Mercury and Methyl Mercury in California Fish, Water, and Sediment: the Importance of Ecosystem Factors

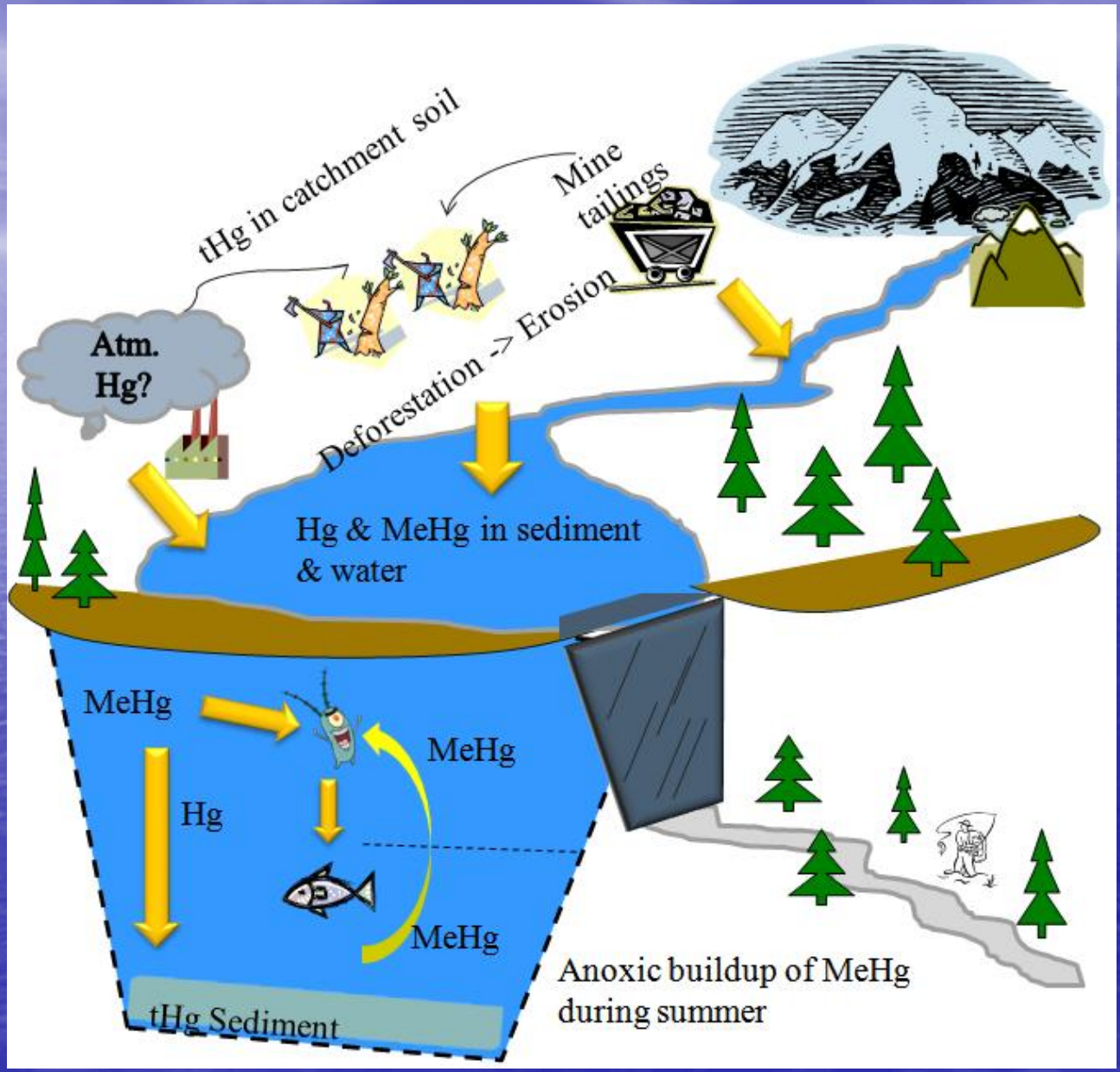
Mark Stephenson
John Negrey
Aroon Melwani
Jay Davis
CA Department of Fish & Game
Moss Landing Marine Laboratories
SFEI

BAF Study

- Was funded by SWRCB for $200K
- This study was an addition to BOG studies
- We were directed to spread effort throughout state
- We relied on volunteer help from RBs for collections for the most part
- RB 5 co funded this project

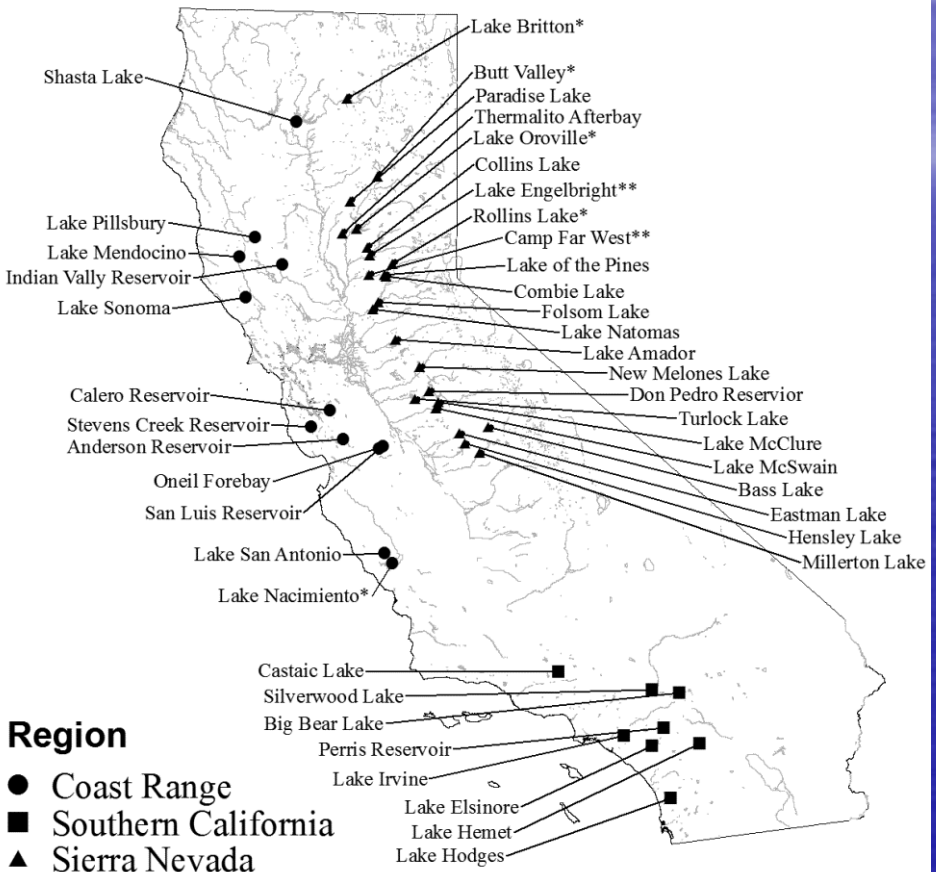
What drives MM in fish in lakes?

- Hypothesis 1: MM comes in from tributaries—upstream processes
- Hypothesis 2: MM is produced within the lake by within lake processes
  - Hg, oxygen levels, nutrients, SO4, wetting and drying from water drawdowns, organics in sediments, etc.

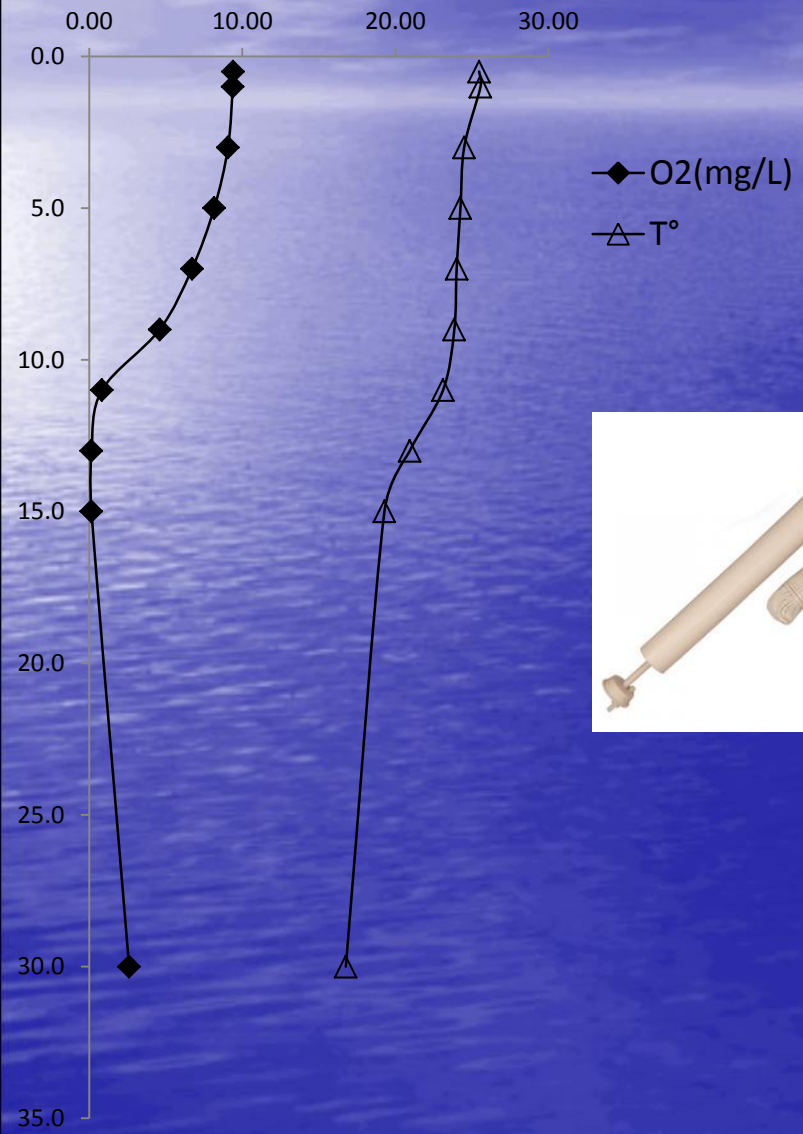

tHg in catchment soil
Mine tailings
Atm. Hg?
Deforestation -> Erosion
Hg & MeHg in sediment & water
MeHg
Hg
MeHg
MeHg
tHg Sediment
Anoxic buildup of MeHg during summer

Objectives

- Characterize aqueous methyl and total mercury concentrations in CA lakes that had BOG Hg data in LMB
- Collect ancillary data (Chlorophylla, Oxygen, DOC, SO4, pH, total Hg in sediment, etc.)
- Examine correlations between fish tissue and ancillary parameters


Lake Britton*
Shasta Lake
Butt Valley*
Paradise Lake
Thermalito Afterbay
Lake Oroville*
Collins Lake
Lake Engelbright**
Rollins Lake*
Lake Pillsbury
Camp Far West**
Lake Mendocino
Lake of the Pines
Indian Vally Reservoir
Combie Lake
Lake Sonoma
Folsom Lake
Lake Natomas
Lake Amador
New Melones Lake
Calero Reservoir
Don Pedro Reservior
Stevens Creek Reservoir
Turlock Lake
Anderson Reservoir
Lake McClure
Lake McSwain
Oneil Forebay
Bass Lake
San Luis Reservoir
Eastman Lake
Hensley Lake
Lake San Antonio
Millerton Lake
Lake Nacimiento*
Castaic Lake
Silverwood Lake
Big Bear Lake
Perris Reservoir
Lake Irvine
Lake Elsinore
Lake Hemet
Lake Hodges
Region
Coast Range
Southern California
Sierra Nevada

Sample Collection

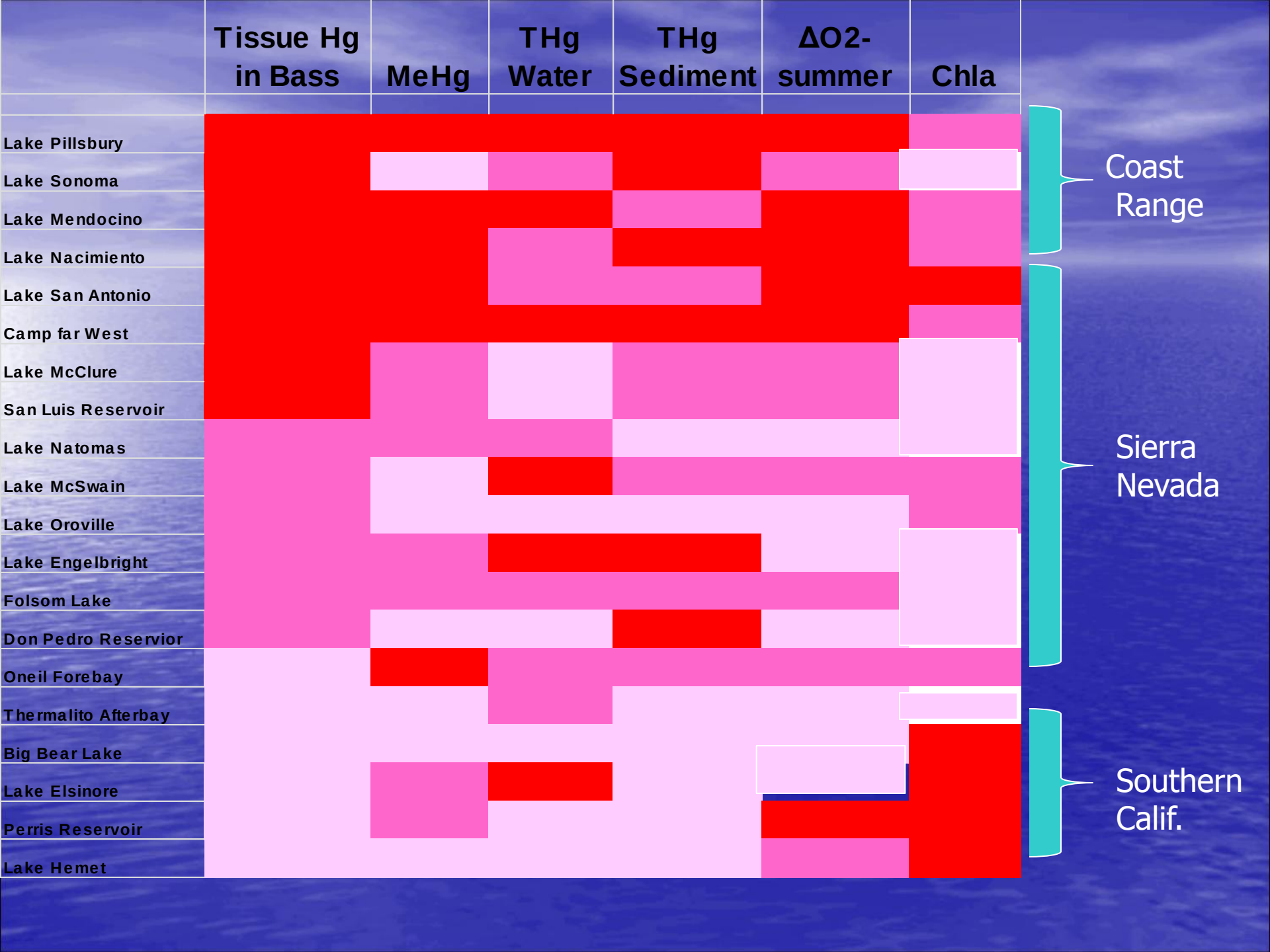


- Temperature, conductivity, pH, & dissolved oxygen were measured at 1-3m intervals throughout water column.
- Epilimnion (Near Surface)
  - Water
    - TMMHg, CHLa, DOC, SO4
- Hypolimnion (Below Thermocline)
  - Water
    - TMMHg
- Sediment collected once at each lake.
- Total Mercury water collected twice (1 winter/ 1 summer)

RESULTS

Correlations with Large Mouth Bass

- THg Sediment *0.55
- tHg in catchment *0.74
- tHg Water 0.53
- MeHg in Water (Summer) 0.39
- Chlorophyll a -0.49


Tissue Hg in Bass
MeHg
THg Water
THg Sediment
ΔO2-summer
Chla
Lake Pillsbury
Lake Sonoma
Lake Mendocino
Lake Nacimiento
Lake San Antonio
Camp far West
Lake McClure
San Luis Reservoir
Lake Natomas
Lake McSwain
Lake Oroville
Lake Engelbright
Folsom Lake
Don Pedro Reservior
Oneil Forebay
Thermalito Afterbay
Big Bear Lake
Lake Elsinore
Perris Reservoir
Lake Hemet
Coast Range
Sierra Nevada
Southern Calif.

Potential BMPS

- Add Nutrients
- Destratify Lake with Bubblers or Pumps
  - Lakes with high MM in LMB that Stratify are identified in Report
  - Need Mass Balance Studies
- Control upstream Mine MM + TM sources

Nutrient MeHg Interactions

- In this study we showed Chlorophyll explained 49% of variation in Hg in Large Mouth Bass
- Similar correlations have also been shown in Florida and New York
- Chris Foe has since used an expanded data set to show MeHg to Chlorophyll ratios explain 70 to 80 percent of variance in Hg in Large Mouth Bass

Nutrient MeHg interactions

- Methyl mercury concentrations in phytoplankton can be up to a million times higher on a weight basis than the concentration in water
- In laboratory studies Pickart has showed zooplankton bioaccumulation of Hg was negatively affected by amount of phytoplankton

Nutrient MeHg Interactions

- Studies in New York and Wisconson showed spikes with NO3 caused Hg in Fish to decrease—this may work in California

Nutrient MeHg Interactions

- Driscoll, Gilmour and others on the East Coast of the US have recently published a paper warning that lowering the nutrient concentrations in the rivers as EPA is advocating may cause an increase in Hg Fish Tissue Concentration
- Current EPA and waterboard policies of lowering nutrients in California may have unintended consequences of raising levels of Hg in fish tissue

Atmospheric Hg is going down in the US

- Dave Krabbenhoft-reasons are not clear
- We have no way to monitor it without fish studies
- Need long term trend stations
- Perhaps 10 stations/year

Conclusions

- Several factors may explain LMB Hg
  - Total Hg in sediments
    - May be a indicator of runoff into lake
    - May indicate within lake production
  - Aqueous MeHg and THg
  - Chla
    - Chlorophyll negatively correlated
    - May be only way to lower Hg in Fish in Sierra Lakes
  - Oxygen

Conclusion

- This study in conjunction with BOG has stimulated other studies and has helped formulate new hypotheses to be tested