Science Panel Update

STEERING COMMITTEE CALL #6
SEPTEMBER 30, 2020

Utah Lake Sediment-Water Nutrient Interactions

- Update
  - Final report received
  - Results incorporated in the SRP and C, N, B Mass Balance

Utah Lake Sediment–Water Nutrient Interactions

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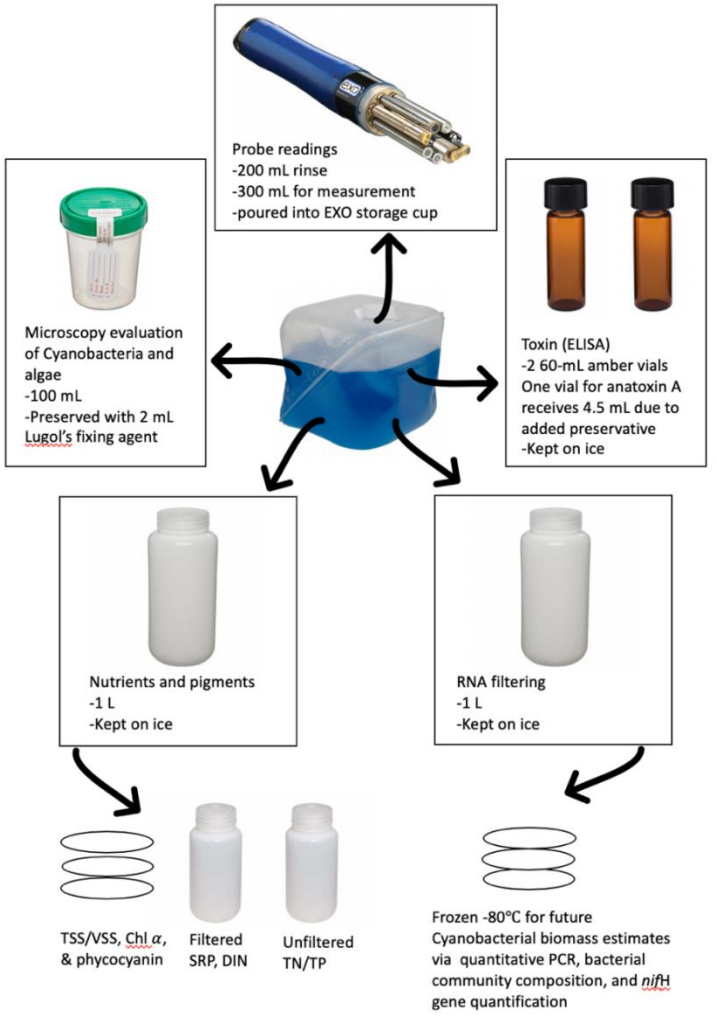
Final Report

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

February 19, 2020
First Revision Submitted: May 19, 2020
Final Revision Submitted May 27, 2020

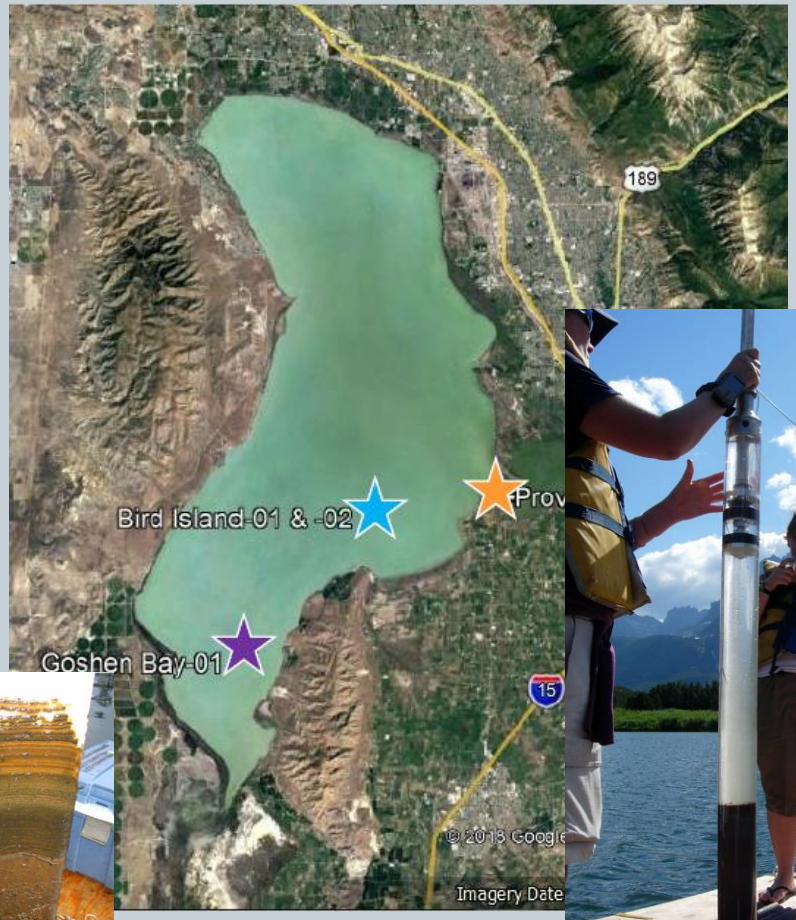
Bioassays to Investigate Nutrient Limitation in Utah Lake

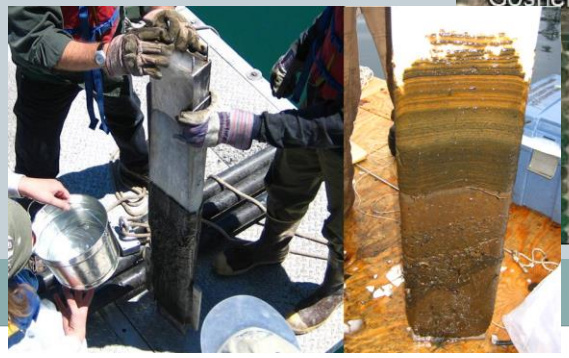
- Update
  - Field sampling completed
    - Bioassays
    - Nitrification/denitrification
    - Nutrient reduction
    - Zooplankton grazing
  - Draft final report due 10/31/2020



Utah Lake Paleolimnological Study

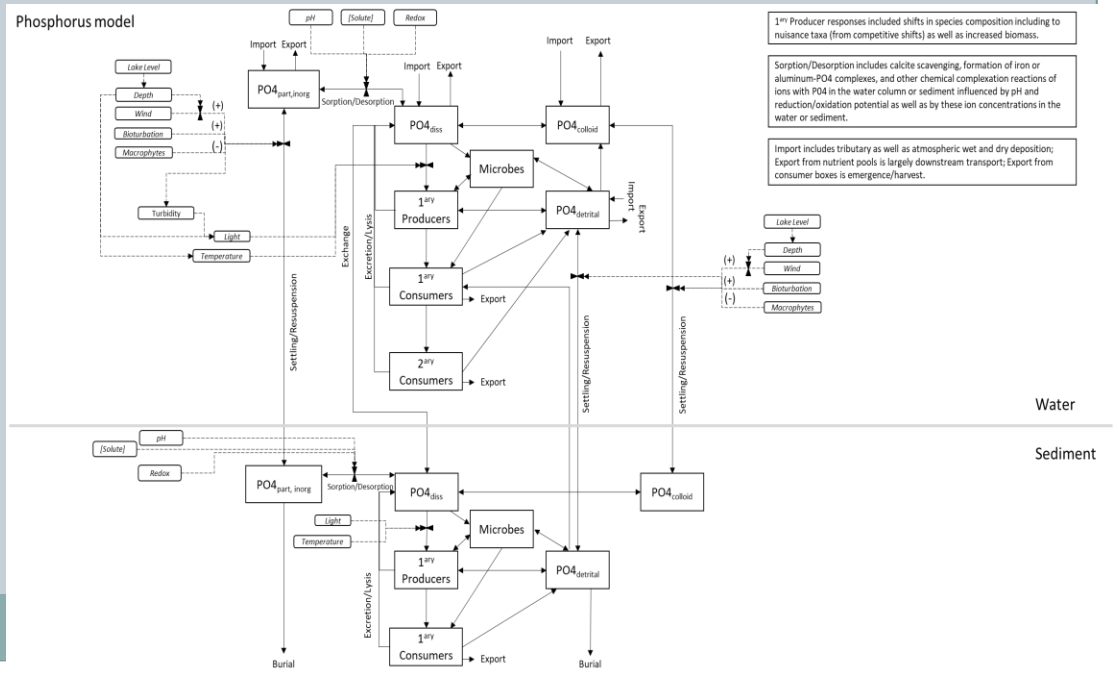
- Update
  - New core collected in Provo Bay
  - Recent results for Bird Island Core
  - Contract status
    - Analytical delays due to COVID-19
    - Extend to 12/31/2021
    - Interim reports Oct 2020, Jan 2021, and Apr 2021





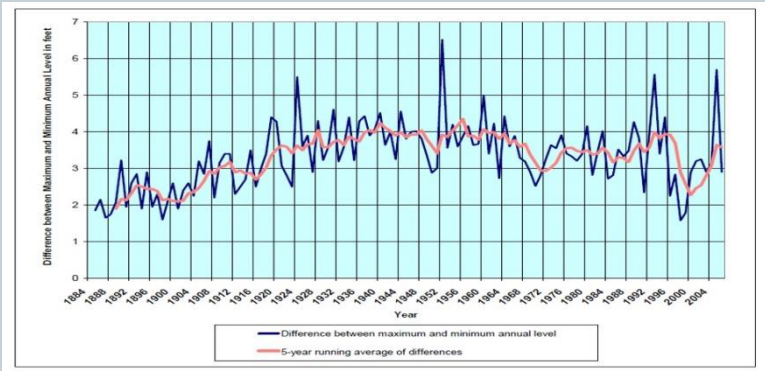
C, N, and P Budgets

- Study Objectives
  - Develop contemporary external mass balance
  - Compile known data on stocks and fluxes
    - Water and sediment
    - SedFlux model
  - Create mass balance model for each element with quantify uncertainty
  - Identify knowledge gaps
- Completion June 30, 2021



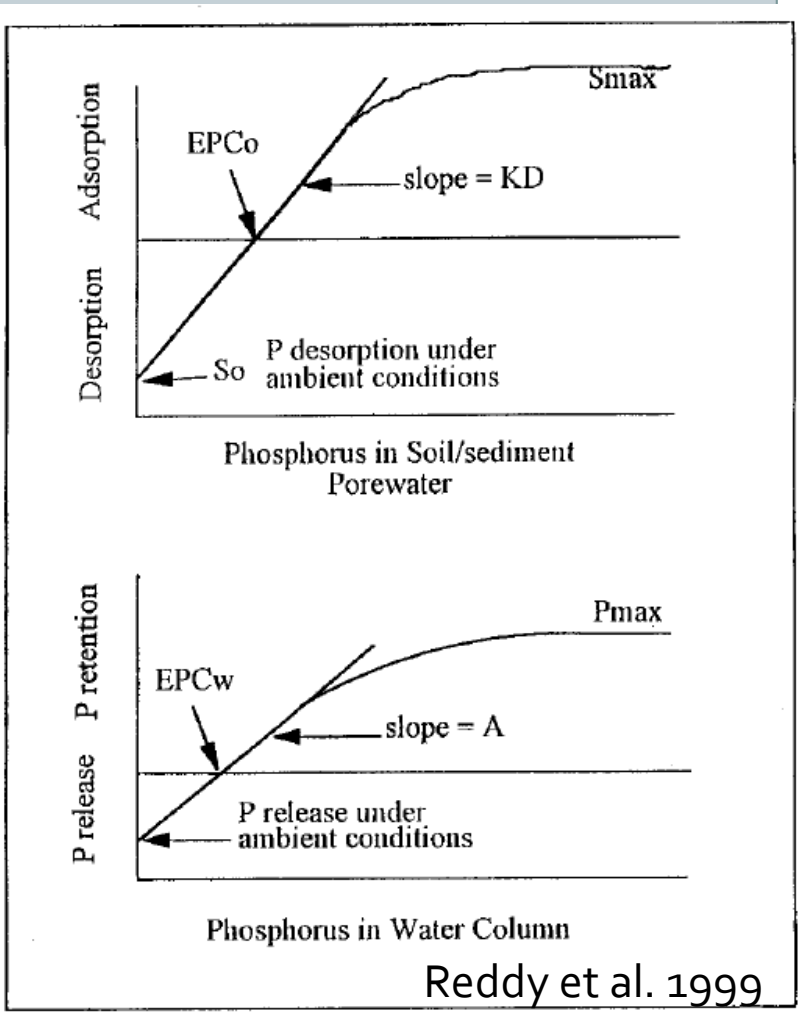
Littoral Sediment RFP

- Study Objectives
  - Review literature on drying effects
  - Measure spatial and temporal extent of drying/wetting patterns (GIS)
  - Measure relationships of drying (duration) and sediment characteristics to rate and magnitude of nutrient release
  - Compare fluxes to other loads
- Completion – December 31, 2021



P-Binding RFP

- Phase 1 Study Objectives
  - Characterize P speciation in water and sediment
  - Create reaction network of P-species
  - Characterize P-scavenging and release
  - Evaluate kinetics of P sorption and desorption
  - Evaluate predictive relationships for model development
  - Complete December 31,2021
- Phase 2 and 3 Objectives
  - Knowledge synthesis (TBD)
  - Fill knowledge gaps (TBD)



Reddy et al. 1999

Engagement on Other Studies

- Science Panel Collaboration
  - WFWQC Atmospheric Deposition
  - TSSD Limnocorrals
- Related Parallel Efforts
  - WFWQC calcite binding
  - WFWQC Paleo

UPDATE FOR STEERING COMMITTEE RESEARCH PLAN, FRAMEWORK, ANALYSIS

Utah Lake Water Quality Study
Steering Committee Call
2020-09-30

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

GOALS

Updates on:

- Technical Framework
- Strategic Research Plan
- Analysis Report and Data Explorer (https://tetratech-wtr-wne.shinyapps.io/UtahLakeDataExplorer/)

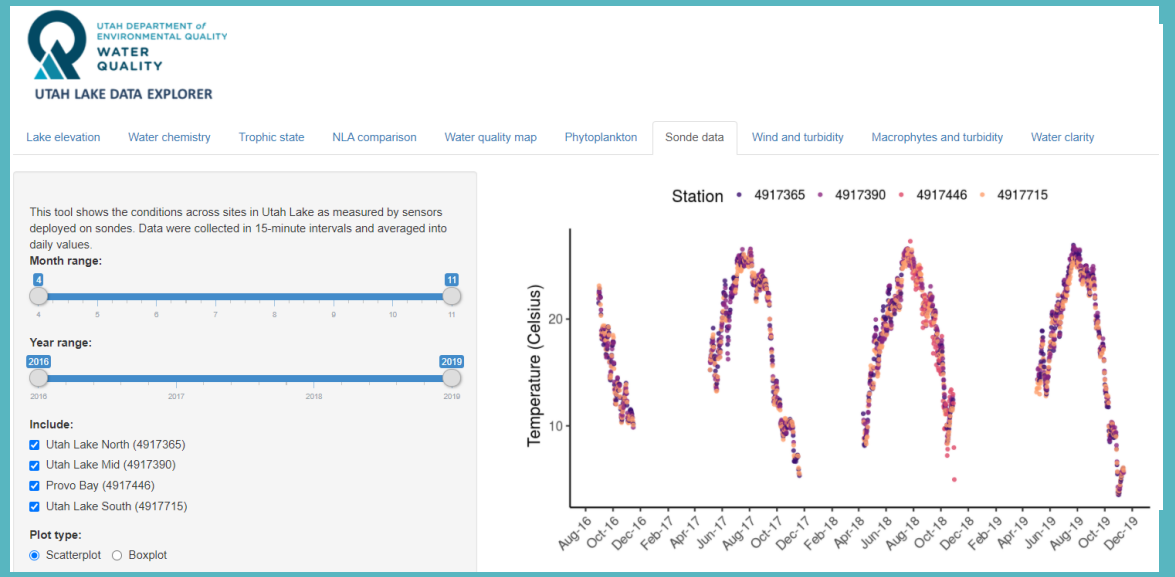
Utah Lake Water Quality Study—
Analysis Update
DRAFT
August 18, 2020

PRESENTED TO

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

PREPARED BY

Tetra Tech
1468 West Ninth Street, Suite 620
Cleveland, OH 44113



TECHNICAL FRAMEWORK UPDATE

- Edits from management goals table will be incorporated
- Main section of document: no new edits to incorporate since last update
- Next steps: pending discussion today, Management Goals table goes back to Science Panel; incorporate into updated Framework for review.

Utah Lake Water Quality Study—Numeric Nutrient Criteria Technical Framework

DRAFT

February 24, 2020
Version 6.0

PRESENTED TO

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

PREPARED BY

Tetra Tech Inc., Ecological Sciences
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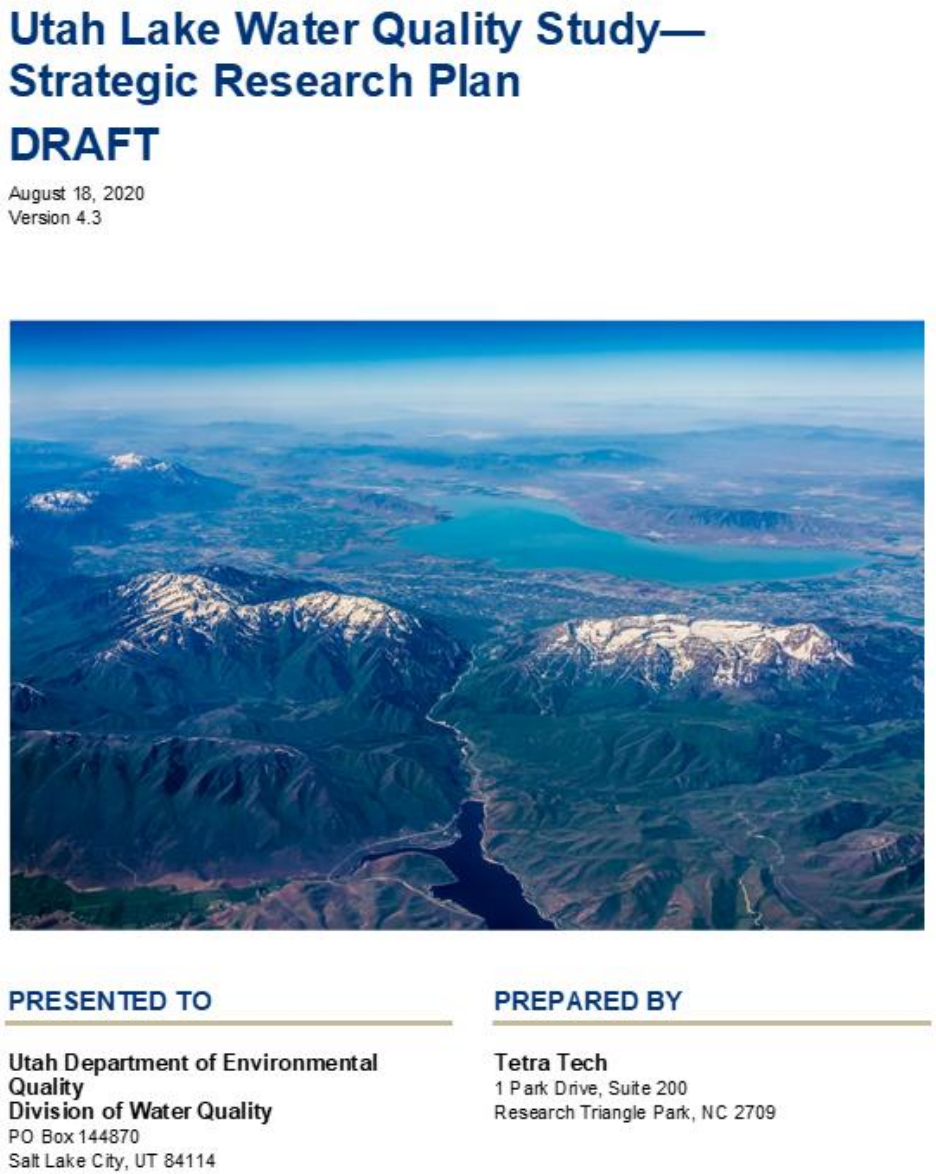
Research Triangle Park, NC 27709

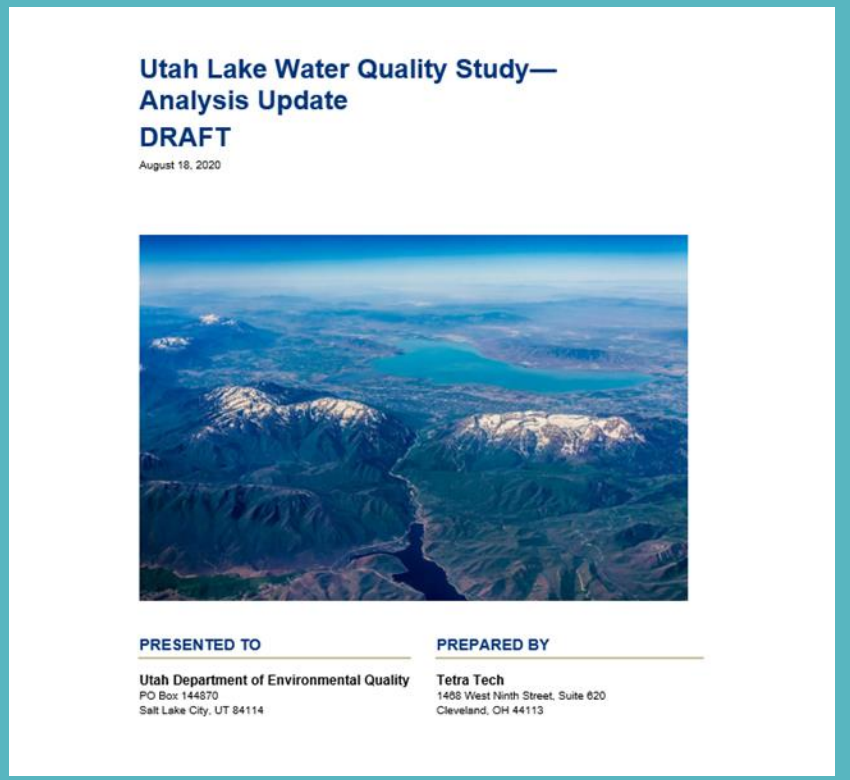
STRATEGIC RESEARCH PLAN UPDATE

- Science Panel has approved the SRP
- Incorporates latest RFPs approved by SC
- Content
  1. Process, ongoing research
  2. Charge questions and NNC development needs mapped to existing/ongoing work
  3. Prioritization of research needs
  4. Strategic research elements for 19 research priorities
- Next steps: incorporate revised framework elements as needed, circulate framework and SRP together for review



ANALYSIS REPORT UPDATE

- Analyses focused on addressing SC charge questions
- Analysis by Tetra Tech incorporated into:
  - Analysis Report
  - Utah Lake Data Explorer https://tetratech-wtr-wne.shinyapps.io/UtahLakeDataExplorer/
- Complete draft shared with Science Panel: August 28, 2020
- Next steps: incorporate SP feedback, send approved version to SC for review


Utah Lake Water Quality Study—
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ANALYSIS AREAS

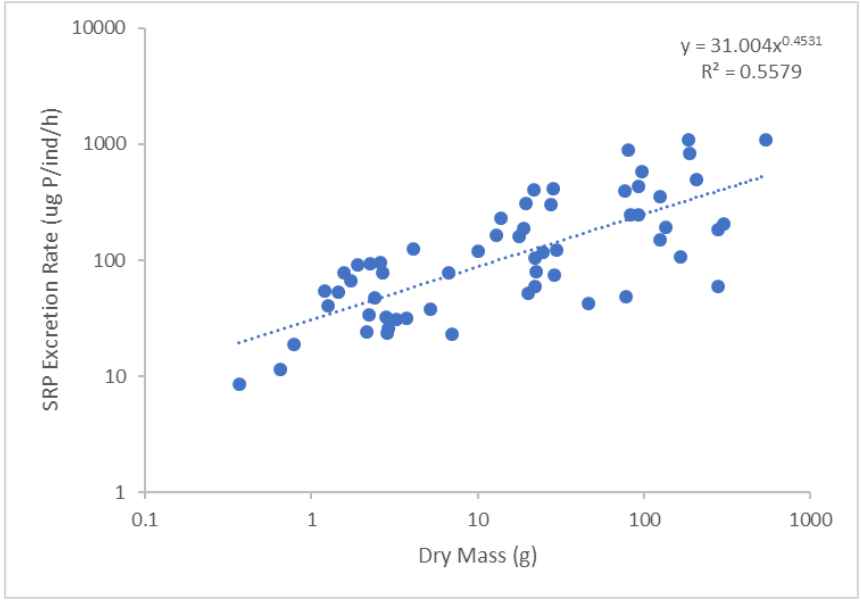
Eight Main Areas: Each tied to specific charge questions

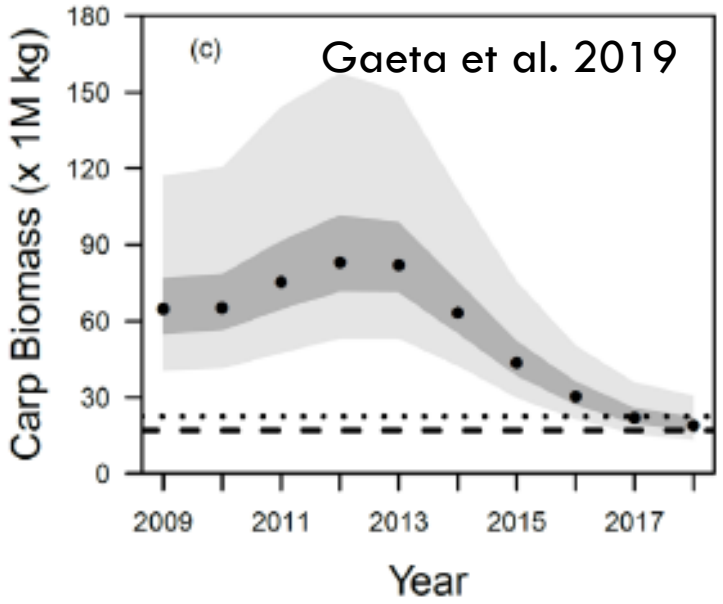
1. Carp excretion
2. Algal cell count, and pigment relationships
3. Sonde data analysis
4. Plankton spatial and temporal analysis (6 subareas)
5. Diatom and macrophyte autecology
6. Wind and turbidity
7. Turbidity and macrophytes
8. Light extinction

1. CARP EXCRETION

Objective: estimate potential nutrient excretion rates from carp
(Charge Q 2.1.i: What contribution do carp make to the total nutrient budget of the lake via excretion rates and bioturbation? How much nutrient cycling can be attributed to carp?)

- A nontrivial proportion of total and bioavailable nutrients are excreted by carp
  - TP: 19-85 % of external loads
  - SRP: 6-28 % of external loads
  - TN: 27-62 % of external loads
  - NH_4^+: 17-39 % of external loads
- Estimates can be incorporated into CNP mass balance analyses
- Excretion impacts on nutrient cycling are changing w/ carp removal

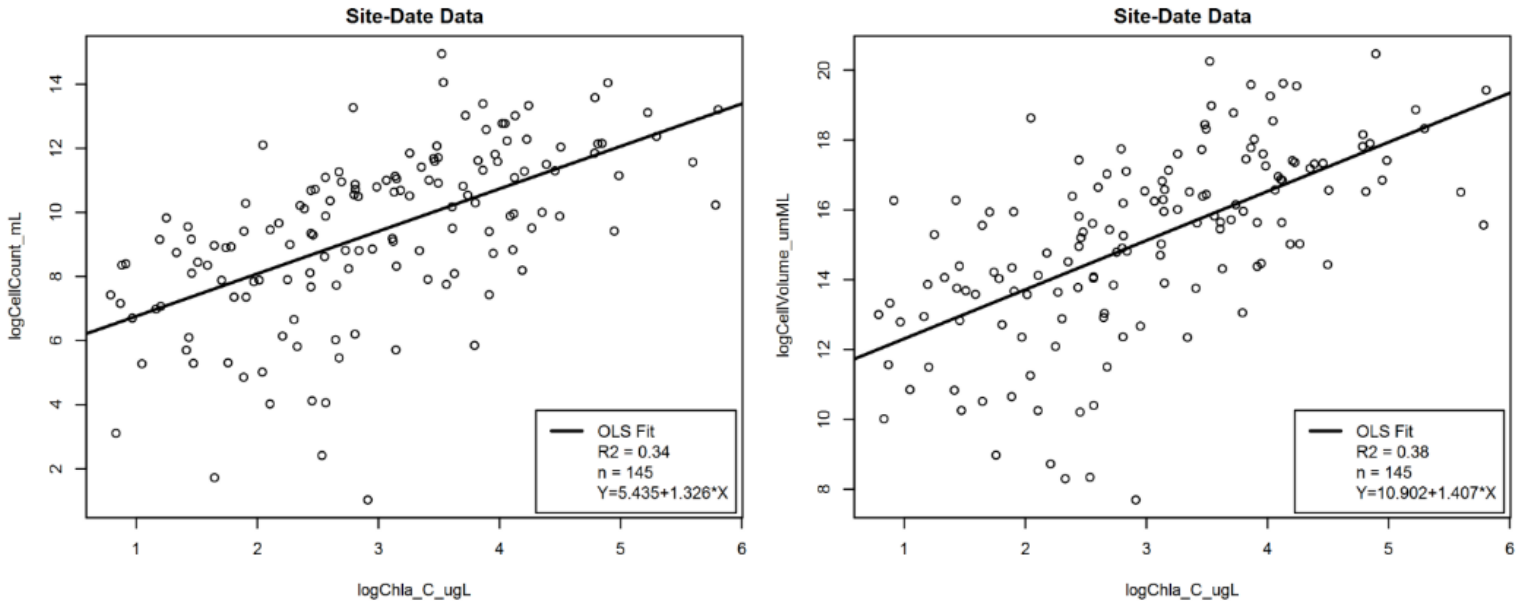




2. ALGAL CELL COUNT AND PIGMENT

Objective: Estimate relationships between cell count, biovolume, and pigment concentrations *(Workshop 3 Q: What is the relationship between cell count, biovolume, and pigment concentration data?)*

- Chlorophyll positively correlated with phytoplankton cell count and biovolume

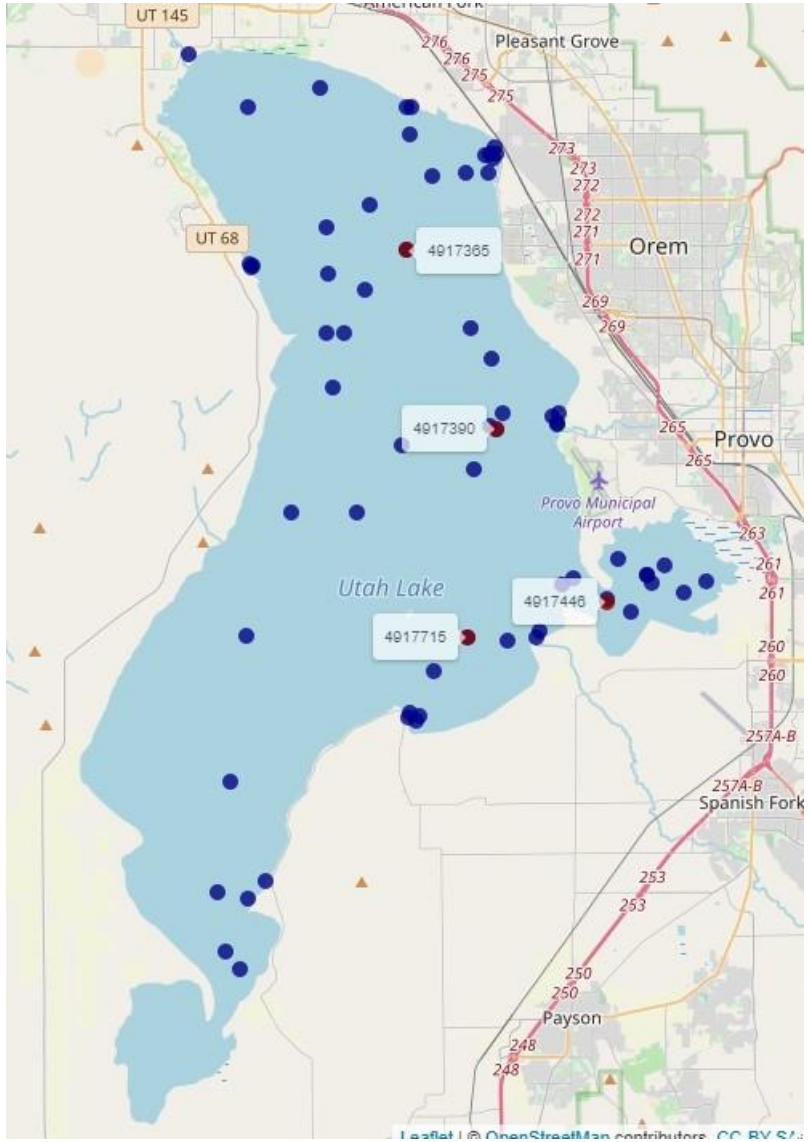


3. SONDE DATA ANALYSIS

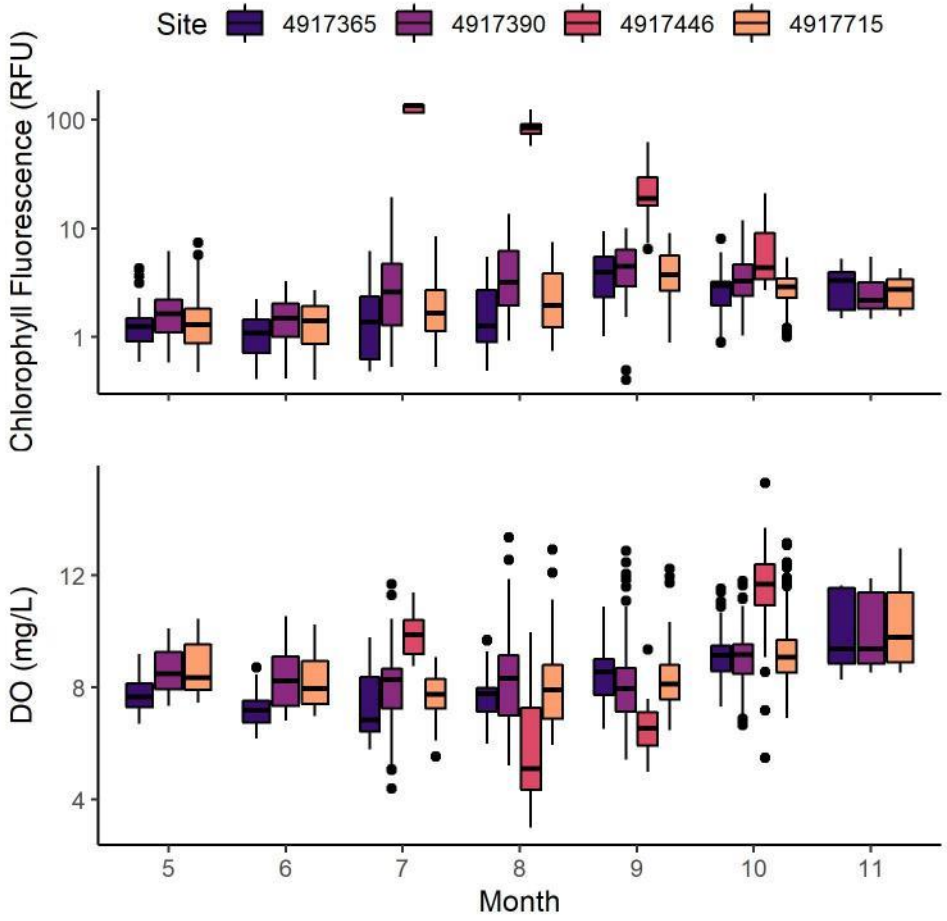
Objective: Extract sonde data and examine relationships among sonde variables. Run descriptive statistics on sonde data. *(Workshop 3 Q: Can sonde data be teased apart?)*

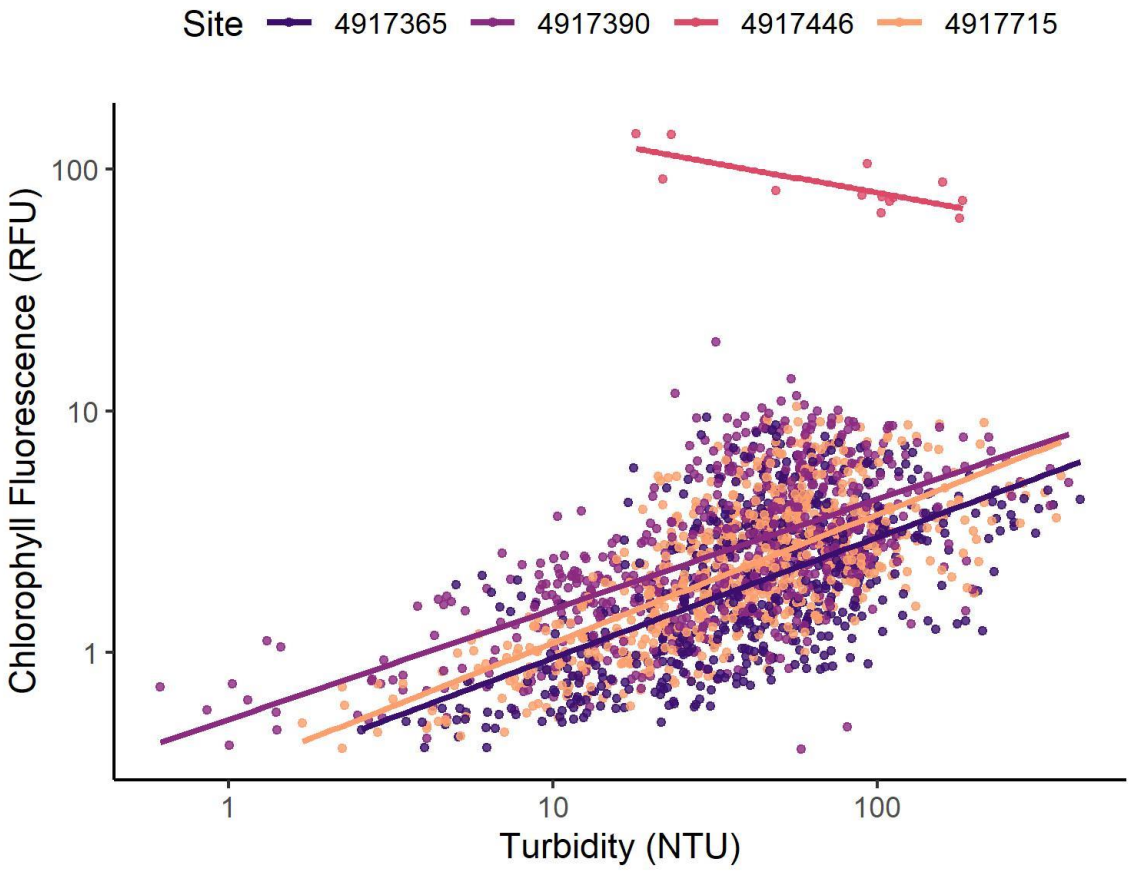
Sites

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



3. SONDE DATA ANALYSIS





4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

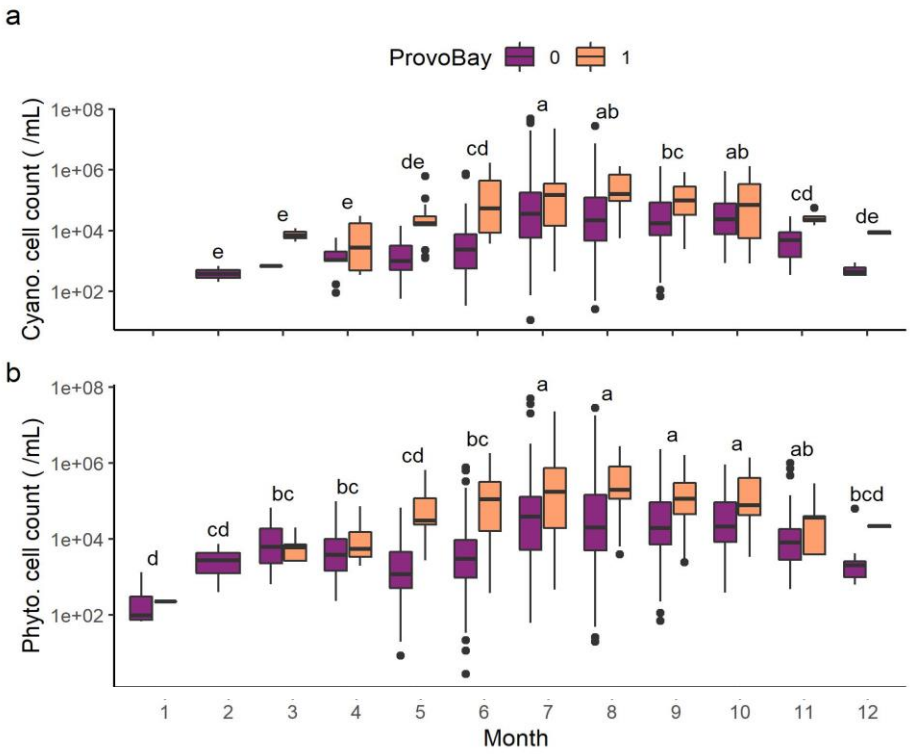
Obj. 1: Estimate temporal patterns in plankton, including HAB, assemblages
(Charge Q 2.3.i: Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?)

Phytoplankton:

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

Zooplankton:

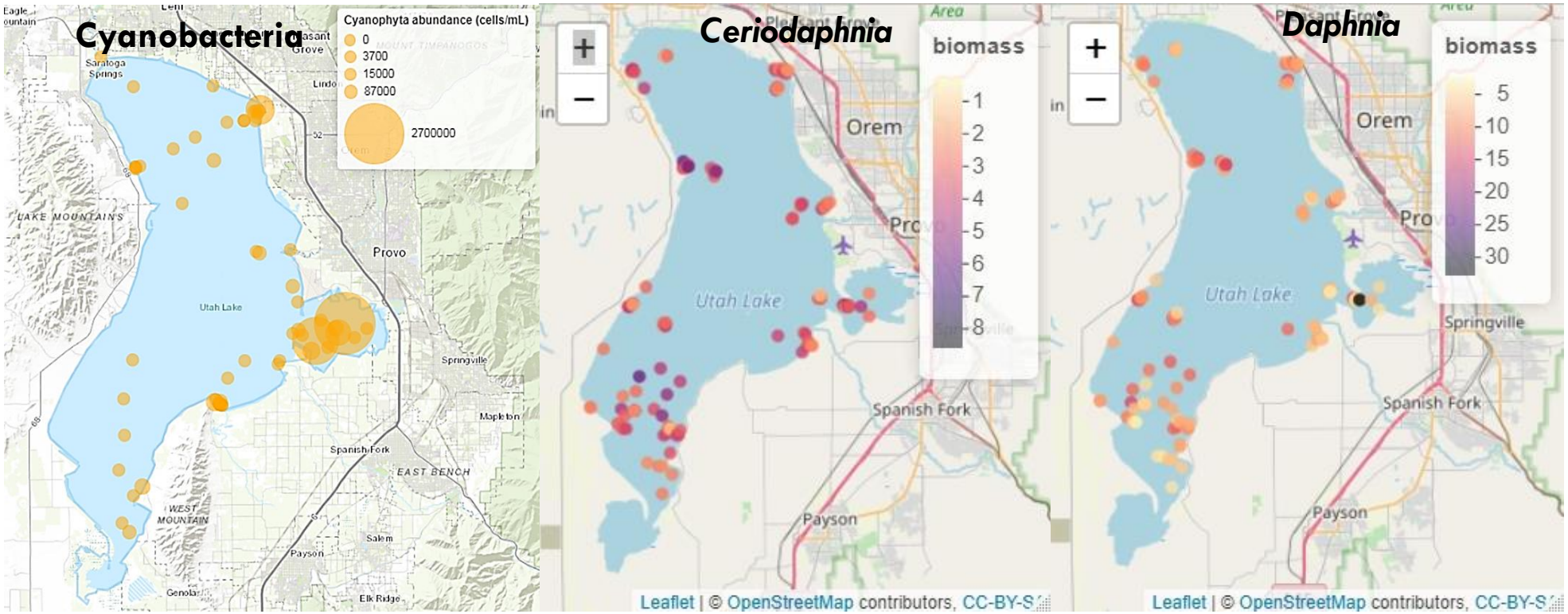
- Some variability by month
- Individual taxa abundance varies widely
- Annual differences attributed to carp removal lake level (Landom and Walsworth draft 2020)



4. PLANKTON SPATIAL ANALYSIS

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

Aggregated spatial distributions: cyanobacteria are localized, zooplankton are variable



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. Multivariate analysis (exploratory)
2. Linear model selection
3. Mixed effects model w/ site as random effect

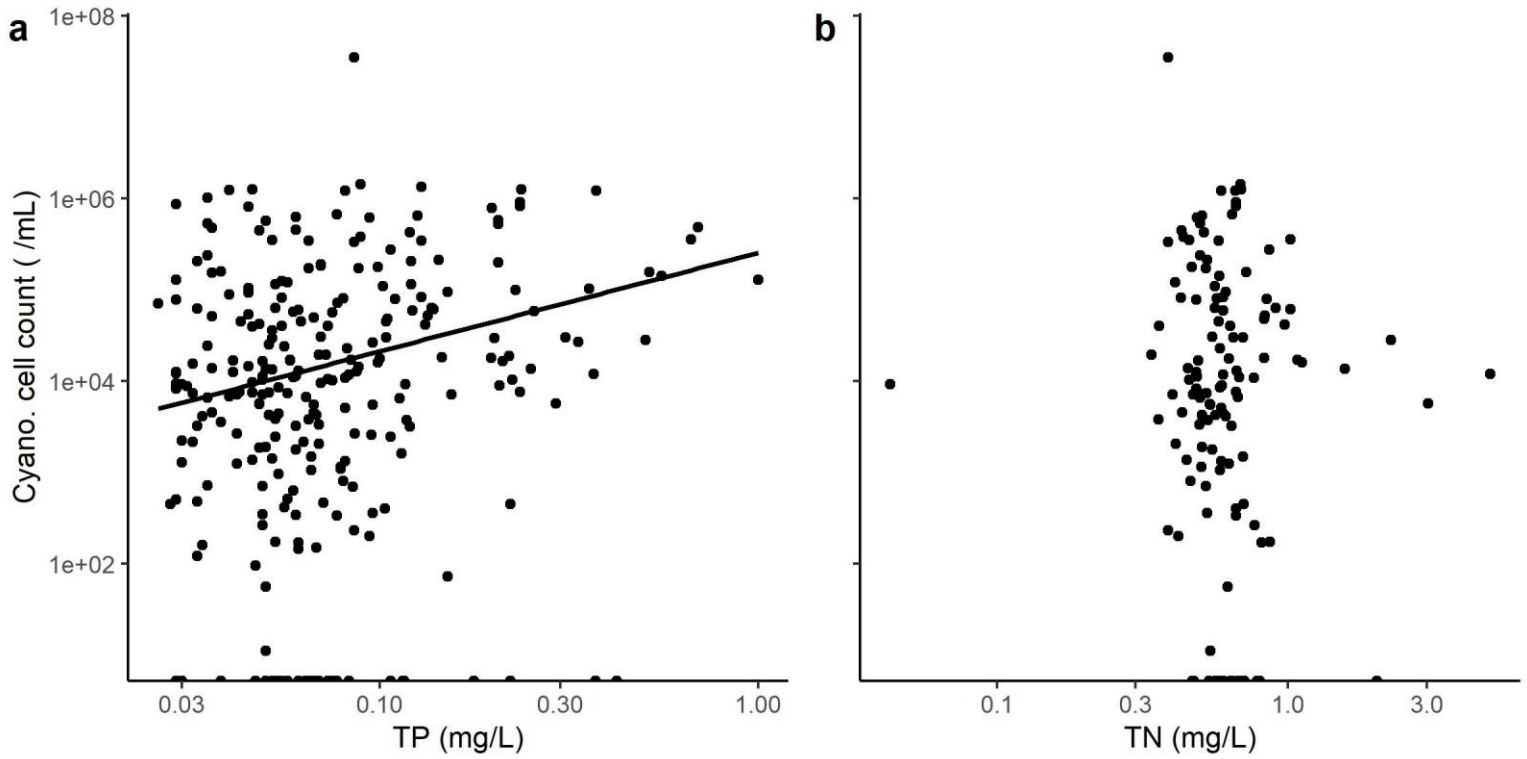
4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

TP significant predictor of total phytoplankton and cyanobacterial abundance

TN was not a significant predictor

Other significant predictors:

- Month
- Water temp (+)
- Lake elevation (-)
- Site, as random effect → random effect of location explains more variance than fixed effects alone
- R^2 = 0.28-0.49

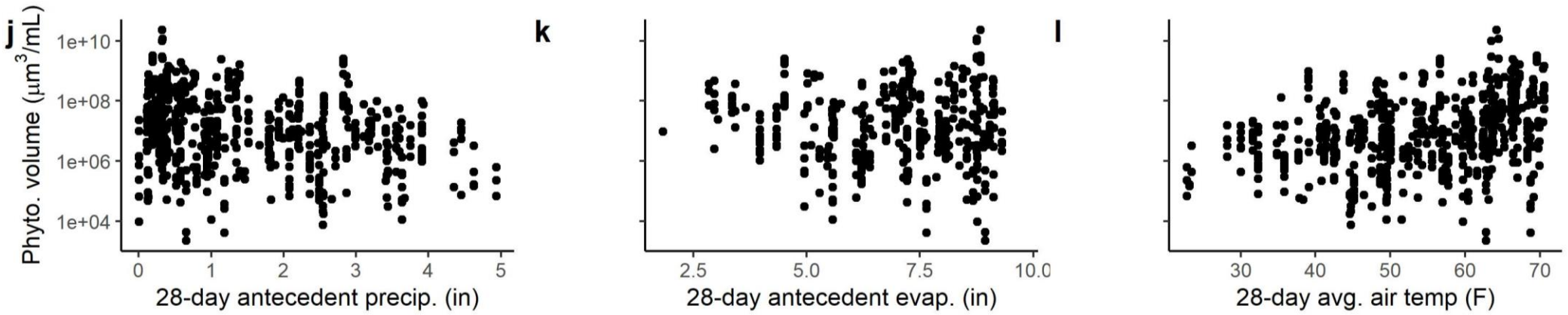


4. PLANKTON SPATIAL AND TEMPORAL ANALYSIS

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

Significant predictors from 28-day antecedent conditions:

- Precipitation (-)
- Evaporation (-)
- Air temperature (+)
- Model also includes log(TP) and site as random effect (R^2 = 0.30-0.41)

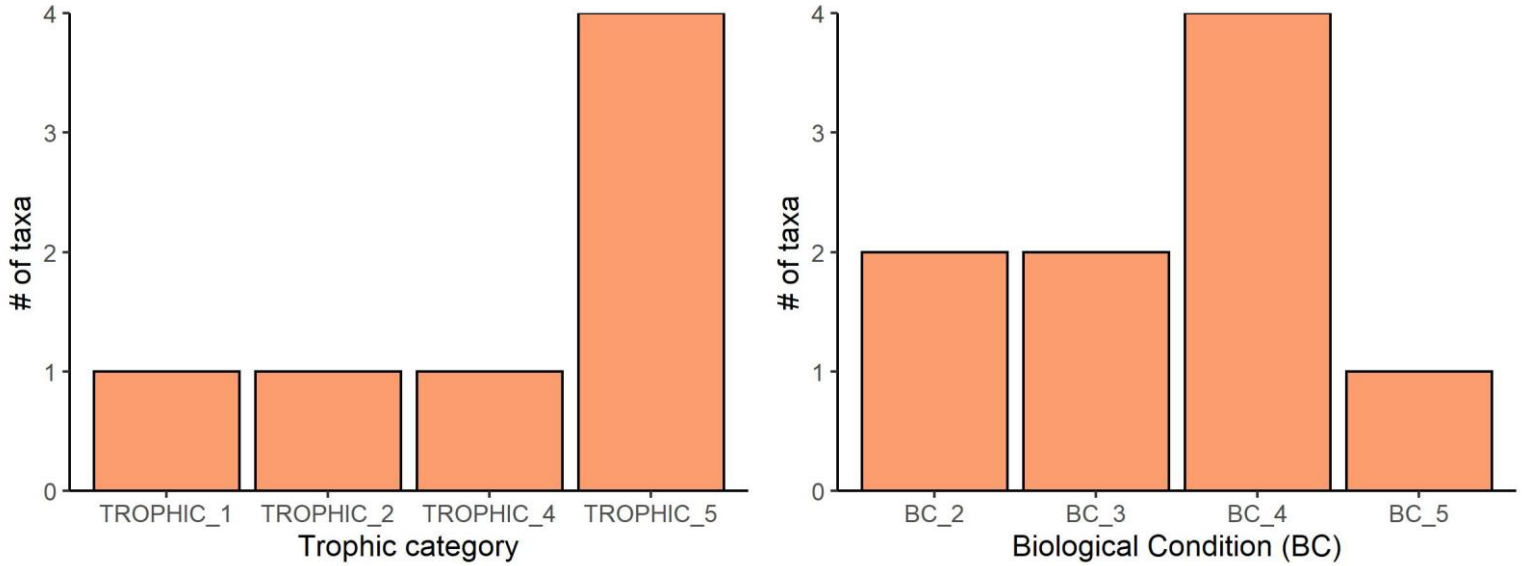


5. DIATOM AND MACROPHYTE AUTOECOLOGY

Objective: Identify the autoecology of Utah Lake diatom and macrophyte species
(Charge Q 2.2: What are the environmental requirements for submerged macrophytes currently present at Utah Lake?)

Current diatoms:

- Range of trophic categories, most common is eutrophenic taxa (5)
- Range of biological conditions, ranging from moderately sensitive (2) to highly tolerant (5)



5. DIATOM AND 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
(Charge Q 2.2.ii: What is the relationship between carp, wind, and macrophytes on non-algal turbidity and nutrient cycling in the lake? What impact could macrophyte reestablishment have?)

Methods

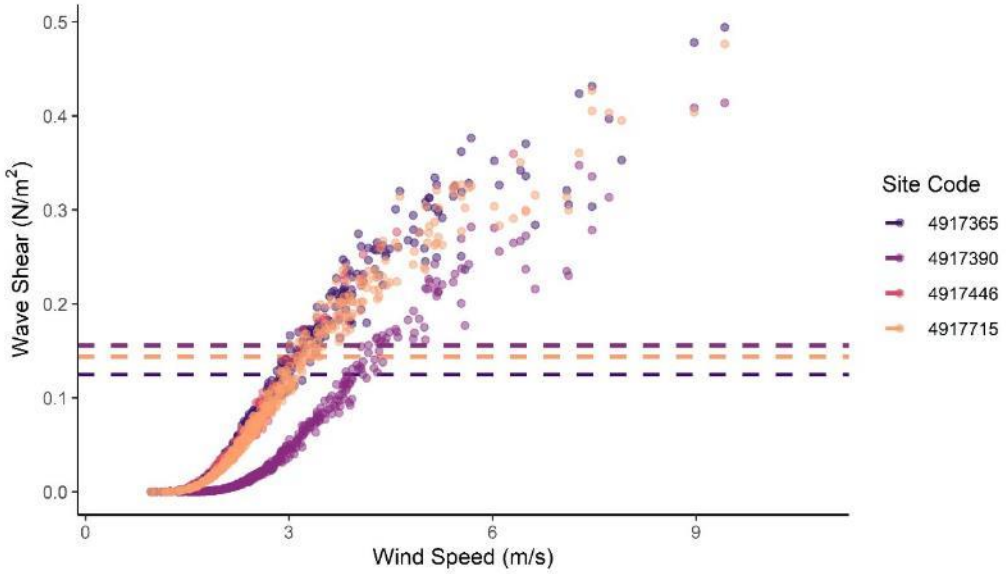
- Wind speed and direction: Provo Airport (also compared w/ Lindon & Spanish Fork)
- Buoy locations: calculate fetch, wave shear stress

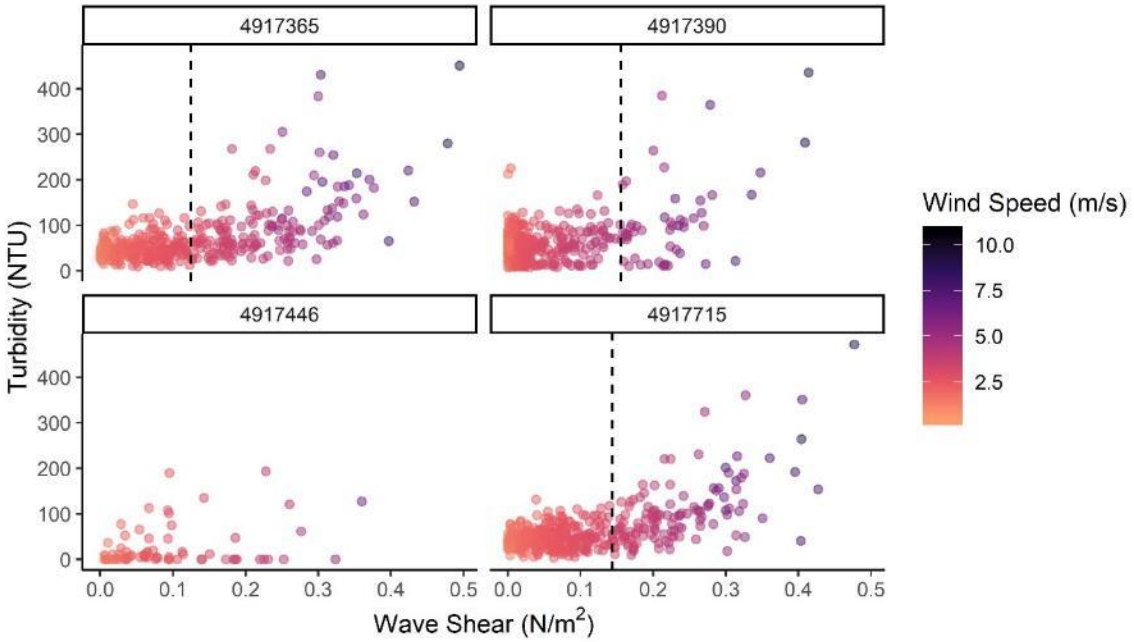
$$\tau_{WAVE} = 0.5 \times \rho \times f_W \times U_w^2$$

- Calculate critical shear value for sediment resuspension

6. WIND AND TURBIDITY: TAKEAWAYS

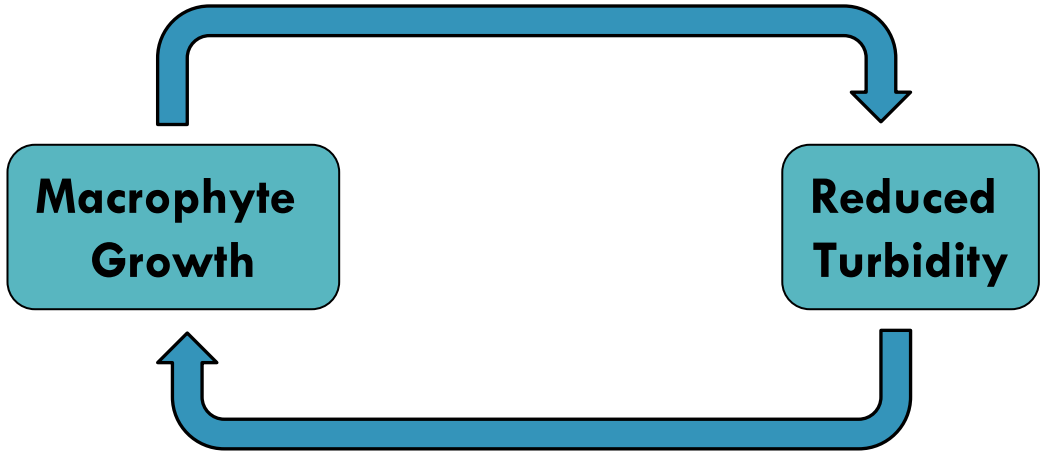
- Wind conditions are sometimes, but not usually sufficient to entrain sediments
- High turbidity under low wind could be a function of slow sinking rates and/or carp





7. TURBIDITY AND MACROPHYTES

Objective: Identify the potential contribution of macrophytes to reducing turbidity
(Charge Q 2.2.ii: What is the relationship between carp, wind, and macrophytes on non-algal turbidity and nutrient cycling in the lake? What impact could macrophyte reestablishment have?)

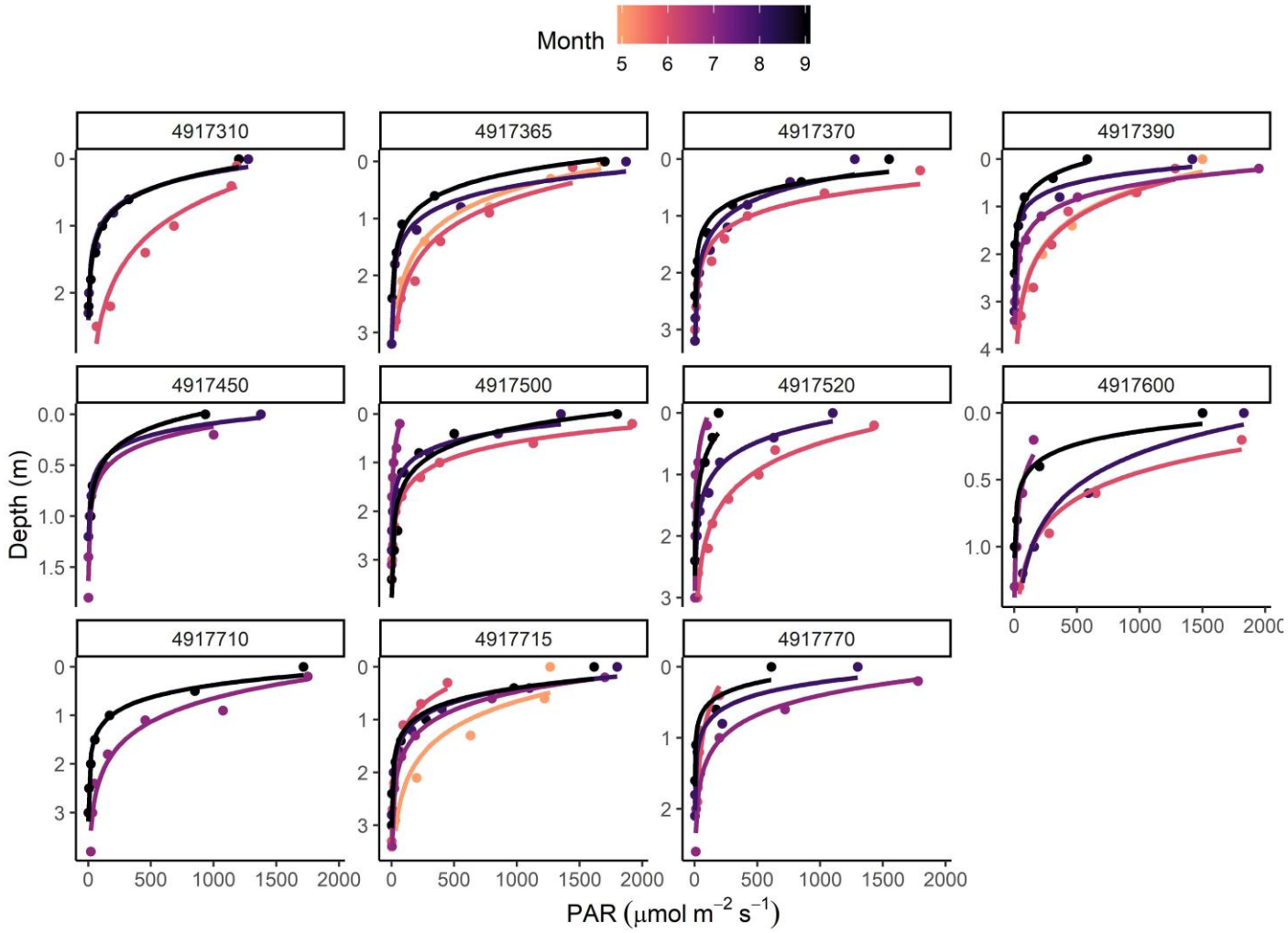


Macrophyte reduction in wave shear	Samples exceeding critical shear
0 % (current)	22 %
20 %	15 %
40 %	6 %
60 %	1 %
80 %	0 %

8. LIGHT EXTINCTION

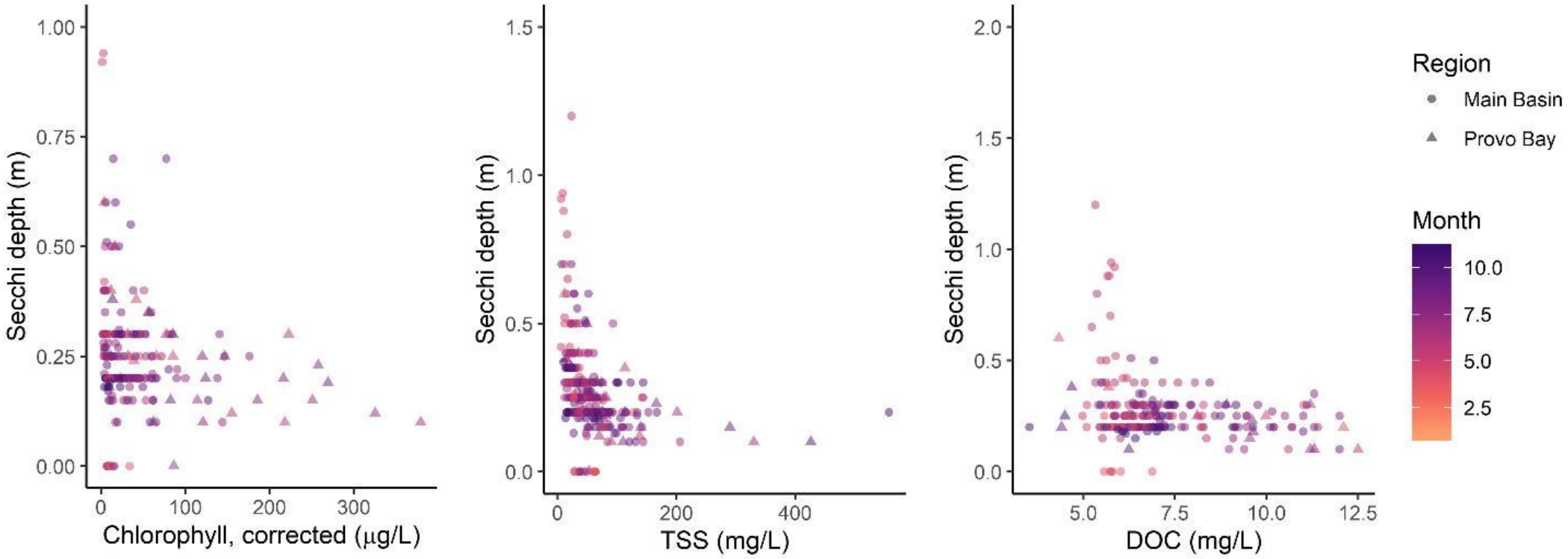
Objective: Identify the potential contribution of turbidity/TSS and algal biomass to turbidity

(Charge Q 2.3.vi: What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?)



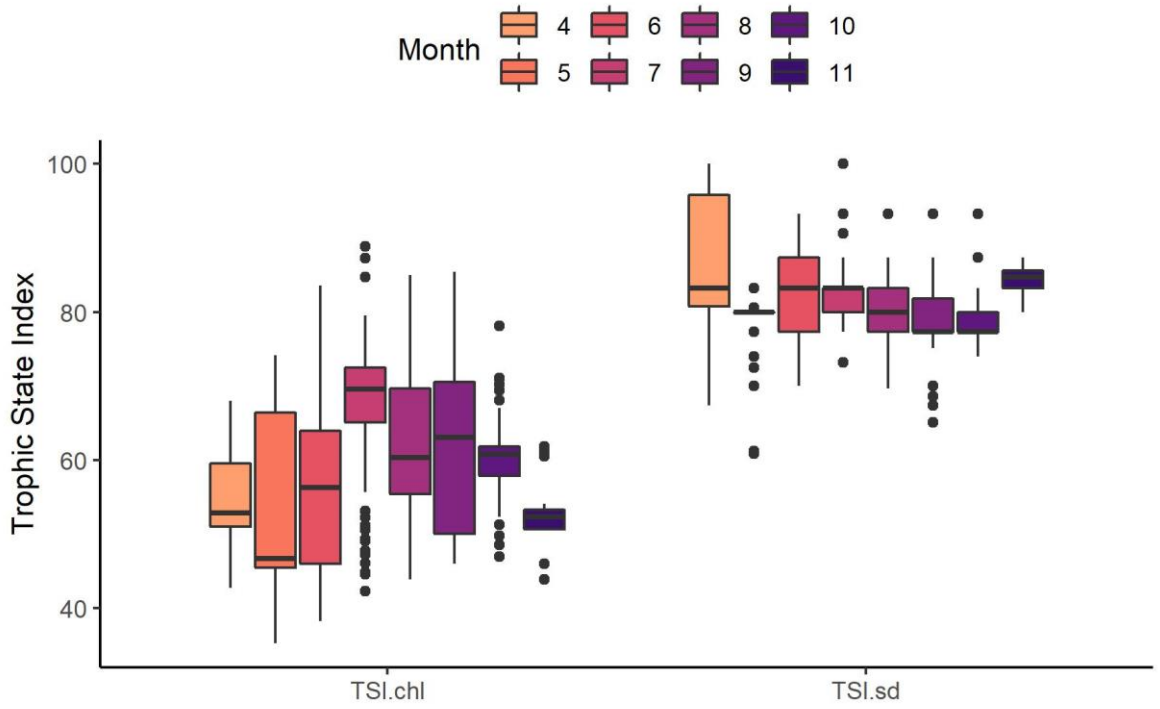
8. LIGHT EXTINCTION

Multiple constituents correlate with light extinction in Utah Lake



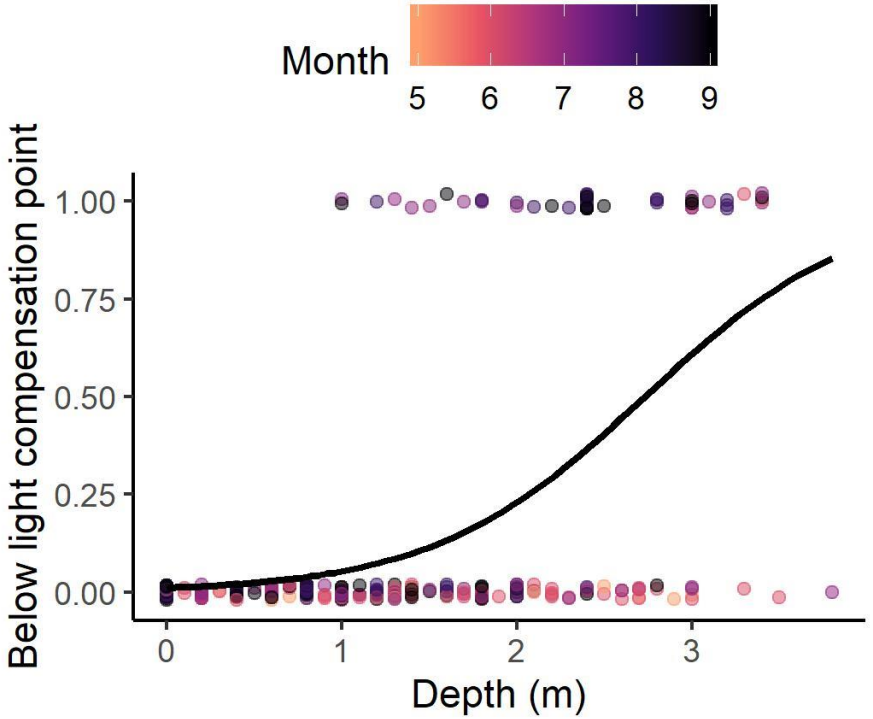
8. LIGHT EXTINCTION

Most light extinction in Utah Lake is non-algal turbidity



8. LIGHT EXTINCTION

- Reduced clarity limits macrophyte growth, particularly at deeper sites
- Deeper depths are more likely to be below the light compensation point (seasonality matters too)
- Shallow zones may be best option for macrophyte restoration (though macrophytes increase clarity)



DISCUSSION AND QUESTIONS

Next steps recap

- Technical Framework
  - Pending discussion today, Management Goals table goes out to Science Panel
  - Incorporate into revised Framework for review
- Strategic Research Plan
  - Incorporate revised Framework elements as needed
  - Circulate framework and SRP together
- Analysis Report and Data Explorer (https://tetratech-wtr-wne.shinyapps.io/UtahLakeDataExplorer/)
  - Incorporate SP feedback
  - Send approved version to SC for review