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# Exploring Biogeochemical Cycling of Mercury In Hypersaline Environments

**Cathryn Sephus<sup>1</sup>**, Amina Schartup<sup>1</sup>, Jeff Bowman<sup>1</sup>, Johannes West<sup>1</sup>,  
the Oceans Across Space and Time (OAST) Team, and Britney Schmidt<sup>2</sup>

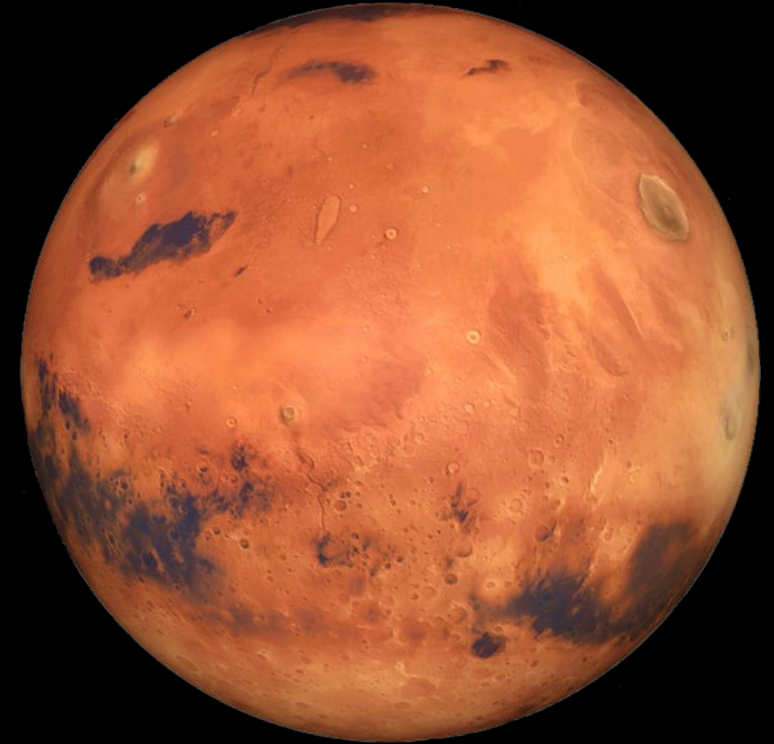
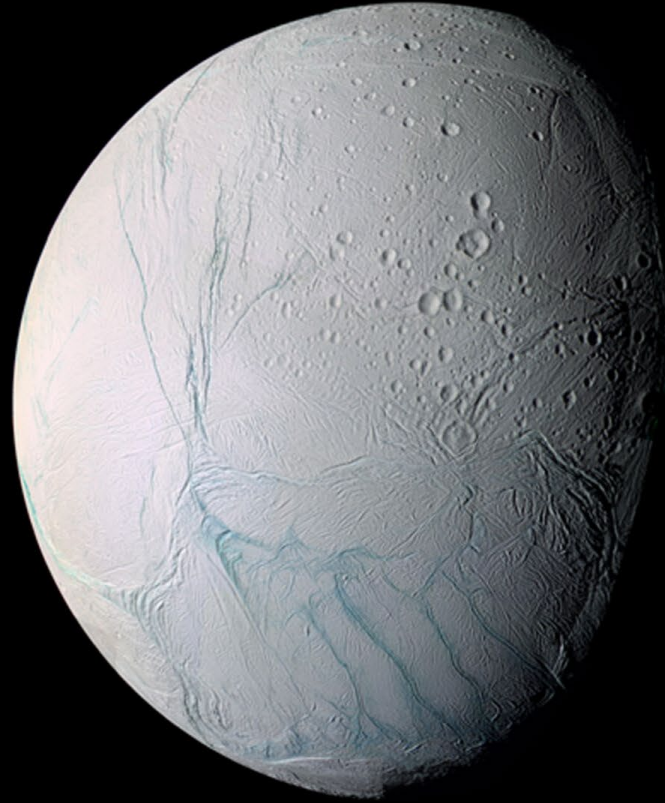
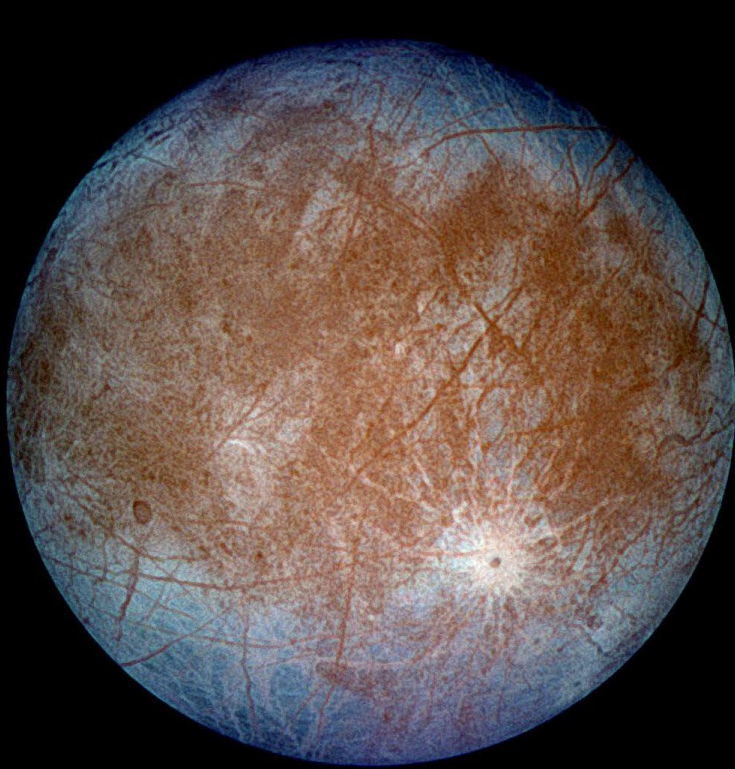
<sup>1</sup>Scripps Institution of Oceanography, University of California - San Diego

<sup>2</sup>Astronomy & Earth and Atmospheric Sciences, Cornell University

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# Brines as environments for understanding life on other worlds



Contemporary

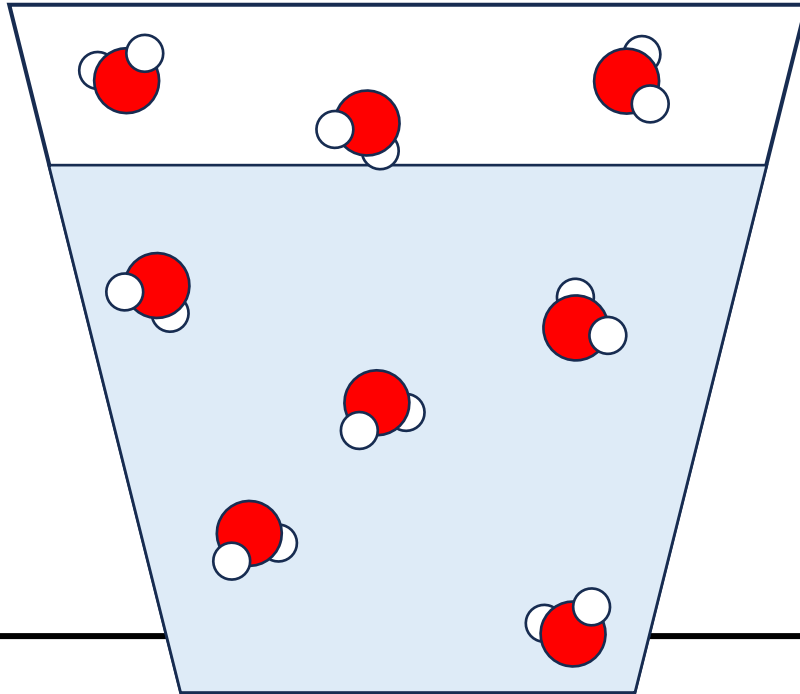
Relict



# Water activity ( $A_w$ ) can be used to assess habitability

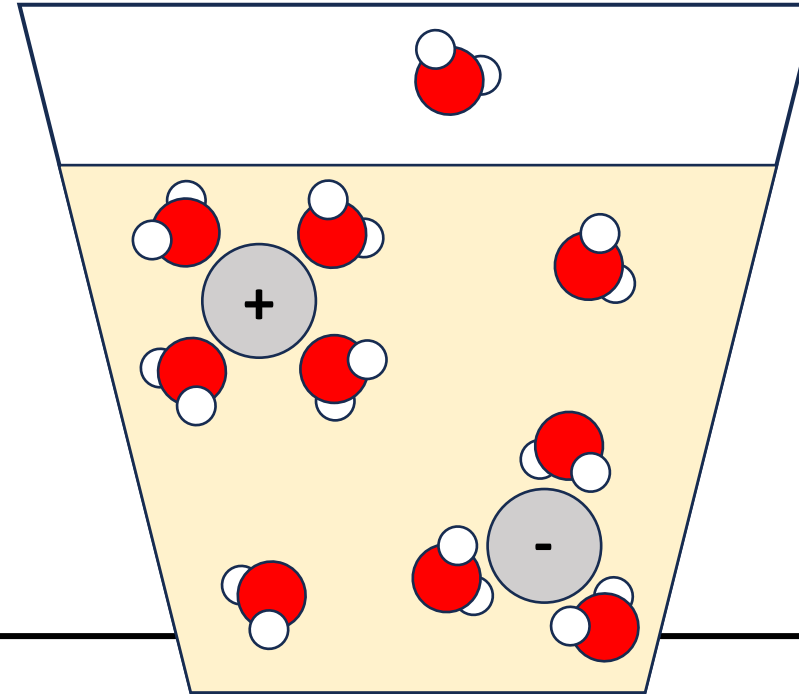
$$A_w = \frac{\text{vapor pressure of brine water}}{\text{vapor pressure of pure water}}$$

Pure Water



All H<sub>2</sub>O molecules are free  
 $A_w = 1.00$

Brine



Fewer H<sub>2</sub>O molecules are free  
 $A_w < 1.00$



# Western Australia Transient Lake (WATL) System



- Western Australia is home to hundreds of ephemeral saline lakes
- Lakes can range from extremely acidic ( $\text{pH} < 3$ ) to alkaline ( $\text{pH} > 8$ )
- $A_w$  of WATL Lakes  $\sim 0.5 - 0.99$
- Elevated levels of trace heavy metals previously reported



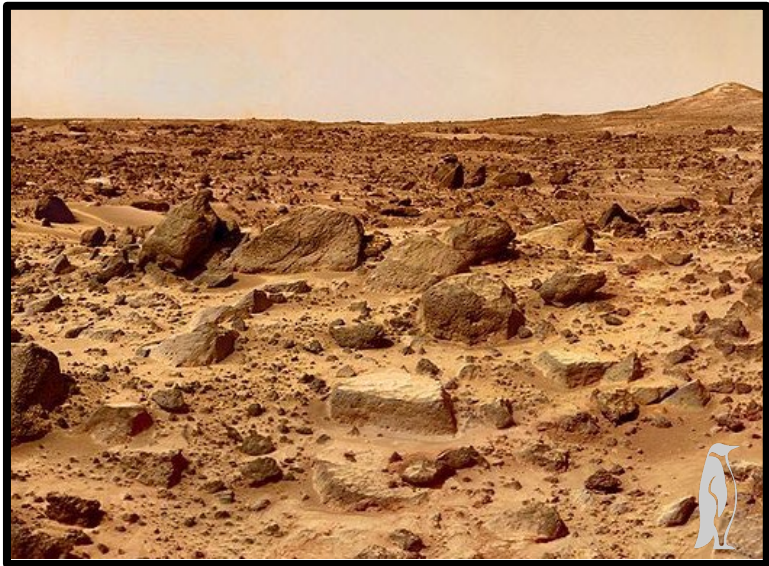
# WATL system – an analogue for ancient Martian Brines

|       | pH        | $A_w$       | Major Evaporites         |
|-------|-----------|-------------|--------------------------|
| WATL  | 2.7 - 9.2 | 0.75 – 0.99 | Gypsum, Halite, Hematite |
| Mars* | 2.1- 6.7  | 0.60 – 0.90 | Gypsum, Halite, Hematite |

\*Noachian (3.7 Gya) - Hesperian (3.1Gya) Era

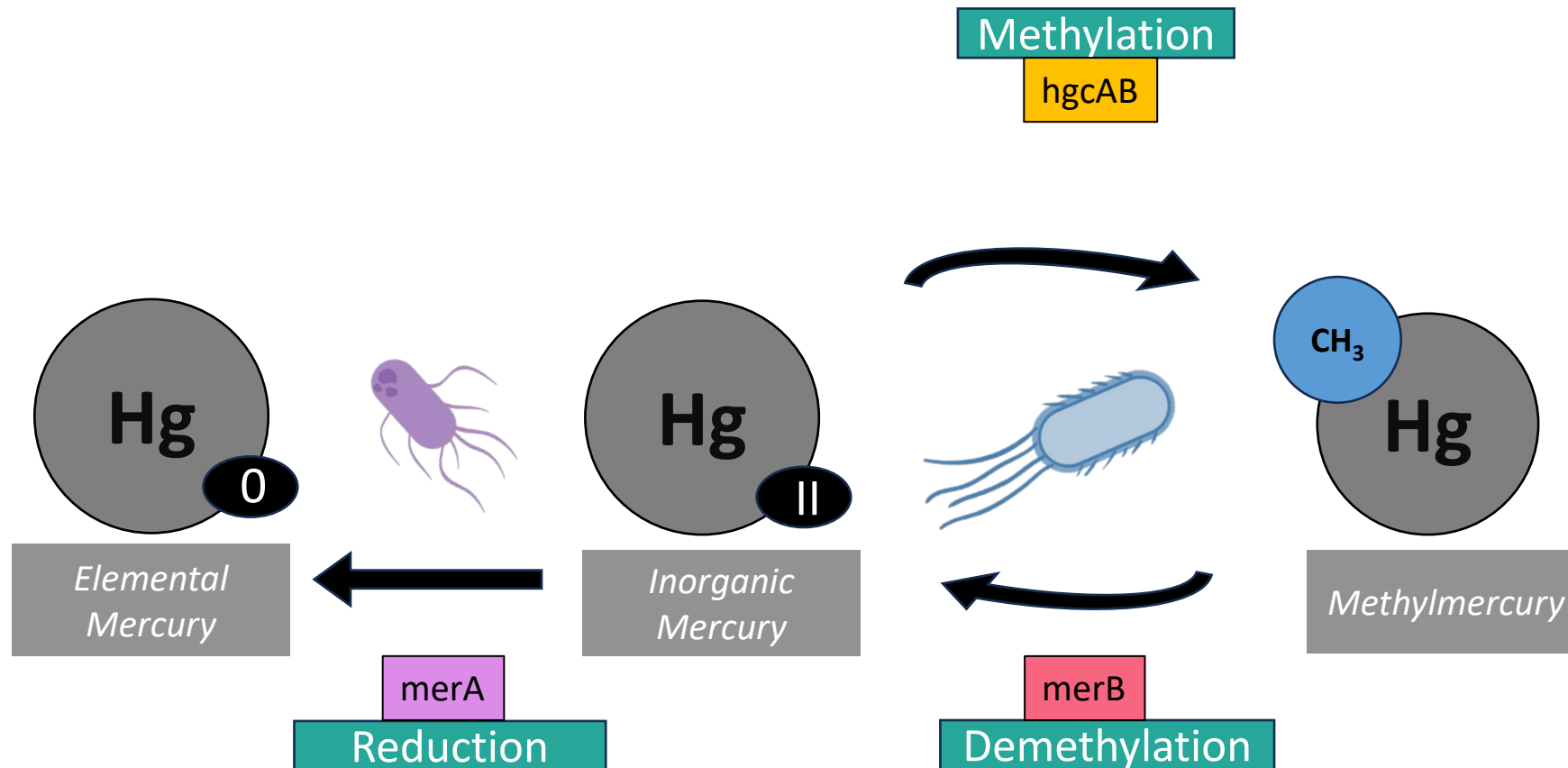


Lake Koorkoordine , Western Australia



The surface of Mars

# Guiding Research Questions

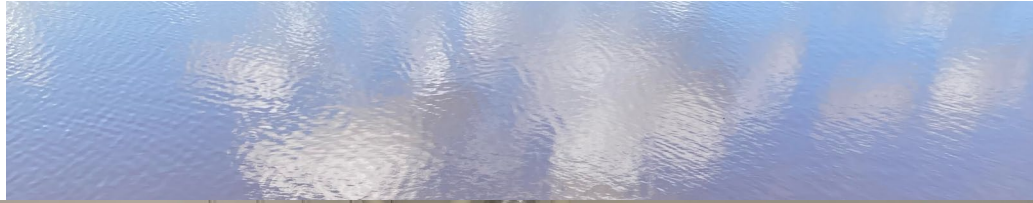


Do pH and water activity affect microbial cycling of mercury in the environment?

Are canonical genes associated with mercury cycling present in these environments?



# Sampling lakes across Western Australia



1

## Sample the site

Water collected using peristaltic pump and sample tubing extended to lake water

2

## Preserve the species

Samples collected were filtered and acidified to preserve metal speciation

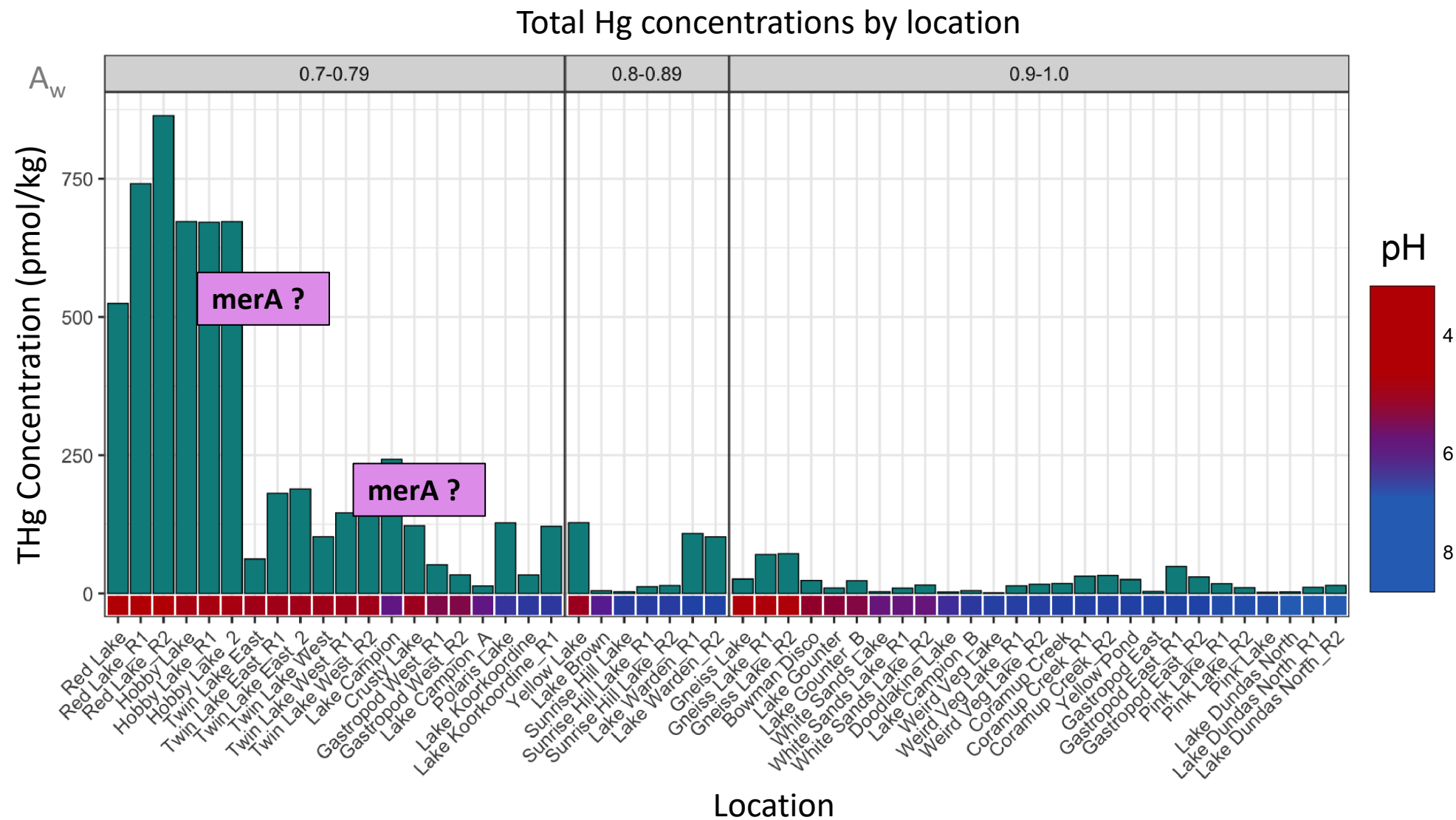
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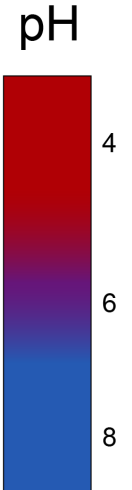
## Analyze the data

Quantification of mercury species was conducted using GC-ICP-MS at SIO

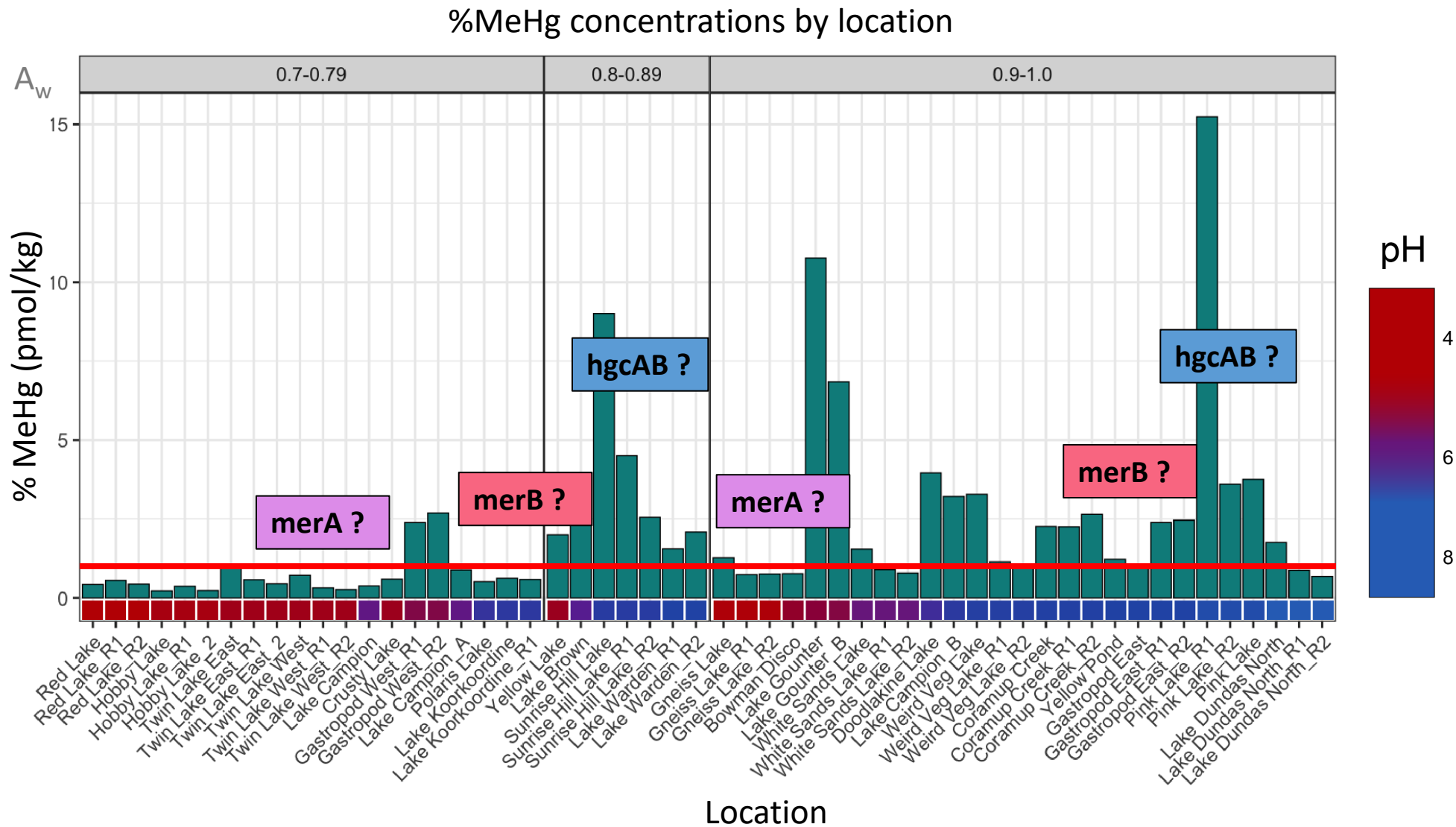


# Mercury concentrations are higher in acidic brines





# Methylmercury production may occur across pH and A<sub>w</sub> levels

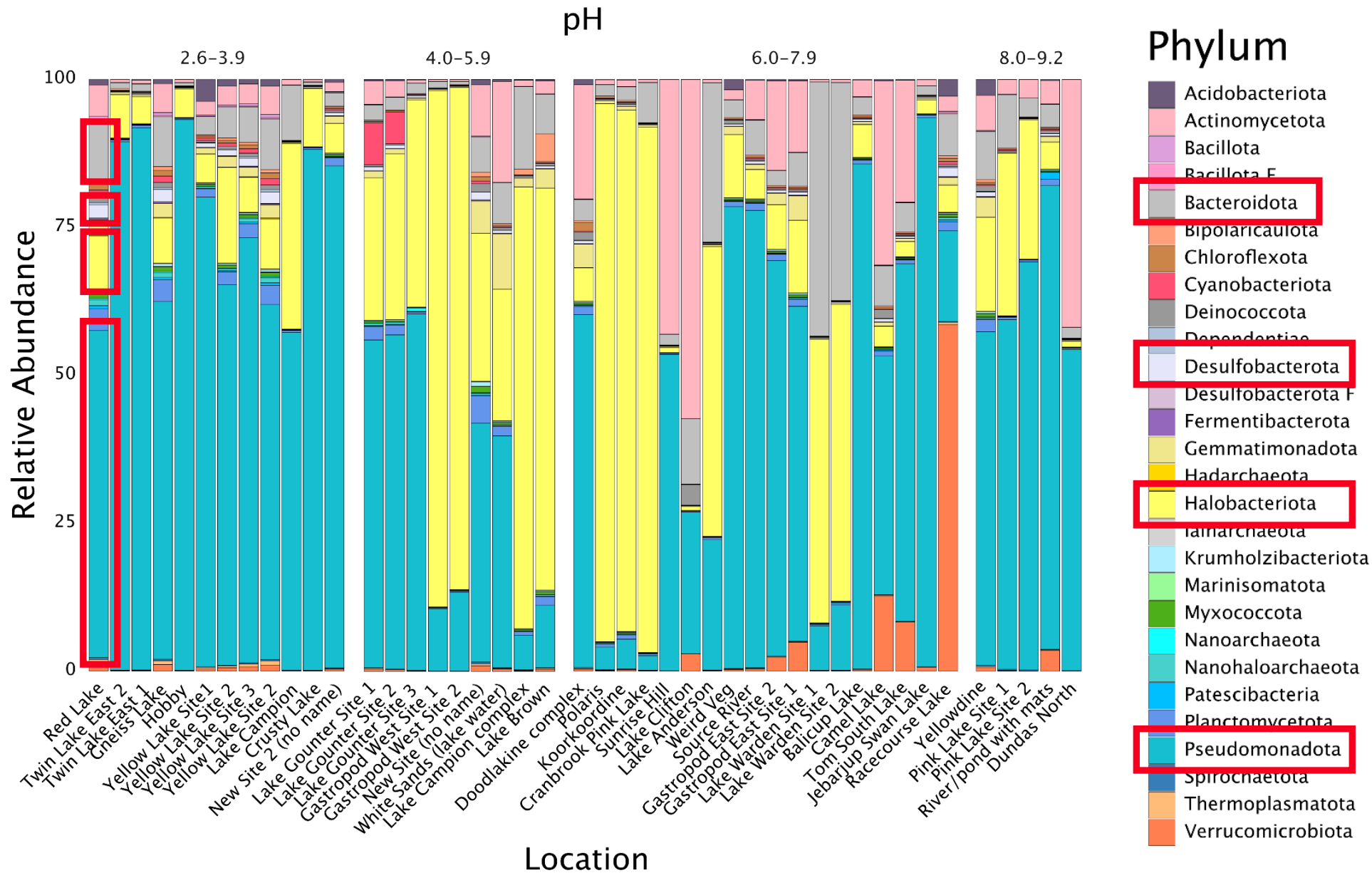


# Microbes known to carry merA genes are abundant across lakes



Benjamin Klempay (SIO)

merA



# MerA gene is present in lakes across pH and $A_w$ levels

Twin Lake West

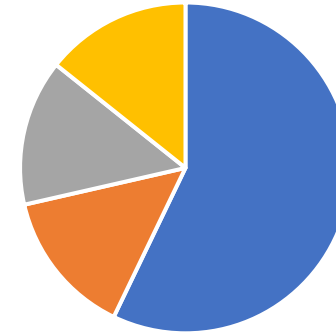


THg 102.45 pmol/kg

pH 2.97

$A_w$  0.7545

merA containing organisms



- Salinisphaeraceae
- Unclassified Bacteria
- Halobacteriaceae
- Methanonatronarchaeles

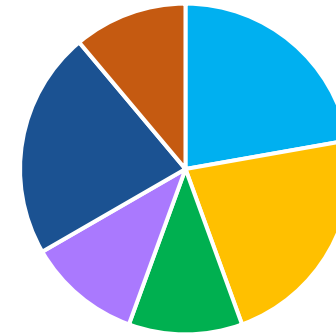
Lake Gounter



THg 9.57 pmol/kg

pH 3.92

$A_w$  0.9061



- Haloarculaceae
- Halobacteriaceae
- Candidatus Wosearchaeota
- Balneolaceae
- Comamonadaceae
- Burkholderiaceae

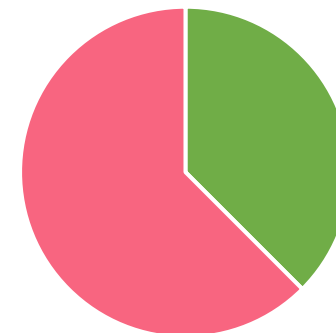
Sunrise Hill Lake



THg 3.30 pmol/kg

pH 7.46

$A_w$  0.9724



- Microbacteriaceae
- Roseobacteraceae



# MerA gene is present in lakes across pH and $A_w$ levels

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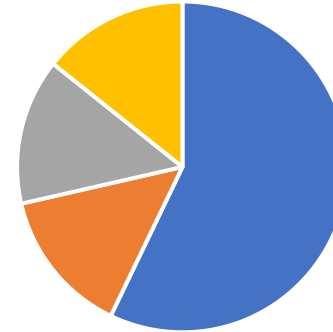


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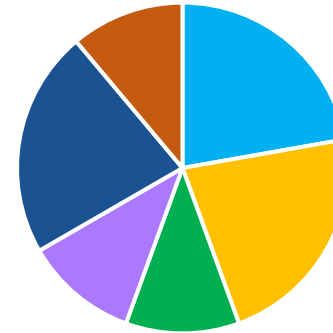
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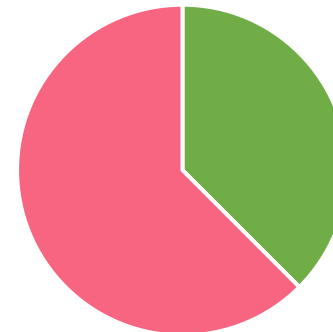
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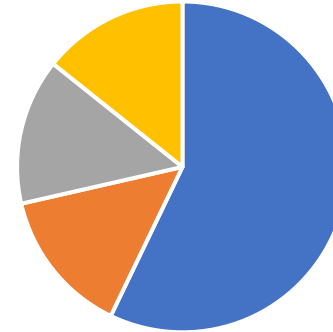


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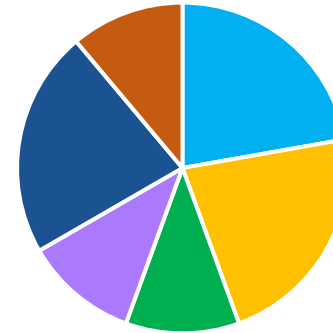
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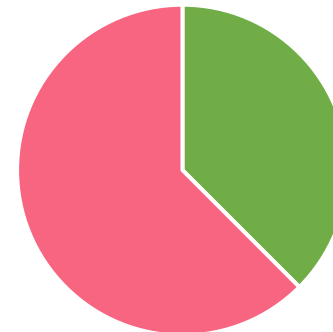
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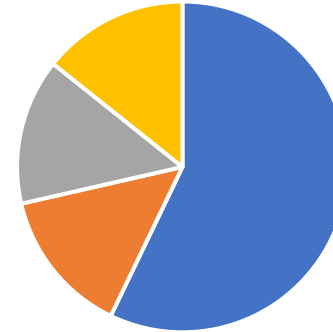


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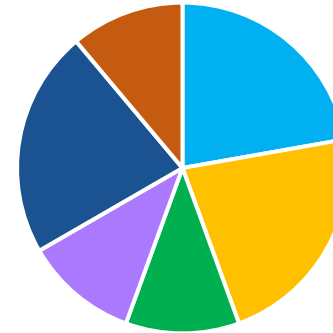
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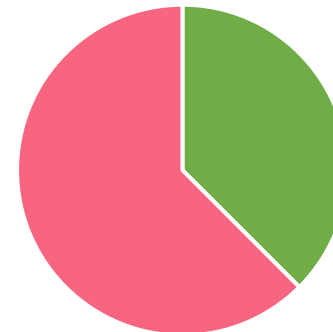
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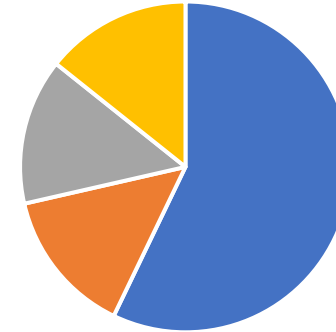


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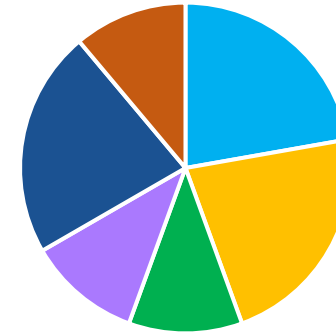
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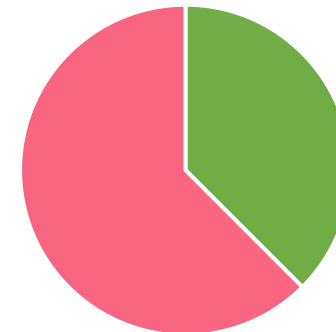
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# Summary & Next Steps

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- **merA and microbes associated with mercury reduction are present** across a range  $A_w$  and pH environments
  - **Biological methylmercury production may occur in these extreme lake environments** spanning a range of pH and  $A_w$  levels
- **Further gene analyses** (Build HMMs and conduct gene searches for localization patterns)
  - **Sequence feature analysis** (determine if mercury cycling genes have distinct properties in this poly-extreme environment?)



# Acknowledgements



**Amina Schartup, PI**



**Jeff Bowman**



**Johannes West**



**Britney Schmidt**



UC San Diego



NATIONAL ACADEMIES  
Sciences  
Engineering  
Medicine



