
Nutrient & Physical Factors Controlling Algal Production in the Great Salt Lake
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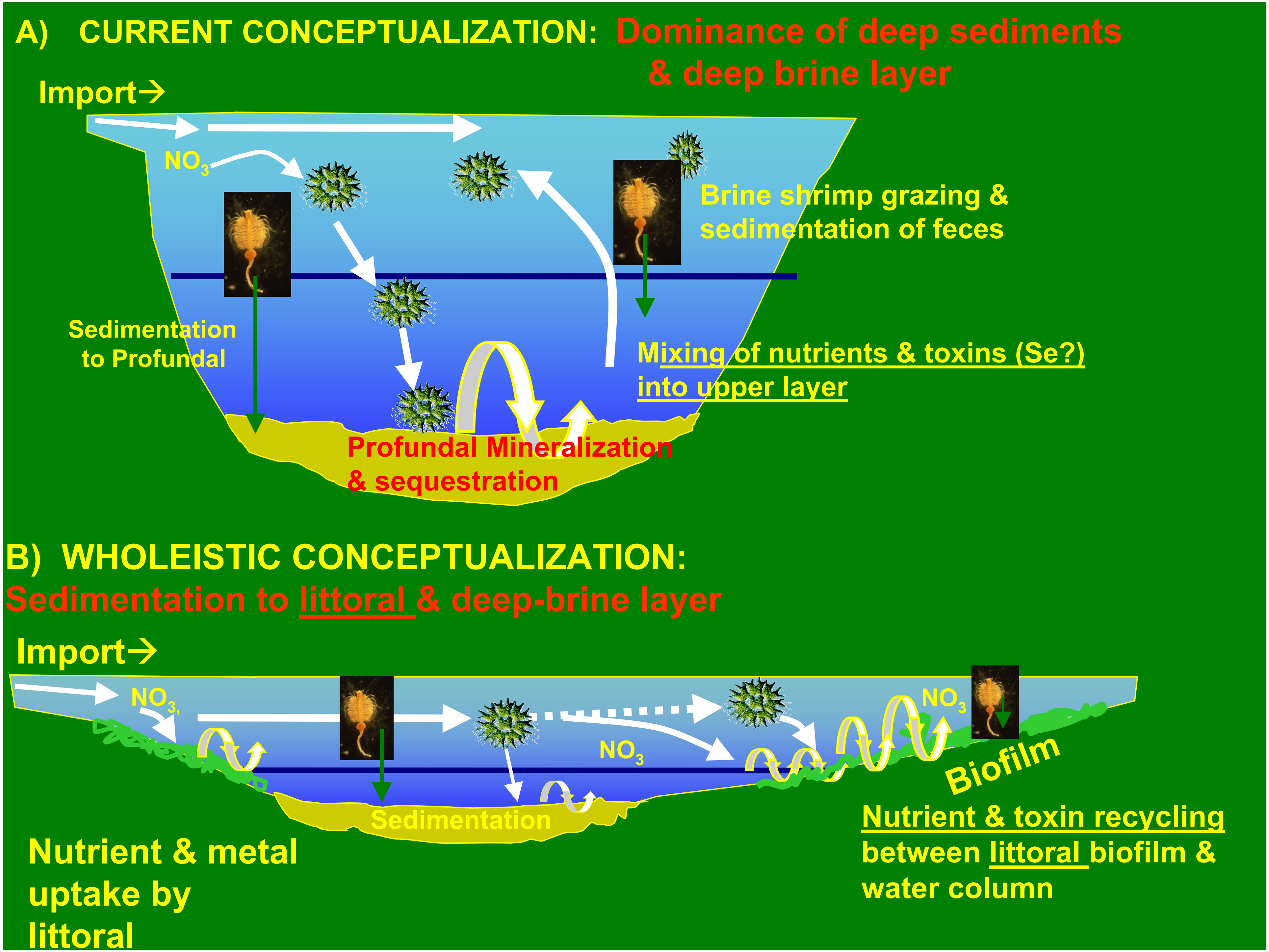
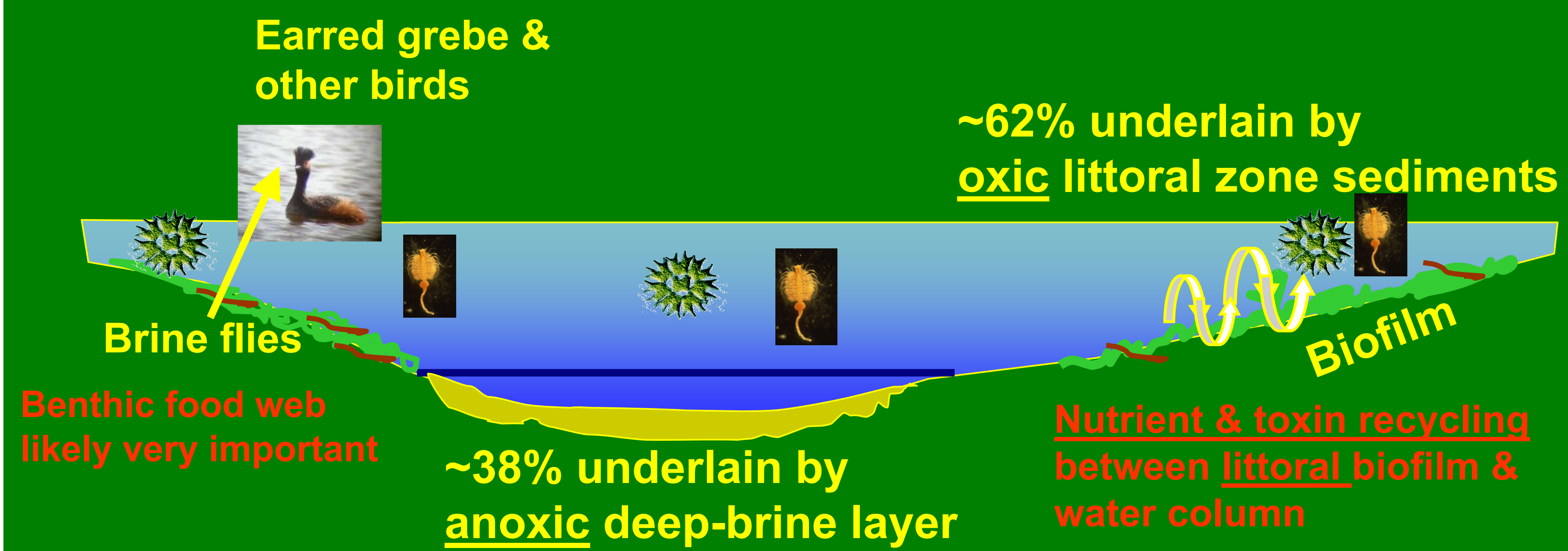
Great Salt Lake Water Quality Science Panel Meeting
March 15, 2005

Outline

- Lake Morphometry and Zones of Production and Regeneration of Nutrients (and Selenium?)
- The ignored benthic community
  - Biostromes (stromatolites), brine flies
  - Open sediments in photic zone
- H_2S and Erosion of the Deep-Brine Layer during Summer
- Nutrient & Grazing Control of Phytoplankton


A) CURRENT CONCEPTUALIZATION: Dominance of deep sediments & deep brine layer
Import→
NO3
Brine shrimp grazing & sedimentation of feces
Sedimentation to Profundal
Mixing of nutrients & toxins (Se?) into upper layer
Profundal Mineralization & sequestration
B) WHOLEISTIC CONCEPTUALIZATION:
Sedimentation to littoral & deep-brine layer
Import→
NO3,
NO3
NO3
Biofilm
Sedimentation
Nutrient & metal uptake by littoral
Nutrient & toxin recycling between littoral biofilm & water column

Lake Morphometry & Production Zones



In summer, when Secchi transparency is > 3 meters, the entire littoral zone down to the deep brine layer has sufficient light for algal photosynthesis.

Stromatolites

Marine stromatolites

Distribution

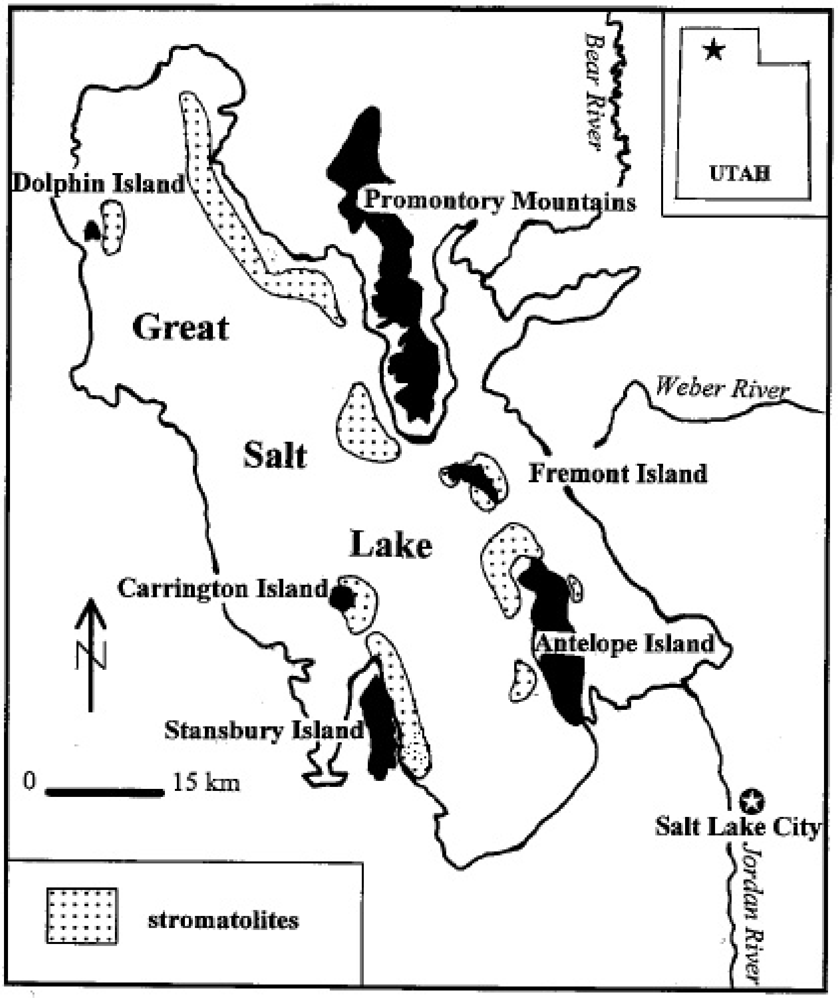
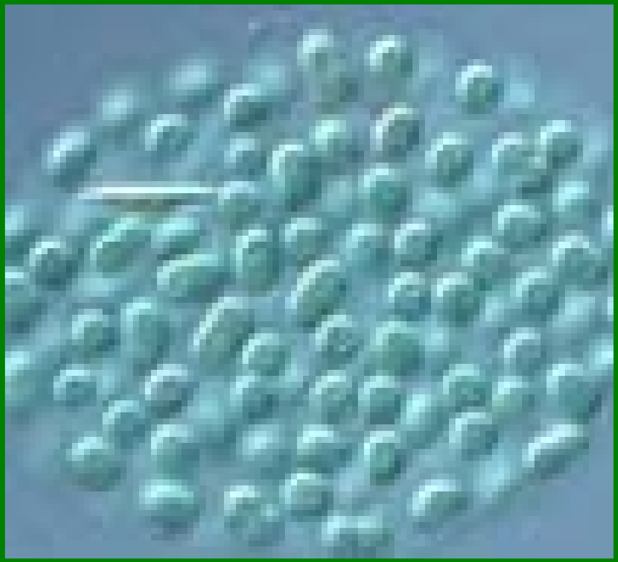


Figure 1. Map of Great Salt Lake, Utah, at its average lake-level elevation of 1280 m.

Pedone and Folk, 1996

Ecology of stromatolites in Great Salt Lake nearly unstudied



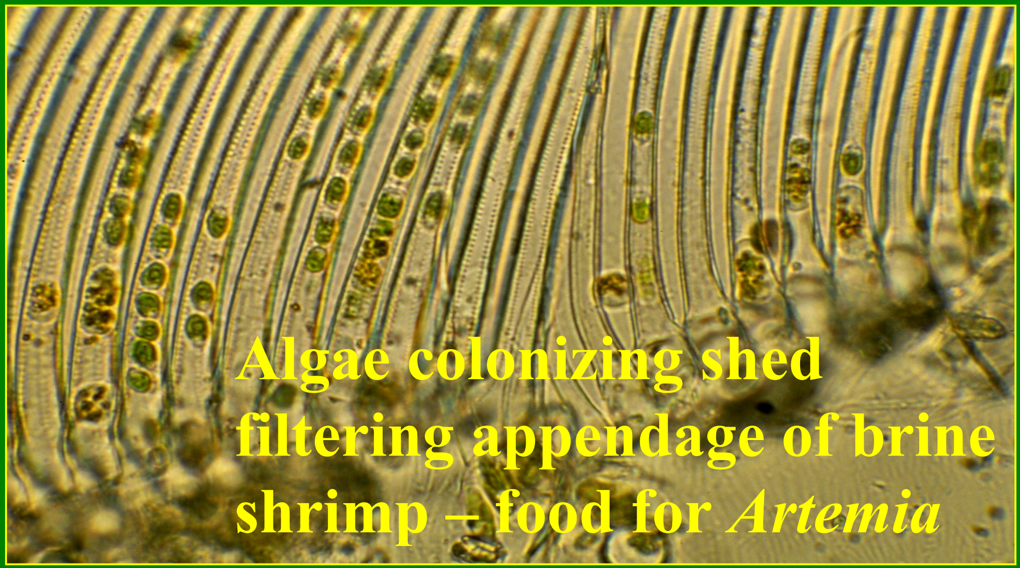
99% unicellular cyanobacteria *Aphanothece sp.* imbedded in calcareous material (Parker et al. 2005)

- No nitrogen fixation (single assay)
- Did not respond to nitrogen, phosphorus, or N+P in bioassay experiment (Parker et al. 2005)

-Solid substrate provides main habitat for brine fly larvae & pupae. Pupal densities 1000-5000/m^2 (Collins 1980)

Ecology of soft substrates in littoral zone even less understood, but the areal extent of these is greater than that of stromatolites

- algal growth on soft substrates
- detrital processing of algae & feces that fall to sediments (*Artemia*, bacteria and protozoan community)

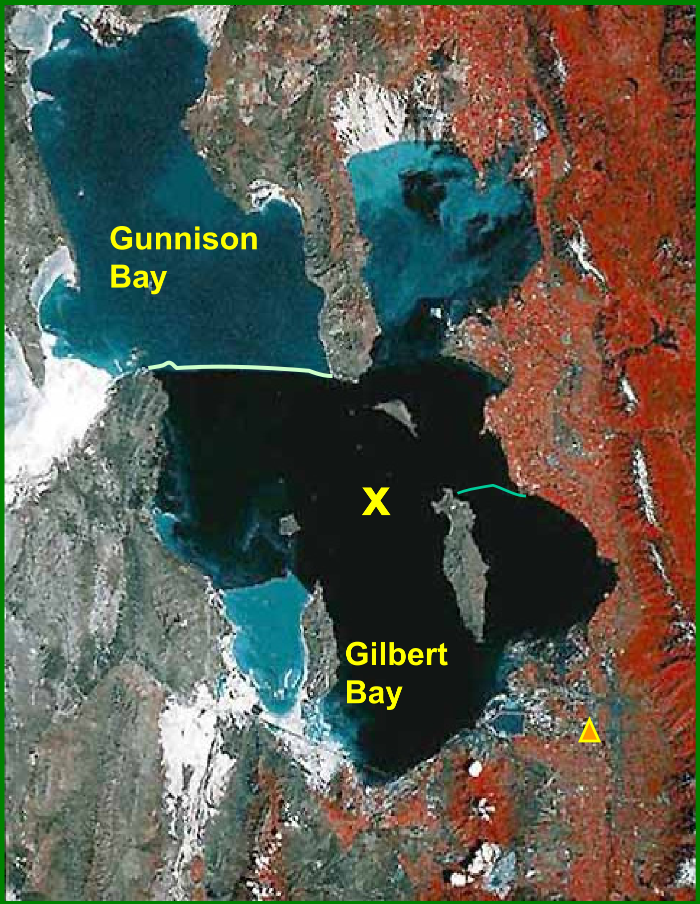


- pollutant mobilization and/or sequestration?

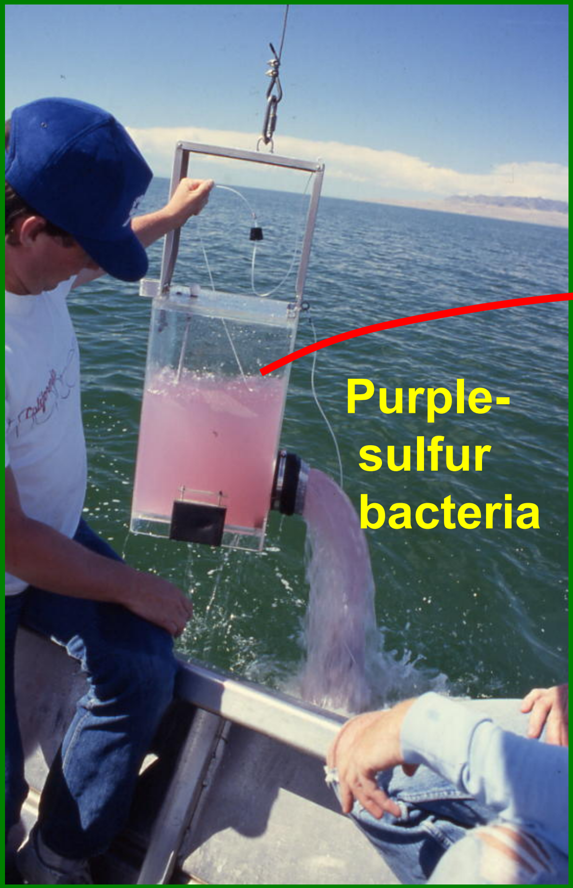
Mixing Processes in Gilbert Bay

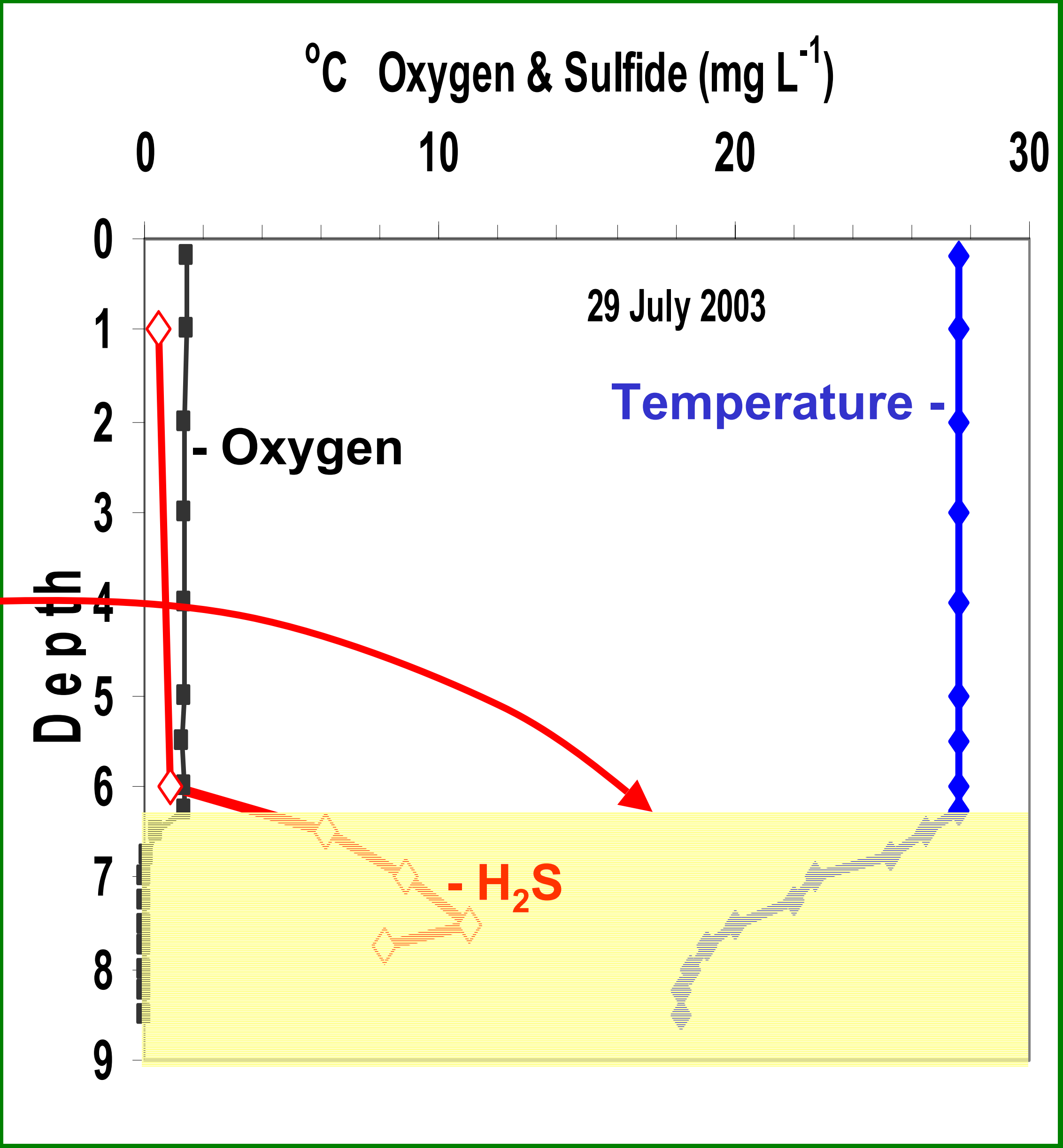
- **Question: Does the deep brine layer in Gilbert Bay erode and release odor causing H_2S?**

- **Approach**
  - **Thermistor string placed in Gilbert Bay from 29 July – 7 Sept, 2003**
  - **Profile sampling of H_2S**

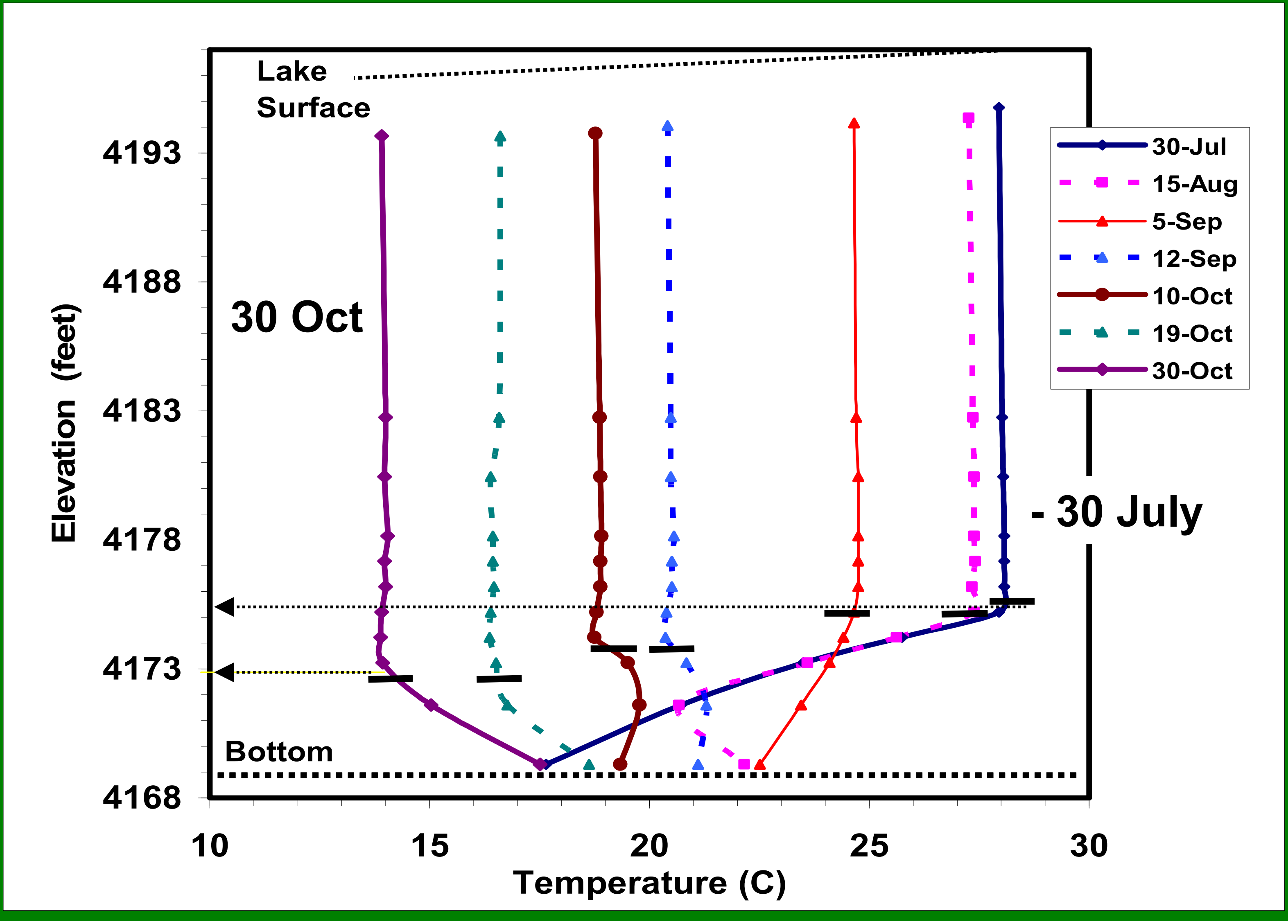


Deep brine layer anoxic with high levels of H_2S





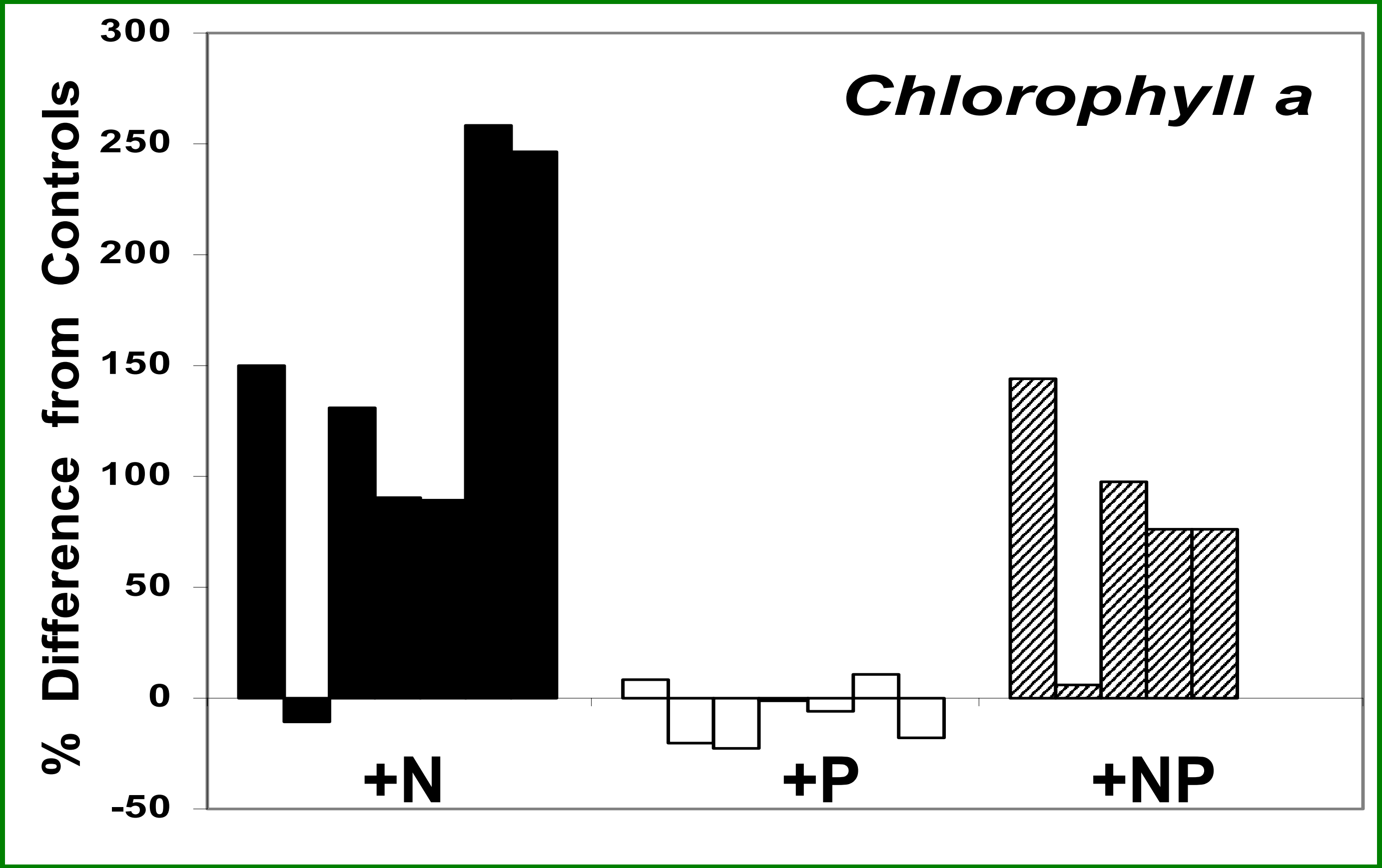
Thermistor data indicated that deep brine layer eroded ~ 2.5 ft (0.75 m) from July-October



Control of phytoplankton in open waters of Gilbert Bay

- **Nutrient control (bottom-up)**
- **Grazing control (top-down)**

- In nutrient addition bioassays, phytoplankton respond to nitrogen additions (NH_4, NO_3), but not to phosphorus
  - Porcella & Holman (1972)
  - Stephens & Gillespie (1976)
  - Wurtsbaugh (1988), Wurtsbaugh et al. (unpublished)



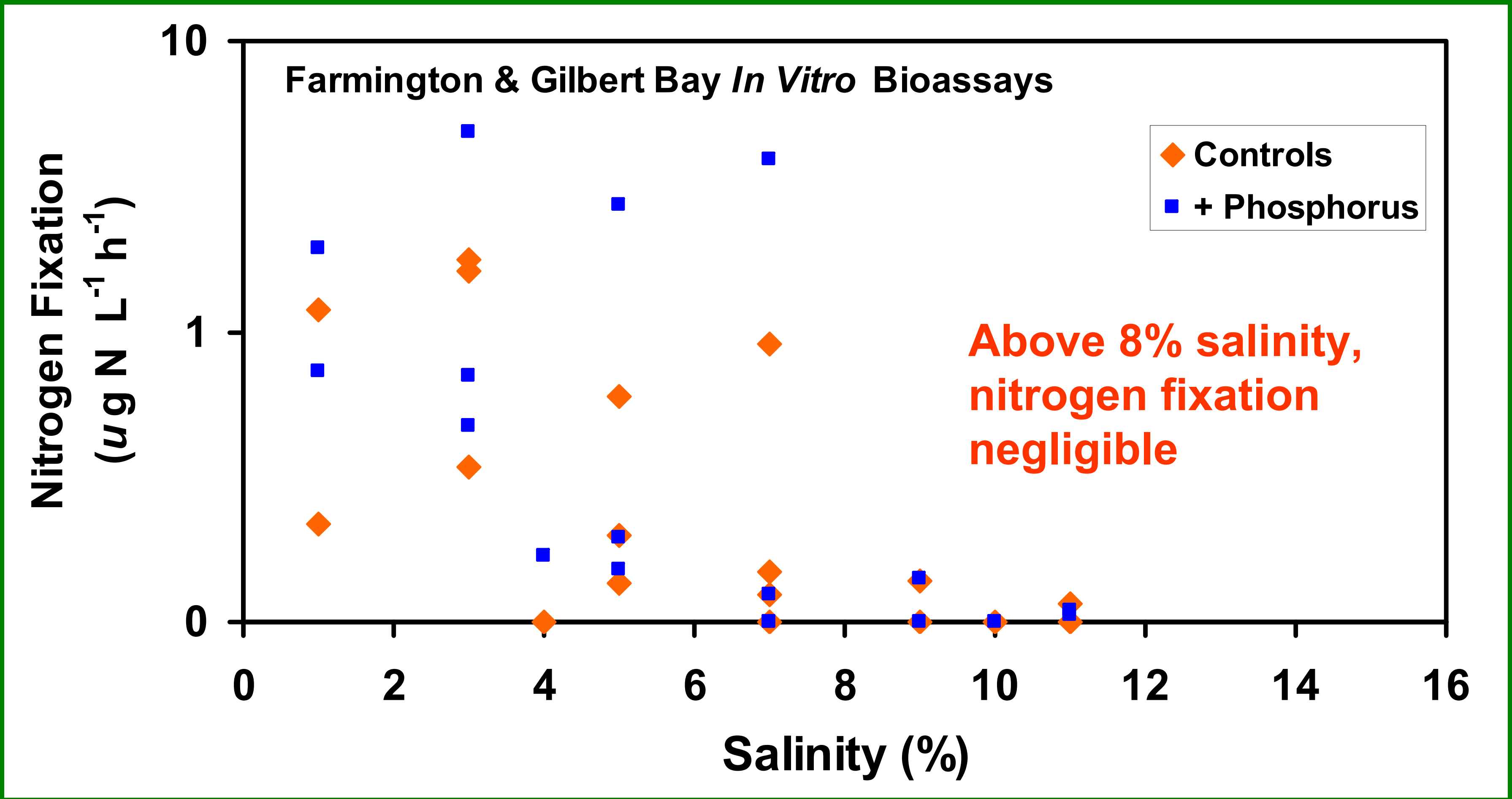
Lakes commonly viewed as N-limited:

- **Ruling hypothesis suggests that <u>nitrogen fixation</u> by cyanobacteria can make up any nitrogen deficit, so that lakes "should" always be P-limited**

- **Why then, are the Great Salt Lake and many other saline and freshwater lakes N-limited?**

- **Two complimentary hypotheses**
  1. **Salinity limits N-fixation**
  2. **P recycled more efficiently in saline lakes**

1. Height Salinity Levels Control Nitrogen Fixation



Adapted from Wurtsbaugh & Marcarelli (2004)

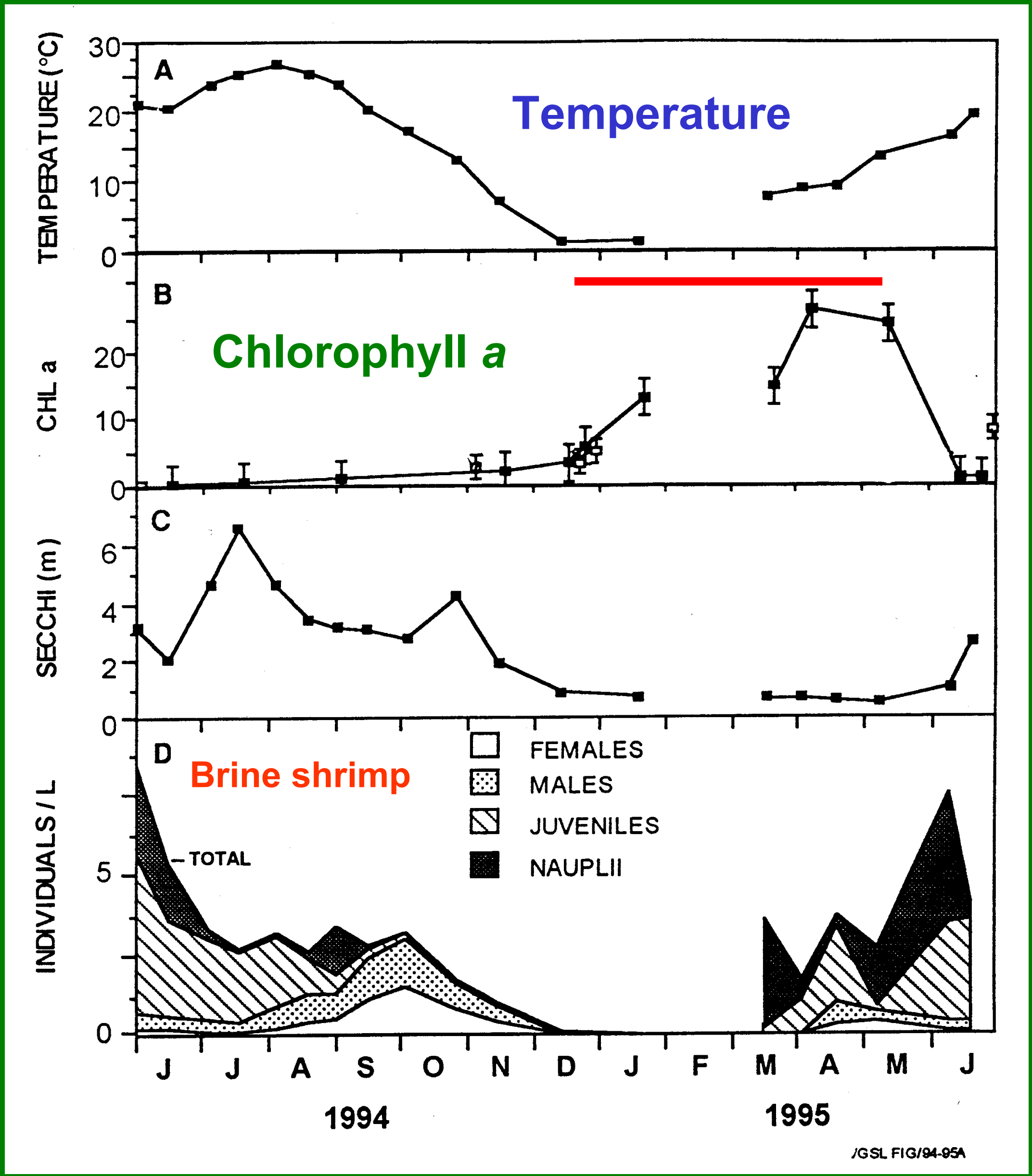
2. Phosphorus cycled more efficiently in saline systems with high $SO_4^{=}$ than in freshwater lakes

Blomqvist S. et al. 2004. Why the limiting nutrient differs between temperate coastal seas and freshwater lakes: A matter of salt.
Limnol. Oceanogr. 49: 2236-2241

- ***Greater phosphorus availability in saline waters, primarily because of enhanced iron sequestration by sulfide***

- ***"This difference is a consequence of the high sulfate content of sea salt, and a main reason why nitrogen normally limits net primary production in … coastal waters, in contrast to the predominant phosphorus limitation of … lakes."***

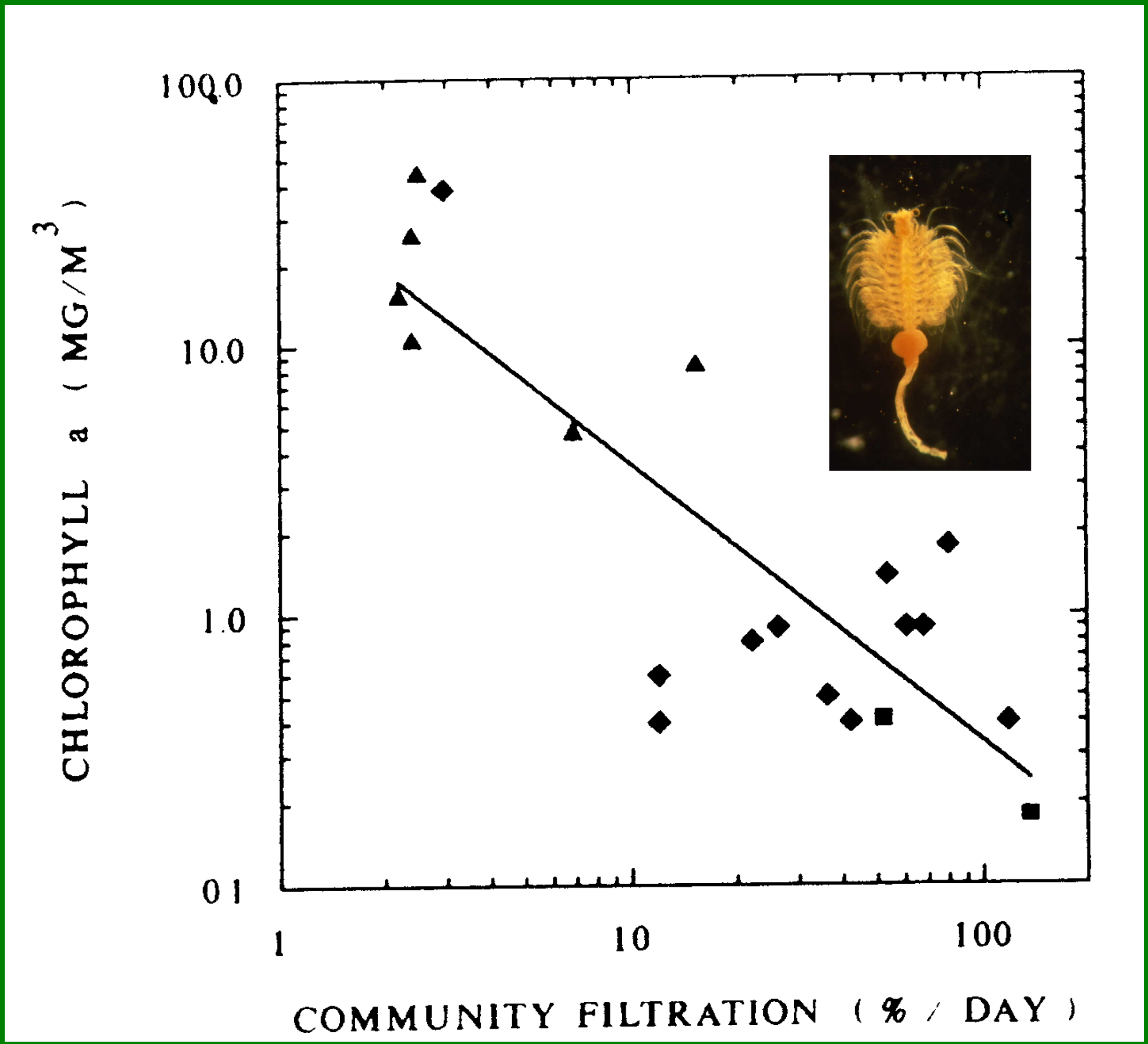
Grazing Control of Phytoplankton



Phytoplankton sparse when *Artemia* abundant <u>and</u> temperatures high

Wurtsbaugh (1995)

Phytoplankton (chlorophyll) correlated with temperature-mediated grazing rate in zooplankton community



Wurtsbaugh (1992)

Summary

- **Both pelagic <u>and</u> benthic communities likely important in nutrient and metal cycling in lake.**
  - **>60% of lake bottom is oxic**
  - **Lake bottom above deep brine layer is in photic zone most of summer**
  - **Benthic zone has both fine sediments & stromatolites**

- **Deep-brine layer & H_2S dynamic, being eroded by wind mixing and replenished by continued flow from north basin.**

- **Phytoplankton in Gilbert Bay are nitrogen-limited. Lack of nitrogen fixation in high salinity water and enhanced recycling of phosphorus may explain this phenomenon**

- **Grazing by *Artemia* and other invertebrates applies top-down control of phytoplankton populations. Grazing effectively moves nutrients (and perhaps toxins) from the pelagic to benthic zone.**


Thanks