

Incorporating Wildlife Mercury Exposure and Risk Estimates using Bioaccumulation Factors (BAF) into BOG California Lake Monitoring

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Introduction

The beneficial uses of numerous water bodies in California are listed under the Clean Water Act as impaired by mercury contamination. As a result of those listings, the Regional Water Quality Control Boards have been developing total maximum daily load limits (TMDLs) for affected water bodies and have included fish tissue methyl mercury objectives designed to protect humans and wildlife. Thus far, only a handful of impaired water bodies have mercury TMDLs. To meet the requirements of the Clean Water Act and to facilitate the development of TMDLs, the State Water Resources Control Board is now developing statewide methyl mercury fish tissue objectives.

The Surface Water Ambient Monitoring Program (SWAMP) via the Bioaccumulation Oversight Group (BOG) has recently completed state-wide surveys of contaminants in sport fish tissue from over 250 lakes in California and throughout coastal waters. However, this impressive effort only focused on human health issues. Because many fish-eating wildlife such as grebes, terns, cormorants, and mergansers eat fish smaller than those that were sampled by BOG, and since fish mercury concentrations are not always indicative of wildlife exposure to mercury, the current BOG surveys do not address whether wildlife beneficial uses may be impaired by mercury in these water bodies.

We are proposing the first step in developing a useful tool for methyl mercury TMDL implementation and wildlife risk determination, specifically calculating bioaccumulation factors (BAFs) for determining mercury concentrations in wildlife from fish. When properly derived, BAFs are valuable because they provide managers and regulators with a quantitative tool to estimate mercury concentrations across environmental matrices, thus enabling them to adequately estimate wildlife exposure without the need for comprehensive sampling at all sites of interest.

Herein, we will develop a coefficient for translating small fish mercury concentrations to avian mercury concentrations, and evaluate whether this coefficient is representative across lakes or differs by lake type or geographic region. Additionally, we will evaluate the risk of mercury exposure to wildlife by comparing measured mercury concentrations in key tissues with effects-thresholds that have been previously developed. Thus, by combining the BAF metrics we

develop among lakes, with known impairment thresholds, we will evaluate and develop a tool that will allow managers to determine risk to wildlife taxa through monitoring fish mercury concentrations.

We present two proposal options. The first option is a 1-year study which samples only 12 lakes. The second option is for a 2-year study which doubles the number of lakes sampled (24 lakes) and increases the coverage into Southern California. We present separate budgets, timelines, and maps for each proposal, however for simplicity we detail the 2-year proposal in the *Objectives* and *Methods* section and put in parenthesis the sample sizes under the 1-year study option.

Objectives

Over two consecutive field seasons in 2012 and 2013, we will sample birds and small fish simultaneously at 24 lakes (*12 lakes for 1-year option*) throughout California during the breeding season when birds are particularly vulnerable to potential mercury-induced reproductive impairment. Using these data, we will then estimate BAFs for wildlife. In developing these BAFs, we will address whether BAFs are appropriate indicators of potential wildlife exposure to mercury, and, if so, whether a state-wide BAF is appropriate or if more refined BAFs are needed that incorporate the type of water body or geographic region.

Specifically, we have three main objectives:

- 1) Sample grebes at 24 California lakes (*12 lakes for 1-year option*) to determine mercury levels in a species at the top of the food chain, and compare these data to known effects thresholds for birds.
- 2) Simultaneously with grebe sampling, collect small fish (<100 mm) at these same 24 lakes (*12 lakes for 1-year option*) to determine if mercury concentrations are above current wildlife diet objectives.
- 3) Use these data in Objectives 1 and 2 to calculate wildlife BAFs, evaluate BAFs usefulness for estimating wildlife exposure, and assess whether BAFs differ by lake type or geographic region.

Methods

We will use western and Clark's grebes (*Aechmophorus spp.*) as our index of mercury exposure to wildlife in California lakes. As piscivorous waterbirds, Grebes are among the animals at the top of the food chains in lakes, and are widely distributed in lakes throughout California. Additionally, grebes become flightless after they arrive at their summer breeding locations. Thus, grebes are ideal representatives for wildlife risk to local, lake-specific contaminant exposure. Grebes also breed at many lakes throughout California (**Figures 1 & 2**), making them susceptible to potential impaired reproduction due to local contamination.

We will sample grebe blood (and eggs where possible) from 24 California lakes (*12 lakes for 1-year option*) during 2012 and 2013. **Figure 2** (and **Figure 1** for the 1-year option) shows the proposed primary and alternate lake sites which will be investigated further and the final 24 lakes (*12 lakes for 1-year option*; **Figure 1**) will be chosen after scouting lakes in the field. We selected lakes based on (1) prior BOG sampling, (2) whether or not the lake was a potential

long-term BOG sampling site, (3) whether grebes breed on the lake, and (4) the relative mercury concentrations in sport fish sampled by BOG in 2007-2011. We will sample up to 12 lakes each year and conduct the field research over a 2-year period so that we can travel to all 24 lakes and sample grebes and fish during a narrow time window in late summer. Grebes will be captured using a combination of dip nets, net guns, gill nets, and shotguns. Grebe eggs also will be sampled when possible, and we will collect 1 egg randomly from each nest (up to 15 nests per lake). Grebes will be sampled from June to October.

Simultaneously, small fish (<100 mm) will be sampled using traps, seines, and dip nets from areas near grebe collections. We will sample 10 individuals each from two different prey fish species from each lake. Efforts will be made to sample the same species across all lakes, and when not possible we will sample fish that overlap in trophic guild. Fish will be sampled within two weeks of grebe sampling.

We will determine mercury concentrations in avian tissues at the USGS Davis and Corvallis Environmental Mercury Labs, and in fish at the Moss Land Marine Lab following EPA method 7473. Specifically, using an integrated sequence of sample drying and combustion, coupled with amalgamation and atomic absorption spectroscopy, we will evaluate mercury concentrations in avian and fish tissues in relation to established reference standards.

Timeline

Proposal Option 1: 12 lakes during 1 field season in 2012.

Field work for this project will be conducted in the summer (June-October) of 2012. Laboratory sample processing and mercury analysis will be conducted in winter and spring of 2012/2013. Data analysis and report writing will occur in spring and summer 2013. A final report will be delivered in October 2013.

Proposal Option 2: 24 lakes during 2 field seasons in 2012 and 2013.

Field work for this project will be conducted in the summers (June-October) of 2012 and 2013. Laboratory sample processing and mercury analysis will be conducted in winter and spring of 2012/2013 and 2013/2014. Data analysis and report writing will occur in spring and summer 2014. An update report after the first field season will be delivered in April 2013. A final report will be delivered in October 2014.

Coordination

This project will be led by four Principal Investigators. Josh Ackerman (USGS-WERC) and Collin Eagles-Smith (USGS-FRESC) will lead the bird sampling field work, bird mercury determination, and wildlife reporting. Mark Stephenson (Moss Landing) and Tom Maurer (USFWS) will lead the fish sampling field work, fish mercury determination, and fish reporting. Bird sampling will be conducted immediately before fish sampling, and then bird collection sampling location coordinates will be communicated to fish sampling personnel for subsequent sampling by the fish team within two weeks of bird sampling.

Budget

Proposal Option 1: 12 lakes during 1 field season in 2012.

The total cost to complete the 1-year project is \$299k, which includes added reporting costs in year-1 to that of the 2-year proposal option below. Funds will be spread over 2 calendar years in 2012 and 2013. Additionally, a match of approximately \$95k is provided by USGS, USFWS, and MLML to support project development, implementation, and interpretation. Salary rates include benefits.

1-YEAR PROJECT BUDGET				
	Year-1	Year-2	Total	In-Kind Total
Salary and Benefits				
Wildlife exposure determination	\$ 70,381	\$ -	\$ 70,381	\$ 38,374
Fish sampling	\$ 43,252	\$ -	\$ 43,252	\$ 5,000
Sample Processing and Mercury Determination				
Grebes (\$100 per sample [12 lakes/yr * 10 grebes/lake * 2 tissues])	\$ 24,000	\$ -	\$ 24,000	\$ -
Fish (\$100 per sample [12 lakes * 10 fish/lake * 2 species])	\$ 24,000	\$ -	\$ 24,000	\$ -
Supplies				
Field supplies, boat gas, equipment and maintenance	\$ 13,500	\$ -	\$ 13,500	\$ 17,250
Lab supplies & equipment	\$ 2,000	\$ -	\$ 2,000	\$ 2,000
Travel				
Per diem	\$ 14,220	\$ -	\$ 14,220	\$ -
Lodging	\$ 10,890	\$ -	\$ 10,890	\$ -
Vehicles	\$ 9,000	\$ -	\$ 9,000	\$ 1,000
Total Direct Costs	\$ 211,243	\$ -	\$ 211,243	\$ 63,624
Indirect Costs	\$ 88,319	\$ -	\$ 88,319	\$ 31,468
Total Costs	\$ 299,563	\$ -	\$ 299,563	\$ 95,092

Proposal Option 2: 24 lakes during 2 field seasons in 2012 and 2013.

The total cost to complete the 2-year project is \$596k, and funds will be spread over 3 calendar years from 2012 to 2014. Additionally, a significant match of approximately \$160k is provided by USGS, USFWS, and MLML in kind. Salary rates include benefits.

2-YEAR PROJECT BUDGET				
	Year-1	Year-2	Total	In-Kind Total
Salary and Benefits				
Wildlife exposure determination	\$ 64,424	\$ 76,679	\$ 141,103	\$ 76,748
Fish sampling	\$ 41,252	\$ 42,902	\$ 84,154	\$ 10,000
Sample Processing and Mercury Determination				
Grebes (\$100 per sample [12 lakes/yr * 10 grebes/lake * 2 tissues])	\$ 24,000	\$ 24,000	\$ 48,000	\$ -
Fish (\$100 per sample [12 lakes * 10 fish/lake * 2 species])	\$ 24,000	\$ 24,000	\$ 48,000	\$ -
Supplies				
Field supplies, boat gas, equipment and maintenance	\$ 13,500	\$ 13,500	\$ 27,000	\$ 17,250
Lab supplies & equipment	\$ 2,000	\$ 2,000	\$ 4,000	\$ 2,000
Travel				
Per diem	\$ 14,220	\$ 14,220	\$ 28,440	\$ -
Lodging	\$ 10,890	\$ 10,890	\$ 21,780	\$ -
Vehicles	\$ 9,000	\$ 9,000	\$ 18,000	\$ 1,000
Total Direct Costs	\$ 203,286	\$ 217,191	\$ 420,477	\$ 106,998
Indirect Costs	\$ 84,750	\$ 91,349	\$ 176,099	\$ 53,056
Total Costs	\$ 288,037	\$ 308,540	\$ 596,576	\$ 160,054

Figure 1. Proposal Option 1: 12 lakes during 1 field season in 2012.

Proposed lakes for sampling western grebe mercury concentrations and fish for calculating BAFs. Red-scale color palette sites are those lakes where grebes are known to have recently bred. Blue-scale color palette sites are those lakes where grebes are known to have bred historically. Green-scale color palette sites are those lakes where grebes occur in the summer but it is not known whether or not they breed. Darker colored sites indicate a long-term BOG site for sport fish trend monitoring. Stars indicate sites that have been previously sampled by BOG for sport fish. Circles indicate the 12 primary lakes selected, whereas squares indicate alternate lakes that will be used if grebes cannot be sampled at a primary lake. The relative size of the symbol indicates mercury concentrations in sport fish from BOG sampling during 2007-2011.

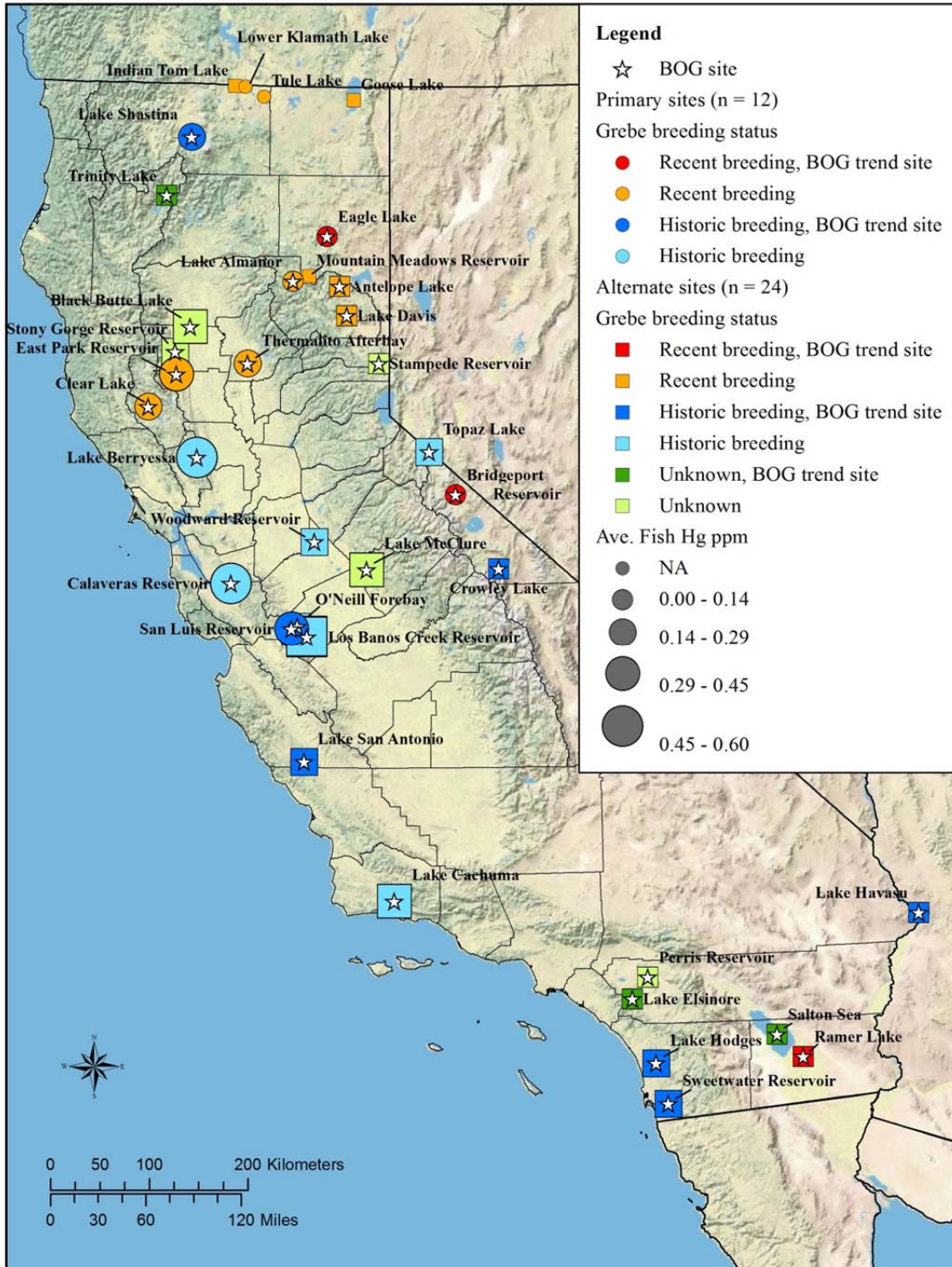


Figure 2. Proposal Option 2: 24 lakes during 2 field seasons in 2012 and 2013.

Proposed lakes for sampling western grebe mercury concentrations and fish for calculating BAFs. Red-scale color palette sites are those lakes where grebes are known to have recently bred. Blue-scale color palette sites are those lakes where grebes are known to have bred historically. Green-scale color palette sites are those lakes where grebes occur in the summer but it is not known whether or not they breed. Darker colored sites indicate a long-term BOG site for sport fish trend monitoring. Stars indicate sites that have been previously sampled by BOG for sport fish. Circles indicate the 24 primary lakes selected, whereas squares indicate alternate lakes that will be used if grebes cannot be sampled at a primary lake. The relative size of the symbol indicates mercury concentrations in sport fish from BOG sampling during 2007-2011.

