Historical Condition Charge Question Update

SUBGROUP MEMBERS: JANICE BRAHNEY, SOREN BROTHERS, GREG CARLING, MITCH HOGSETT, MICHAEL MILLS, HANS PAERL

SCIENCE PANEL 10/20 MEETING

CHARGE QUESTIONS

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?

i. Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?

iii. How have environmental conditions changed over time?

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)

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?

4.1. What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources? This question may require the identification of primary sources of nutrients.

MAIN EVIDENCE LIST

Brimhall. 1972. Recent history of Utah Lake as reflected in its sediments. A first report. Geology Studies Volume 19 part 2. Brigham Young University

Bolland RF. 1974. Paleoecological interpretation of the diatom succession in the recent sediments of Utah Lake, Utah. University of Utah PhD Dissertation.

Javakul, Grimes, and Rushforth. 1983. Diatoms in sediment cores in Utah Lake, Utah. U.S.A. Hydrobiologia 98: 159-170.

King LR. 2019. The response of Utah Lake's plant and algal community structure to cultural eutrophication. Utah State University Master's Thesis.

Brahney, J et al. 2021. Paleolimnology of Utah Lake Update, presentation to the Utah Lake Science Panel

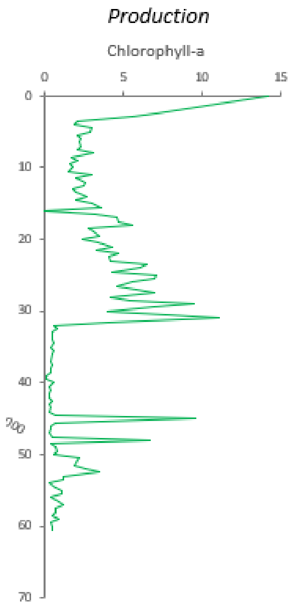
Williams, R., 2021. Determining the anthropogenic effects on eutrophication of Utah Lake since European settlement using multiple geochemical approaches. BYU Master's Thesis

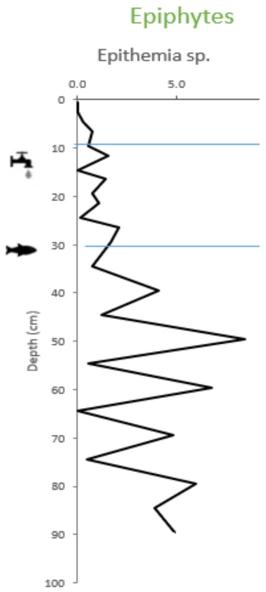
INTERIM SYNTHESIS STATEMENTS

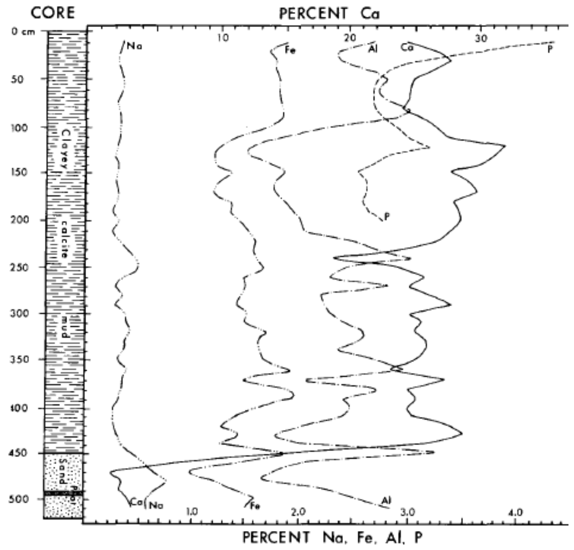
Charge Question #1 **1.1. What does the diatom community and macrophyte community in the paleo record tell us about the historical trophic state and nutrient regime of the lake?**

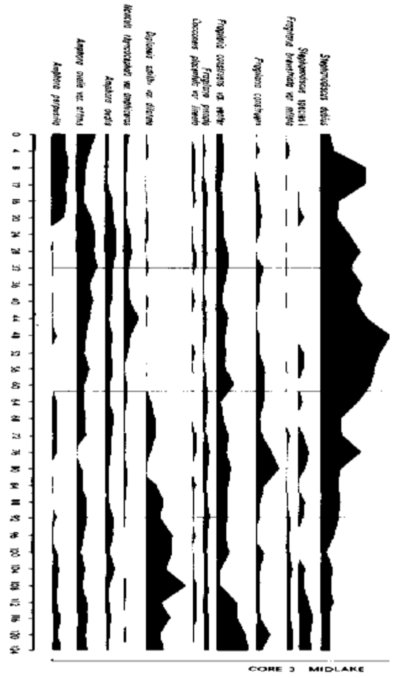
- Overall, there is a higher degree of eutrophication and nutrient concentrations in Utah Lake at present compared to pre-industrial times, with associated shifts in the biological community that is preserved in the paleolimnological record.

The assessments of confidence around these relationships are detailed as part of the response for each relevant sub-question.





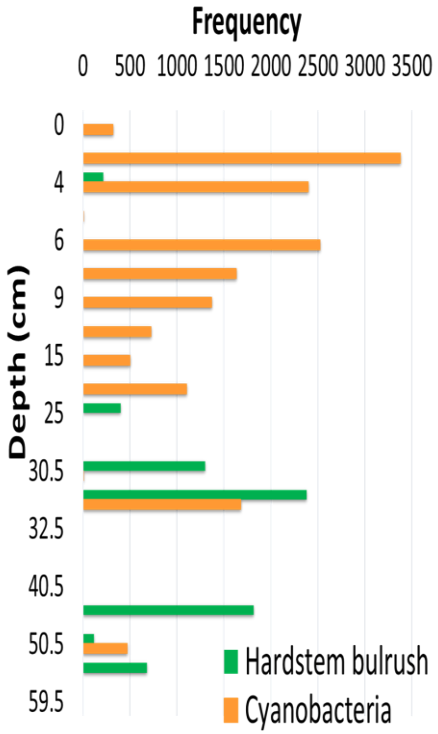


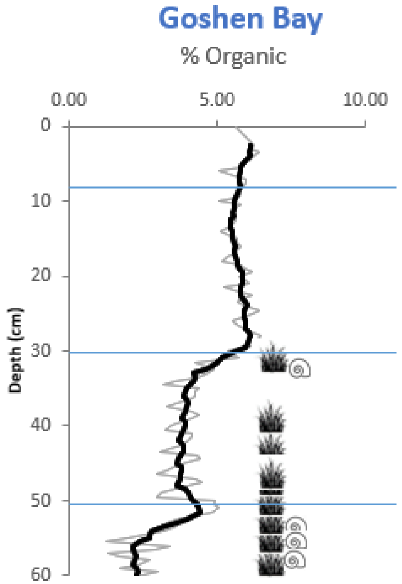


INTERIM SYNTHESIS STATEMENTS

Charge Question #2 **1.1.i. Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?**

- Given the available information, the SP has **high confidence** that <u>diatoms and macrophytes can be detected in sediment cores</u>. Historical presence of hardstem bulrush has been confirmed at GB and PB sites, Gastropods feed on plant material and their presence in the historical sediments of Goshen Bay and Provo Bay suggest that plant material was readily available near these cores. Benthic and epiphytic diatoms dominated under pre-industrial conditions in GB and BI, with an increasing relative prevalence of planktonic diatoms approaching present day

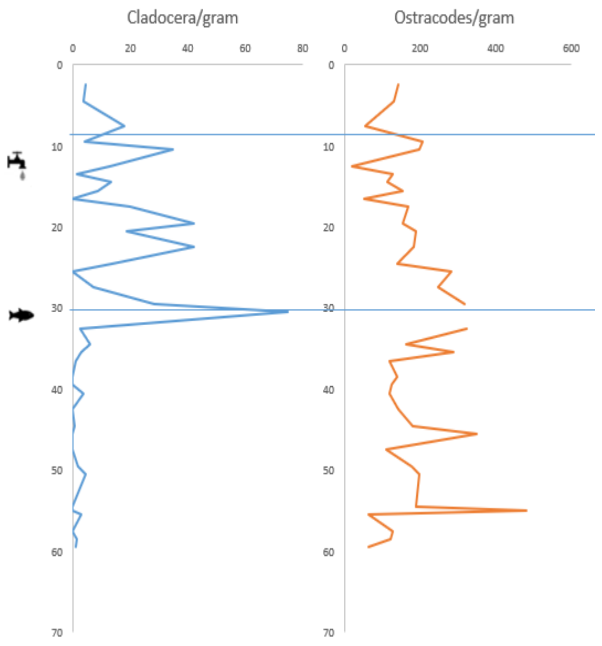


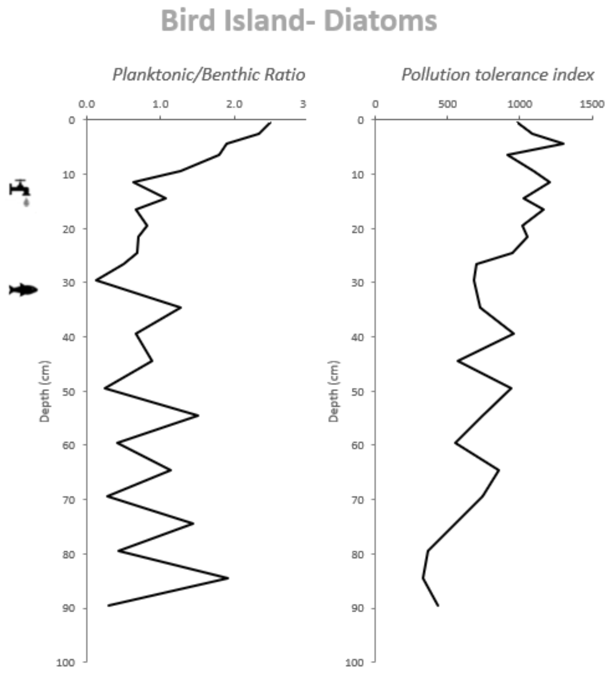


INTERIM SYNTHESIS STATEMENTS

Charge Question #3 **How have environmental conditions changed over time?**

Given the available information, the SP has **high confidence** that environmental conditions have <u>changed from oligo-mesotrophic conditions to eutrophic conditions</u> with a prevalence of pollution-tolerant taxa from preindustrial times to present day. Anodonta mussel shells were collected from BI and N cores and may be sensitive to turbidity as well as fish extirpation. The SP **has medium confidence** that the <u>historical macrophyte-dominated state was negatively impacted by reductions in water clarity</u>, but relationships evaluating the mechanistic link with nutrients will require further study as part of the EFDC-WASP application to Utah Lake.

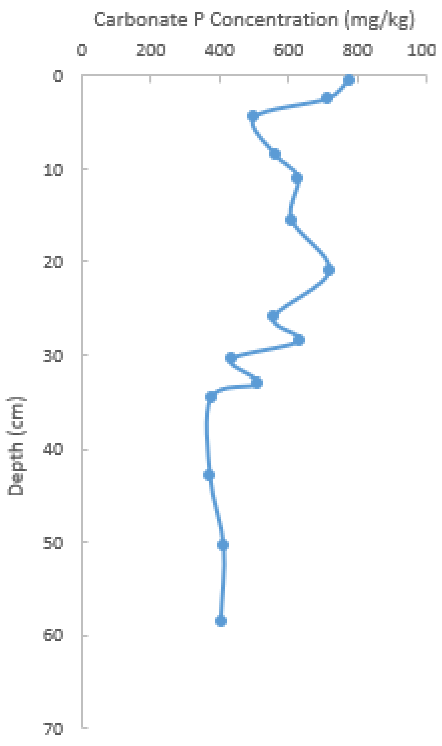


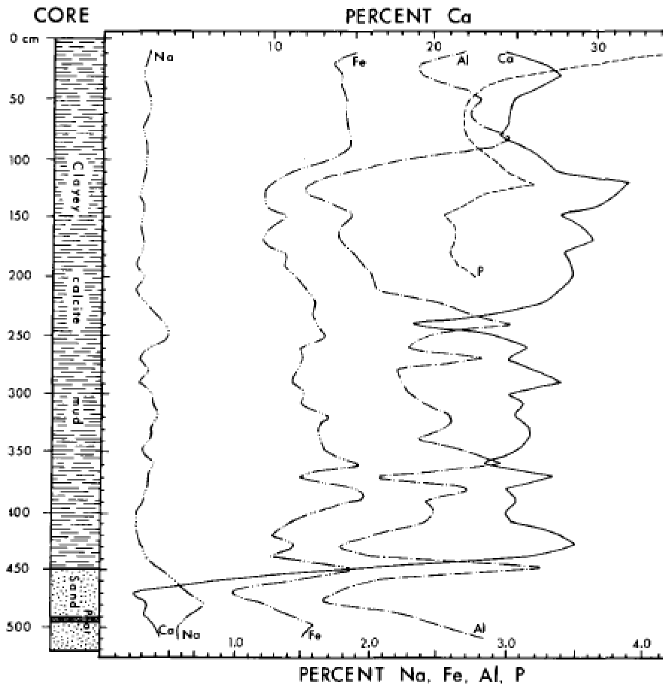


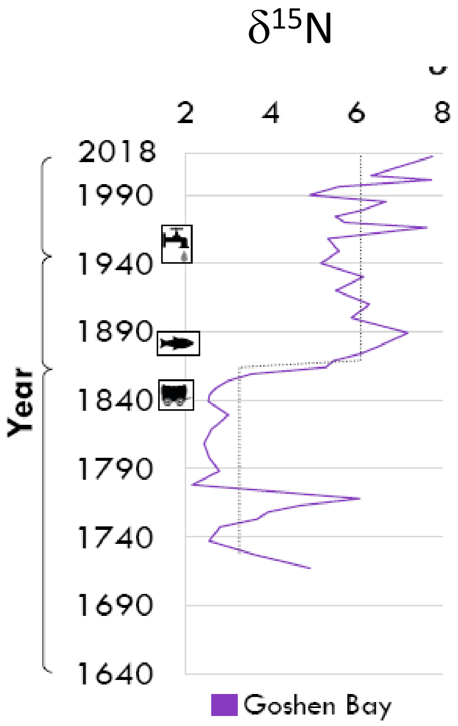
INTERIM SYNTHESIS STATEMENTS

Charge Question #3 **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)**

Given the available information, the SP has **high confidence** that concentrations and forms of P, N, silicon, calcium, iron, and aluminum have changed from preindustrial times to present day, with indicators consistently pointing to a shift to more eutrophic conditions in Utah Lake.





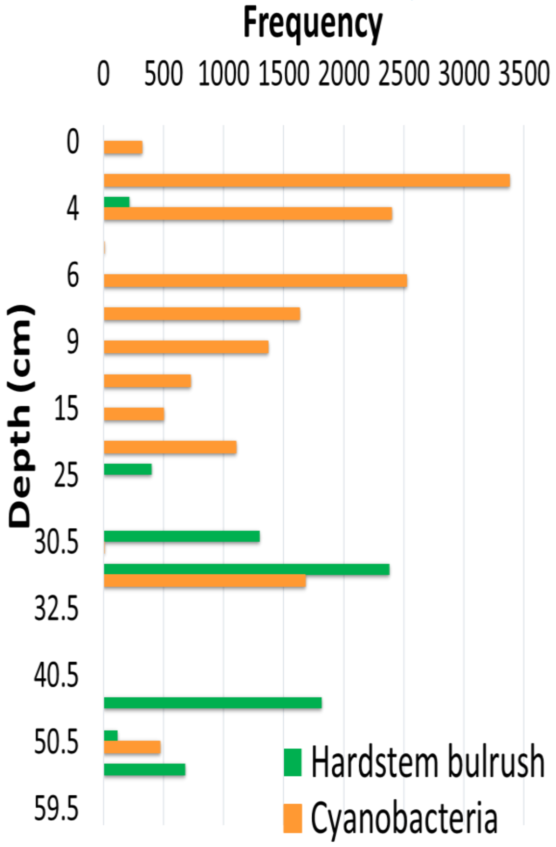


INTERIM SYNTHESIS STATEMENTS

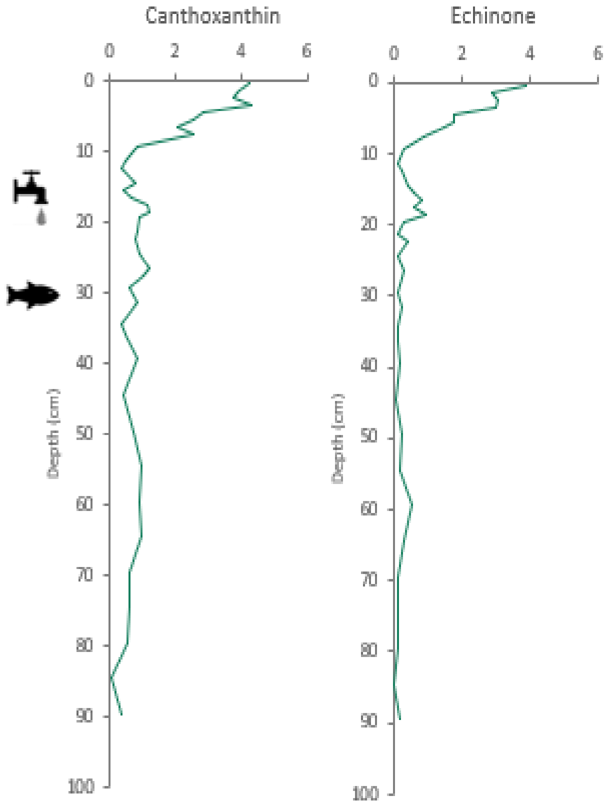
Charge Question #3 **1.4. What do phytopigments and DNA in the paleo record tell us about the historical water quality, trophic state, and nutrient regime of the lake?**

Given the available information, the SP has **high confidence** that the independent lines of evidence from phytopigments and DNA show a <u>shift from oligo-mesotrophic conditions to eutrophic conditions</u> from pre-industrial time to present, indicative of an increase in nutrient abundance, in Utah Lake

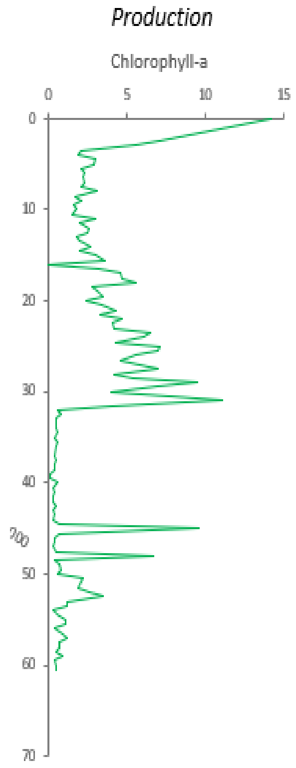
Goshen Bay



Bird Island



Goshen Bay



INTERIM SYNTHESIS STATEMENTS

Charge Question #3 **4.1. What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources? This question may require the identification of primary sources of nutrients.**

Given the available information, the SP hypothesizes the current nutrient regime of Utah Lake would be lower under a reduced human nutrient input scenario. However, direct evidence to answer this question has been limited to date and this statement thus has **low confidence**. Upcoming work with the ULWQS will increase confidence to assess this question.

FORTHCOMING STUDIES AND ANALYSES

1. Mechanistic lake (EFDC-WASP) and watershed modeling (Tetra Tech)
2. Utah Lake nutrient mass balance and internal loading analysis (Michael Brett)
3. Paleolimnological back-calculation of P mass balance?
4. Analysis of cladocera species composition and size structure as well as chironomid community composition
5. Paleo study by Steve Nelson and student

Macrophytes and Diatoms Charge Question Update

SUBGROUP MEMBERS: JANICE BRAHNEY, SOREN BROTHERS, MITCH HOGSETT, JAMES MARTIN

SCIENCE PANEL 10/20 MEETING

CHARGE QUESTIONS

- 1.1.ii. What were the environmental requirements for diatoms and extant and locally extirpated macrophyte species?
- 2.2 What are the environmental requirements for submerged macrophytes currently present at Utah Lake?
  - i. What is the role of lake elevation and drawdown in macrophyte recovery? Are certain species more resilient to drawdowns and nutrient related impacts? Can some species establish/adapt more quickly?
  - 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?
- 4.2. Assuming continued carp removal and current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30-50 years)?

EVIDENCE LIST

- Utah Lake Specific Literature
  - 8 studies
    - Bollard, Brahney, Brotherson, King, Landom and Miller et al.
- Shallow Lake Literature
  - 7 studies
- June Sucker Recovery Program Research
- ULWQS Analysis Report (Tetra Tech)

INTERIM SYNTHESIS STATEMENTS

What were the environmental requirements for diatoms and extant and locally extirpated macrophyte species?

- "The SP has **medium confidence that historical macrophyte communities in Utah Lake were made up of clear-water submerged species** including stoneworts as well as emergent macrophytes such as hardstem bulrush (Goshen Bay) since these species have been identified in the sediments."
- Phragmites are an invasive species along the shoreline and efforts to remove phragmites are ongoing.

Officials conduct a controlled burn Tuesday at Utah Lake to destroy an invasive reed that harms native vegetation. | Stuart Johnson, Deseret News | Purchase Photo

INTERIM SYNTHESIS STATEMENTS

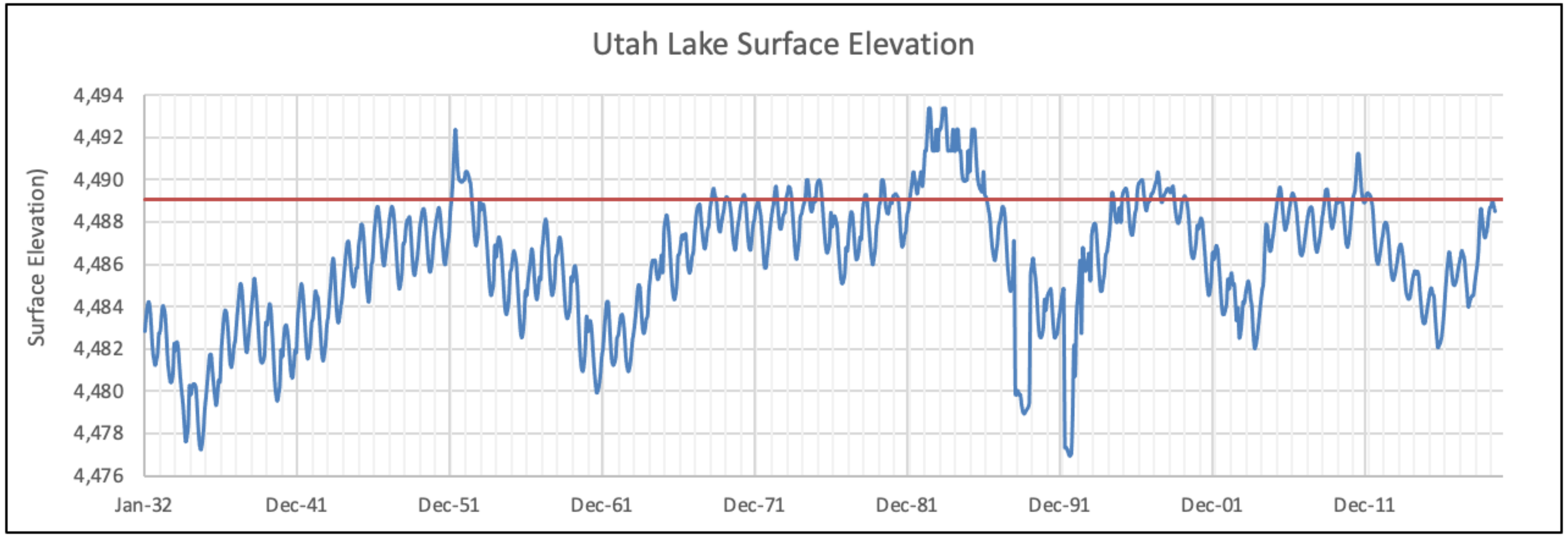
2.2. What are the environmental requirements for submerged macrophytes currently present at Utah Lake?

- "The SP has **medium confidence that submerged macrophytes in Utah Lake require higher water clarity than currently exists in Utah Lake**. Additional considerations that will impact macrophyte recovery in the lake include sediment substrate and sheltering from mechanical disturbance, which have not been evaluated in Utah Lake to date, as well as water level."

INTERIM SYNTHESIS STATEMENTS

2.2.i. What is the role of lake elevation and drawdown in macrophyte recovery? Are certain species more resilient to drawdowns and nutrient related impacts? Can some species establish/adapt more quickly?

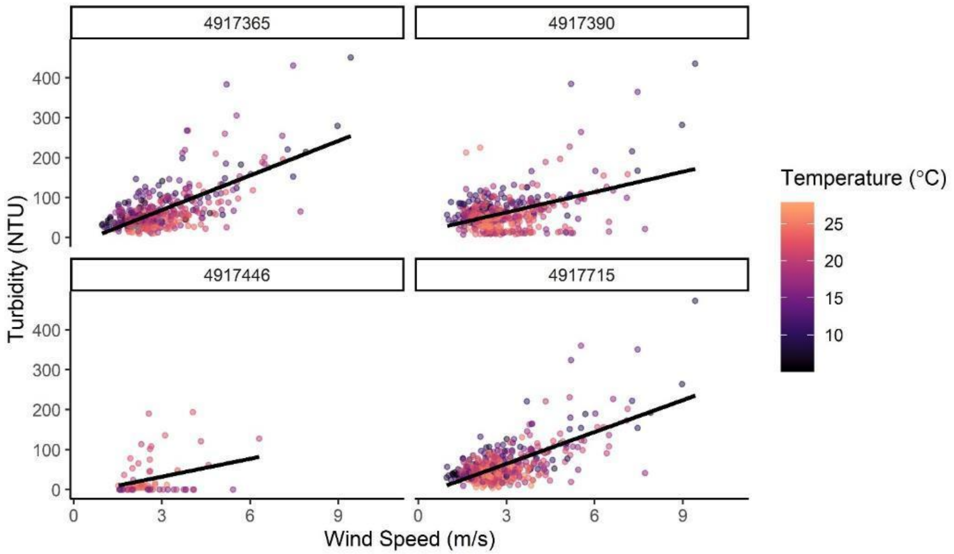
- "The SP has **medium confidence that low water levels in Utah Lake negatively impact the growth and reestablishment of submerged macrophytes, while emergent macrophytes are less affected by variable water levels**. If Utah Lake historically experienced seasonal changes in water level, macrophyte communities may be more resilient to water level-related changes if they mimic natural variability in magnitude and timing."



INTERIM SYNTHESIS STATEMENTS

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?

- "The SP has **high confidence** that wind and carp increase non-algal turbidity in Utah Lake, with wind being the primary hypothesized driver of increases in turbidity and carp being a contributing factor. Macrophyte recovery has the capacity to stabilize sediments and reduce sediment resuspension events, although there is a **good deal of uncertainty around the magnitude of this relationship**."
    - ~75% of turbidity is non-algal



INTERIM SYNTHESIS STATEMENTS

4.2. Assuming continued carp removal and current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30-50 years)?

- "The SP hypothesizes that nutrient management and carp removal efforts will improve environmental conditions relevant for macrophyte reestablishment. However, direct evidence about the potential magnitude of these improvements is not currently available, and this statement thus has **low confidence**."
  - Carp disturb sediments (consume vegetation, increase turbidity, increase sediment nutrient release)

The Utah Department of Natural Resources and other agencies remove carp from Utah Lake near Sandy Beach through the ice as part of the states effort to improve the lake Tuesday, Jan. 21, 2014. To date nearly 13.6 million pounds of carp have been removed. | Jeffrey D. Allred,

FORTHCOMING STUDIES AND ANALYSES

- EFDC-WASP modeling

Sediments Charge Question Update

SUBGROUP MEMBERS: GREG CARLING, JANICE BRAHNEY, JAMES MARTIN, MITCH HOGSETT, THERON MILLER

SCIENCE PANEL 10/20 MEETING

CHARGE QUESTIONS

2.4. How do sediments affect nutrient cycling in Utah Lake?

i. What are current sediment **equilibrium P concentrations** (EPC) throughout the lake?

What effect will reducing inputs have on water column concentrations? If so, what is the expected **lag time for lake recovery** after nutrient inputs have been reduced?

ii. What is the **sediment oxygen demand of, and nutrient releases** from, sediments in Utah Lake under current conditions?

iii. **Does lake stratification [weather patterns] result in anoxia and phosphorus release** into the water column? Can this be tied to HAB formation?

EVIDENCE LIST

Goel R, Carling G, Li H, Smithson S. 2020. Utah Lake sediment-water nutrient interactions. Final Report. Prepared for Utah Department of Environmental Quality.

Hogsett M, Li H, Goel R. 2019. The role of internal nutrient cycling in a freshwater shallow alkaline lake. Environmental Engineering Science 36(5): 551-563.

Randall MC, Carling GT, Dastrup DB, Miller T, Nelson ST, Rey KA, Hansen NC, Bickmore BR, Aanderud ZT. 2019. Sediment potentially controls in-lake phosphorus cycling and harmful cyanobacteria in shallow, eutrophic Utah Lake. PLoS ONE 14(2): e0212238.

Tetra Tech. 2021. Utah Lake Carbon, Nitrogen, and Phosphorus Budgets Study. Draft report submitted to Utah Division of Water Quality.

INTERIM SYNTHESIS STATEMENTS

2.4.i. What are current sediment equilibrium P concentrations (EPC) throughout the lake? What effect will reducing inputs have on water column concentrations? If so, what is the expected lag time for lake recovery after nutrient inputs have been reduced?

“Given the available information, the **SP has low confidence in the ability to assess EPC** in Utah Lake, the impacts of reduced P loading, and the expected lag time between reducing P inputs and lower water column P concentrations given the capacity for internal sediment loading. The SP hypothesizes that EPC is such that reducing P inputs may cause an increase in internal sediment P loading, but it is unclear how long elevated internal loading may last. Upcoming work with the ULWQS will increase confidence to assess this question.”

INTERIM SYNTHESIS STATEMENTS

2.4.ii. What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions?

“Given the available information, the SP has high confidence that the sediments in Utah Lake consume oxygen, with higher rates in Provo Bay (4.5 g m^{-2} d^{-1}) than in the main basin (1-3 g m^{-2} d^{-1}). The sediments overall represent a net sink for total nutrients, but bioavailable forms of N and P (soluble reactive P/orthophosphate, ammonium, nitrate) are released from the sediments depending on water column chemistry and organic matter content of sediments.“

INTERIM SYNTHESIS STATEMENTS

2.4.iii. Does lake stratification [weather patterns] play a result in anoxia and phosphorus release into the water column? Can this be tied to HAB formation?

“Given the available information, the SP has medium confidence that lake thermal stratification does not occur on a widespread seasonal scale, and the potential impacts on bottom water redox conditions and P release from the sediments are limited. Alternate processes, including anoxic microzones, diel fluctuations in water column DO, and sediment resuspension are mechanisms that are more likely at play in Utah Lake.”

FORTHCOMING STUDIES AND ANALYSES

- Mechanistic lake (EFDC-WASP) and watershed modeling (Tetra Tech)
- Paleolimnological study
- P binding study
- Littoral sediment study
- TSSD Limnocorral Study

Fish, Aquatic Life, and Birds Charge Question Update

SUBGROUP MEMBERS: MICHAEL BRETT, SOREN BROTHERS, MITCH HOGSETT, THERON MILLER, MICHAEL MILLS

SCIENCE PANEL 10/20 MEETING

CHARGE QUESTIONS

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?

2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

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?

ii. What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?

iii. How much non-algal turbidity and nutrient cycling is due to wind action versus carp foraging? How much does sediment resuspension contribute to light limitation, and does wind resuspension contribute substantially in the absence of carp?

2.5. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife:

i. Where and when in Utah Lake are early life stages of fish present?

ii. Which species are most sensitive and need protection from nutrient-related impacts?

EVIDENCE LIST

- Paleo Study - King 2019
- Carp Excretion Estimates – Tetra Tech 2021
- Carp Studies – Miller and Provenza 2007; Miller and Crowl 2006; Landom et al. 2019
- Wind vs Carp – Miller and Crowl 2006; Landom et al. 2019; Tetra Tech 2021
- Early fish life stages – PSOMAS and SWCA 2007
- Species sensitivity - NA

INTERIM SYNTHESIS STATEMENTS

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?

Given the available information***, the SP has medium confidence that the introduction of carp to Utah Lake circa 1881 is associated with a transition to eutrophic conditions***, around the same time that evidence of wastewater treatment nutrient effluent loads were also detected. Given the concurrent timing of carp introduction and increases in anthropogenic nutrient loading, it is challenging to parse the specific mechanisms and magnitude of the impacts of carp alone on the trophic state of Utah Lake.

Justification: One study of direct sample cores from Utah Lake

INTERIM SYNTHESIS STATEMENTS

2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

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?

Given the available information, the ***SP has medium confidence that carp excrete a substantial amount of N and P in Utah Lake***, on the order of 19-85% of external P loads, 23-60 % of P net retention, and 27-62 % of external N loads. Carp excretion represents nutrient recycling rather than a discrete input or output from Utah Lake, so comparisons of excretion rates with external loading should be made with caution.

Justification: Observational study of carp populations from Utah Lake and compiled scientific data on carp excretion rates

INTERIM SYNTHESIS STATEMENTS

2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

2.1.ii. What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?

Given the available information, the ***SP has high confidence that carp removal efforts relieve negative pressures on macrophyte community growth and reestablishment, reduce nutrient recycling through the carp population, reduce bioturbation that mobilizes sediments and creates more turbid conditions***. Macrophyte reestablishment is unlikely to occur spontaneously with carp removal efforts alone and may require active planting efforts and/or external nutrient loading reductions. Carp removal efforts may have mixed impacts on phytoplankton growth, because carp bioturbation and recycling have the capacity to both reduce transparency and also mobilize sediment nutrient pools into the water column.

Justification: Direct experimental manipulations in Utah Lake, Utah Lake excretion estimates, macrophyte recovery/stable state literature

INTERIM SYNTHESIS STATEMENTS

2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

2.1.iii. How much non-algal turbidity and nutrient cycling is due to wind action versus carp foraging? How much does sediment resuspension contribute to light limitation, and does wind resuspension contribute substantially in the absence of carp?

Given the available information, the ***SP has medium confidence that carp and wind both contribute to increased non-algal turbidity and light limitation of photosynthesis in Utah Lake***, with wind being the primary hypothesized driver of increases in non-algal turbidity. However, there is low confidence in the ability to assess the relative impacts of carp and wind, because available studies did not evaluate these impacts concurrently.

Justification: Direct experimental manipulations in Utah Lake; Utah Lake wind/shear calculations, light attenuation calculations from extensive dataset

INTERIM SYNTHESIS STATEMENTS

2.5.i. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife, where and when in Utah Lake are early life stages of fish present?

Given the available information, ***the SP has medium confidence that spawning and rearing habitat meets the needs for some species in certain in-lake and tributary sites in Utah Lake but does not for other species and sites***. The tables above provide more detail on specific species and sites.

Justification: Direct observational data from Utah Lake in TMDL study with literature derived habitat needs

INTERIM SYNTHESIS STATEMENTS

2.5.ii. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife, which species are most sensitive and need protection from nutrient-related impacts?

Given the available information, the ***SP is not prepared to assess which species are in need of protection from nutrient-related impacts***.

Justification: Existing research hss not focused on sensitivity of June Sucker to nutrients

HABs
Charge Question Update

SUBGROUP MEMBERS: JANICE BRAHNEY, MITCH HOGSETT, THERON MILLER, HANS PAERL

SCIENCE PANEL 10/20 MEETING

CHARGE QUESTIONS

- 2.3. What are the linkages between changes in nutrient regime and Harmful Algal Blooms (HABs)?
  - i. Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?
  - ii. Which nutrients are controlling primary production and HABs and when?
  - iii. If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?
  - iv. How do other factors affect HAB formation in Utah Lake (e.g., climate change; temperature; lake stratification; changes in zooplankton and benthic grazers and transparency)
  - v. What is the role of calcite "scavenging" in the phosphorus cycle?
  - vi. What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?
- 4.3. If the lake stays in a phytoplankton-dominated state, to what extent can the magnitude, frequency, and extent of harmful and nuisance algal blooms be reduced through nutrient reductions?

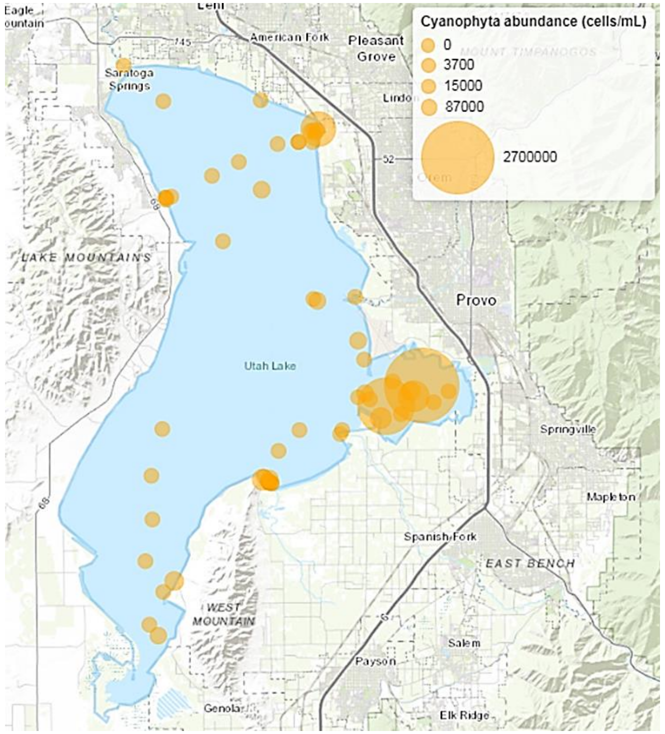
EVIDENCE LIST

- DWQ Monitoring Data
- Bioassay Study (Aanderud Group)
- ULWQS Analysis Report (Tetra Tech)

INTERIM SYNTHESIS STATEMENTS

Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?

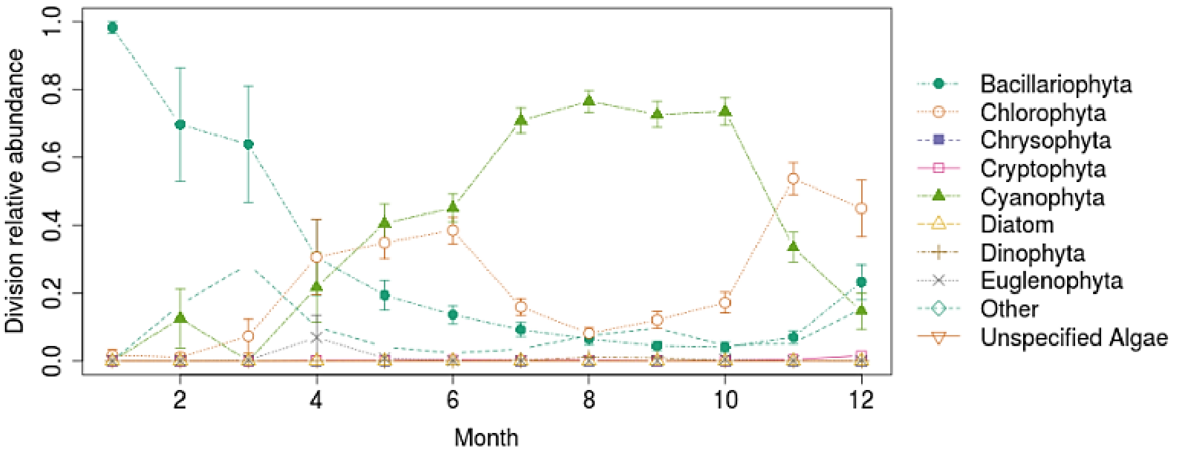
The SP has medium confidence that cyanobacteria grow across all parts of Utah Lake, but HAB hot spots occur in Provo Bay and in the northeast part of the main basin of Utah Lake. HABs in Provo Bay occur near major nutrient sources from POTWs, but it is unclear if HABs in the northeast main basin occur due to a proximity to nutrient sources.



INTERIM SYNTHESIS STATEMENTS

Which nutrients are controlling primary production and HABs and when?

The SP is highly confident that both N and P limit primary production in Utah Lake, and the degree of limitation of one or both nutrients varies across the growing season, location in the lake, and taxa of interest



East	No limitation	No limitation	P	No limitation	No limitation
West	N+P	No limitation	N	No limitation	No limitation
Provo Bay	P	N+P	P	No limitation	No limitation

Total phytoplankton nutrient limitation

East	No limitation	N+P	N+P	N+P	N+P
West	P	No limitation	N+P	N+P	N+P
Provo Bay	N+P	N	N	N+P	N

INTERIM SYNTHESIS STATEMENTS

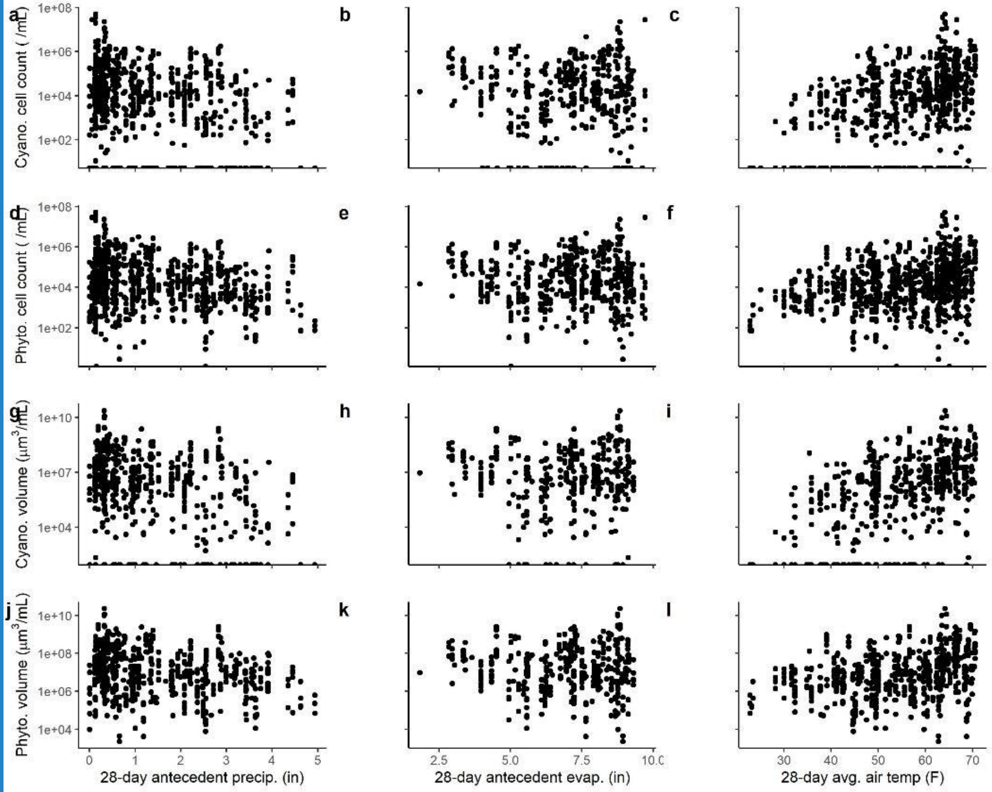
If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?

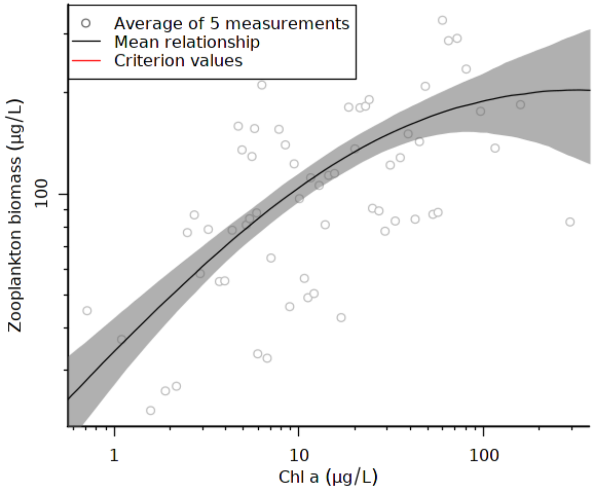
The SP has a medium degree of confidence that lower lake elevations are associated with larger HABs. However, lake elevation appears to have a smaller impact than nutrients, and lake elevation encompasses several possible drivers which may co-occur in Utah Lake and should be parsed as part of future efforts.

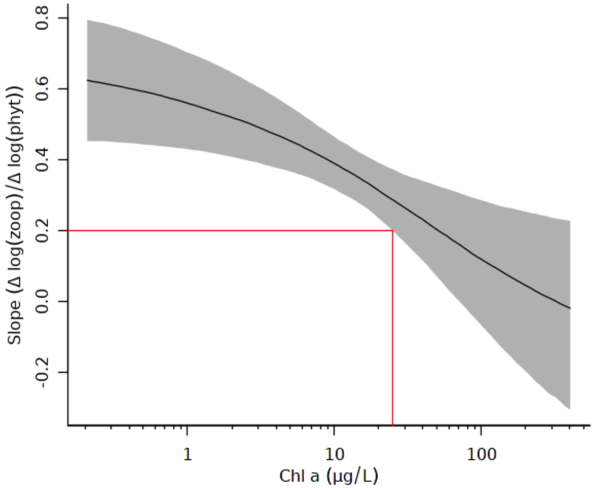
INTERIM SYNTHESIS STATEMENTS

How do other factors affect HAB formation in Utah Lake (e.g., climate change; temperature; lake stratification; changes in zooplankton and benthic grazers and transparency)

The SP has medium confidence that climate-related factors (precipitation, evaporation, air temperature) may have significant impacts on HAB formation in Utah Lake, with negative relationships between HABs and precipitation and evaporation, and positive relationships between HABs and temperature. The SP has medium confidence that lake stratification is unlikely to impact HABs in Utah Lake due to the transient nature of thermal stratification. The impact of zooplankton and benthic grazers on HABs in Utah Lake is unknown at this time.







INTERIM SYNTHESIS STATEMENTS

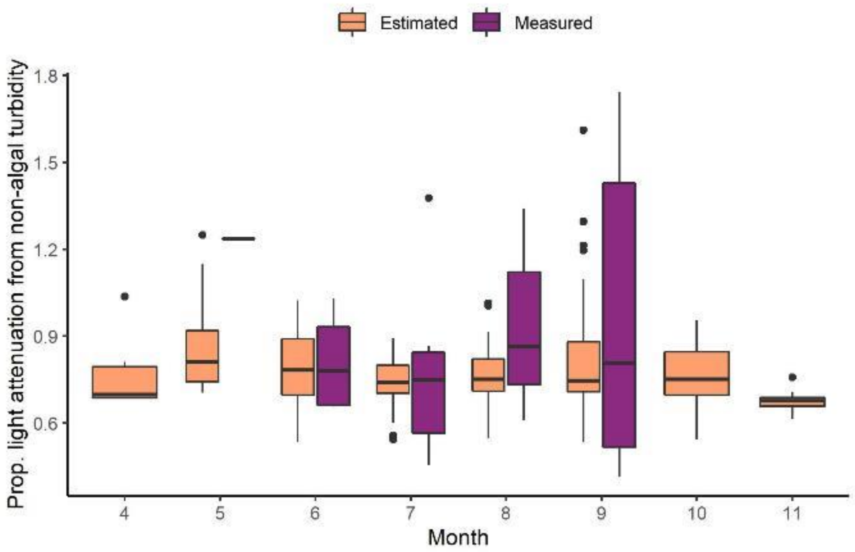
What is the role of calcite “scavenging” in the phosphorus cycle?

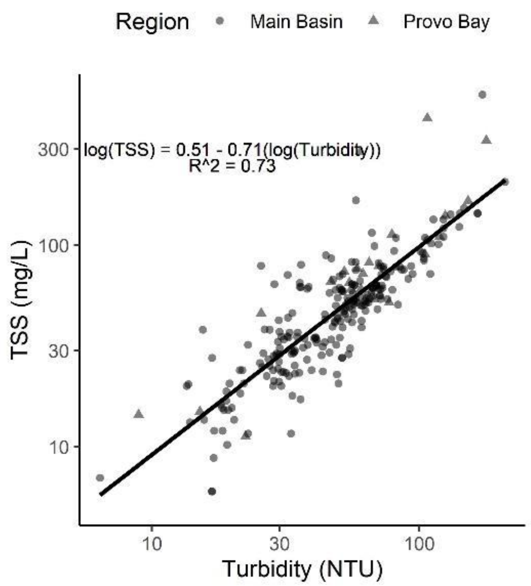
Previous work indicates that calcite precipitation may be a dominant pathway for P sedimentation in Utah Lake (LeMonte et al. 2021). Uncertainty remains as to whether calcite precipitation renders P non-bioavailable to phytoplankton, and how much sediment P returns to the water column for phytoplankton uptake. The forthcoming P binding study (LeMonte et al. 2021) will address these knowledge gaps and help to answer this question.

INTERIM SYNTHESIS STATEMENTS

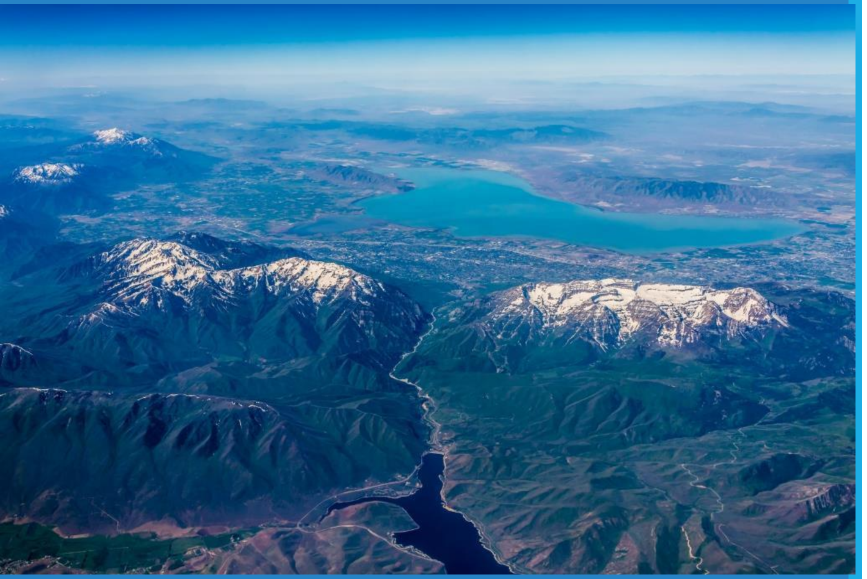
What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?

The SP has high confidence that light extinction occurs rapidly with depth in Utah Lake, and the majority of light attenuation is due to non-algal turbidity, with a minor but substantial part of light attenuation occurring due to phytoplankton.





INTERIM SYNTHESIS STATEMENTS



If the lake stays in a phytoplankton-dominated state, to what extent can the magnitude, frequency, and extent of harmful and nuisance algal blooms be reduced through nutrient reductions?

The interim assessment of the SP is that information is not currently available to evaluate this question. The SP hypothesizes that reductions in nutrients will result in decreased phytoplankton abundance, but the extent and rate of phytoplankton reductions are dependent on the combined effect of external and internal nutrient loading.

FORTHCOMING STUDIES AND ANALYSES

- P binding study
- Empirical stressor-response analyses
- EFDC-WASP modeling
- Mike Brett mass balance analysis
- Janice Brahney sediment core analysis (P bioavailability)

Criteria Development Charge Question Update

SUBGROUP MEMBERS: MITCH HOGSETT, JAMES MARTIN, THERON MILLER

CHARGE QUESTIONS

- Charge question #3 – **What additional information is needed** to define nutrient criteria that support existing beneficial uses?
  - 3.1 – For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife
  - 3.2 – For primary contact recreation
  - 3.3 – For agricultural uses including irrigation of crops and stock watering

EVIDENCE LIST

- ULWQS— Numeric Nutrient Criteria Technical Framework (Tetra Tech, 2021)
- ULWQS Management Goals: Science Panel Responses to Steering Committee Questions. (ULWQS Science Panel, 2020)

EVIDENCE LIST

- ULWQS Management Goals: Science Panel Responses to Steering Committee Questions. (ULWQS Science Panel, 2020)

Management Goal	Assessment Endpoint	Relevant to developing in-lake N and P criteria?	Is the measure currently quantifiable?
Primary contact recreation (2a)			
Harmful algal blooms (HAB) will not create toxins that threaten public health.	Algal toxin concentrations	Yes	Yes
HAB occurrence is limited in spatial extent and infrequent to support robust recreational industry and community.	Magnitude, frequency, and duration of algal blooms.	Yes	Yes
Improve submersible recreation (swimming, paddle boarding, water skiing, etc.) experience.	Magnitude, frequency, and duration of algal blooms.	Yes	Yes
Swimming beaches and shoreline access locations are open all summer without nuisance algae or public health advisories.	Magnitude, frequency, and duration of algal blooms.	Yes	Yes

Management Goal	Assessment Endpoint	Relevant to developing in-lake N and P criteria?	Is the measure currently quantifiable?
Warm Water Fishery (3b)			
Warm water fishery is robust and healthy.	Water quality conditions	Yes	Yes
Warm water fishery is robust and healthy.	Food abundance and diversity	Yes	Yes, but limited
HAB toxins do not cause fish mortality.	Algal toxin concentrations	Yes	Yes
Warm water fishery can support reproductive populations of June Sucker.	Water quality conditions	Yes	Yes
Macrophyte habitat can support June sucker recovery and early life stages of other ecologically or recreationally important fish species.	Macrophyte abundance and distribution in Provo Bay, Utah Lake Littoral Zones, and Provo River delta.	Yes	Yes, but limited

EVIDENCE LIST

- ULWQS— Numeric Nutrient Criteria Technical Framework (Tetra Tech, 2021 – SC Approved 8/25/2021)

Beneficial Use	Assessment Endpoint	Stressor	Response	Empirical S-R Data Available	Mechanistic Model Output
Recreation, Aquatic Life, Agriculture, Drinking Water	Algal toxins	Chlorophyll *a*	Microcystin concentration	Yes	No
Recreation, Aquatic Life, Agriculture, Drinking Water	Algal toxins	Cyanobacterial abundance	Microcystin concentration	Yes	No
Recreation	Algal blooms	Chlorophyll *a*	Cyanobacterial abundance	Yes	Yes
Recreation, Aquatic Life	pH	Chlorophyll *a*	pH	Yes	Yes
Recreation	Lake visitation				
Recreation	Lake visitation				
Recreation	Lake visitation				
Recreation	Public perception				

Beneficial Use	Assessment Endpoint	Stressor	Response	Empirical S-R Data Available	Mechanistic Model Output
Criteria Setting		TN	Chlorophyll *a*	Yes	Yes
Criteria Setting		TP	Chlorophyll *a*	Yes	Yes
Criteria Setting		TN	Cyanobacterial abundance	Yes	Yes
Criteria Setting		TP	Cyanobacterial abundance	Yes	Yes
Criteria Setting		TN	K_d, Secchi depth	Yes	Yes
Criteria Setting		TP	K_d, Secchi depth	Yes	Yes

INTERIM SYNTHESIS STATEMENTS

- “For each of beneficial use, several lines of evidence have available information.”
- “…the missing information is **not likely to impact confidence** in developing NNC,…”
- “The SP has **high confidence** that NNC that protect the beneficial uses of Utah Lake can be developed **with available data sources**.”

FORTHCOMING STUDIES AND ANALYSES

- Empirical stressor-response analysis
- Mechanistic lake and watershed models
- FWS & USGS studies on toxin impacts on aquatic life
- DWQ additional monitoring (e.g., saxitoxins)
- Richards et al. food web model
- Richards et al. MIBI
- RFP: Recreation perception surveys to establish water quality objectives for Utah Lake

UTAH LAKE WATER QUALITY MODEL DEVELOPMENT

ULWQS Science Panel Meeting

2021-10-20

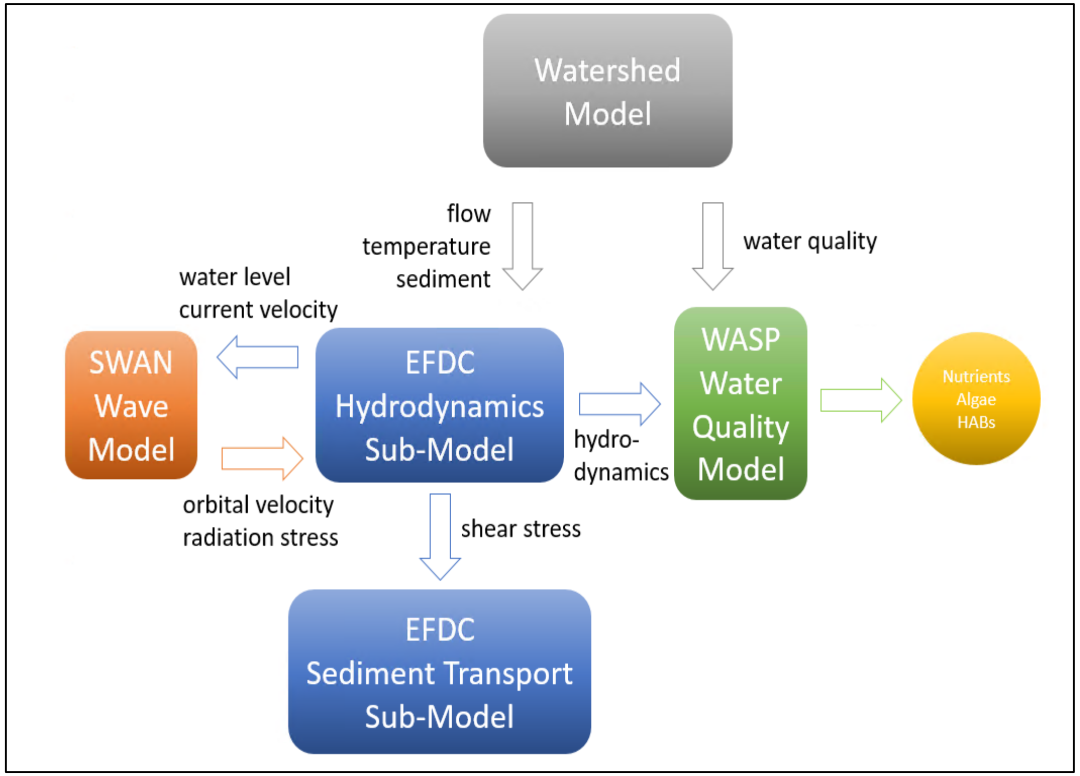
Presented by Kevin Kratt, Tetra Tech

TOPICS

- Status of modeling
- Overview of the watershed model selection approach and recommendation
- Overview of the revised EFDC and WASP Quality Assurance Project Plan (QAPP)
- Science Panel discussion
- Request Science Panel approval
- Public discussion

Status Update

- Watershed Model
  - Worked with SP to define objectives for the watershed model
  - Prepared watershed model selection technical memorandum for SP review
- Lake Model
  - Finished reviewing existing model
  - Prepared memorandum with findings/recommendations
  - Prepared updated lake modeling QAPP for SP review



Watershed model selection approach

1. Define objectives for the watershed model
2. Identify criteria based on the objectives
3. Evaluate and rank multiple models by the criteria
4. Recommend a model(s) for study

Watershed Model Objectives

- Provide appropriate temporal, spatial, and process resolution of surface water and shallow groundwater flows and pollutant loadings to Utah Lake
- Simulate continuous (as opposed to event-based) existing, historic, and potential future conditions
- Simulate point and nonpoint sources and provide output necessary to develop source assessments and allocations
- Allow for simulation of key stressors originating from the watershed (e.g., phosphorus, nitrogen)
- Provide output with sufficient accuracy to support management/regulatory decisions
- Output should be in a format that allows for linkage with the EFDC-WASP Utah Lake model

Criteria to Support Watershed Model Objectives

- Key watershed characteristics and simulation capabilities (e.g., simulates parameters of concern, simulates runoff and shallow groundwater pathways)
- Source representation (e.g., represents loads from distinct land covers, able to simulate loads from septic systems)
- Suitability criteria (e.g., feasible to link to EFDC/WASP, capable of simulating potential reductions from different sources, ease of use)
- General platform (e.g., sufficient documentation, public domain, stable code)

Watershed Model Ranking Process

- Each model criterion was rated based on relative importance
- Numeric rating scheme used to quantify and rank the modeling platforms

Criteria rating scheme (i.e., points awarded) for model evaluation

Relative Importance	Model does not meet criterion	Model partially meets criterion	Model meets criterion
Low	0	1	2
Medium	0	3	4
High	0	5	6

Table 2. Summary of model evaluation for the Utah Lake watershed

Key: green check (✓) = model meets criterion, yellow check (✓ (partial)) = model partially meets criterion, red cross (✗) = model does not meet criterion

Criterion	Relative Importance	APEX	DHSVM/ RHESS	GSSHA	GWLF	HEC-RAS/HMS	HSPF	LSPC	SWAT	SWMM	Univ of Utah	WARMF
Key watershed characteristics and simulation capabilities												
Includes dynamic, processed-based hydrology and water quality simulation	High	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓ (partial)	✓
Simulates flows and loads from direct runoff and shallow groundwater	High	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓ (partial)	✓
Simulates state variables, processes, and loads for the water quality constituents of concern including but not limited to:												
Sediment: including both upland and channel erosion and sediment transport	High	✓ (partial)	✗	✓	✓ (partial)	✓ (partial)	✓	✓	✓ (partial)	✗	✗	✓
Nutrients: build-up and wash-off of nutrients on the landscape, represents species for nitrogen and phosphorus as well as particulate, dissolved, and total forms, simulates stream transport and cycling	High	✓ (partial)	✗	✓	✓ (partial)	✓ (partial)	✓	✓	✓ (partial)	✗	✓ (partial)	✓
Dissolved oxygen (DO)	Medium	✗	✗	✓ (partial)	✗	✓	✓	✓	✓ (partial)	✗	✗	✓
Biological oxygen demand (BOD) and carbon (dissolved organic carbon and total organic carbon)	High	✗	✗	✓ (partial)	✗	✓	✓	✓	✓ (partial)	✗	✓ (partial)	✓
Algae in streams (floating and attached)	Medium	✗	✗	✓ (partial)	✗	✓	✓	✓	✓ (partial)	✗	✗	✓
Water temperature	Medium	✗	✓	✓ (partial)	✗	✓	✓	✓	✓ (partial)	✗	✗	✓
pH/alkalinity and/or important cations (Ca)	Medium	✗	✗	✓ (partial)	✗	✓	✓	✓	✗	✗	✗	✓
[illegible]												

Watershed Model Ranking Results

Model	Score for High Criteria (Max = 150)	Total Score (Max = 196)	Overall rank
HSPF	150	189	1st
LSPC	144	183	2nd
SWAT	145	181	3rd
WARMF	136	173	4th
GSSHA	127	147	5th
HEC-RAS/HMS	125	145	6th
DHSVM/ RHESS	121	139	7th
SWMM	127	137	8th
GWLF	119	136	9th
Univ of Utah	131	134	10th
APEX	100	121	11th

Revised Lake Modeling QAPP

- Purpose of QAPP
  - Describe project, goals, and objectives
  - Explain project organization, personnel, and schedule
  - Document data quality objectives
  - Describe various aspects of the modeling process
  - Explain how usability of model will be assessed
- Utah Lake QAPP previously prepared and approved by Science Panel in 2019
- Tetra Tech updated it for our work on the lake model

QAPP Outline

1) INTRODUCTION
2) PROJECT DESCRIPTION
3) PROJECT MANAGEMENT
4) QUALITY OBJECTIVES
5) MODEL FRAMEWORK
6) DATA COLLECTION AND ACQUISITION
7) MODEL PERFORMANCE EVALUATION- EFDC AND SWAN
8) MODEL PERFORMANCE EVALUATION- WASP
9) MODEL USABILITY DETERMINATION AND RECONCILIATION
10) PROJECT REPORTS AND DOCUMENTATION

REFERENCES

ATTACHMENT A. TETRA TECH'S SCOPE OF WORK

ATTACHMENT B: STANDARD OPERATING PROCEDURE FOR SOFTWARE DEVELOPMENT AND VALIDATION

ATTACHMENT C: STANDARD OPERATING PROCEDURE FOR GEOSPATIAL AND DATA MANAGEMENT

Key Items Updated in Lake Modeling QAPP

- Summarized which charge questions the models can help address (Section 2.1)
- Presented new modeling team and schedule (Section 3)
- Added information about the SWAN model (Sections 6 and 7)
- Updated discussion of analyzing performance uncertainty using First Order Variance Analysis (Section 7.6)
- Purposefully did not add model acceptance criteria (Section 9)

Science Panel Discussion

Request Science Panel Approval

Public Discussion