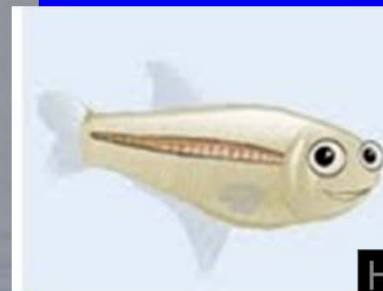


# Incorporating Wildlife Mercury Exposure and Risk Estimates using Biomagnification Factors into BOG California Lake Monitoring



Josh Ackerman<sup>1</sup>, Collin Eagles-Smith<sup>2</sup>, Alex Hartman<sup>1</sup>, Tom Maurer<sup>3</sup>, and Mark Stephenson<sup>4</sup>

<sup>1</sup>U.S. Geological Survey, Western Ecological Research Center, Davis Field Station, University of California-Davis, California

<sup>2</sup>U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon

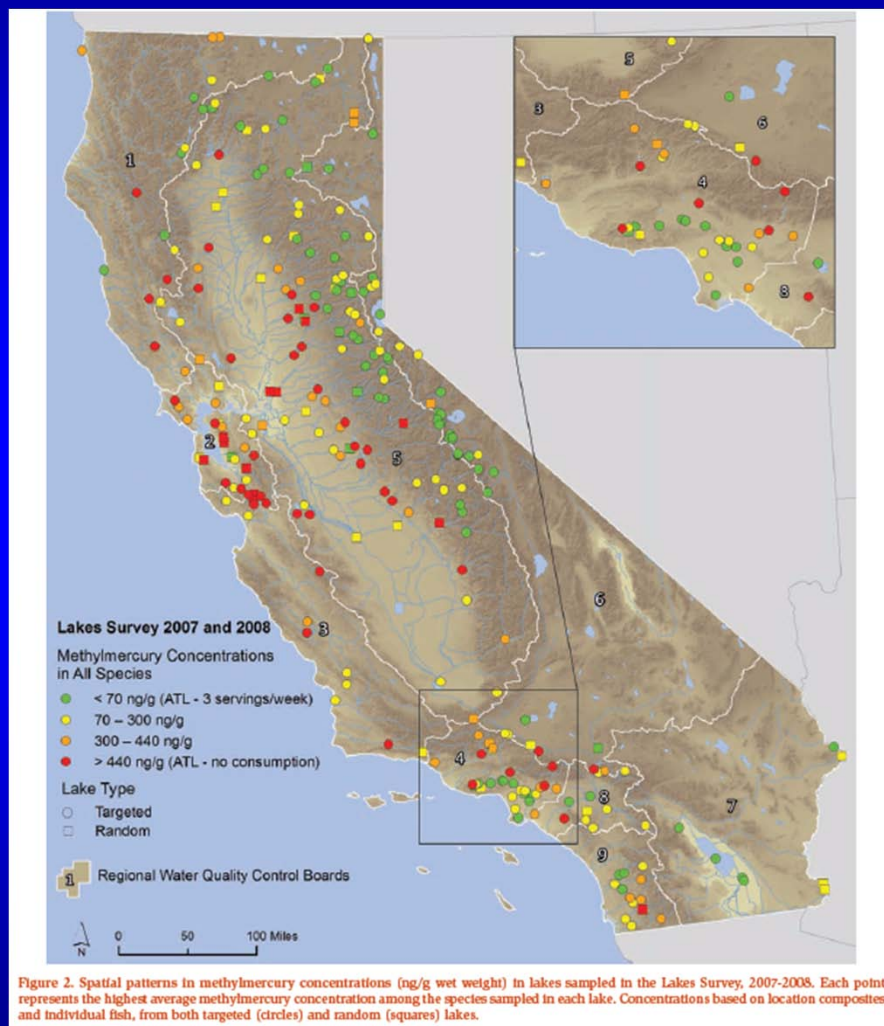
<sup>3</sup>U.S. Fish and Wildlife Service, Environmental Contaminants Program, Sacramento, California

<sup>4</sup>California Department of Fish and Game Moss Landing Marine Lab, Santa Cruz, California

(February 9, 2012)

# Bioaccumulation Oversight Group (BOG) for Surface Water Ambient Monitoring Program (SWAMP)

- Completed state-wide survey of contaminants in sport fish tissue from >250 lakes in California
- Focus on sport fish and human health
- Found widespread mercury contamination in lakes throughout California
- BOG data guiding TMDL implementation and criteria development to protect human health



Davis, J.A., A.R. Melwani, S.N. Bezalel, J.A. Hunt, G. Ichikawa, A. Bonnema, W.A. Heim, D. Crane, S. Swenson, C. Lamerdin, and M. Stephenson. 2010. Contaminants in Fish from California Lakes and Reservoirs, 2007-2008: Summary Report on a Two-Year Screening Survey. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

# Bioaccumulation Oversight Group (BOG) for Surface Water Ambient Monitoring Program (SWAMP)

- Yet risk to wildlife is not incorporated
- Wildlife considered a “beneficial use” in California lakes
- Will TMDL criteria for human health be protective of wildlife as well?
- How do we determine wildlife exposure across such a wide spatial extent?
- Logistically more difficult to sample wildlife than fish

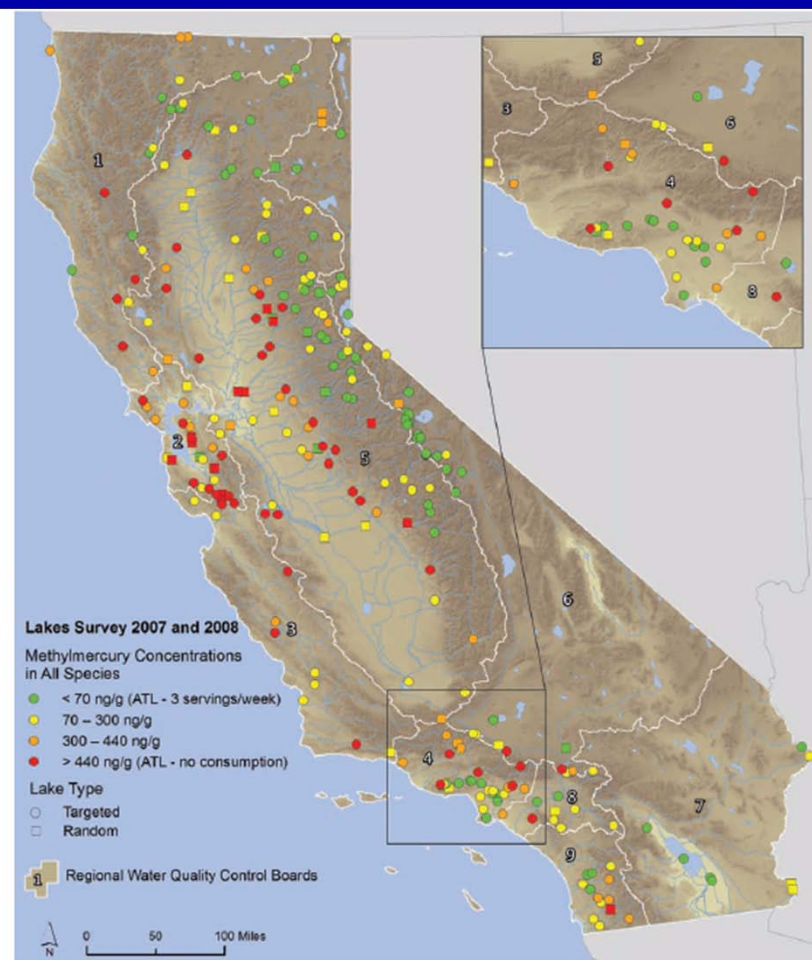
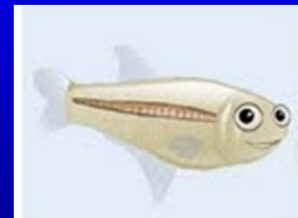


Figure 2. Spatial patterns in methylmercury concentrations (ng/g wet weight) in lakes sampled in the Lakes Survey, 2007-2008. Each point represents the highest average methylmercury concentration among the species sampled in each lake. Concentrations based on location composites and individual fish, from both targeted (circles) and random (squares) lakes.

# The Biomagnification Factor Approach

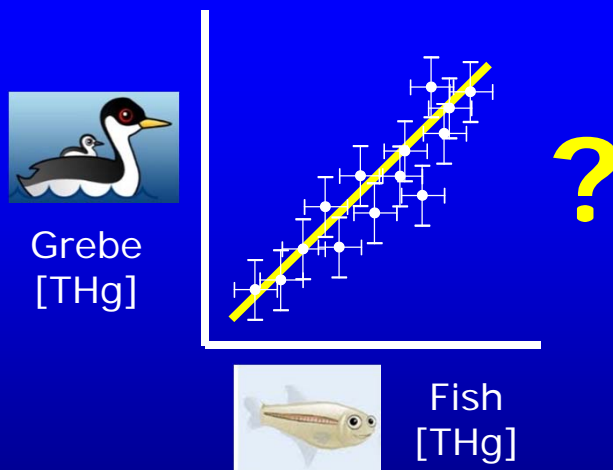
- Biomagnification factors can be used to estimate wildlife exposure from more easily sampled animals, like fish
- Biomagnification factors (BMF) will be calculated for each lake using the following formula:

$$BMF = \frac{\text{mean [THg] grebe blood } \frac{\mu\text{g}}{\text{g}}_{ww}}{\text{mean [THg] whole prey fish } \frac{\mu\text{g}}{\text{g}}_{ww}}$$



# Key Objective

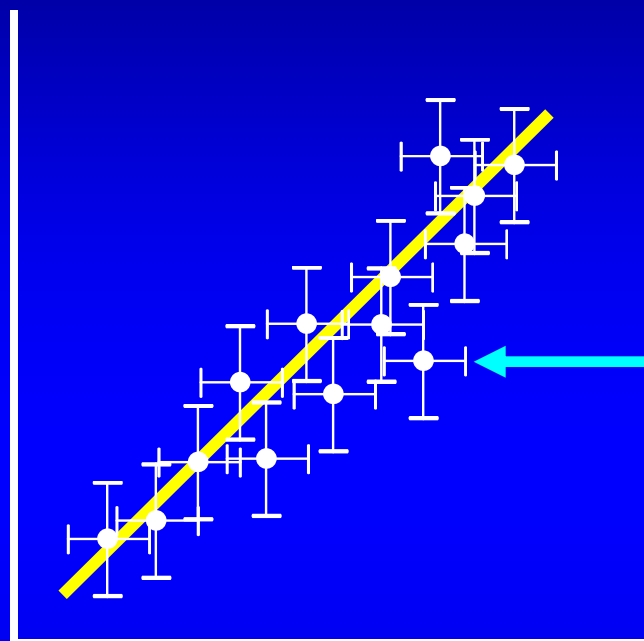
- Assess the applicability of the Biomagnification Factor approach to predicting wildlife exposure across CA lakes
- Is Hg exposure in grebes highly correlated with Hg concentrations in prey fish across the State?



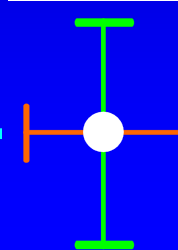
# Sample Sizes per Lake



Grebe Blood/Egg  
[THg]  $\mu\text{g/g ww}$

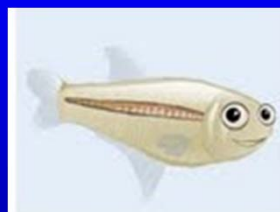


1 Lake



$Y = \text{Mean} \pm \text{SE of 20 grebe tissues}$

$X = \text{Mean} \pm \text{SE of 20 fish from 2 species}$



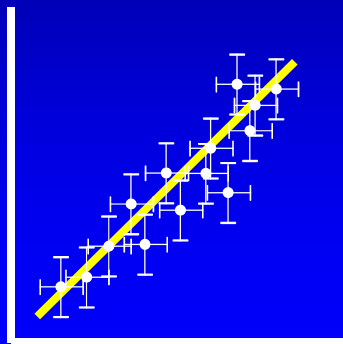
Whole Fish  
[THg]  $\mu\text{g/g ww}$

# Key Objective

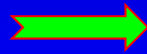
Is grebe Hg correlated with prey fish Hg?



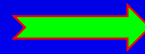
Grebe  
[THg]



Fish  
[THg]



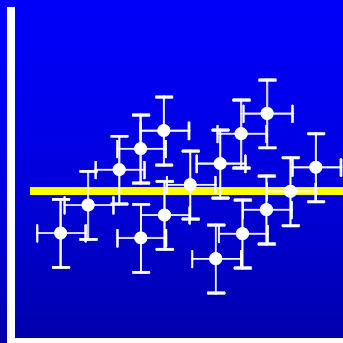
**IF  
YES**



Use BMF model to  
predict wildlife  
exposure across  
lakes



Grebe  
[THg]



Fish  
[THg]



**IF  
NO**



Evaluate  
relationships within  
environmental  
variables, like  
"region" or lake  
"type"

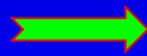
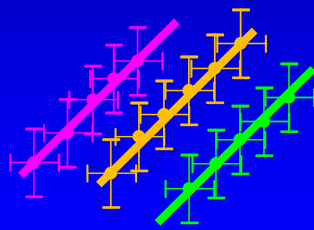


# Key Objective

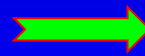
Is grebe Hg correlated with prey fish Hg?



Grebe  
[THg]



**IF  
YES**



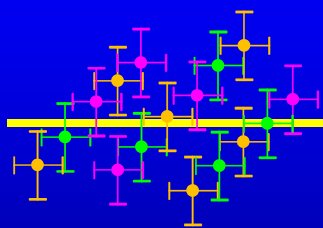
**Develop category-  
specific BMFs**



Fish  
[THg]



Grebe  
[THg]



**IF  
STILL  
NO**



**Wildlife exposure  
may not be  
effectively predicted  
using fish  
monitoring, and  
wildlife would need  
to be monitored  
directly. Suggest not  
using BMF approach.**



# Key Objective

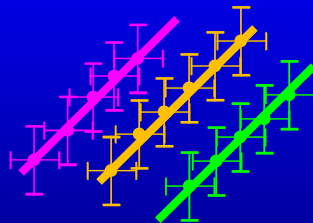
Is grebe Hg correlated with prey fish Hg?

## BMF Approach Works

Develop  
BMF Tool for  
Managers



Grebe  
[THg]



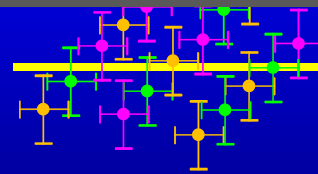
Fish  
[THg]

## BMF Will Not Work

Suggest to  
Managers to  
Not Use  
BMF  
Approach



Grebe  
[THg]



Fish  
[THg]

# Biomagnification Factor Tool for Managers

	Model Input		Model Output	
	Prey Fish	Sport Fish	Grebe Blood (estimated)	Risk to Wildlife
[THg] µg/g ww	0.30		3.30	High Risk
or				
[THg] µg/g dw	1.20			
% moisture	75%			
<b>Environmental Factors (examples)</b>				
Lake Elevation				
Lake Size				

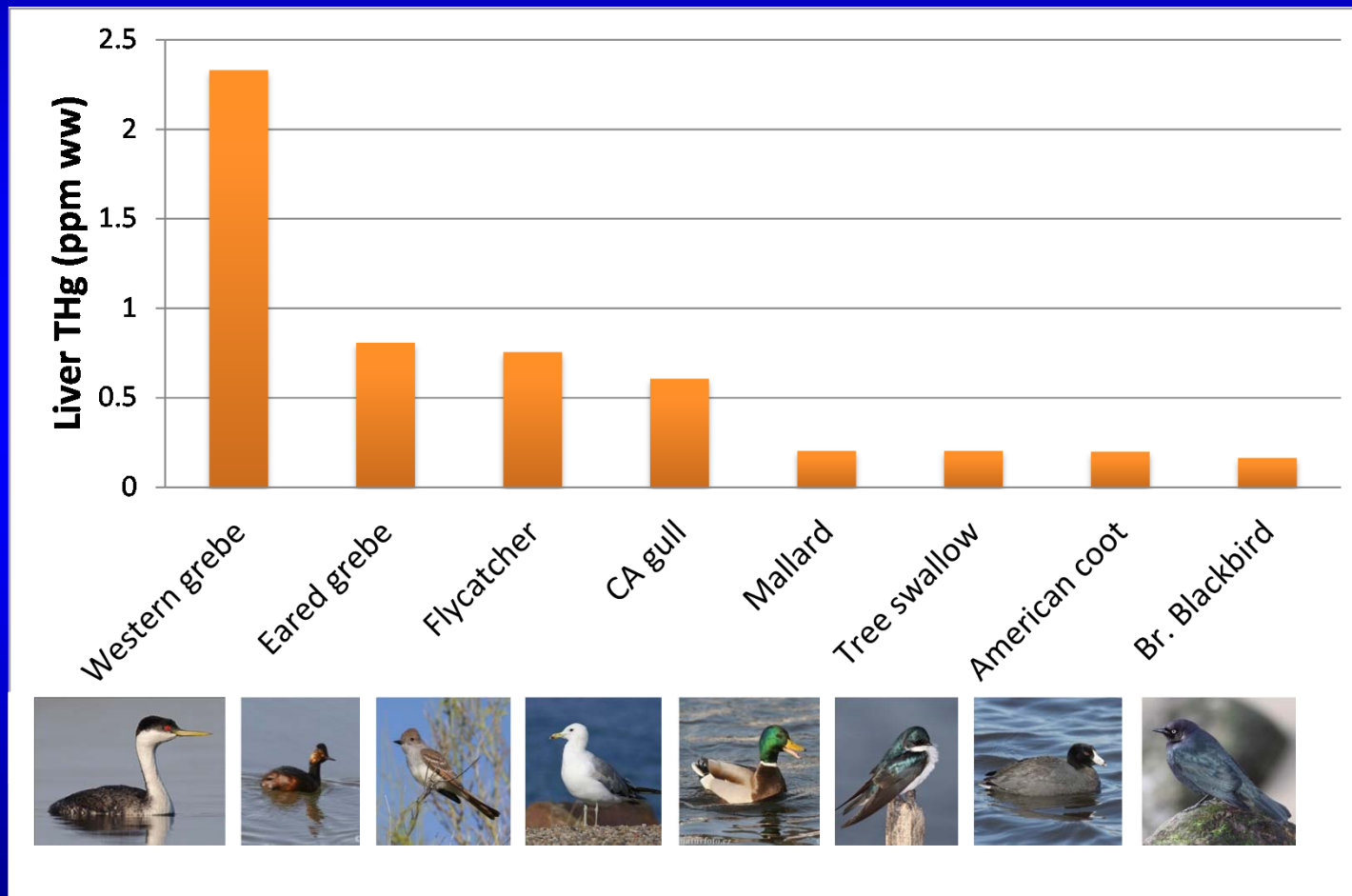
BMF assumed to be 11 in this example

# Western Grebes as Wildlife Biosentinel for Lakes

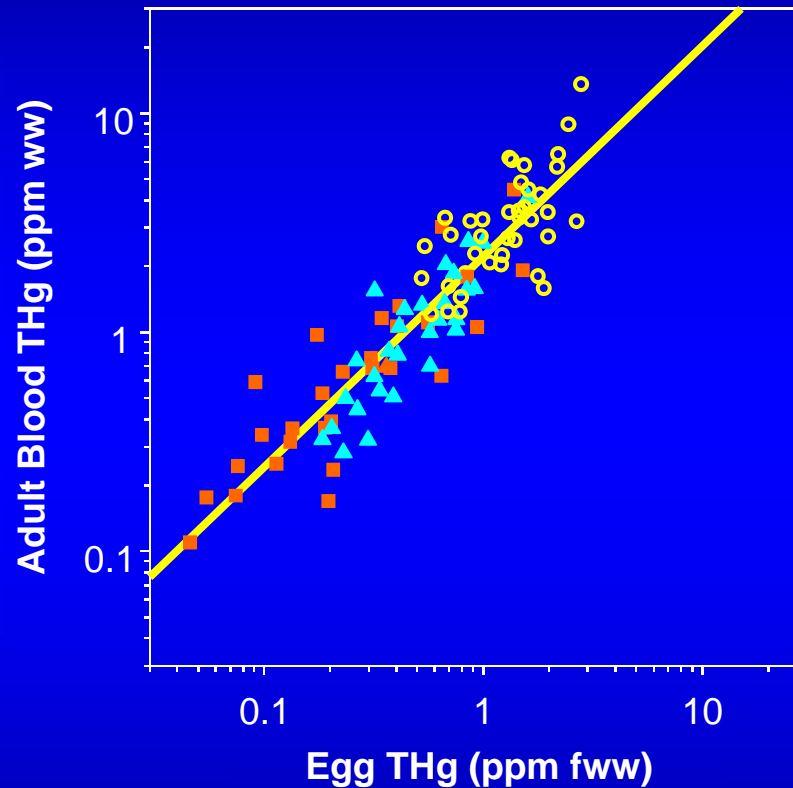
- Eat fish (25-100 mm), among wildlife at the top of the food chain
- Widely distributed on California lakes
- Breed on many California lakes
- Become flightless at breeding locations, contaminant exposure will be localized
- Species of conservation concern

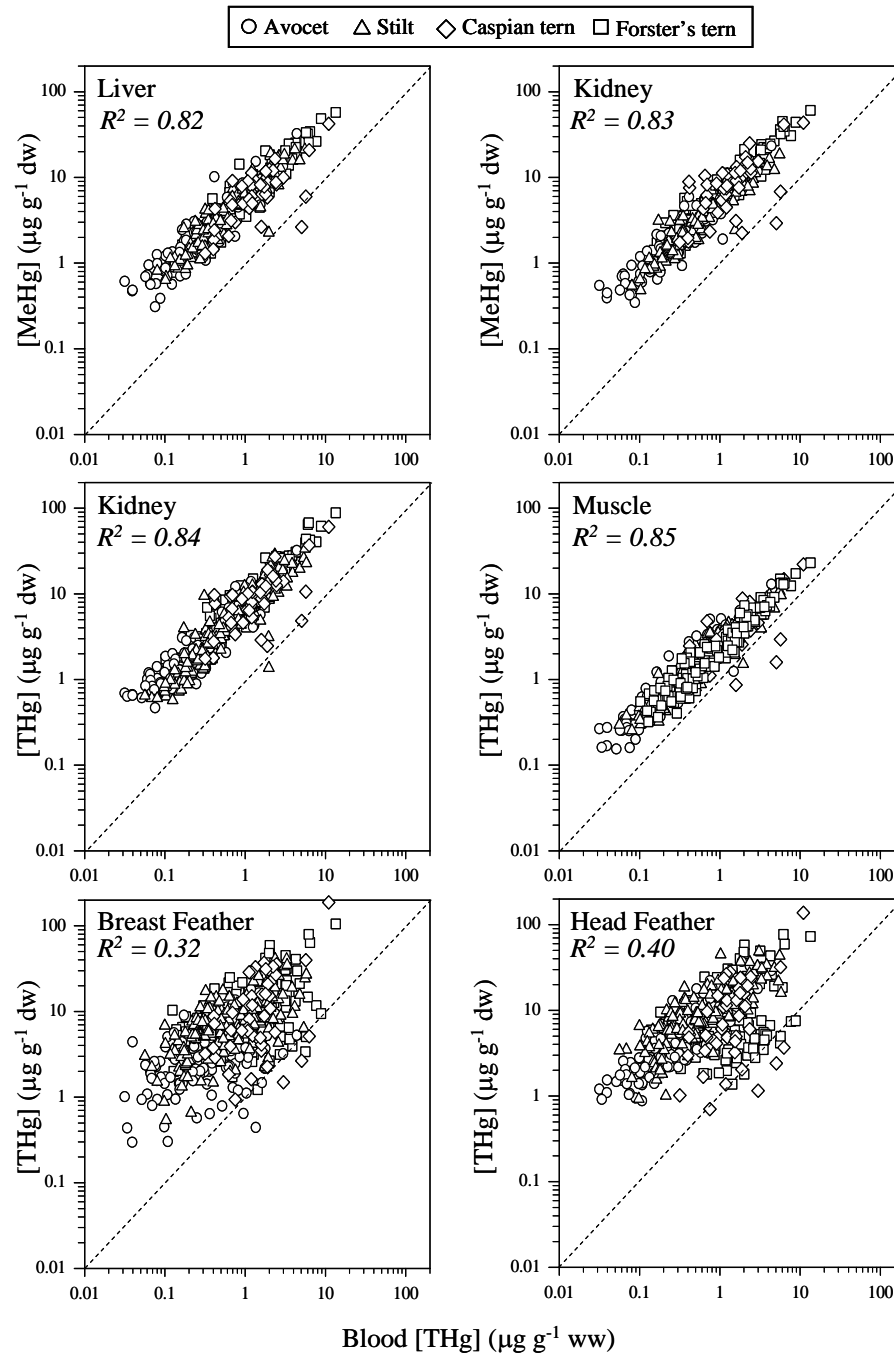


# Grebes Have High Mercury Exposure in Lakes (Eagle Lake, CA)



# Adult Blood will be Sampled to Index Wildlife Risk





## Tissue Type

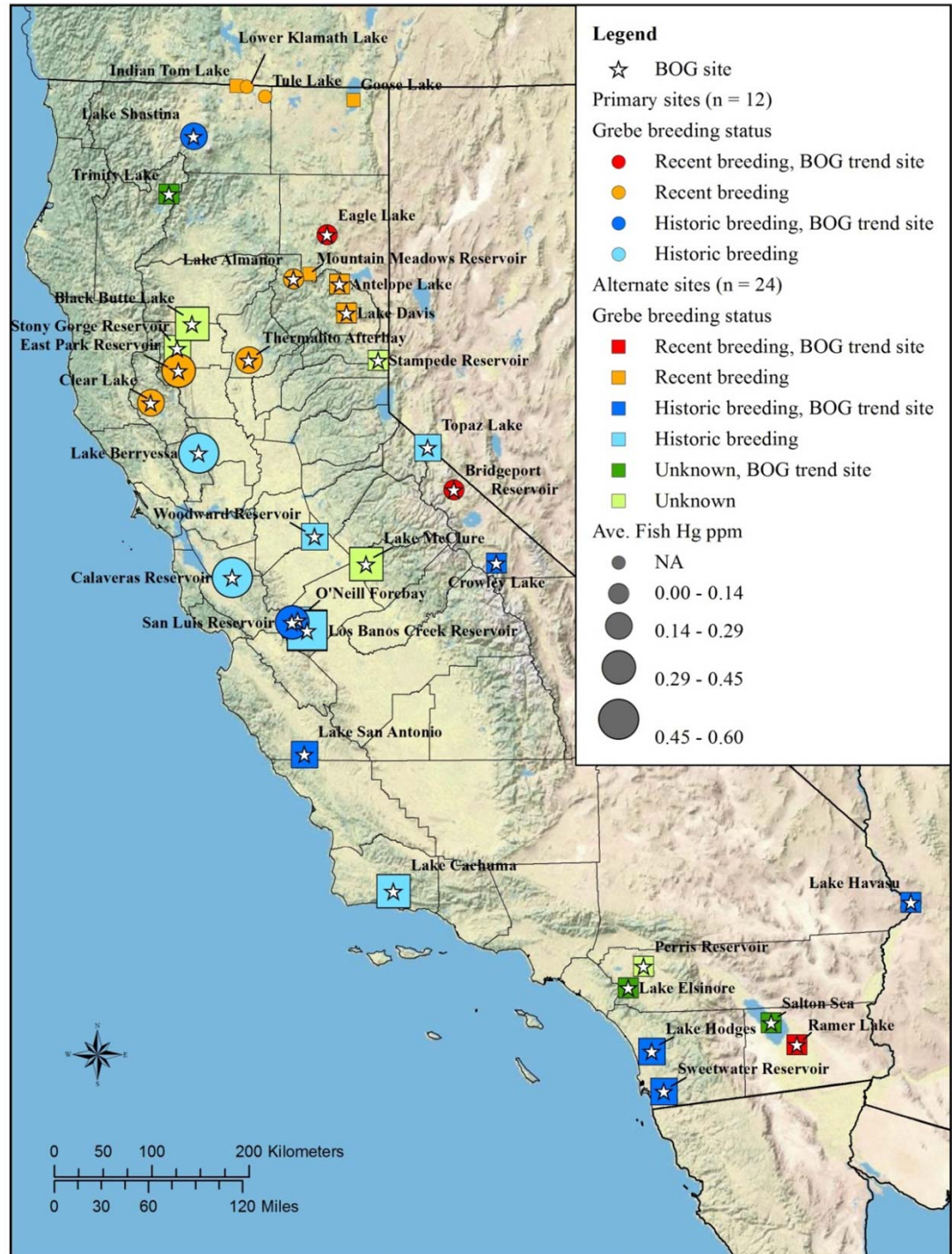
➔ *blood* is a good index for internal tissue THg and MeHg concentrations in birds

# Lake Selection Based On:

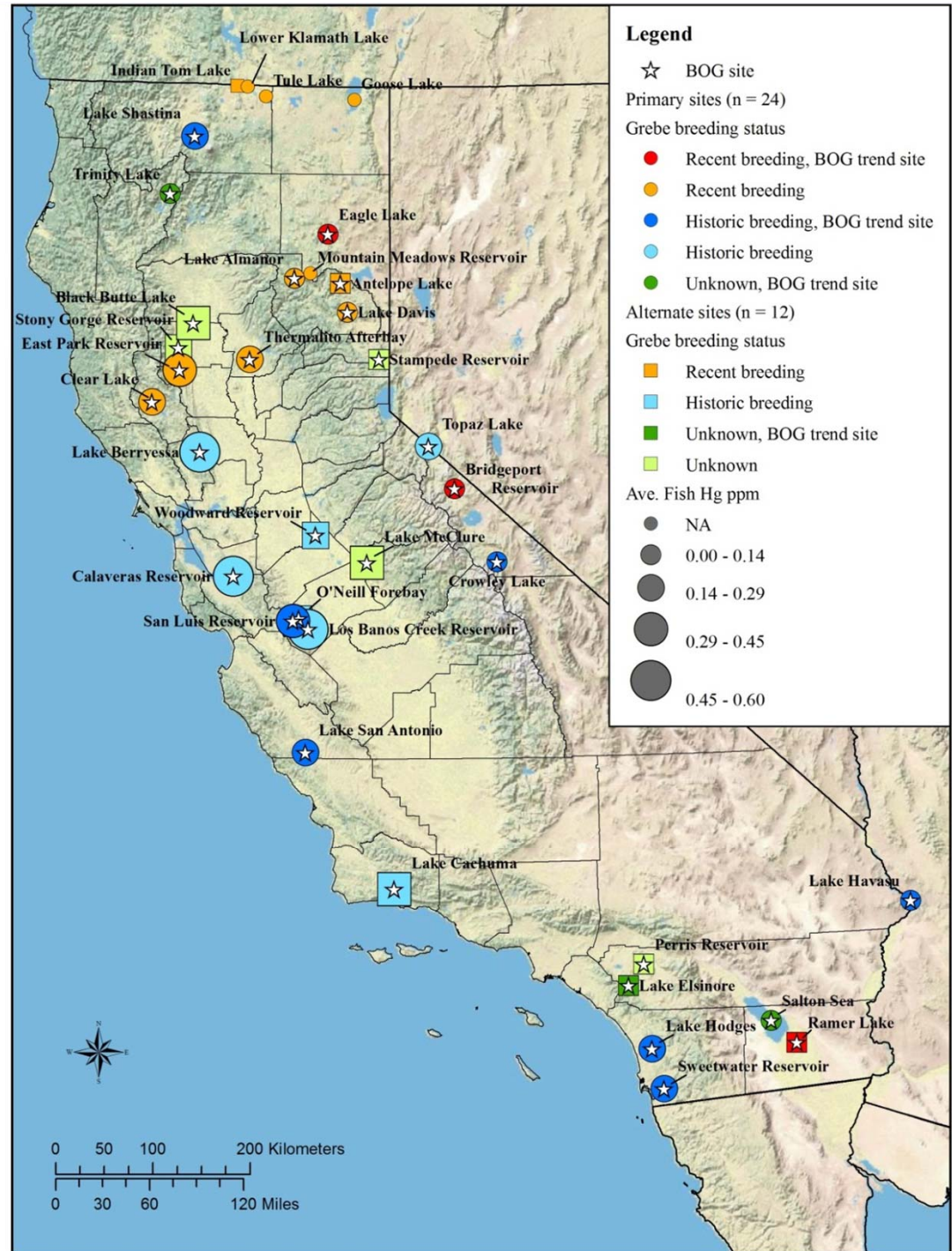
- Prior BOG sampling
- Whether or not the lake was a potential long-term BOG sampling site
- Whether grebes breed on the lake
- Relative mercury concentrations in sport fish sampled by BOG in 2007-2011



# Option 1: 12 lakes during 1 field season in 2012



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



# Project Leads

- Bird sampling, Hg determination, and bird reporting:
  - PIs: Dr. Josh Ackerman (USGS-WERC) and Dr. Collin Eagles-Smith (USGS-FRESC)
  - Lead Field Coordinator: Dr. Alex Hartman (USGS-WERC)
- Fish sampling, Hg determination, and fish reporting:
  - PIs: Mark Stephenson (Moss Landing) and Tom Maurer (USFWS)
  - Lead Field Coordinator: Gary Ichikawa (Moss Landing)
- Bird sampling will be conducted immediately before fish sampling, with fish sampling <2 weeks of bird sampling



# Project Permits and Coordination

- Permits submitted:
  - Federal Migratory Bird Permit
  - Federal Bird Banding Laboratory
  - California Scientific Collection Permit
  - Nevada Scientific Collection Permit
- Local Coordination (to date):
  - Keiller Kyle, Audubon (Audubon's California nest monitoring: Eagle Lake, Lake Almanor, Clear Lake, Thermalito Afterbay)
  - David Arsenault, Audubon-Plumas Chapter (Eagle Lake & Lake Almanor)
  - Ryan Martin, Department of Water Resources (Thermalito Afterbay)
  - Dr. Dan Anderson, University of California-Davis (California grebe experts)
  - Kris Robinson, University of California-Davis (MS Thesis on grebes)
  - Renee Weems, University of California-Davis (MS Thesis on grebes)
  - Randi Logsdon, SCP coordinator, California Department of Fish and Game
  - Steve Hampton, Office of Spill Prevention and Response, California Department of Fish and Game
  - Jennifer Brown, Federal Migratory Bird Permit Specialist, USFWS
  - Jenni Jeffers, Nevada Department of Wildlife (Topaz Lake)

### ***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**

	<b>Year-1</b>	<b>Year-2</b>	<b>Total</b>	<b>In-Kind Total</b>
<b>Salary and Benefits</b>				
Wildlife exposure determination	\$ 70,381	\$ -	\$ 70,381	\$ 38,374
Fish sampling	\$ 43,252	\$ -	\$ 43,252	\$ 5,000
<b>Sample Processing and Mercury Determination</b>				
Grebe tissue	\$ 24,000	\$ -	\$ 24,000	\$ -
Fish tissue	\$ 24,000	\$ -	\$ 24,000	\$ -
<b>Supplies</b>				
Field supplies, boat gas, equipment and maintenance	\$ 13,500	\$ -	\$ 13,500	\$ 17,250
Lab supplies & equipment	\$ 2,000	\$ -	\$ 2,000	\$ 2,000
<b>Travel</b>				
Per diem	\$ 14,220	\$ -	\$ 14,220	\$ -
Lodging	\$ 10,890	\$ -	\$ 10,890	\$ -
Vehicles	\$ 9,000	\$ -	\$ 9,000	\$ 1,000
<b>Total Direct Costs</b>	\$ 211,243	\$ -	\$ 211,243	\$ 63,624
<b>Indirect Costs</b>	\$ 88,319	\$ -	\$ 88,319	\$ 31,468
<b>Total Costs</b>	\$ 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**

	<b>Year-1</b>	<b>Year-2</b>	<b>Total</b>	<b>In-Kind Total</b>
<b>Salary and Benefits</b>				
Wildlife exposure determination	\$ 64,424	\$ 76,679	\$ 141,103	\$ 76,748
Fish sampling	\$ 41,252	\$ 42,902	\$ 84,154	\$ 10,000
<b>Sample Processing and Mercury Determination</b>				
Grebe tissue	\$ 24,000	\$ 24,000	\$ 48,000	\$ -
Fish tissue	\$ 24,000	\$ 24,000	\$ 48,000	\$ -
<b>Supplies</b>				
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
<b>Travel</b>				
Per diem	\$ 14,220	\$ 14,220	\$ 28,440	\$ -
Lodging	\$ 10,890	\$ 10,890	\$ 21,780	\$ -
Vehicles	\$ 9,000	\$ 9,000	\$ 18,000	\$ 1,000
<b>Total Direct Costs</b>	\$ 203,286	\$ 217,191	\$ 420,477	\$ 106,998
<b>Indirect Costs</b>	\$ 84,750	\$ 91,349	\$ 176,099	\$ 53,056
<b>Total Costs</b>	\$ 288,037	\$ 308,540	\$ 596,576	\$ 160,054

# Questions Needing Answers

- 1) One or two year study?
- 2) Which lakes to sample?
- 3) Archive samples for other contaminants?
- 4) Sport fish archived until analysis funds can be found?