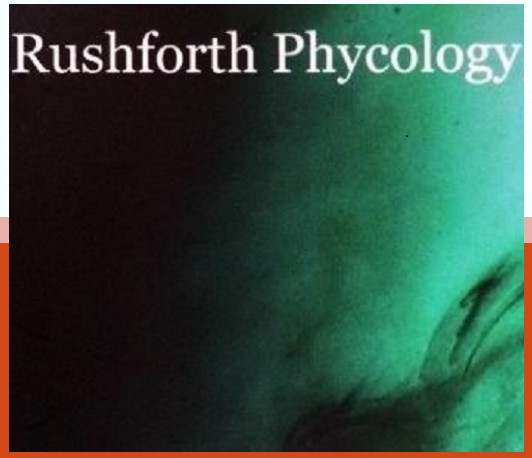


November 10, 2015

PHYTOPLANKTON DYNAMICS
and the
CONDITION OF UTAH LAKE

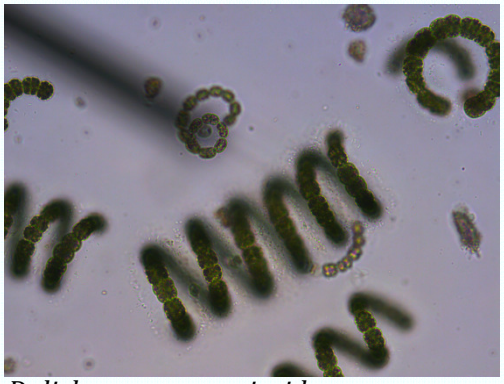
as related to the
Utah Lake Water Quality Work Plan

Work Plan Questions Related to Phytoplankton

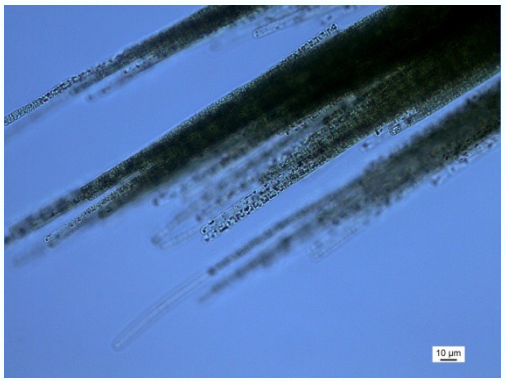
- What are the current water quality concerns on Utah Lake?
- Does the current data reflect historic impairments, or are there new water quality impairments?
- Which water quality parameters indicate trends?
- What are the connections amongst the water quality parameters and effects on aquatic life?
- Have water quality changes coincided with changes in fish populations, macroinvertebrate populations, phytoplankton and zooplankton species abundance?
- What is the influence of nutrient loading, from both point and nonpoint sources, in driving the productivity of Utah Lake?
- How does nutrient loading vary by season and by hydrological condition?
- What are the current sources of nutrients, and the future expected sources, and how would changes in the nutrients affect water quality conditions of the lake?
- Has the lake ever been in a clear state, and if so, is restoration to a clear lake a desirable and achievable goal?
- What is the quality of water, including nutrients, algae, and organic matter, that is exported from Utah Lake to the Jordan River.
- What determines the frequency, occurrence and impact of harmful algae blooms (HABs) in Utah Lake?

Identifying Harmful Algal Blooms (HABs) in Utah Lake

Utah Lake, October 8, 2014

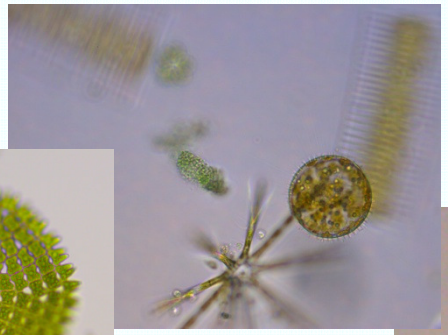


Dolichospermum spiroides

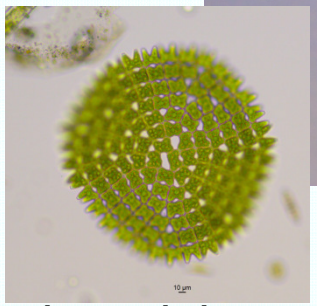


Aphanizomenon flos-aquae

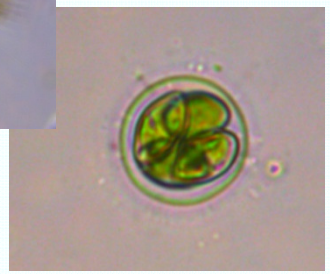
Cyanobacteria (Blue-Green) Bloom



Diatom assemblage



Pediastrum duplex



Oocystis borgei

Chlorophyta (Green Algae) Dominant. Very little cyanobacteria present.

Utah Lake, August 25, 2015

Complexities of Cyanobacteria Blooms

Although they have always occurred, cyanobacteria blooms have only recently become frequent and extensive enough to warrant public attention and management decisions.

Global Lake Ecological Observatory Network (GLEON)

Theory Working Group: BLOOM

Project Lead: Ana Morales

http://gleon.org/research/projects/bloom

How are "blooms" defined?

- Many working definitions exist
- Most address public health
- No cohesive ecological definition exists in the literature
- Ecological definition important for management decisions
- Related to beneficial use (support of warm water species, etc.)

Questions Regarding Ecological Impacts of Cyanobacteria Blooms Critical to Management

- How might the definition of a bloom vary according to differences in space (e.g., surface scum vs. whole water column)?
- How do we adjust sampling protocols to account for a surface bloom rather than a bloom throughout the entire water column?
- What drivers determine the longevity of a bloom is the composition of a bloom maintained throughout?
- What are the drivers of diversity within blooms? We often think of blooms as monospecific, but more frequently, they are not.
- What factors determine how many taxa can co-exist under "bloom conditions?"
- How often are blooms dominated by different groups?
- Does diversity within a bloom fluxuate between cyanobacteria dominance vs. diatom vs. dinoflagellate vs. green algae blooms?
- Do toxins have inhibitive or facilitative interactions?

HABs Particularly Difficult to Understand in Utah Lake

- large, shallow lakes create frequent and significant turbulence

- difficult to identify drivers of community development due to frequent resuspension of sediment

- loss of macrophytes leaves no habitat for epiphyton (algae attached to other plants) and therefore no competition for free floating phytoplankton

- impact of sediment resuspension impacts growth patterns of phytoplankton, favoring buoyant cyanobacteria

- research suggests that filamentous cyanobacteria in eutrophic shallow lakes may have "alternative stable states" and that a blue-green community may resistant to perturbations or delayed in their response to detrimental conditions (hysteretic), which are theoretically transitory. *

- Stronger competitors in turbid, low light conditions due to gas vesicles that allow cells to float to the surface

*Marten Scheffer, Sergio Rinaldi, Alessandra Gragnani, Luuc R. Mur, and Egbert H. van Nes 1997. ON THE DOMINANCE OF FILAMENTOUS CYANOBACTERIA IN SHALLOW, TURBID LAKES. Ecology 78:272–282

Data Acquisition – Phytoplankton Data

- significant amount of data exists on the phytoplankton of Utah Lake prior to 1990
- multiple publications have been based on this data and inform current understanding of phytoplankton in the lake
- may be beneficial to review and include data preceeding1990
- work plan tasks such as using data to determine if Utah Lake is experiencing an ecosystem shift will require historical data
- at least 3 sediment cores besides the core listed in the Work Plan data table have been collected and analyzed. Results have been published.
- contemporary data is less comprehensive

Literature Review

Existing Utah Lake Annotated Bibliographies:

Annotated bibliographies describing available reports, proposals, and publications on Utah Lake began with the TMDL study in 2004 and continued with efforts to implement an ecosystem monitoring program during the early stages of the
Carp removal program.

Phytoplankton: Rushforth
Zooplankton, water quality, and biology: Landom