Do Brine Shrimp Bioaccumulate Methylmercury From the Deep Brine Layer of the Great Salt Lake?

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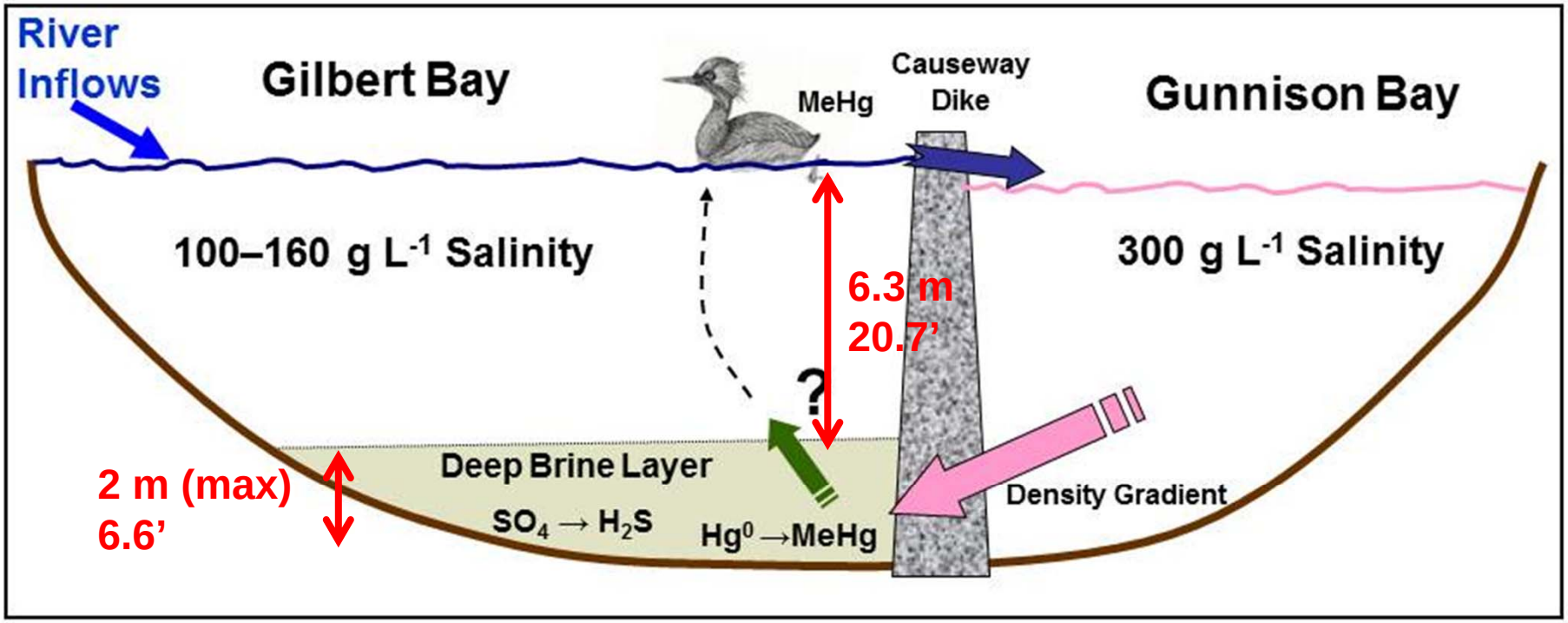
Project Funded by

The Division of Forestry, Fire & State Lands

Formation of the Deep brine layer (Monimolimnion)



- **Background**

- **Although there is normally insufficient light for photosynthesis, the deep brine layer is extremely rich in sedimenting organic material**

- **Total mercury, and especially methyl mercury, is extremely high in deep-brine layer (Naftz et al. 2008)**

- **Because of the high density water, the deep-brine layer has limited ability to mix into the upper mixed layer. However, some limited mixing is expected, but the amount is unknown.**

- **Objectives**

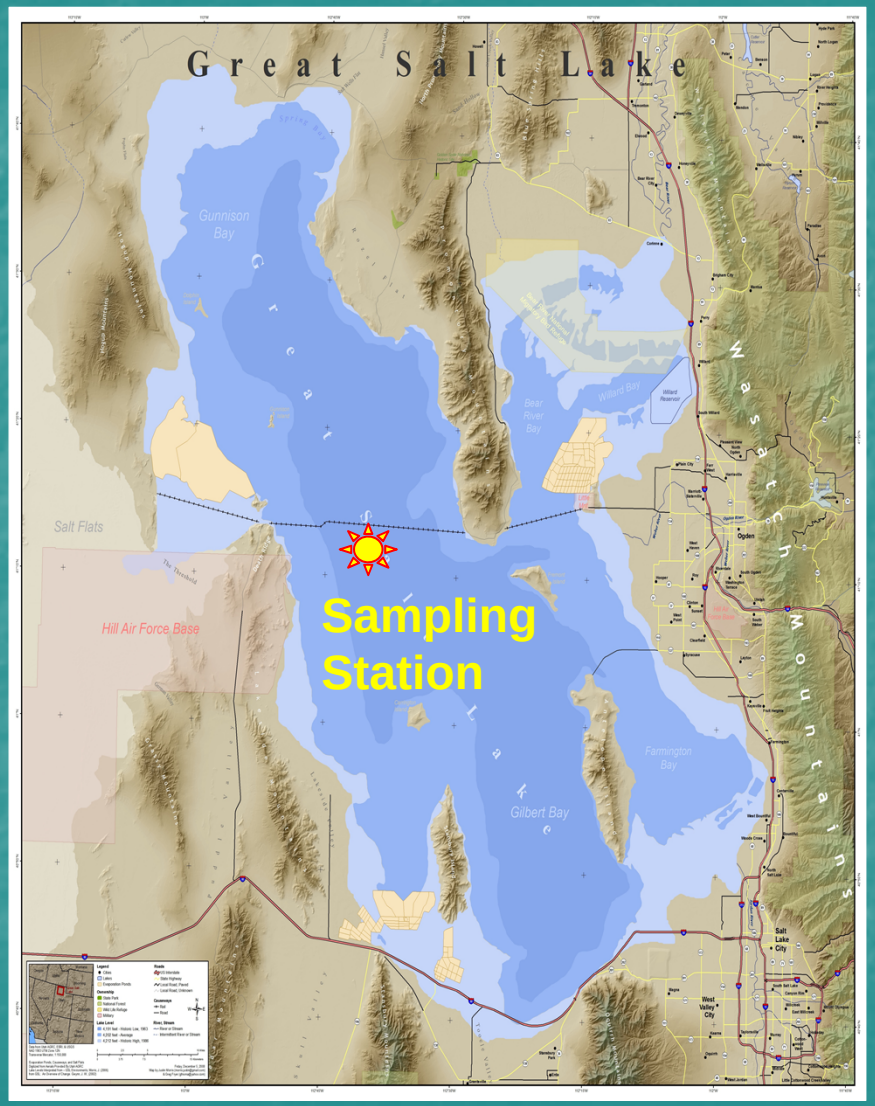
- **Determine if brine shrimp graze at the interface of the deep brine layer and take up mercury from that layer**

- **Determine whether mercury uptake by shrimp is enhanced if deep brine layer is mixed into the upper layer**

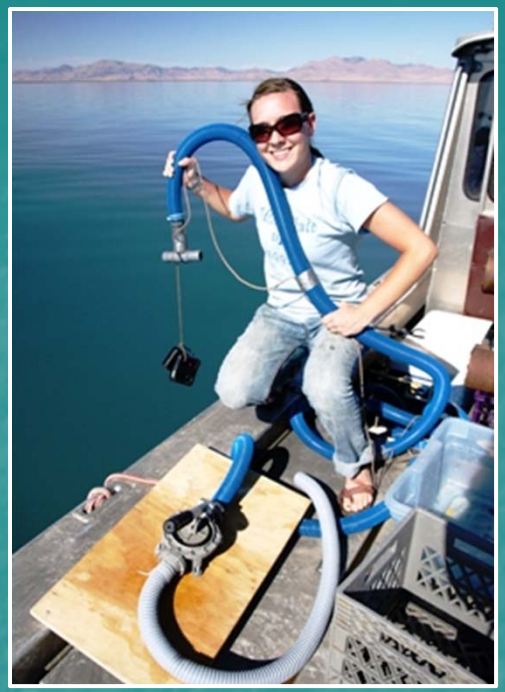
Study Design

- Measure profiles of mercury and relevant limnological parameters in an area of Gilbert Bay underlain by the deep brine layer
- Measure mercury uptake of brine shrimp in mesocosms that simulated a water column with, and without, a deep brine layer
- Measure mercury uptake in brine shrimp when deep brine layer water is mixed with surface water
- Preliminary measurements & experiments in 2009, more detailed ones in 2010

Field study (2010)

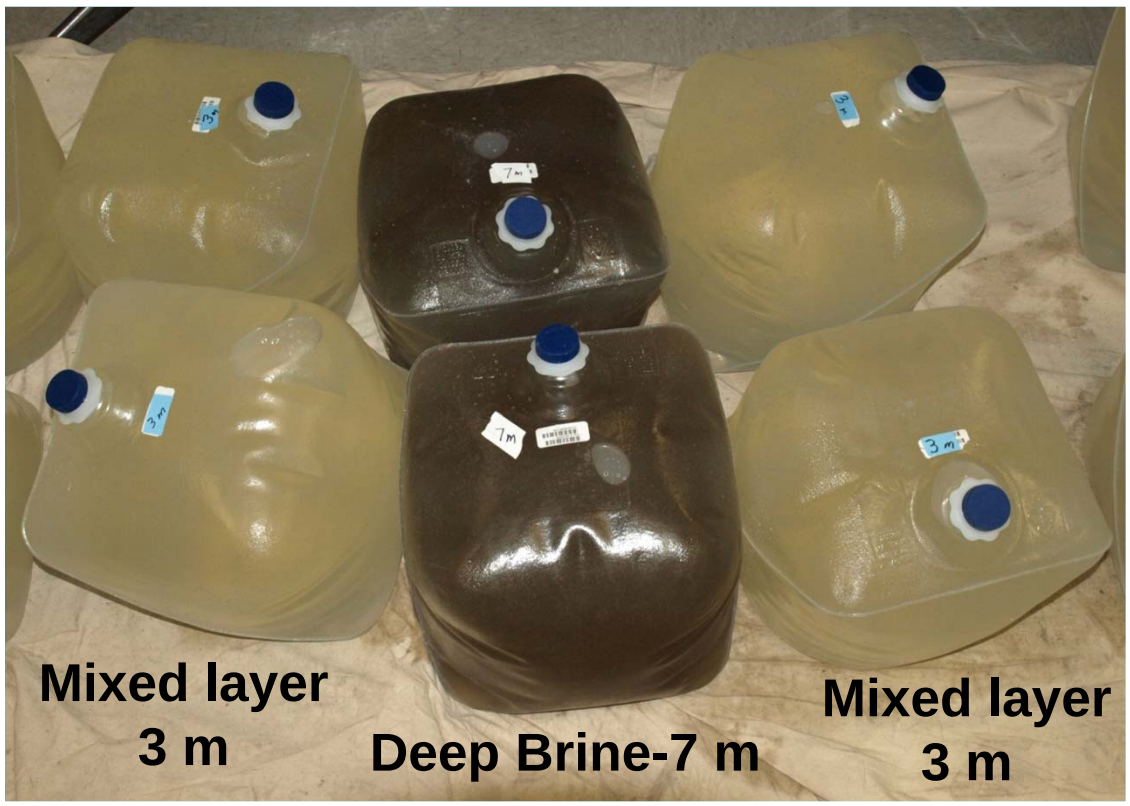


Pumped water from specific depths For chemical analyses & brine shrimp counts



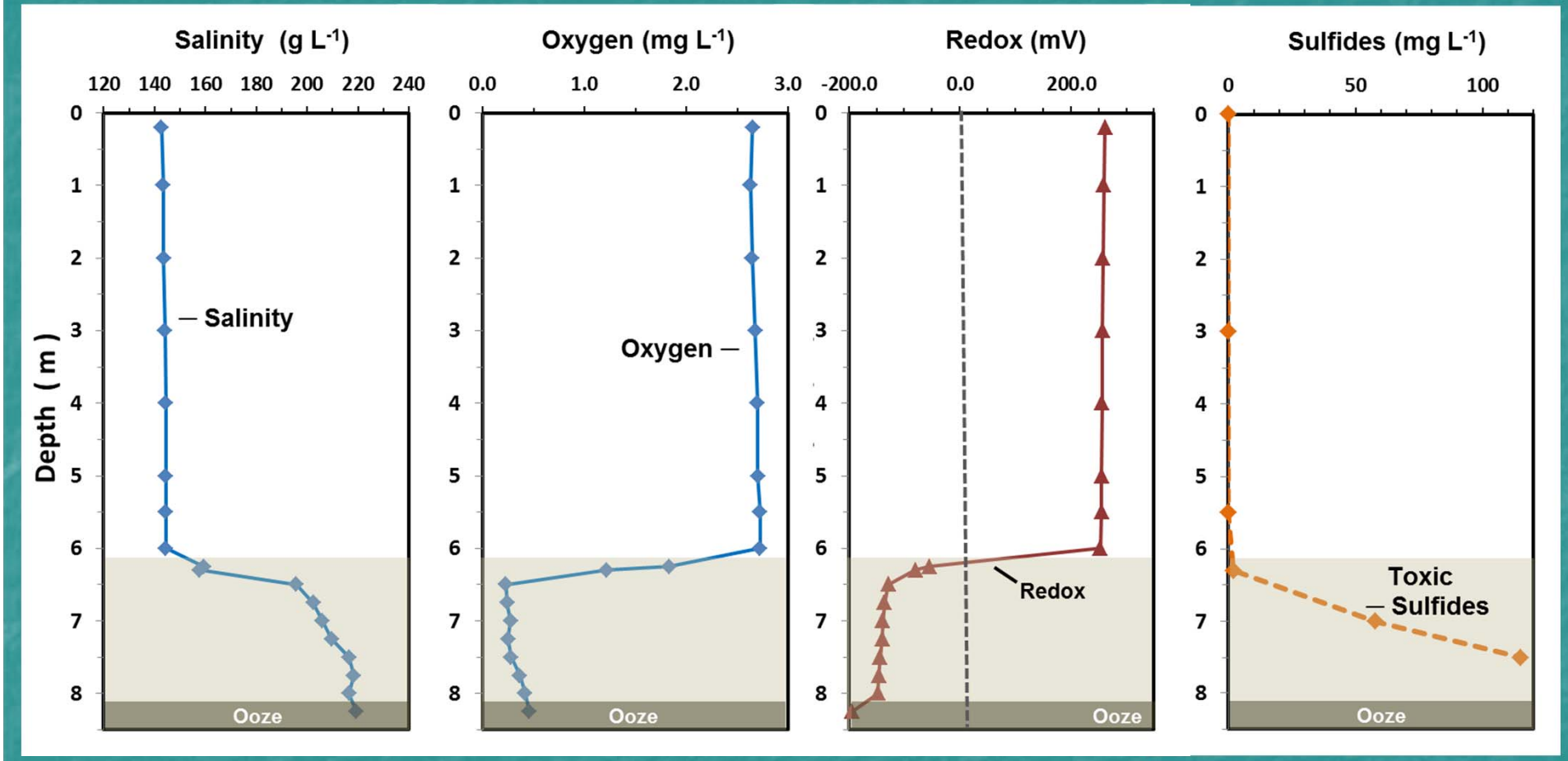
Collected water for laboratory experiments

Deep Brine Water Characteristics

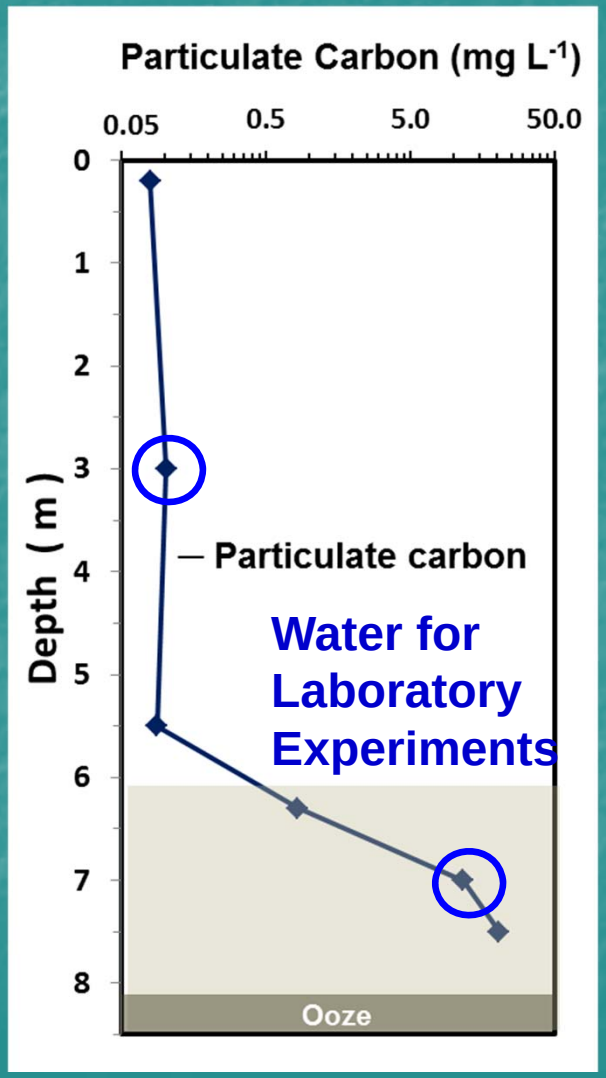


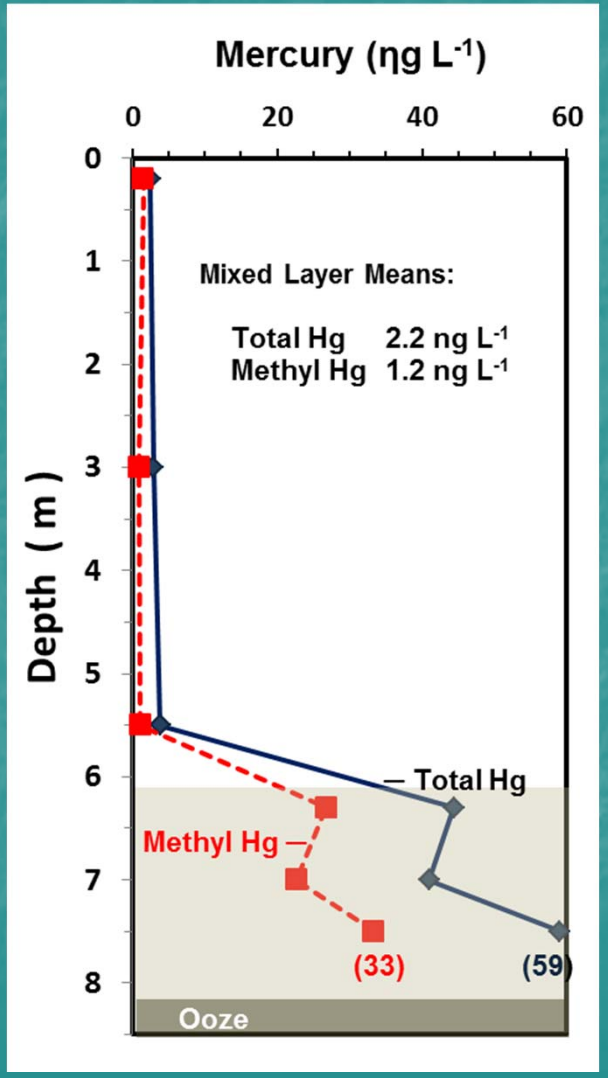
- **High organic matter**
  - **Particulate**
  - **Dissolved organic carbon (DOC)**
    3 m – 42 mg C/L
    7 m – 53 mg C/L
  - **DOC binds with and maintains mercury in solution**
- **Anoxic**
- **H_2S – rich (toxic)**
  - **Sulfide reduction linked to production of methyl mercury**
- **High mercury, especially methyl mercury**

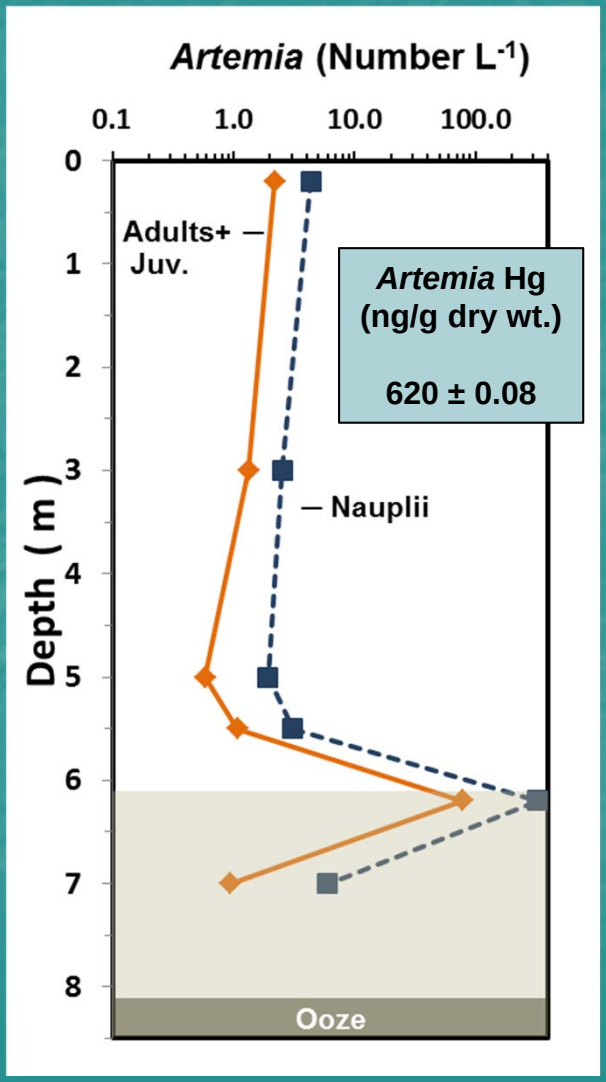
Field study (August 3, 2010)



Field study (August 3, 2010)





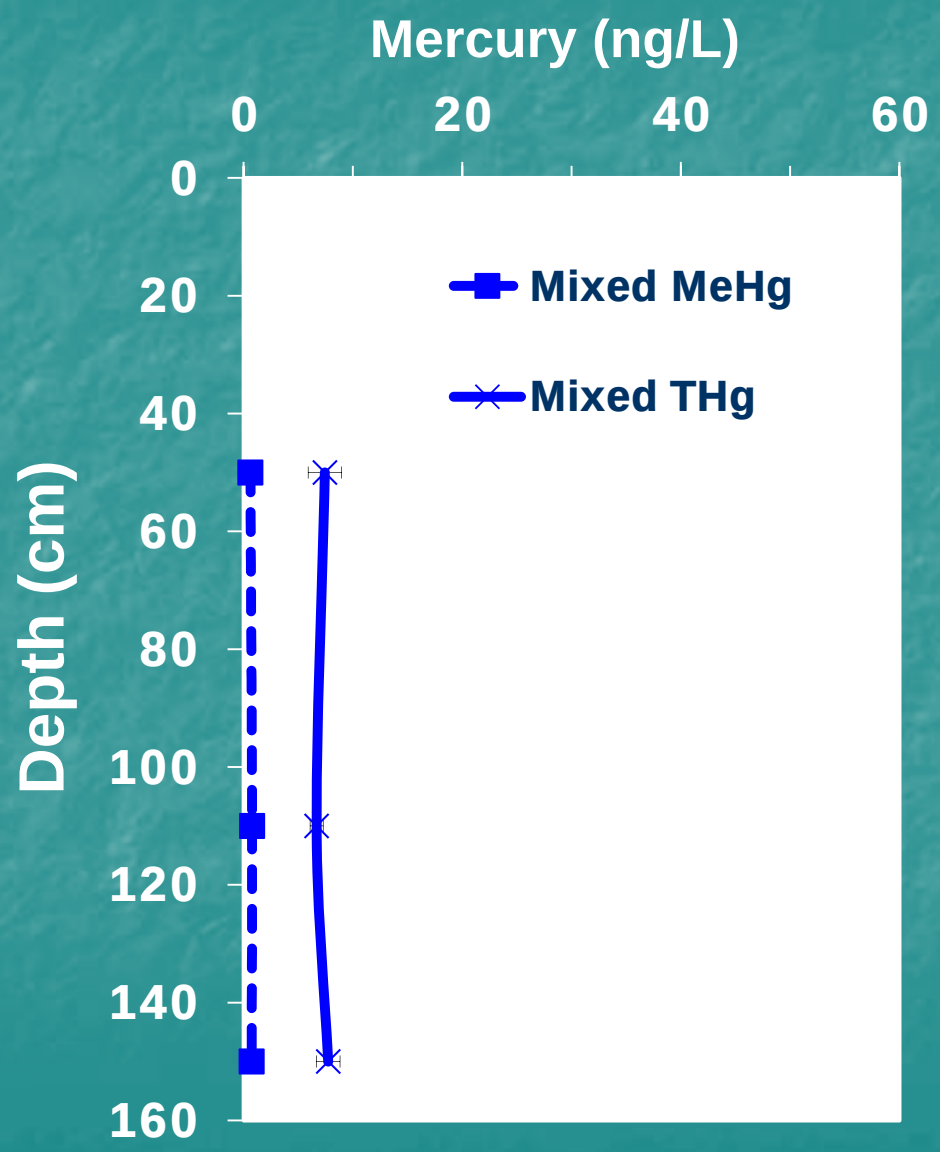


Vertical stratification simulation Experimental Design:

- Six, 46-L columns
- 3 columns with deep brine water, 3 without
- 18:16 light:dark regime to promote photosynthesis
- 27°C
- 10 *Artemia* nauplii / L
- 14 day-long experiment (*Artemia* mature)

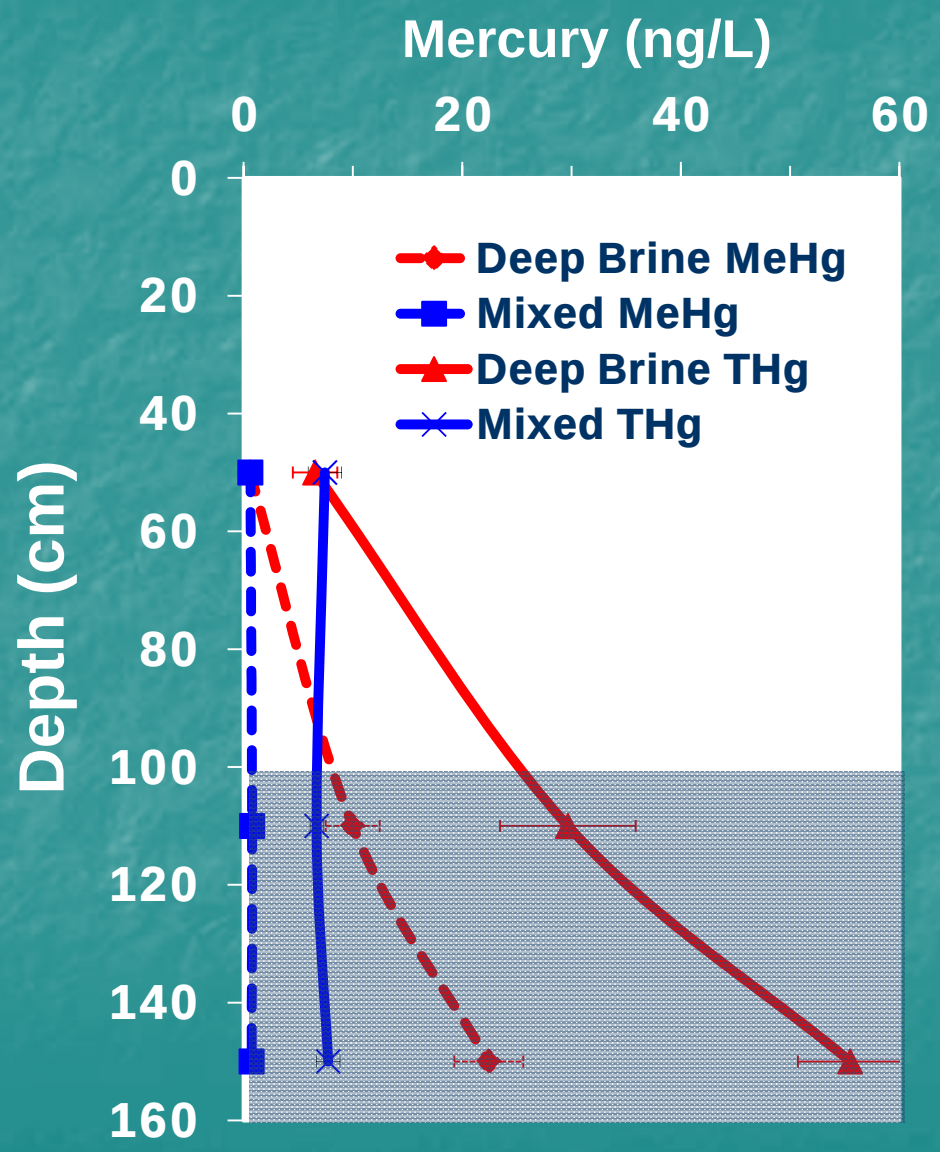
Mercury concentrations in columns

- **Mixed columns**
  - **Uniform Concentrations**
  - **Methyl Hg – 0.7 ng/L**
  - **Total Hg – 7.3 ng/L**



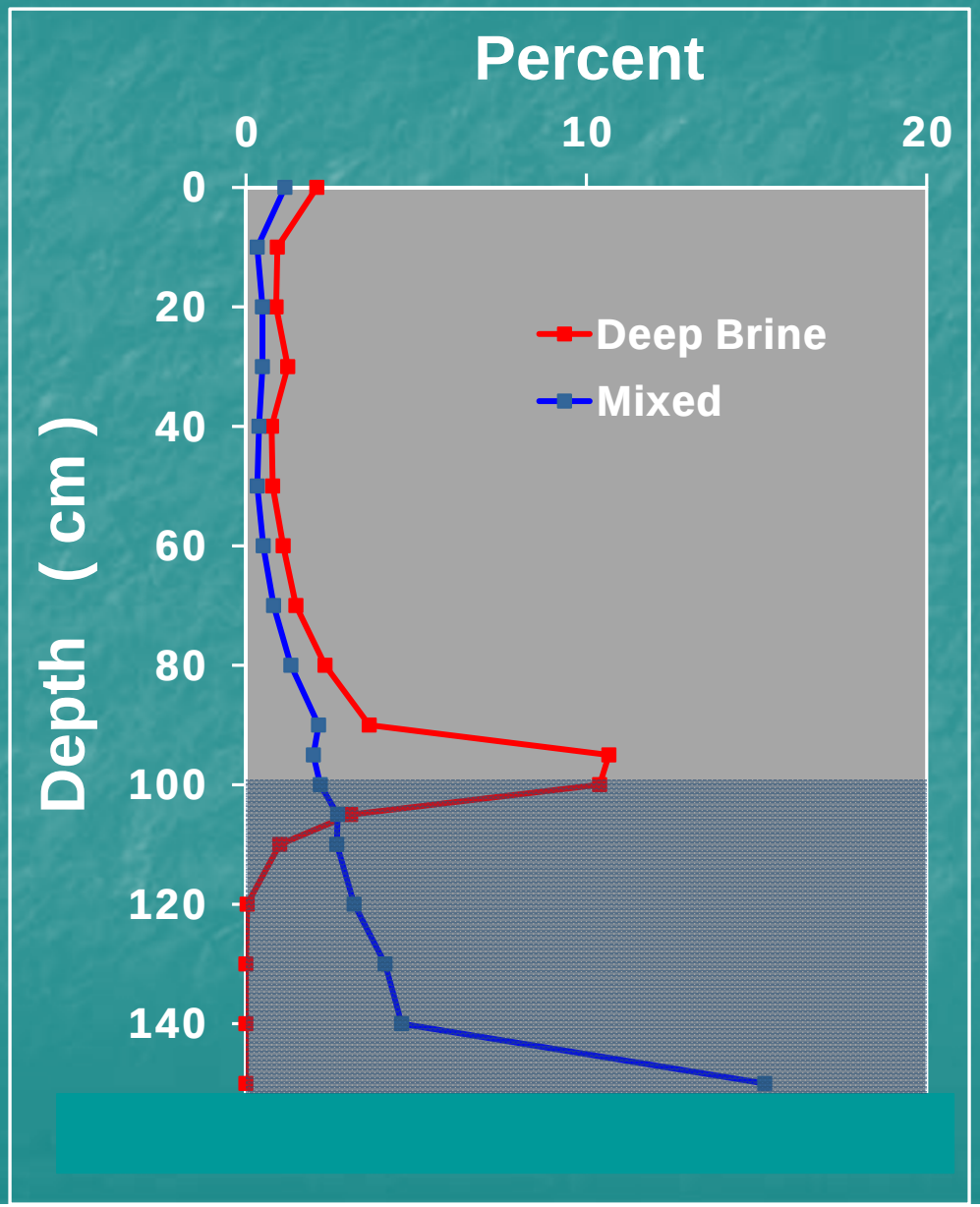
Mercury concentrations in columns

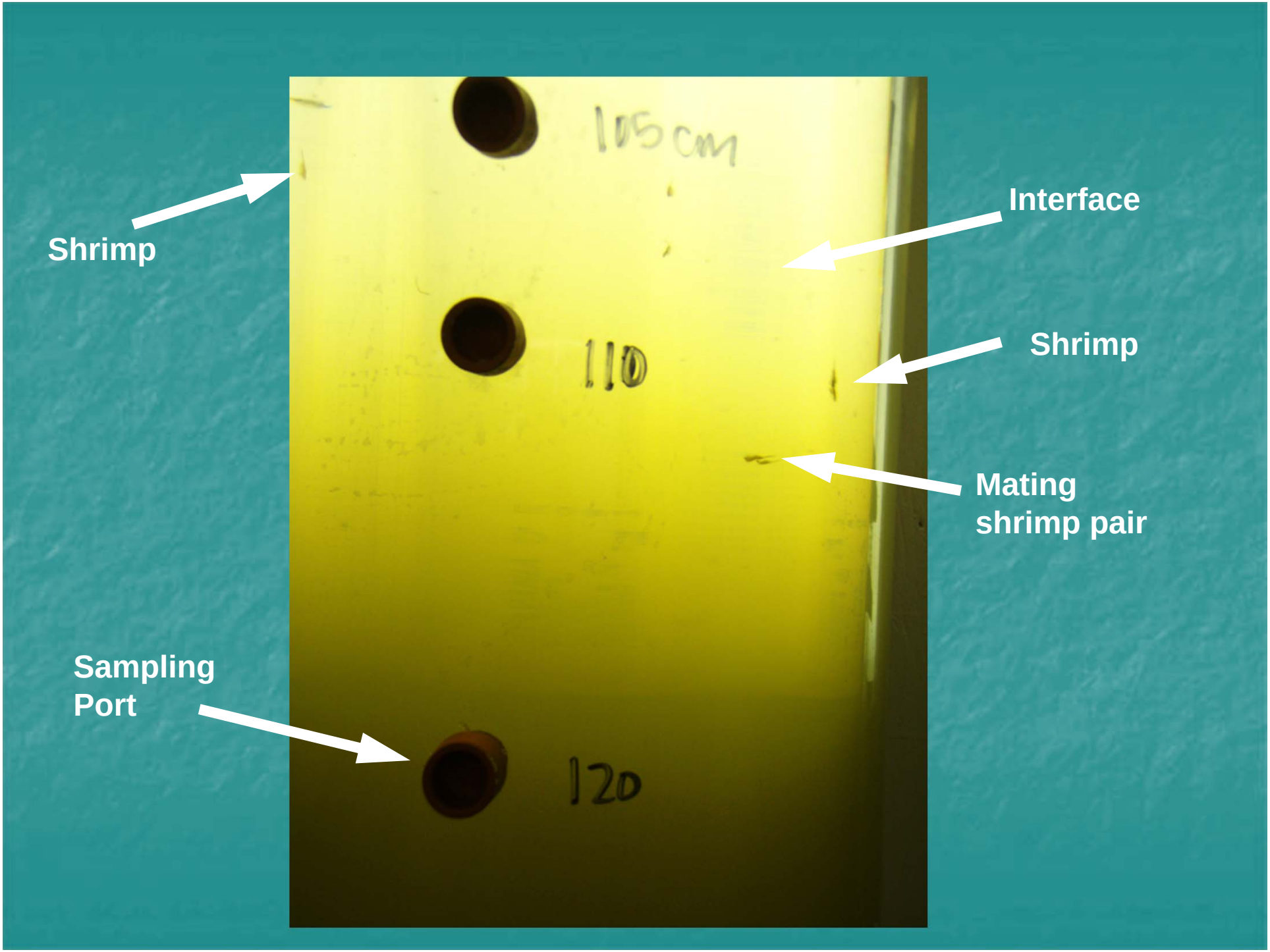
- Mixed columns
  - Uniform Concentrations
  -
- Deep-brine columns: High Hg in deeper water
  - Methyl Hg
    - 1-22 ng/L
  - Total Hg
    - 6-56 ng/L



Artemia Distribution in columns

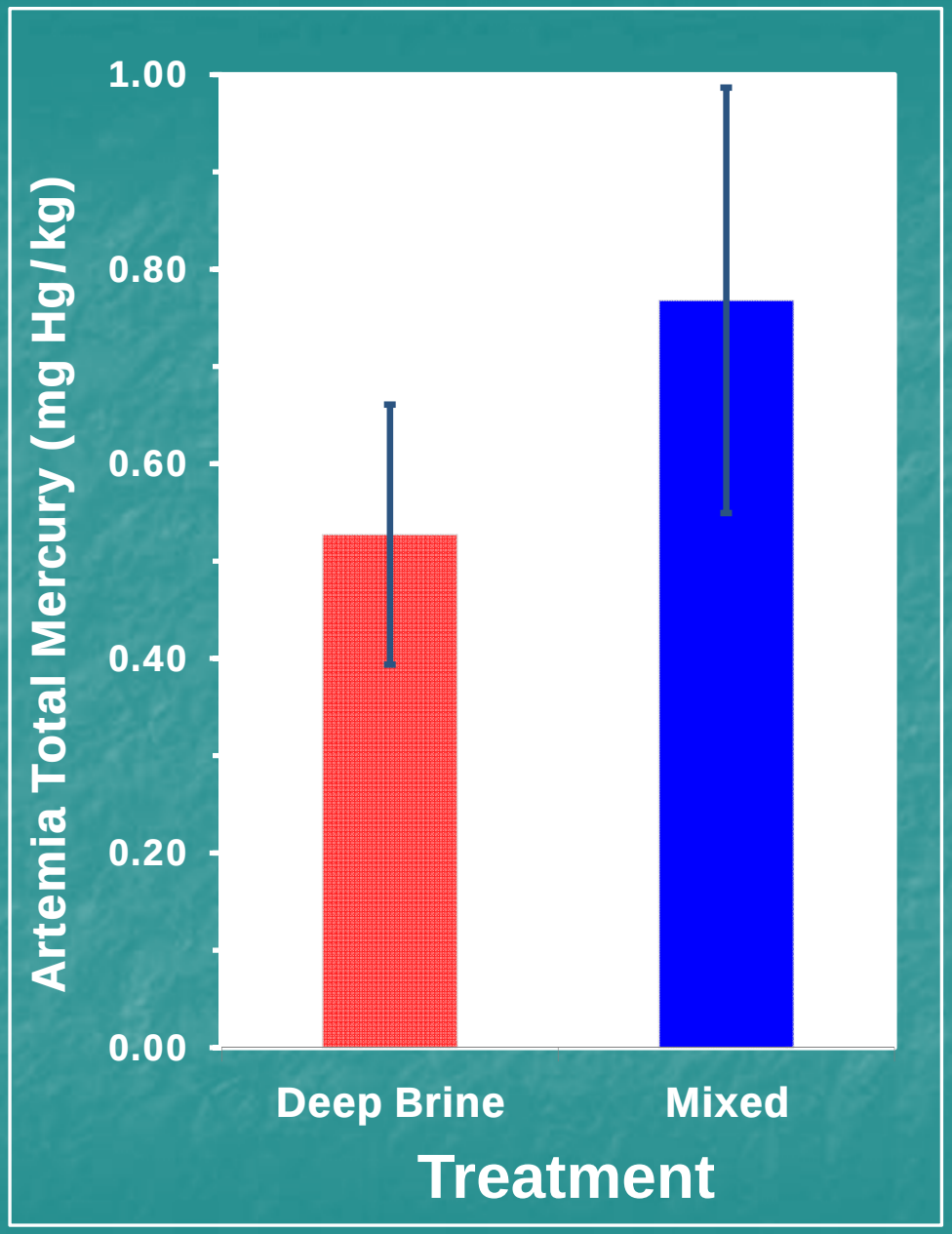
- **Shrimp concentrated at top and bottom in mixed-layer treatments**
- **They concentrated at deep-brine interface in the stratified columns**




105 cm
110
120
Shrimp
Interface
Shrimp
Mating
shrimp pair
Sampling
Port

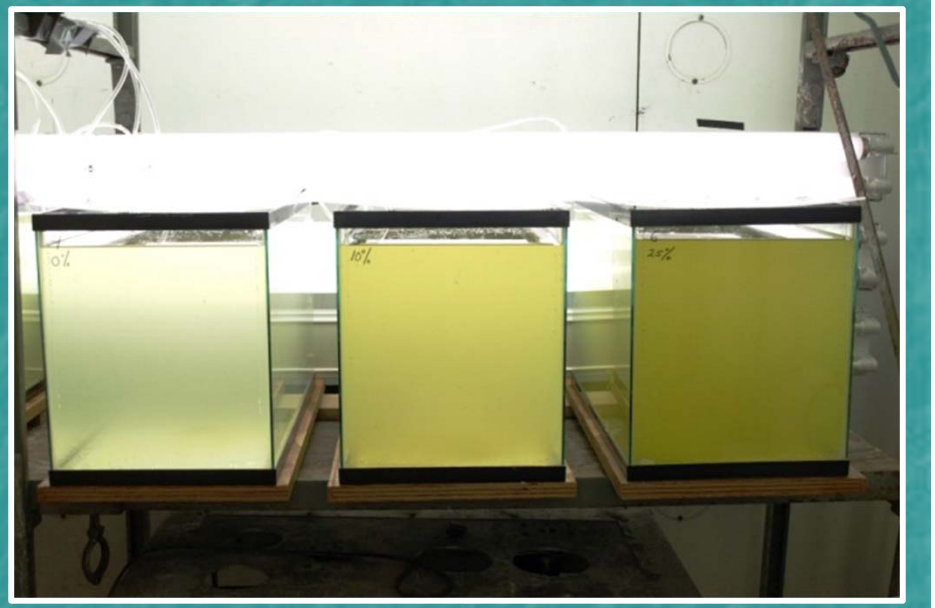
Mercury in brine shrimp adults

- At end of experiment brine shrimp in deep brine treatment had <u>lower</u> levels of mercury, despite exposure to higher mercury levels.



Mixing simulation experiment in 34-L aquaria

- Three treatments (2 replicates each)
  - 0% deep brine; 100% mixed-layer
  - 10% deep brine; 90% mixed
  - 25% deep brine; 75% mixed

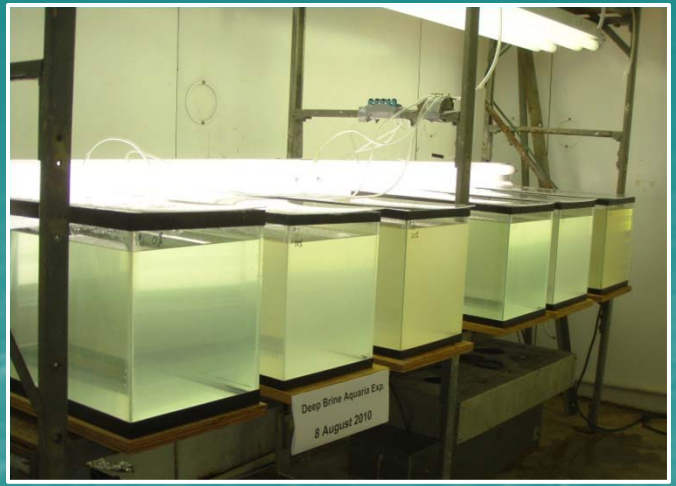


0% 10% 25%

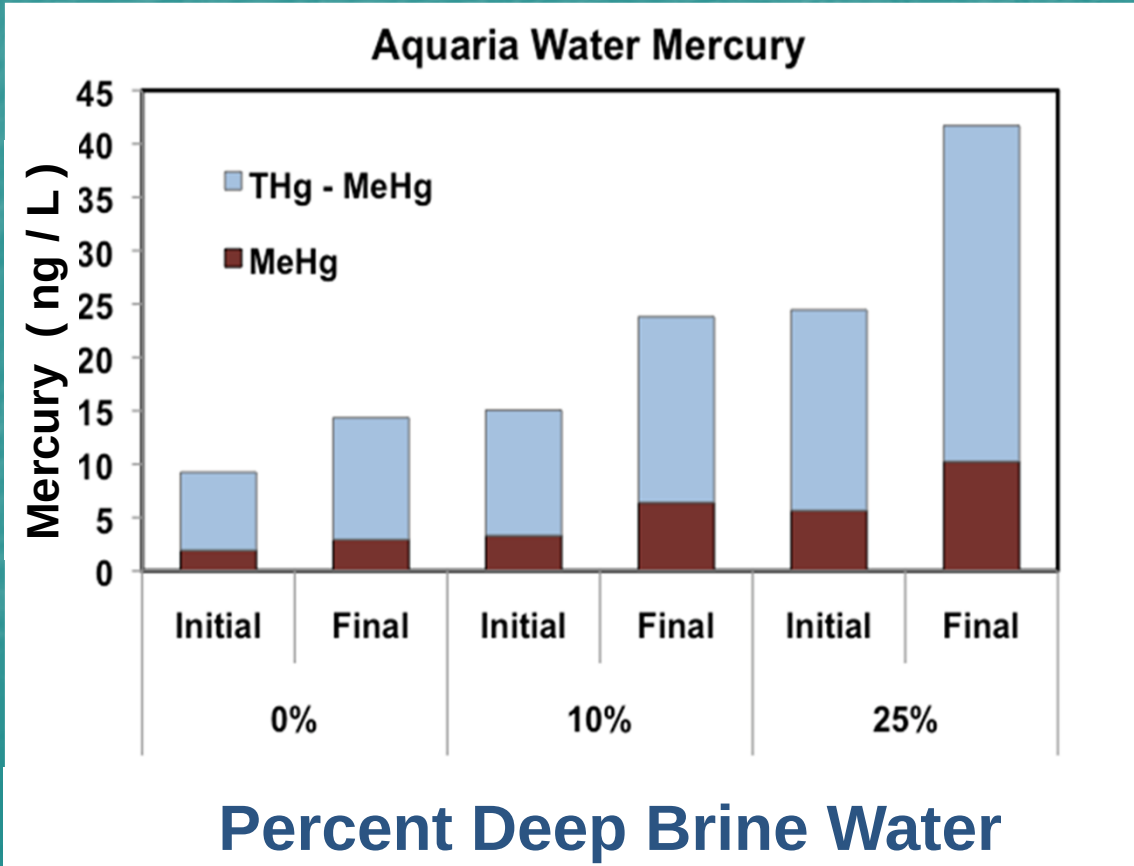
Deep Brine Water

- 18:16 light:dark
- 27°C
- 10 *Artemia* nauplii/L
- 14 day-long experiment (*Artemia* mature)
- Aerated initially for 1 day to remove H_2S; 1 hr/day subsequently

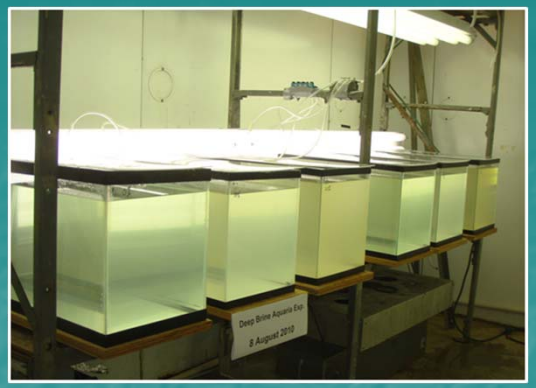
Mixing simulation

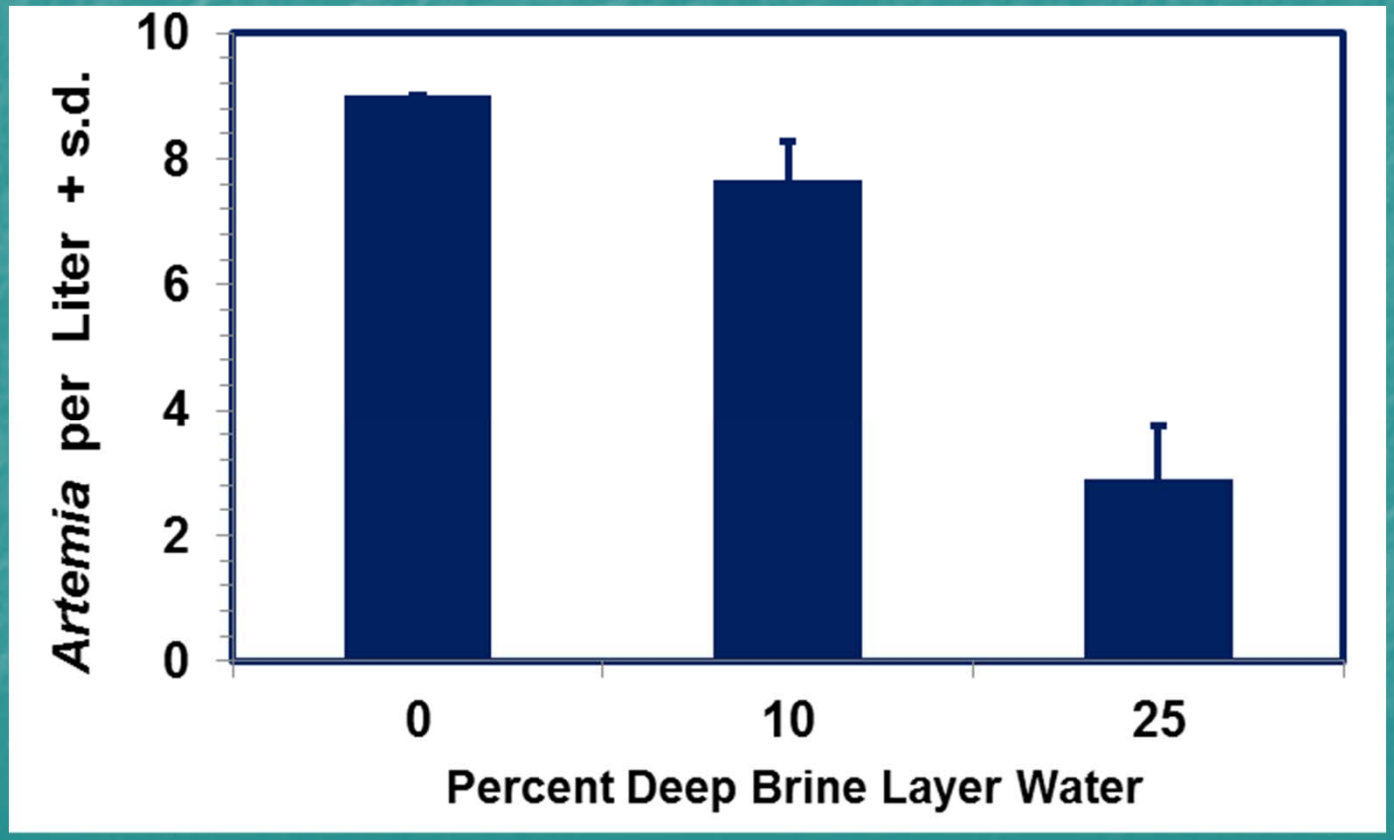


- Significantly higher mercury with more deep brine water
- Increasing mercury from beginning to end of experiment (due to aeration?)



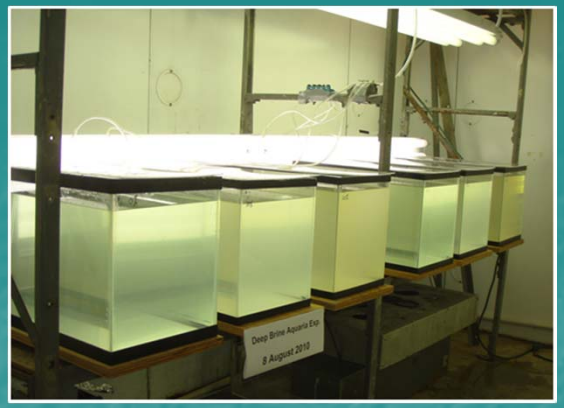
Poor *Artemia* survival after 14 d in treatments with higher proportions of deep-brine water

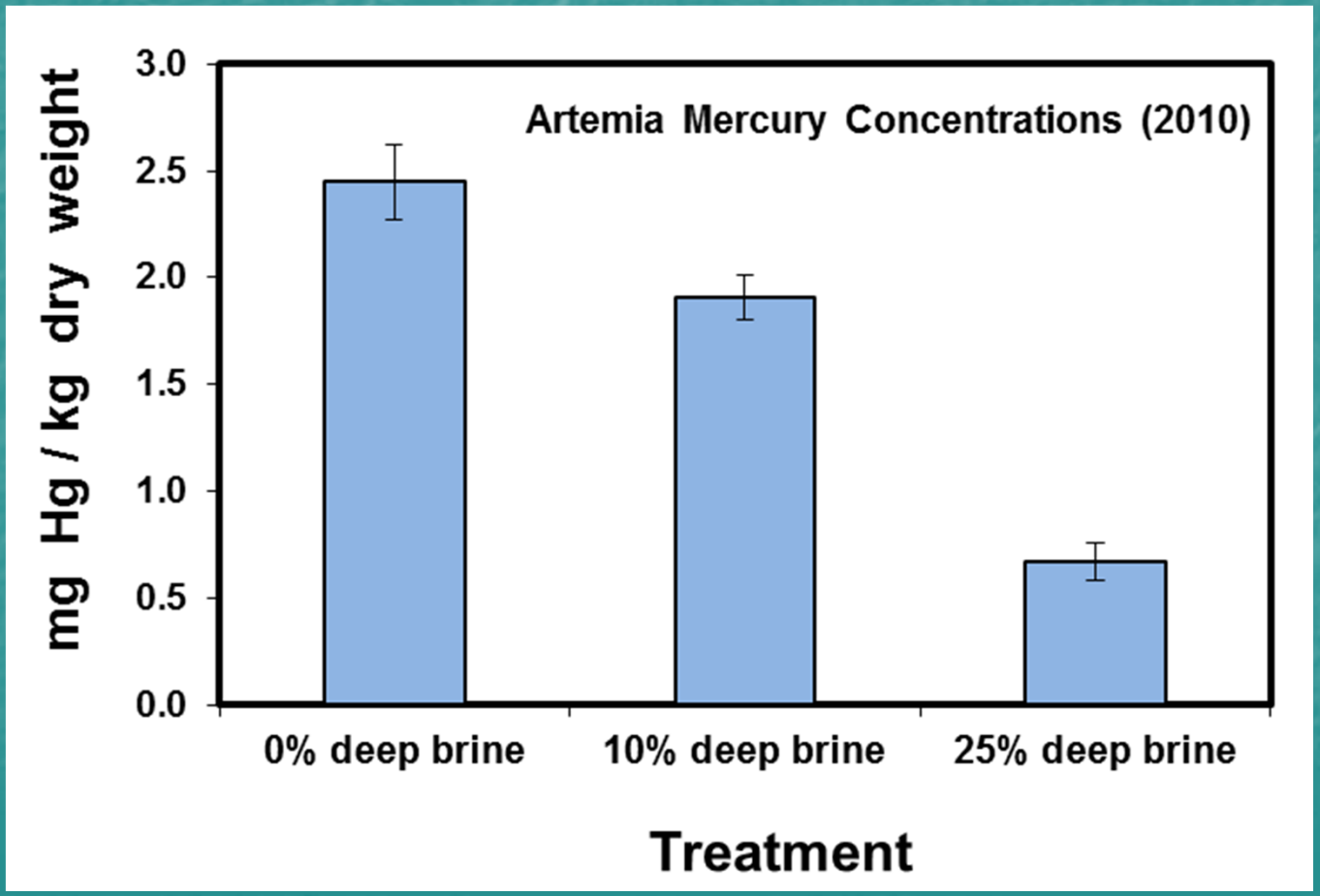




ANOVA: $p = 0.002$

But, <u>lower</u> mercury levels in *Artemia* in treatments with more deep-brine water (higher mercury concentrations)





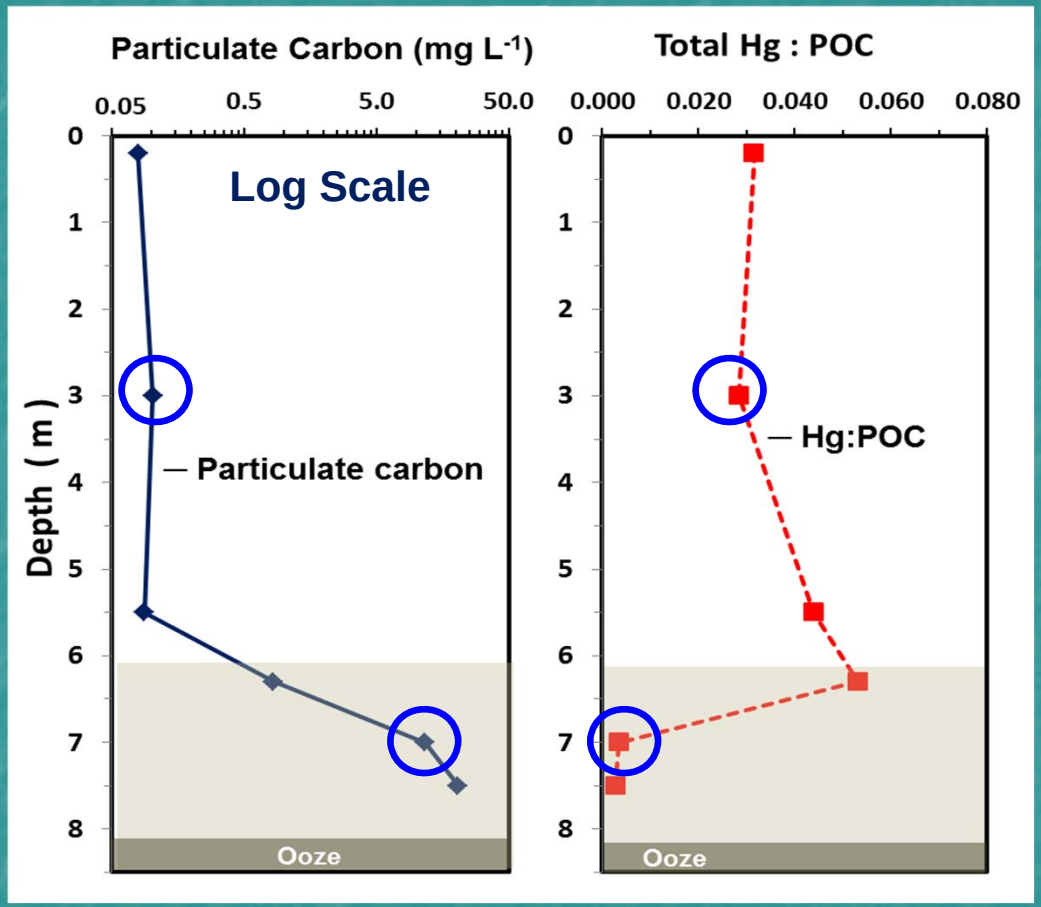
ANOVA; $p < 0.000$

Conclusions for Deep Brine Layer Experiments

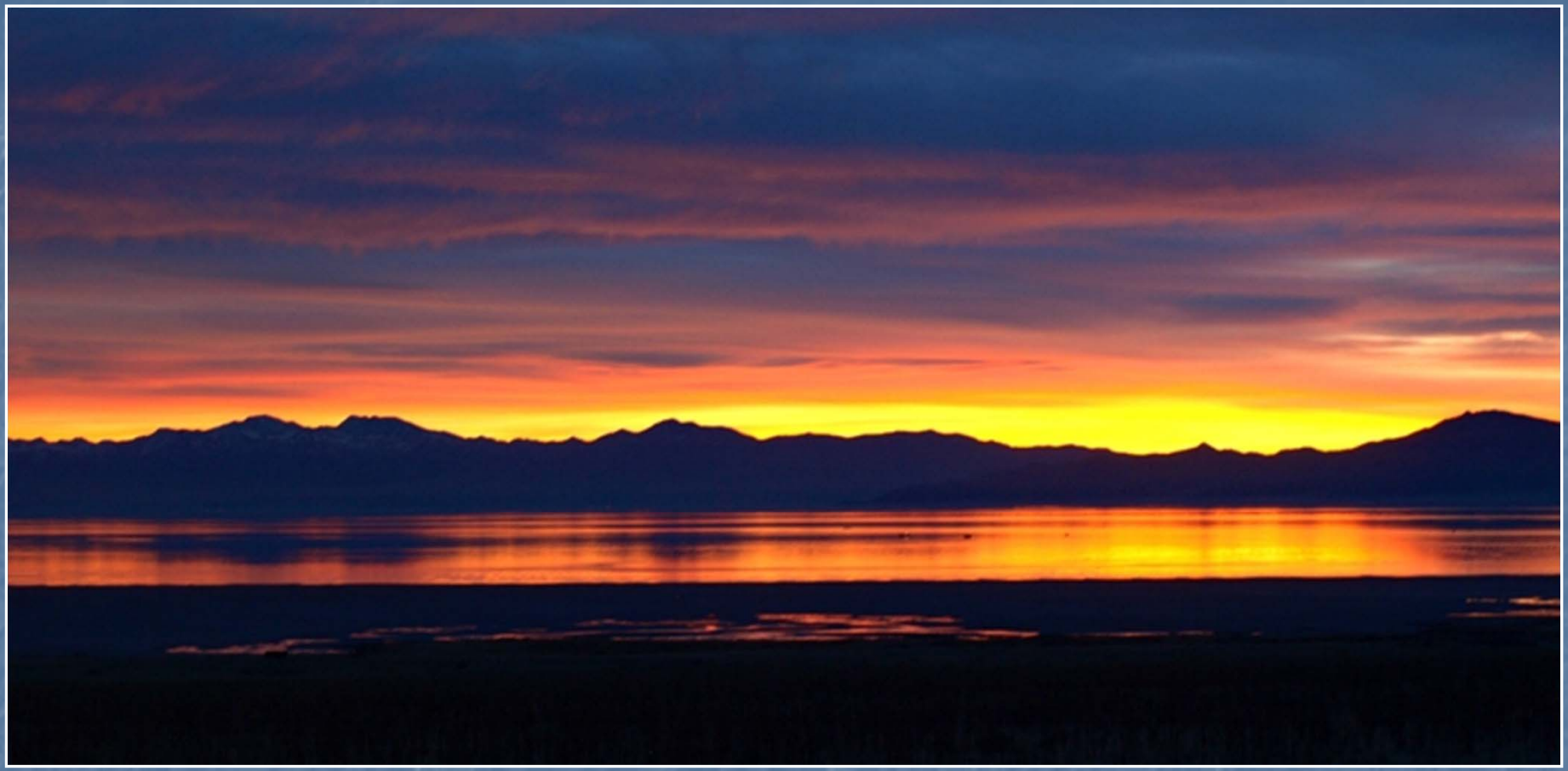
- *Artemia* enter upper layer of deep brine layer, but do not penetrate far
- In Column Experiment, growth and survival unaffected by presence of deep brine layer
- In Aquaria Mixing Experiment, survival much lower in treatments with deep brine layer water: toxic component unknown

Conclusions for Deep Brine Layer Experiments

- In both experiments mercury concentrations in *Artemia* were <u>lower</u> when exposed to deep brine layer water with high methyl and total mercury concentrations



- Likely explanation: High particulate carbon concentrations in deep brine layer dilutes the mercury shrimp are consuming. Ratios of total mercury to particulate organic carbon (Hg:POC) are considerably *lower* in the deep brine layer than in the overlying mixed layer.



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 & the Utah Division of Forestry, Fire and State Lands