

Establishing a Baseline for Contaminant Trends in California Reservoirs

Castaic Lake & Pyramid Lake Los Angeles County

Scott F. Jedrusiak
California State University, Northridge, CA

Collaborators: Priya Ganguli; Scott Hauswirth; Gregory Jesmok; Byran Fuhrmann; Marc Beutel

This presentation is taking place on the traditional, ancestral, and contemporary lands the Tongva and Acjachemen Peoples. I recognize this land holds great historical, spiritual, and personal significance to the original inhabitants.

The California State Water Project (SWP)

- Water delivery system extending >700 miles
 - 34 reservoirs and lakes
 - 701 miles of aqueducts
 - 5 power plants
 - 24 pumping plants
- Provides ~30% of water to Southern CA
 - Augmented by Colorado River Aqueduct and groundwater



West Branch of the State Water Project

- Emergency drinking water reservoirs & source of hydroelectric power
- West branch flows through Pyramid Lake and ends at Castaic Lake (reservoirs)
- ~40 to 50 miles north of Los Angeles
- Project focuses on Castaic Lake & tributaries
 - Also sampled Pyramid Lake



Initial Project Motivation

- Initial purpose: investigate sources of bioaccumulative mercury (Hg) in Castaic Lake
- >100 CA reservoirs impaired due to Hg & PCBs in fish
 - Includes Castaic & Pyramid
 - *10:25am talk in Breakout Rm 1 (Greg Jesmok)*
 - Advisories based on fish tissue, not water quality



Discovered Lack of Water Quality Data at Depth

- Many reservoirs used as recreation areas (e.g., Castaic & Pyramid)
 - Human contact primarily in shallow water (e.g., swimming, boating)
 - Resource agency data primarily from shallow waters

We aim to contribute to existing data by evaluating water column depth profiles (>200 ft) at Castaic and Pyramid Lakes



Sampling

- Multiple depth profiles
(35 – 75 m)
(115 – 250 ft)



- Surface Water (<1 m)
- Streams (inflow & outflow)
- Lake perimeters
(Castaic, Pyramid, Quail, Lake Elizabeth)
- Lake surface algal bloom



Just a few of the student researchers who have supported this work...



Analyses

- **In-situ water quality** (temp, DO, pH, salinity, ORP, turbidity)
- **Trace metals via ICP-MS**
- Mercury speciation (CVAFS)
- Anions (liquid chromatography)
- PAHs & PCBs (gas chromatography)
- Dissolved organic carbon
- Suspended particulate matter

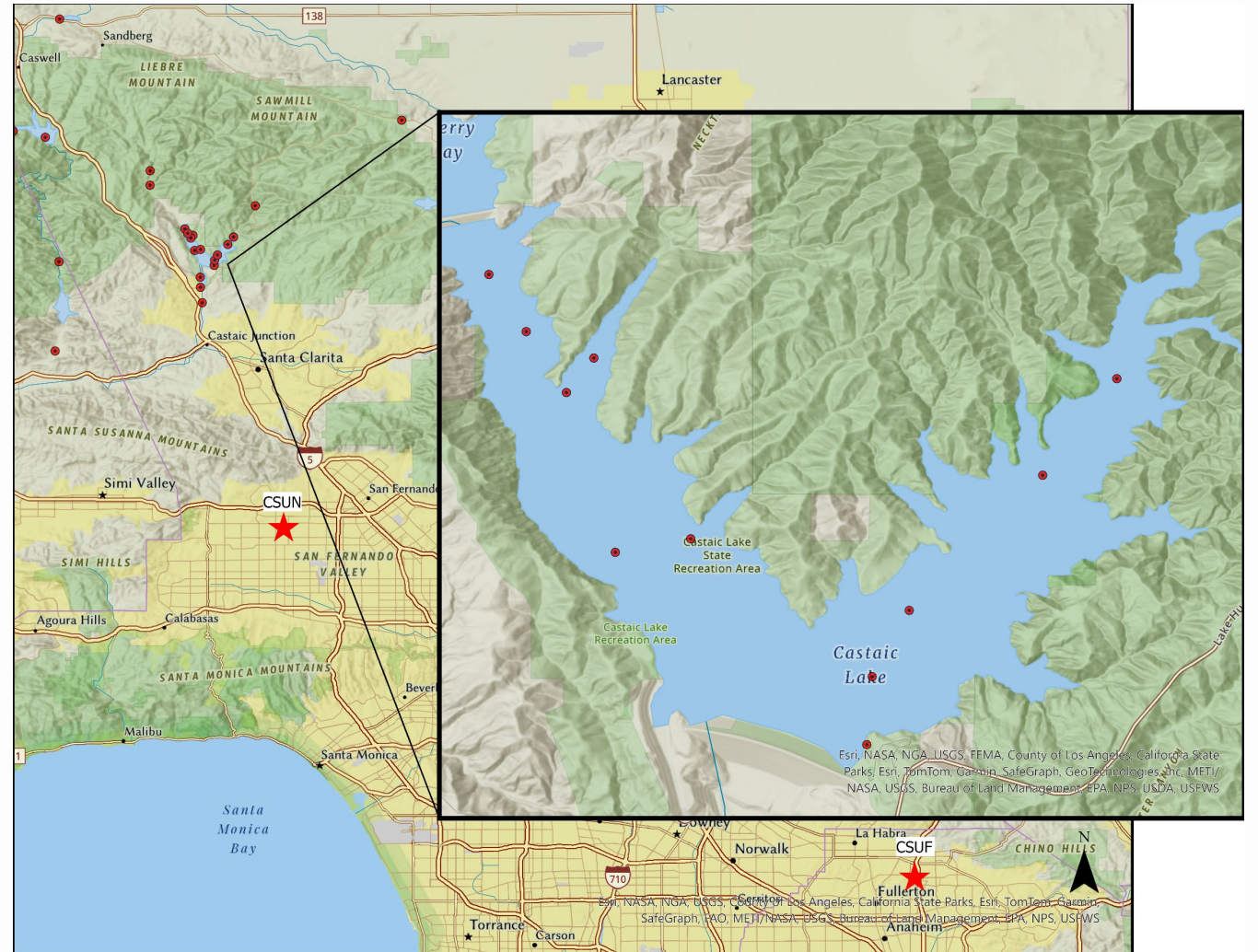
Metals in Reservoirs

Why study metals if not listed as impaired?

- Seasonal temp changes can disconnect deep water from atmosphere
 - Altering oxygen concentrations can affect behavior of metals
- Global warming may exacerbate this process
- Climate change also makes Southern CA reservoirs more susceptible to wildfire impacts
- This work provides a baseline

Hypothesis

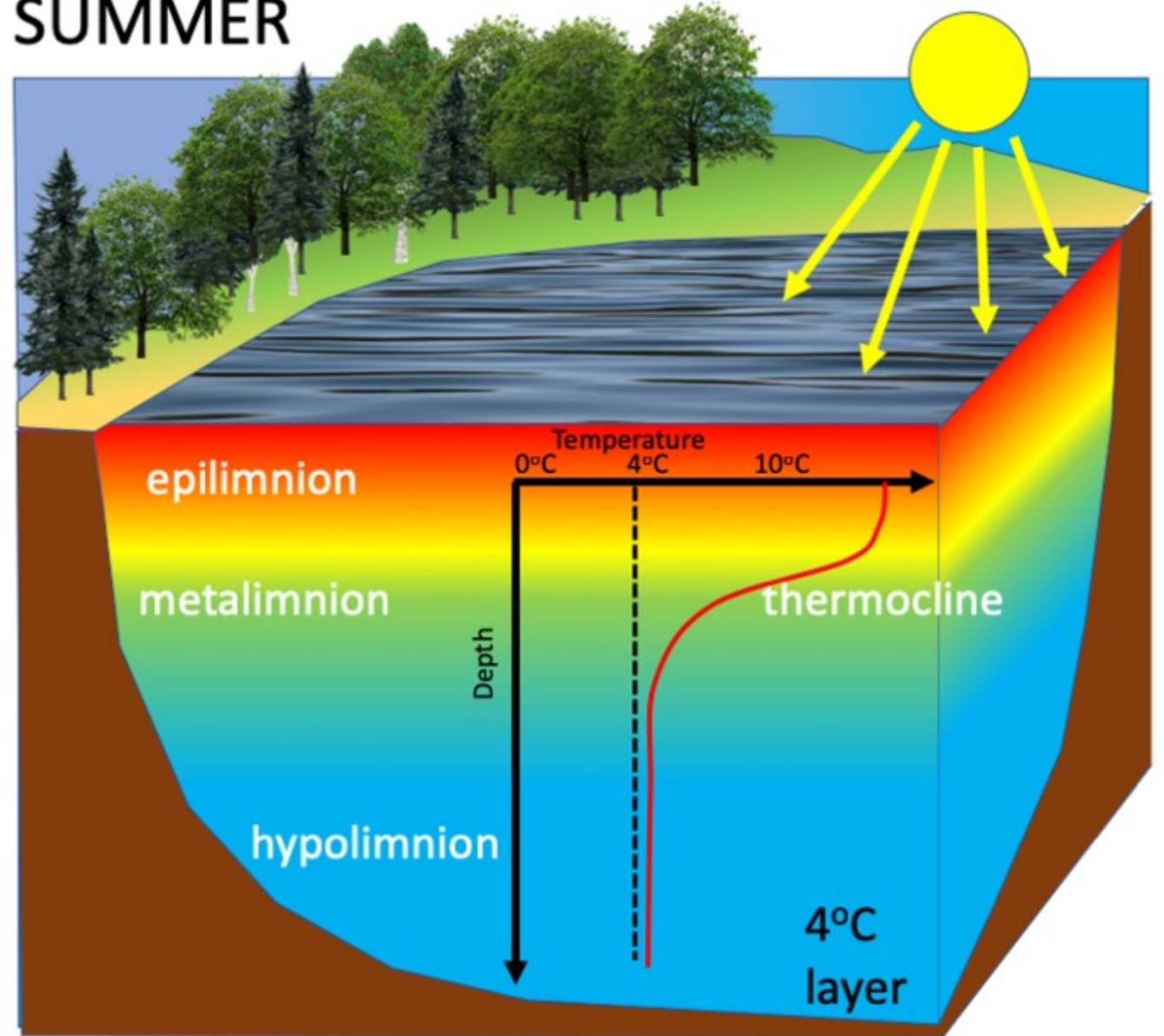
Water column stratification results in oxygen depletion at depth and the release of sediment-bound metals



Water Column Stratification

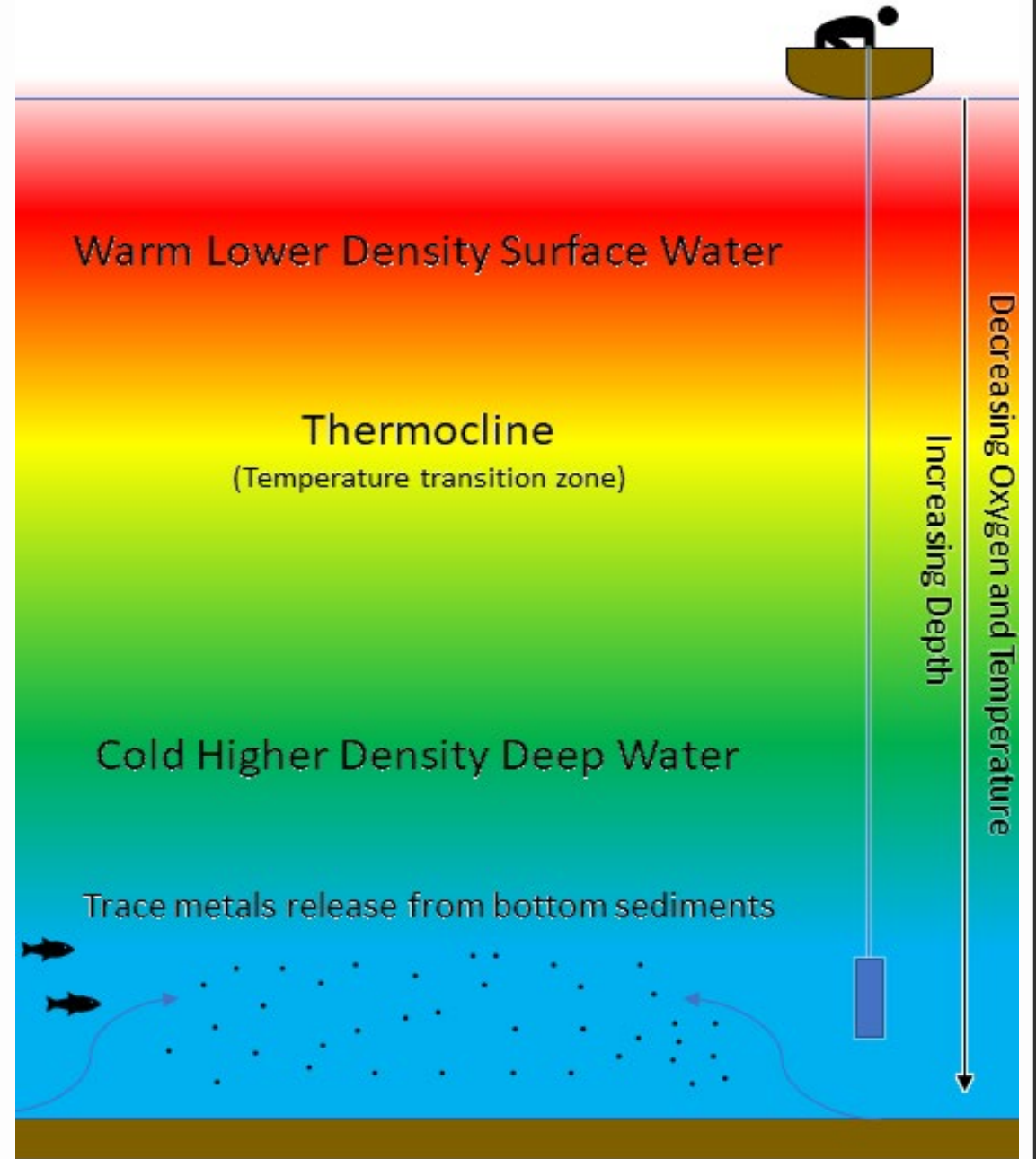
- Lake/reservoir surface warms during summer
- Surface water becomes LESS DENSE than cooler underlying water
- Deep water loses contact with atmosphere
- Biological process deplete oxygen affecting redox state of deep water & sediments

SUMMER

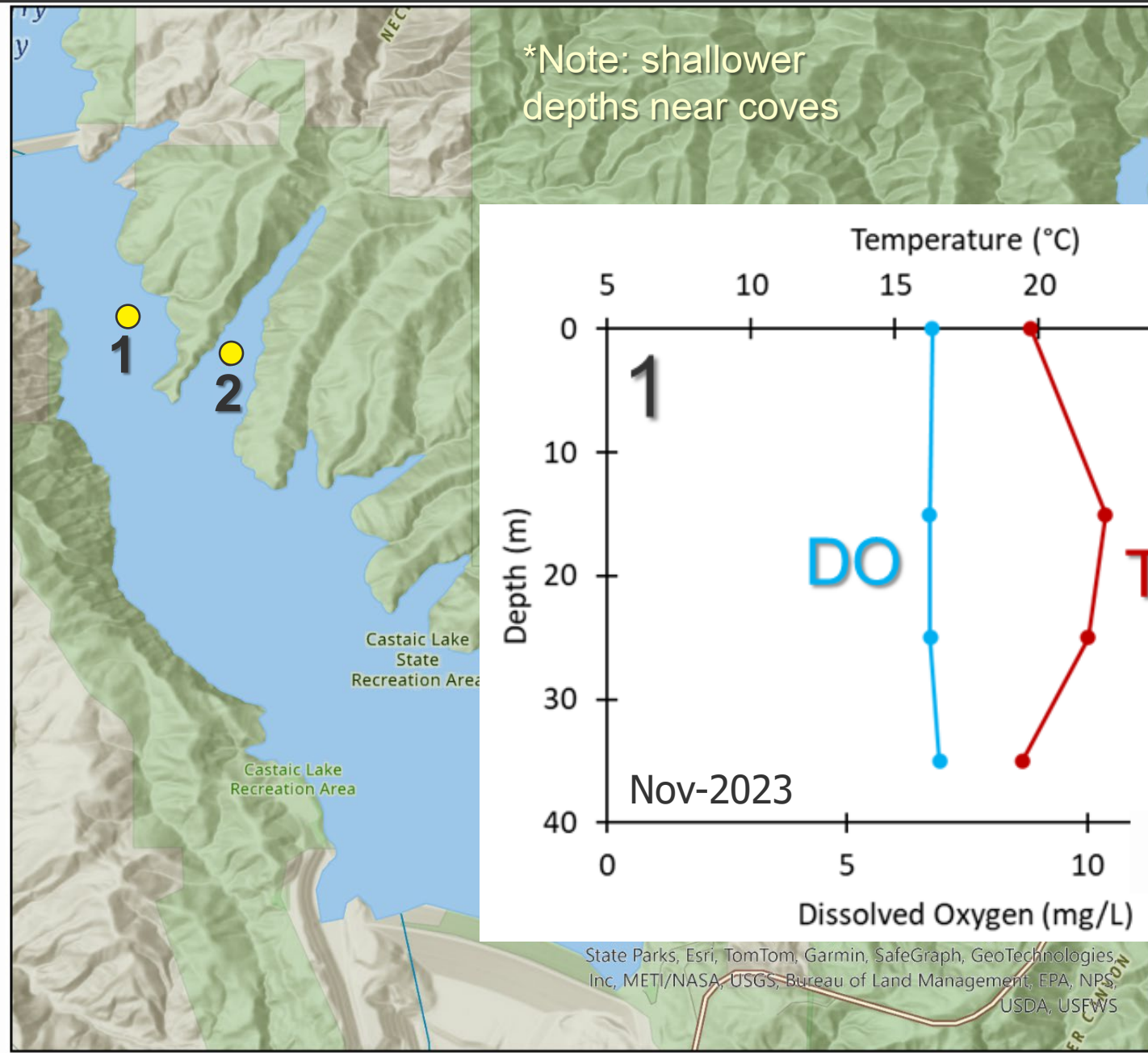


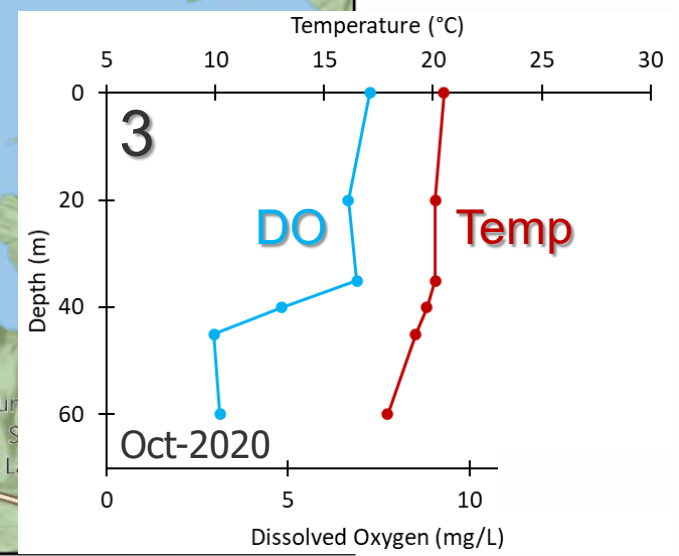
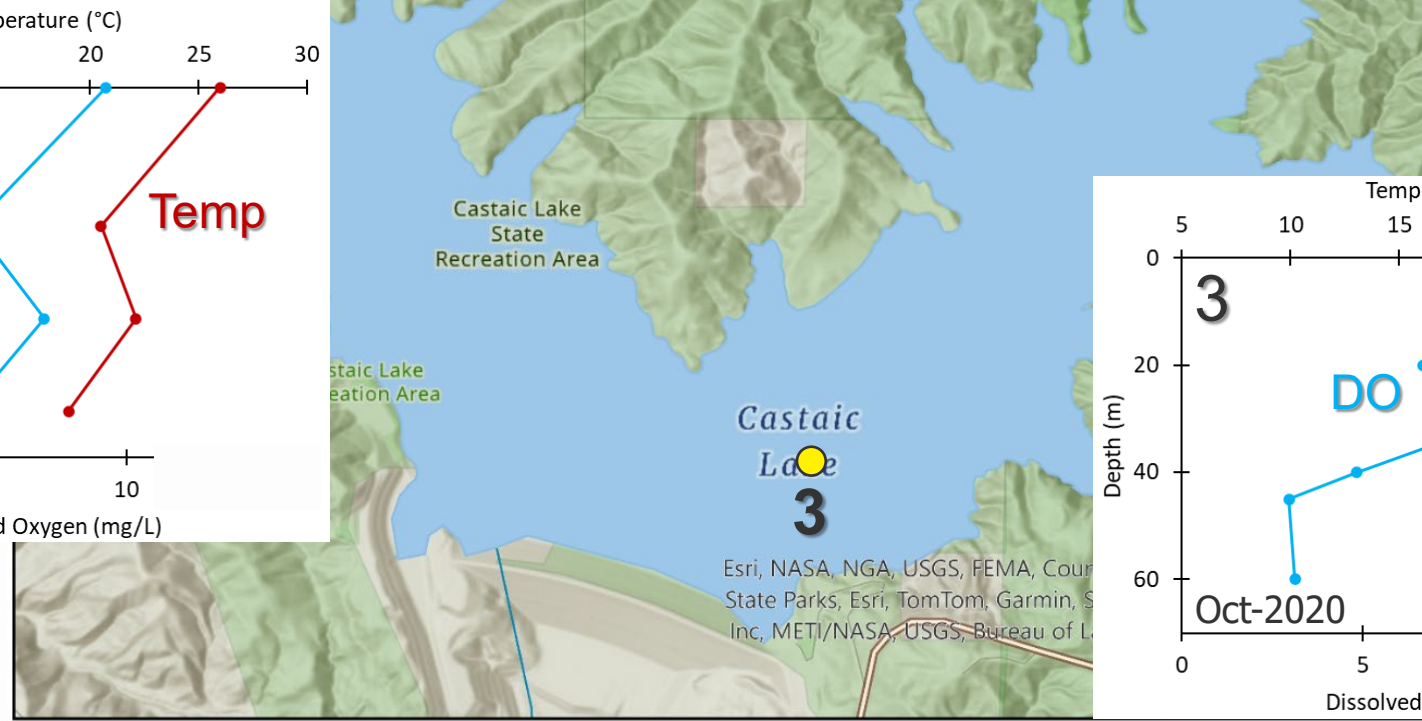
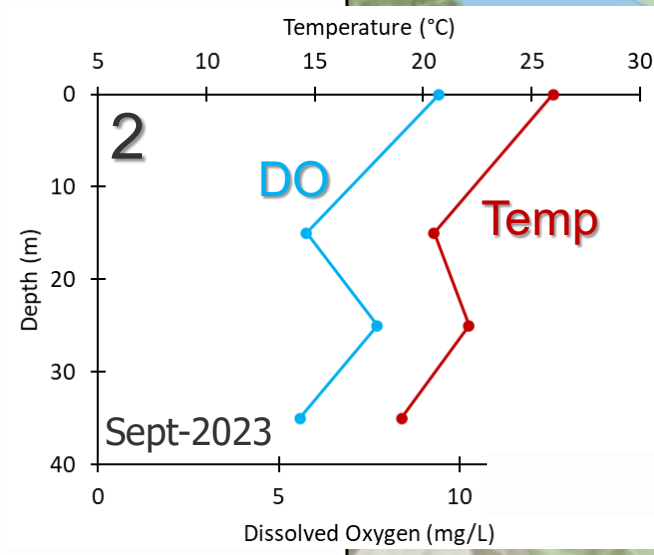
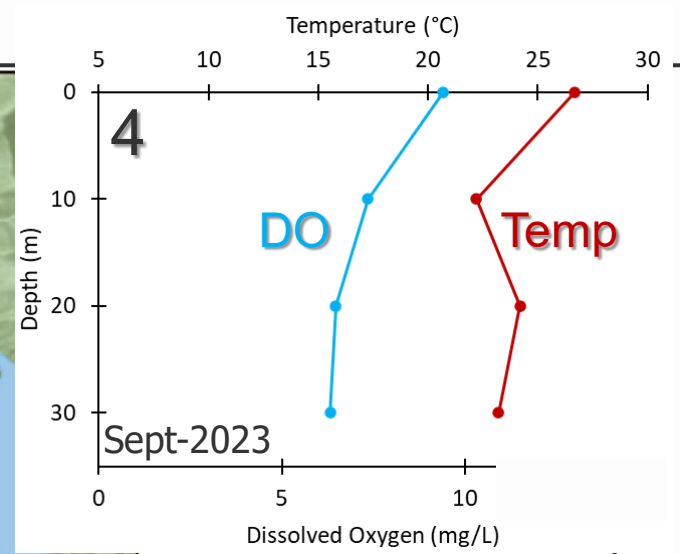
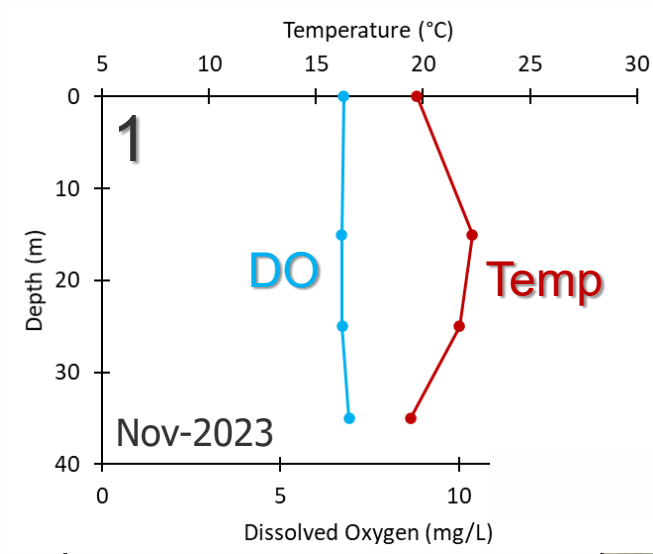
Redox State Can Affect Metal-Particle Interactions

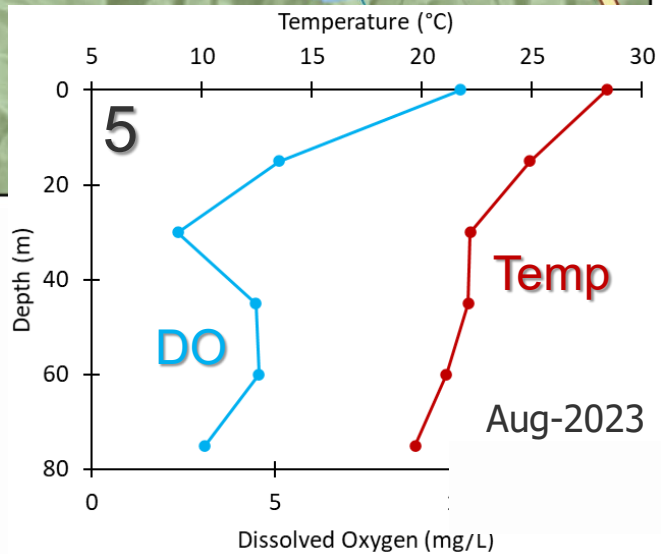
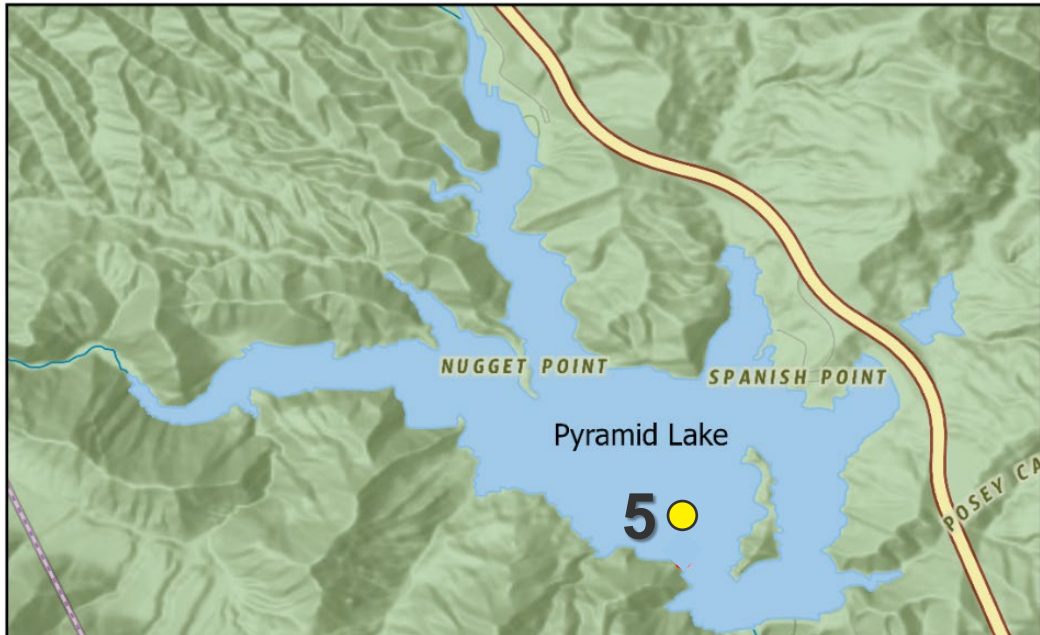
- Changes in redox state can affect the sorption and desorption of metals onto particles in water and sediment



- Following slides include several depth profiles
- Temp (red) on top x-axis
- DO (blue) on bottom x-axis
- Temp & DO scales do not change
- Depth (y-axis) shallower near coves





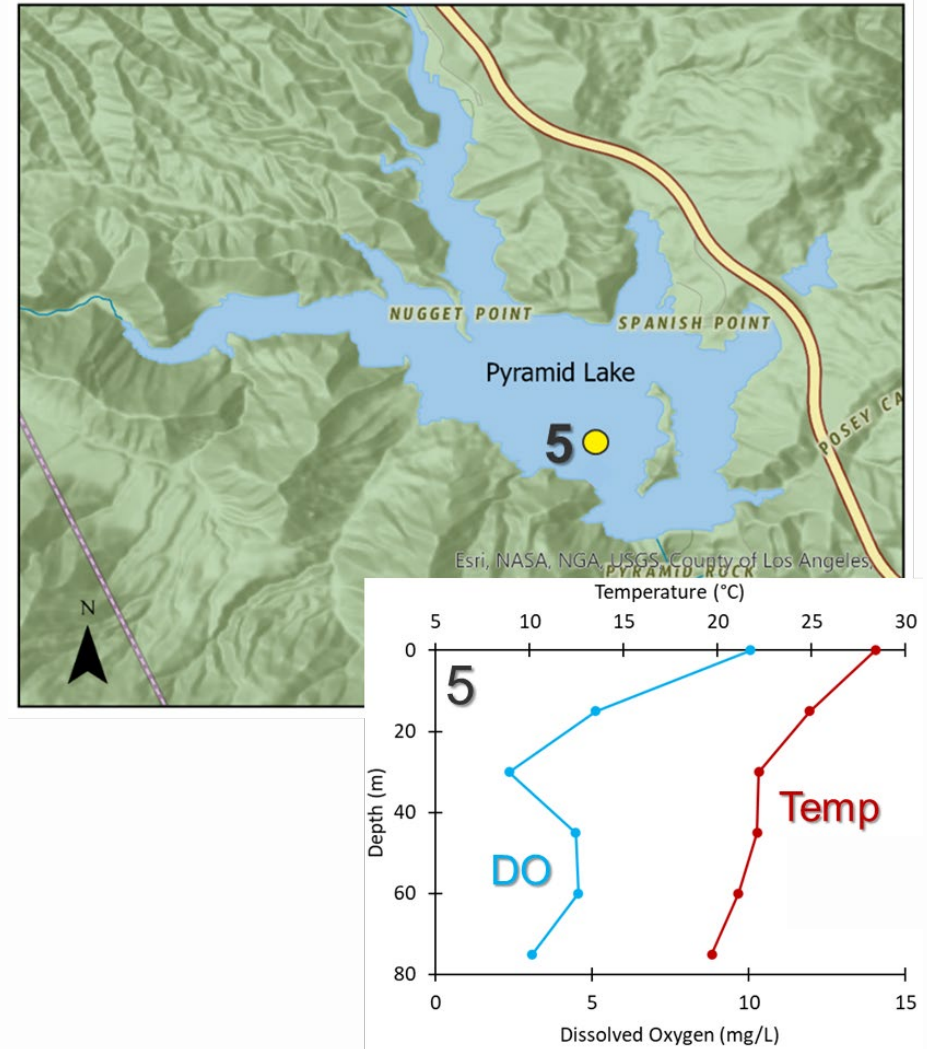
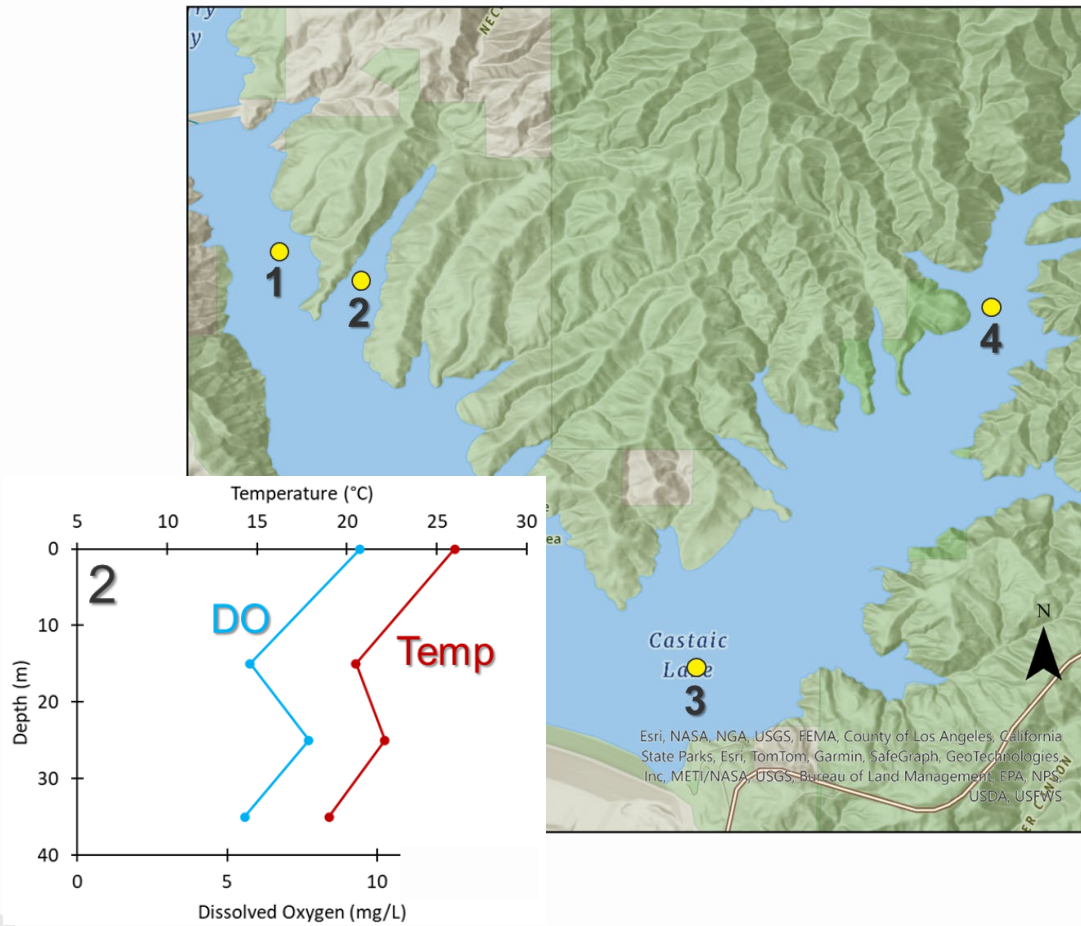


We did not capture extreme stratification

- Temp ranged from ~18 – 28°C
- Surface water DO ~10 mg/L
 - near coves: >5 mg/L (<40 m)
 - near thalweg: ~3 mg/L (65 – 75 m)
- Timing of sampling?
- Pump station & dam releases may induce mixing?



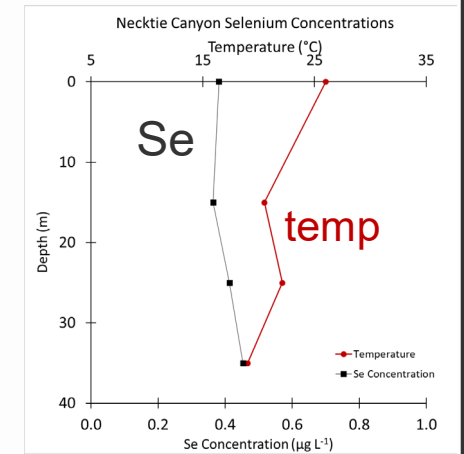
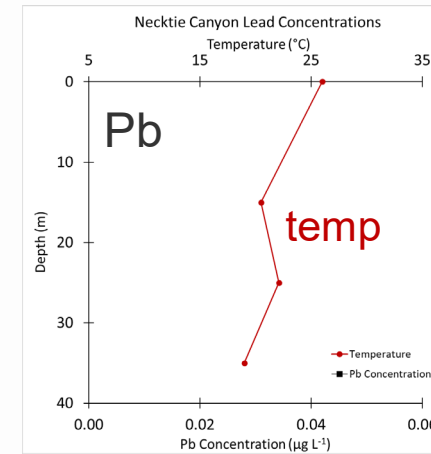
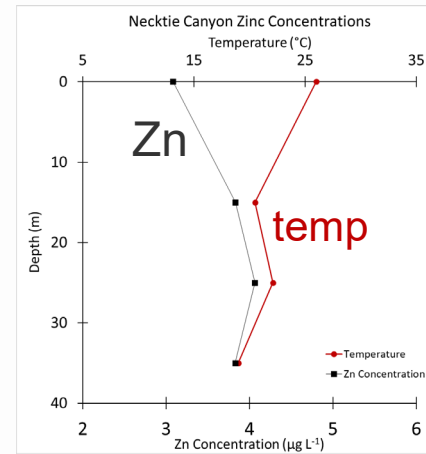
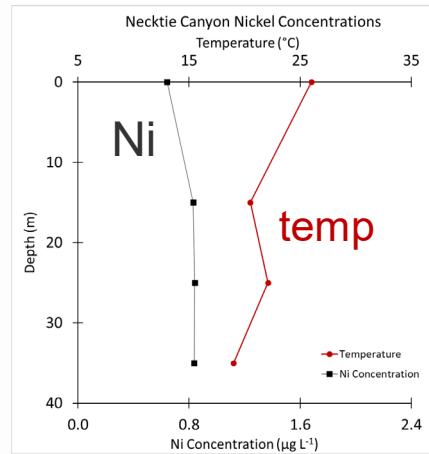
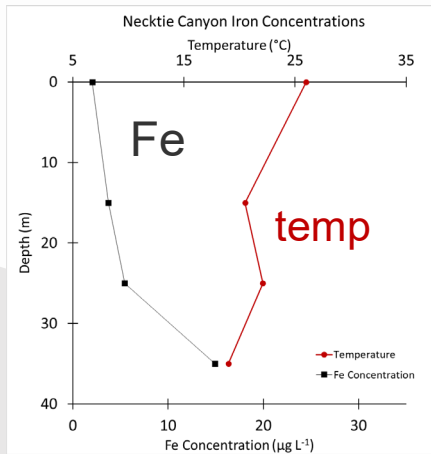
Will focus on Necktie Canyon (Site 2) in Castaic Lake and Pyramid Lake (Site 5)



Necktie Canyon

09/14/2023

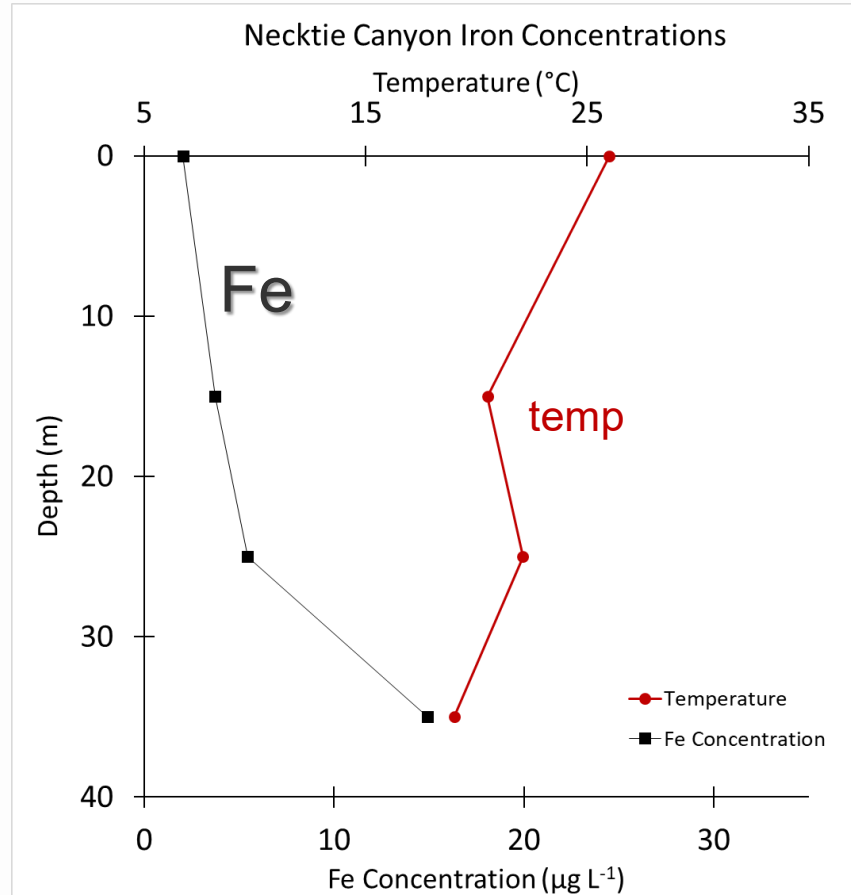
- Filtered (<0.22 μm) samples (unfiltered pending)
- Subset of metals analyzed



Necktie Canyon

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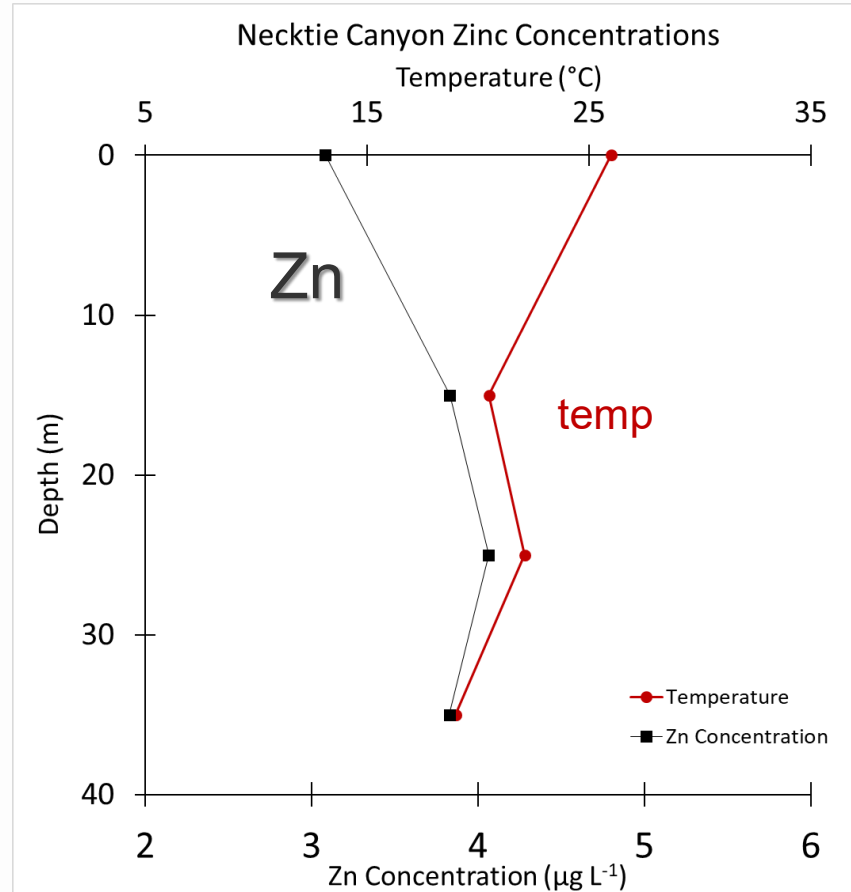
- Filtered (<0.22 μm) samples (unfiltered pending)
- Filtered Fe increases at depth
- Suggests transition from insoluble Fe^{3+} to soluble Fe^{2+}



Necktie Canyon

09/14/2023

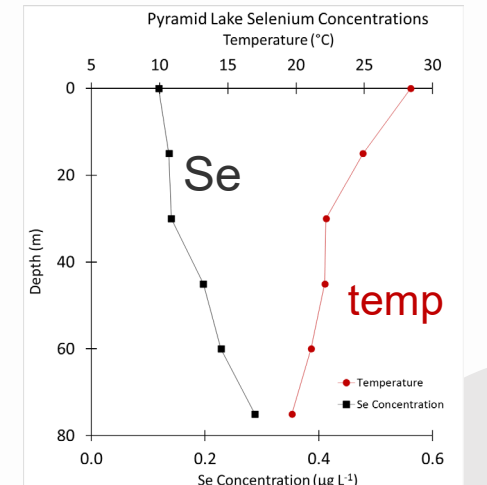
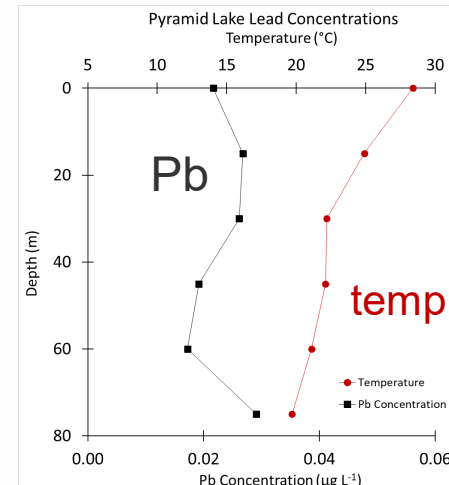
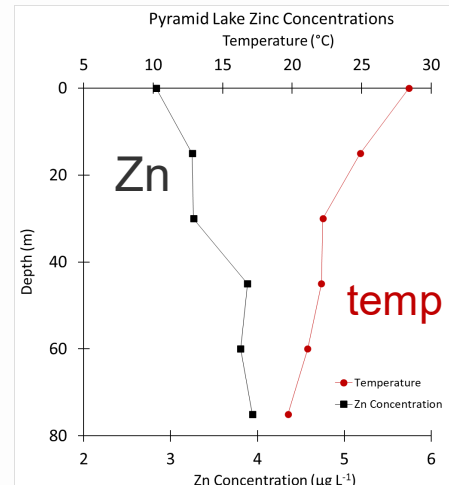
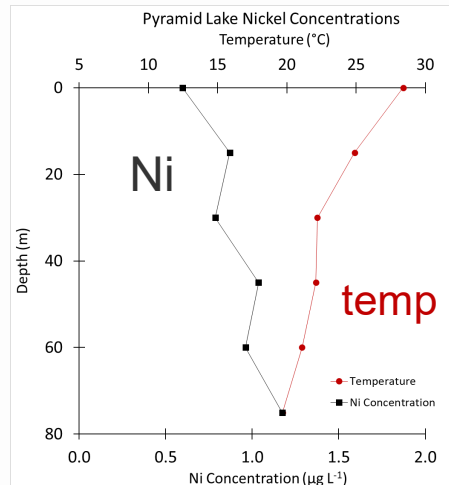
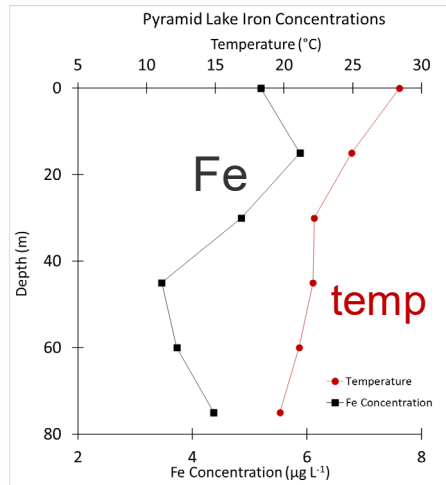
- Filtered (<0.22 μm) samples (unfiltered pending)
- Slight increase in filtered Zn
 - $\sim 2 \mu\text{g/L}$ at surface
 - $\sim 4 \mu\text{g/L}$ at depth
- Desorption from particles?
 - ...but low SPM
 - unfiltered data will help resolve this question



Pyramid Lake

08/16/2023

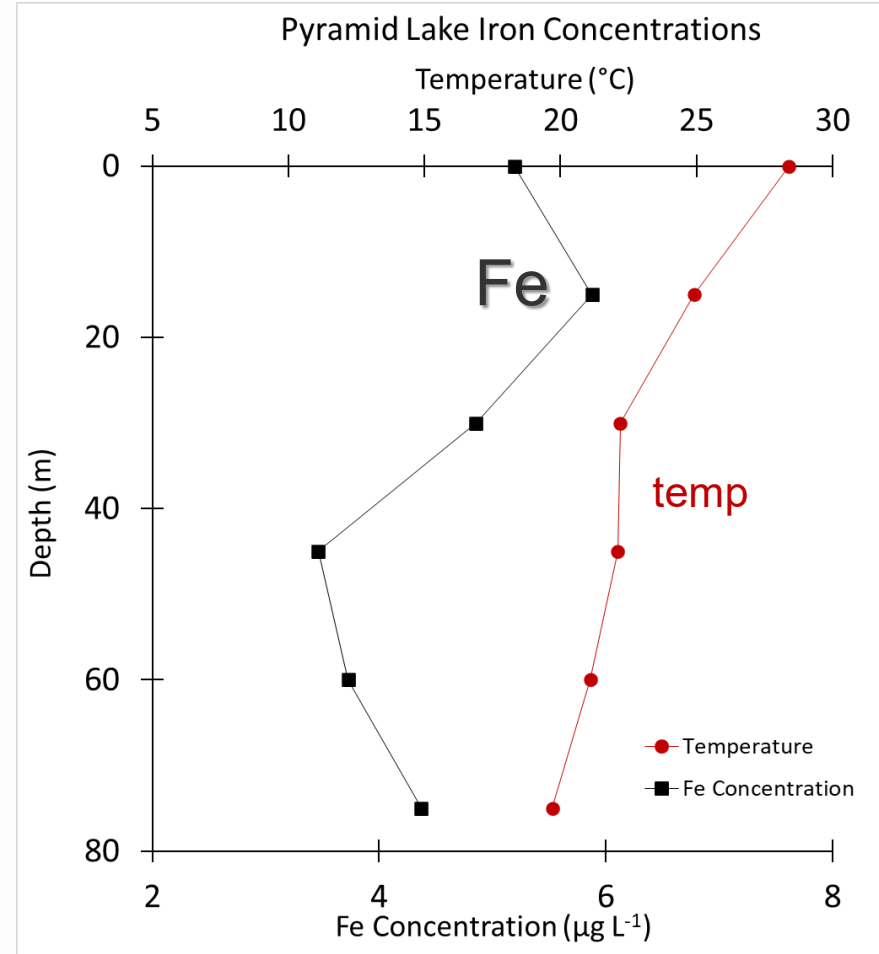
- Filtered (<0.22 μm) samples (unfiltered pending)



Pyramid Lake

08/16/2023

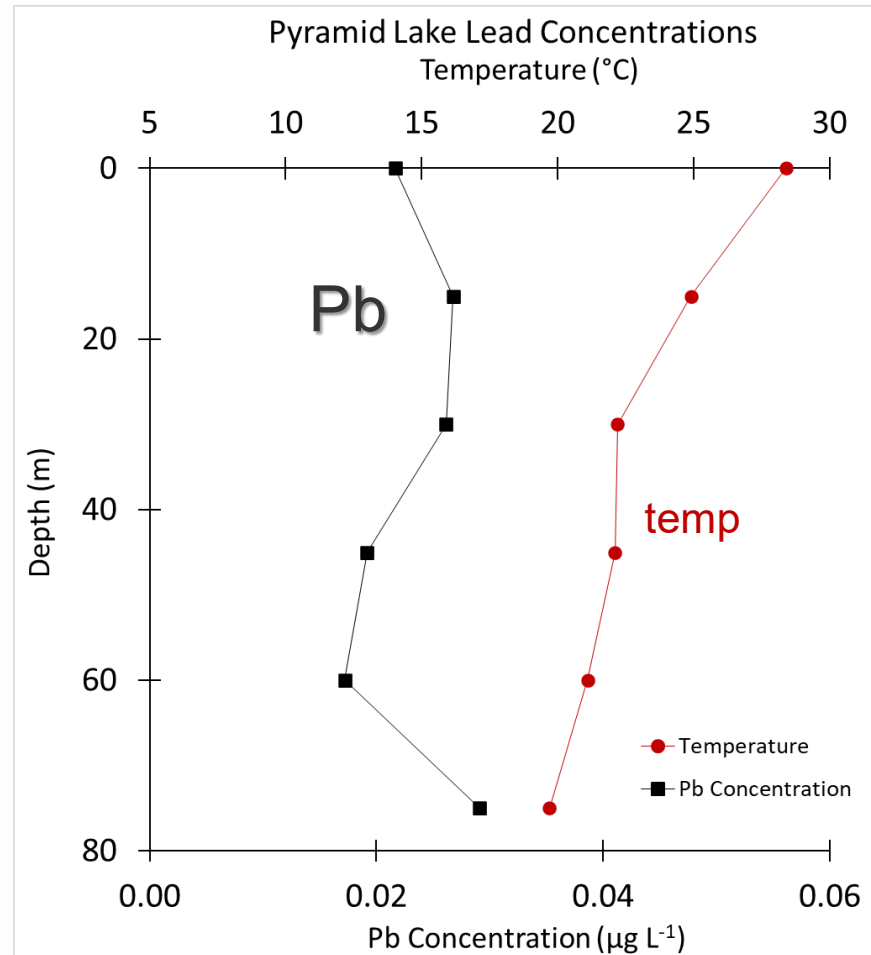
- Filtered (<0.22 μm) samples (unfiltered pending)
- Fe concentrations variable with depth
- Variability in water density may affect rate of particle sinking



Pyramid Lake

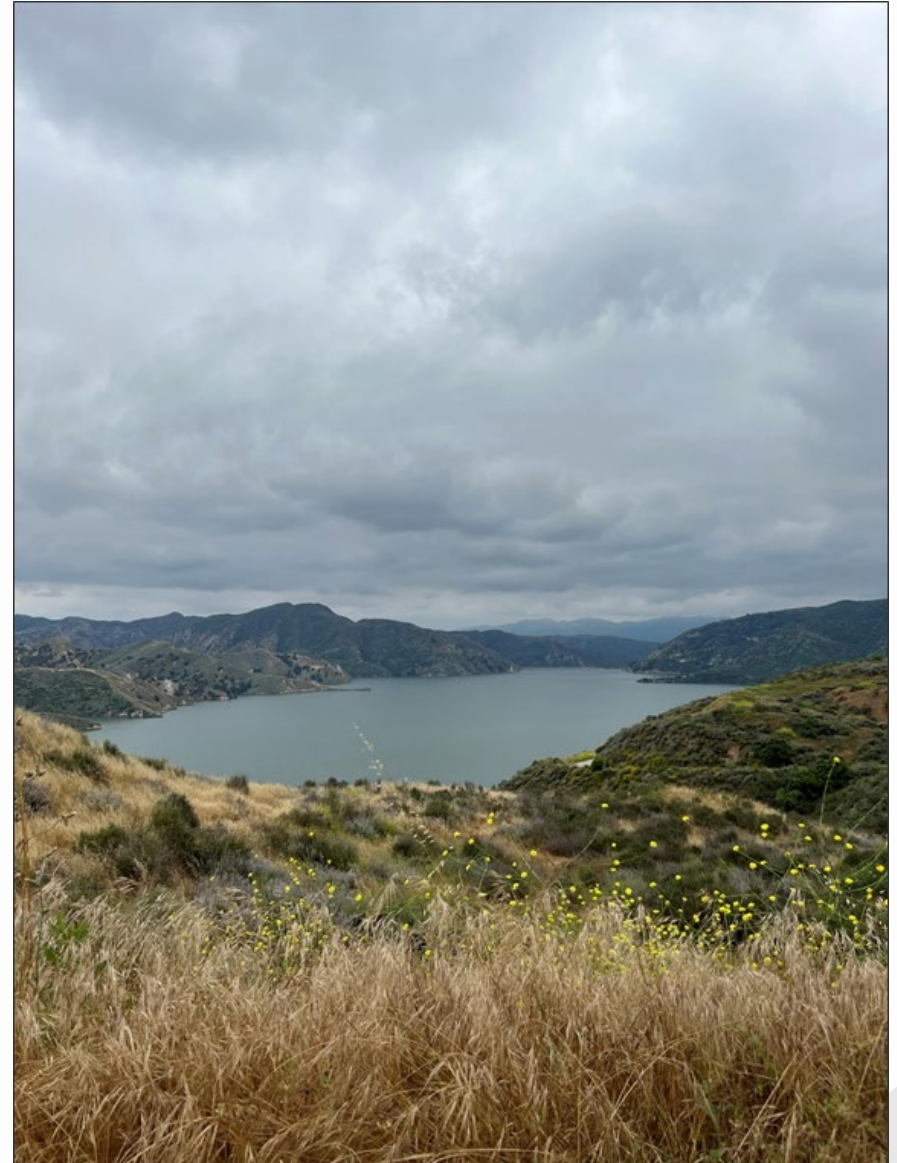
08/16/2023

- Filtered (<0.22 μm) samples (unfiltered pending)
- Pb detected in Pyramid, but at low concentrations (<0.04 $\mu\text{g/L}$)



Conclusions

- Filtered metal concentrations below drinking water standards
- Unfiltered sample data will provide additional insights
- Need to capture more intense stratification to test hypothesis
 - Timing of sampling
 - Mixing may be induced by reservoir water exchange
 - May need to sample additional reservoirs



References

- Fuhrmann, B., Beutel, M., Ganguli, P., Zhao, L., Brower, S., Funk, A., and Pasek, J., 2021, Seasonal patterns of methylmercury production, release, and degradation in profundal sediment of a hypereutrophic reservoir: *Lake and reservoir management*, v. 37, p. 360–377, doi:10.1080/10402381.2021.1940397.
- Jesmok, G.S.; Hauswirth, S.C.; Ganguli, P.M., 2020. Mercury Dynamics in Castaic Lake State Recreation Area, California, California Lake Management Society Annual Conference (Virtual). (oral)
- Memet, V., 2020, Environmental, ecological and health risks of trace metals in sediments of a large reservoir on the Euphrates River (Turkey): *Environmental research*, v. 187, p. 109664, doi:10.1016/j.envres.2020.109664.
- Murphy, S.F., McCleskey, R.B., Martin, D.A., Holloway, J.M., and Writer, J.H., 2020, Wildfire-driven changes in hydrology mobilize arsenic and metals from legacy mine waste: *The Science of the total environment*, v. 743, p. 140635, doi:10.1016/j.scitotenv.2020.140635.
- Wells, M. G., & Troy, C. D. (2022). Surface Mixed Layers in Lakes. In *Encyclopedia of Inland Waters* (pp. 546–561). Elsevier. <https://doi.org/10.1016/B978-0-12-819166-8.00126-2>
- Zhang, C., Yu, Z.-G., Zeng, G.-M., Jiang, M., Yang, Z.-Z., Cui, F., Zhu, M.-Y., Shen, L.-Q., and Hu, L., 2014, Effects of sediment geochemical properties on heavy metal bioavailability: *Environment international*, v. 73, p. 270–281, doi:10.1016/j.envint.2014.08.010.

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