e., no change)
- Reducing both external & internal loads is key
- Need a sediment nutrient model for long-term change (Aviah!)
- Need hydrology back to 1979

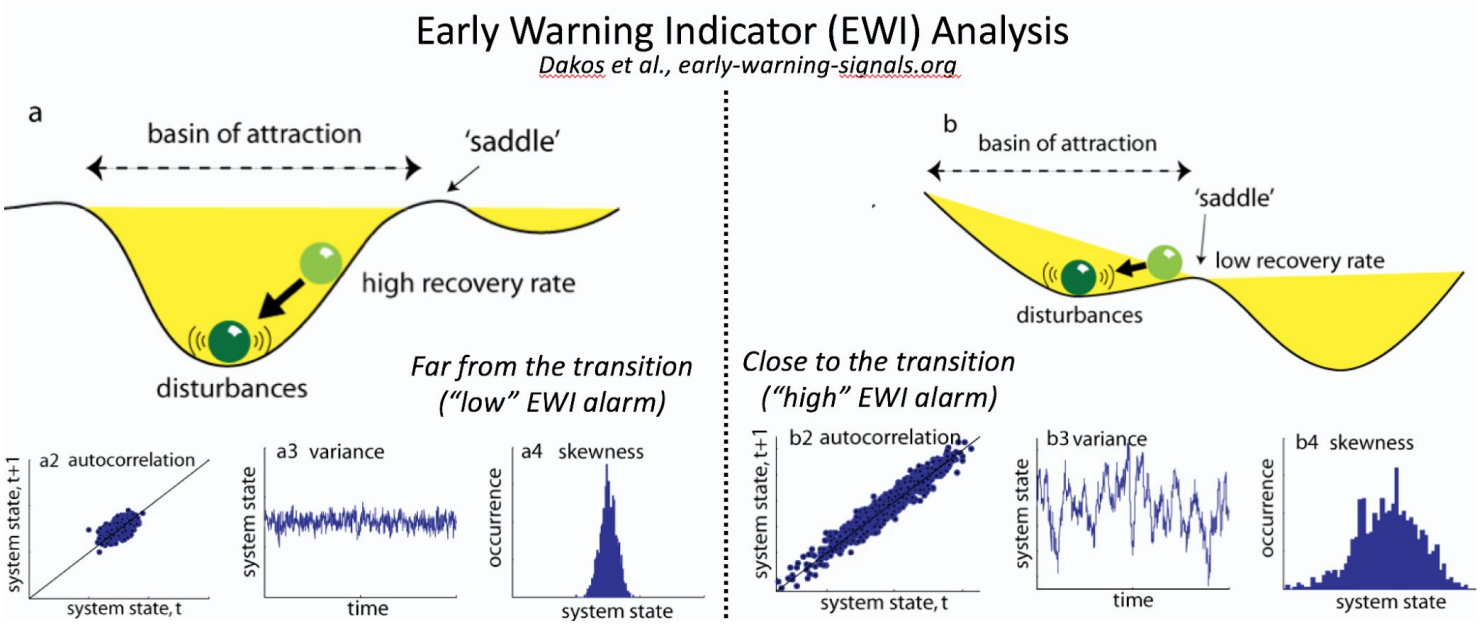
Sunapee GLM modeling

Nicole's Ph.D. Chapter 1 Q's

A) How do land use and climate change interact to affect water quality in an oligotrophic lake over three decades?



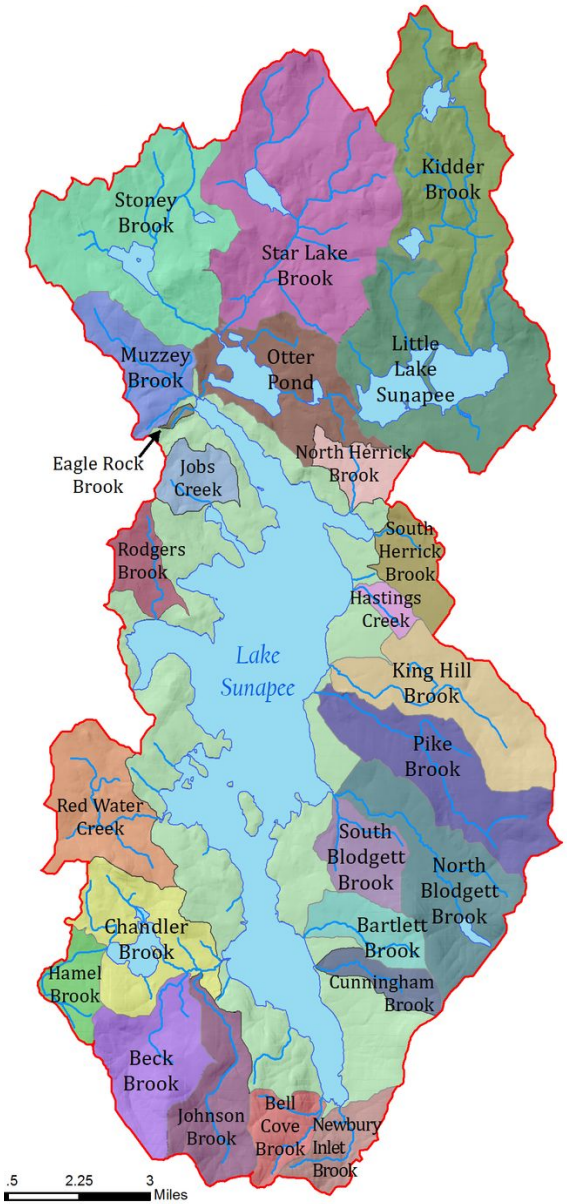
B) How can we manage water quality in a real-world oligotrophic lake?



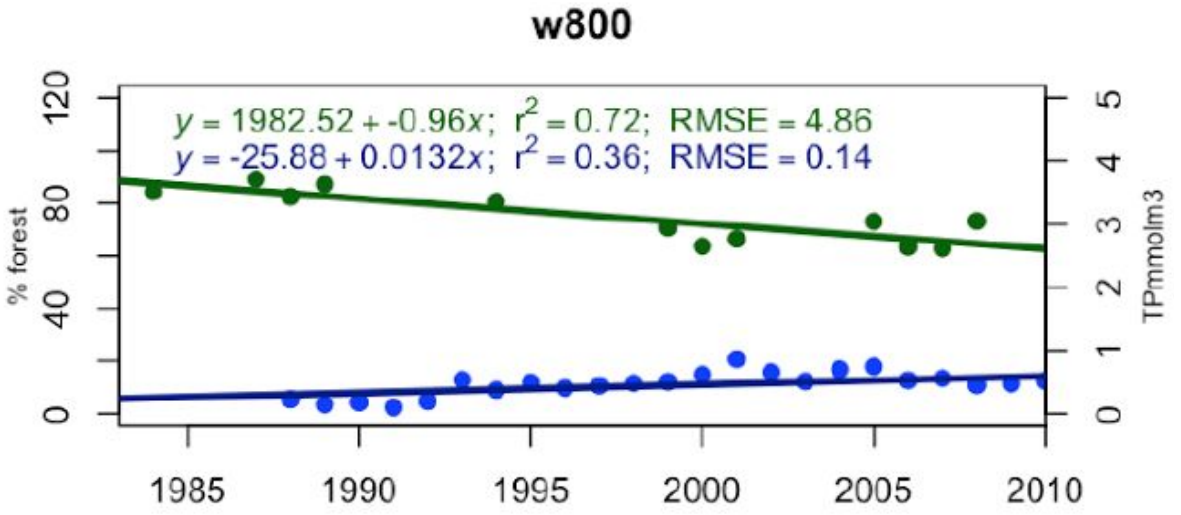
Landsat of Sunapee 30 years ago vs. now

1984

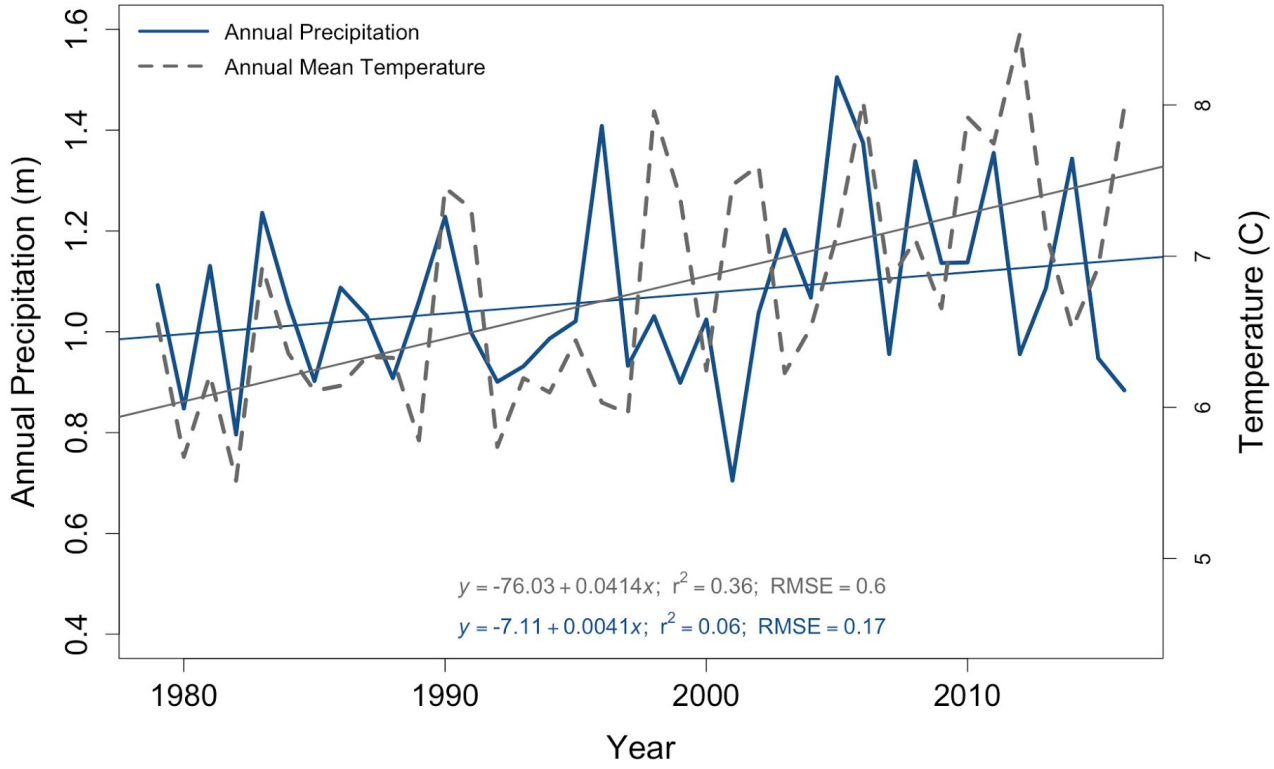
2008



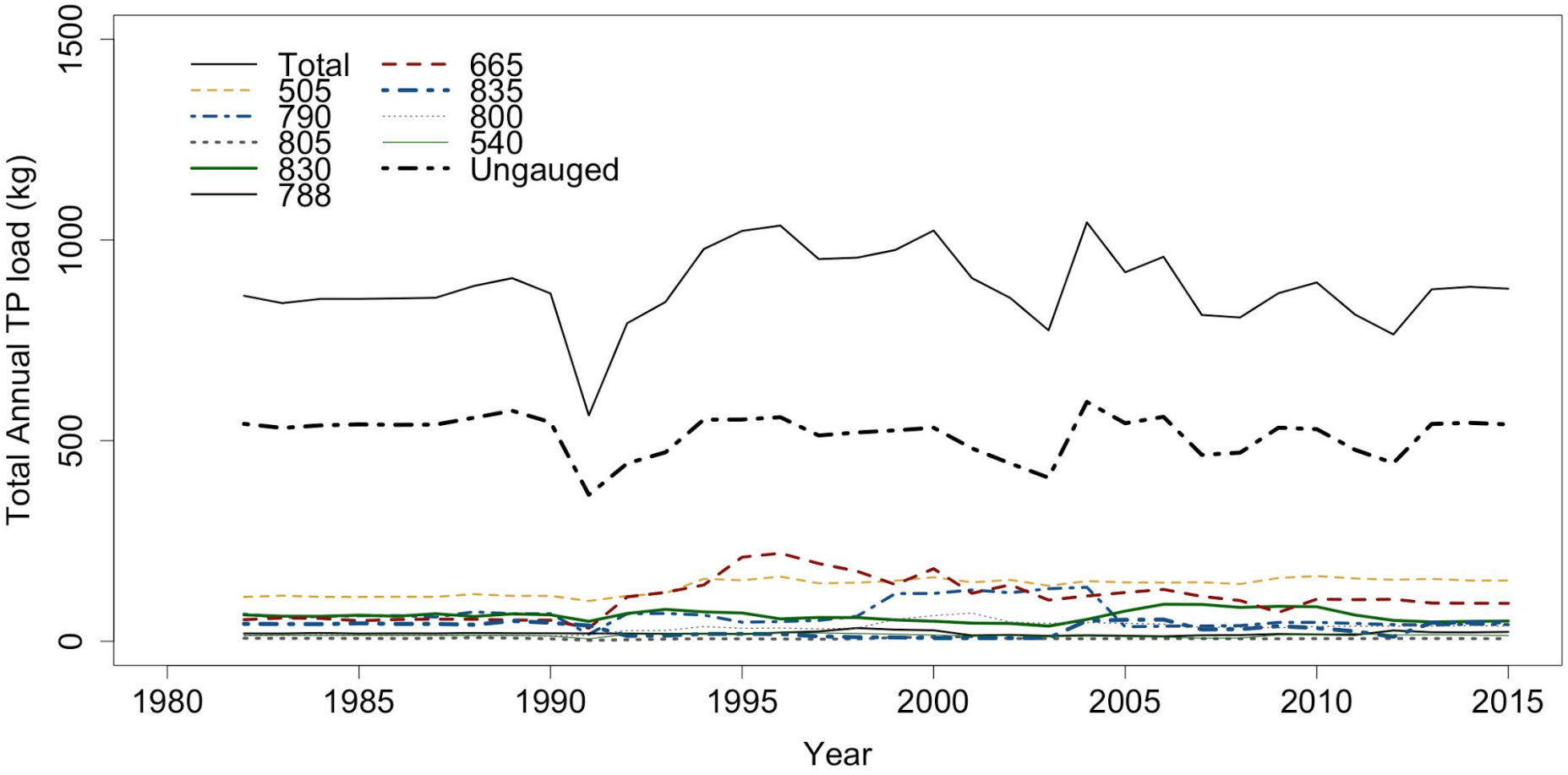
Annual % forest cover and mean annual TP in stream



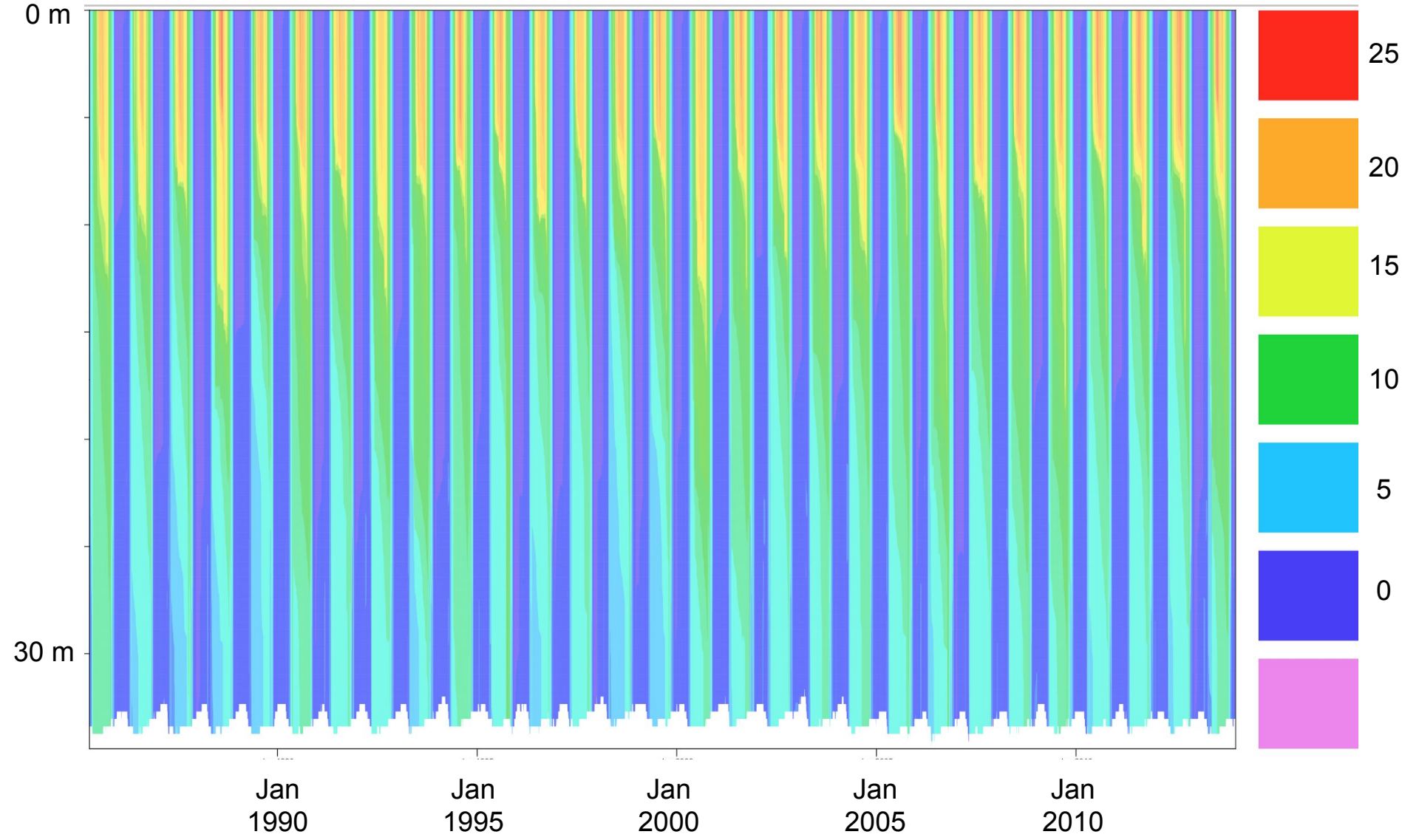
Total Annual Precipitation and Mean Annual Temp.



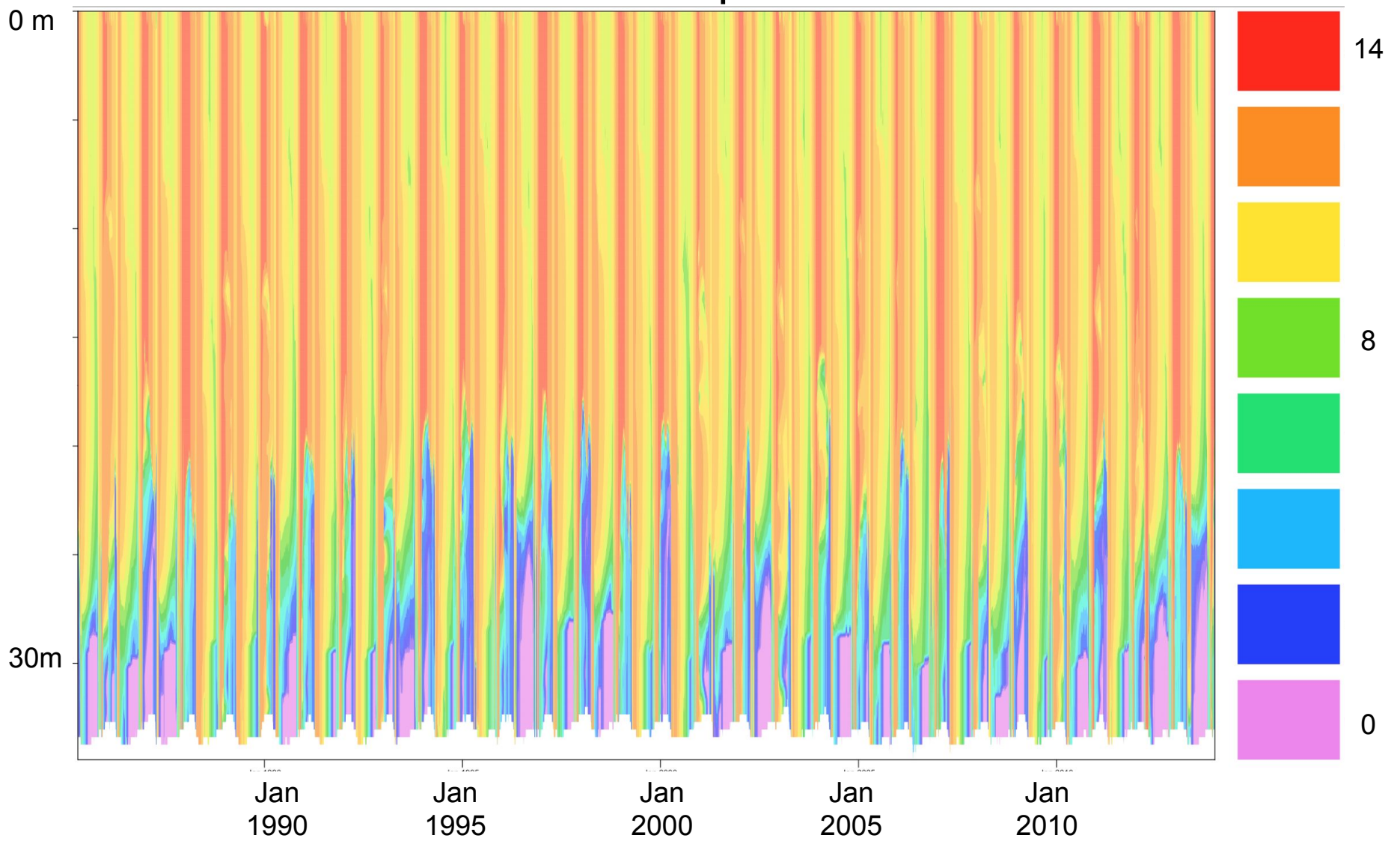
Inflow Stream Loading to Sunapee (bootstrapped)



Simulated Temperature Profile: deep hole site in Lake Sunapee 1985 - 2013



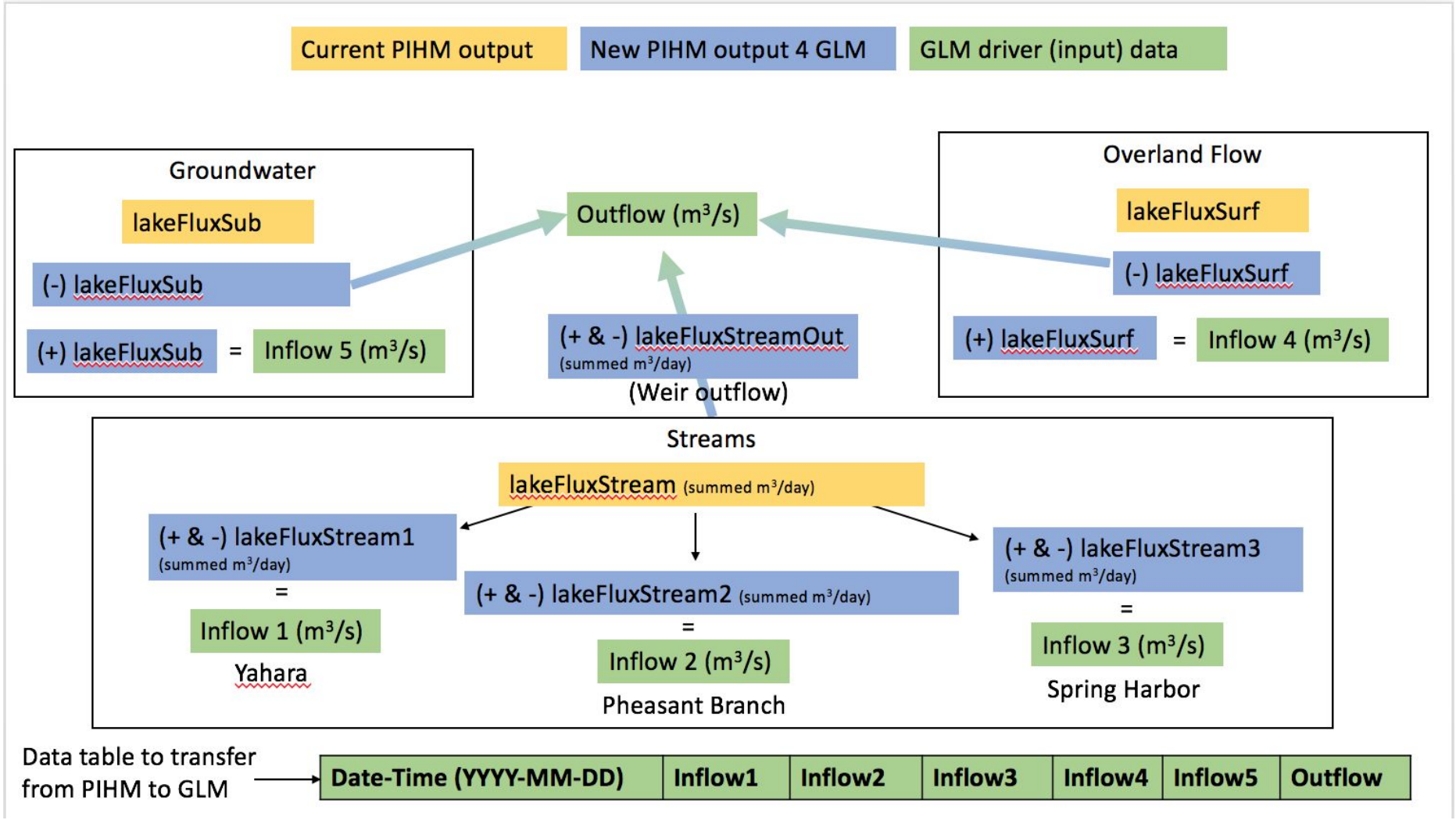
Simulated Dissolved Oxygen Profile: deep hole site in Lake Sunapee 1985 - 2013



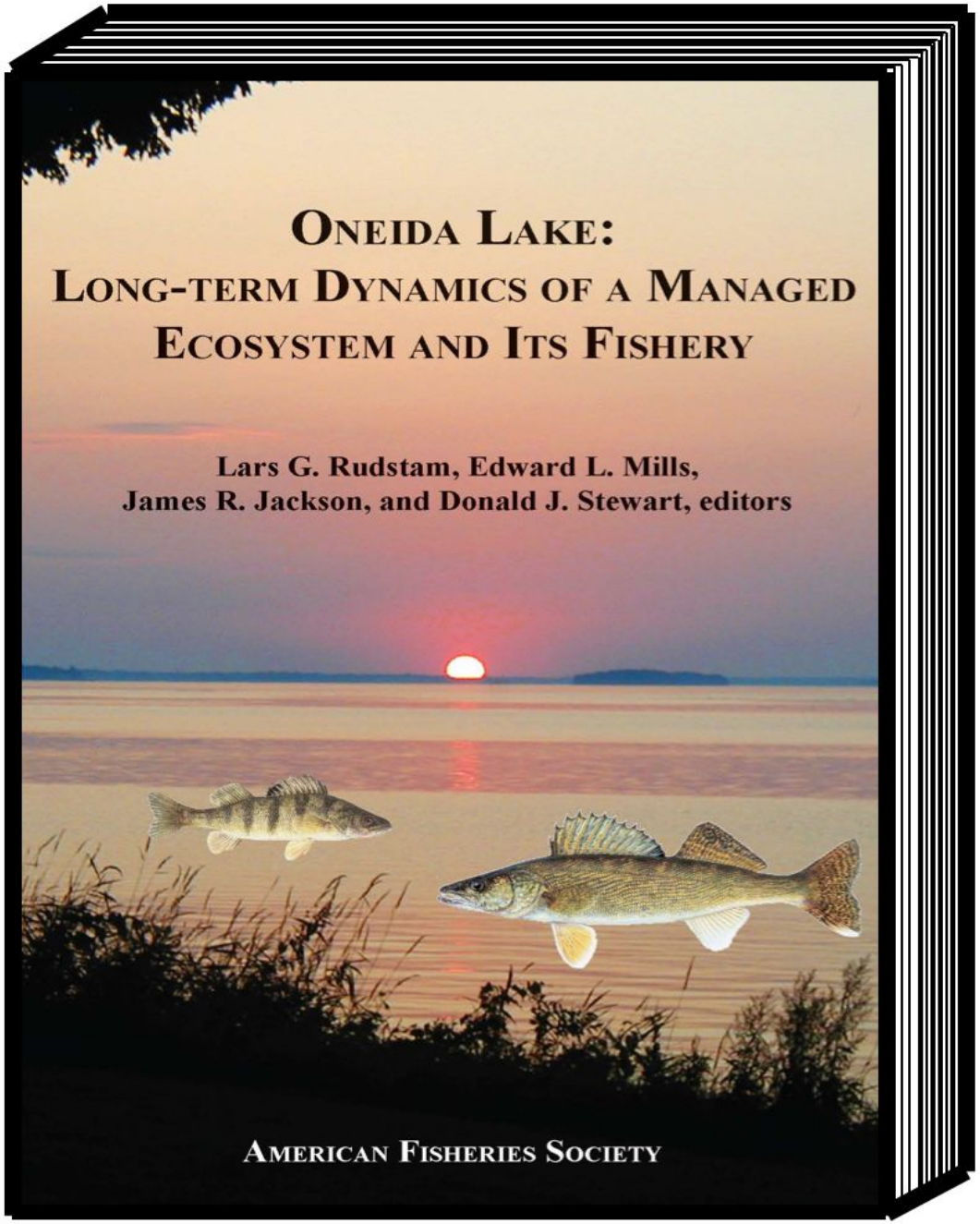
Next steps for Sunapee GLM modeling:

1. Collect additional DO data to inform littoral modeling and eutrophication signals from land use change (Nicole in Sunapee next summer)
2. Finish calibrating phytoplankton (Nicole + Cayelan)
3. Need to get the PIHM water budget for Sunapee (Chris, Yu)
4. Investigating the use of EWIs as a tool (see Nicole's poster this evening!)
5. Collaborating with LSPA to use model to inform watershed plan revisions (more on this at Kak's talk tomorrow morning)
6. Use the calibrated model for hindcasting and forecasting land use scenarios
    a. Tap into LSPA's historical documents (Leah, Mike, Kak, Nicole) to inform scenario development
7. Collaborate with NASA team studying land use change in northeastern US catchments (Cayelan, Nicole, Kak at meeting in July in Sunapee)

PIHM → GLM coupling workflow, developed at PSU workshop Sep 2016 by Yu, Lele, Nicole, Cayelan



Oneida GLM modeling

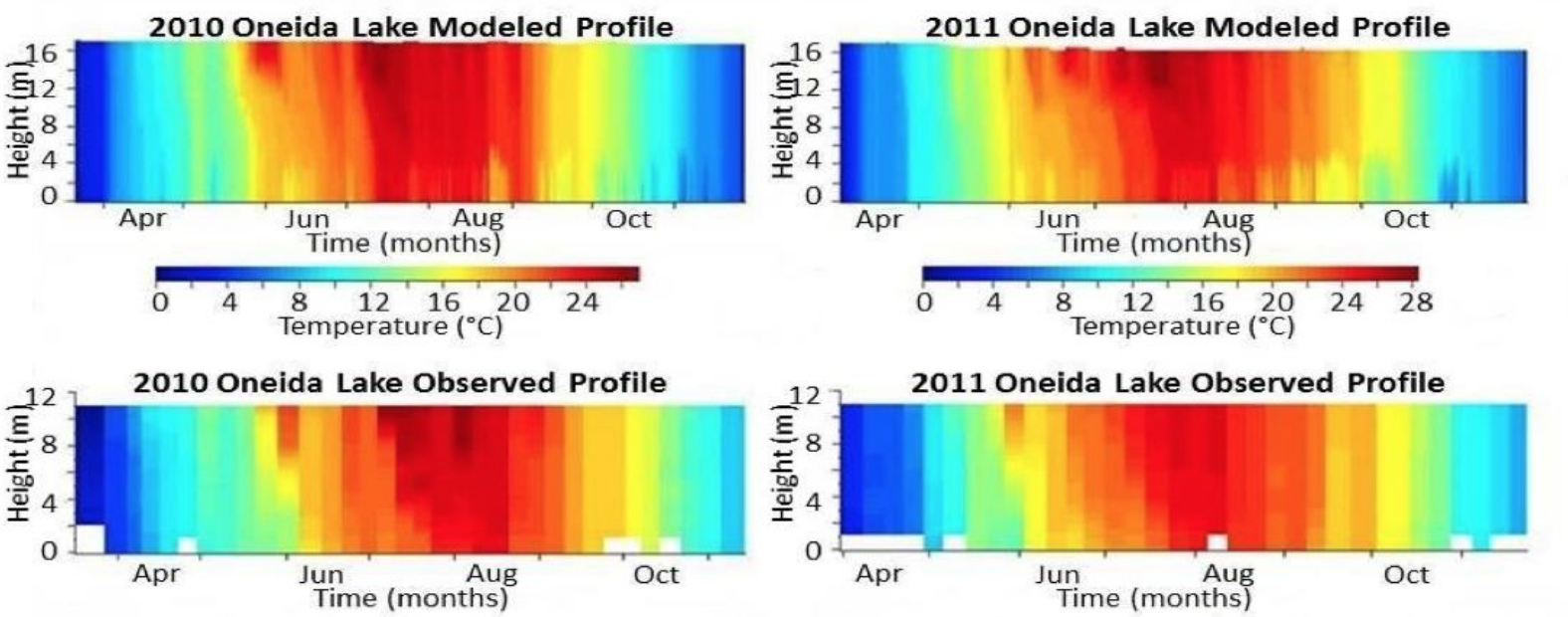


Includes data sets updated to 2015

Available on Knowledge Network for Biocomplexity

Organized for GLM on CHN website

Increased temperature
Other climate effects? Stratification

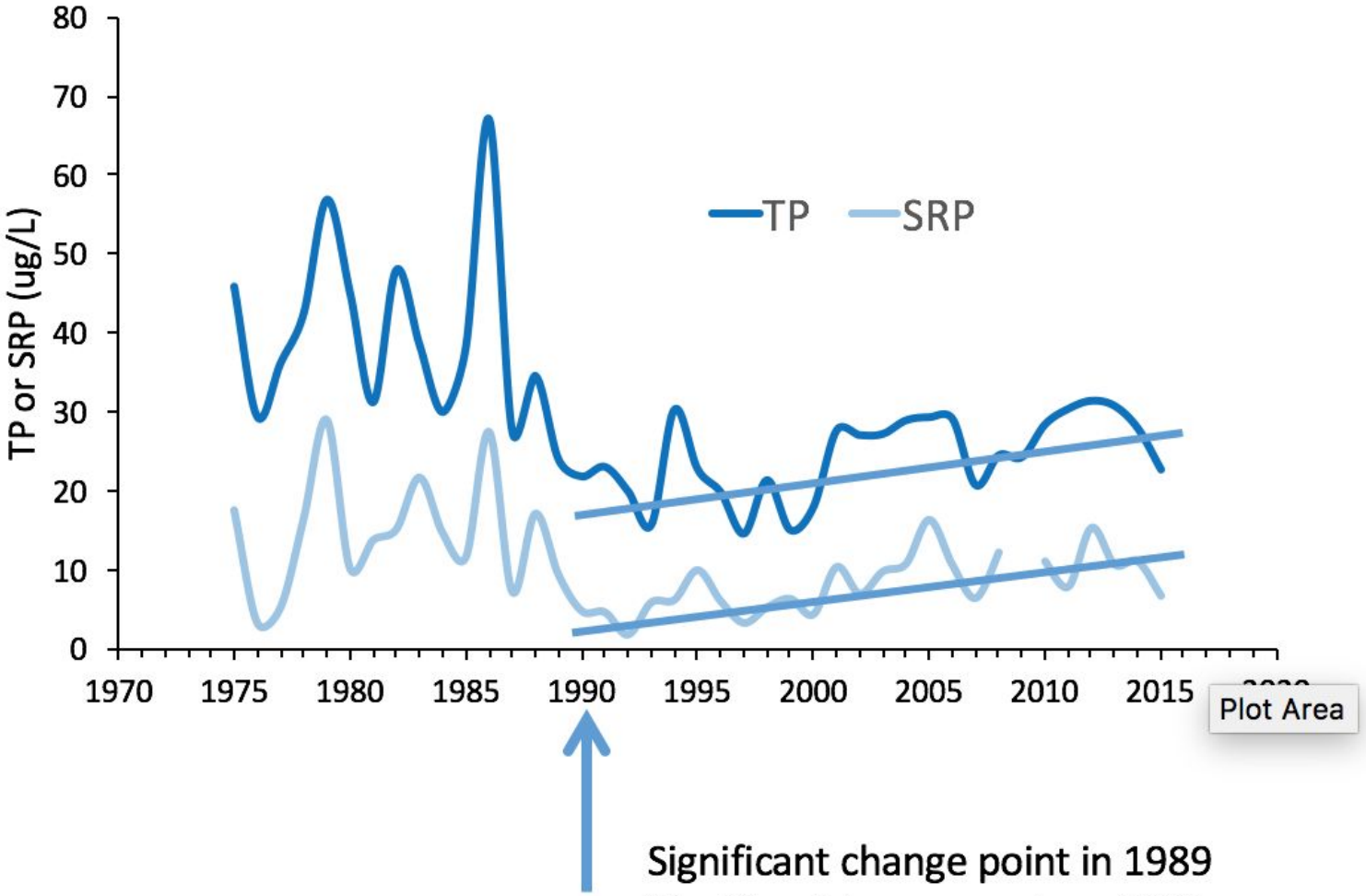


Number of consecutive stratified days (>1 C difference)

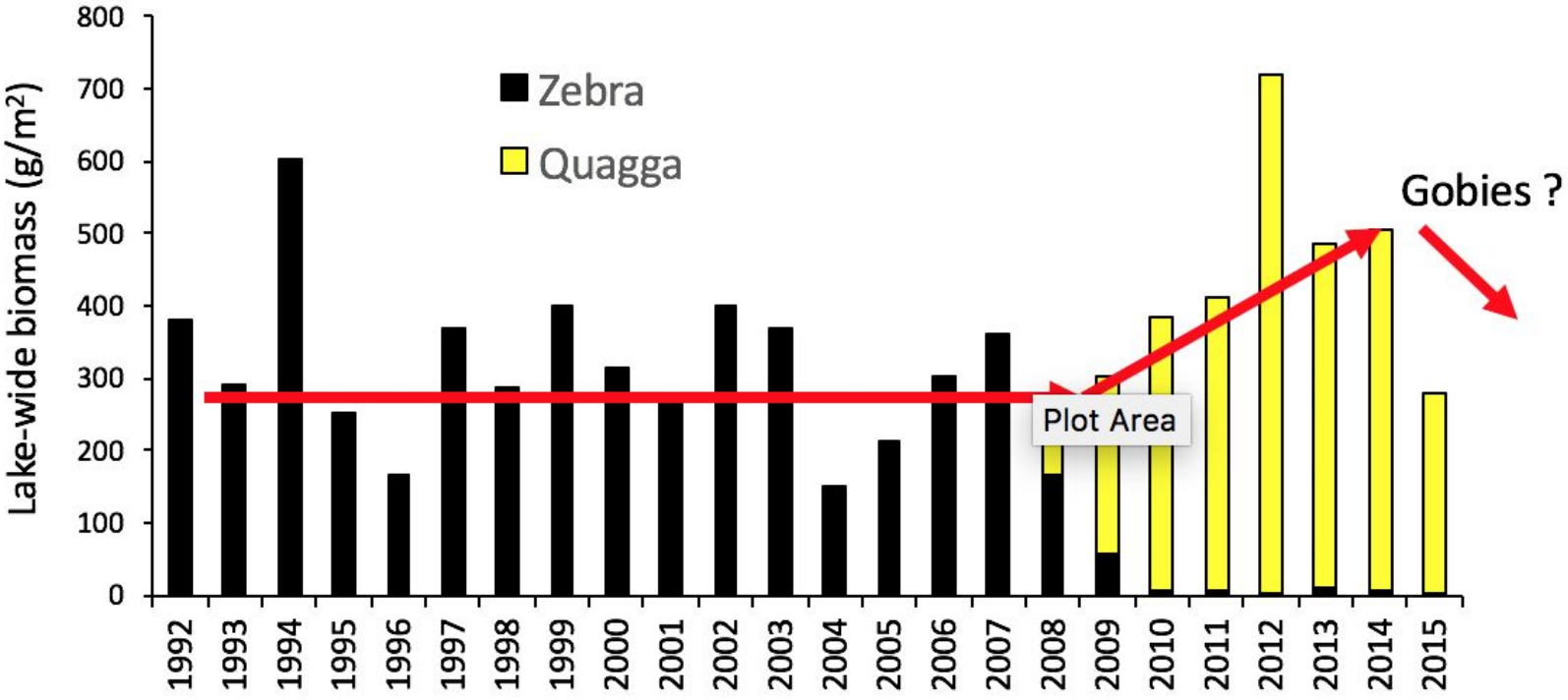
2002-2011:	24 days
2041-2050:	58 days
2090-2099:	85 days

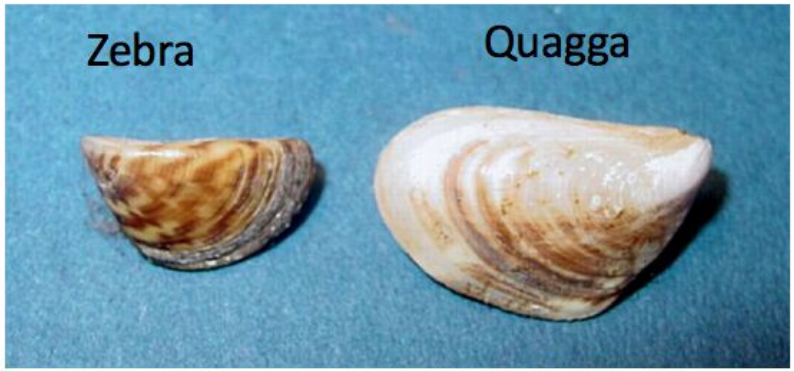
Hetherington et al. 2015

May-Oct TP and SRP levels



Zebra and Quagga mussels





Next steps for upcoming year for overarching GLM team

1. Finish phytoplankton calibration for Sunapee + Mendota (Cayelan, Nicole, Paul)
2. Codify GLM-AED calibration strategy across lake models
3. Finalize 1979-present driver data collation for Mendota (Chris, Yu, Paul, Hilary)
4. Get PIHM data for Sunapee (Chris, Yu, Nicole, Cayelan)
5. Force both lakes with different land use + human decision-making scenarios (all)
6. Move Oneida GLM model forward (Lars)