Utah Lake Water Quality Study
Science Panel Meeting
June 13, 2019
The ether

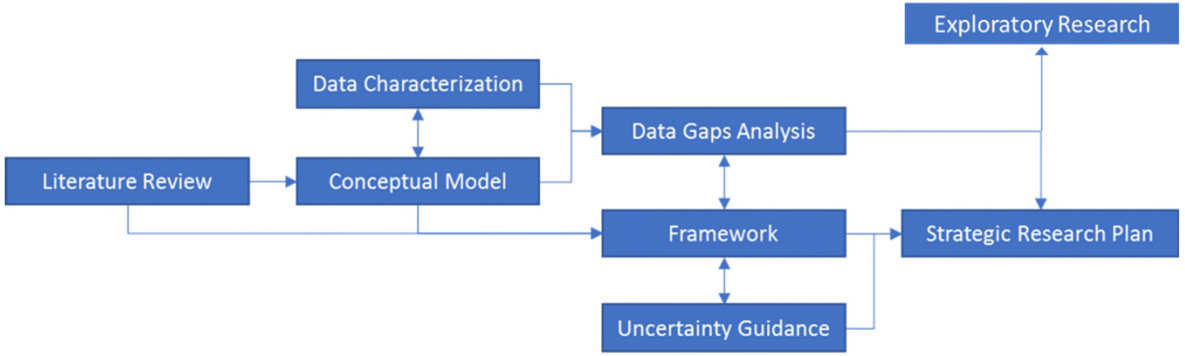
Project team updates

Utah Lake Nutrient Criteria Development Technical Support

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

Framework

- "develop a scientifically defensible approach for water quality criteria development"



Framework

- Developing
- Overview and Background
  - Review
  - Conceptual Model
  - Data Characterization
  - Uncertainty
- Approach
  - Developing lines
  - Combining lines
  - Recommending values
  - Communicating

Utah Lake Water Quality Study—Numeric Nutrient Criteria Technical Framework

[DATE], 2019

PRESENTED TO

Utah Department of Environmental Quality
Division of Water Quality
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PREPARED BY

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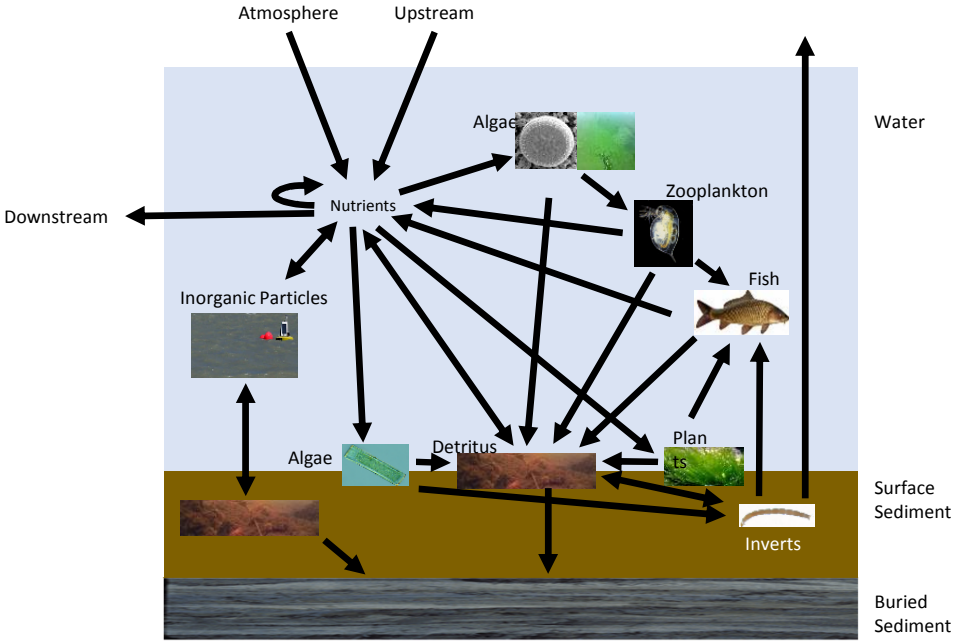
Framework

- Next Steps
  - Continue working on draft
  - Send out working draft in July

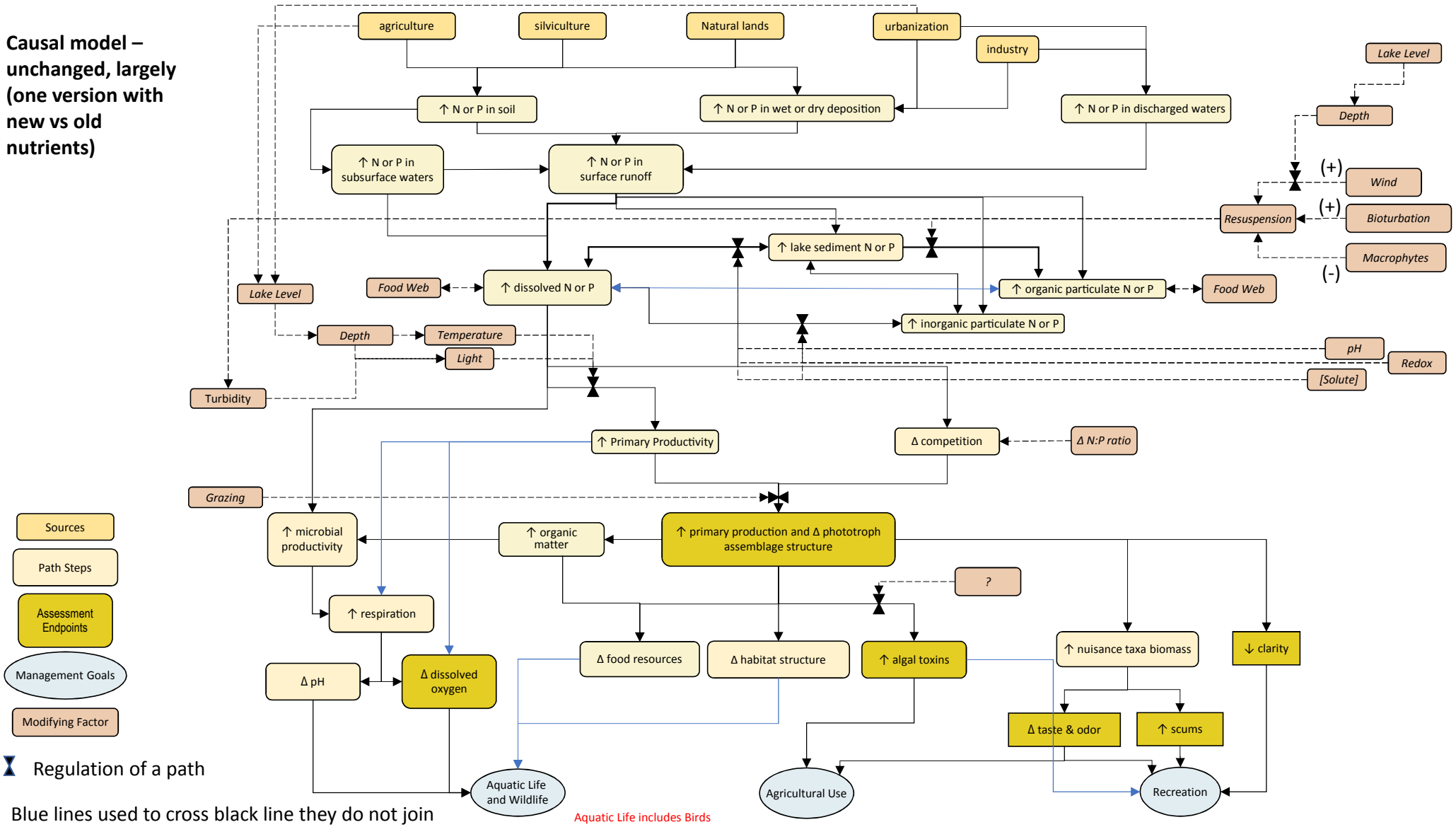
Conceptual Models

- Updates sent out

Simplified - unchanged

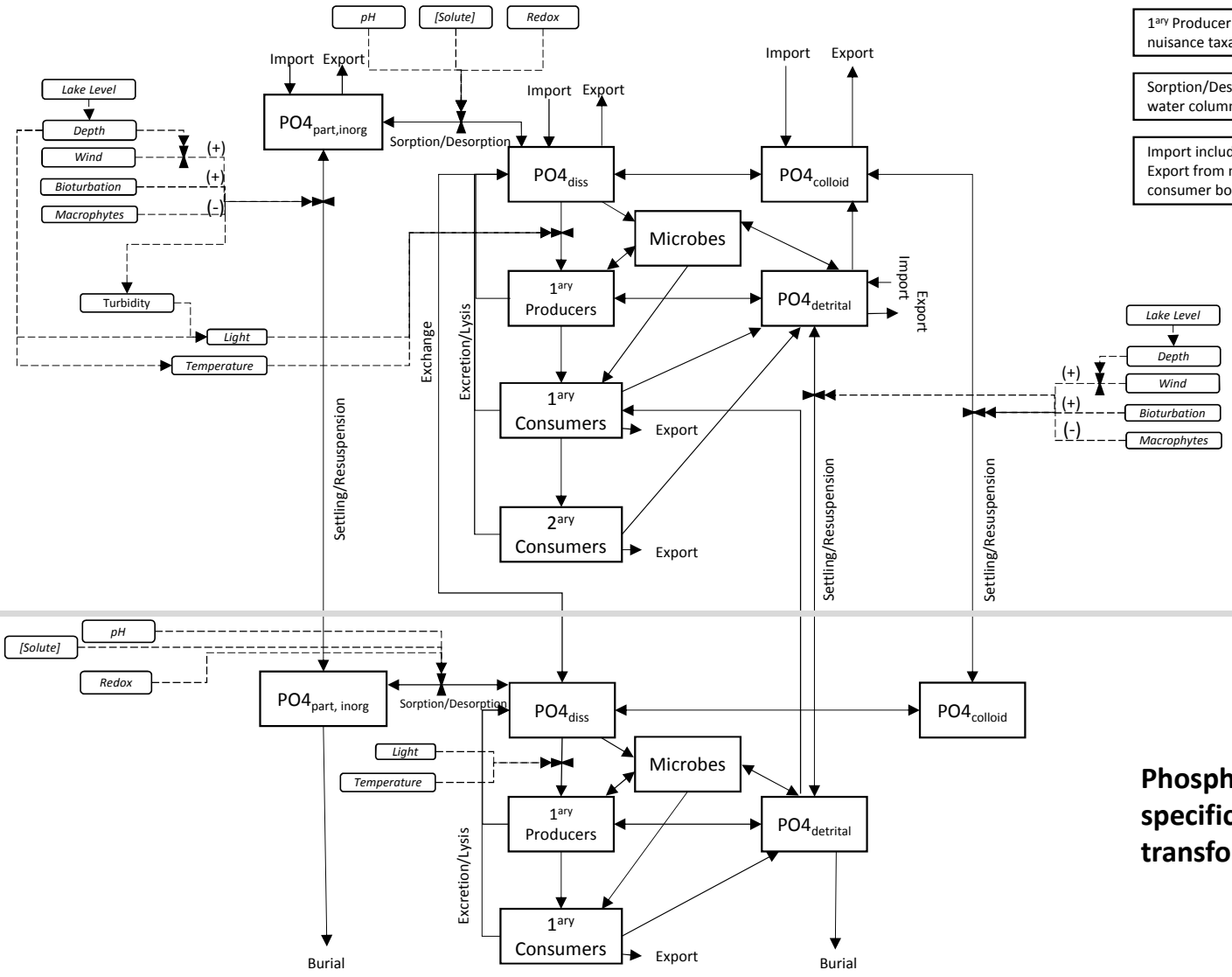


Causal model – unchanged, largely (one version with new vs old nutrients)



Blue lines used to cross black line they do not join

Aquatic Life includes Birds

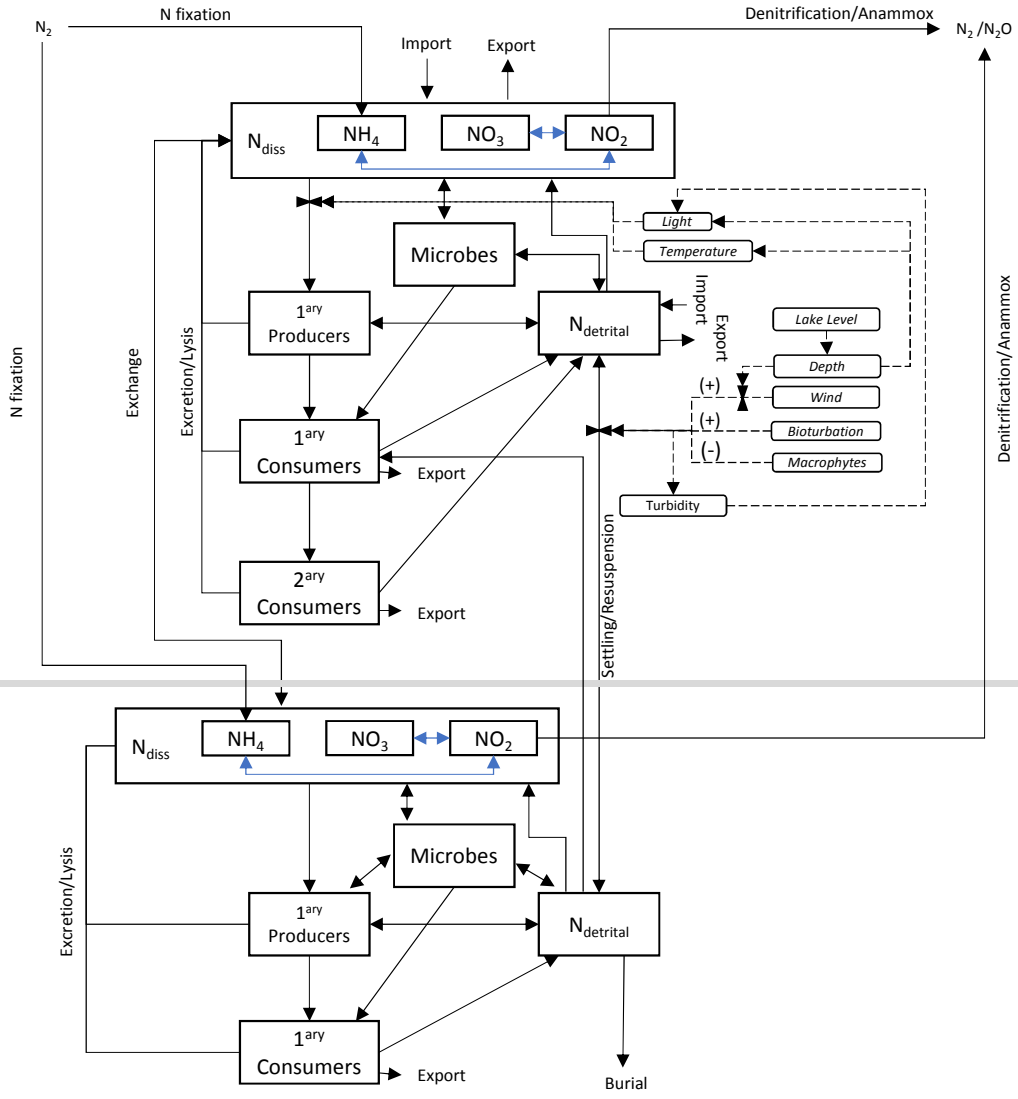


1ary Producer responses included shifts in species composition including to nuisance taxa (from competitive shifts) as well as increased biomass.

Sorption/Desorption includes calcite scavenging of dissolved P from the water column influenced by pH, etc.

Import includes tributary as well as atmospheric wet and dry deposition; Export from nutrient pools is largely downstream transport; Export from consumer boxes is emergence/harvest.

Phosphorus model – beefed up specificity, external effects, transformations



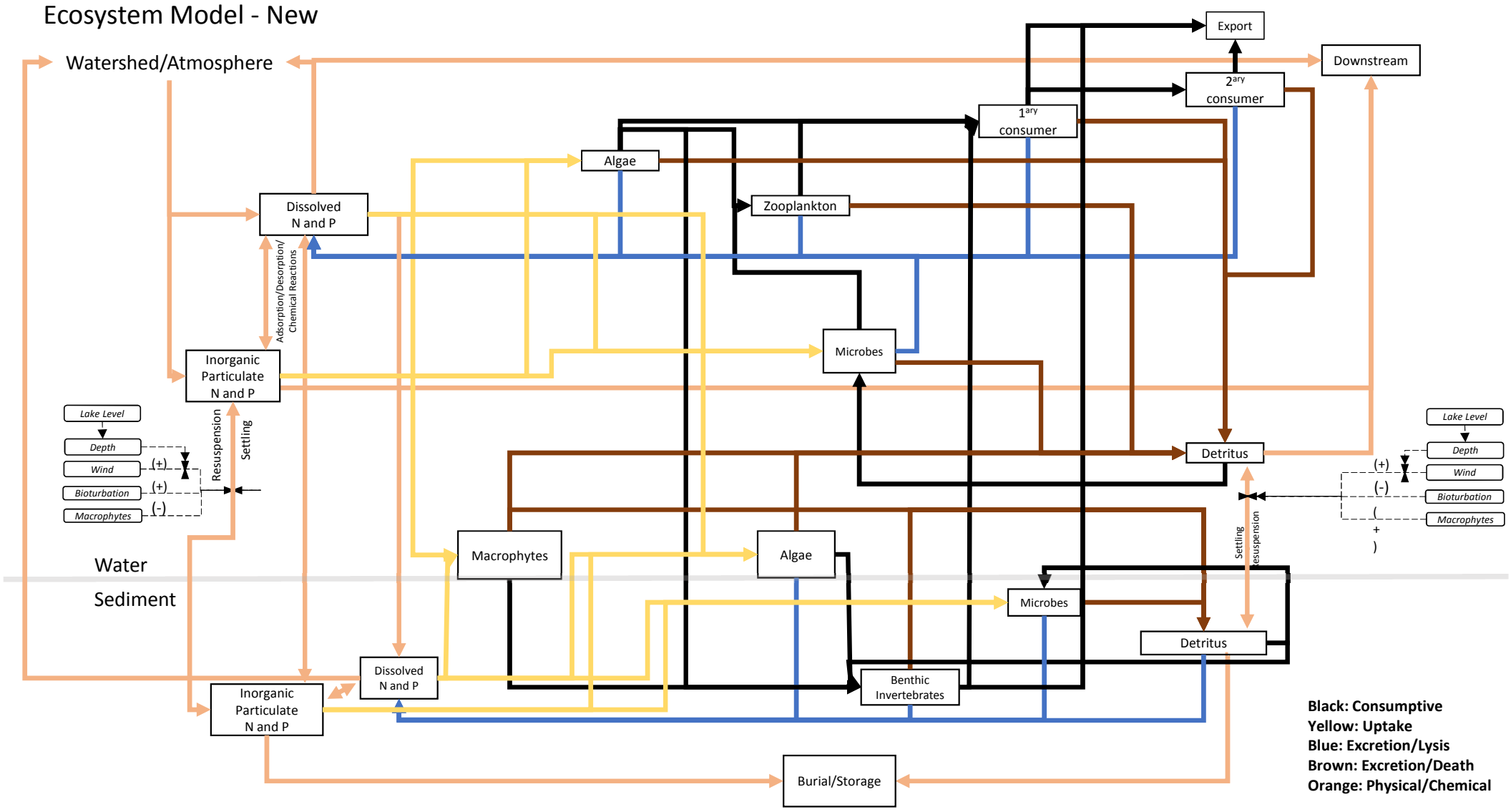
1ary Producer responses included shifts in species composition including to nuisance taxa (from competitive shifts) as well as increased biomass.

Blue arrows in N_{diss} include several microbially mediated N transformations.

Import includes tributary as well as atmospheric wet and dry deposition; Export from nutrient pools is largely downstream transport; Export from consumer boxes is emergence/harvest.

Reactions within the N_{diss} box including nitrification (ammonium oxidation and nitrite oxidation) and nitrate/nitrite reduction

Nitrogen model – beefed up specificity, external effects, transformations


Ecosystem Model - New
Watershed/Atmosphere
Export
Downstream
2ary consumer
1ary consumer
Algae
Zooplankton
Dissolved N and P
Adsorption/Desorption/ Chemical Reactions
Microbes
Inorganic Particulate N and P
Lake Level
Depth
Wind
Bioturbation
Macrophytes
(+)
(+)
(-)
Resuspension
Settling
Detritus
Water
Sediment
Macrophytes
Algae
Microbes
Detritus
Benthic Invertebrates
Dissolved N and P
Inorganic Particulate N and P
Burial/Storage
Black: Consumptive
Yellow: Uptake
Blue: Excretion/Lysis
Brown: Excretion/Death
Orange: Physical/Chemical

Conceptual Models

- Next Steps:
  - Any Science Panel feedback?
  - Otherwise, we will put these to rest and use them moving forward.

Data Characterization

- Scott and team sent data (1.3 GB)
  - Flow, Elevation, Meteorology
  - Chemistry, Sonde Data
  - Phytoplankton, HAB, Zooplankton, Macroinvertebrate, Fish
- Mark Fernandez and I began implementing draft analysis plan
  - Any feedback still welcome

Data Analysis

- 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

Task 1. Carp Excretion

- Goal: Estimate potential excretion rates of carp
- Data:
  - Carp population density data
  - Excretion data (Mike Vanni excretion data – thanks to Ryan King)
- Methods:
  - Calculate excretion rate by size/individual, apply to population data

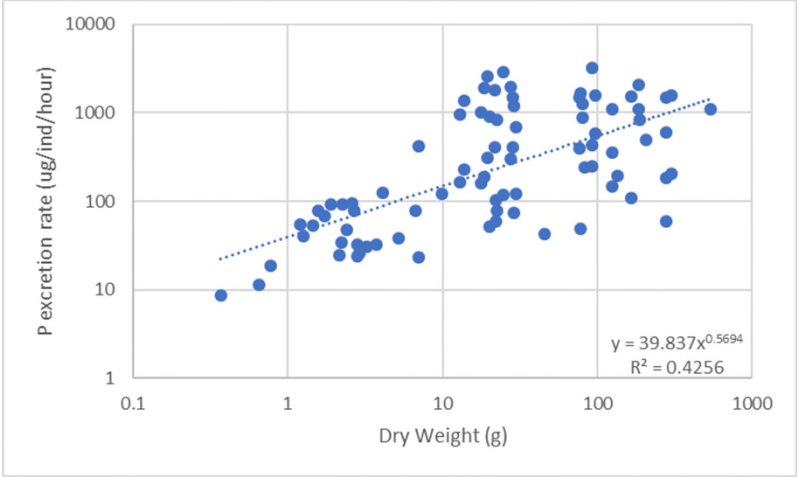
Task 1. Carp Excretion

- Population Density
  - Pre-removal (SWCA 2005):
    - Population Size: 7.5 million adults (2+)
    - Average weight: 2.4 kg/ind (wet), 0.48 kg/ind (dry)
    - Total Biomass: 18m kg (wet), 3.6m kg (dry)

    - Younger carp: 100million (<2)
    - Ballpark size: 0.01 – 0.120 kg/ind (dry)

Task 1. Carp Excretion

- Excretion
  - Mike Vanni dataset
    - *Cyprinus carpio*
    - 85 excretion estimates, developed curve
    - Multiplied by size estimates
    - Range:
      - Adults: 88,000 kg/y
      - Young: 129,000 to 532,000 kg/y
      - Total: 217,490 to 621,952 kg/y
    - 75 % reduction
      - Total: 54,373 to 155,238 kg/y



Task 1. Carp Excretion

- Excretion
  - Mike Vanni dataset
    - 75 % reduction
      - Total: 54,373 to 155,238 kg/y
    - In context:
      - Total P inputs: 138,255 to 269,978 kg/y (Brett 2019, Merritt and Miller 2016, Psomas and SWCA 2007)
      - Carp excretion is from 20% to 112% of total inputs

Task 2. Algal Cell Count and Pigment Relationship

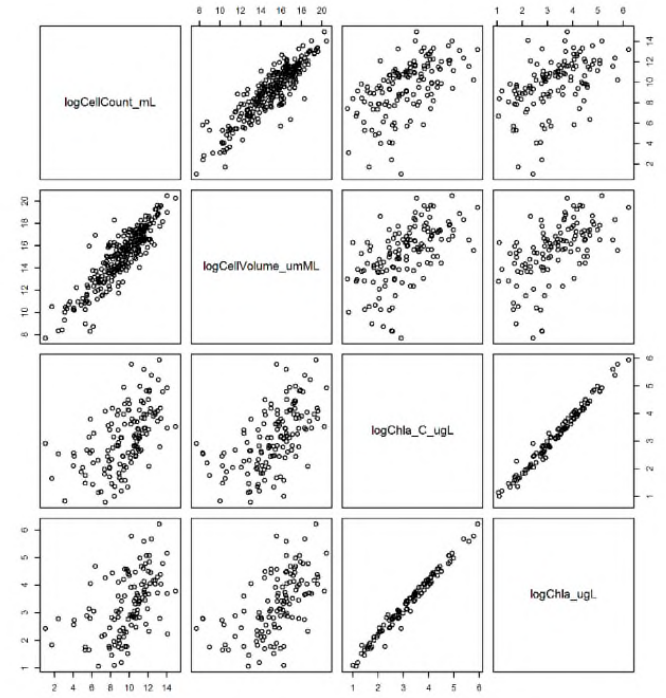
- Goal: Estimate relationships between cell count, biovolume, and pigment concentrations

- Data:
  - Phytoplankton cell count and biovolume
  - Water quality chlorophyll a data

- Methods:
  - Simple correlation/regression

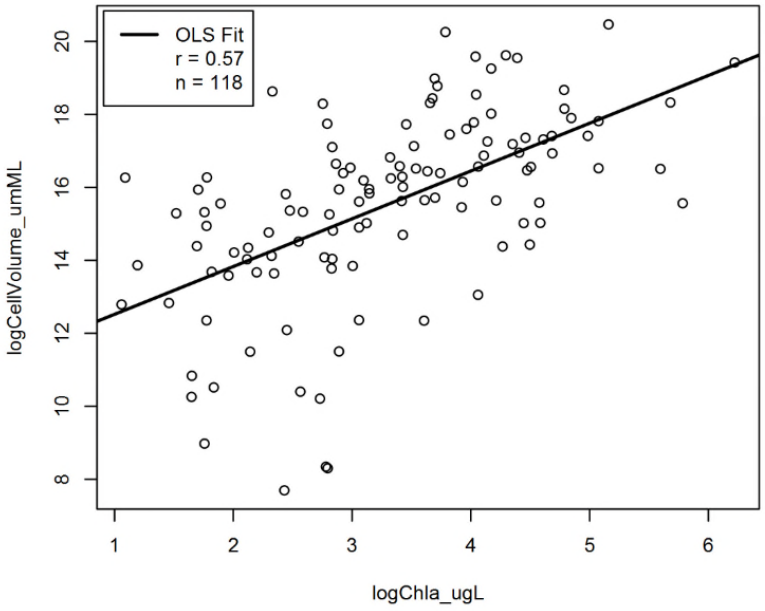
Task 2 Algal Cell Count and Pigment Relationship

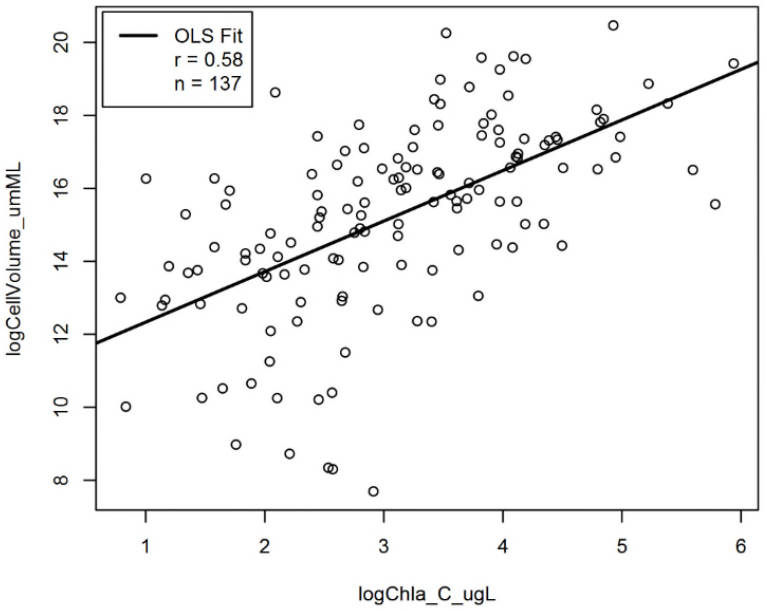
- Scatterplot



Task 2. Algal Cell Count and Pigment Relationship

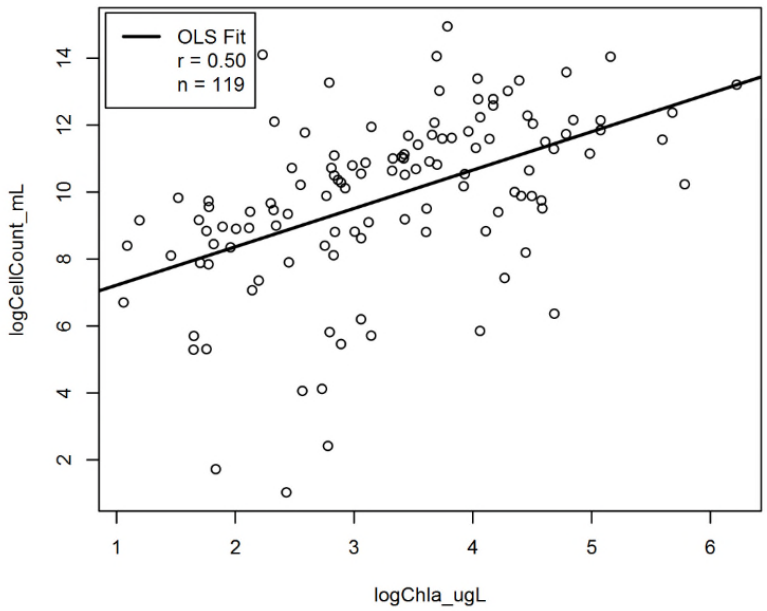
- Results:

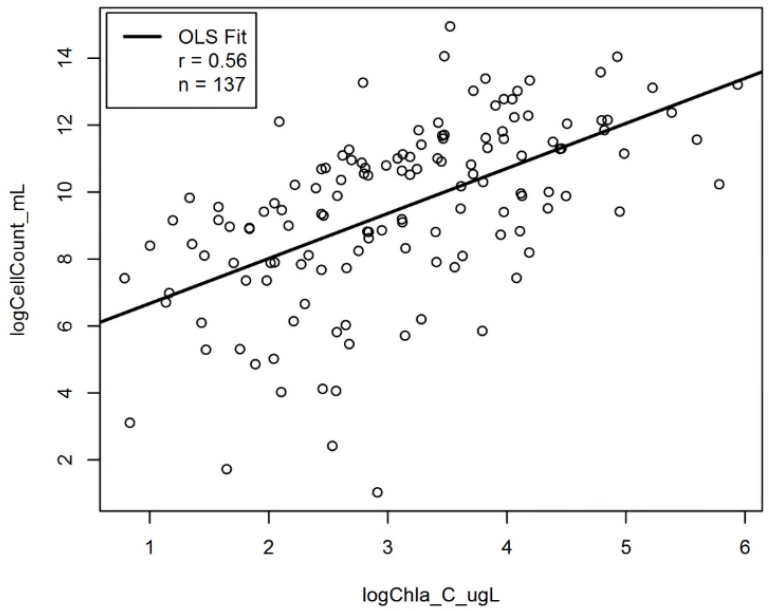




Task 2. Algal Cell Count and Pigment Relationship

- Results:





Task 3. Sonde Data Analysis

- Goal: Extract sonde data and examine relationships among sonde variables

- Remind us what the interest is here?
- I think Soren had ideas at previous meeting?

- We have 4 sonde locations (Phycocyanin, Chlorophyll, DO, pH, Conductivity, Temperature, Turbidity)

- Methods: TBD

Task 4. Plankton Temporal and Spatial Analysis

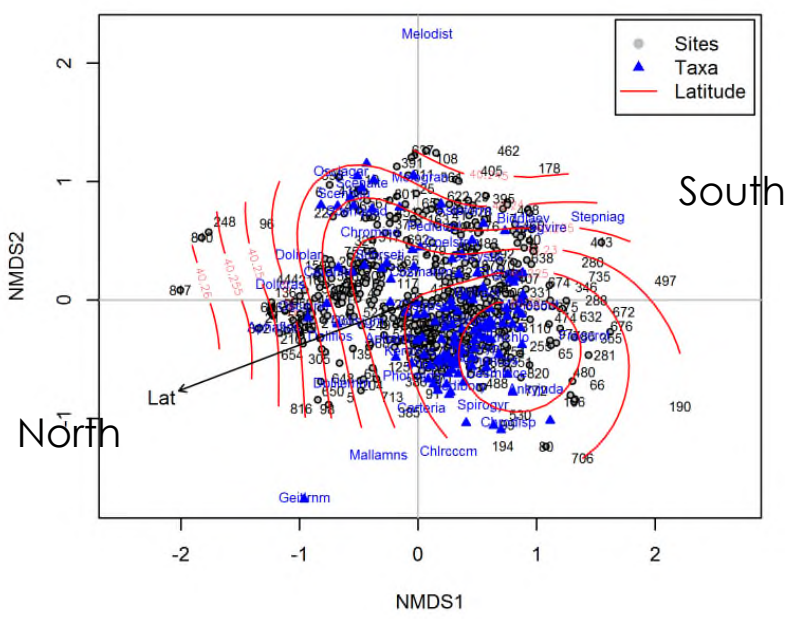
- Goal: Estimate temporal and spatial patterns in plankton, including HAB, assemblages

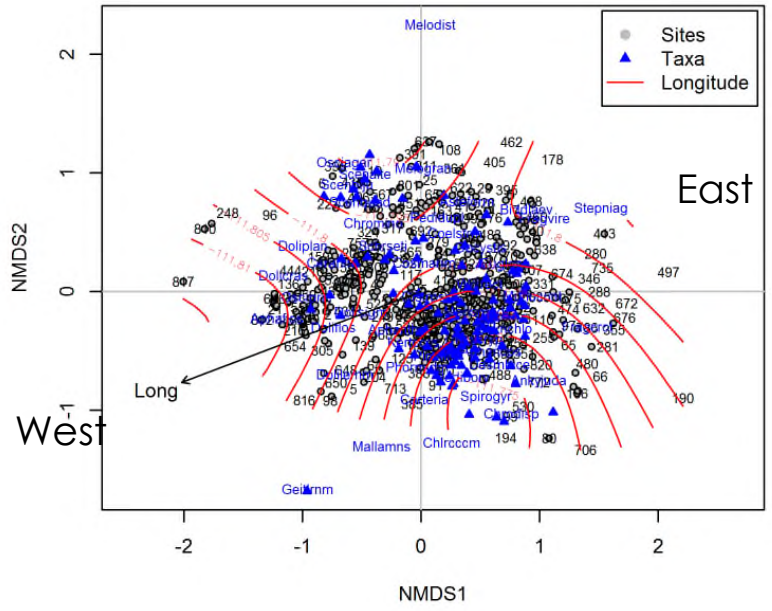
- Data:
  - Phytoplankton cell count data (OTUs designated)
  - Site location information
  - Other water chemistry data

- Methods:
  - Non-metric multidimensional scaling models
  - Overlays

Task 4. Plankton Temporal and Spatial Analysis

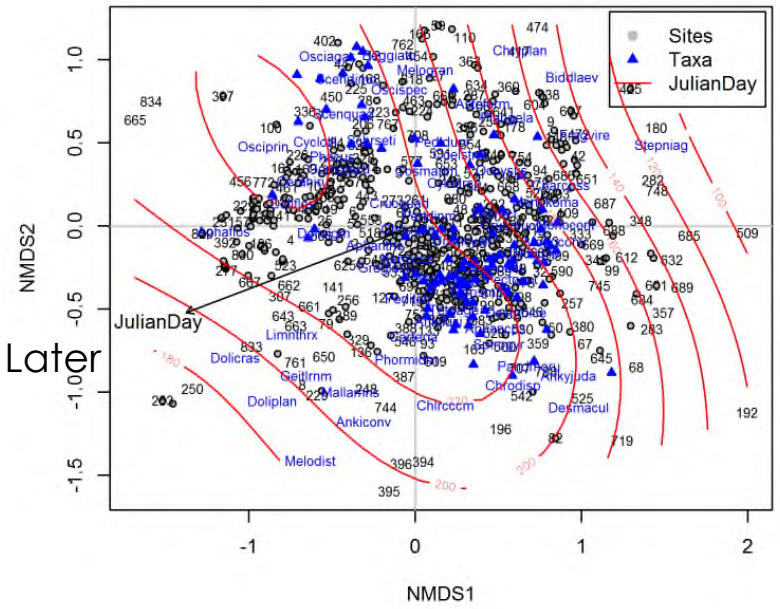
- Results: Spatial





Task 4. Plankton Temporal and Spatial Analysis

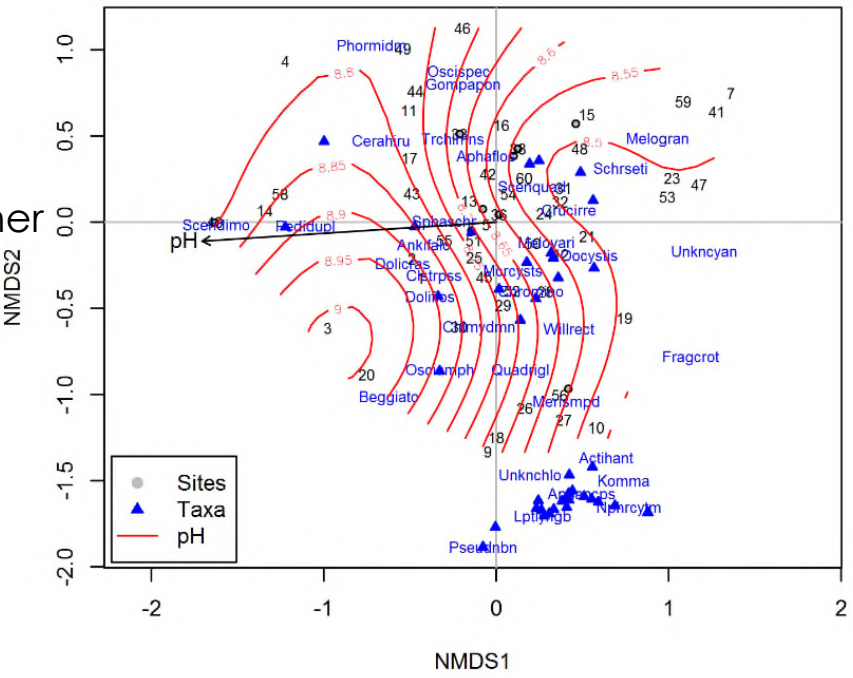
- Results: Temporal



Task 4. Plankton Temporal and Spatial Analysis

- Results: Miscellaneous Chemical
- Only paired chemistry and plankton
- pH

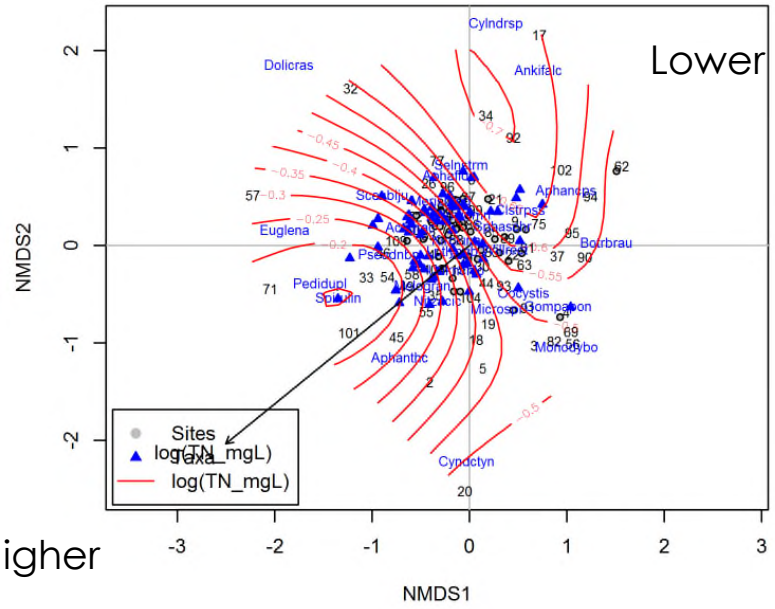
Higher



Lower

Task 4. Plankton Temporal and Spatial Analysis

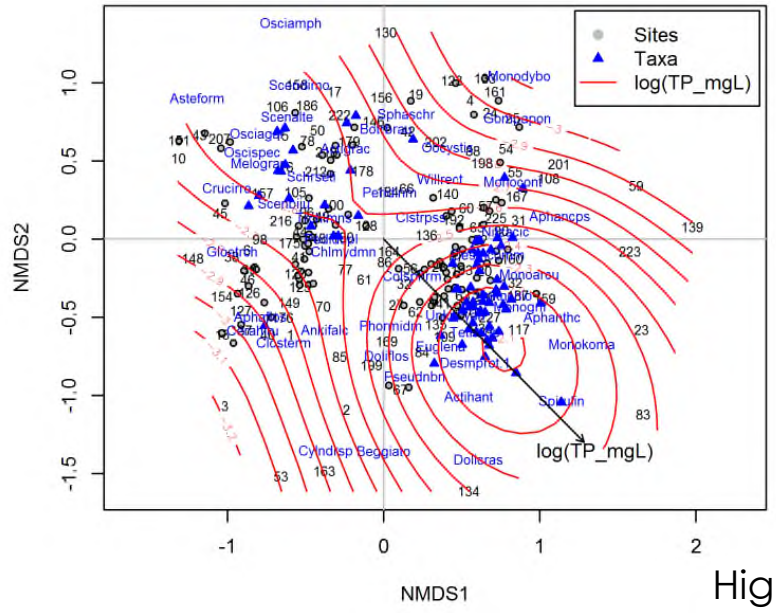
- Results: Miscellaneous Chemical
- Only paired chemistry and plankton
- TN



Task 4 Algal Cell Count and Pigment Relationship

- Results: Miscellaneous Chemical
- Only paired chemistry and plankton
- TP

Lower



Higher

Task 5. Diatom and Macrophyte Autecology

- Goal: Identify the environmental requirements of Utah Lake diatom and macrophyte species

- Data and Methods:
  - Literature based summary of what we know of:
    - Diatom: nutrient requirements
    - Macrophytes: nutrient, light, inundation

- Results:
  - TBD

Task 6. Wind and Turbidity

- Goal: Identify wind condition necessary to entrain bottom sediments in Utah Lake.

- Data:
  - Wind speed
  - Sediment characteristics

- Methods:
  - Calculate critical shear stress
  - Compare to wind induced sheer stress

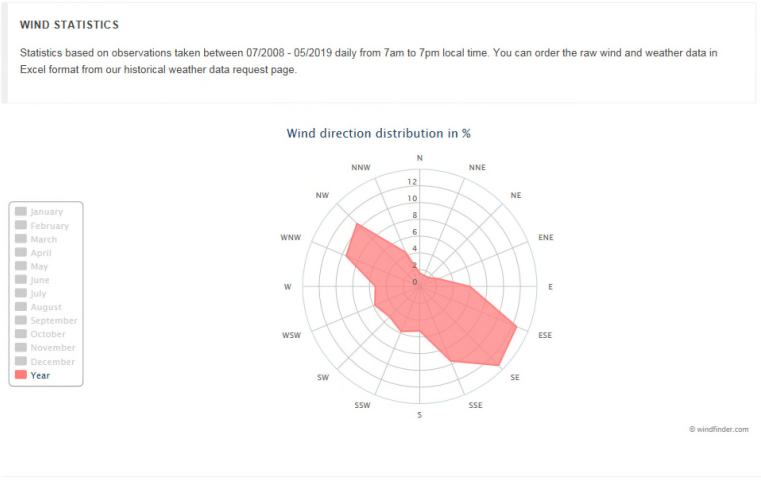
Task 6. Wind and Turbidity

Windfinder.com

- Results:
  - Chao et al. 2008 (Shallow lake cohesive sediment transport, Adv in Wat Res)
  - Chung et al. 2009 (Sediment resuspension in a shallow lake, Wat Res Res)
  - Shear stress (Pascals or N/m^2):
    - $\tau_{wave} = 0.5\ \rho f_w U_w^2$
    - ρ = water density; f_w = bottom friction factor (2/sqrt(Reynolds number)); U_w = amplitude of the orbital wave velocity
    - Need wave height, period, and length (Coastal Engineering Research Center 1984, Shore Protection Manual I)
    - Ignoring $\tau_{velocity}$ per other papers on shallow lakes – is that wise?

Task 6. Wind and Turbidity

- Results:
  - Wind speed: Provo airport, long-term data average = 2.63 m/s
  - Wind direction: Average =145.8 degrees (SSE/SE) (non-trivial until you find a website)
  - Fetch: at this direction is 15 miles



Windfinder.com

Task 6. Wind and Turbidity

- Results:
  - Critical shear stress (N/m^2):
    - Easy: $\tau_{crit} = 0.06(g)(\rho s-\rho)D$ (for stream coarse beds)
    - Hard: Need to work on finding an appropriate method

    I need estimates of : median particle size, sediment density for Utah Lake

Task 6. Wind and Turbidity

- Very Very Preliminary Results:
  - Shear stress

depth (m)	Wind speed (m/s)	τ_w (N/m2)
1.5	2.63	0.106740
3	2.63	0.026731
6	2.63	0.001515

depth (m)	Wind speed (m/s)	Fetch (m)	τ_w (N/m2)
3	2.63	24140	0.026731
3	2.63	12070	0.023028
3	2.63	6035	0.018406

depth (m)	Wind speed (m/s)	τ_w (N/m2)
3	0.986	Very low
3	2.63	0.026731
3	4.67	0.188448

  - Critical Shear: 5.88

  - So, this **needs work** and is ongoing
  - Any help appreciated

Task 7. Turbidity and Macrophytes

- Goal: Identify the potential contribution of macrophytes to reducing turbidity.

- Data:
  - Effect of macrophytes on stabilizing sediments through reducing shear and holding sediments
  - Papers from Soren, Eric, and Janice – will look into how to calculate

- Methods:
  - TBD

Task 8. Light extinction

- Goal: Identify the potential contribution of turbidity/TSS and algal biomass to turbidity.

- Data and Methods:
  - TSS, Secchi, Kd, VTSS
  - Empirical formulae for light attenuation
  - Calculate Utah Lake specific value (upcoming PAR data)
  - Calculate contribution of non-algal TSS and chlorophyll to k_d
  - Calculate light available at lake bottom across range of TSS and Chlorophyll values

- Results:
  - TBD

Data Analysis

- Next Steps:
  - Heads down, keep at it
  - More in July

Uncertainty Analysis

- Draft document sent out
- Goal: "*characterize scientific uncertainty including confidence of scientific findings and quantified measures of uncertainty, where possible*"

Utah Lake Water Quality Study—Uncertainty Guidance

June 5, 2019

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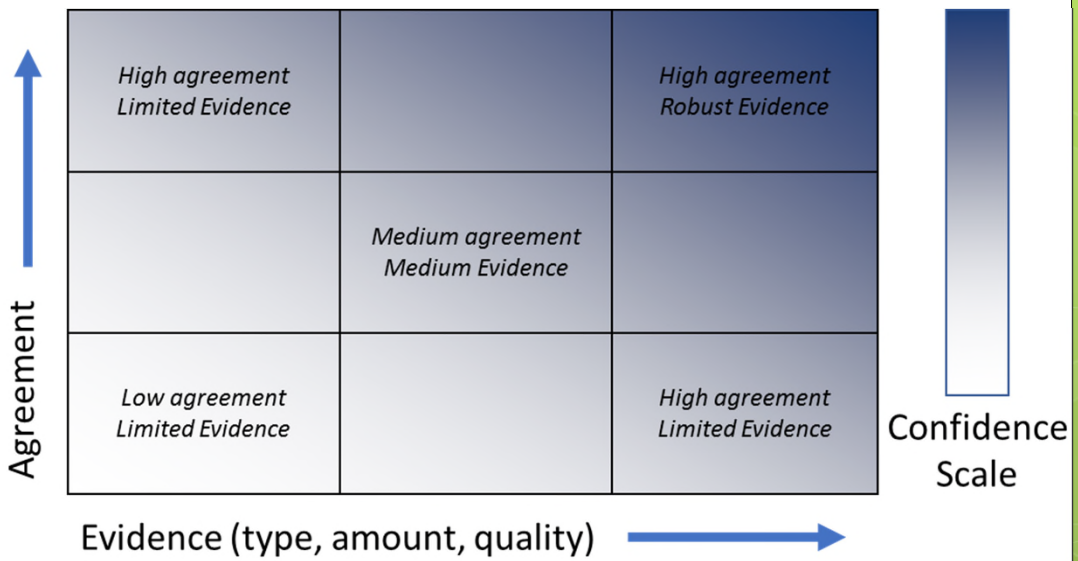
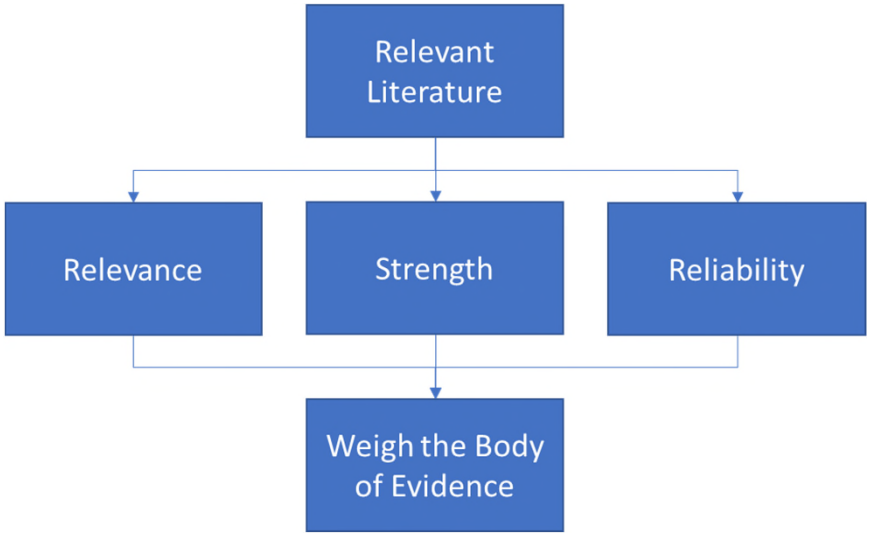
Uncertainty Analysis

- Evaluation based on:
  - Evidence
  - Agreement
- Statements convey:
  - Confidence – not statistical
  - Likelihood – can be statistical
- Based on IPCC



Uncertainty Analysis

- Evaluating different lines:
  - Empirical Analyses
  - Mechanistic Models
  - Literature
- Communication:
  - Traceable accounts



How to weigh literature – from USEPA 2016

Uncertainty Analysis

- Next steps:
  - Mostly guiding principles – details will emerge with work
  - Feedback from Science Panel
  - Revise and Finalize

Questions/Comments