Storms can both stimulate *and* inhibit phytoplankton communities: lessons from a whole-ecosystem lake mixing experiment

Mary E. Lofton[1], Ryan P. McClure[1], Shengyang Chen[2], Charlotte W. Harrell[1], Jonathan P. Doubek[1], Nicole K. Ward[1], Madeline E. Schreiber[3], John C. Little[4], Cayelan C. Carey[1]

[1]Virginia Tech, Dept. of Biological Sciences, Blacksburg, VA, USA; [2]The University of Sydney, School of Civil Engineering, Sydney, Australia; [3]Virginia Tech, Dept. of Geosciences, Blacksburg, VA, USA; [4]Virginia Tech, Dept. of Civil and Environmental Engineering, Blacksburg, VA, USA

SUMMARY: Storms have "mixed" effects on phytoplankton

- Predicted future increases in storm intensity in North America may affect prevalence and occurrence of phytoplankton blooms
- We conducted whole-ecosystem lake mixing manipulations to assess response of phytoplankton to intense storms
- Results suggest storms are stimulatory AND inhibitory, depending on storm duration and intensity
- Next step: use GRAPLEr to run thousands of lake ecosystem model simulations under different climate scenarios

Research Question: How does storm-driven mixing affect phytoplankton community biomass and composition?

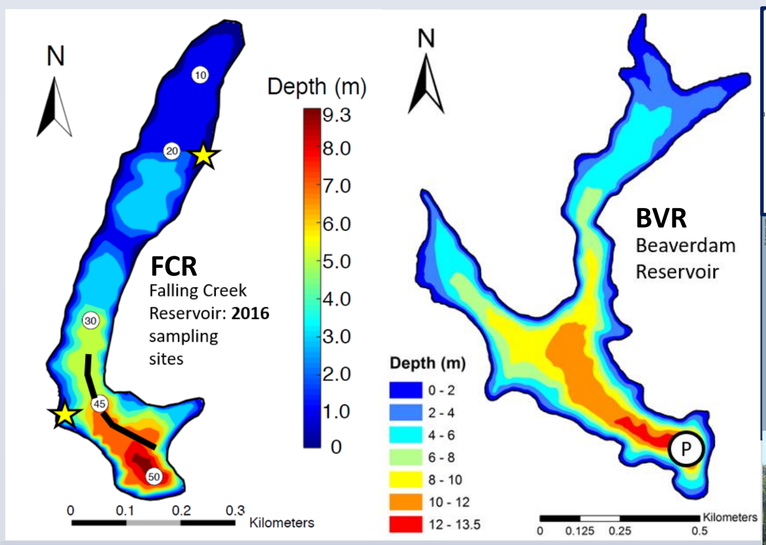
Hypotheses:

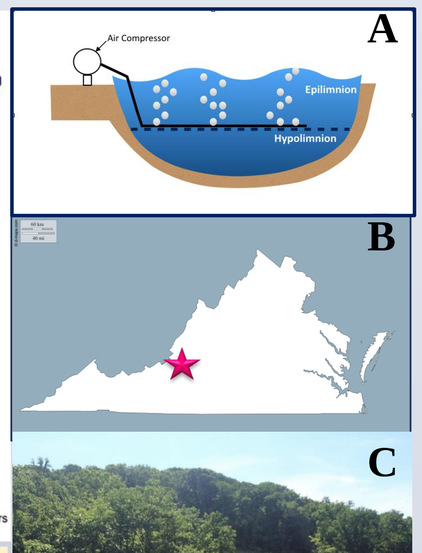
1. *Mixing will stimulate growth and production of green algae and diatoms (by resuspending them higher in the water column).*
2. *Mixing will adversely affect cyanobacteria (by destroying gas vesicles).*

Amy H. Remley Foundation

METHODS: Whole-ecosystem lake mixing experiment

- Two storm simulations in 2016 using engineered mixing system
- Monitored phytoplankton with high-frequency fluorescence profiles of water column
- Compared results to nearby reference reservoir using before-after-control-impact (BACI) analysis



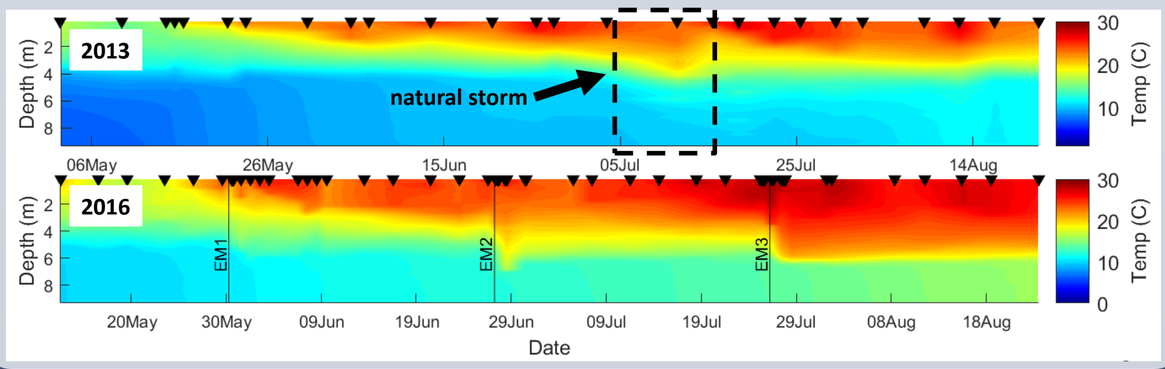


A) Schematic diagram of epilimnetic mixer in FCR
B) Approximate location of reservoirs in Virginia
C) Epilimnetic mixer in operation at FCR

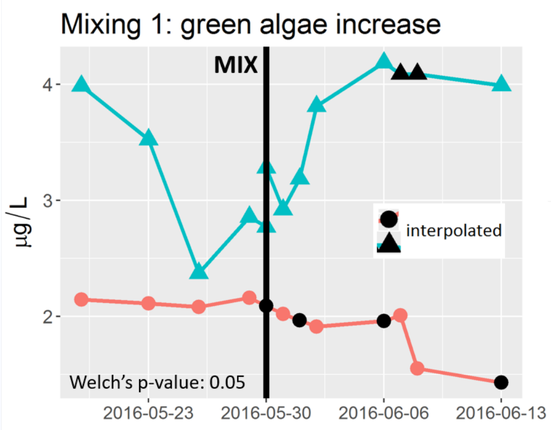
Mixing Event	Intensity	Duration	Date
1	high (25 scfm)	6 hrs.	May 30, 2016
2	medium (15 scfm)	24 hrs.	June 27-28, 2016

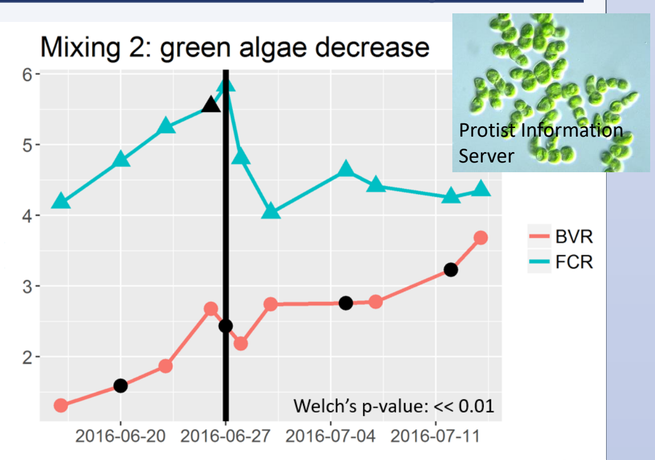
RESULTS: Phytoplankton increase after 1st mixing, not 2nd

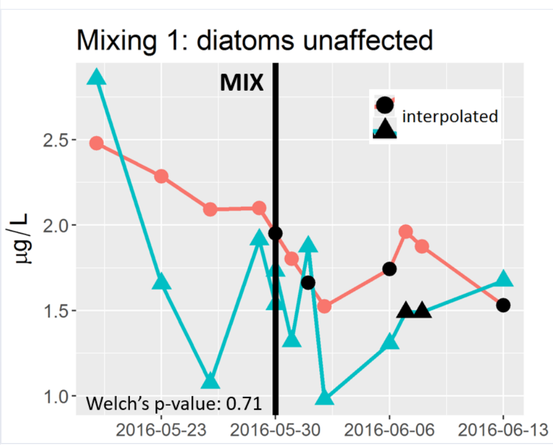
- Mixing experiments successfully lowered thermocline as a storm would
- Short (<6 hours), intense mixing events stimulated green algae and cyanobacteria and led to an overall increase in phytoplankton biomass
- Less intense mixing events of longer duration (>20 hours) had a negative effect on green algae but did not affect other phytoplankton groups.

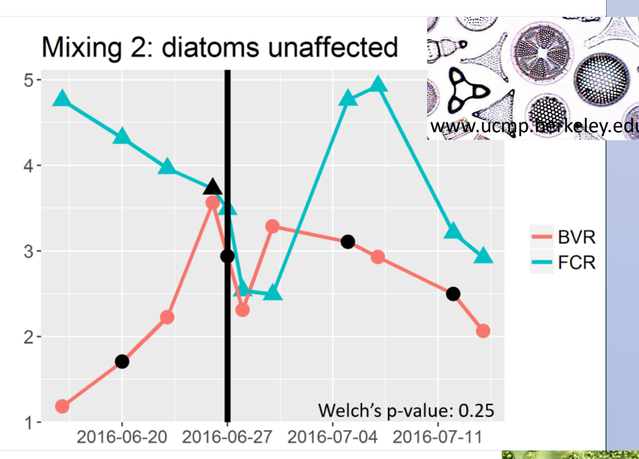


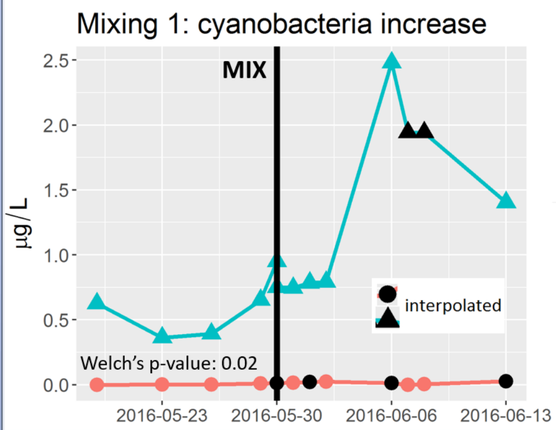
RESULTS: Green algae and cyanobacteria most responsive

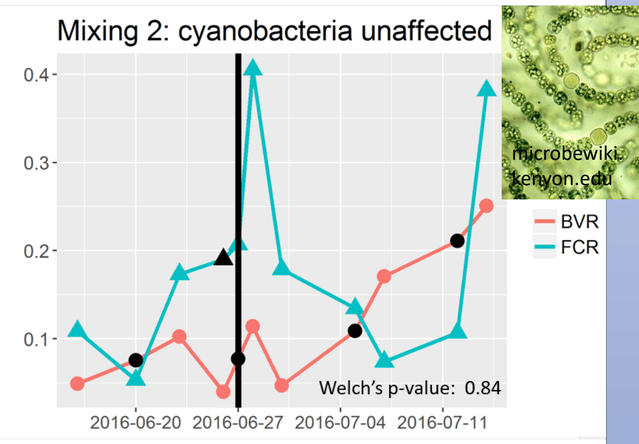


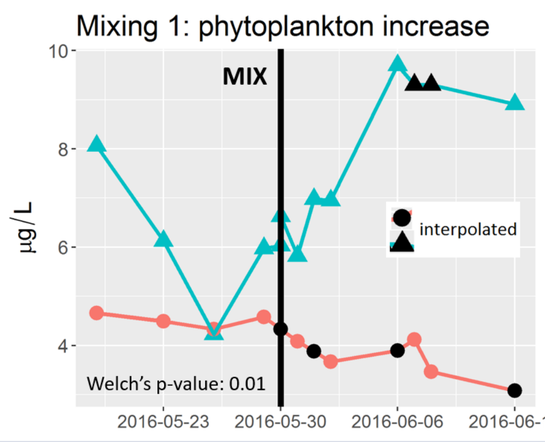


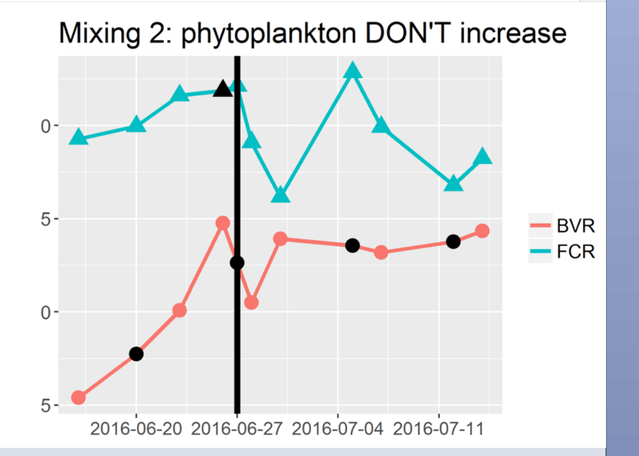












DISCUSSION: Impact of environmental variables/life cycles

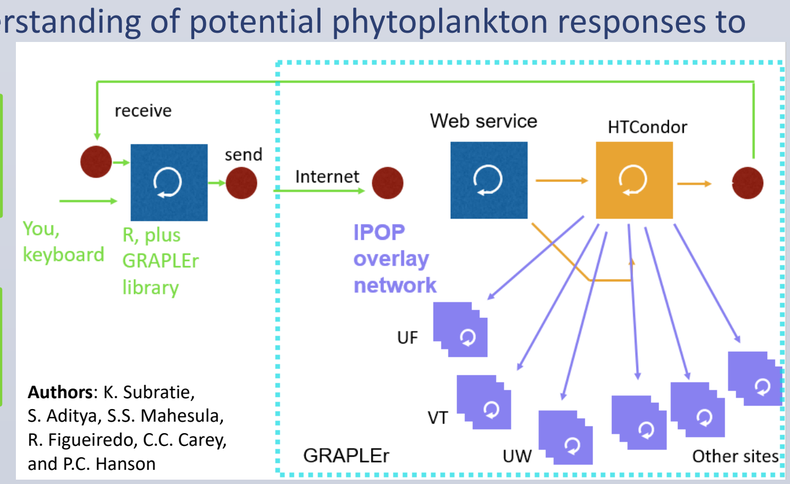
- Mixing may entrain nutrients from below the thermocline
- Mixing may decrease light penetration into water column
- Mixing may stimulate recruitment of dormant phytoplankton cells from the sediments to subsidize water column populations

NEXT STEPS: PRAGMA Lake Expedition

- **GRAPLEr:** R package designed through a PRAGMA Expedition collaboration to help lake ecologists access distributed computing capacity
- We will run thousands of lake ecosystem model simulations under various climate scenarios
- **GOAL:** increased understanding of potential phytoplankton responses to future climate change

GLM The General Lake Model
hydrodynamic lake physics model

AED Aquatic Ecodynamics
water quality model coupled to GLM



Authors: K. Subratie, S. Aditya, S.S. Mahesula, R. Figueiredo, C.C. Carey, and P.C. Hanson

Acknowledgements: Barbara Niederlehner for analytical lab support; Katie Krueger and Kylie Campbell for being wonderful field techs; NSF PRAGMA grant #1234983