STRATEGIC RESEARCH PLAN DEVELOPMENT

Utah Lake Water Quality Study
Science Panel Meeting
December 10-11, 2019
Salt Lake City, UT

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

Goals

- Review mapping of information
- Review discussions on gaps and research needs
- Conduct research need prioritization exercise

Mapping Current Research Effort Charge Questions

- Historic Condition

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

Any additional clarification needed to facilitate answering these questions?

Mapping Current Research Effort Charge Questions

- Current Condition

Questions		Being addressed
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?		Partially
	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?	Data analysis covers all but bioturbation
	ii. What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?	No
	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?	Partially by data analysis and EFDC model as to wind action; some literature for carp.
2.2 What are the environmental requirements for submerged macrophytes currently present at Utah Lake?		Partially
	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?	No
	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?	Data analysis
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? Data analysis	Data analysis
	ii. Which nutrients are controlling primary production and HABs and when?	Bioassay RFP
	iii. If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?	Data analysis
	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)	Data analysis
	v. What is the role of calcite “scavenging” in the phosphorus cycle?	Sediment RFP
	vi. What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?	Data analysis

Any additional clarification needed to facilitate answering these questions?

Mapping Current Research Effort Charge Questions

- Current Condition

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?	Partially with the Sediment RFP
	ii. What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions?	Sediment RFP
	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?	No
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?	No
	ii. Which species are most sensitive and need protection from nutrient-related impacts?	No

Any additional clarification needed to facilitate answering these questions?

Mapping Current Research Effort Charge Questions

- Other Questions – no research activity
  - *Does SP need to provide feedback to SC on this?*
  - *Who decides what the assessment endpoints are for this – SC or SP?*

3. **What additional information is needed to define nutrient criteria that support existing beneficial uses?**
   1. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife
   2. For primary contact recreation
   3. For agricultural uses including irrigation of crops and stock watering

Mapping Current Research Effort Charge Questions

- Other Questions – no research activity
  - *Believe 4.1 can be addressed with the models*
  - *How to address 4.2?*
  - *Isn't 4.3 the focus of the NNC effort? Need to identify if (1) HABs are responsive to nutrients and then (2) what the NNC needs to be to get them to protective levels (which is another question)*

- 4.1 What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources?
- 4.2 Assuming current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30- 50 years)?
- 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?

Mapping Current Research Effort

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed
Reference-based	Paleolimnological reconstruction of past conditions	Can inform what reference conditions were, whether conditions previously supported desired assessment endpoint conditions, if and how much such conditions have changed adversely, and whether such conditions are once again achievable	Historic phosphorus, nitrogen, and silicon concentrations	Paleo RFP
			Historic water quality, trophic state, and nutrient regime	Paleo RFP
			Can past diatom communities and macrophyte communities be detected in sediment cores? If so, what were those communities like?	Partially through the paleo RFP (at least with question 1, not sure yet about question 2)
	Model based prediction	The model will be set to minimal or no human contributions and model responses will be evaluated. This will help inform what achievable conditions might be	What are appropriate inputs to use for natural nutrient (N and P) loads?	Partially through paleo RFP, atmospheric deposition studies, and reference-based studies for tributary inputs.
	Direct observation	Provides context for other lines of evidence and can be used as a measure of baseline values for N and P	There are limited observed reference data from Utah Lake and few if any comparable reference lakes due to Utah Lake's unique features	Data analyses, to the degree possible (all data from Utah Lake have been compiled; data from comparable lakes may be evaluated as well)

Mapping Current Research Effort

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed
Stressor-Response	Empirical	Can help identify nutrient concentrations where negative impacts to assessment endpoints become evident. N and P are the causal variables. Endpoints that are currently being considered are cyanobacteria cell counts, chlorophyll-a, dissolved oxygen and potentially cyanotoxin concentrations.	Endpoint #1: cyanobacteria cell counts. At what concentrations do cyanobacterial cell counts exceed 100,000/ml.	Data analysis and Mechanistic Modeling (all data from Utah Lake have been compiled; data from comparable lakes may be evaluated as well)
			Endpoint # 2: chlorophyll-a concentrations. Need to investigate at what point chlorophyll-a concentrations become unacceptable for contact recreation by the public. Which nutrient (N or P) is limiting? Does turbidity interact with nutrients to influence chlorophyll-a? How much P is biologically active? (need to investigate the relationship between primary productivity, pH and calcite)	Partially with Data analysis, literature, and Bioassay and Sediment RFPs.

Mapping Current Research Effort

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed
Stressor-Response	Empirical continued…	Will help identify thresholds where nutrient concentrations cause negative responses as measured by the assessment endpoints	Endpoint # 3: Dissolved oxygen. Is anoxia an issue in Utah Lake?	Data analyses, to the degree possible provided available DWQ data.
			Endpoint # 4: Cyanotoxin concentrations. Which cyanotoxins are present and what are their drivers?	Partially via data analysis and ongoing research.
			Endpoint # 5: biological endpoints (e.g., macrophytes, phytoplankton, invertebrates and fish)	Not currently

Mapping Current Research Effort

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed
	Mechanistic model	Allows for exploration of multiple future scenarios to help support cause-effect relationships observed in the empirical S-R relationships. The model(s) can be used to generate N and P load targets that meet desired beneficial use conditions, which can then be translated into concentrations for assessment	There are limitations with the model itself - see Figure 4; the purple boxes show what is not covered by the model, and blue-dashed boxes show which items are only covered to a limited degree	Through ongoing and future model development
Stressor Response			Model Uncertainty. Are more novel approaches for model uncertainty advised?	To be discussed by SP.
			There are limitations with the data going into the model	Partially. Some, like the path step for wet and dry deposition are being improved through additional research. Others, like those related to water clarity and aquatic life, are not currently being addressed

Discussions on Research Gaps and Ideas

- From our discussions
- For all ideas:
  - *Review literature/empirical analysis before committing to a study*
  - *Think demo study (Provo Bay)*

Biology	• **Carp Effects on Macrophytes (and linkage to biogeochemistry)** • **Carp Effects on Zooplankton (and does this influence algal response)** • **Macrophyte role (to biogeochemistry)** • **Macrophyte recovery potential (Provo Bay demo)** • **Toxin Production and N Species**
Physical	• **Lake Level (Effect on Macrophytes; Effect on Biogeochemistry)** • **Turbidity Effect on Primary Producers**
Sediments	• **Calcite Scavenging (how bioavailable is SRP – does bioassay address?)** • **Sediment Budgets (C, N, and P; nutrient flux chambers)** • **How Large is Internal vs External Loading (How long would recovery take?)**
Modeling	• **Adding modules to the WQ models (sediment diagenesis, calcite scavenging)** • **Alternative models (PCLake – cyano/macrophyte state change)**
Endpoints	• **Recreational Surveys (not universal support)**

Revisiting Mapping Ideas and Charge

- So, now revisiting our mapping – what do/do not the proposed ideas address
- Historic Conditions

Questions	Being addressed	Anything Proposed?
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	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	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	

Revisiting Mapping Ideas and Charge

- Current Conditions

Questions		Being addressed	Anything Proposed?
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?		Partially	
	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?	Data analysis covers all but bioturbation	Yes
	ii. What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?	No	Yes
	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?	Partially by data analysis and EFDC model as to wind action; some literature for carp.	Yes
2.2 What are the environmental requirements for submerged macrophytes currently present at Utah Lake?		Partially	
	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?	No	Yes
	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?	Data analysis	Yes

Revisiting Mapping Ideas and Charge

- Current Conditions

Questions		Being Addressed	Anything Proposed?
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? Data analysis	Data analysis	
	ii. Which nutrients are controlling primary production and HABs and when?	Bioassay RFP	Yes
	iii. If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?	Data analysis	Yes
	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)	Data analysis	Yes
	v. What is the role of calcite “scavenging” in the phosphorus cycle?	Sediment RFP	Yes
	vi. What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?	Data analysis	

Revisiting Mapping Ideas and Charge

- Current Conditions

Questions	Being Addressed	Anything Proposed?
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?	Partially with the Sediment RFP	Yes
ii. What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions?	Sediment RFP	Yes
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?	No	No
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?	No	No
ii. Which species are most sensitive and need protection from nutrient-related impacts?	No	No

Revisiting Mapping Ideas and Charge

- Other Questions
  - *Does SP need to provide feedback to SC on this?*
  - *Who decides what the assessment endpoints are for this – SC or SP*

3.	**What additional information is needed to define nutrient criteria that support existing beneficial uses?**	
1.	For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife	NO
2.	For primary contact recreation	YES
3.	For agricultural uses including irrigation of crops and stock watering	NO

Revisiting Mapping Ideas and Charge

- Other Questions – no research activity
  - *Believe 4.1 can be addressed with the models*
  - *How to address 4.2?*
  - *Isn't 4.3 the focus of the NNC effort? Need to identify if HABs are responsive to nutrients (1) and then (2) what the NNC needs to be to get them to protective levels (which is another question)*

• 4.1 What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources?	NO
• 4.2 Assuming current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30- 50 years)?	YES?
• 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?	YES

Revisiting Mapping Ideas and Charge

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed	Anything Proposed?
Reference-based	Paleolimnological reconstruction of past conditions	Can inform what reference conditions were, whether conditions previously supported desired assessment endpoint conditions, if and how much such conditions have changed adversely, and whether such conditions are once again achievable	Historic phosphorus, nitrogen, and silicon concentrations	Paleo RFP	No
			Historic water quality, trophic state, and nutrient regime	Paleo RFP	No
			Can past diatom communities and macrophyte communities be detected in sediment cores? If so, what were those communities like?	Partially through the paleo RFP (at least with question 1, not sure yet about question 2)	No
	Model based prediction	The model will be set to minimal or no human contributions and model responses will be evaluated. This will help inform what achievable conditions might be	What are appropriate inputs to use for natural nutrient (N and P) loads?	Partially through paleo RFP, atmospheric deposition studies, and reference-based studies for tributary inputs.	No
	Direct observation	Provides context for other lines of evidence and can be used as a measure of baseline values for N and P	There are limited observed reference data from Utah Lake and few if any comparable reference lakes due to Utah Lake's unique features	Data analyses, to the degree possible (all data from Utah Lake have been compiled; data from comparable lakes may be evaluated as well)	No

Revisiting Mapping Ideas and Charge

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed	Anything Proposed ?
Stressor-Response	Empirical	Can help identify nutrient concentrations where negative impacts to assessment endpoints become evident. N and P are the causal variables. Endpoints that are currently being considered are cyanobacteria cell counts, chlorophyll-a, dissolved oxygen and potentially cyanotoxin concentrations.	Endpoint #1: cyanobacteria cell counts. At what concentrations do cyanobacterial cell counts exceed 100,000/ml.	Data analysis and Mechanistic Modeling (all data from Utah Lake have been compiled; data from comparable lakes may be evaluated as well)	No
			Endpoint # 2: chlorophyll-a concentrations. Need to investigate at what point chlorophyll-a concentrations become unacceptable for contact recreation by the public. Which nutrient (N or P) is limiting? Does turbidity interact with nutrients to influence chlorophyll-a? How much P is biologically active? (need to investigate the relationship between primary productivity, pH and calcite)	Partially with Data analysis And Bioassay and Sediment RFPs.	Yes

Revisiting Mapping Ideas and Charge

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed	Anything Proposed ?
Stressor-Response	Empirical continued…	Will help identify thresholds where nutrient concentrations cause negative responses as measured by the assessment endpoints	Endpoint # 3: Dissolved oxygen. Is anoxia an issue in Utah Lake?	Data analyses, to the degree possible provided available DWQ data.	No
			Endpoint # 4: Cyanotoxin concentrations. Which cyanotoxins are present and what are their drivers?	Partially via data analysis and ongoing research.	Yes
			Endpoint # 5: biological endpoints (e.g., macrophytes, phytoplankton, invertebrates and fish)	Not currently	Yes?

Revisiting Mapping Ideas and Charge

- NNC Research Needs

Approach	Line of evidence	How will it help inform NNC	Knowledge gaps	Being addressed	Anything Proposed?
	Mechanistic model	Allows for exploration of multiple future scenarios to help support cause-effect relationships observed in the empirical S-R relationships. The model(s) can be used to generate N and P load targets that meet desired beneficial use conditions, which can then be translated into concentrations for assessment	There are limitations with the model itself - see Figure 4; the purple boxes show what is not covered by the model, and blue-dashed boxes show which items are only covered to a limited degree	Through ongoing and future model development	Yes
Stressor Response			Model Uncertainty. Are more novel approaches for model uncertainty advised?	To be discussed by SP.	No
			There are limitations with the data going into the model	Partially. Some, like the path step for wet and dry deposition are being improved through additional research. Others, like those related to water clarity and aquatic life, are not currently being addressed	Yes?

Prioritization Exercise

- You have a list of proposed ideas
- You've also been given a list of mapping the charge question needs to existing work
- Work in groups to prioritize
- Recommended format: modified Delphi method
  - *Step 1: Rank right away – highest priority to least*
  - *Step 2: Discuss/deliberate*
  - *Step 3: Re-vote and report back*