1-1-2011

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

Wayne A. Wurtsbaugh
Utah State University

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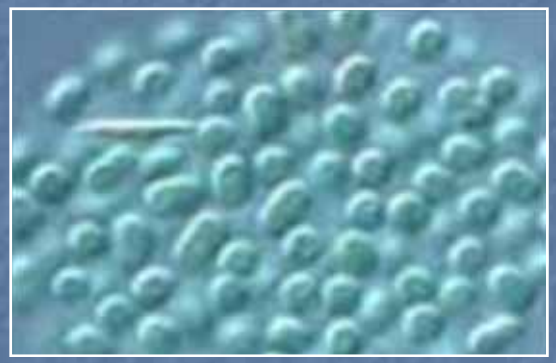
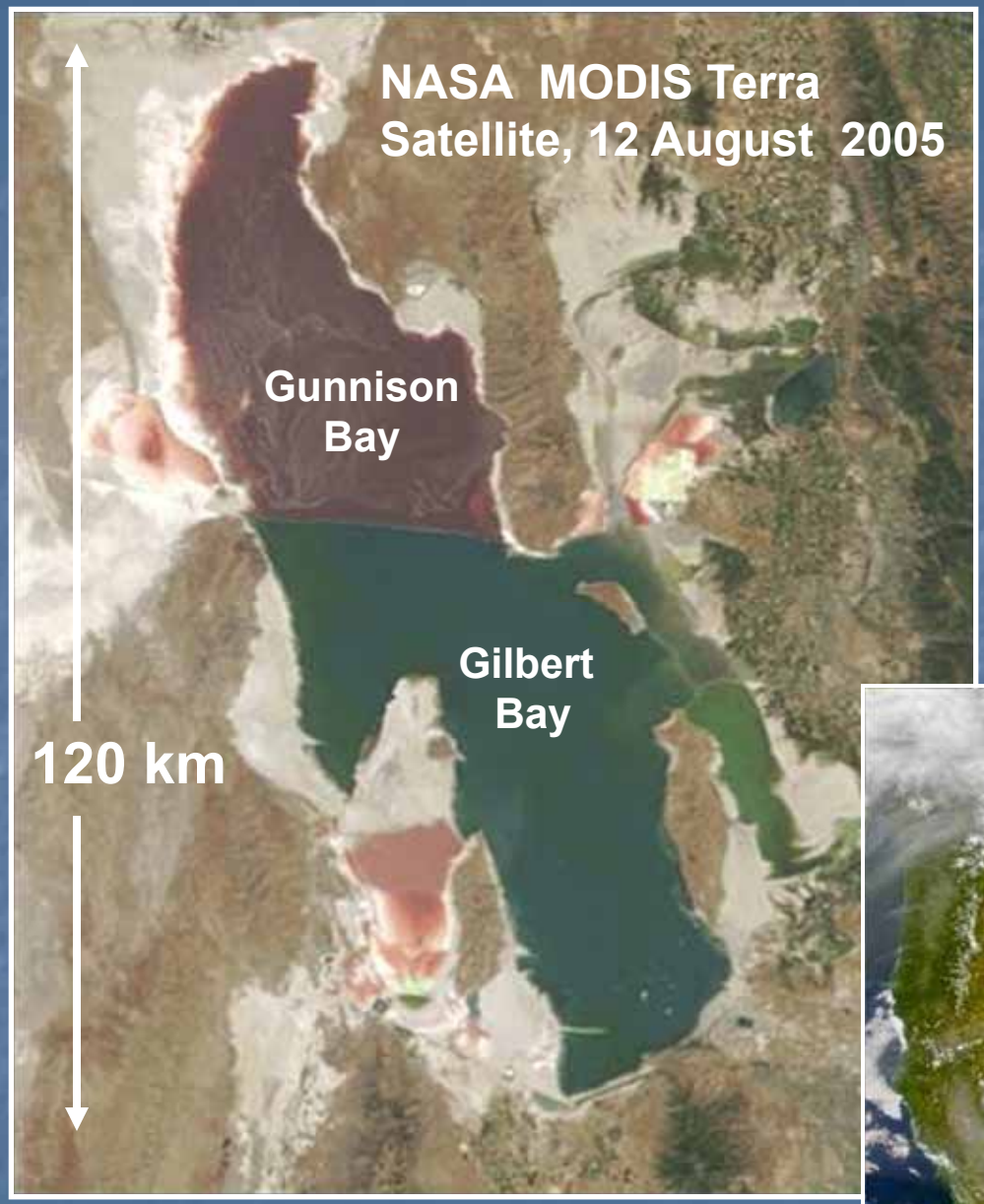


ISSLR 2011 – Mar Chiquita

Great Salt Lake

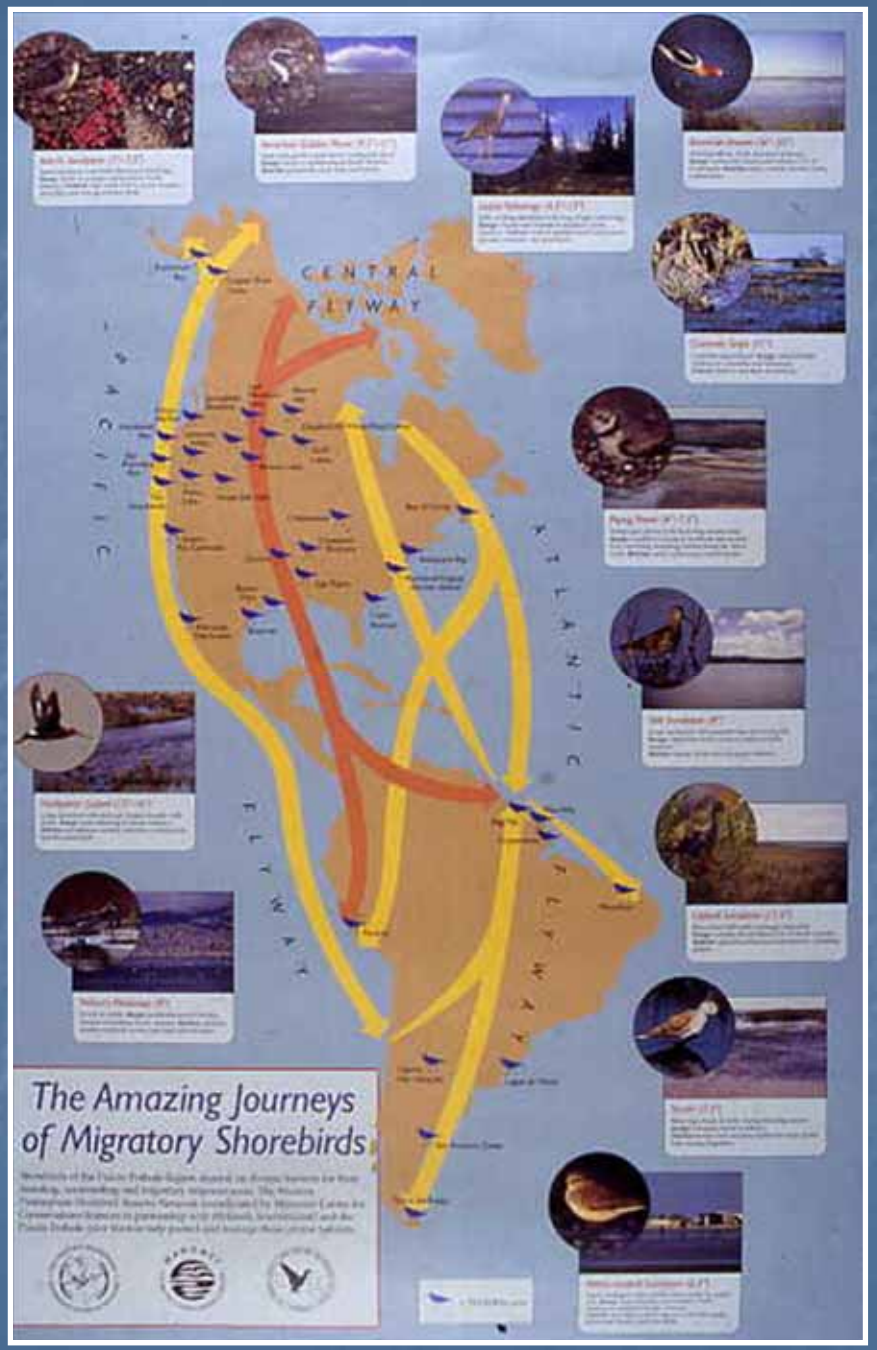


- Area ~ 4300 km^2
- Mean depth 4.5 m
- Salinity 10-30%
- Mean Chl *a* 21 µg/L
- Total Hg 2-8 ng/L

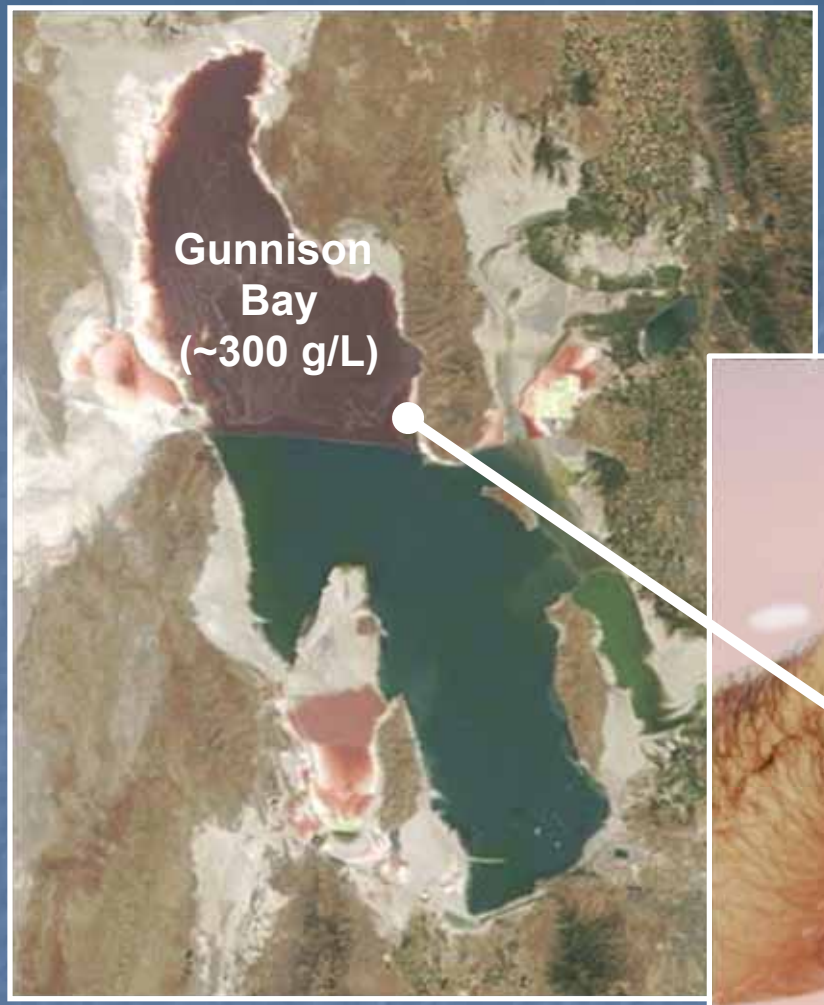
Birds

Western Hemispheric Shorebird Reserve (1991)

Abundant Food Resources



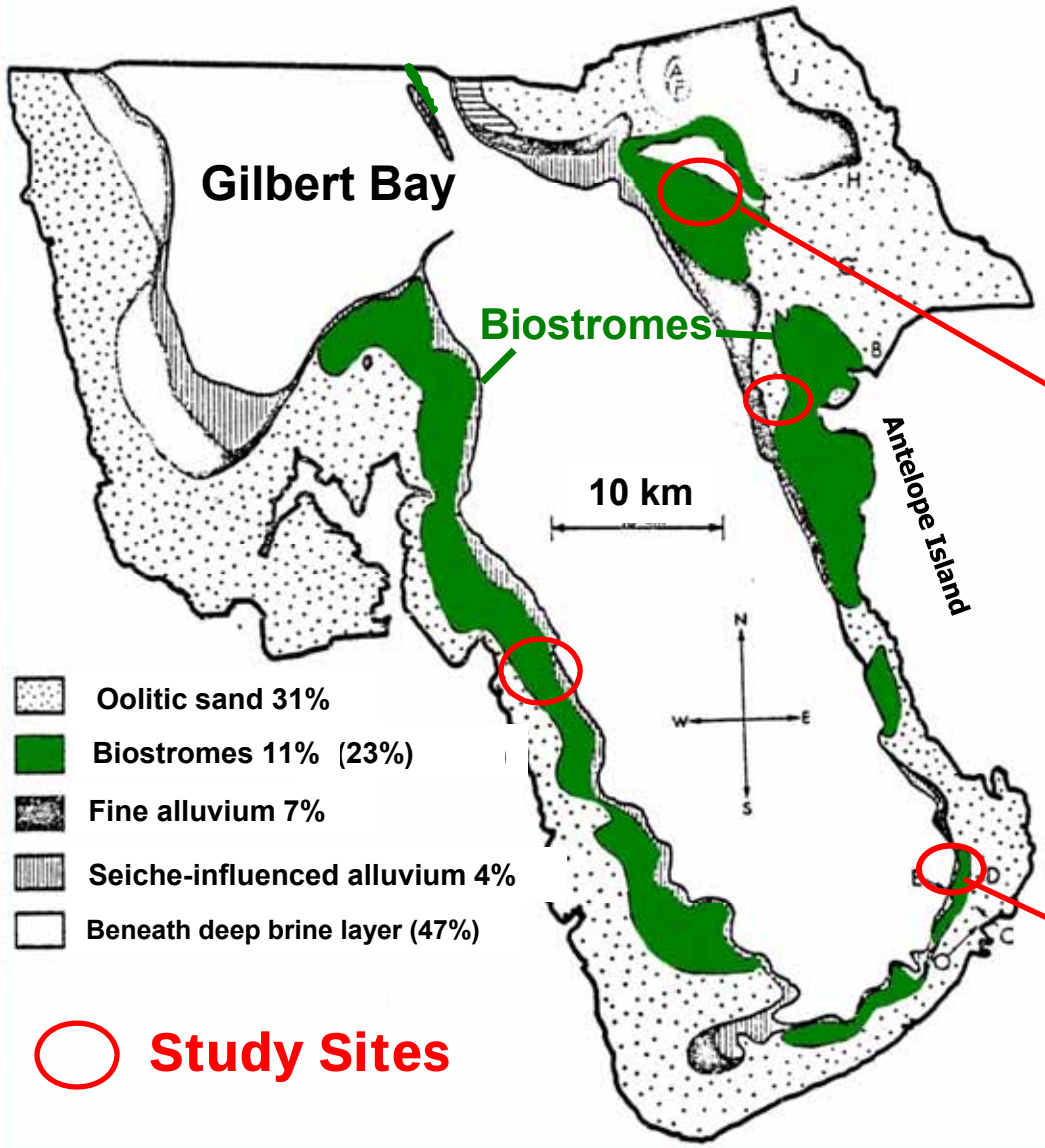
Biostrome Structures



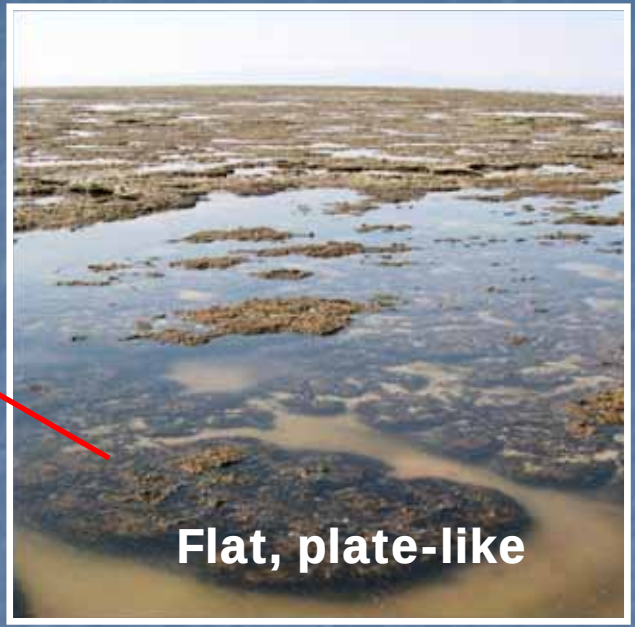
No macroinvertebrate community in 300 g/L waters

Biostrome Structures

Biostrome Distribution in Gilbert Bay



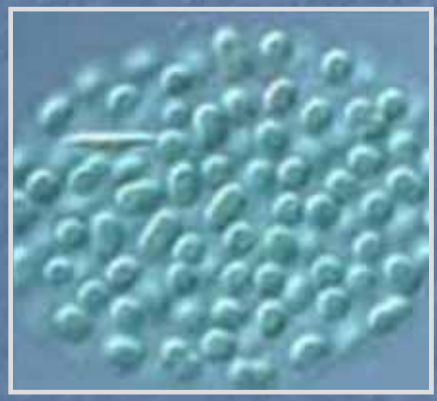
After Eardley (1938)



Mounds, ca. 1-m high

Stromatolites (Biostromes)

Dominant hard substrate for periphyton, brine fly larvae & pupae

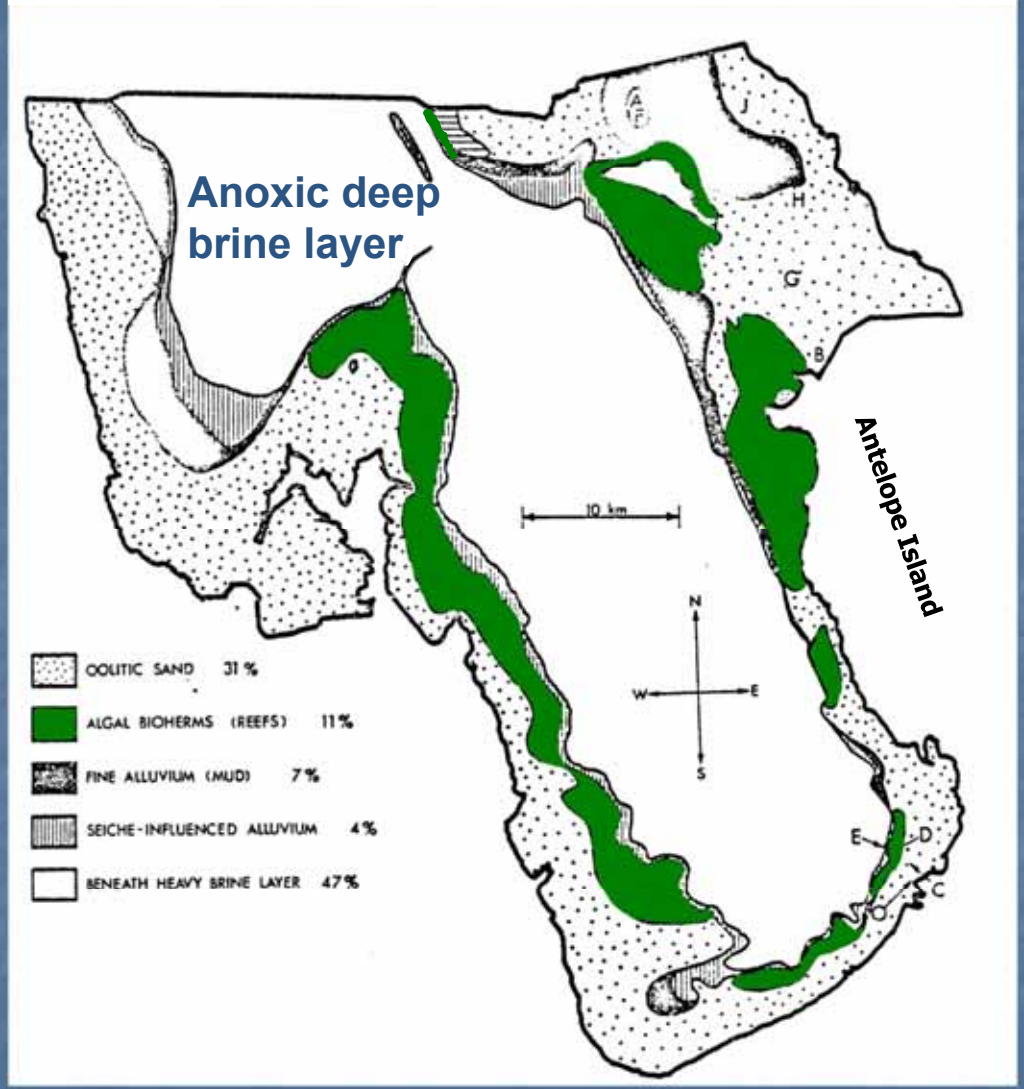


Aphanothece sp. (cyanobacteria)

Food Web Importance: Principal Brine Fly Habitat

Ephydra cinerea

Distribution in Gilbert Bay



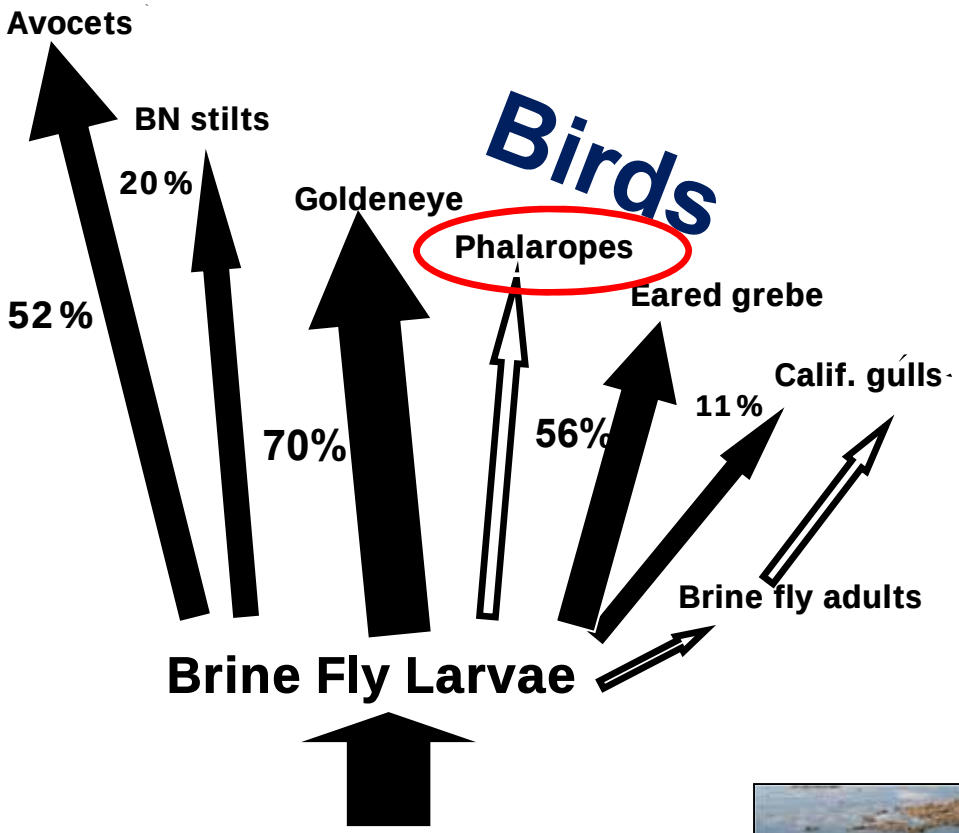
Simple Food Web

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

Gilbert Bay Food Web

Great Salt Lake Diet Analyses

Hypothesized, literature



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

Goldeneye
(Diet: 70% brine fly larvae)

Cinnamon teal

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

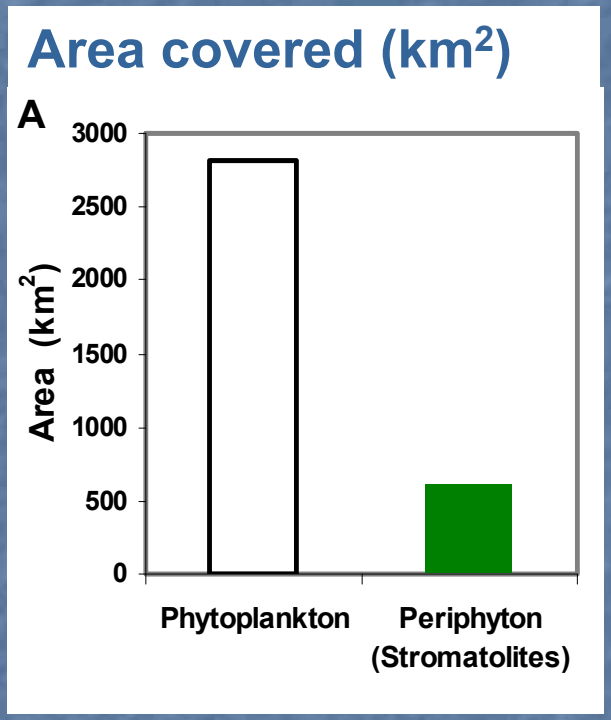
Selenium – 2006-07 (2 stations, June)

Hydride generation & atomic fluorescence spectrometry – Frontier Geosci.

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

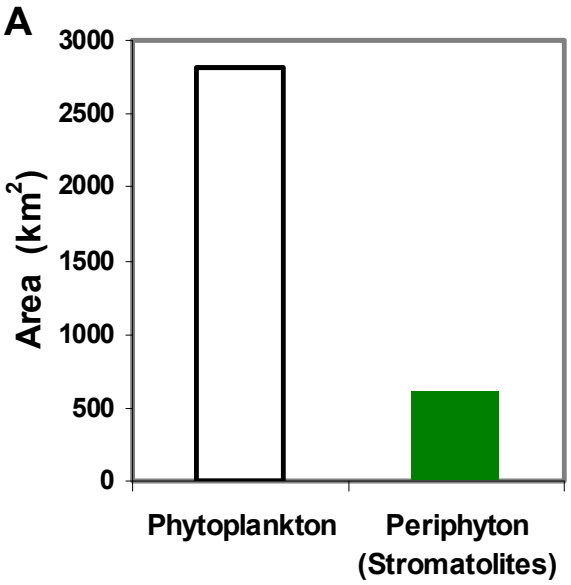
Cold vapor atomic fluorescence spectrometry (USGS Lab)

Abundance of Periphyton on Stromatolites Compared to Phytoplankton in Gilbert Bay

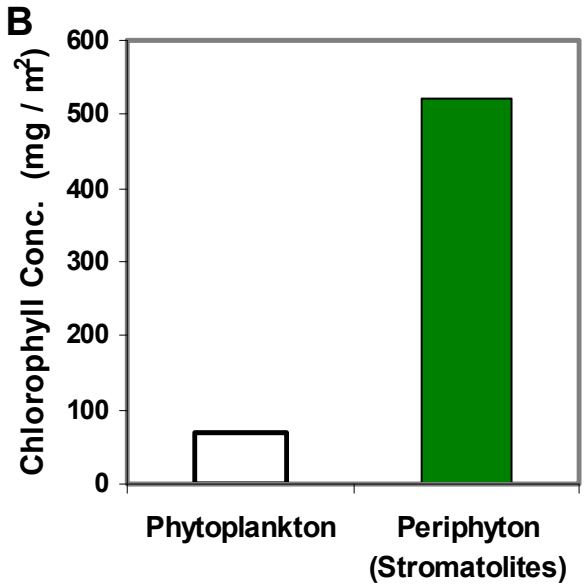


Abundance of Periphyton on Stromatolites Compared to Phytoplankton

Area (km^2)



Chlorophyll Conc.



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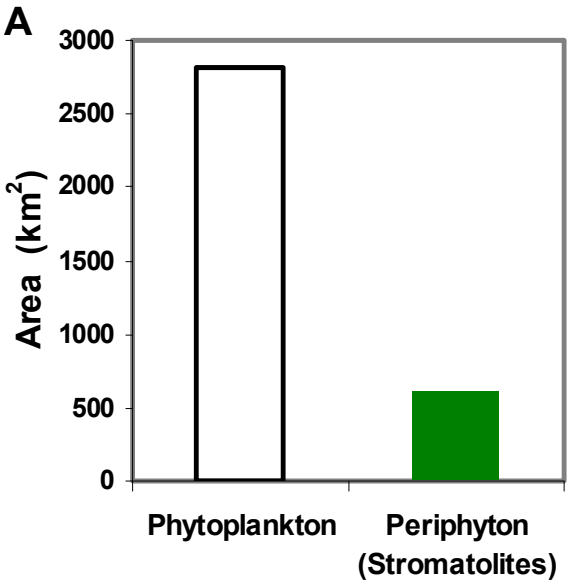
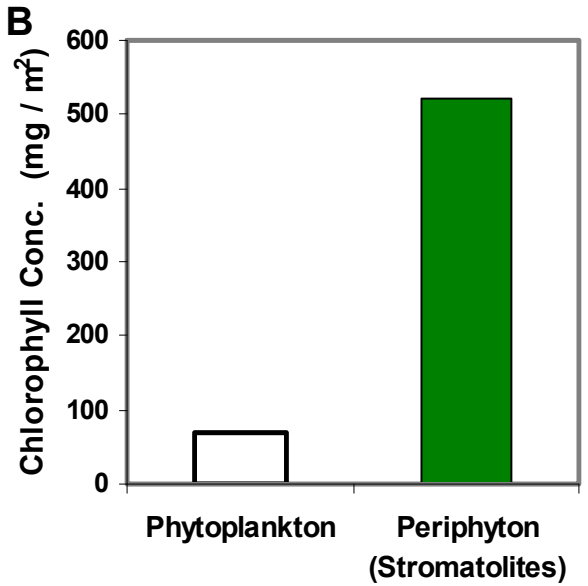


X

Chlorophyll Conc.



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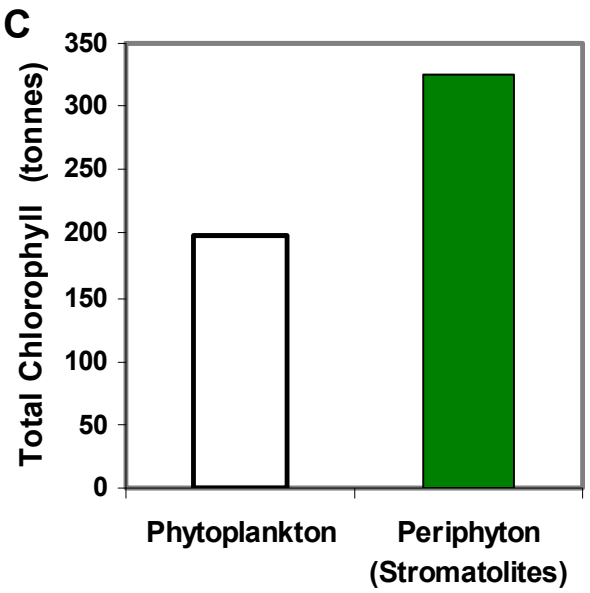
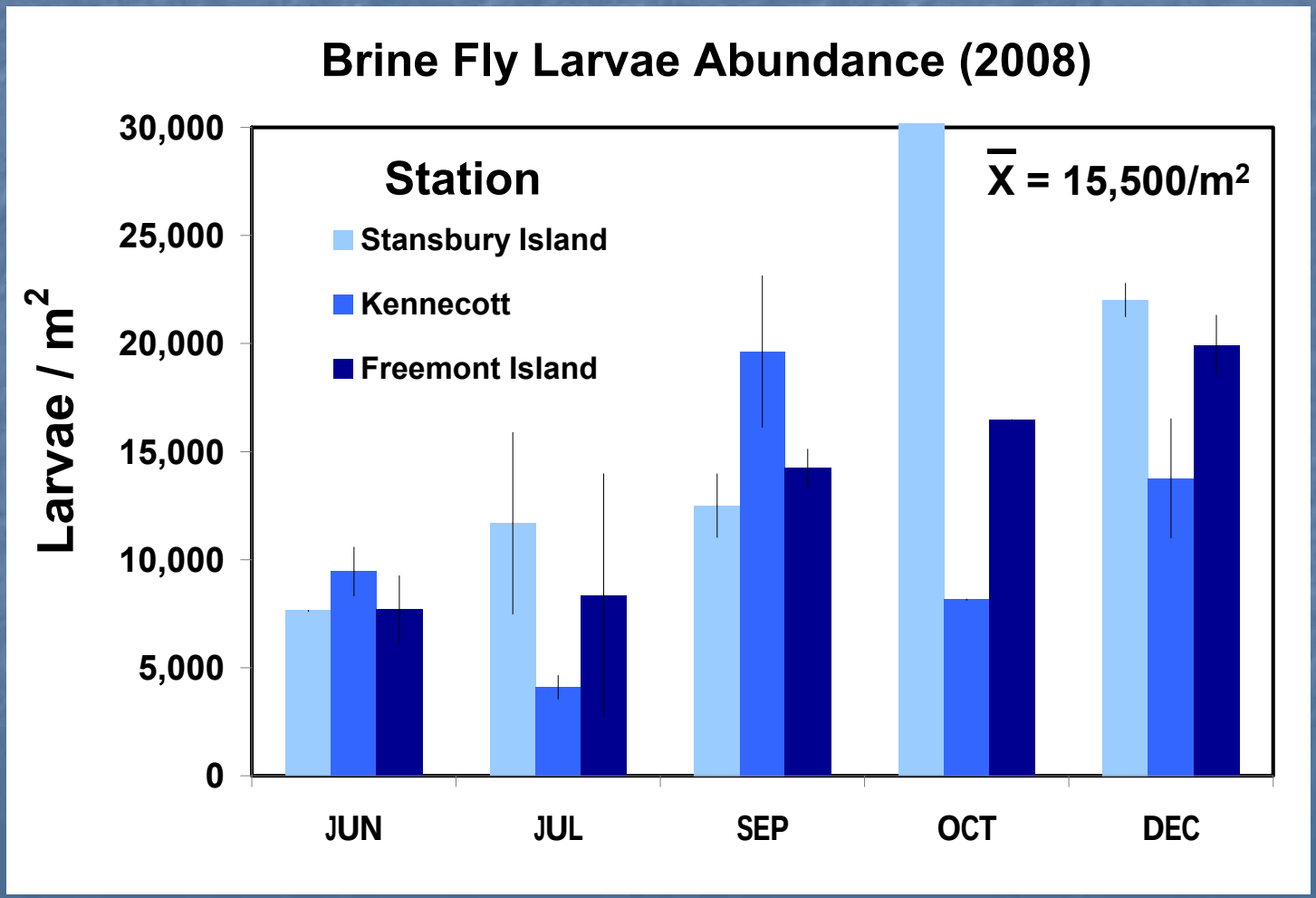
Total Chlorophyll



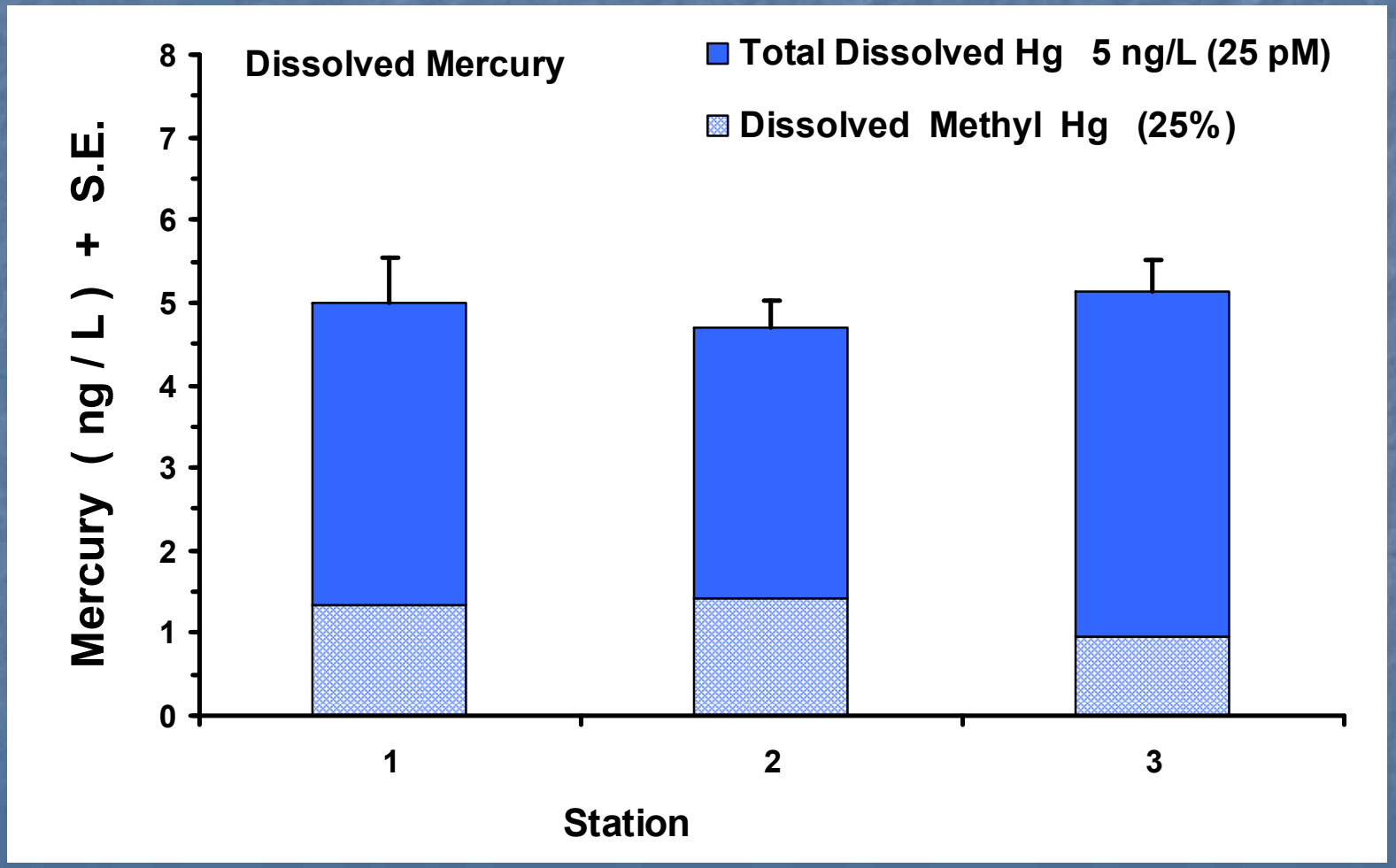
Periphyton on biostromes is a very important component of primary producers for Gilbert Bay

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

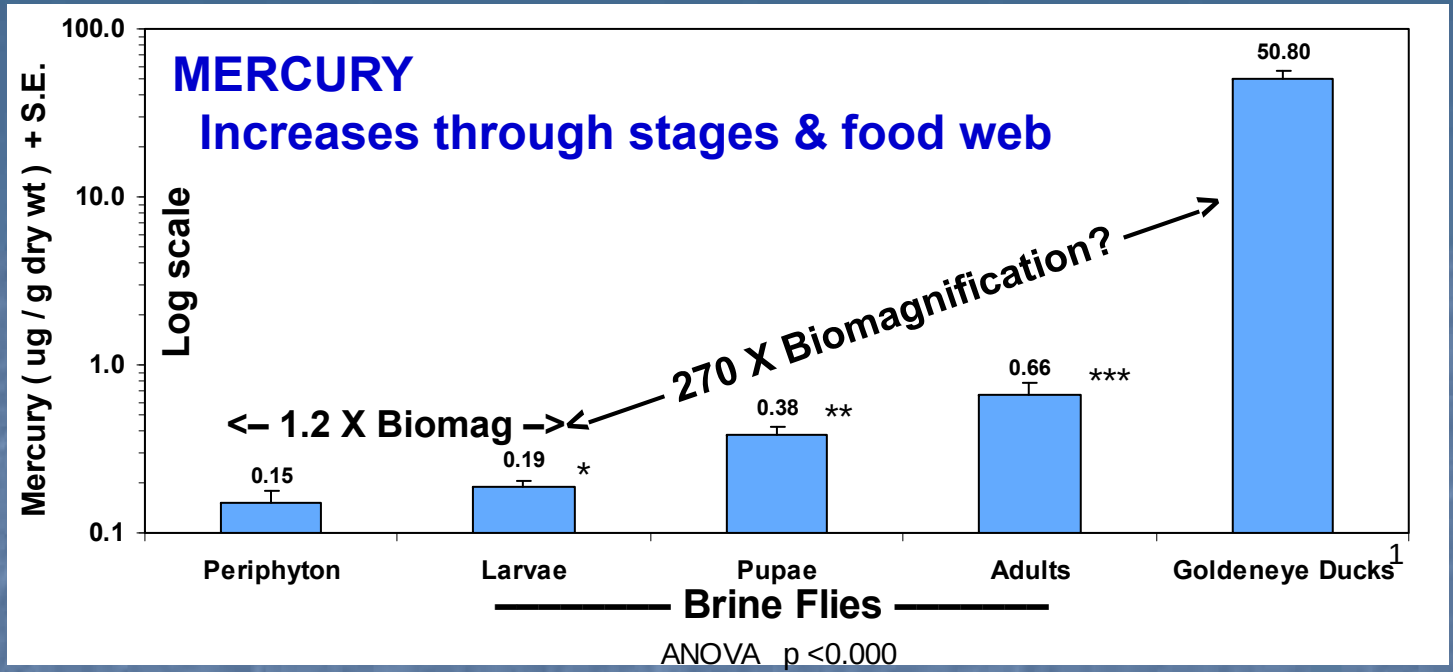
Brine fly larvae very abundant on stromatolites

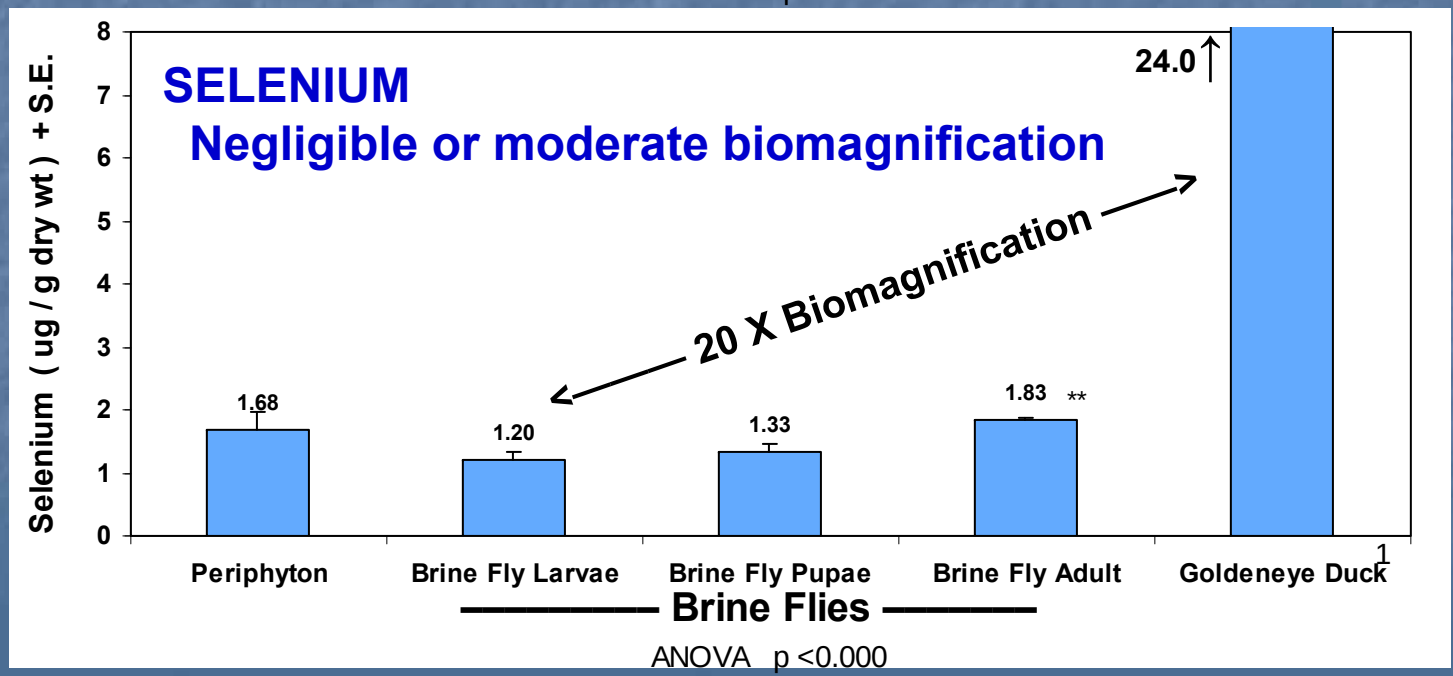


High Dissolved Mercury Concentrations Over Biostromes



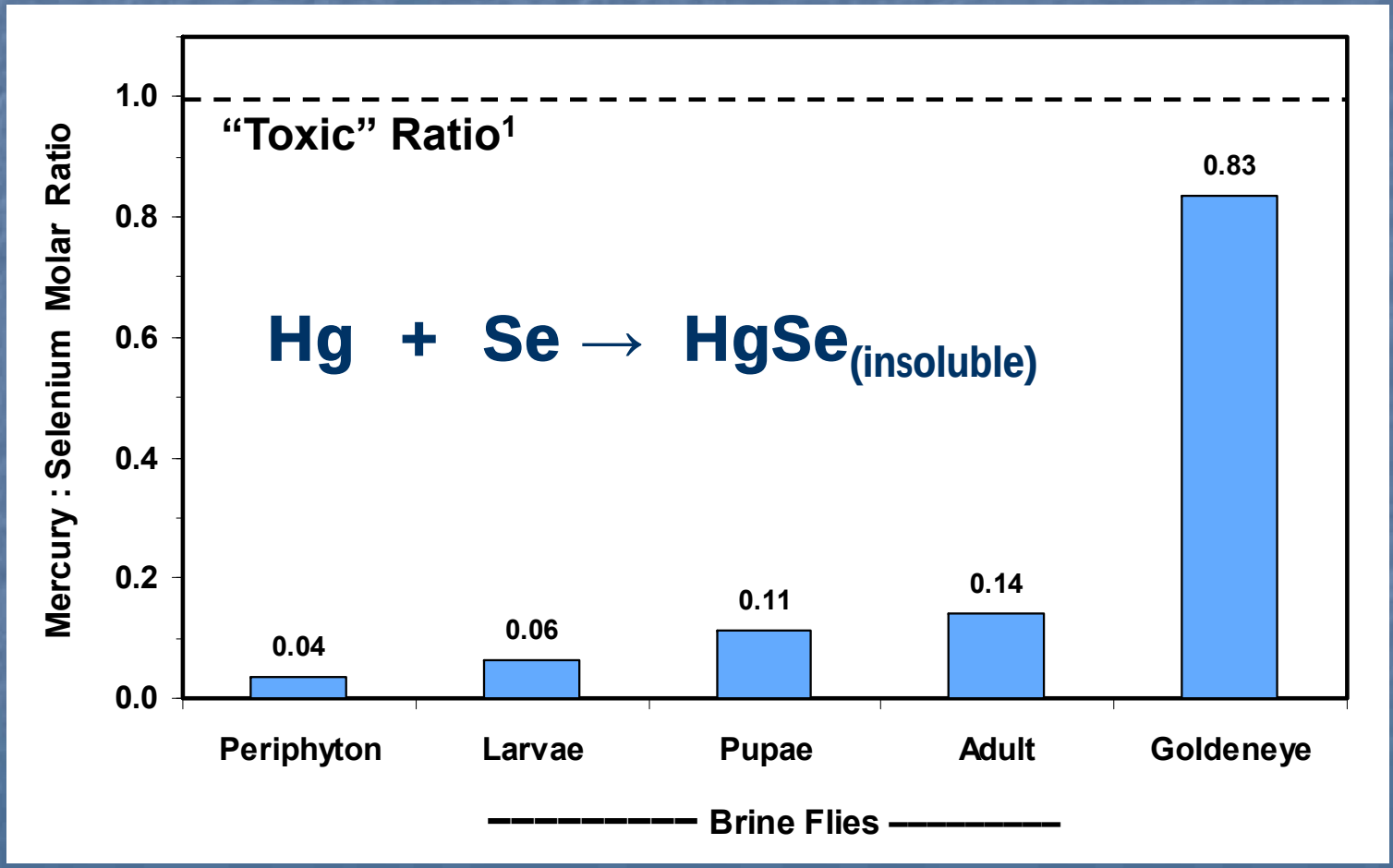
ANOVA: p = 0.252





[1]Goldeneye 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



[1]Ganther 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

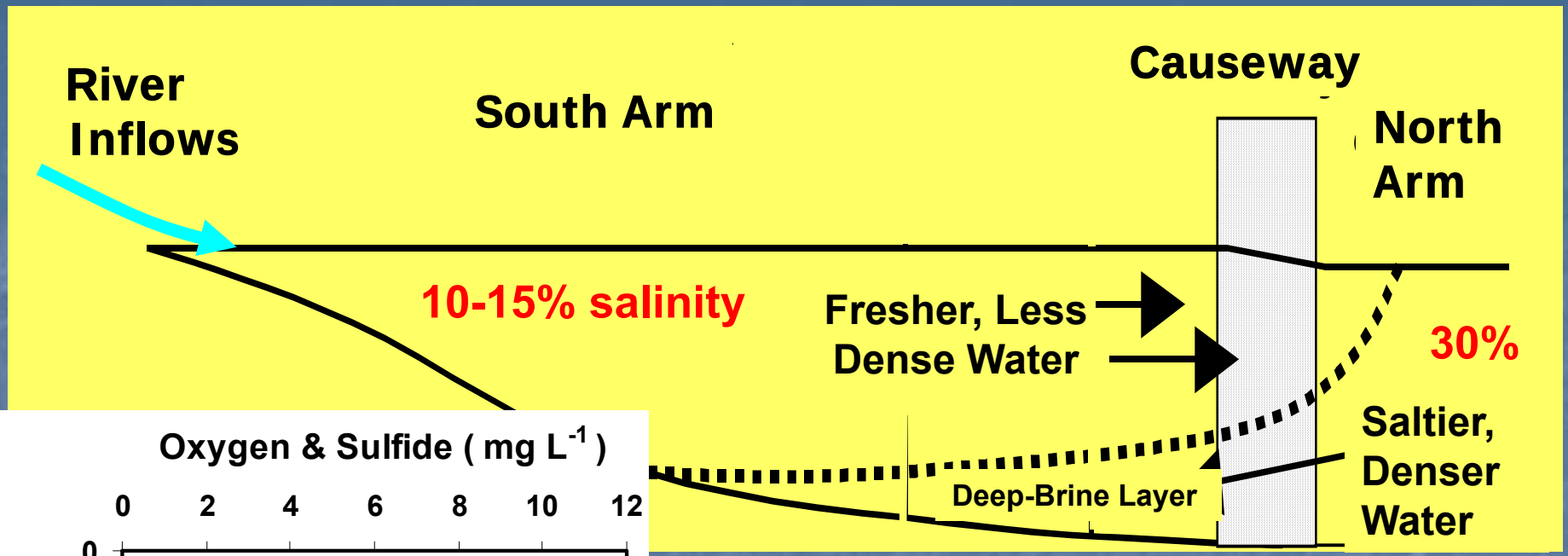
- Natural concentration in salt lake ?
- Long-range atmospheric deposition ?
- Legacy mining contributions & recycling ?

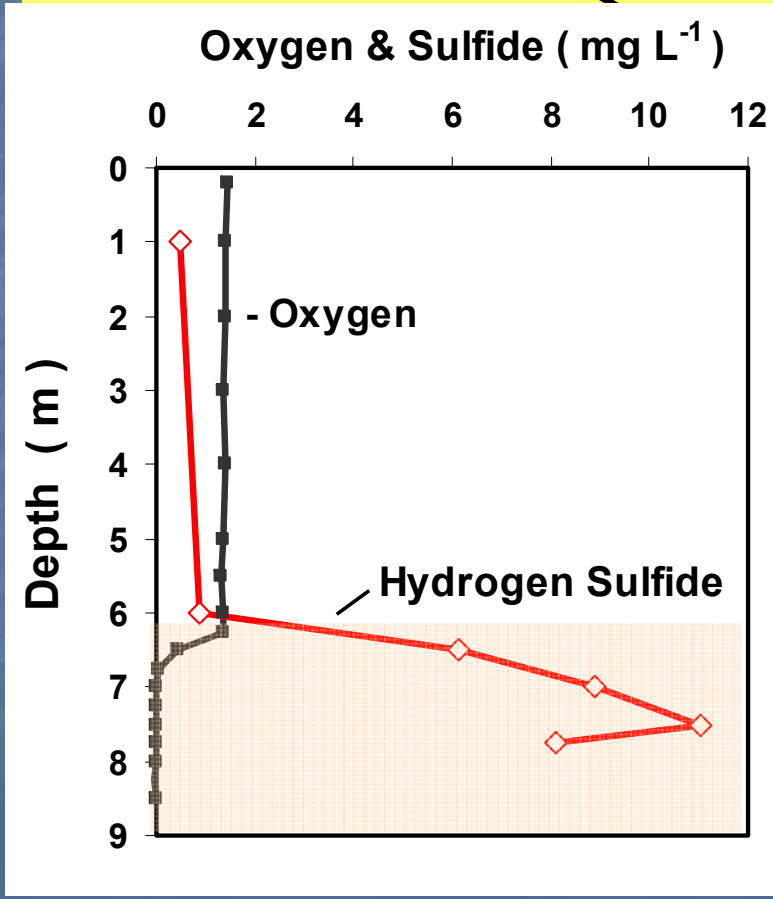
- Current atmospheric Hg deposition to lake[1] 36 kg/yr
  is not abnormally high

- Legacy gold/silver mining Hg use
  in Utah[2] (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



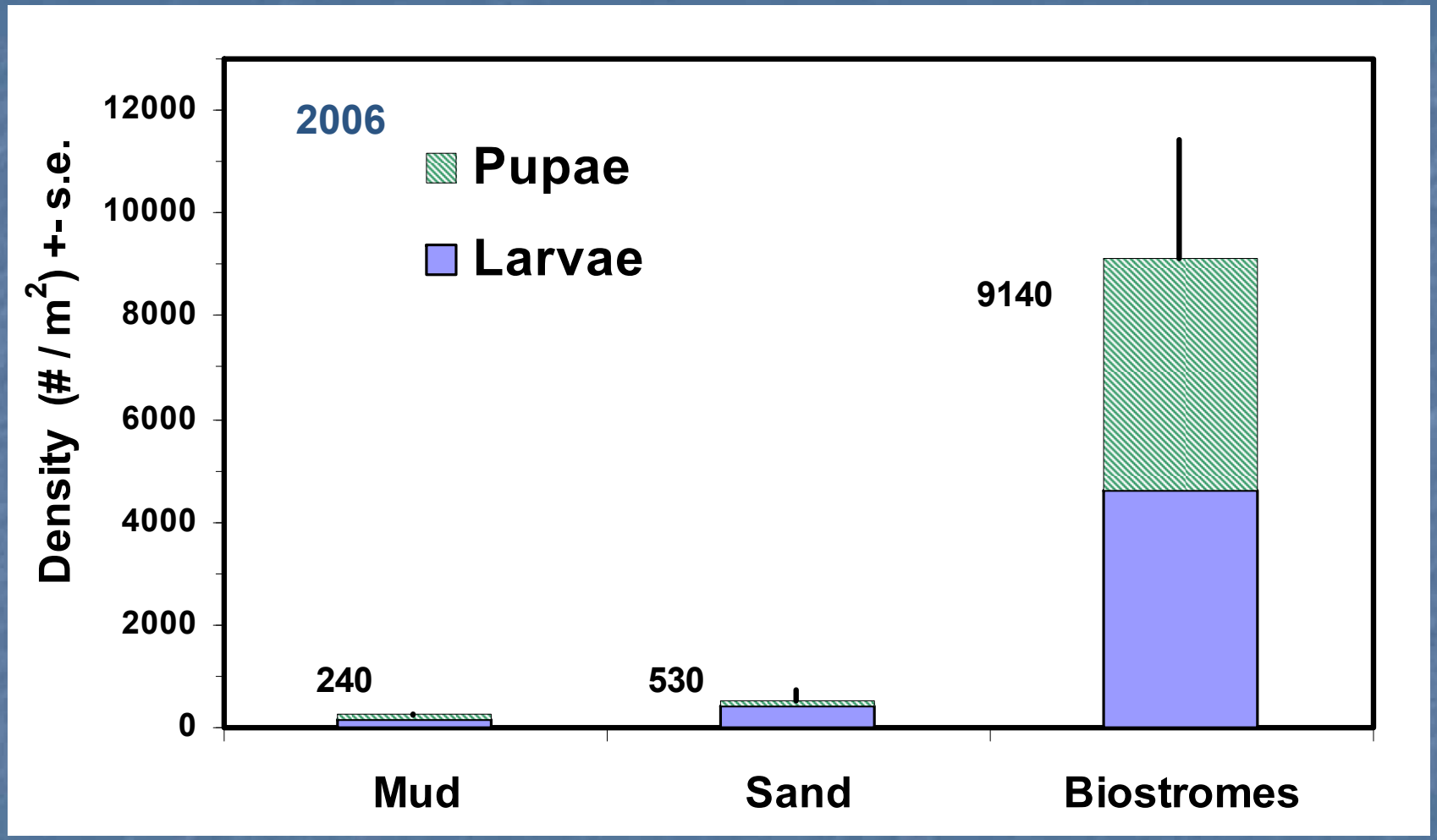


Mercury methylation rates are likely high:

$Hg^0 \rightarrow$ Methyl Hg

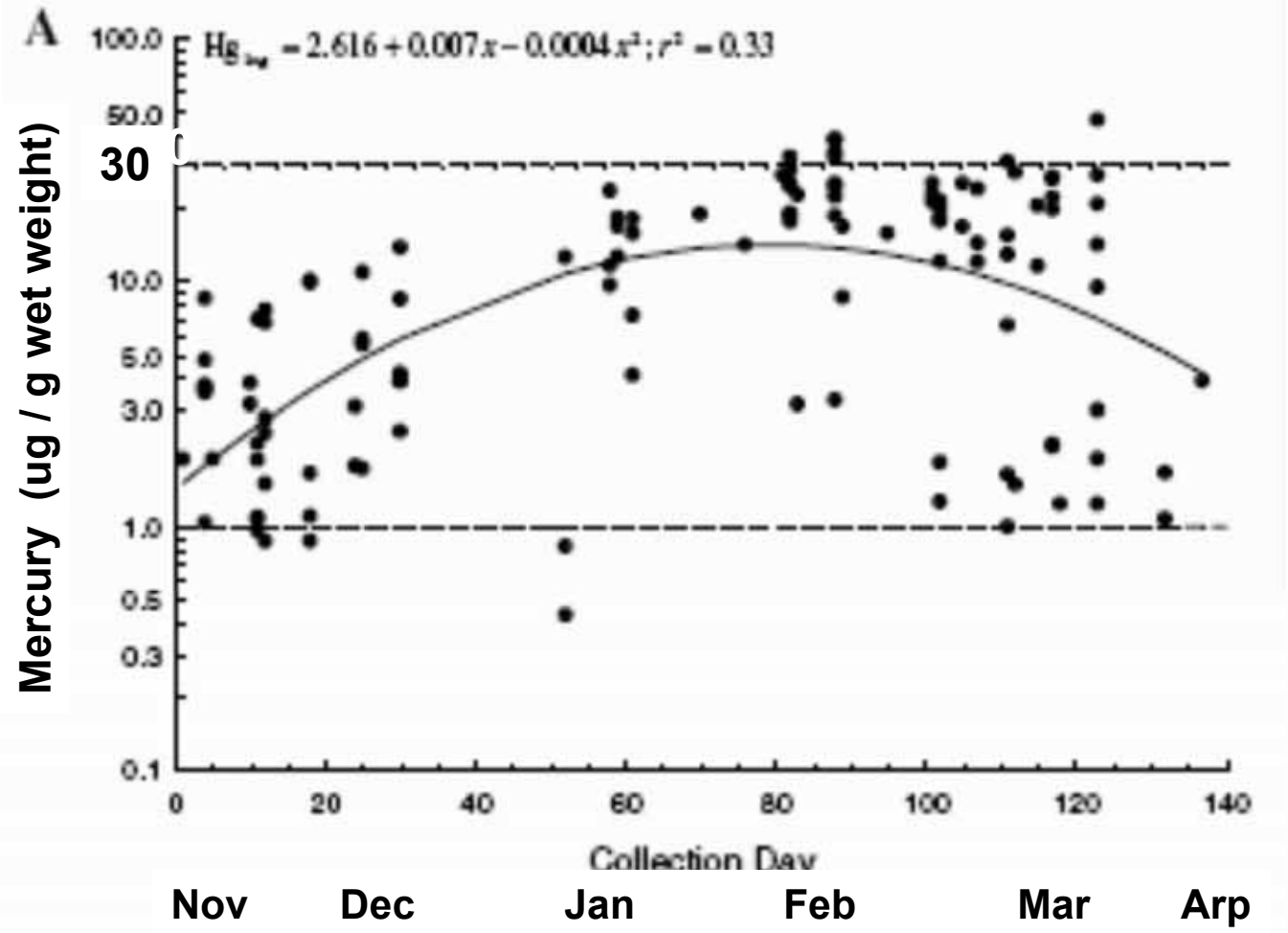
$\updownarrow$

$SO_4^{=} \rightarrow H_2S$


2006
Pupae
Larvae
Density (# / m2) +- s.e.
12000
10000
8000
6000
4000
2000
0
240
530
9140
Mud
Sand
Biostromes

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