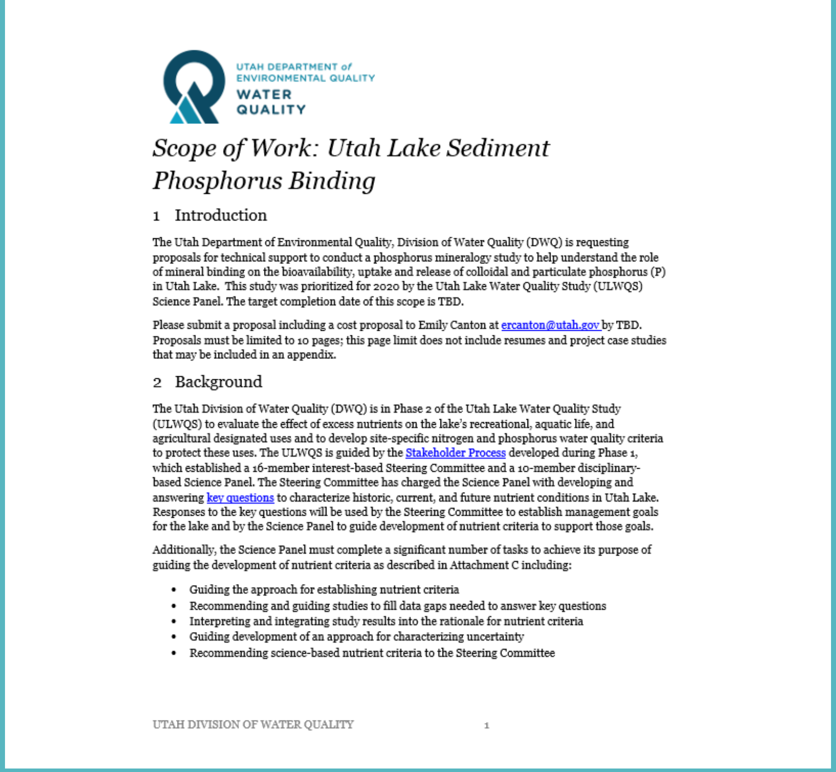
ULWQS P BINDING RFP UPDATE FOR SCIENCE PANEL

Kateri Salk

2020-08-28

GOALS

1. Provide overview of changes to RFP
2. Solicit questions, comments
3. Agree on any revisions and/or approve


UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Scope of Work: Utah Lake Sediment Phosphorus Binding

1 Introduction

The Utah Department of Environmental Quality, Division of Water Quality (DWQ) is requesting proposals for technical support to conduct a phosphorus mineralogy study to help understand the role of mineral binding on the bioavailability, uptake and release of colloidal and particulate phosphorus (P) in Utah Lake. This study was prioritized for 2020 by the Utah Lake Water Quality Study (ULWQS) Science Panel. The target completion date of this scope is TBD.

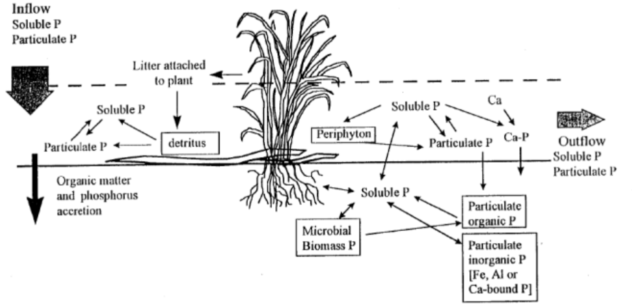
Please submit a proposal including a cost proposal to Emily Canton at ercanton@utah.gov by TBD. Proposals must be limited to 10 pages; this page limit does not include resumes and project case studies that may be included in an appendix.

2 Background

The Utah Division of Water Quality (DWQ) is in Phase 2 of the Utah Lake Water Quality Study (ULWQS) to evaluate the effect of excess nutrients on the lake's recreational, aquatic life, and agricultural designated uses and to develop site-specific nitrogen and phosphorus water quality criteria to protect these uses. The ULWQS is guided by the Stakeholder Process developed during Phase 1, which established a 16-member interest-based Steering Committee and a 10-member disciplinary-based Science Panel. The Steering Committee has charged the Science Panel with developing and answering key questions to characterize historic, current, and future nutrient conditions in Utah Lake. Responses to the key questions will be used by the Steering Committee to establish management goals for the lake and by the Science Panel to guide development of nutrient criteria to support those goals.

Additionally, the Science Panel must complete a significant number of tasks to achieve its purpose of guiding the development of nutrient criteria as described in Attachment C including:

- Guiding the approach for establishing nutrient criteria
- Recommending and guiding studies to fill data gaps needed to answer key questions
- Interpreting and integrating study results into the rationale for nutrient criteria
- Guiding development of an approach for characterizing uncertainty
- Recommending science-based nutrient criteria to the Steering Committee



UPDATES SINCE LAST DISCUSSION

Calls w/ SP members to develop knowledge and needs

- Ongoing studies
- Mineralogy
- Modeling

Separate RFP into 3 phases

- Phase 1: Mineralogy
- Phase 2: Knowledge synthesis
- Phase 3: Fill knowledge gaps

Proposed plan: Solicit proposals for phase 1, phases 2-3 will follow later

PROBLEM STATEMENT

- P speciation in water column and sediment is not well characterized (esp. sorbing)
- Not clear how to predict P speciation and binding under varying conditions
  - Current – seasonal differences, lake level, productivity, etc.
  - Future – as a result of management
- Factors impacting P speciation are not well characterized
- Not clear which forms of P are bioavailable, and how sorption impacts bioavailability

OBJECTIVES: PHASE 1 (MINERALOGY)

1. Characterize chemical speciation of P in water column and sediment
   - Free forms
   - Soluble complexes
   - Precipitates
   - Sorbed species
2. Create reaction network of processes involving P
3. Characterize P scavenging and release under a series of specified conditions to ID mechanisms → estimate expected fractional distribution of P in each form
4. Evaluate kinetics of P sorption and desorption, evaluate desorption hysteresis
5. Evaluate predictive relationships for P binding over a range of specified conditions (pH, redox, etc.)
   - Sorption isotherms
   - Partition coefficients

TASKS: PHASE 1 (MINERALOGY)

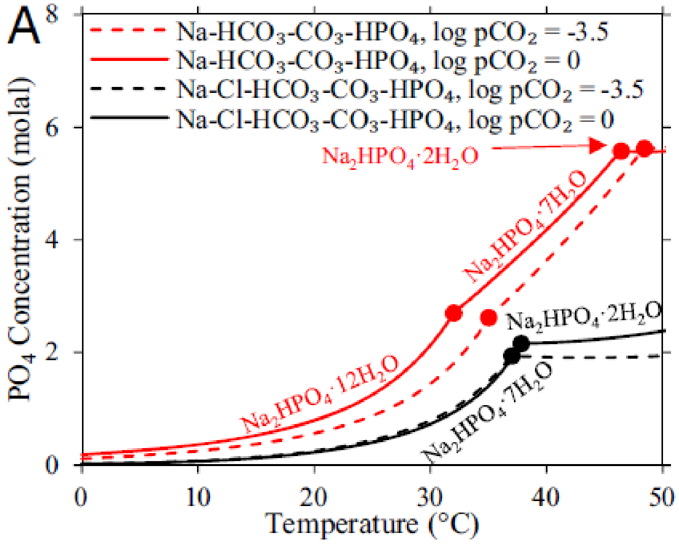
1.1: Literature review and preliminary reaction network

1.2: Sampling and analysis plan

1.3: Mineralogy experiments and data reporting

1.4: Review and analysis

1.5: Technical report



Toner and Catling 2019

Reactions and Equilibrium Constants

Reaction equation	Reference to equilibrium constant
$CO_2 + H_2O = H_2CO_3^*$	21[a]
$H_2CO_3^* = CO_3^{2-} + 2H^+$	21
$HCO_3^- = CO_3^{2-} + H^+$	22
$CaHCO_3^+ = Ca^{2+} + HCO_3^-$	23
$CaCO_3^0 = Ca^{2+} + CO_3^{2-}$	24
$CaOH^+ = Ca^{2+} + OH^-$	25[b]
$H_2O = OH^- + H^+$	26
$H_3PO_4 = H_2PO_4^- + H^+$	27
$H_2PO_4^- = HPO_4^{2-} + H^+$	28
$HPO_4^{2-} = PO_4^{3-} + H^+$	29
$KHPO_4^- = K^+ + HPO_4^{2-}$	30[b]
$CaH_2PO_4^+ = Ca^{2+} + H_2PO_4^-$	31
$CaHPO_4^0 = Ca^{2+} + HPO_4^{2-}$	31
$CaPO_4^- = Ca^{2+} + PO_4^{3-}$	32

House and Donaldson 1986

OBJECTIVES: PHASE 2 (KNOWLEDGE SYNTHESIS)

1. Synthesize knowledge from mineralogy study and previous/ongoing studies
2. Interpret how previous work on extractable P relates to mineral P
3. Evaluate which study outcomes can inform environmentally relevant conditions
4. ID remaining knowledge gaps

OBJECTIVES: PHASE 3 (FILL GAPS)

1. Address gaps identified in phase 2
2. Determine which chemical forms of P are bioavailable, and in which fractions they reside
3. Predict impact of changing external P loading on P binding and release
4. Predict extent and timescale of water column-sediment P equilibration in response to management
5. Apply P chemical species and reactions to process models for Utah Lake

QUESTIONS/COMMENTS/APPROVAL

STRATEGIC RESEARCH PLAN

Utah Lake Water Quality Study
Science Panel Call
August 28, 2020

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

Review final draft SRP

Get any remaining feedback

Move to approve

GOALS

Utah Lake Water Quality Study—Strategic Research Plan

DRAFT

August 18, 2020
Version 4.3

PRESENTED TO

Utah Department of Environmental Quality
Division of Water Quality
PO Box 144870
Salt Lake City, UT 84114

PREPARED BY

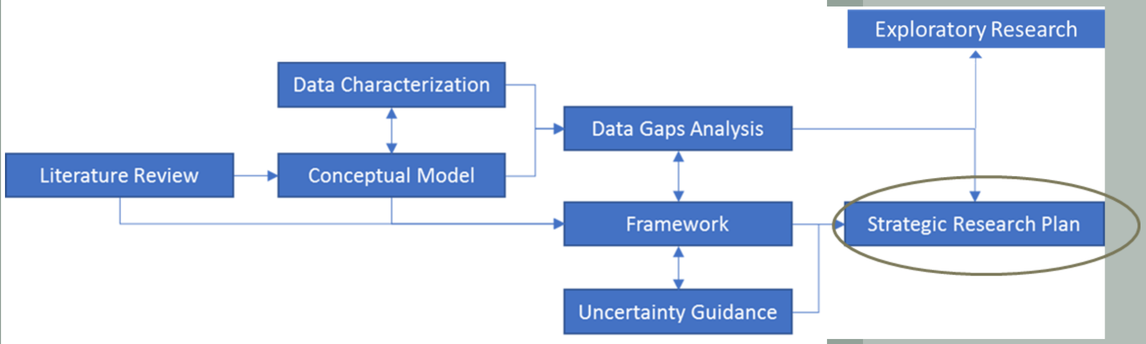
Tetra Tech
1 Park Drive, Suite 200
Research Triangle Park, NC 2709

STRATEGIC RESEARCH PLAN: PAST AND PRESENT

- Workplan (Task 6)
- SRP designed to:
  - Fill knowledge gaps
  - Target initial charge questions and conceptual model
  - Include problem statement, objectives and approaches
- Exploratory Research Plan: First three RFPs – ignite research actions
- SRP: Current RFPs (Littoral Sediment, CNP Budgets and P-Binding) and Future Work
- Understand this is a living document

RESEARCH PLAN SECTIONS 1-3

- Introduction: Process, ongoing research (1)
- Charge question (2) and NNC development needs (3) mapped to existing/ongoing work
- Summaries of research needs



Questions	Being addressed
1.1. What does the diatom community and macrophyte community in the paleo record tell us about the historical trophic state and nutrient regime of the lake?	Partially
i. Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?	Paleo RFP
ii. What were the environmental requirements for diatoms and extant macrophyte species?	No
iii. How have environmental conditions changed over time?	Data analysis
1.2. What were the historic phosphorus, nitrogen, and silicon concentrations as depicted by sediment cores? (add calcium, iron, and potentially N and P isotopes)	Paleo RFP
1.3. What information do paleo records (eDNA/scales) provide on the population trajectory/growth of carp over time? What information do the paleo records provide on the historical relationship between carp and the trophic state and nutrient regime of the lake?	No
1.4. What do photopigments and DNA in the paleo record tell us about the historical water quality, trophic state, and nutrient regime of the lake?	Paleo RFP

4.1 PRIORITIES

- Listed priorities
  - Listing and ranking
- RFPs for highest priority elements
- SRP "closes the loop" on the remainder
- Reference for future RFP planning and development

	Research ideas	Mean Ranking - Feb 2020	
1	**How large is internal vs external loading (how long would recovery take?)**	**2.3**	✓
2	**Sediment budgets (C, N, and P; nutrient flux chambers)**	**3.6**	✓
3	**Calcite scavenging (how bioavailable is SRP – does bioassay address?)**	**4.3**	✓
4	**Adding modules to the WQ models (sediment diagenesis, calcite scavenging)**	**4.3**	✓
5	Carp effects on nutrient cycling	7.3	
6	Lake level (effect on macrophytes)	9.2	✓
7	Bioassays that incorporate sediment (next phase mesocosms)	9.4	
8	Macrophyte recovery potential (Provo Bay demo)	10.0	
9	Lake-level effects on biogeochemistry and nutrient cycling	10.2	✓
10	Environmental controls on toxin production	11.1	
11	Turbidity effect on primary producers	11.2	
12	Resuspension rates from bioturbation	11.7	
13	Carp effects on zooplankton (and does this influence algal response)	11.8	
14	Carp effects on macrophytes	12.1	
15	Toxin Production and N Species	13.7	
16	Recreational surveys	13.8	
17	Macrophyte role (to biogeochemistry)	14.0	
18	Additional atmospheric deposition data	14.6	
19	Alternative models (PCLake – cyano/macrophyte state change)	14.9	

SRP SECTION 4.2 – SPECIFIC RESEARCH PROJECTS

- Lays out strategic research elements for the 19 research priorities
  - Problem Statement
  - Existing Data and Information
  - Objectives
  - Expected Outcome/Outputs
  - Capacity to Address with Mesocosms

- Does not include approach – to be determined when they become future RFPs

MESOCOSM OPPORTUNITIES

- Mesocosms could address many areas
  - Calcite Binding
  - Carp Effects – turbidity, zooplankton, macrophytes
  - Macrophyte recovery/effects – turbidity, biogeochemistry
  - Lake Level
  - Bioassay Gen 2
  - Turbidity effects on primary producers
  - Toxin controls
- To help with TSSD planning
- Highlighted in SRP

SRP-RFP RECONCILIATION

- SRP updated to reflect current RFPs
- Littoral Sediment C, N and P stock and flux (4.2.6 and 4.2.9)
- C, N, and P mass balance: external and internal (4.2.1 and 4.2.2)
- P-binding (4.2.3 and 4.2.4) – NEWEST VERSION
- N-fixation – working with Aanderud lab (4.2.1)

	Research ideas	Mean Ranking - Feb 2020	
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**Atmospheric deposition was deprioritized by the Science Panel, as it is expected that an ongoing atmospheric deposition study may preclude or reduce the need for additional work on atmospheric deposition. Existing atmospheric deposition data will be included in external load calculations for research idea 1.*

PROCESS TO FINALIZE

- Completed identifying projects (DONE)
- Drafted RFP elements (DONE)
- We filled out RFP components – iterated with you (DONE)
  - SP Finalized RFPs (Littoral, CNP done; Calcite doing) (DONE)
  - SP Finalizes SRP - TODAY
- Complete RFPs/SRP
  - RFPs to SC for approval (Littoral, CNP – DONE, P-binding TO DO)
  - RFPs out for bid (CNP – DONE, Littoral soon, P-binding - later)
  - SRP to SC for approval (Late Summer/Fall)

Utah Lake Water Quality Study—
Strategic Research Plan

DRAFT

August 18, 2020
Version 4.3

PRESENTED TO

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Division of Water Quality
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QUESTIONS/DISCUSSION

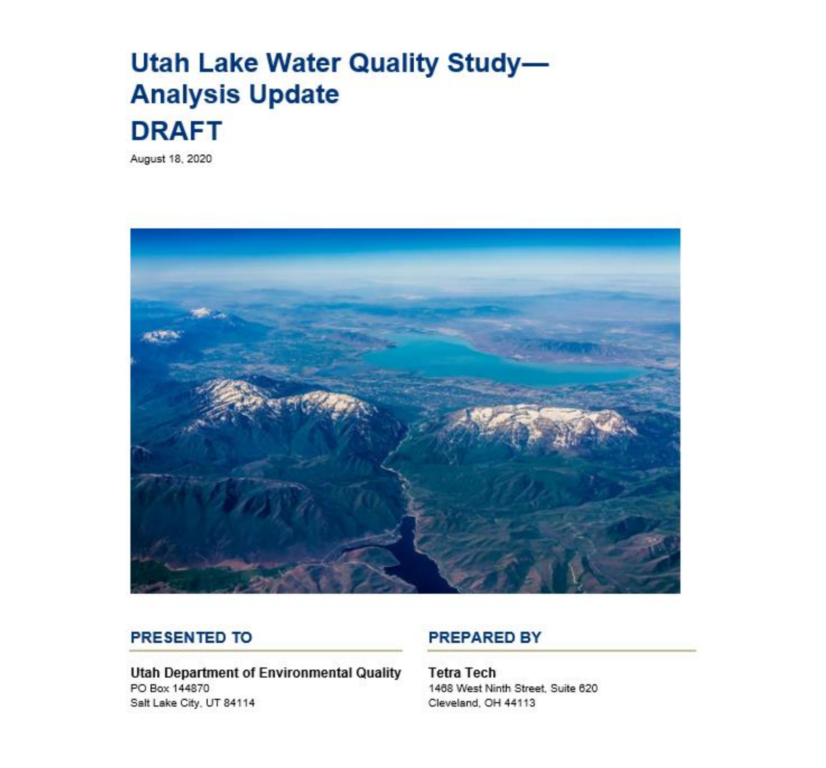
ULWQS ANALYSIS UPDATE FOR SCIENCE PANEL

Kateri Salk

2020-08-28

GOALS

1. Summarize latest updates to Analysis Report and Data Explorer App
2. Solicit preliminary feedback and set stage for additional written feedback


Utah Lake Water Quality Study—
Analysis Update
DRAFT
August 18, 2020

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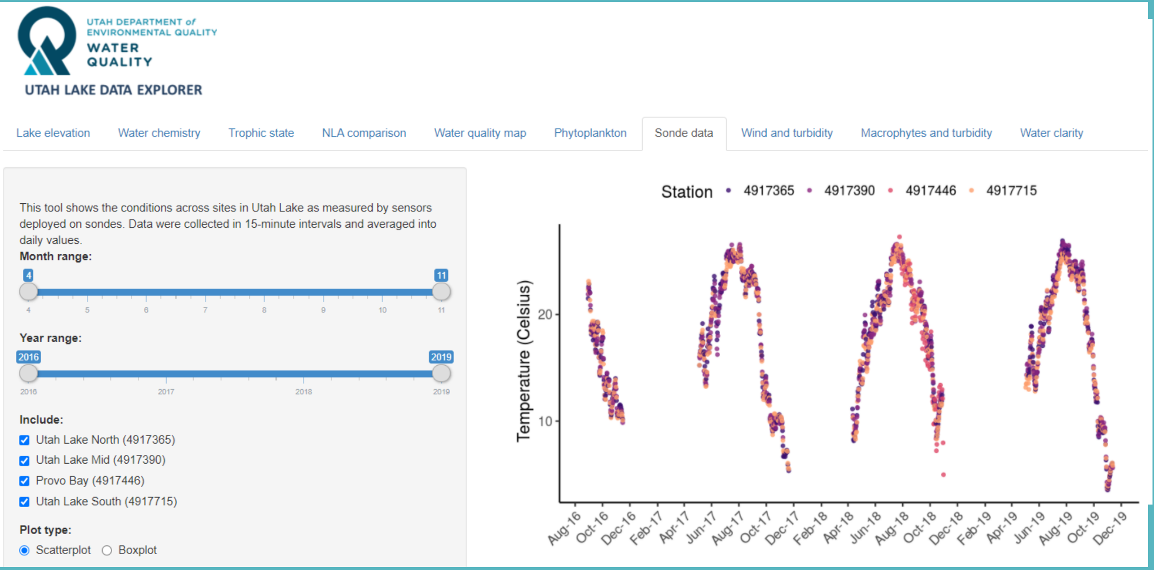


ANALYSIS AREAS

Eight Main Areas: Each tied to specific charge questions

1. Carp excretion
2. Algal cell count, and pigment relationships
3. Sonde data analysis
4. Plankton spatial and temporal analysis (6 subareas)
5. Diatom and macrophyte autecology
6. Wind and turbidity
7. Turbidity and macrophytes
8. Light extinction

1. CARP EXCRETION

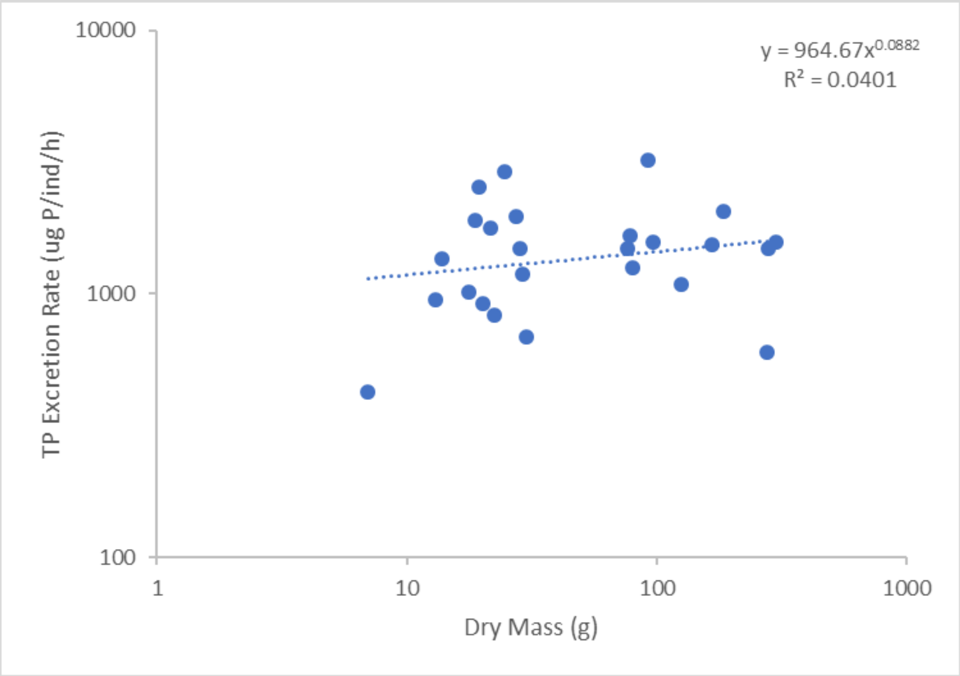
Objective: estimate potential nutrient excretion rates from carp

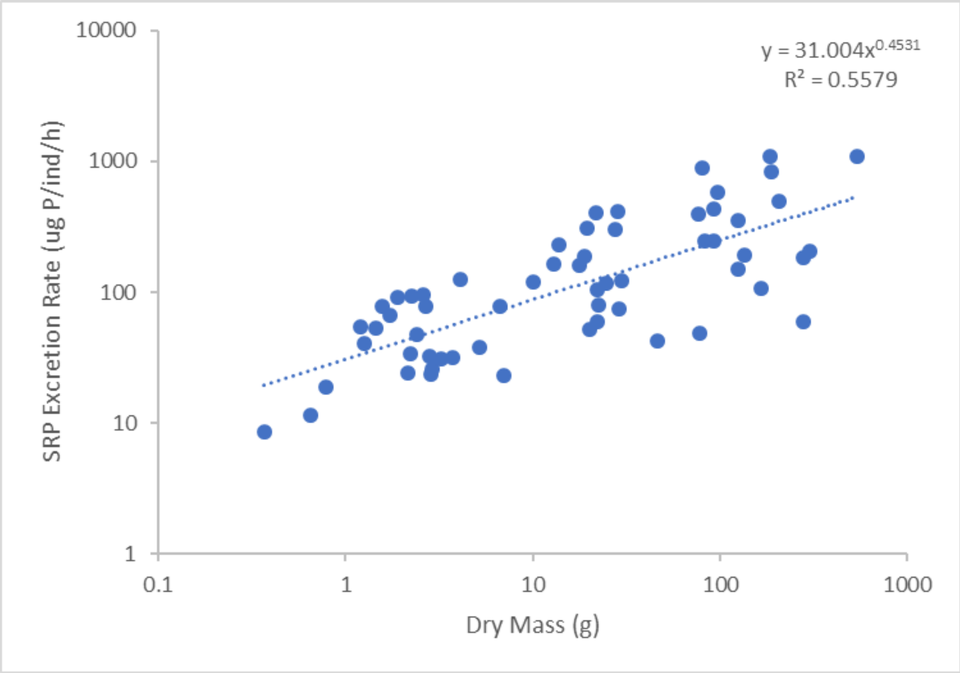
Methods

- Utah Lake carp size, wet:dry weight, total biomass (Gaeta and Landom 2016, Gaeta et al. 2019)
- Carp excretion data (R. King pers. Comm)
- Compare N and P excretion rates with external loads (Psomas and SWCA 2007, Merrit and Miller 2016, Brett 2019)

1. CARP EXCRETION

- Excreted TP: 19-85 % of external loads, 23-60% of net retention
- Excreted SRP: 6-28 % of external loads, 7-20 % of net retention

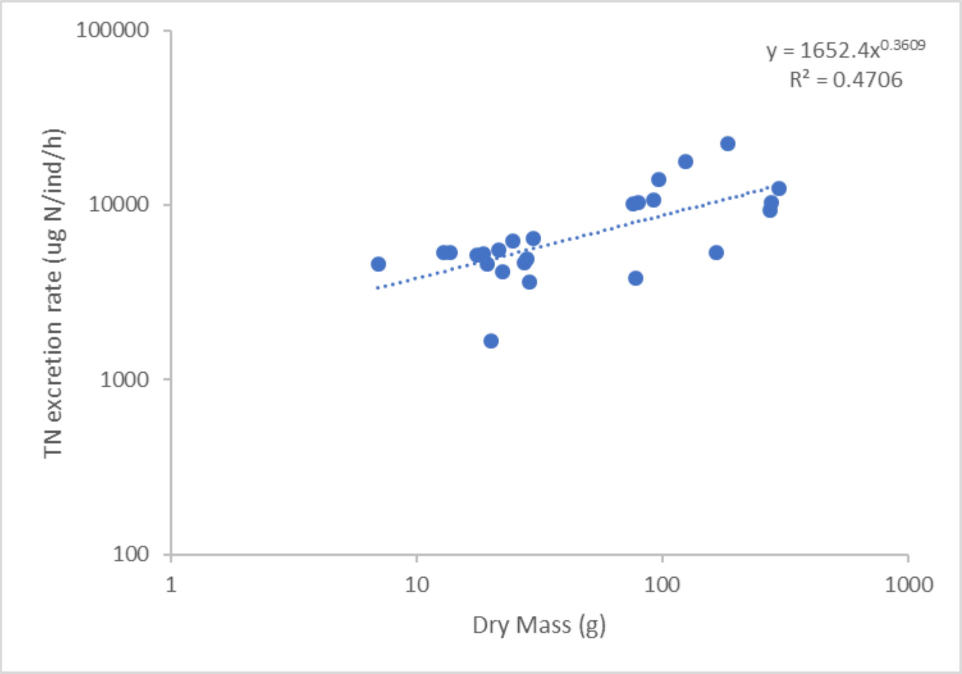


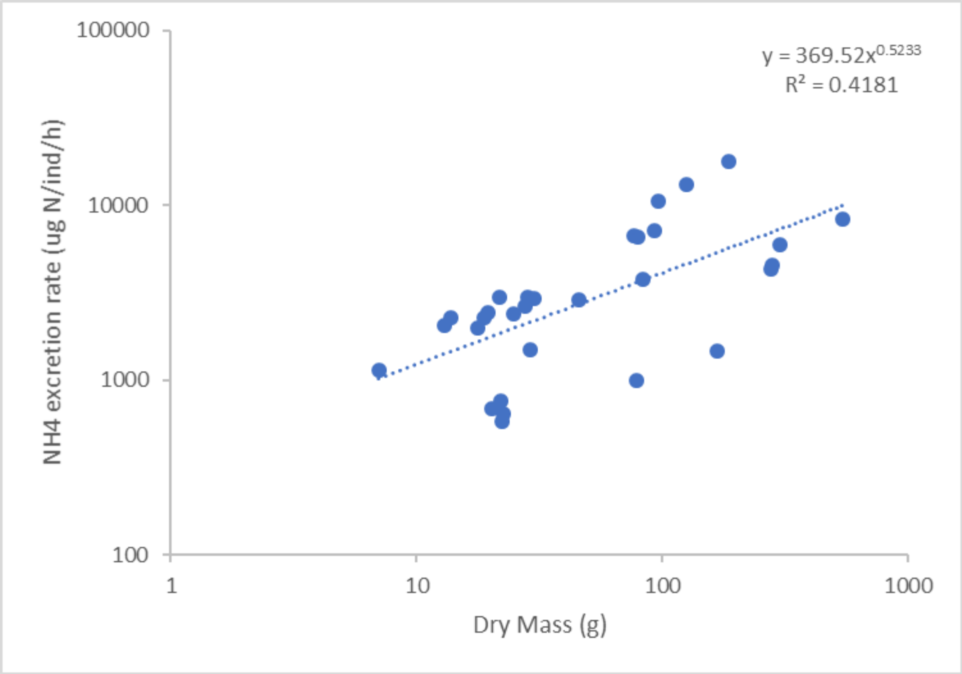


*Based on 2018 population estimates

1. CARP EXCRETION

- Excreted TN: 27-62 % of external loads
- Excreted NH_4^+: 17-39 % of external loads

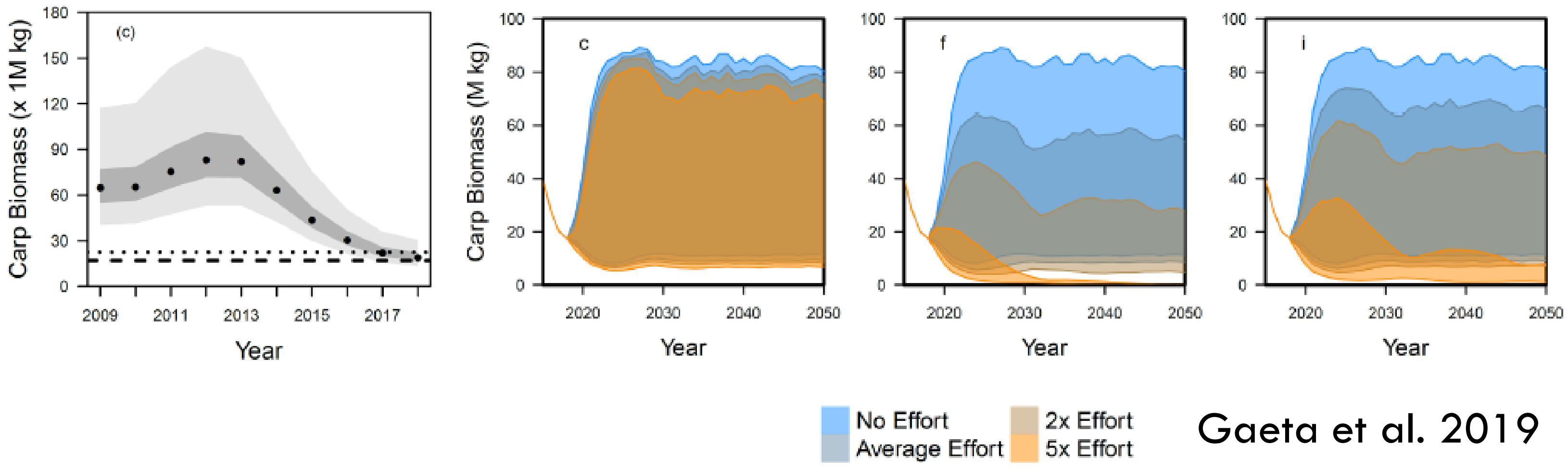




*Based on 2018 population estimates

1. CARP EXCRETION: TAKEAWAYS

- A nontrivial proportion of total and bioavailable nutrients are excreted by carp
- Estimates can be incorporated into CNP mass balance analyses
- Excretion impacts on nutrient cycling are changing w/ carp removal



Gaeta et al. 2019

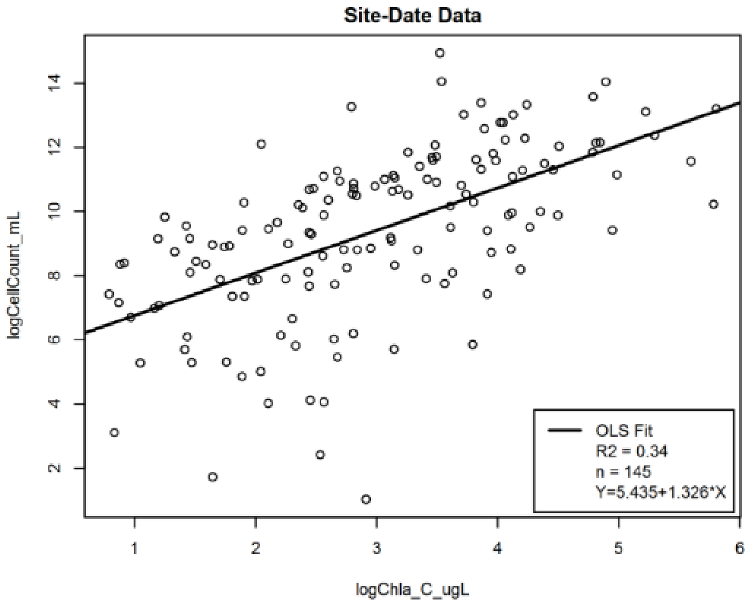
2. ALGAL CELL COUNT AND PIGMENT

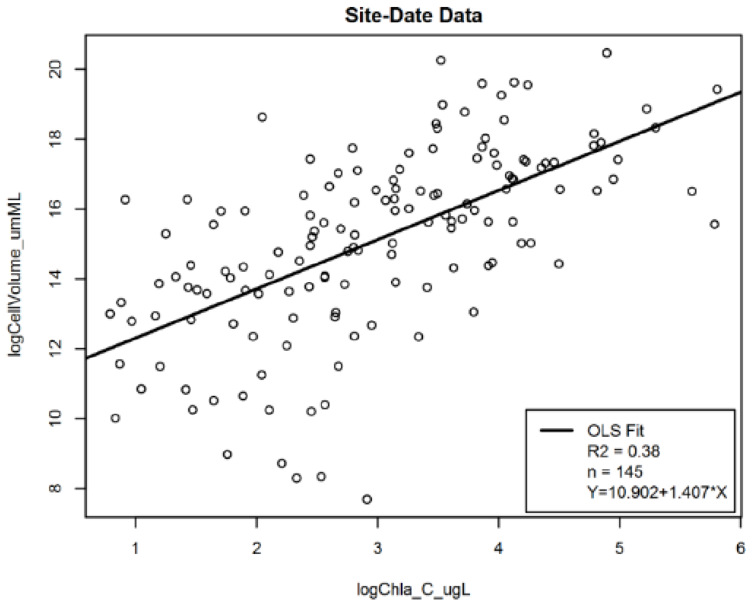
Objective: Estimate relationships between cell count, biovolume, and pigment concentrations

Methods: linear regression of chlorophyll and biomass

2. ALGAL CELL COUNT AND PIGMENT

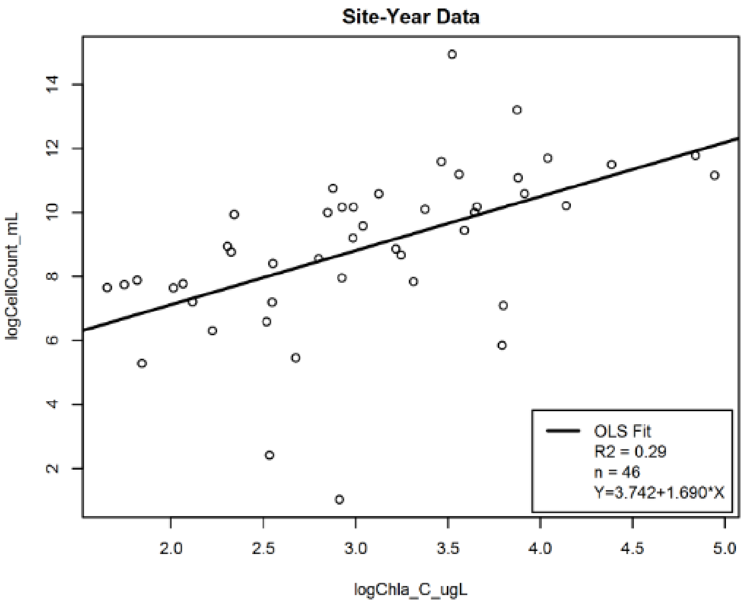
- For individual sites on individual dates
- Chlorophyll (corrected) explains
  - 34 % of cell count
  - 38 % of biovolume

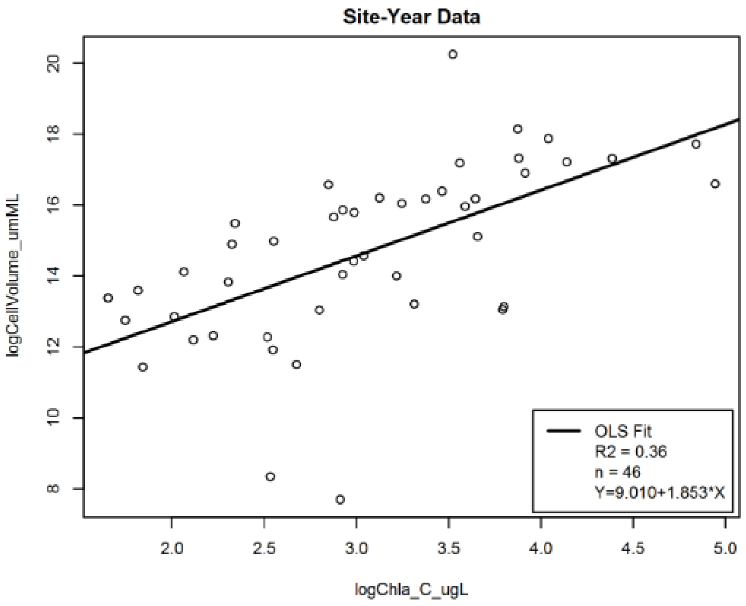




2. ALGAL CELL COUNT AND PIGMENT

- For annual averages of individual sites
- Chlorophyll (corrected) explains
  - 29 % of cell count
  - 36 % of biovolume



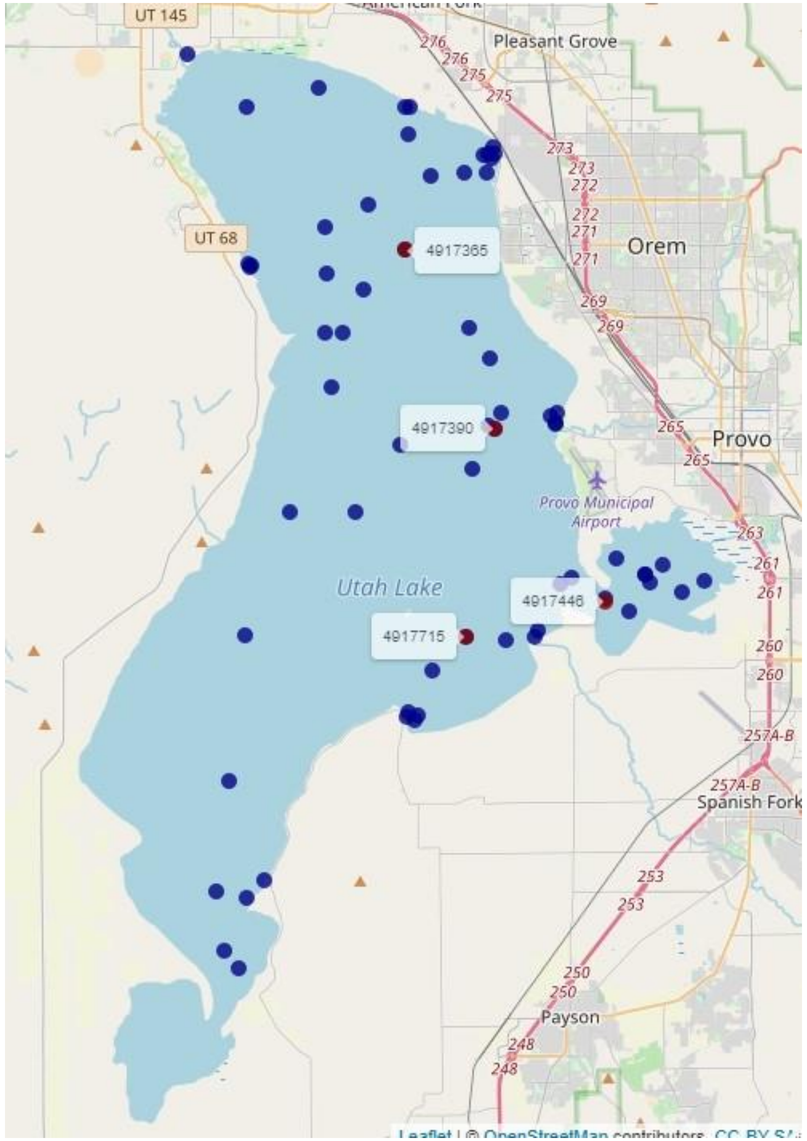


3. SONDE DATA ANALYSIS

Objective: Extract sonde data and examine relationships among sonde variables. Run descriptive statistics on sonde data.

Sites

- North
- State Park (Middle)
- South
- Provo Bay

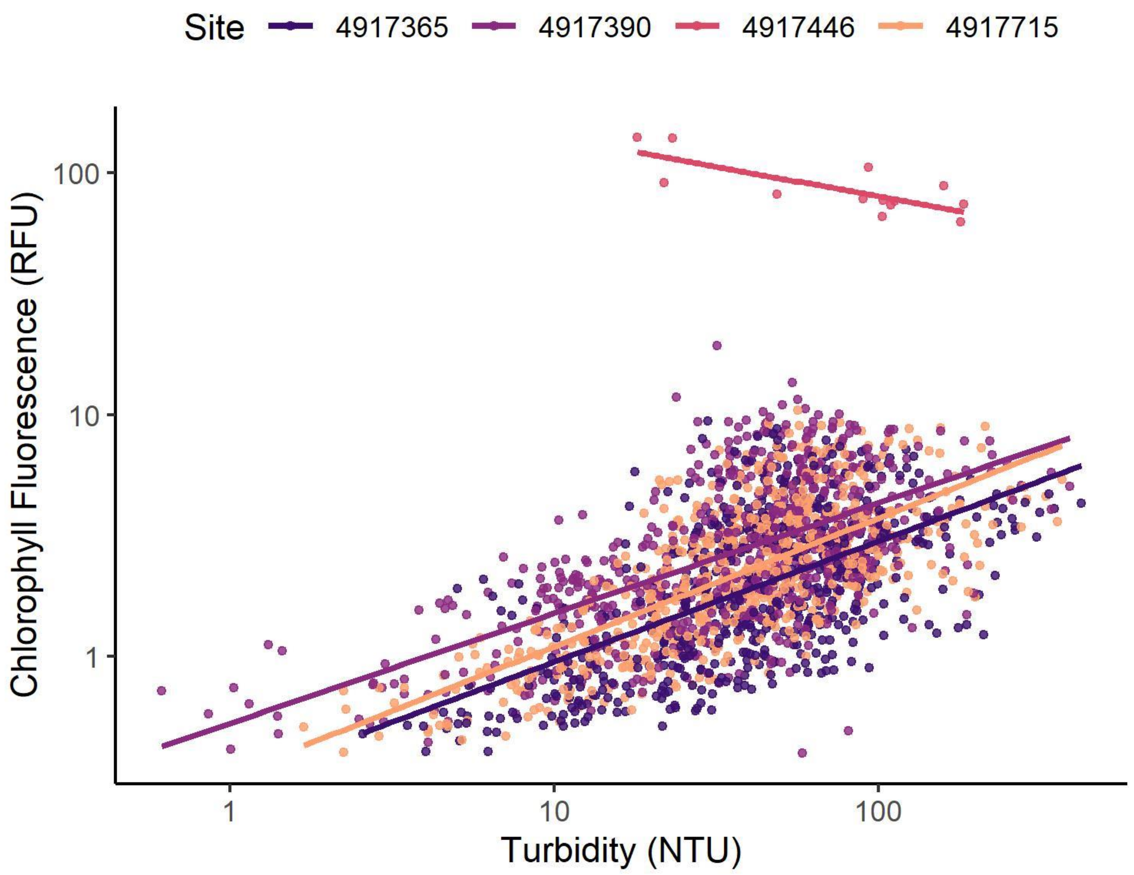


3. SONDE DATA ANALYSIS

[Data Explorer demo]

3. SONDE DATA ANALYSIS

- Turbidity and chlorophyll are positively correlated in main basin (sites similar)
- Limited data in Provo Bay



4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

Objectives:

- Estimate temporal patterns in plankton, including HAB, assemblages.
- Estimate spatial patterns in plankton, including HAB, assemblages.
- Test for a relationship between nutrient concentrations and HAB abundances.
- Test for a relationship between lake level and HAB abundances.
- Test for a relationship between temperature, stratification and HAB abundances.
- Test for a relationship between antecedent precipitation and HAB abundances.

4. PLANKTON TEMPORAL ANALYSIS

Obj. 1: Estimate temporal patterns in plankton, including HAB, assemblages

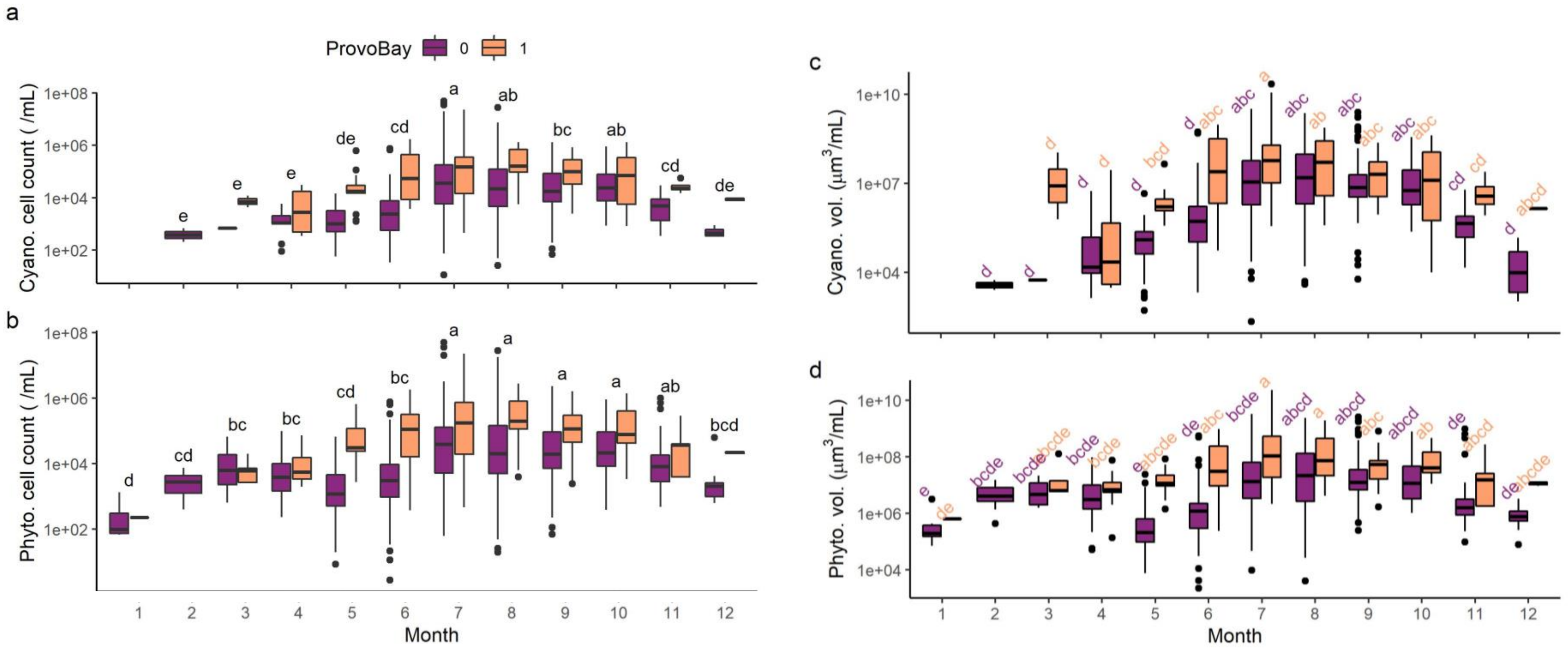
Methods:

- Phytoplankton from UDEQ → total and cyanobacteria
- OTU reconciliation
- Zooplankton from Landom (Landom et al. 2019)
- Divided into large and small taxa, pooled by month and year

4. PHYTOPLANKTON TEMPORAL ANALYSIS

Summer samples generally highest, Provo Bay generally higher than main basin

Individual taxa by month available on Data Explorer

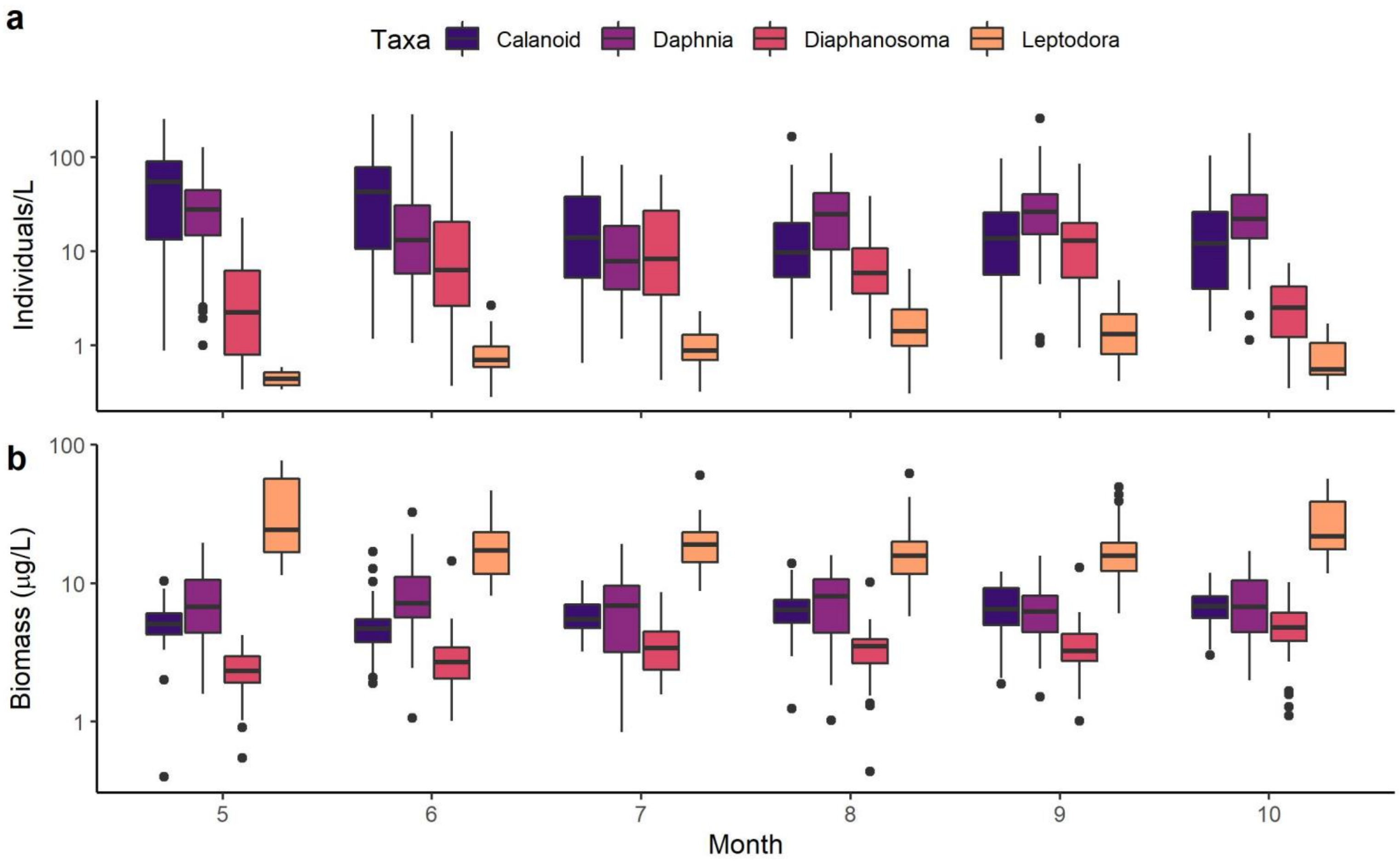


4. ZOOPLANKTON TEMPORAL ANALYSIS

Large-bodied taxa:

- Some variability by month
- Leptodora (large predator) has low counts, high biomass
- *Daphnia* and calanoid copepods generally more abundant than *Diaphanosoma*

Annual distributions (in report) attributed to carp removal (Landom and Walsworth draft 2020)

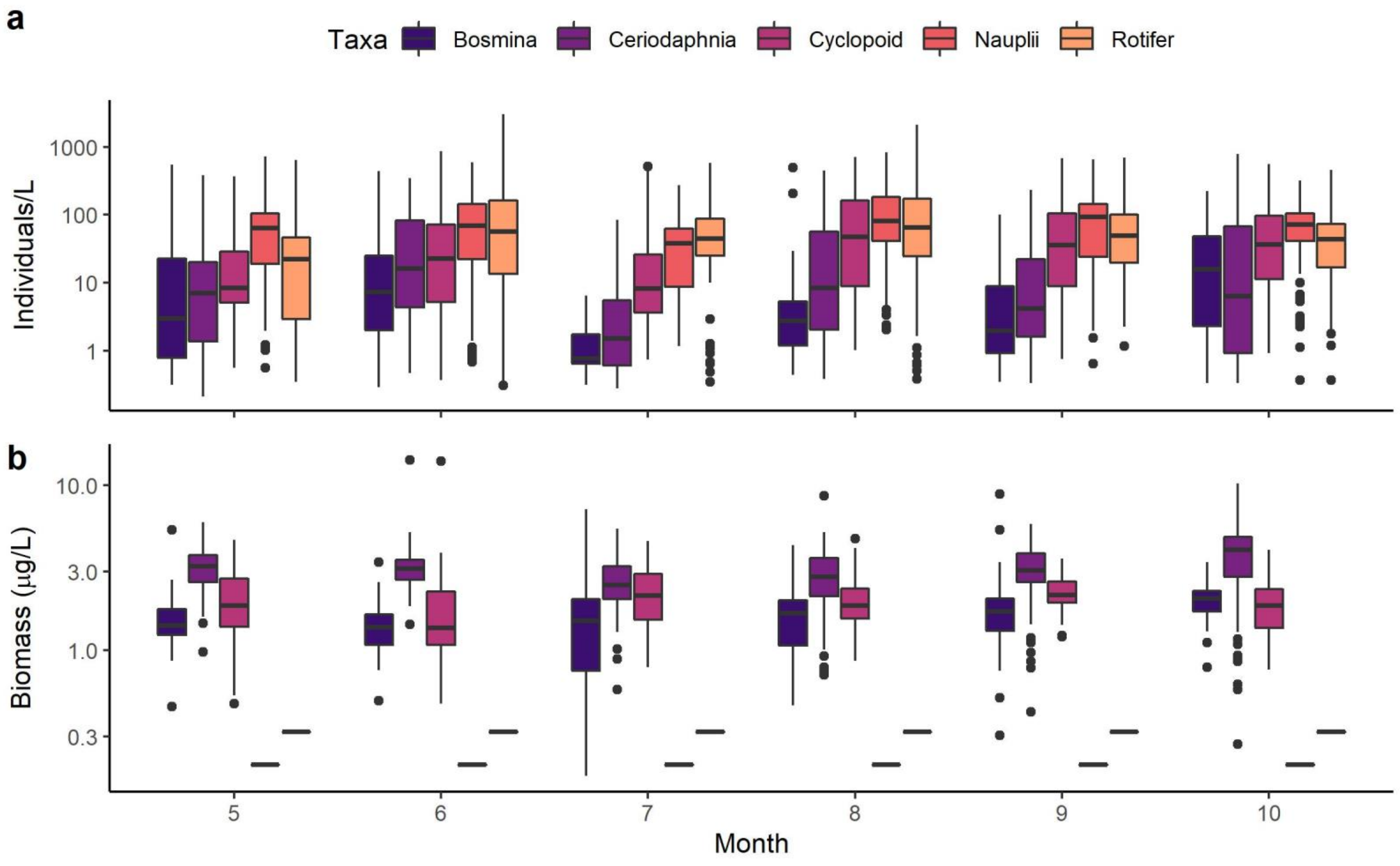


4. ZOOPLANKTON TEMPORAL ANALYSIS

Small-bodied taxa:

- Some variability by month
- Nauplii and rotifers abundant but low biomass

Annual distributions (in report) attributed to carp removal and lake level (Landom and Walsworth draft 2020)



4. PLANKTON SPATIAL ANALYSIS

Obj. 2: Estimate spatial patterns in plankton, including HAB, assemblages

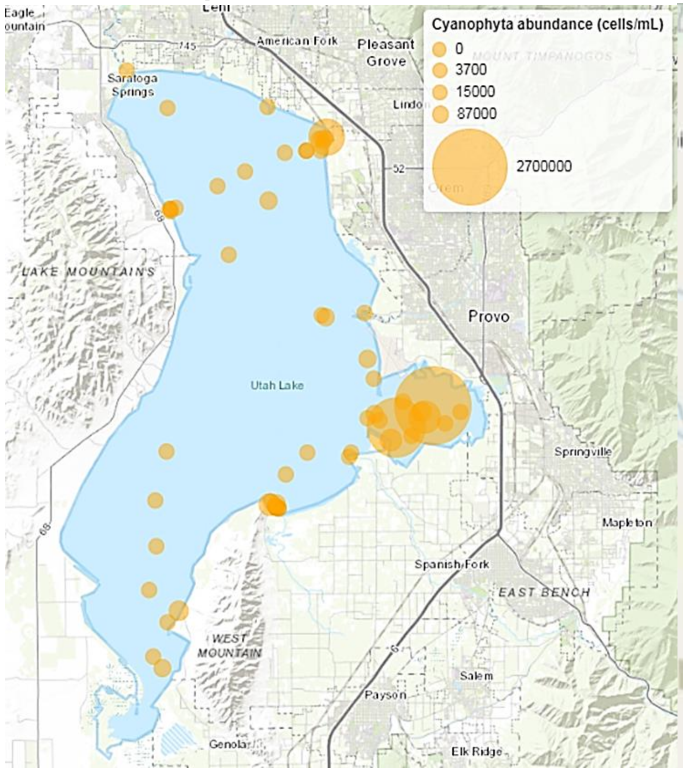
Methods:

- Phytoplankton from UDEQ → total and cyanobacteria
- OTU reconciliation
- Zooplankton from Landom (Landom et al. 2019)

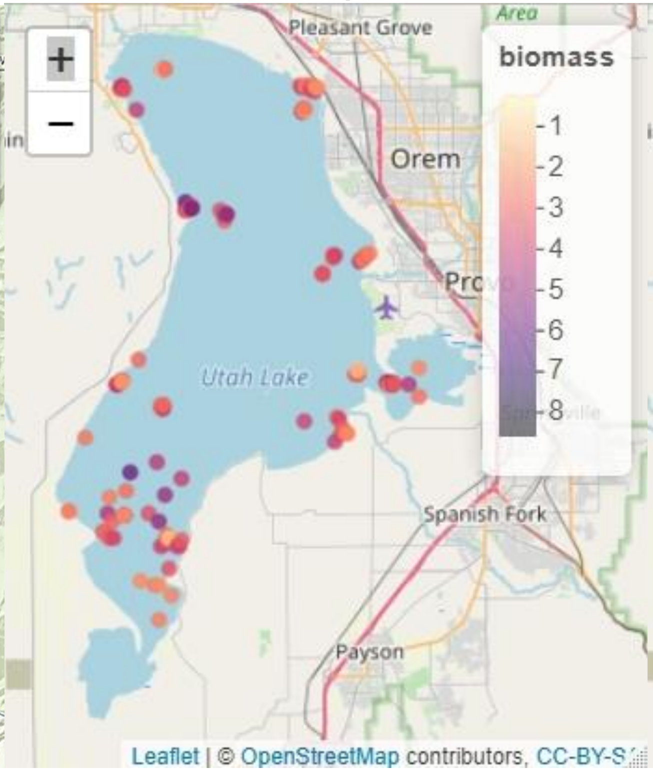
4. PLANKTON SPATIAL ANALYSIS

Aggregated spatial distributions: cyanobacteria are localized, zooplankton are variable

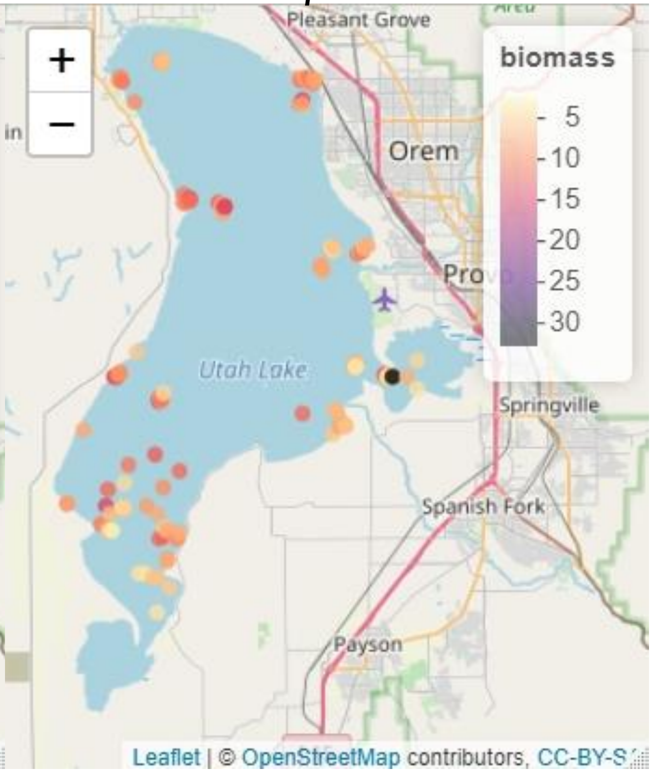
Cyanobacteria



Ceriodaphnia



Daphnia



4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

Obj: 3-5:

- Test for a relationship between nutrient concentrations and HAB abundances.
- Test for a relationship between lake level and HAB abundances.
- Test for a relationship between temperature, stratification and HAB abundances.

Methods:

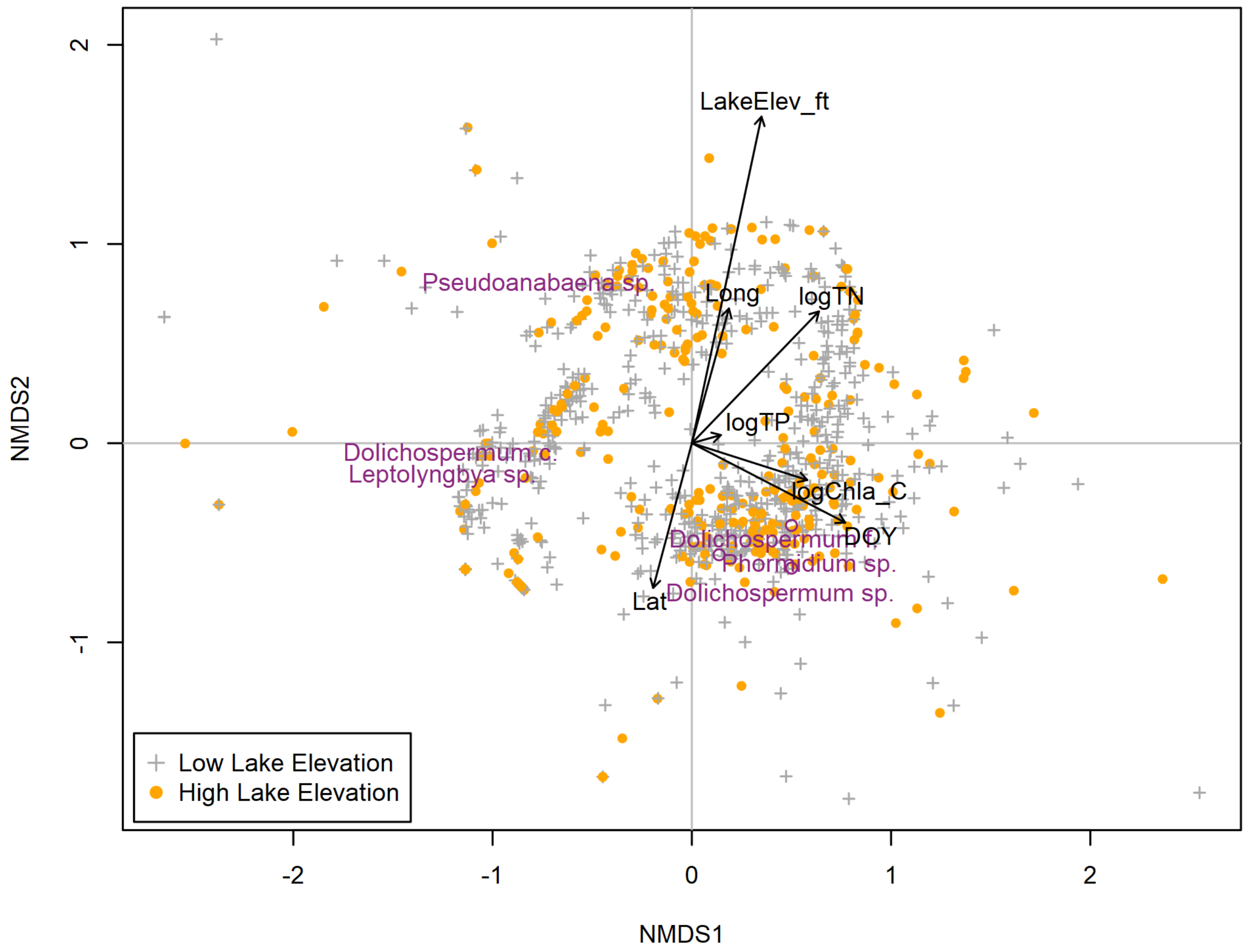
1. NMDS: TP, TN, water temp, lake elevation, month
2. Predict cyanobacterial biomass w/ linear model selection
3. Mixed effects model w/ site as random effect

4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

Multivariate analysis: NMDS

- Environmental variables load as vectors onto axes
- Samples scatter across four quadrants
- Cyanobacterial taxa plotted at location of loadings, some cluster together

→ These variables (or variations thereof) are good candidates for linear modeling

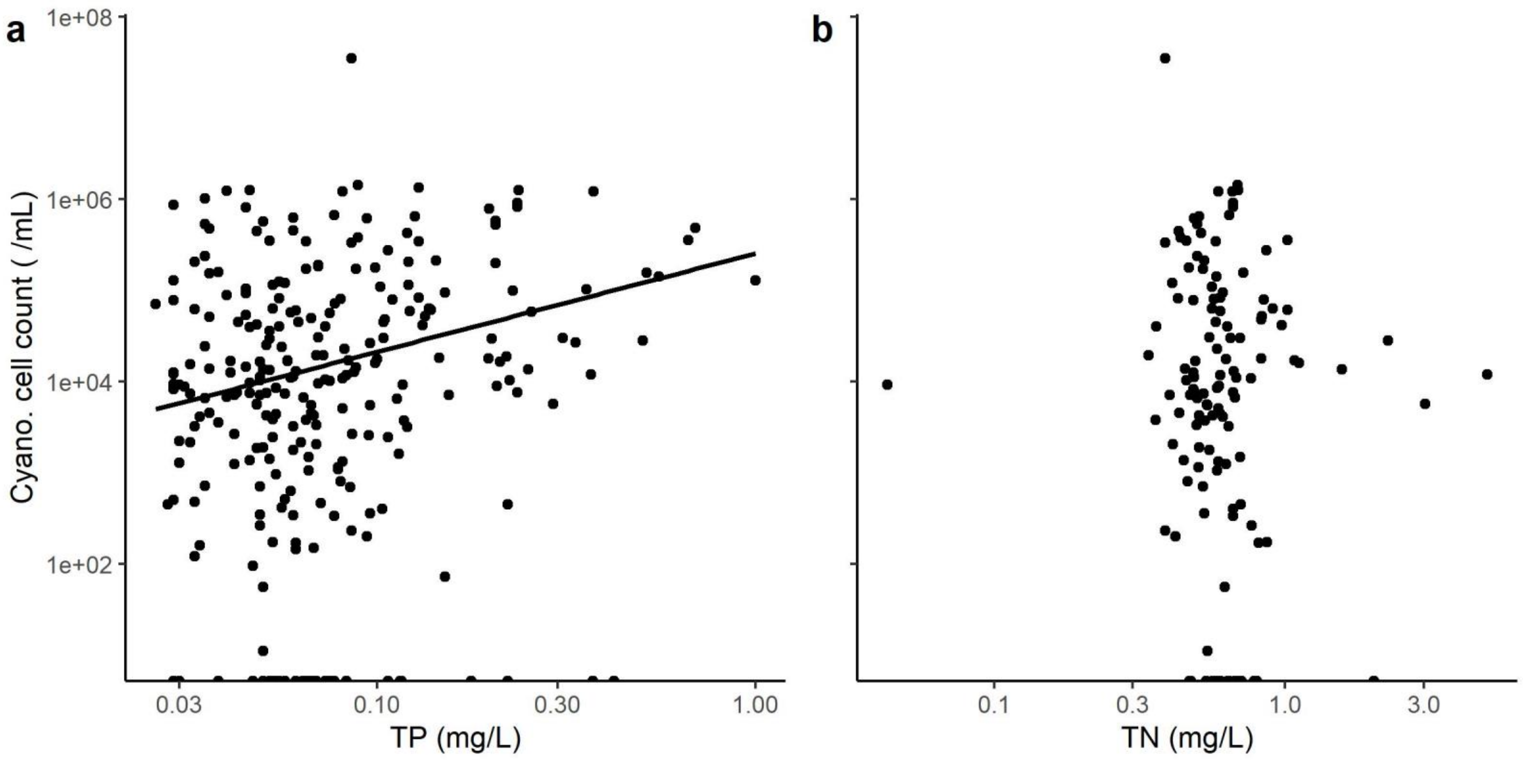


4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

TP significant predictor of:

- Total cell count
- Total biovolume
- Cyano. cell count
- Cyano. biovolume

TN was not a significant predictor



4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

Mixed effects model

- Significant predictors in bold
- + or - coefficients
- Spatial variability (site) explains more variance than fixed effects alone

Variable	log(cyano. cell count)	log(total cell count)	log(cyano. biovol.)	log(total biovol.)
Intercept	**1202.21**	**1656.15**	-5.07	**9.72**
Month 5	4.58	1.59	6.72	0.78
Month 6	4.43	1.98	6.23	0.81
Month 7	4.92	2.48	6.81	1.37
Month 8	6.34	3.37	8.74	2.20
Month 9	**7.16**	3.54	**9.97**	3.14
Month 10	**11.05**	**6.17**	**16.76**	**6.49**
Month 11	**10.32**	**5.57**	**16.58**	**5.92**
log(TP)	**1.20**	**0.58**	**1.70**	**1.08**
Water temp.	**0.39**	**0.21**	**0.67**	**0.30**
Lake elevation	**-0.27**	**-0.37**	--	--
1|Site	random	random	random	random
Marginal R^2	0.31	0.35	0.28	0.37
Conditional R^2	0.33	0.49	0.28	0.44

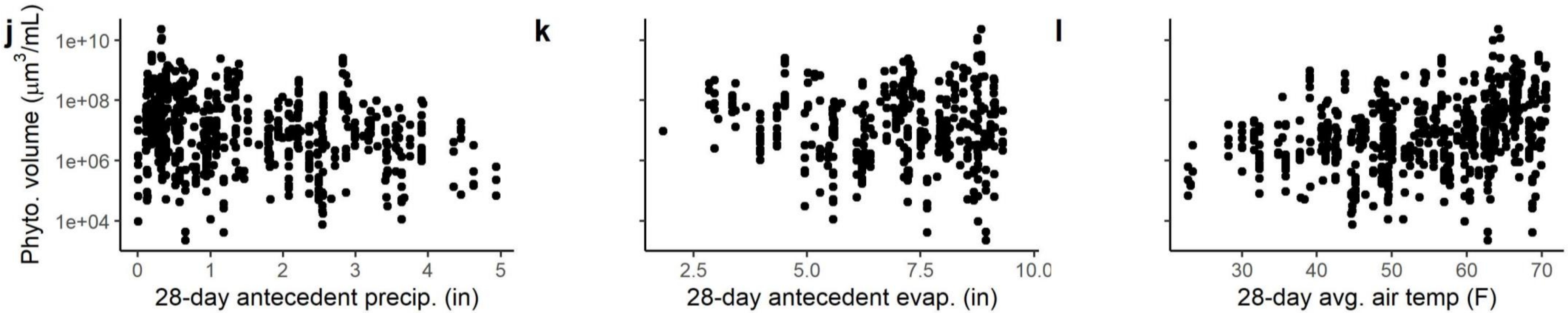
4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

Obj. 6: Test for a relationship between antecedent precipitation and HAB abundances

Methods

- Weather data from NOAA (Jordan Basin, HUC 160202)
- Rolling sum of antecedent precipitation and evaporation (7, 14, 28 days)
- Rolling mean of antecedent air temperature (7, 14, 28 days)
- Annual precipitation and air temp for water year
- 28-day antecedent conditions were best option

4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS



Variable	log(cyano. cell count)	log(total cell count)	log(cyano. biovol.)	log(total biovol.)
Intercept	**8.53**	**11.45**	**12.76**	**18.92**
log(TP)	**1.10**	**1.08**	1.03	**0.97**
28-day precip.	**-1.18**	**-0.91**	**-1.54**	**-0.97**
28-day evap.	**-1.73**	**-1.25**	**-2.26**	**-1.23**
28-day air temp.	**0.28**	**0.18**	**0.35**	**0.15**
1|Site	random	random	random	random
Marginal R^2	0.32	0.33	0.24	0.27
Conditional R^2	0.37	0.41	0.30	0.34

5. DIATOM AND MACROPHYTE AUTOECOLOGY

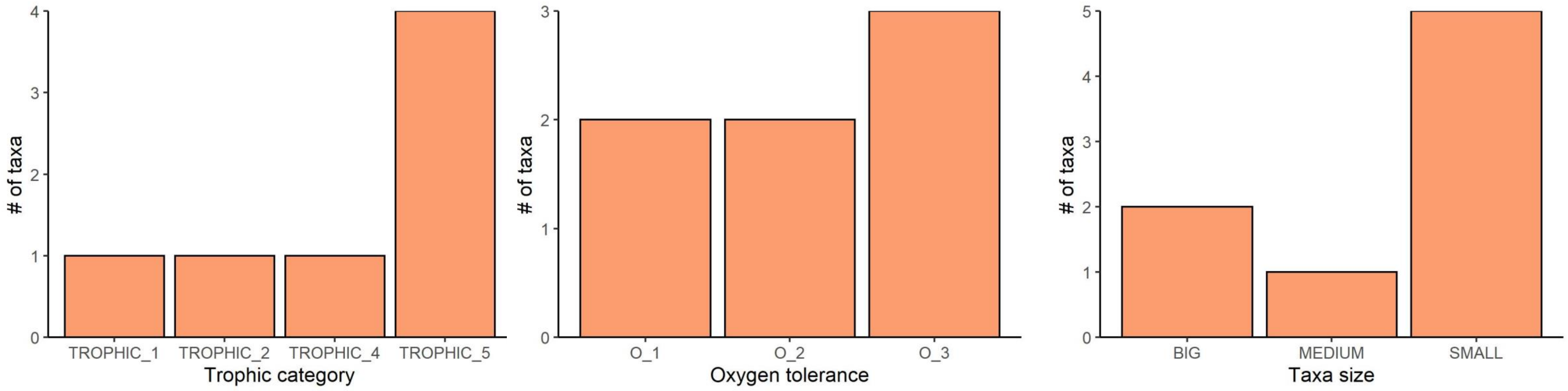
Objective: Identify the autoecology of Utah Lake diatom and macrophyte species

Methods

- Diatom index: RIVPACS
- Current and paleolimnological diatom assemblages (Bolland 1974)
- Macrophyte index: FreshwaterEcology.Info (WISER consortium)
- Current and recent submerged macrophytes (Brotherson 1981, Miller and Crowl 2006, Landom et al. 2019)

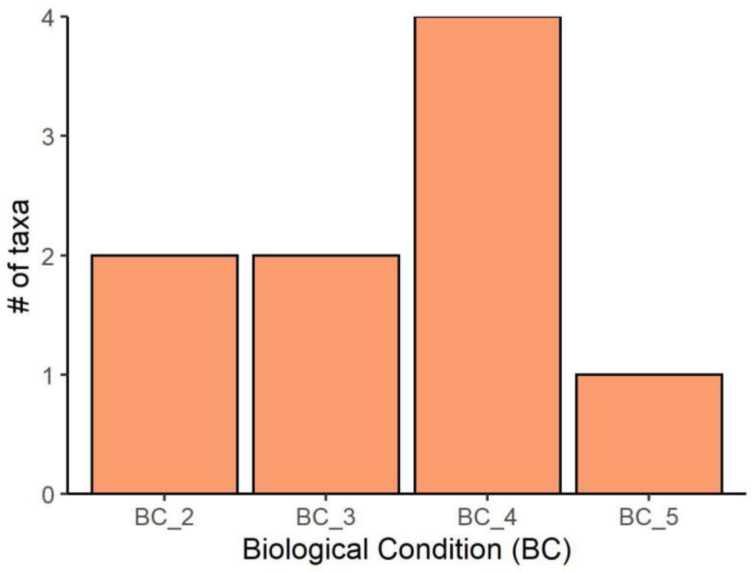
5. DIATOM AUTOECOLOGY: CURRENT

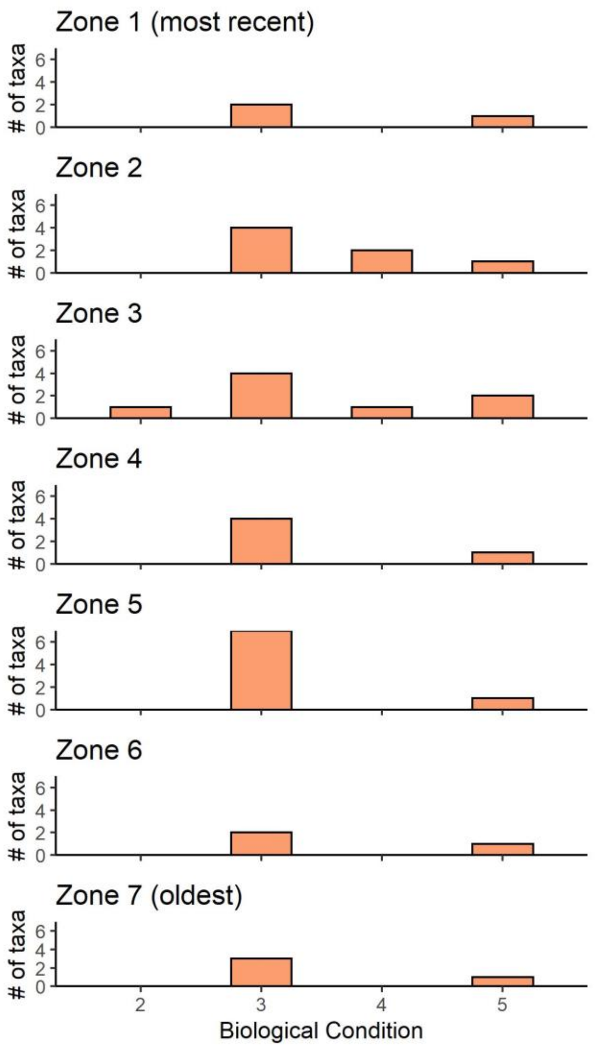
- Most common: eutraphenic taxa (trophic category = 5)
- Oxygen tolerance: range from nearly 100 % (1) to > 50% saturation (3)
- Range of sizes



5. DIATOM AUTOECOLOGY

- Current diatoms: biological condition range from moderately sensitive (2) to highly tolerant (5)
- Paleolimnological diatoms: biological condition range generally from ubiquitous (3) to highly tolerant (5)





5. MACROPHYTE AUTOECOLOGY

- Nutrient metrics: LMICM and Ellenberg
- Higher the score, higher the nutrients
- Wide range in nutrient scores, but most recent reports have exclusively high scores

Taxa	LMICM	Ellenberg	Citation (for Utah Lake)
Ceratophyllum demersum	7.82	8	Brotherson 1981 Landom et al. 2019
Elodea canadensis	7.42	7	Brotherson 1981
Myriophyllum spicatum	7.30	7	Brotherson 1981
Potamogeton crispus	8.02	5	Brotherson 1981
Potamogeton filiformis	2.96	5	Brotherson 1981
Potamogeton foliosus	-	-	Brotherson 1981
Potamogeton latifolius	-	-	Brotherson 1981
Potamogeton nodosus	-	-	Brotherson 1981
Potamogeton pectinatus	8.64	8	Brotherson 1981 Miller and Crowl 2006
Potamogeton praelongus	4.08	4	Brotherson 1981
Stuckenia pectinata	-	-	Landom et al. 2019

6. WIND AND TURBIDITY

Objective: Identify wind condition necessary to entrain bottom sediments in Utah Lake

Methods

- Wind speed and direction: Provo Airport (also compared w/ Lindon & Spanish Fork)
- Buoy locations: calculate fetch, wave shear stress

$$\tau_{WAVE} = 0.5 \times \rho \times f_W \times U_w^2$$

- Calculate critical shear
- Compare wind speed, shear stress, turbidity

6. WIND AND TURBIDITY

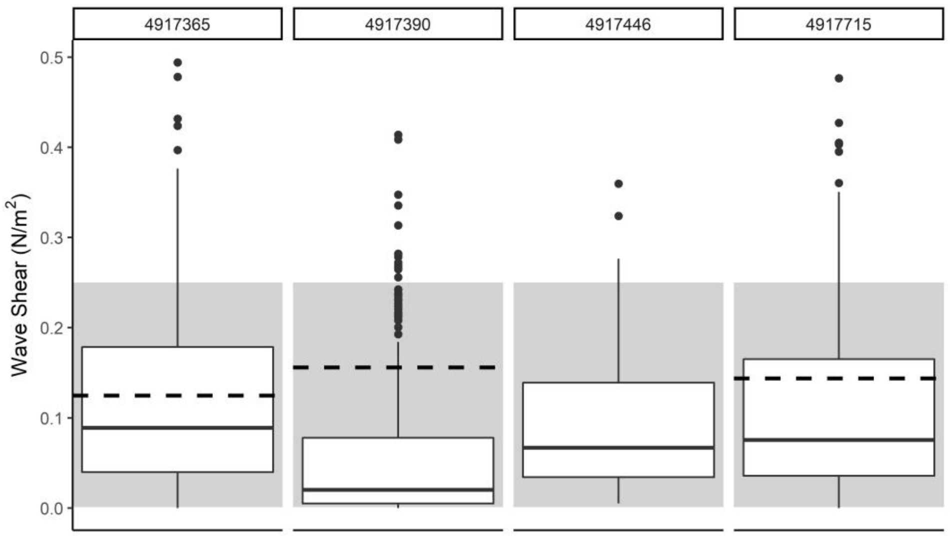
[Data Explorer demo]

6. WIND AND TURBIDITY

Most observations fell below critical shear

- North: 76 %
- State Park: 93 %
- South: 85 %
- Provo Bay: not established

Most wave shear values fell within published range of critical shear (gray shading)

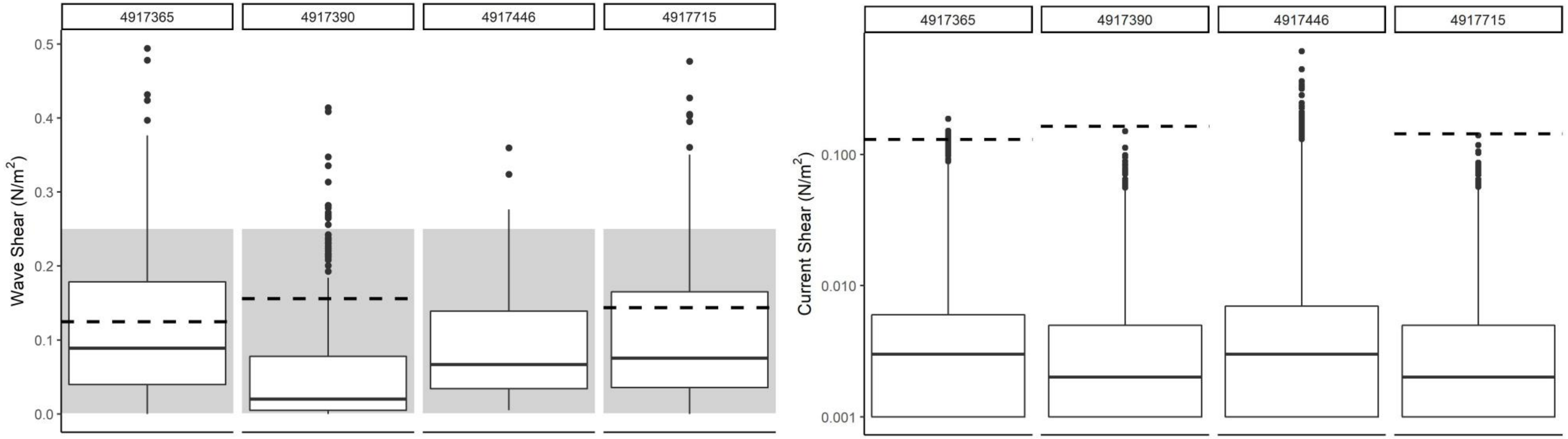


6. WIND AND TURBIDITY

Current shear obtained from Utah Lake EFDC/WASP model (Nick von Stackelberg)

Comparing wave shear with current shear

- Wave shear > current shear
- Current shear rarely exceeds critical shear

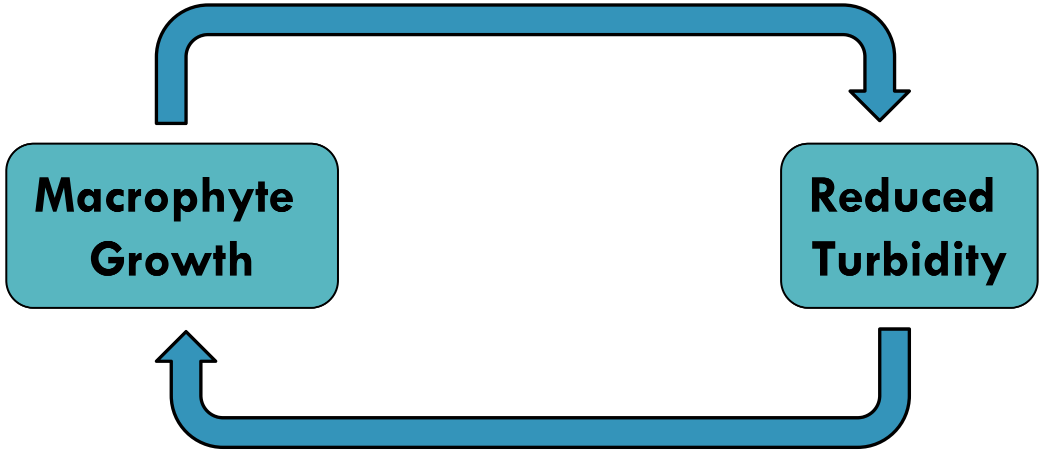


6. WIND AND TURBIDITY: TAKEAWAYS

- Wind conditions are sometimes, but not usually sufficient to entrain sediments
- High turbidity under low wind could be a function of slow sinking rates and/or carp

7. TURBIDITY AND MACROPHYTES

Objective: Identify the potential contribution of macrophytes to reducing turbidity



Methods

- Compare observed wave shear and critical shear
- Compute theoretical reduction in wave shear w/ macrophyte cover

7. TURBIDITY AND MACROPHYTES

[Data Explorer demo]

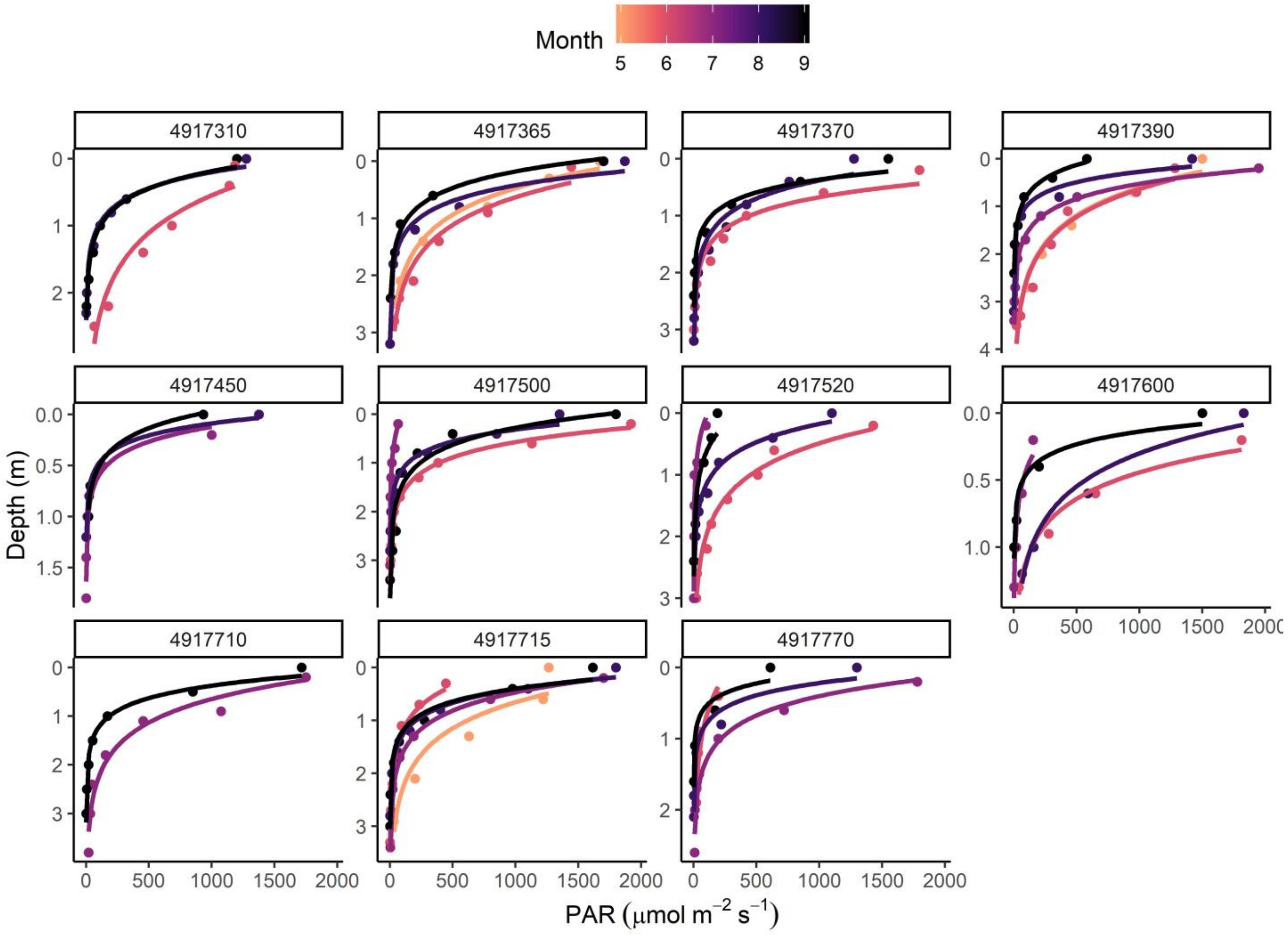
8. LIGHT EXTINCTION

Objective: Identify the potential contribution of turbidity/TSS and algal biomass to turbidity

Methods

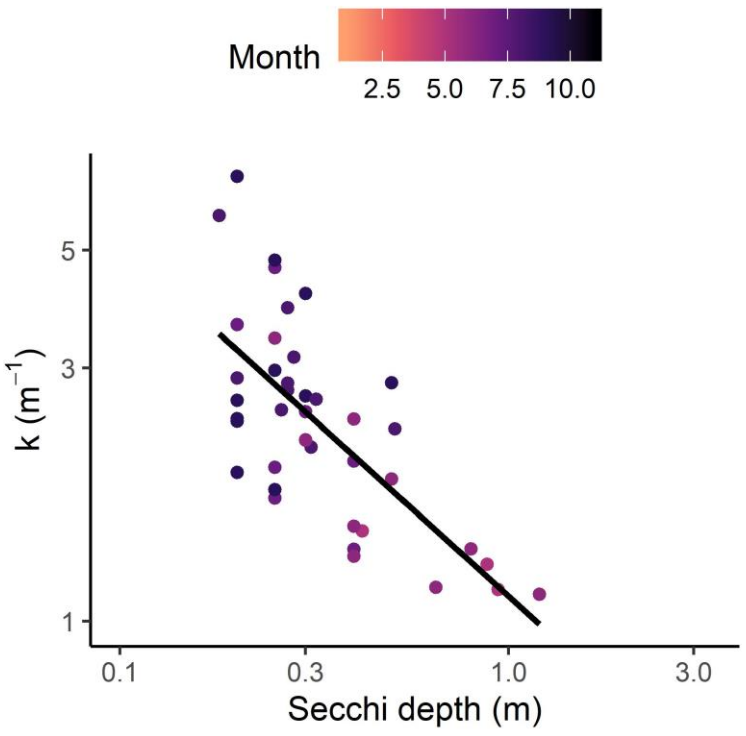
- Light profiles → PAR light attenuation coefficient (k)
- Model light compensation depth for macrophyte growth
- Calculations
  - Non-algal turbidity
  - Observed vs. expected Secchi depth
  - Model selection to predict k and Secchi depth from multiple constituents

8. LIGHT EXTINCTION



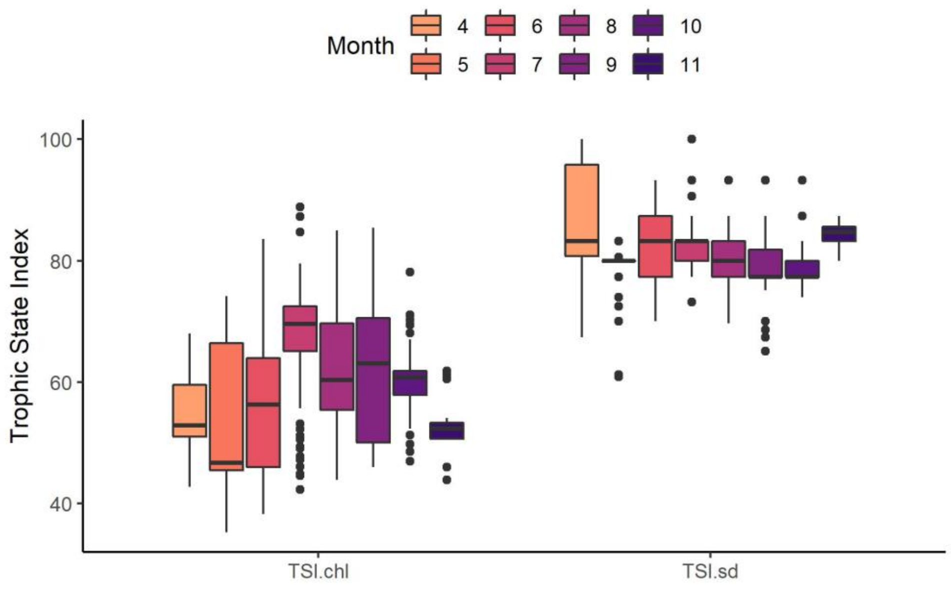
8. LIGHT EXTINCTION

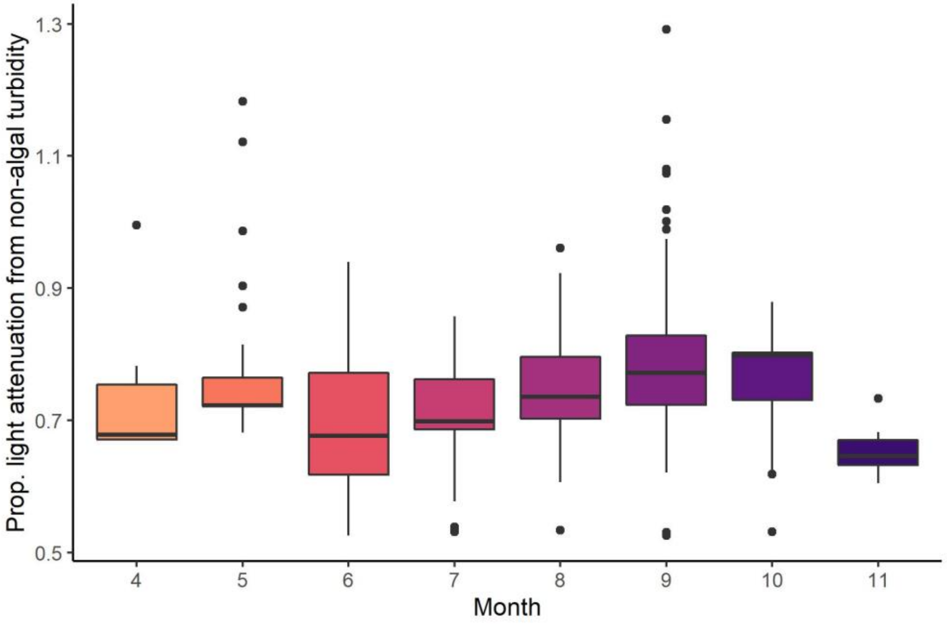
Strong relationship between k and Secchi depth



8. LIGHT EXTINCTION

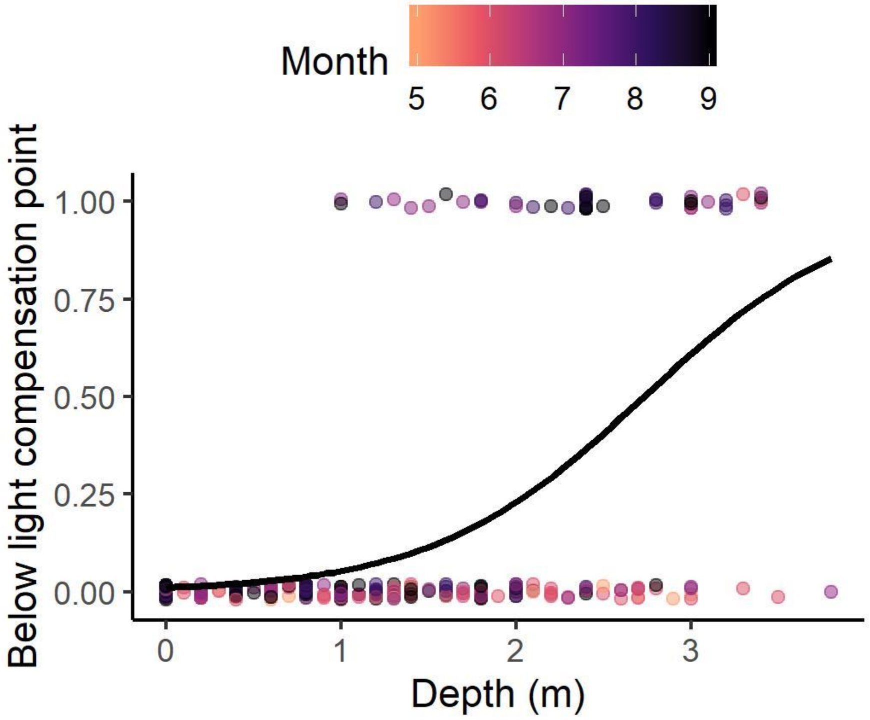
Most light extinction in Utah Lake is non-algal turbidity





8. LIGHT EXTINCTION

- Published light compensation points for submerged macrophytes: commonly 7-20 µmol m^{-2} s^{-1}
- Observed light conditions > compensation point? (0/1)
- Logistic regression to predict probability a depth will be below the compensation point
  - @ 1 m: 5 %
  - @ 2 m: 23 %
  - @ 3 m: 61 %
  - Equal odds: 2.73 m
  - Time of year makes a difference
- Shallow zones may be best option for macrophyte restoration (though macrophytes increase clarity)



8. LIGHT EXTINCTION

[Data Explorer demo]

8. LIGHT EXTINCTION: TAKEAWAYS

- Multiple constituents contribute to low clarity in Utah Lake, mainly suspended solids
- Reduced clarity limits macrophyte growth, particularly at deeper sites
- Clarity changes seasonally

NEXT STEPS

Science Panel members provide feedback on Analysis Report and Data Explorer

- “Ongoing questions” are noted, where appropriate → consider these
- Any updates or additions to analyses?