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Mercury and Selenium Bioaccumulation in the Stromatolite Community of the Great Salt Lake, Utah, USA

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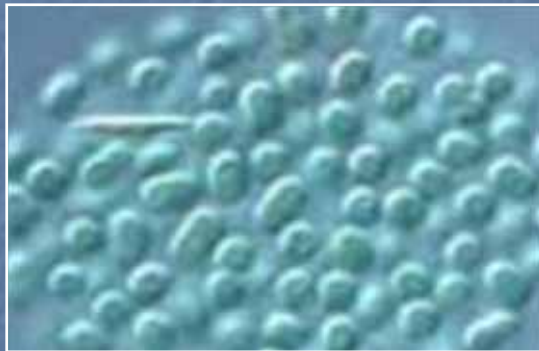
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Mercury and selenium bioaccumulation in the stromatolite community of the Great Salt Lake, Utah, USA

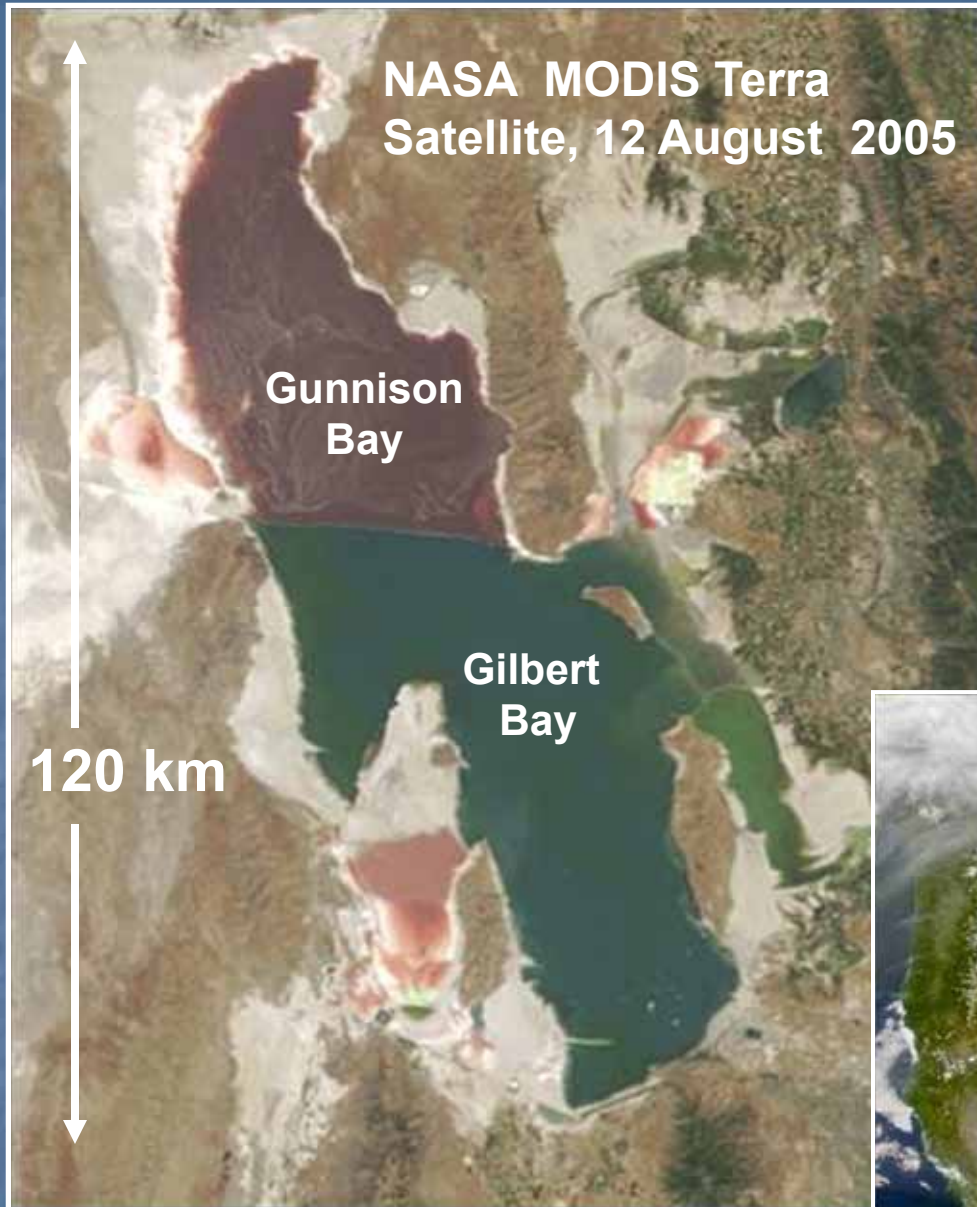
Wayne Wurtsbaugh
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ISSLR 2011 – Mar Chiquita

Great Salt Lake

- Area ~ 4300 km²
- Mean depth 4.5 m
- Salinity 10-30%
- Mean Chl a 21 µg/L
- Total Hg 2-8 ng/L



Birds

Western Hemispheric Shorebird Reserve (1991)

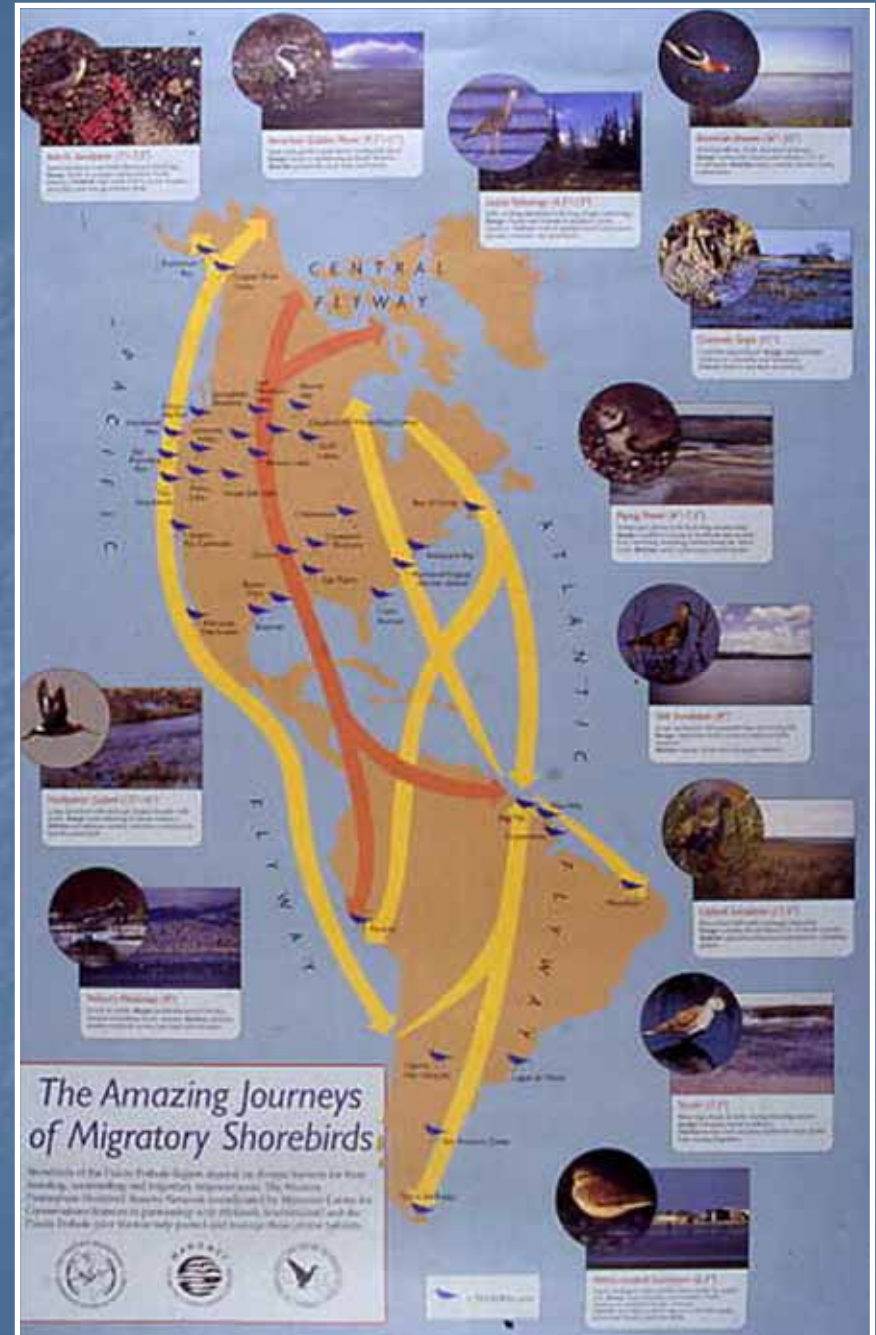


Artemia

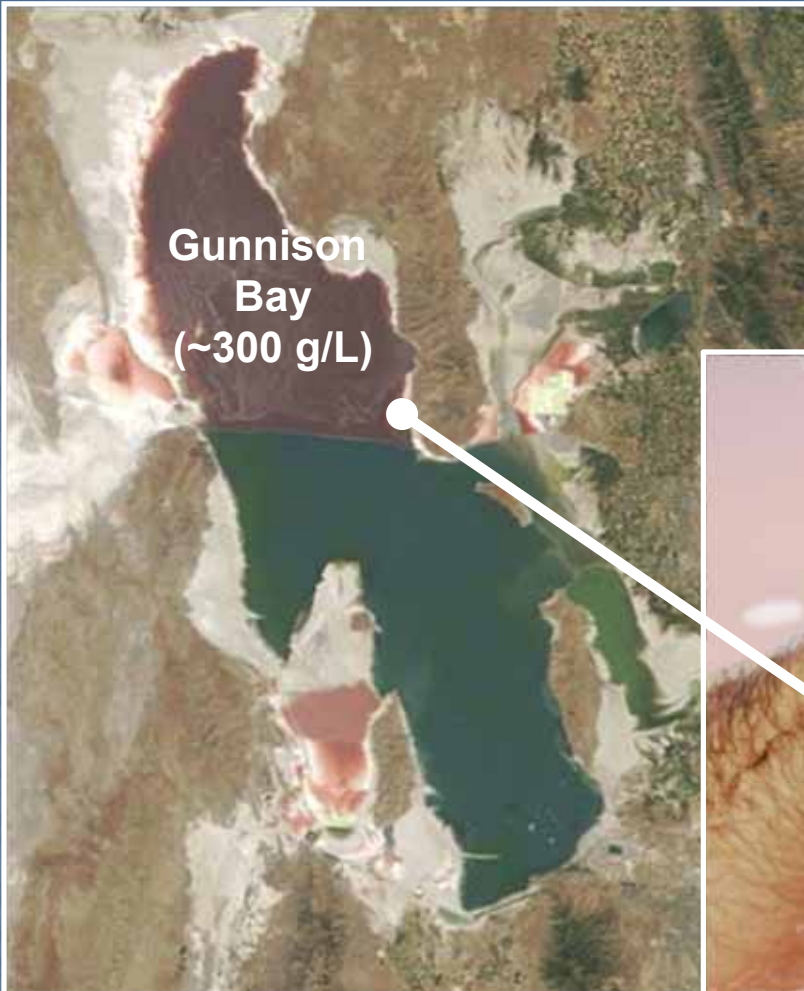
Abundant
Food
Resources



Ephydra cinerea



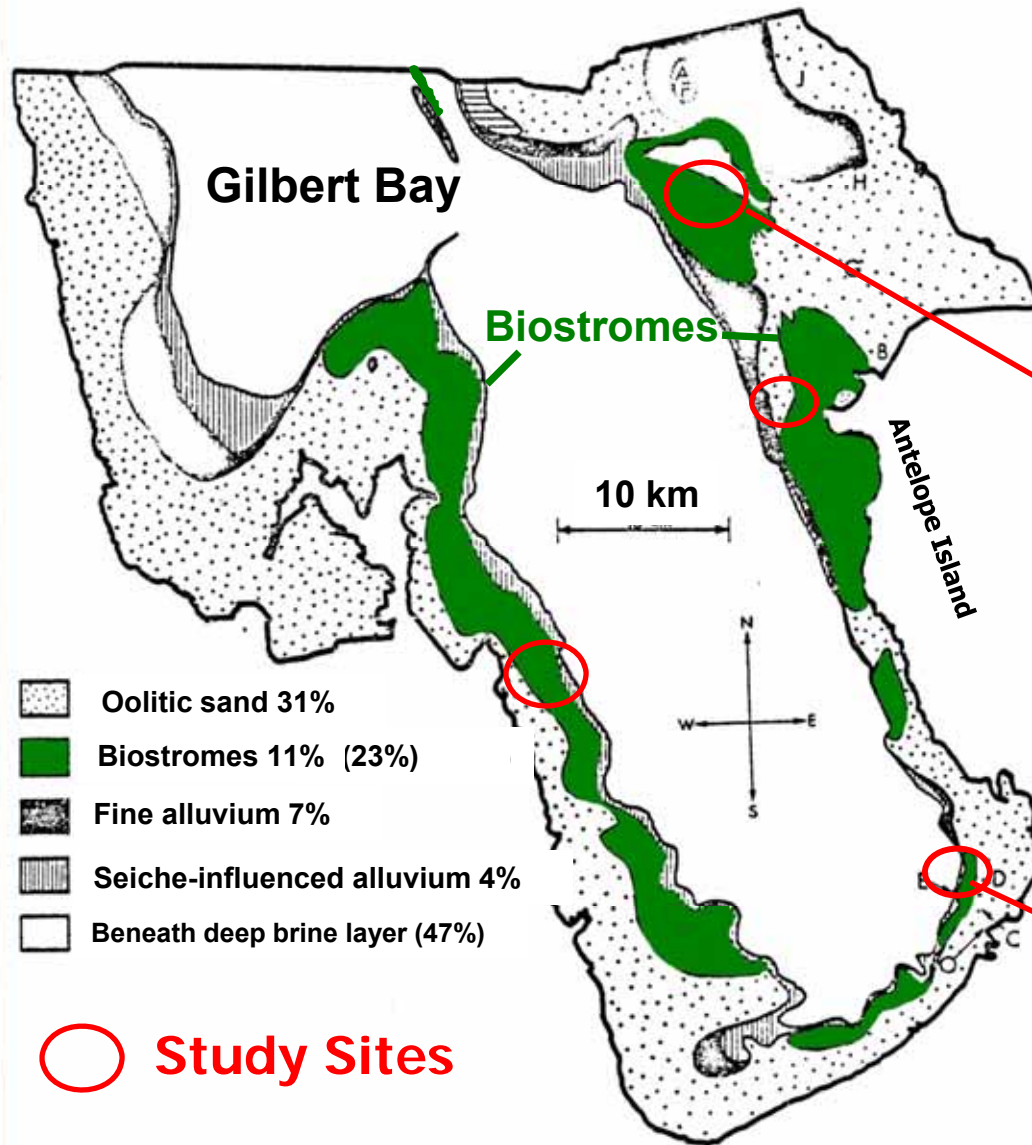
Biostrome Structures



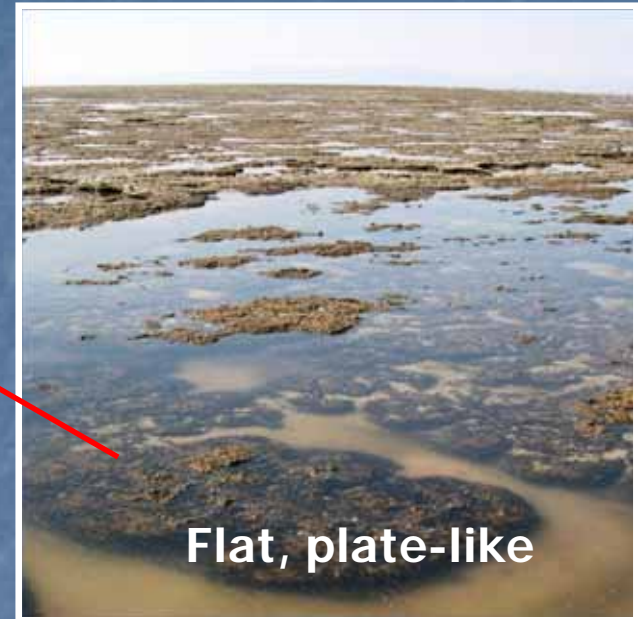
No macroinvertebrate community in 300 g/L waters

Biostrome Structures

Biostrome Distribution in Gilbert Bay

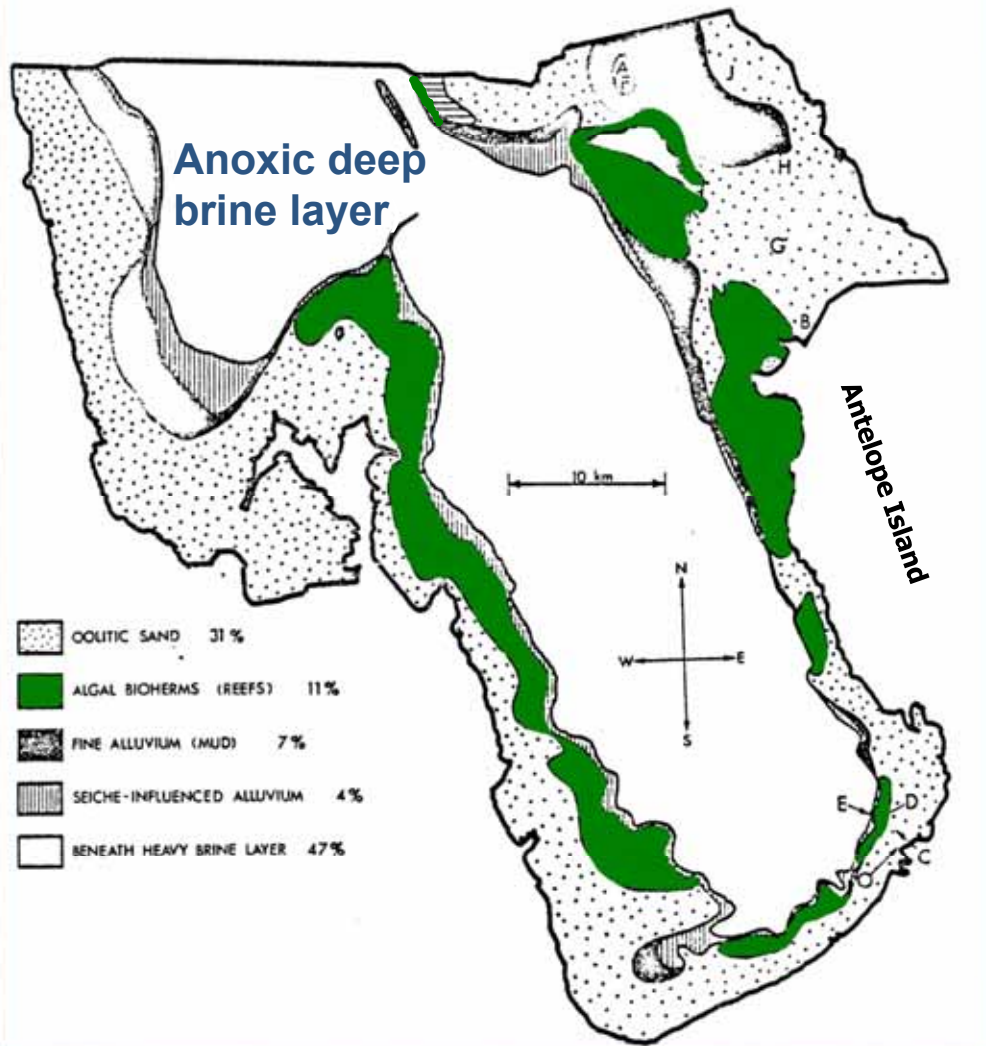


After Eardley (1938)



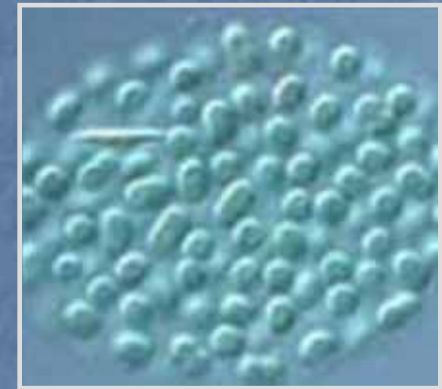
Mounds, ca. 1-m high

Distribution in Gilbert Bay



Stromatolites (Biostromes)

Dominant hard substrate for
periphyton, brine fly larvae &
pupae



Aphanothece sp.
(cyanobacteria)

Food Web Importance:
Principal Brine Fly Habitat



Ephydra cinerea

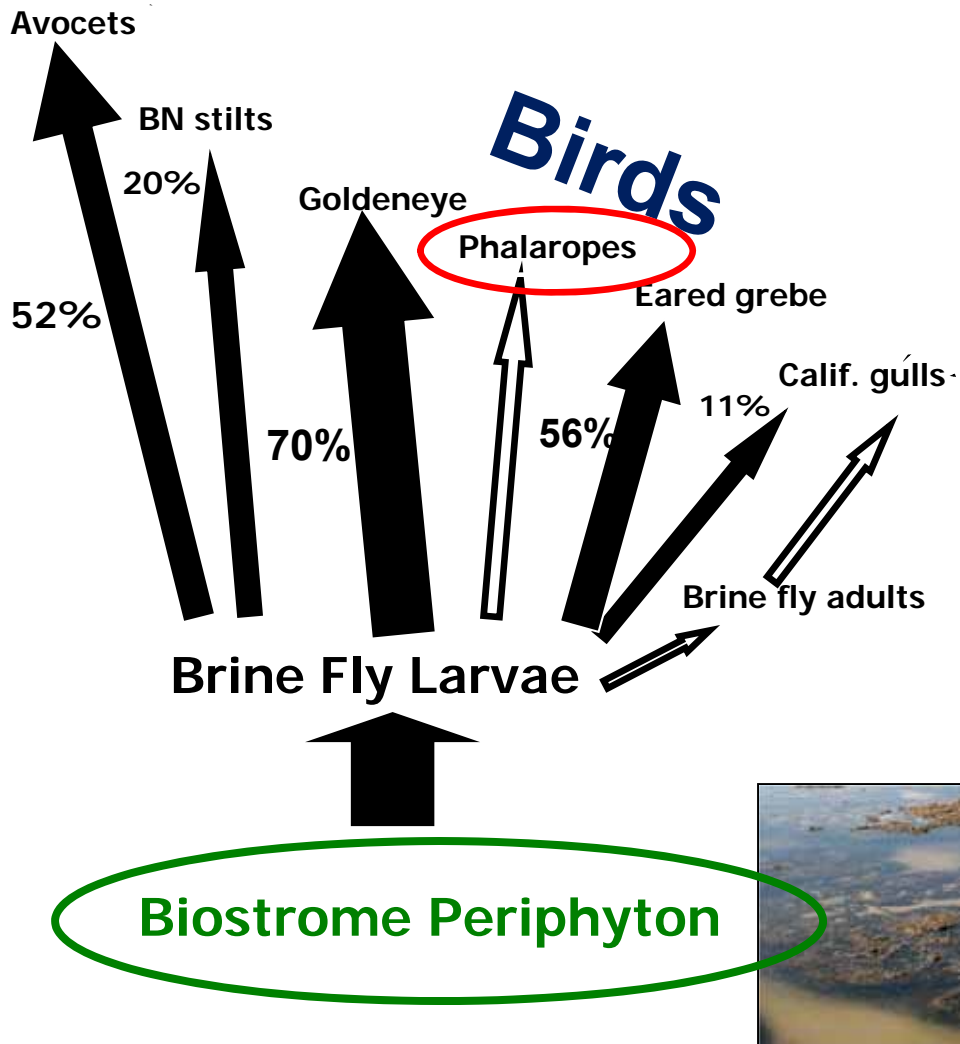
Simple Food Web



Cyanobacteria → Brine fly larvae → Goldeneye, grebes,
(*Aphanothece* sp.) and adults avocets, gulls, etc.



Gilbert Bay Food Web



Background for study

- High mercury levels in the Great Salt Lake, especially methyl mercury (Naftz et al. 2008).
- Concern about selenium because of request from mining company to discharge selenium into the lake

Few fish, but still there is a Mercury-Human Health Issue – **Consumption Advisories** on Three Species of Ducks



Northern shoveler



Cinnamon teal



Goldeneye
(Diet: 70% brine fly larvae)

Questions

- How important are the stromatolite communities for algal and invertebrate production in the Great Salt Lake?
- Do mercury and selenium bioaccumulate in the stromatolite communities and contribute to the high mercury loads in ducks that feed in the lake?
 - Part of two larger studies by agencies & universities on mercury & selenium contamination in the lake

Stromatolite Sampling Methods

- Brine fly larvae & pupae:
Bucket Sampler & SCUBA
Scrub stromatolite
surface with brush



Sample pumped
to boat & sieved

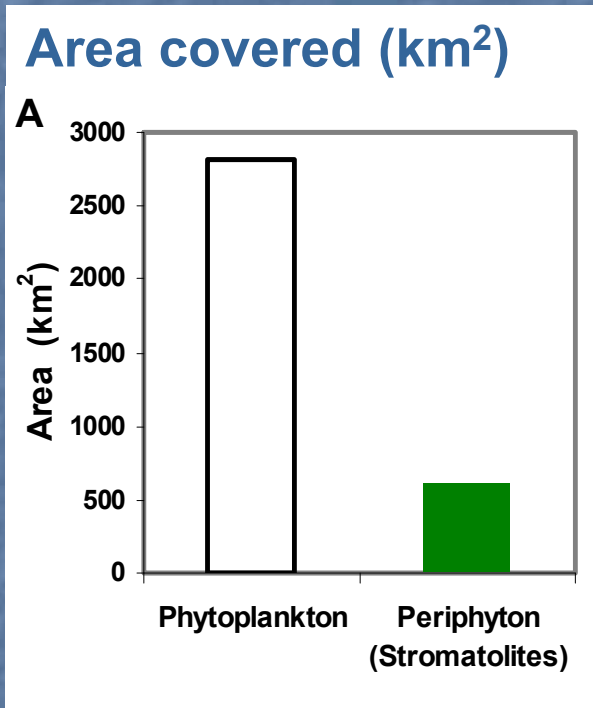
Selenium – 2006-07 (2 stations, June)

Hydride generation & atomic fluorescence spectrometry – Frontier Geosci.

Mercury – 2008 (3 stations, 5 times, June – Dec)

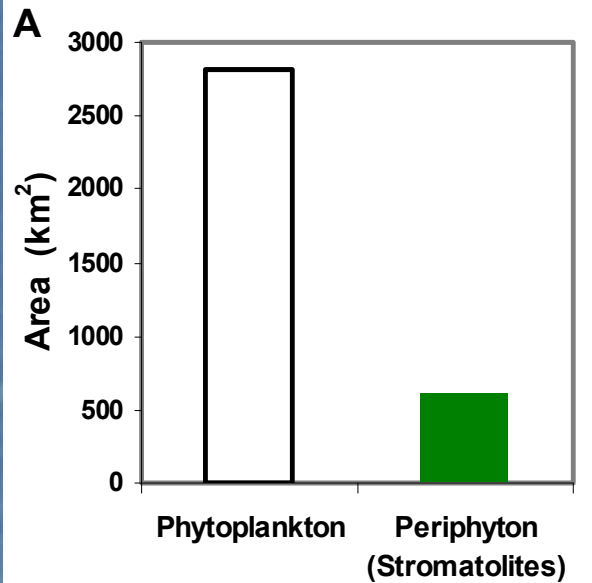
Cold vapor atomic fluorescence spectrometry (USGS Lab)

Abundance of Periphyton on Stromatolites Compared to Phytoplankton in Gilbert Bay

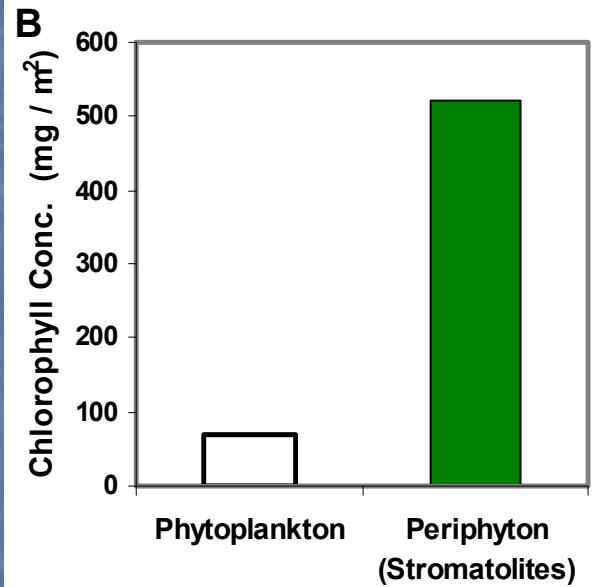


Abundance of Periphyton on Stromatolites Compared to Phytoplankton

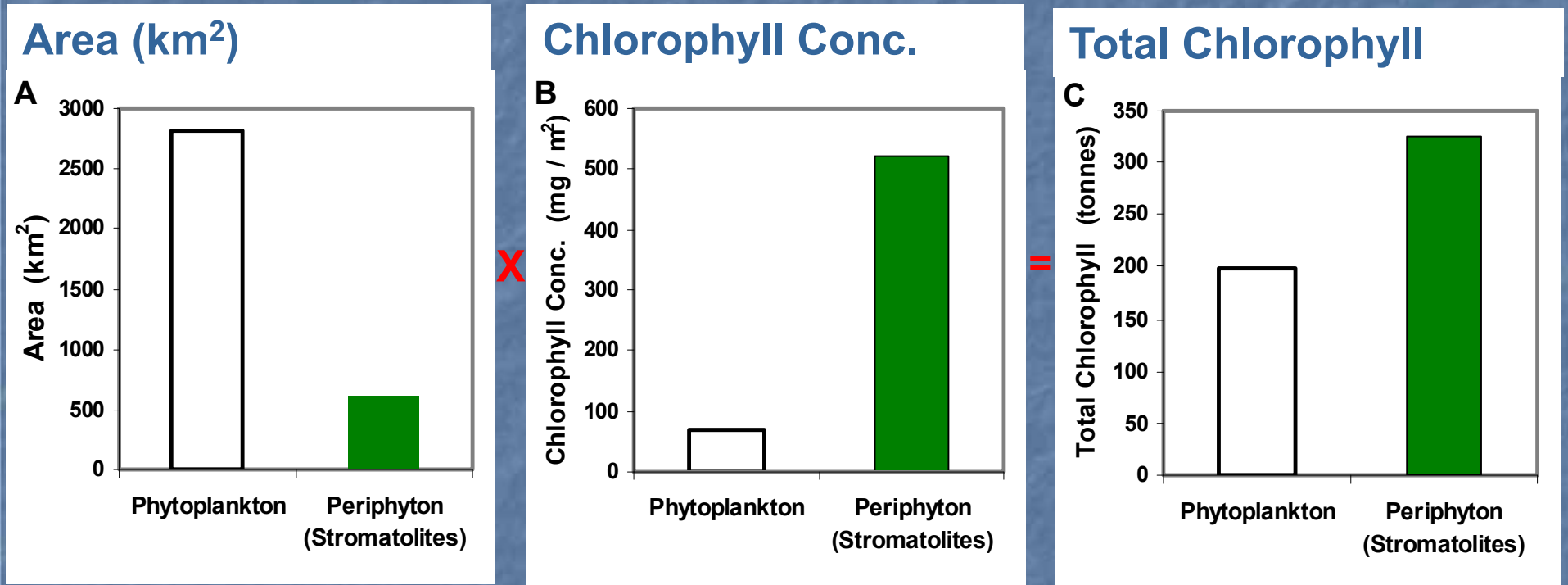
Area (km²)



Chlorophyll Conc.



Abundance of Periphyton on Stromatolites Compared to Phytoplankton



Periphyton on biostromes is a very important component of primary producers for Gilbert Bay

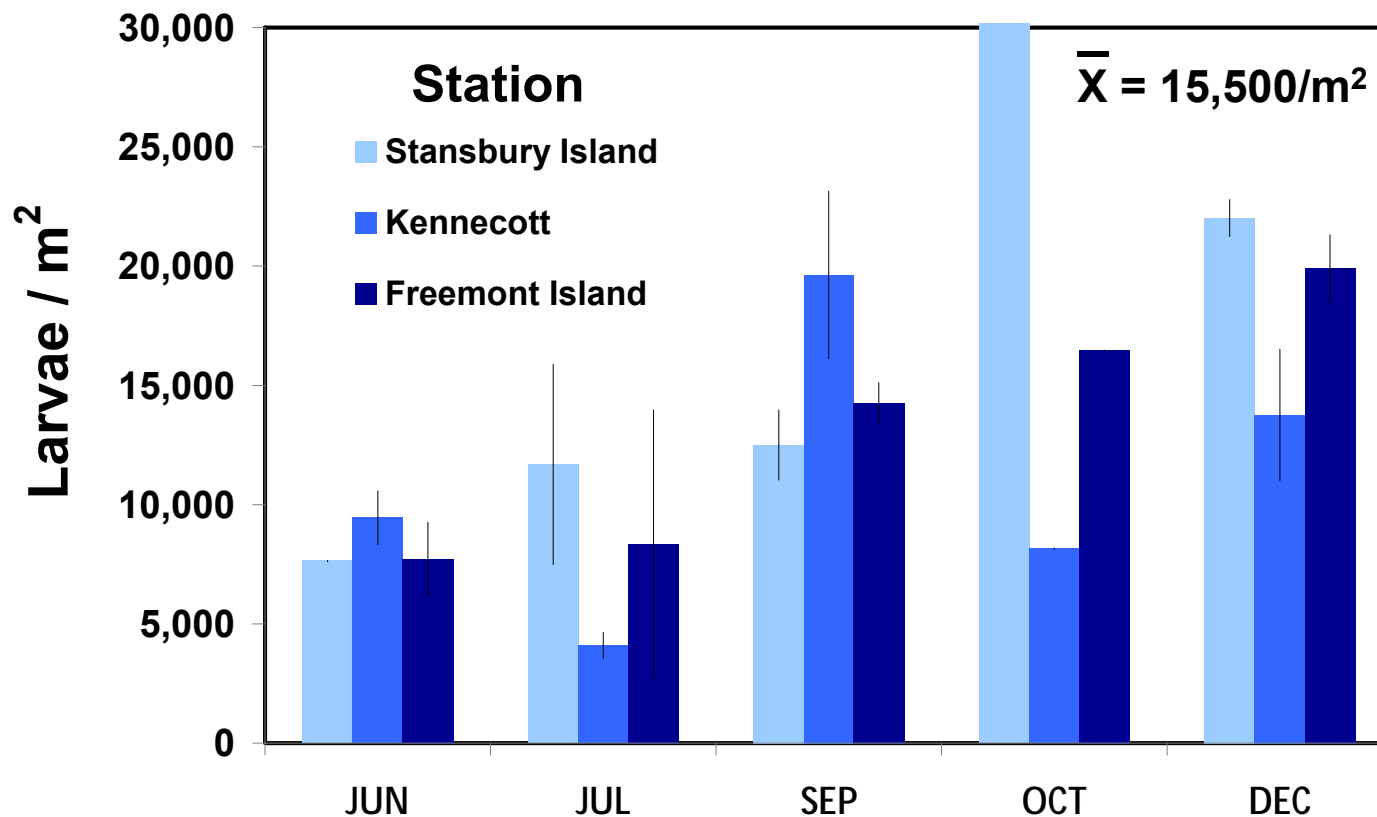
*Based on May-October phytoplankton in Gilbert Bay (2002-2005), and summer periphyton values

Brine fly larvae very abundant on stromatolites

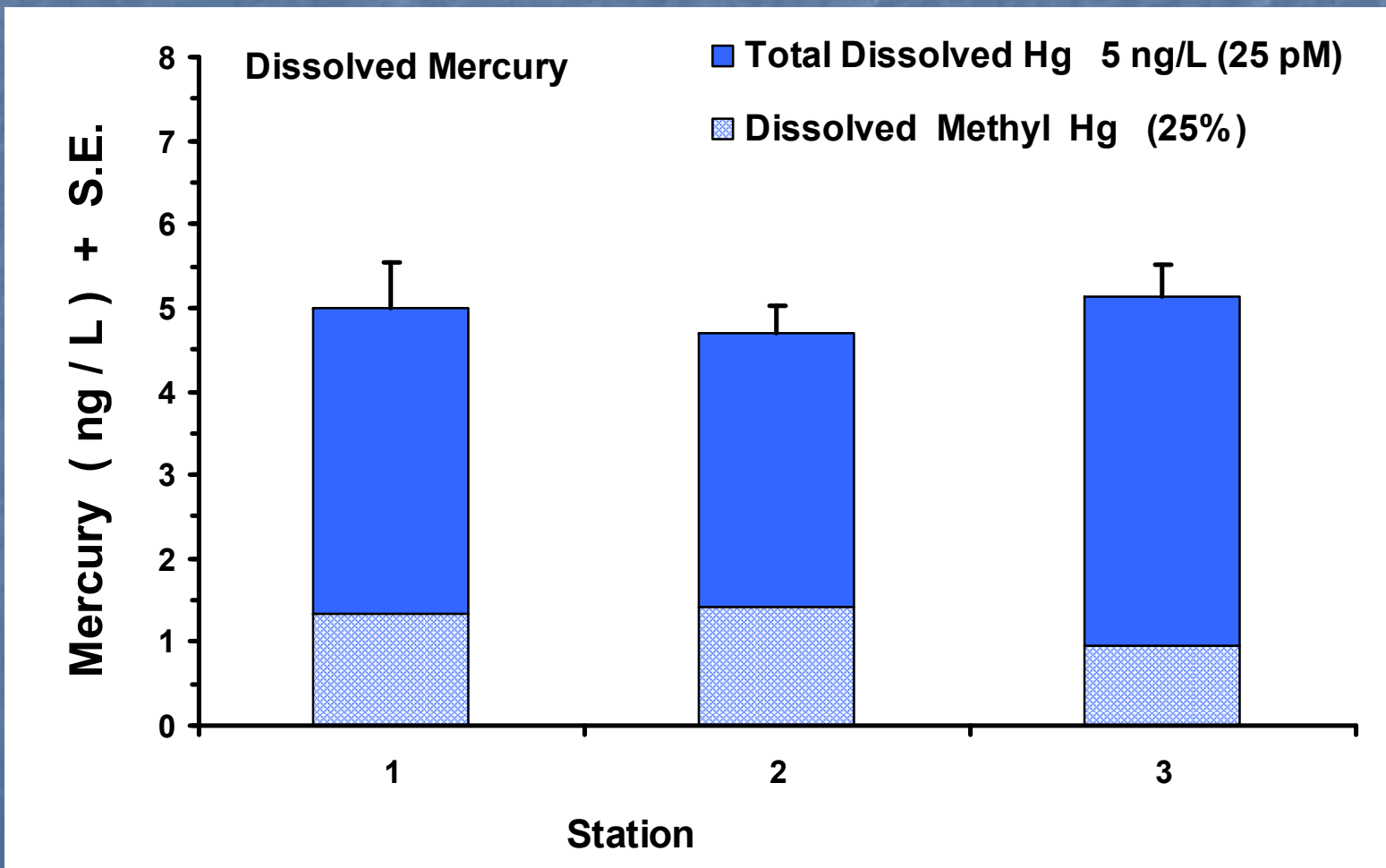


10 mm

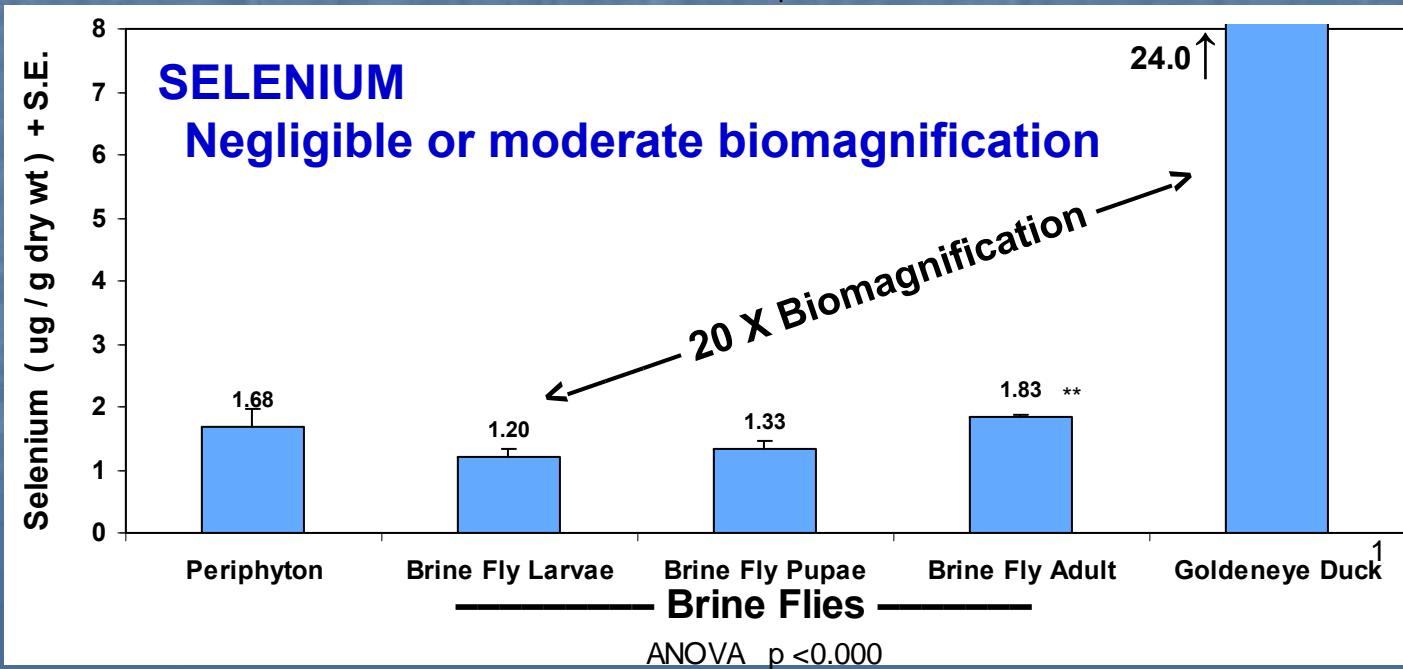
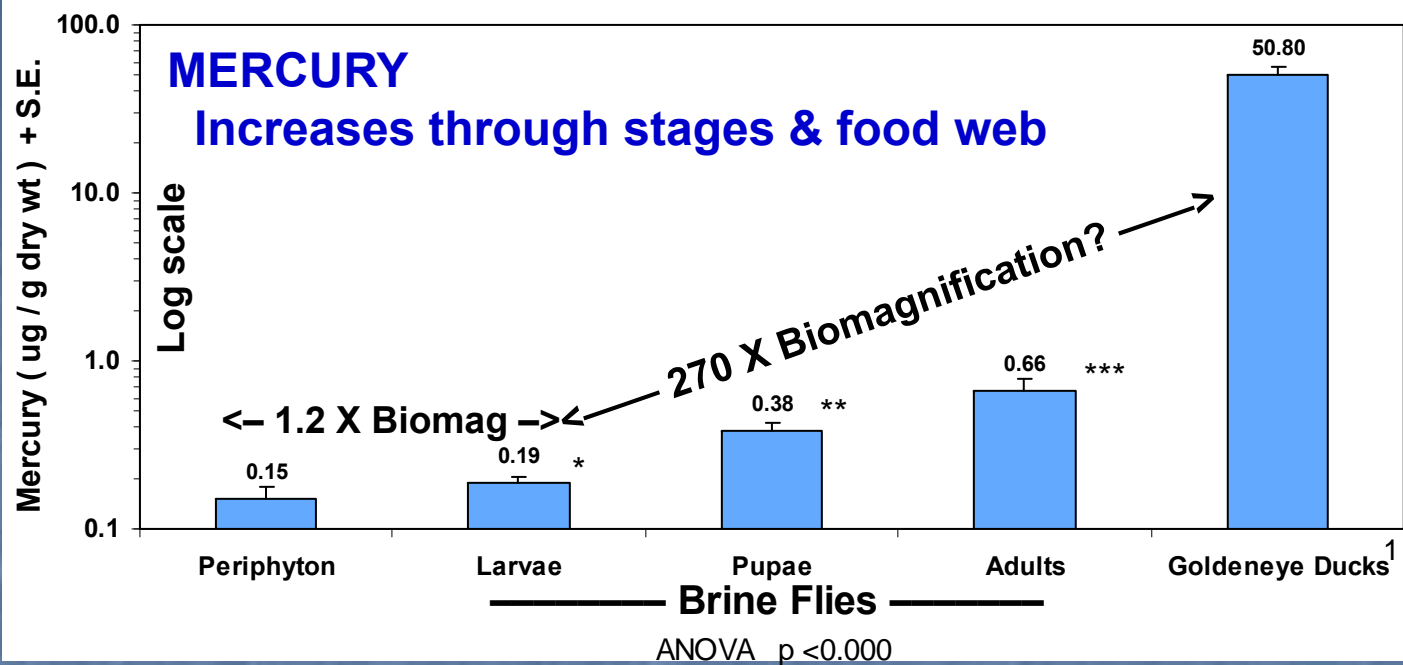
Brine Fly Larvae Abundance (2008)



High Dissolved Mercury Concentrations Over Biostromes

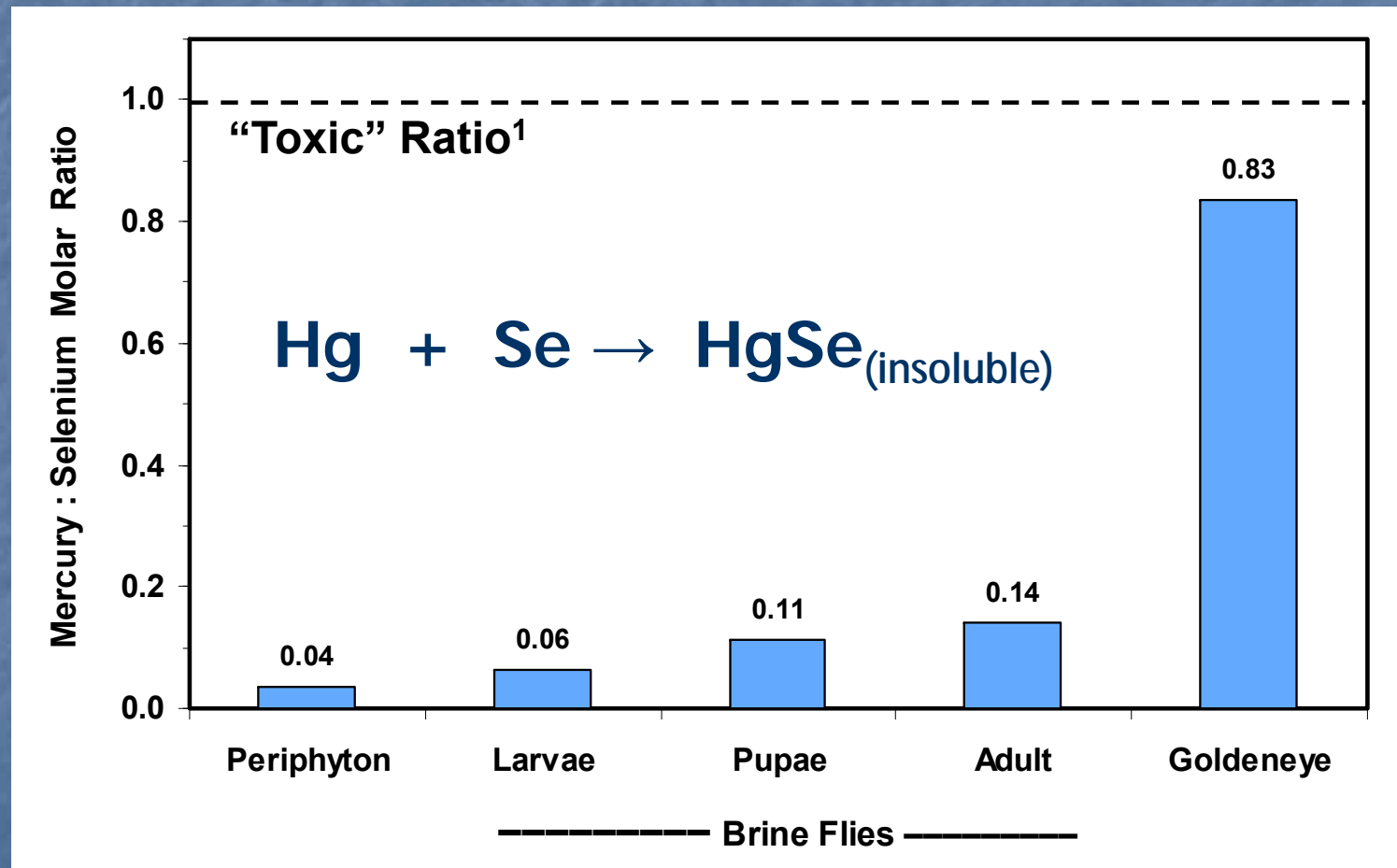


ANOVA: $p = 0.252$



¹Goldeneye Data from Vest et al. 2008

Low Hg:Se Molar ratios suggest that although Hg levels are high in the biota, toxicity may be minimized by sequestration



¹Ganther et al. 1972; Ralston et al. 2007

Conclusions

- **Stromatolites/periphyton and brine flies are important in the economy of the lake, and important in the diets of many bird species, likely rivaling the importance of brine shrimp as a food source.**
- **Mercury concentrations are high in biostromes and in brine flies, but biomagnification not important in the periphyton → brine fly larvae transfer.**
- **Goldeneye ducks have very high mercury concentrations: either there is very high biomagnification in the brine fly → duck transfer, or the ducks are obtaining mercury from elsewhere.**
- **Hg:Se ratios < 1 suggest that even the high mercury levels may not be toxic to the biota**

Questions?



Acknowledgements:

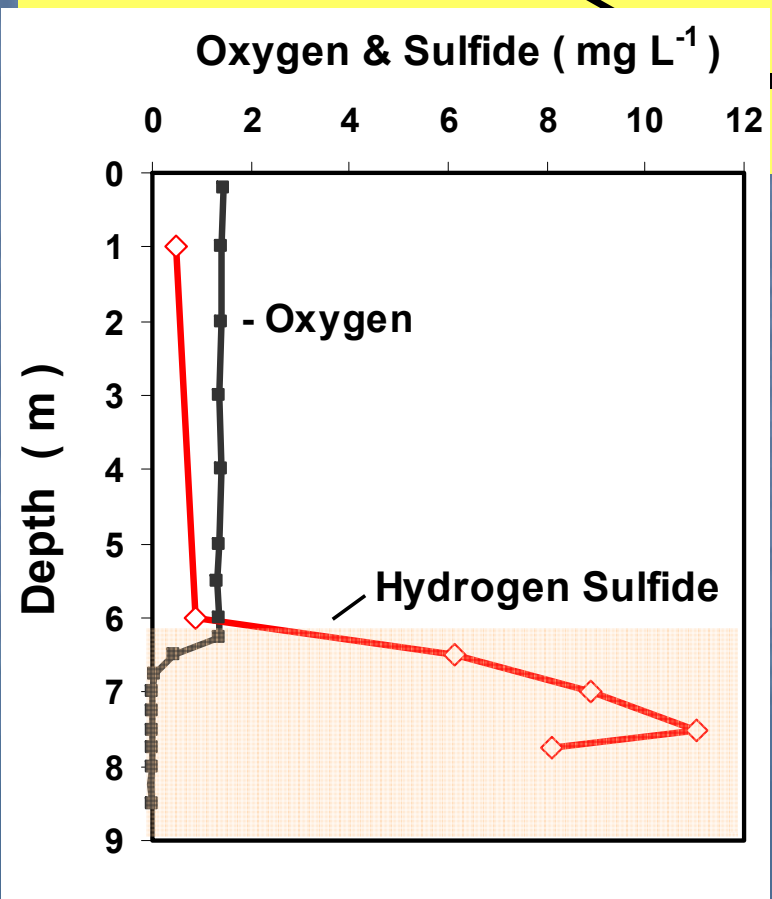
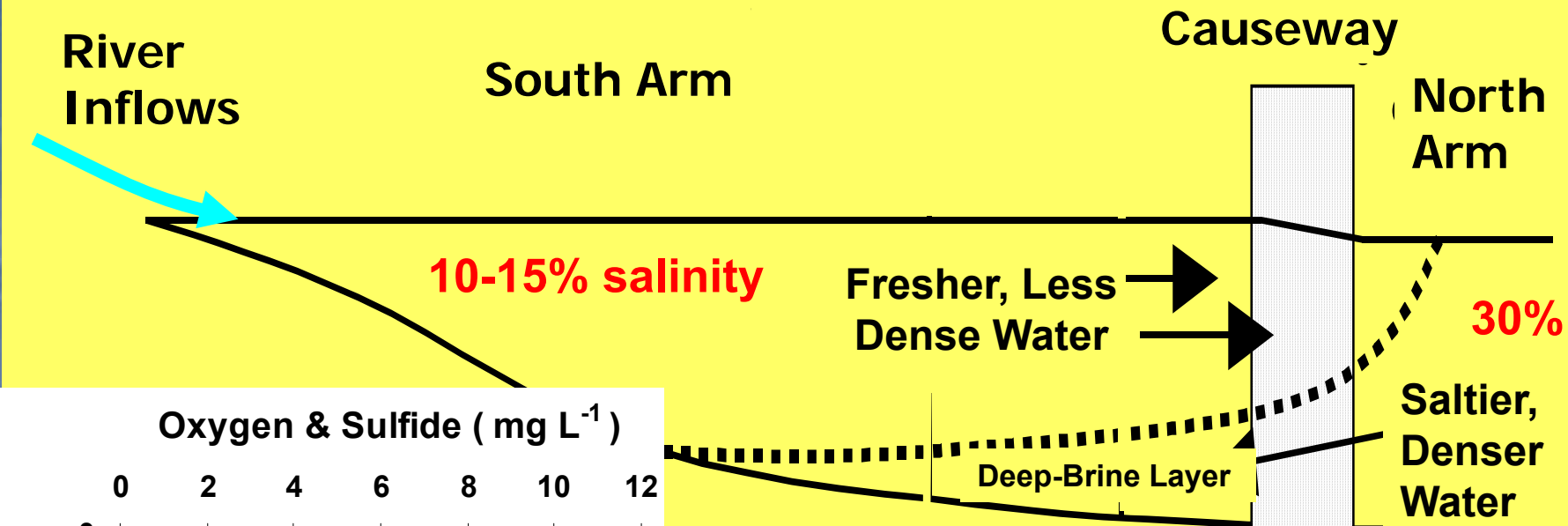
- Caleb Izdepski, Ian Washbourn, Michelle Kang, Jodi Gardberg, John Whitehead, John DeWild, David Naftz, Josh Vest
- Funding provided by the Utah Division of Water Quality

Source of High Mercury Unknown

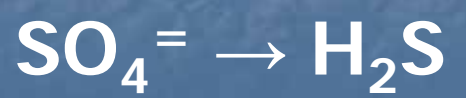
- Natural concentration in salt lake ?
 - Long-range atmospheric deposition ?
 - Legacy mining contributions & recycling ?
- Current atmospheric Hg deposition to lake¹ 36 kg/yr
is not abnormally high
 - Legacy gold/silver mining Hg use
in Utah² (1864-present) 19,900,000 kg
(136,000 kg/yr)

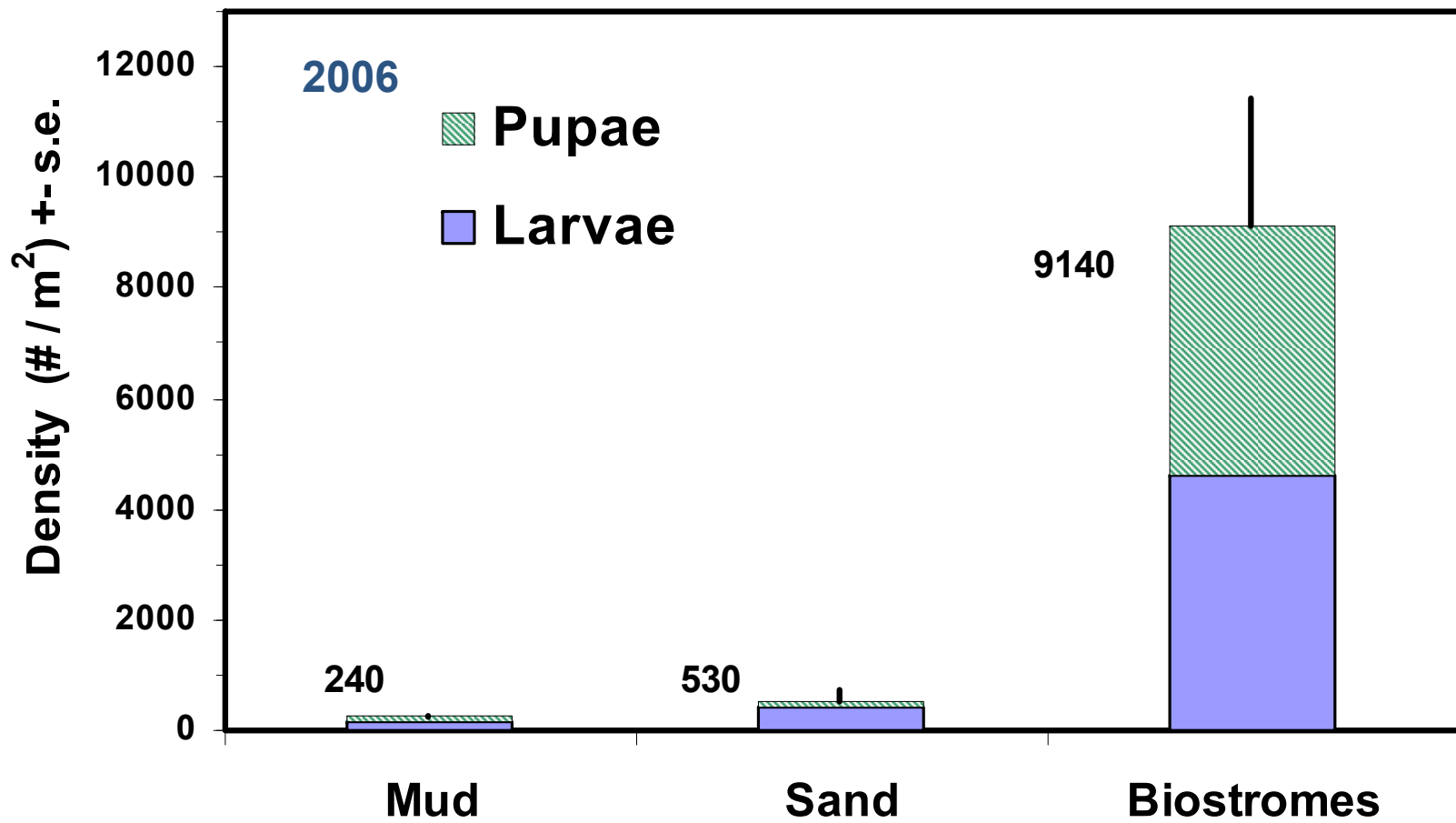
¹ Peterson & Gustin (2009)

² C.L. Ege, Selected Mining Districts of Utah, UGS Misc. Pub. 05-5 2005



Mercury methylation rates are likely high:

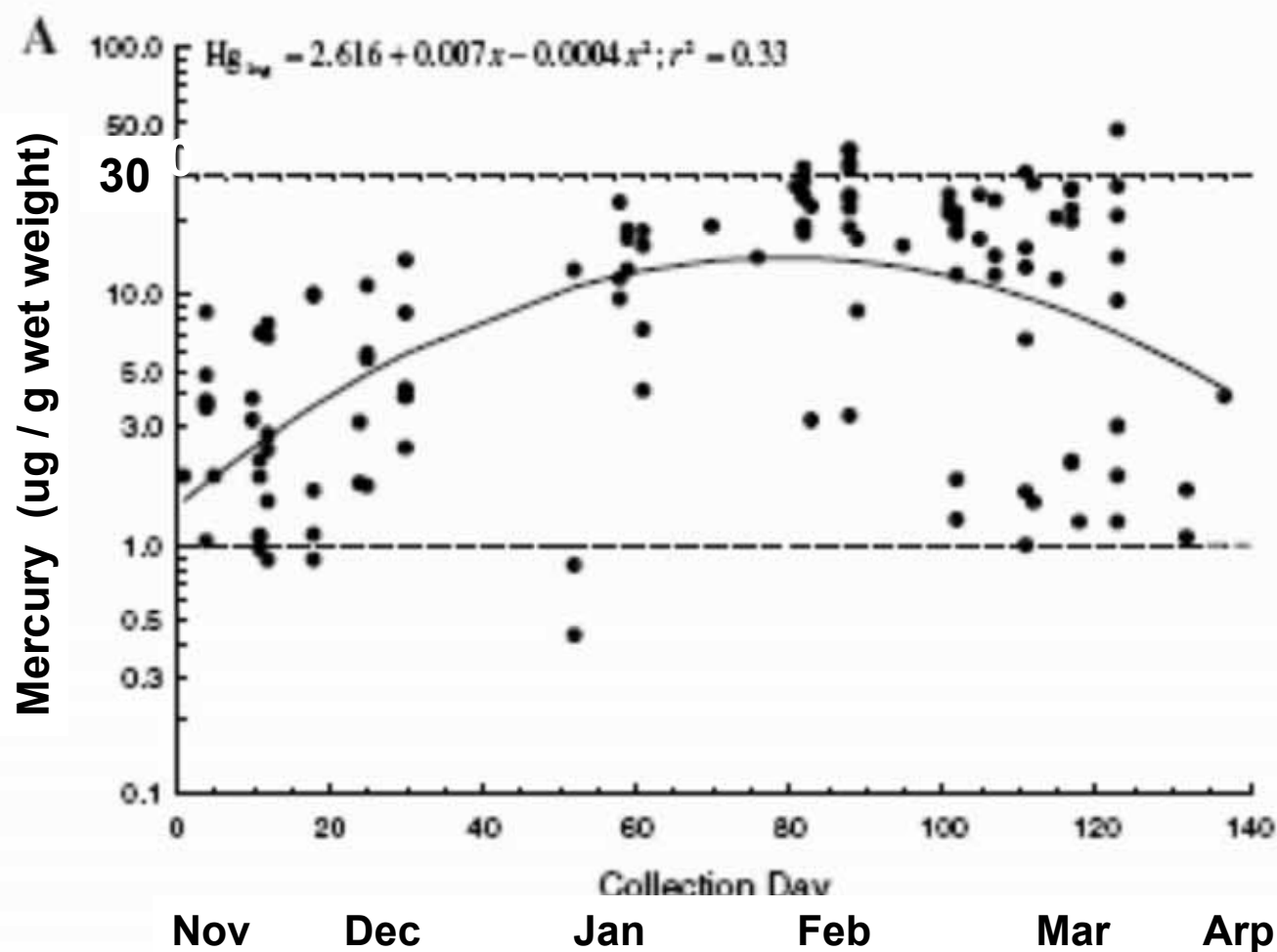




Goldeneye increase Hg levels ~8X after arriving at Great Salt Lake and feeding on brine fly larvae.



Arch Environ Contam Toxicol (2009) 56:302–316 Vest et al.



Biostrome Sampling Methods



Stromatolite chunks broken off underwater

- Chl *a* extracted
- Periphyton removed
 - With & without acidification to remove carbonates



Adult brine flies collected on shore with net

- All Hg analyses by cold vapor atomic fluorescence spectrometry at the U.S. Geological Survey Wisconsin Mercury Research Laboratory