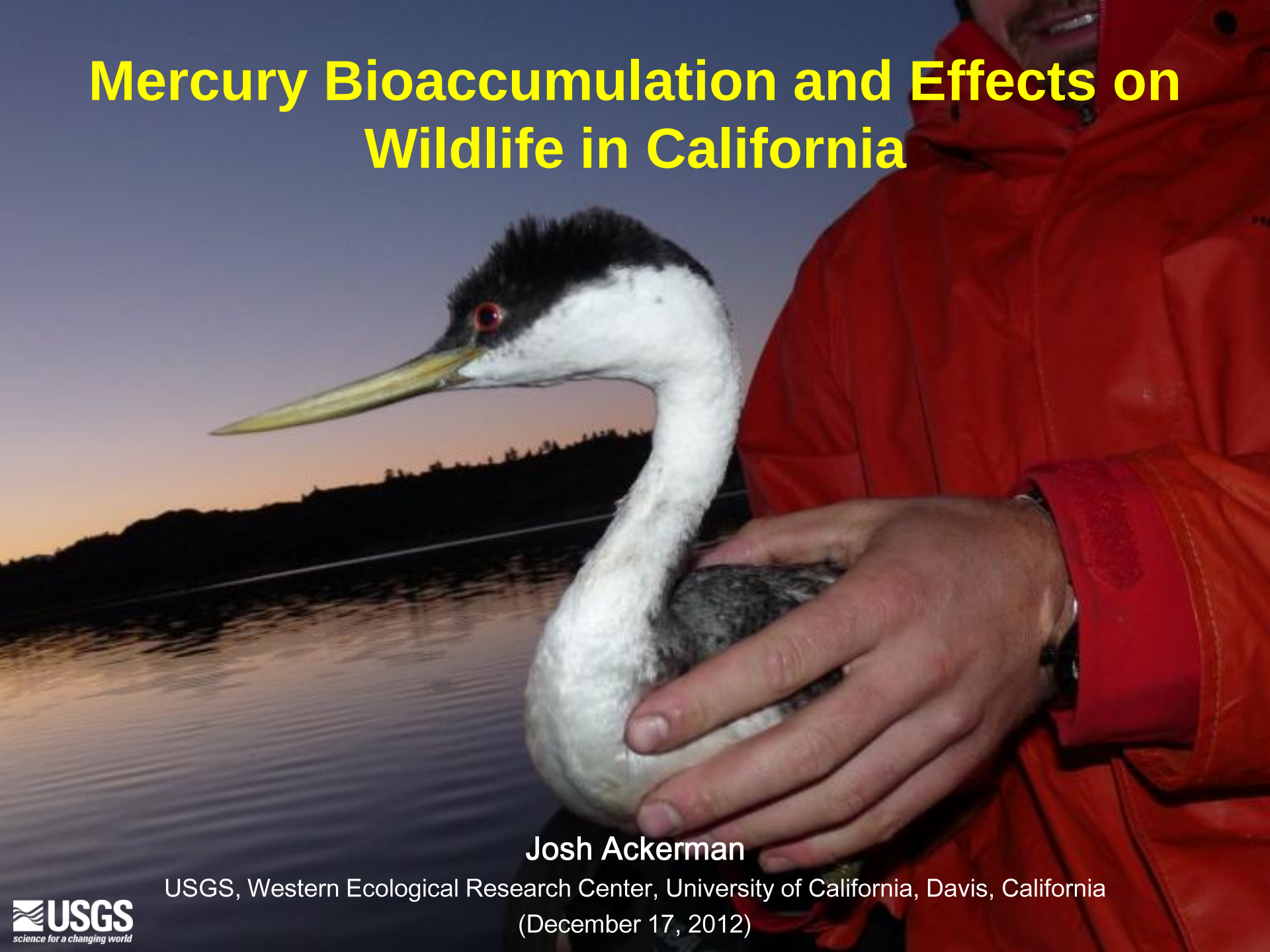
Mercury Bioaccumulation and Effects on Wildlife in California



Josh Ackerman

USGS, Western Ecological Research Center, University of California, Davis, California

(December 17, 2012)

USGS
science for a changing world

Outline

1. General mercury exposure levels among species and regions

2. Main factors influencing mercury concentrations in wildlife
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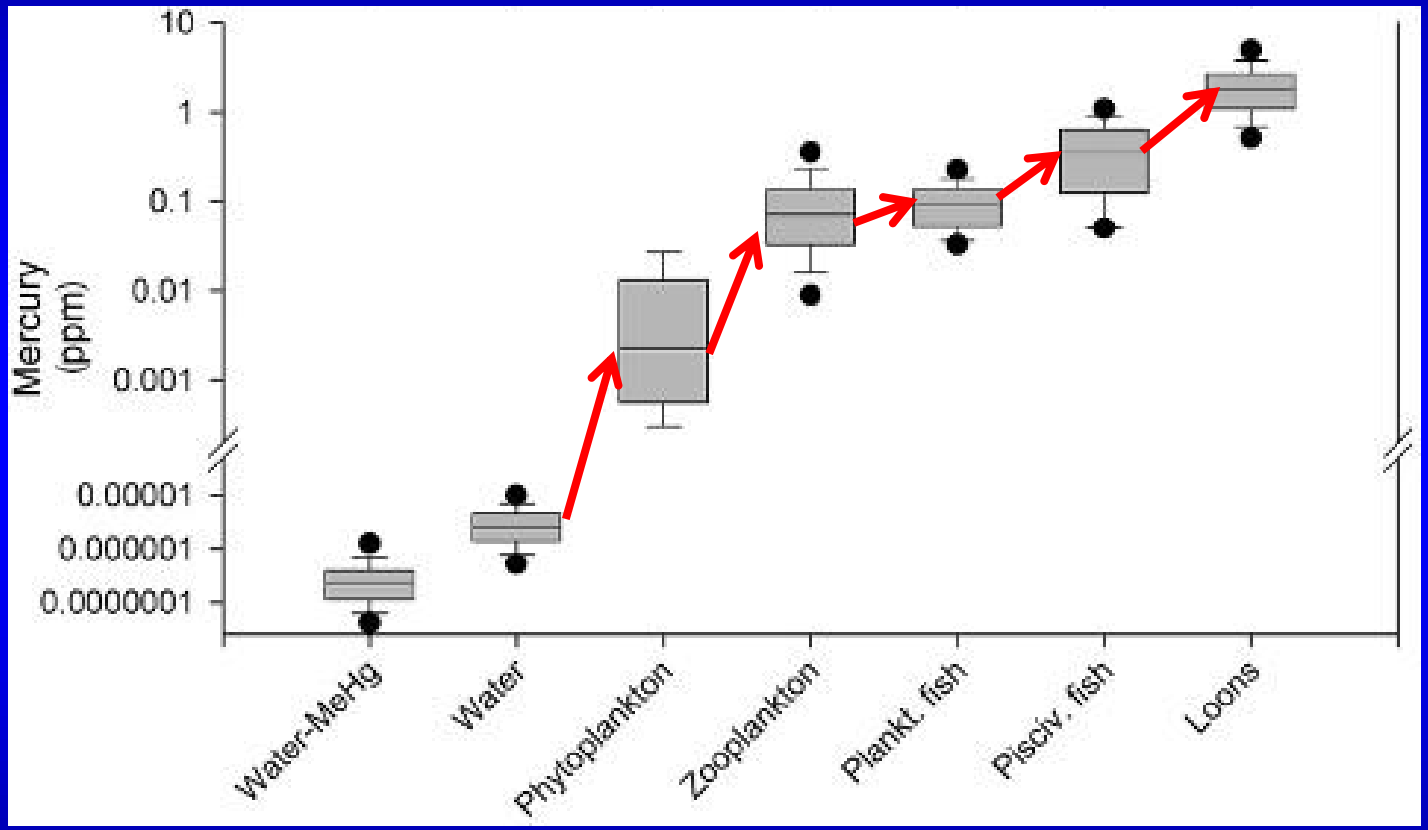
   - Timing
     - Date (long-term and short-term changes)
     - Physiology

3. Toxicity of mercury to wildlife
   - Sublethal effects on adults
   - Impaired reproduction
     - Egg hatchability
     - Chick survival

4. Current BOG research on wildlife

Methyl Mercury Biomagnifies Through Food Webs



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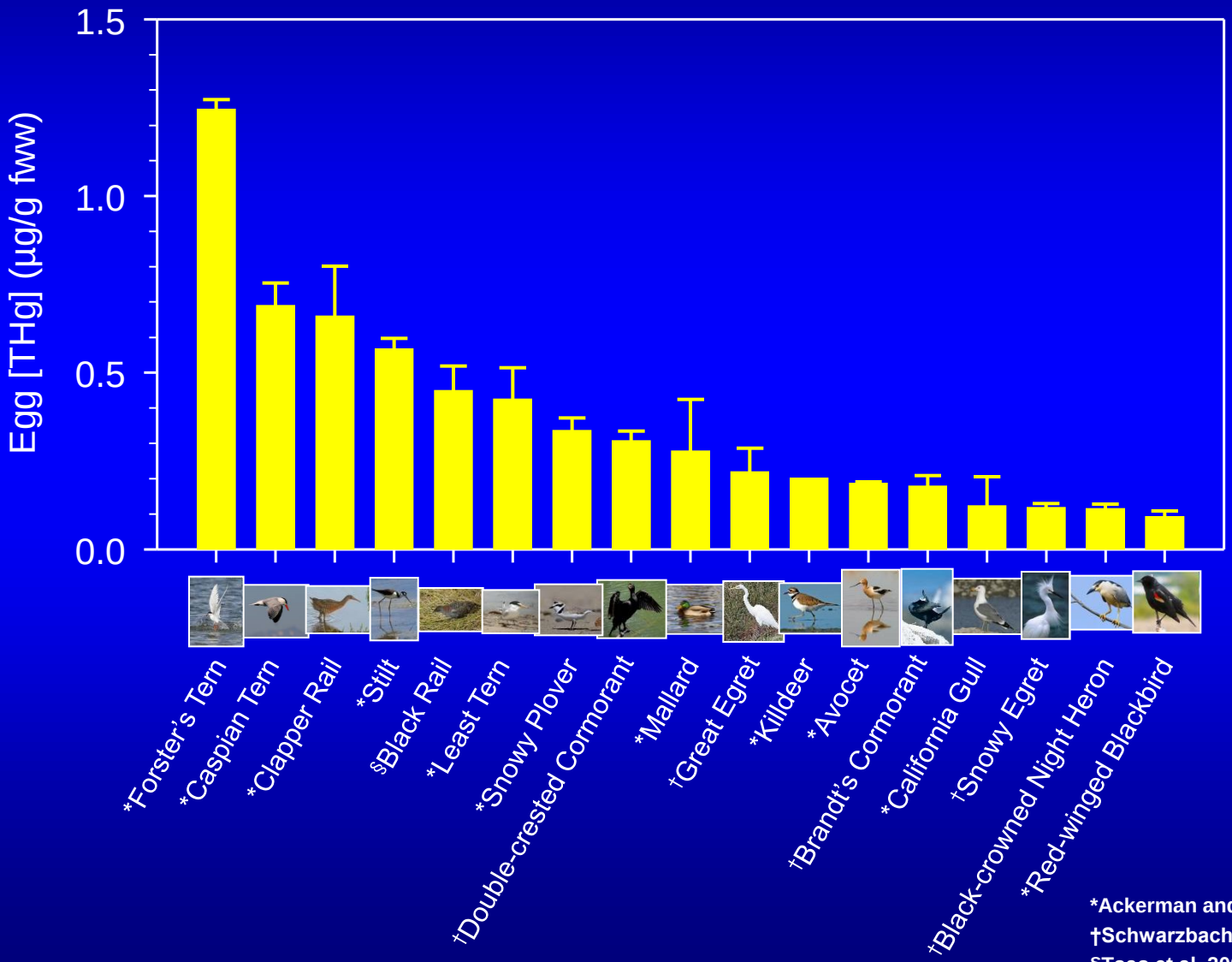
Driscoll et al. 2007

Bird Mercury Exposure in Bay

(San Francisco Bay: 17 species, *N*>4,000)



*Ackerman and Eagles-Smith 2008
†Schwarzbach and Adelsbach 2003
§Tsao et al. 2008

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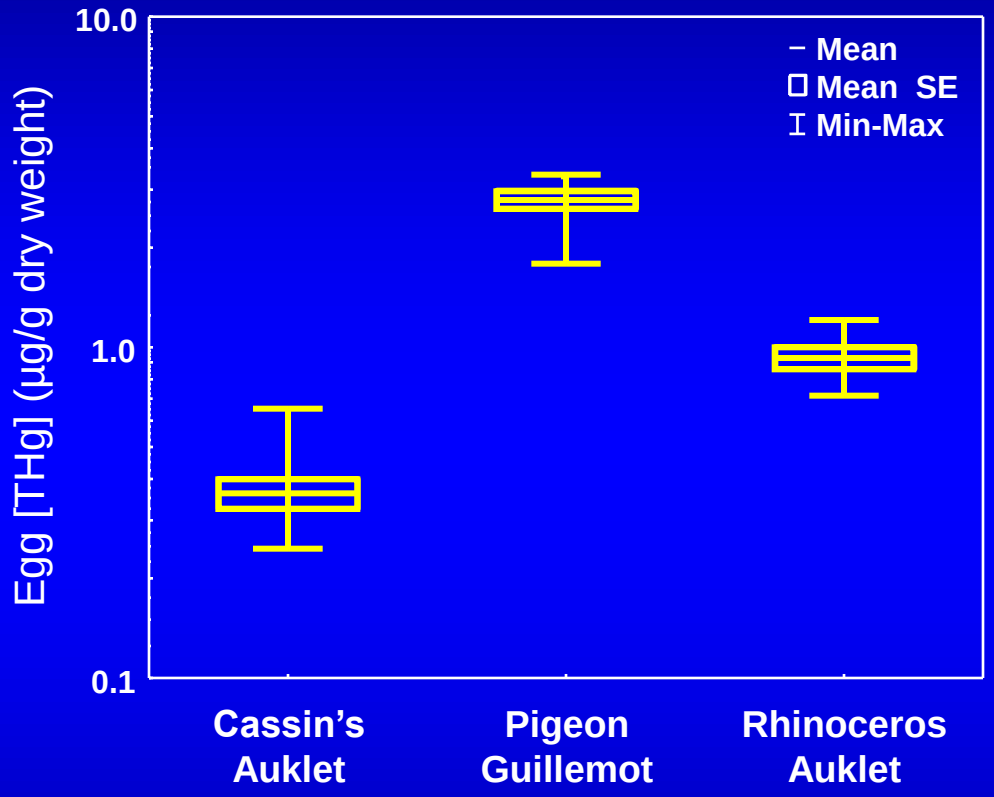
Bird Mercury Exposure along Coast
(Farallon Islands)



Cassin's auklet

Pigeon guillemot

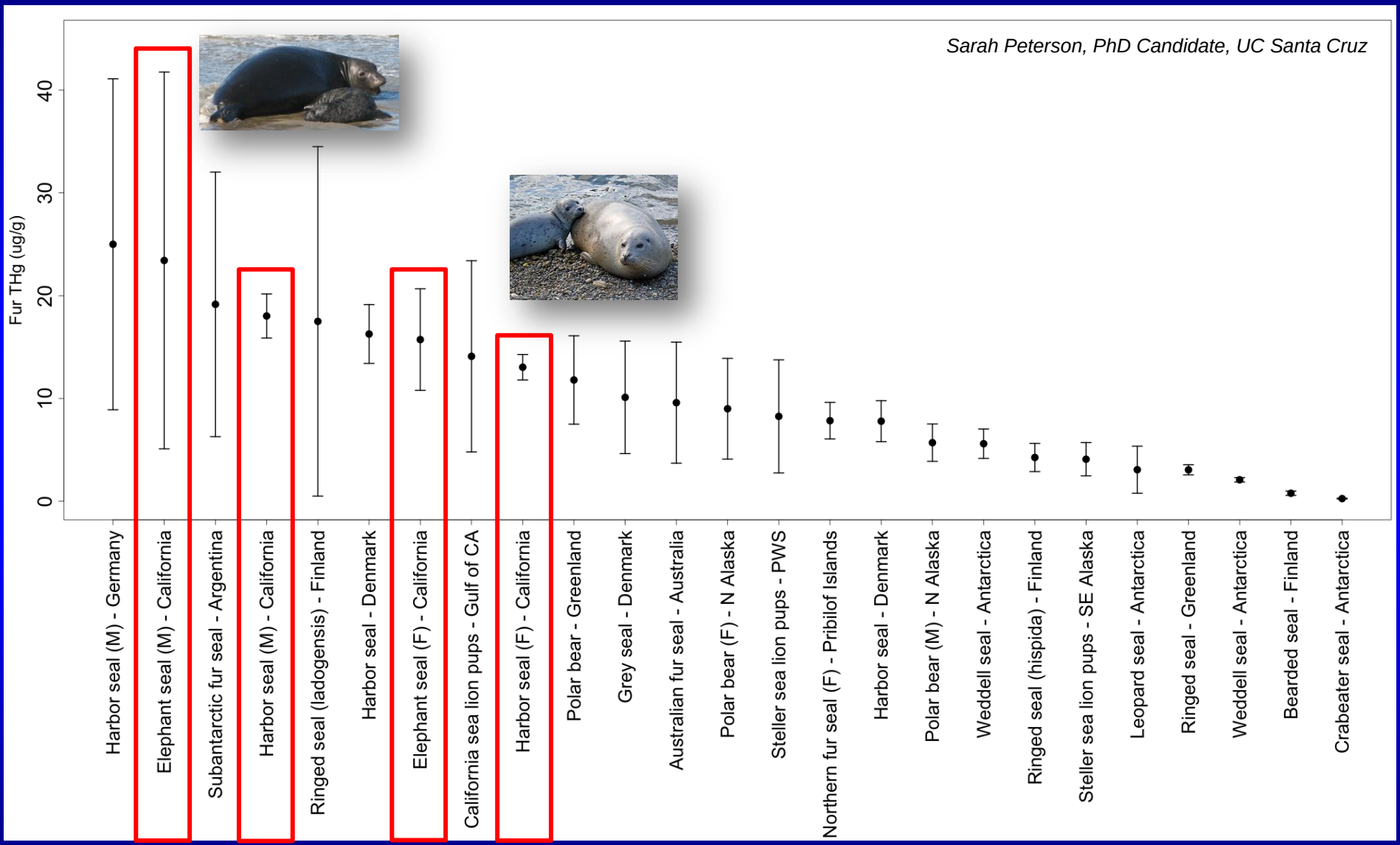
Rhinoceros auklet

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

prbo
PRBO Conservation Science

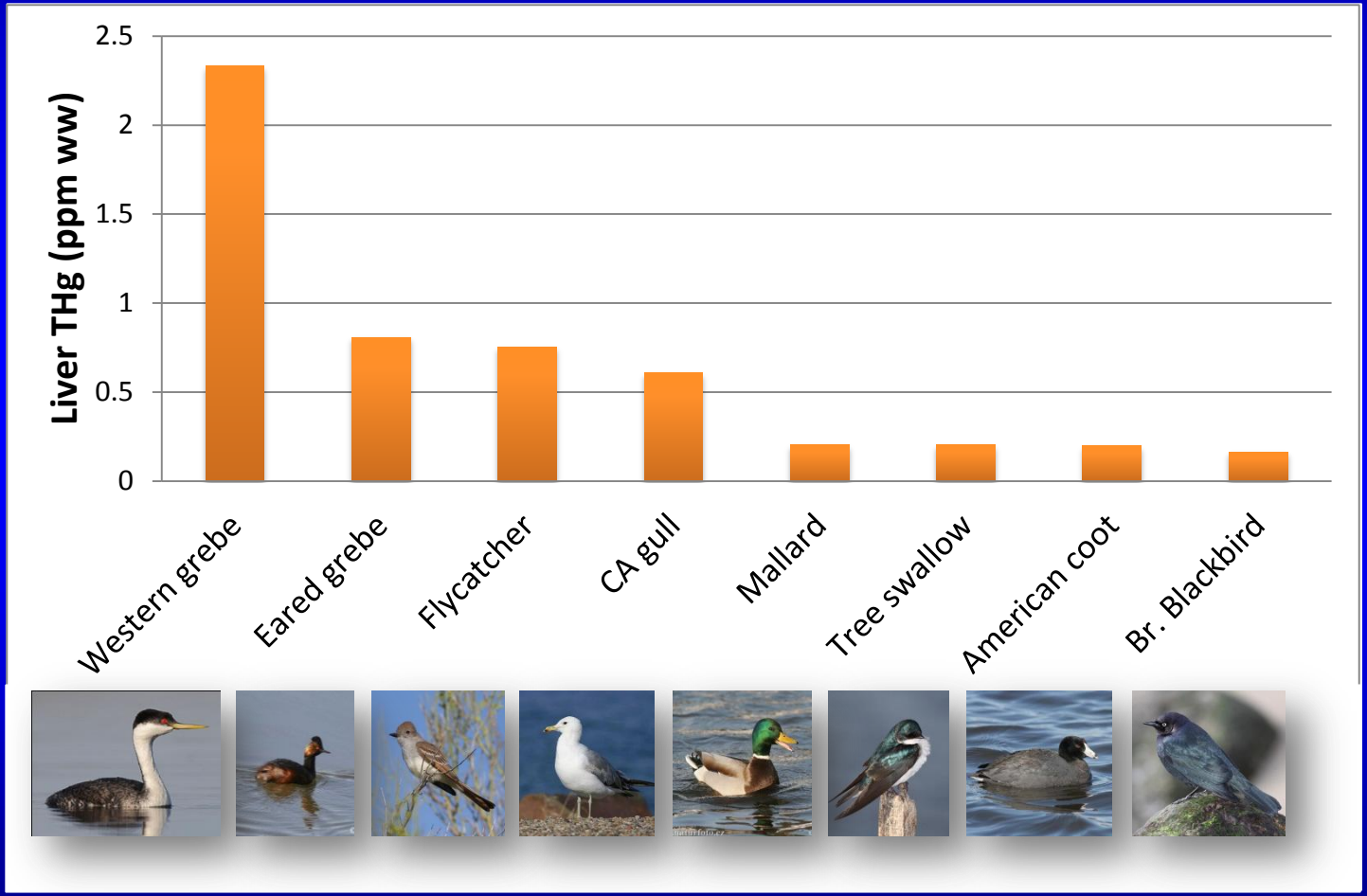
Kevin Aceituno, USFWS, unpublished

Marine Mammal Mercury Exposure along Coast



Wenzel et al 1993, Fossi et al 1997, Brookens et al 2007, Medvedev et al 1997, Aubail et al 2011, Elorriaga-Verplancken et al 2008, Dietz et al 2011, Bacher 1985, Cardona-Marek et al 2009, Castellini et al 2012, Gray et al 2008, *Basu et al 2007, ** Thompson et al 1996, ***Basu et al 2009

Bird Mercury Exposure in Lakes (Eagle Lake)

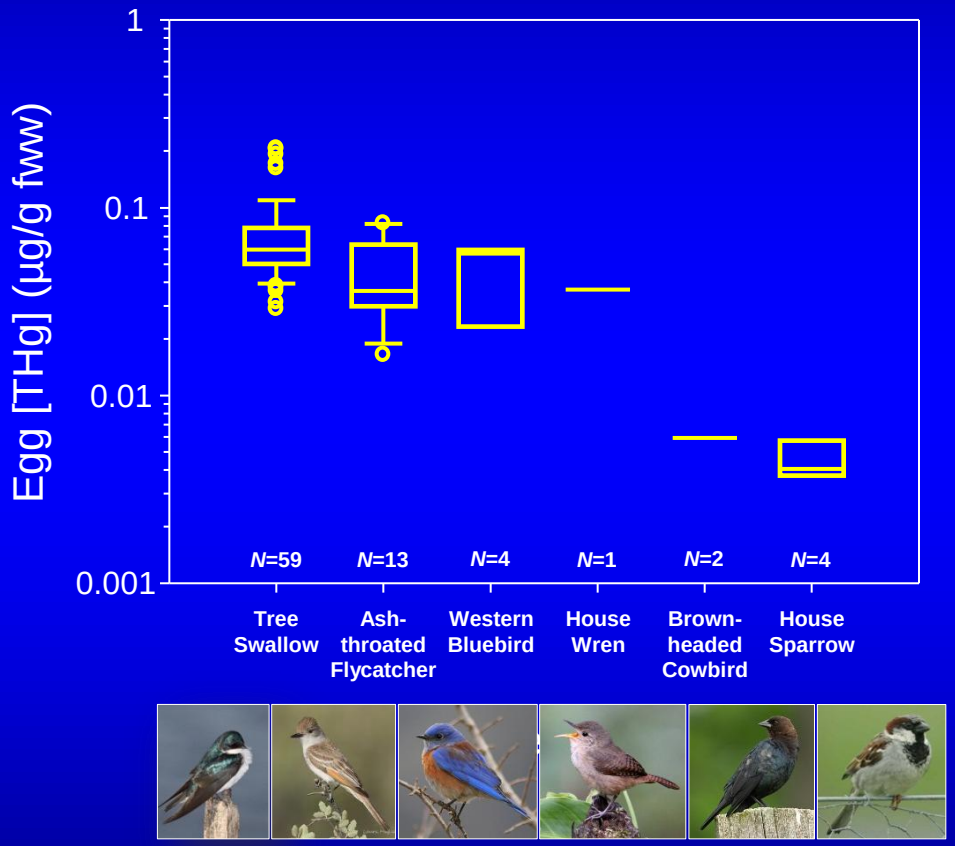


2.9 ppm ww (8.5 ppm dw) demethylation threshold

USGS science for a changing world

Eagles-Smith et al., unpublished data

Bird Mercury Exposure along Rivers (Putah Creek)



USGS science for a changing world

Ackerman, USGS unpublished

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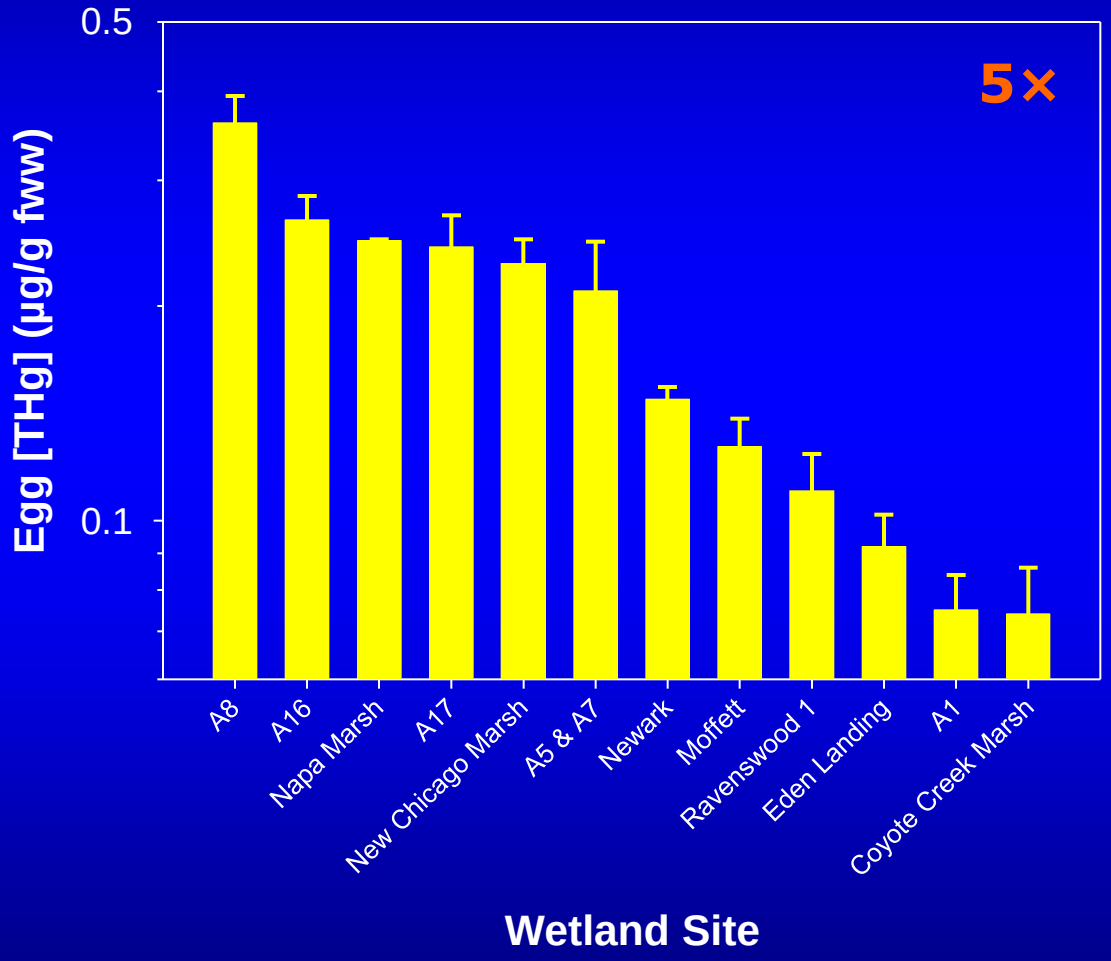
Egg Mercury Varies by Site

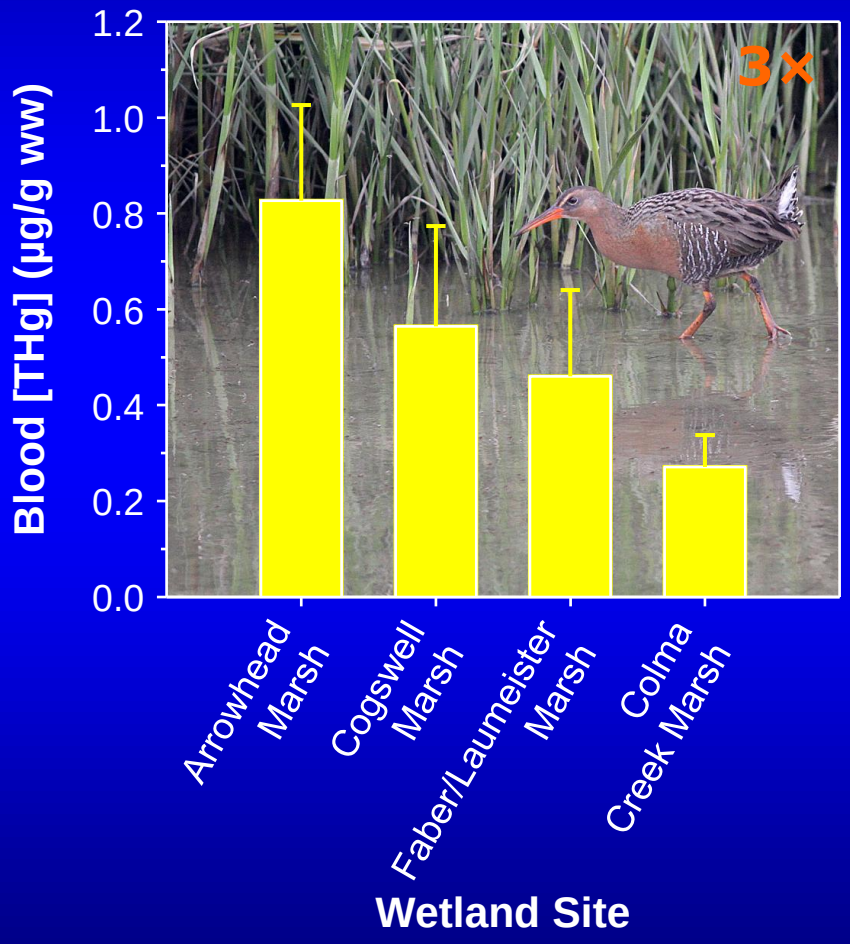
Avocets in San Francisco Bay

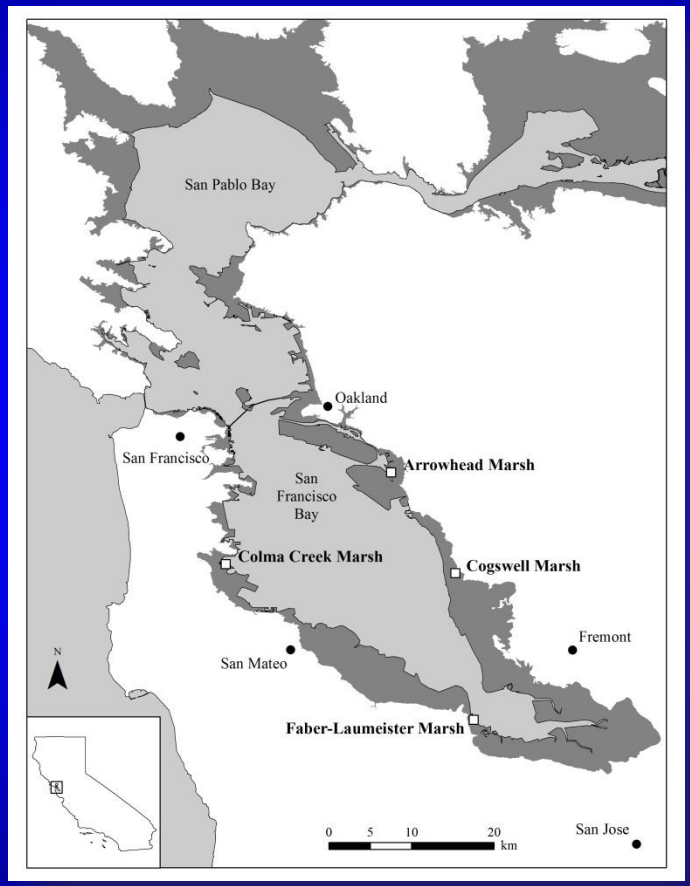


USGS science for a changing world

Ackerman, USGS unpublished

Mercury in Endangered Clapper Rails Varies by Site

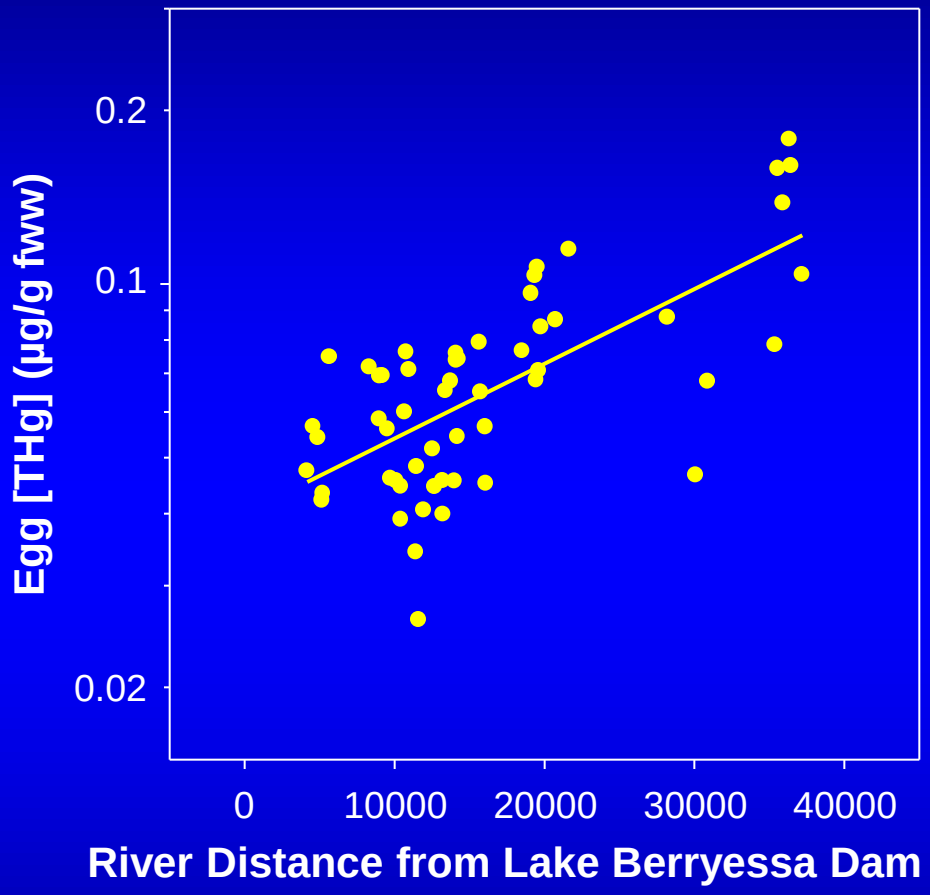




USGS science for a changing world

Ackerman et al. 2012

Mercury in Tree Swallow Eggs along Putah Creek

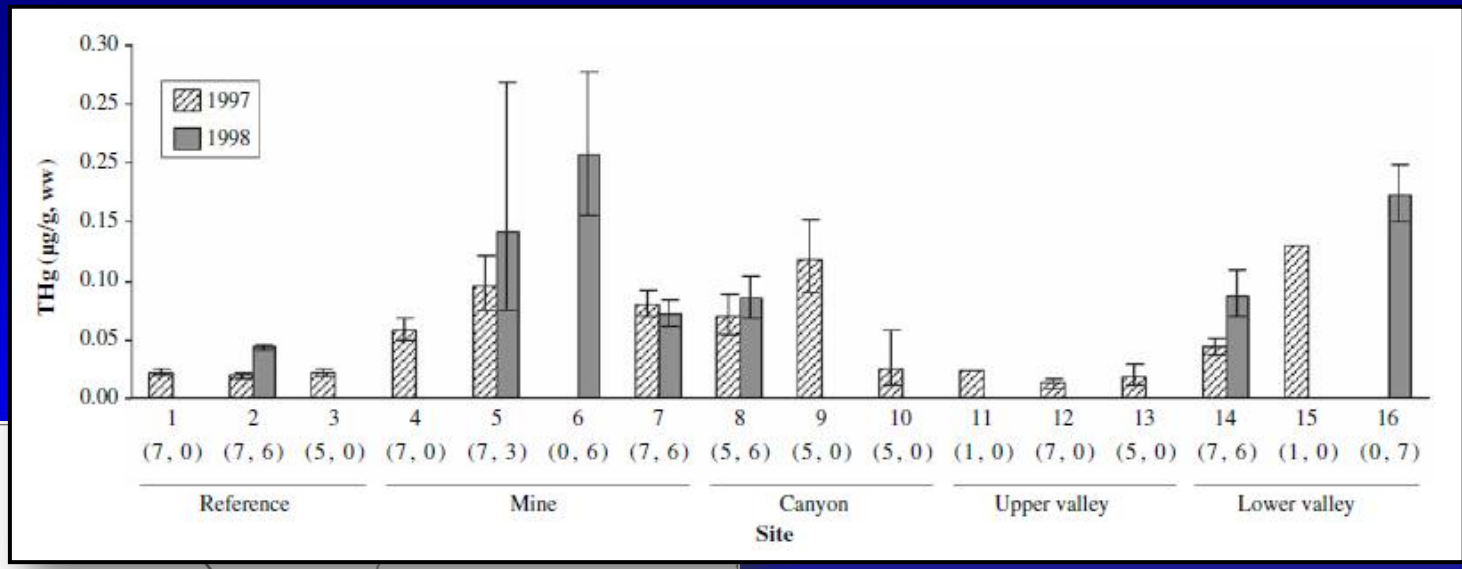


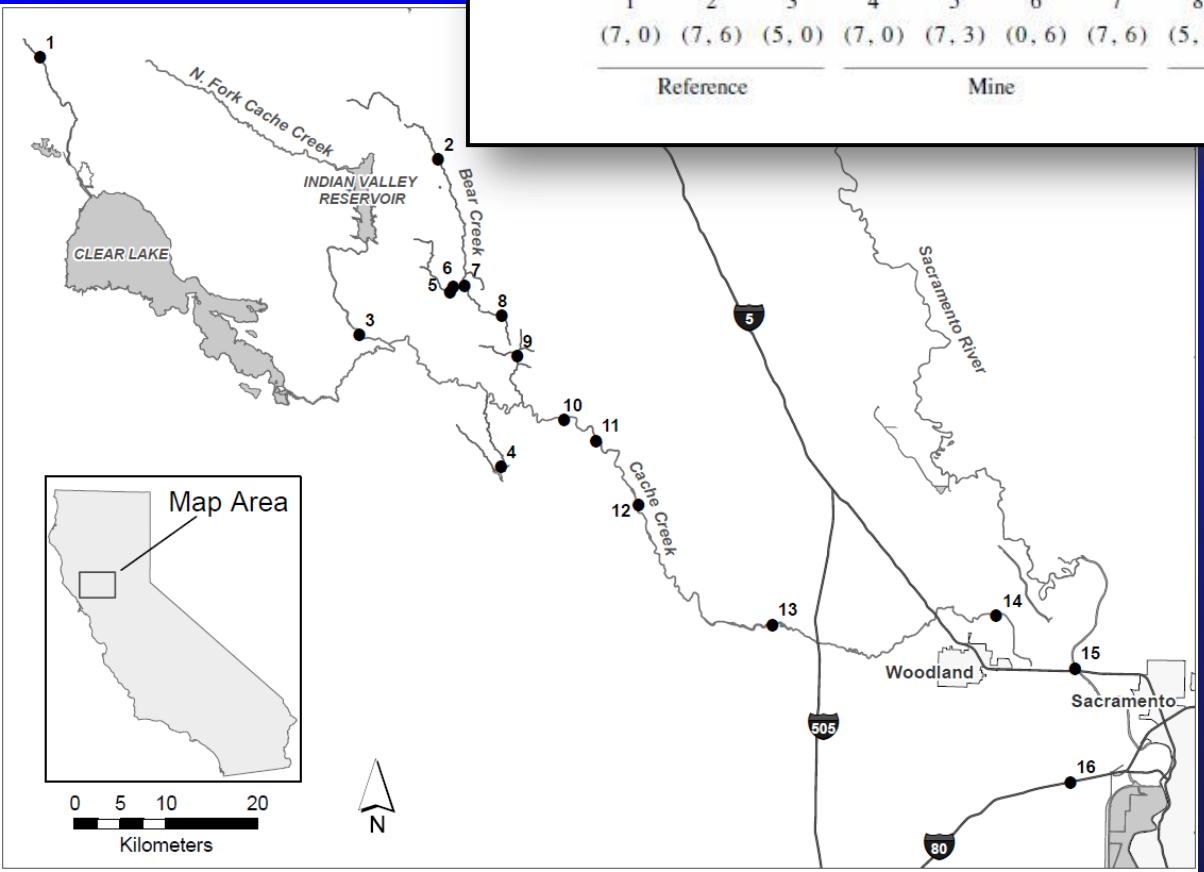
$P<0.0001$
$F_{1,51}=44.4$
$R^2=0.57$*
$N=55$ eggs

Ackerman, USGS unpublished

USGS science for a changing world

Mercury in Cliff Swallow Eggs along Cache Creek

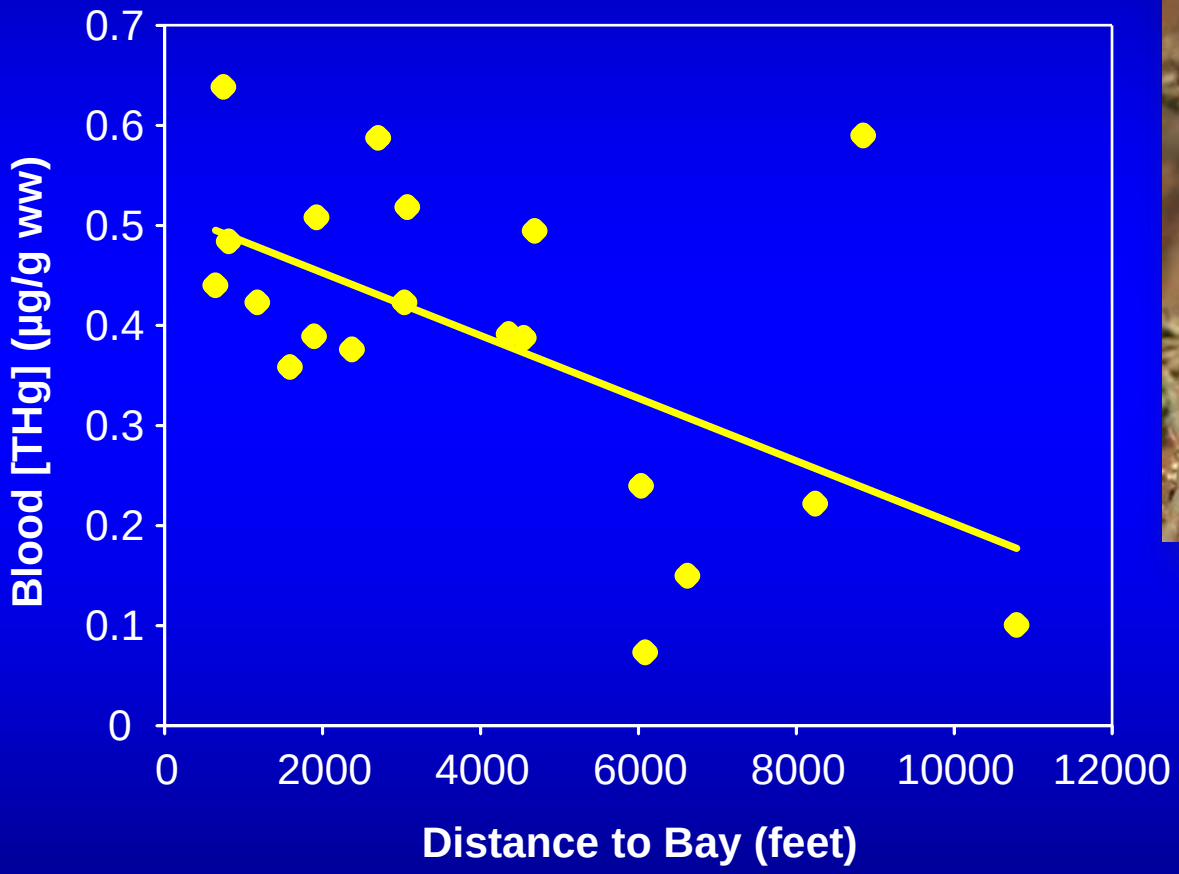




USGS science for a changing world

Hothem et al. 2008

Mercury in Tidal Marsh Song Sparrows Adjacent to San Francisco Bay



Grenier et al., SFEI unpublished

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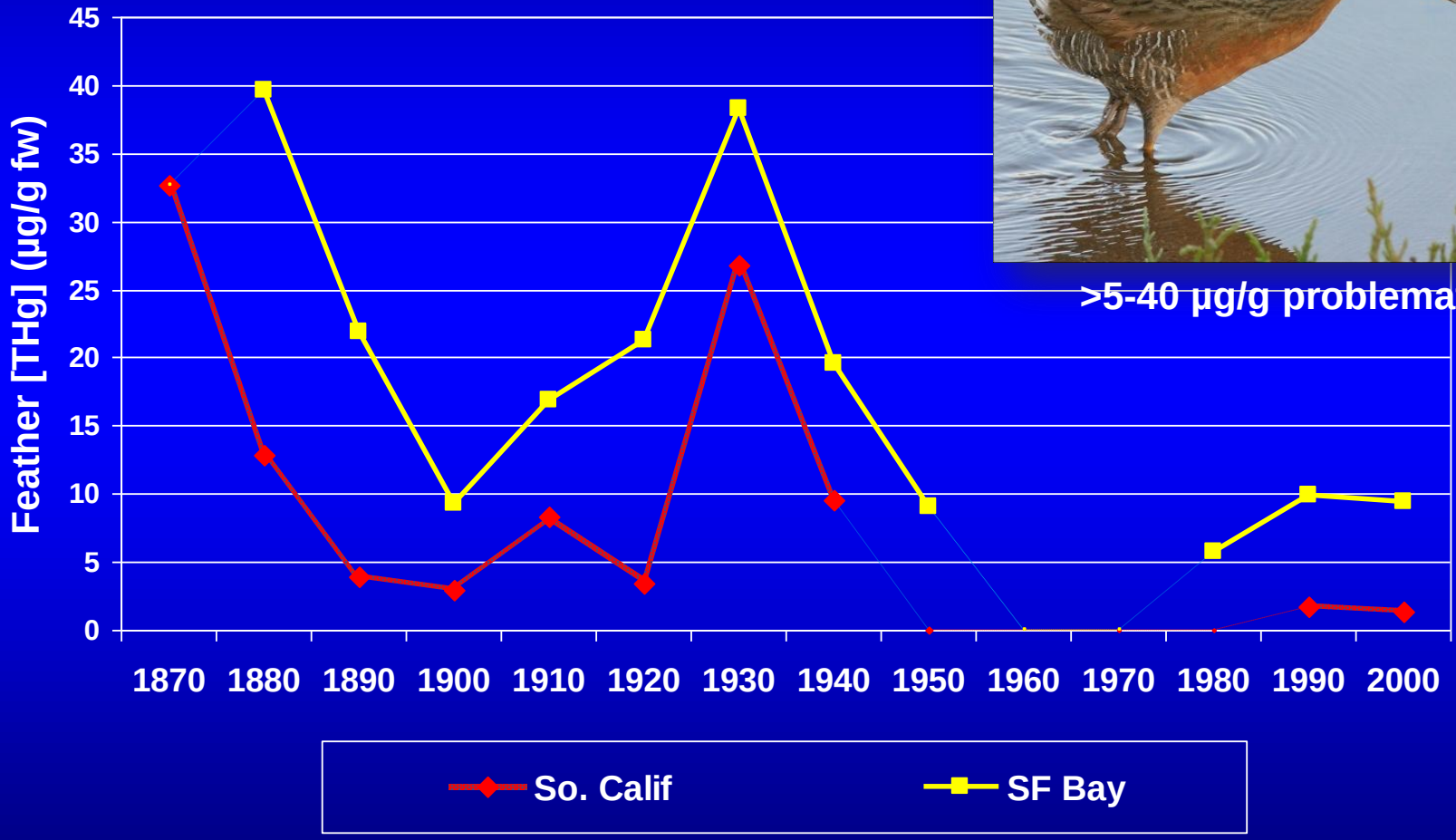
Mercury in Endangered Clapper Rails

(Decadal mean Hg in museum specimens)

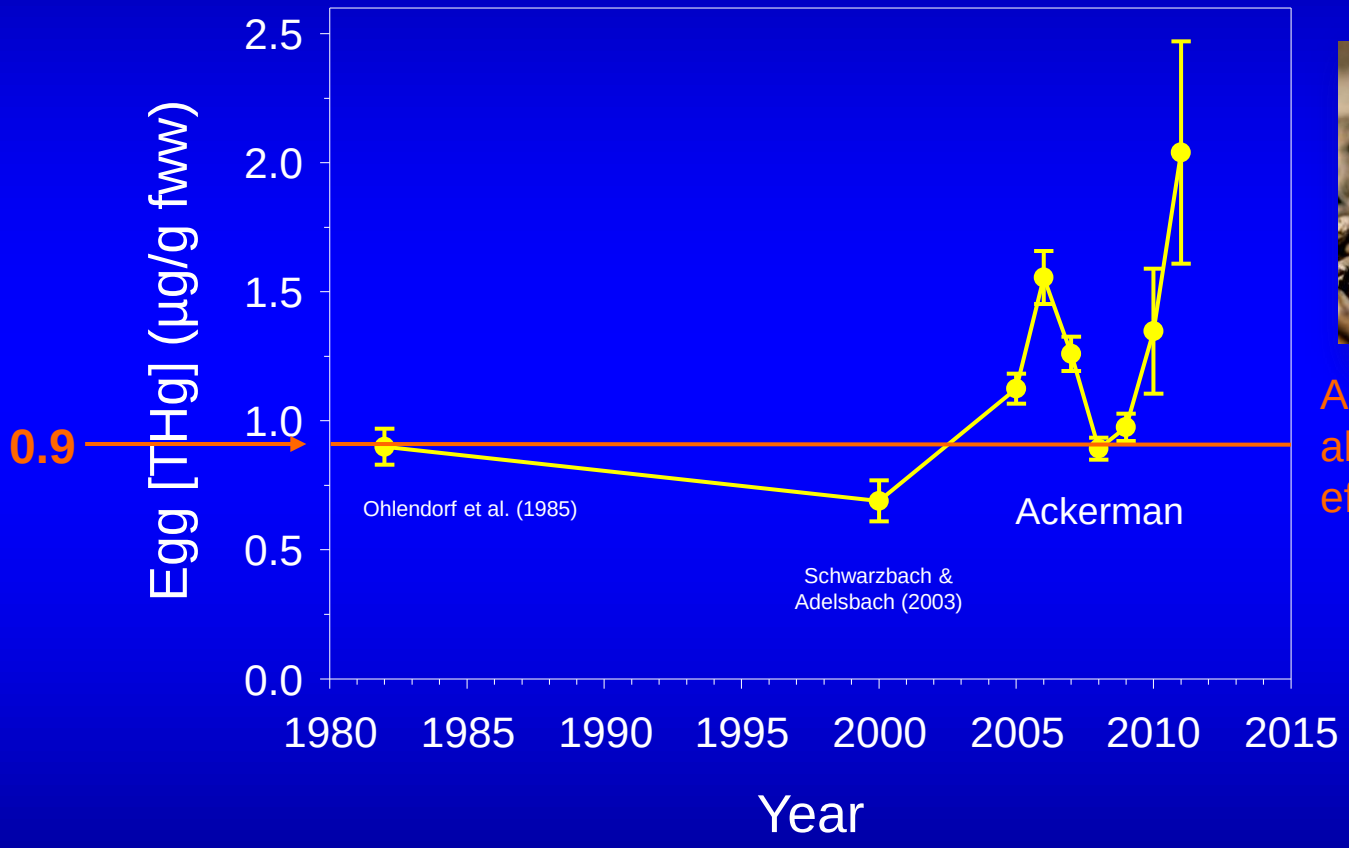
>5-40 µg/g problematic



USGS science for a changing world

Schwarzbach et al., USGS unpublished

Tern Egg Mercury Concentrations in San Francisco Bay May be Increasing



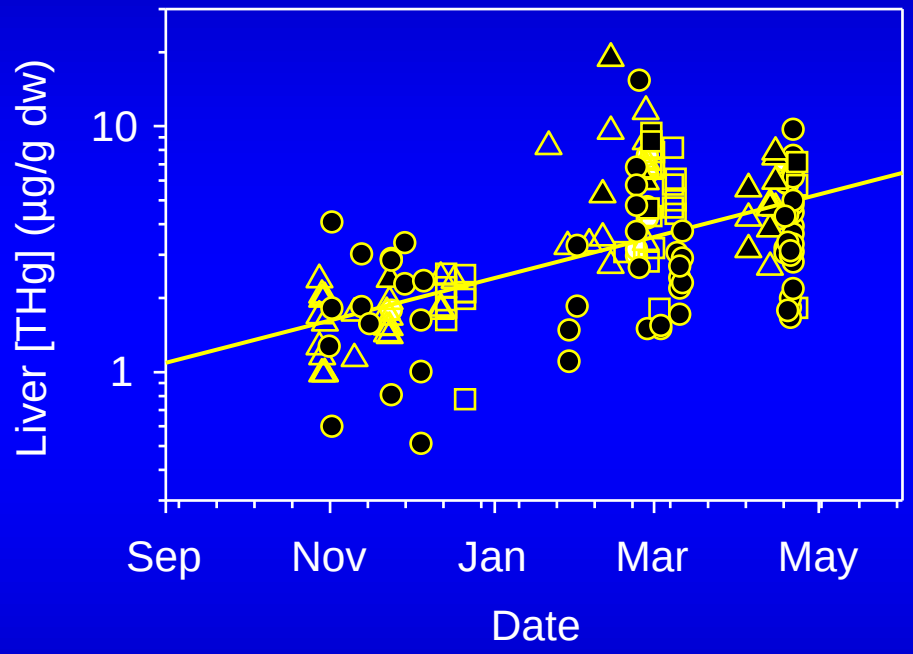
Annual mean egg Hg above detectable effects

*0.88 µg/g fww = 10% reduction in egg hatchability and 18% reduction in nest survival

USGS science for a changing world

Ackerman, USGS unpublished

Seaduck Mercury Exposure in San Francisco Bay



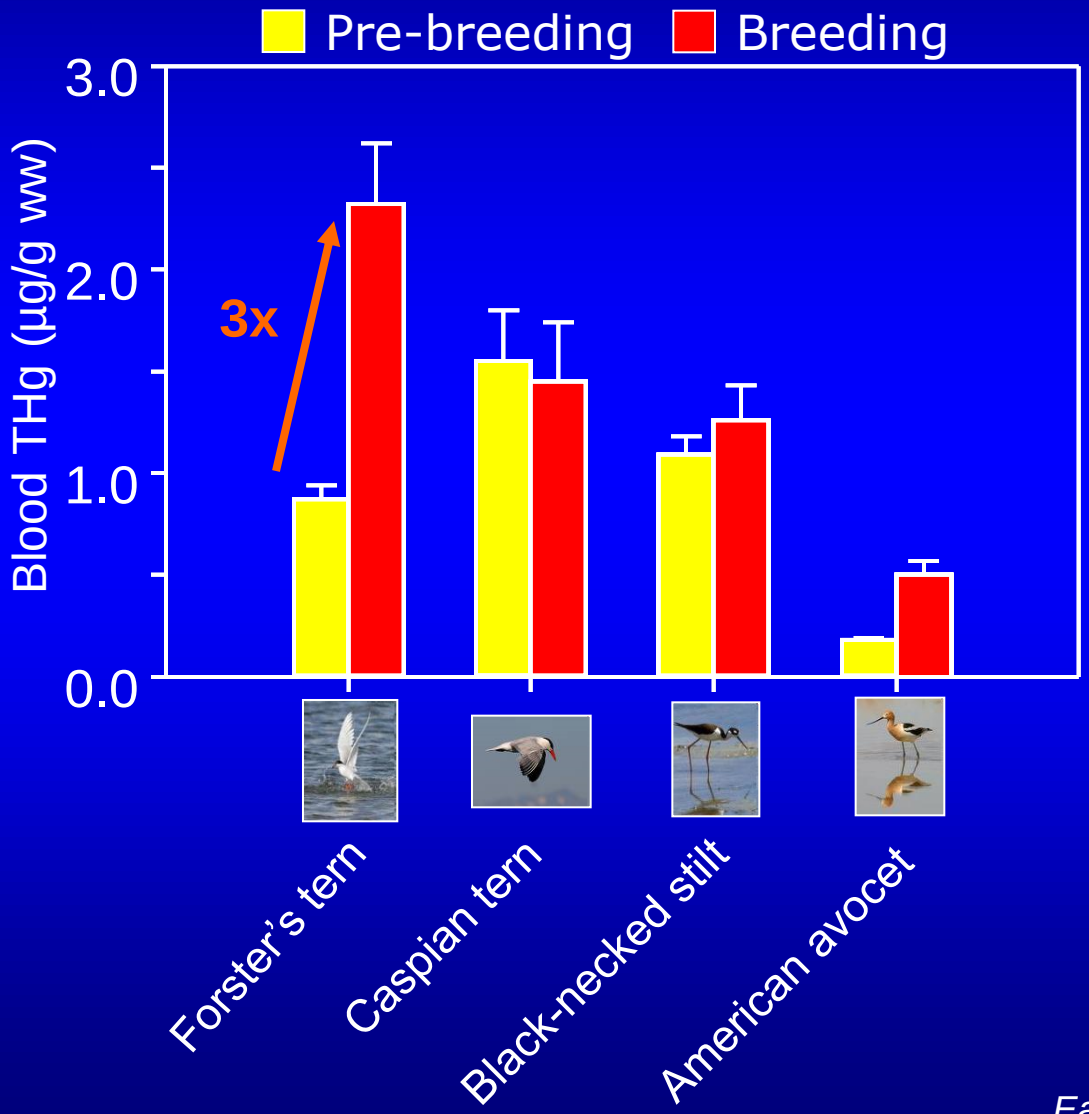
Central Bay
North Bay
Suisun Bay

Females
Males

Eagles-Smith et al. 2009

USGS science for a changing world

Waterbird Mercury Exposure in San Francisco Bay



USGS science for a changing world

Eagles-Smith et al. 2009

Mercury in Prey Fish Highest During Bird Reproduction

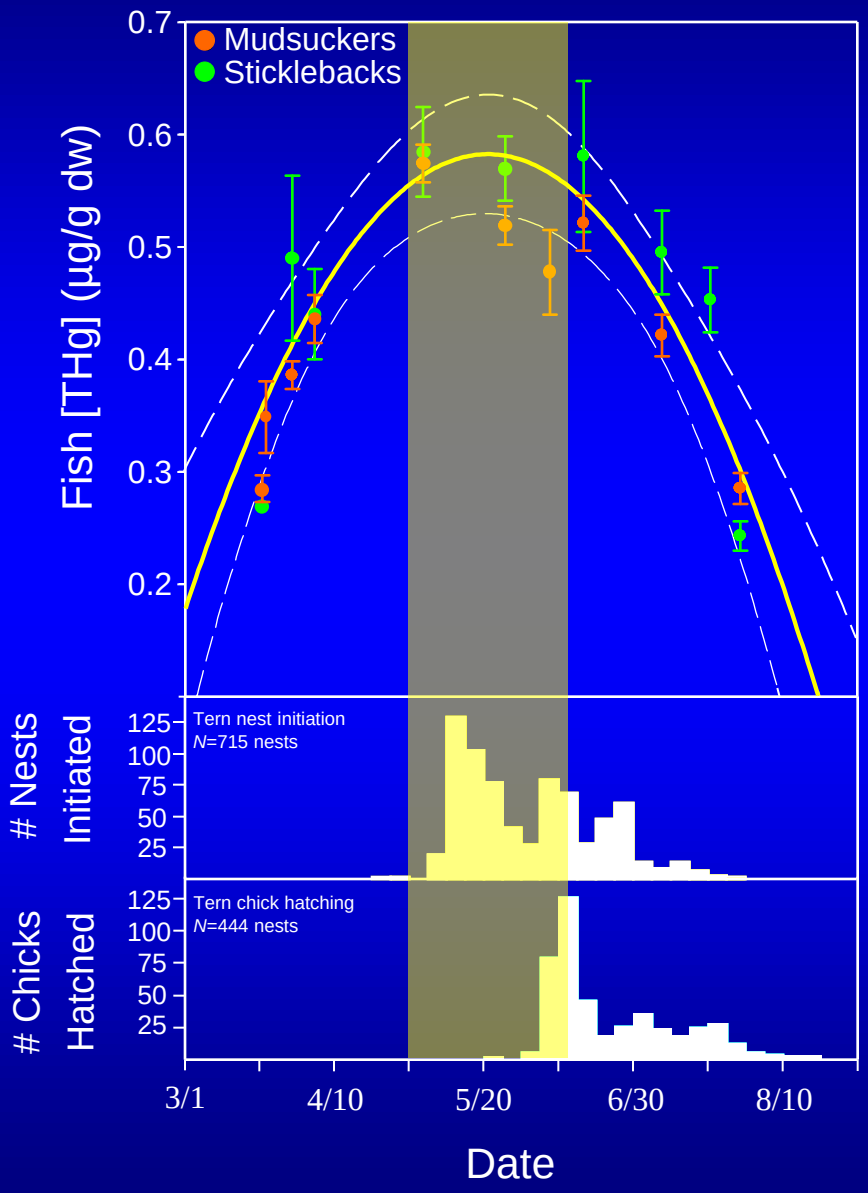


Photo by Ken Phenicie

% at peak prey Hg

68% nests initiated

31% chicks hatch

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Eagles-Smith & Ackerman 2009

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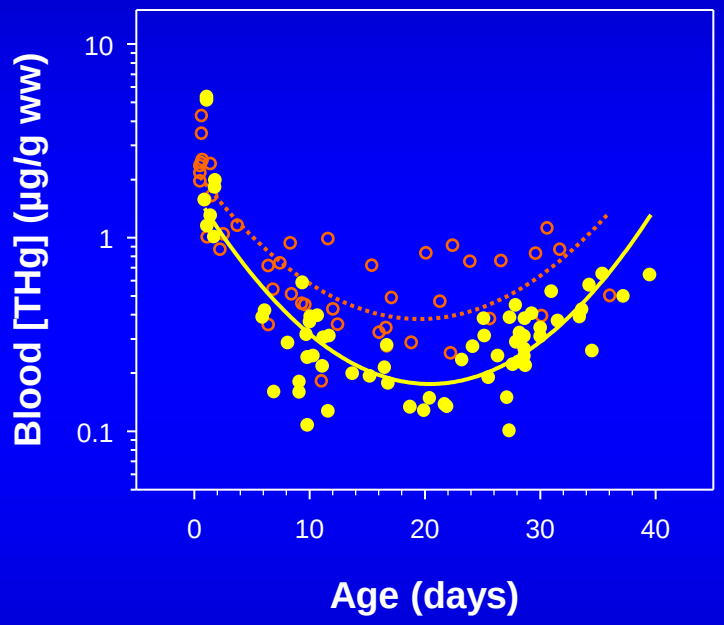
4. Current BOG research on wildlife

Mercury as Tern Chicks Age

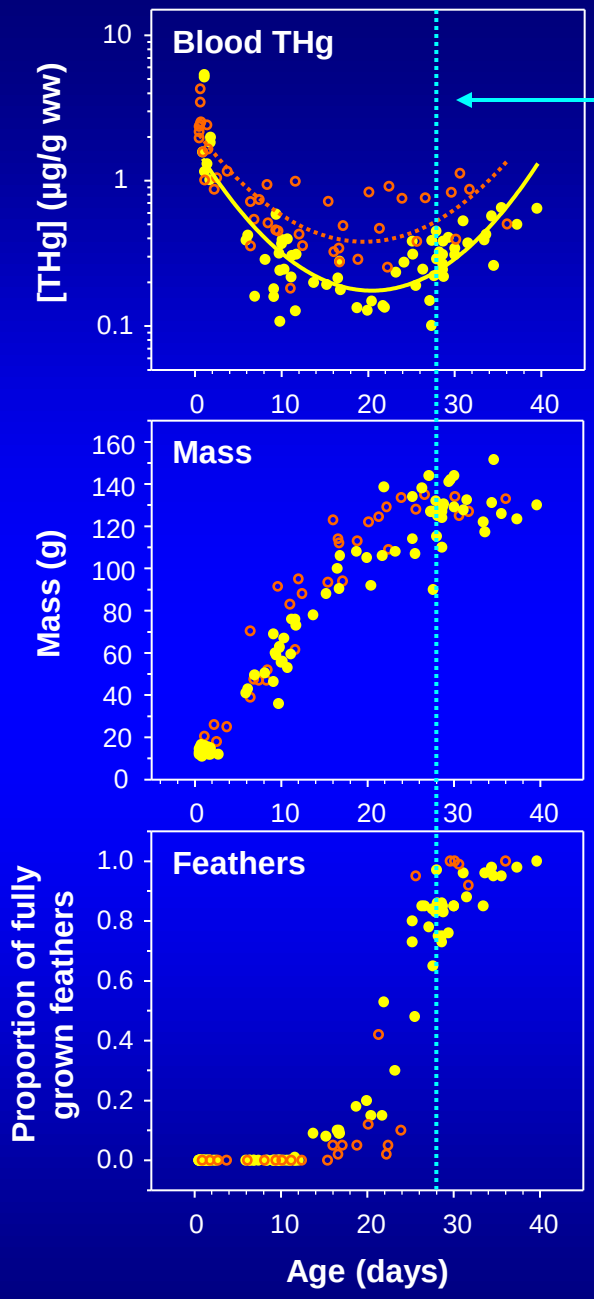


Low Hg site N7

High Hg site A16

USGS science for a changing world

Ackerman et al. 2011



Fledge at 28 days of age

Low Hg site N7

High Hg site A16

Ackerman et al. 2011

USGS science for a changing world

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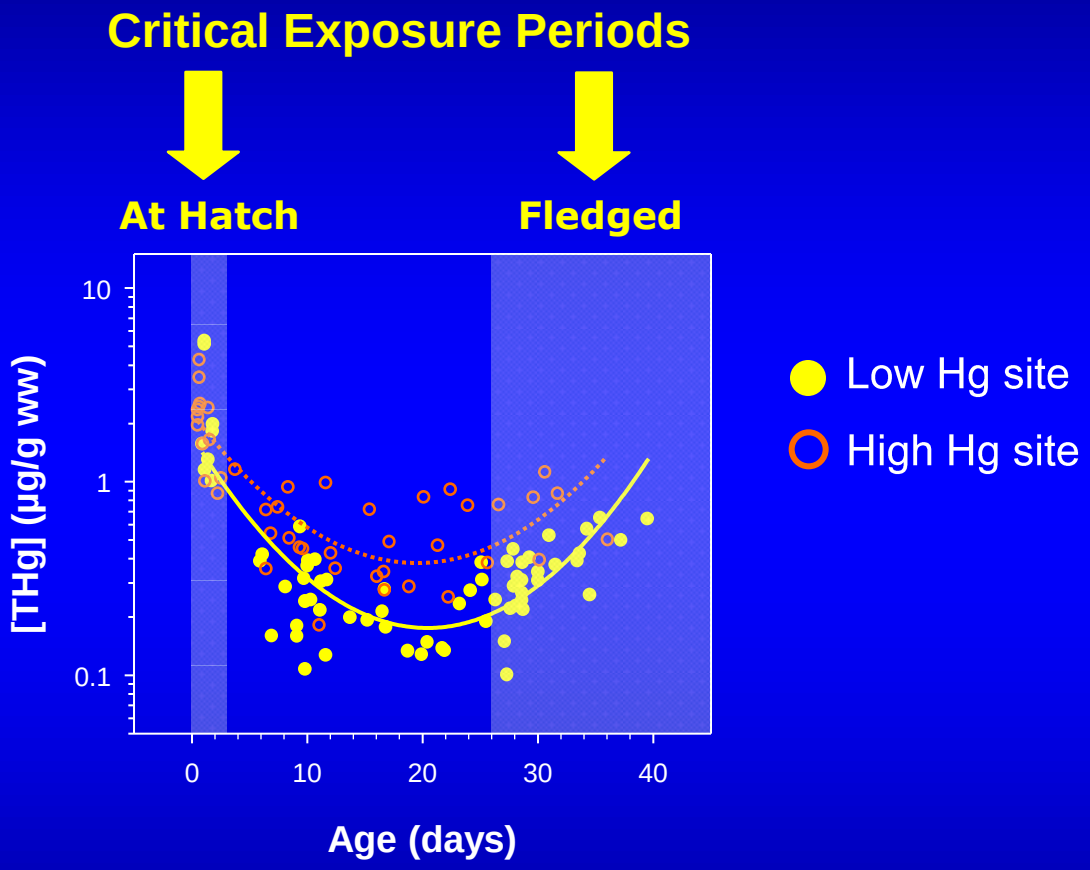
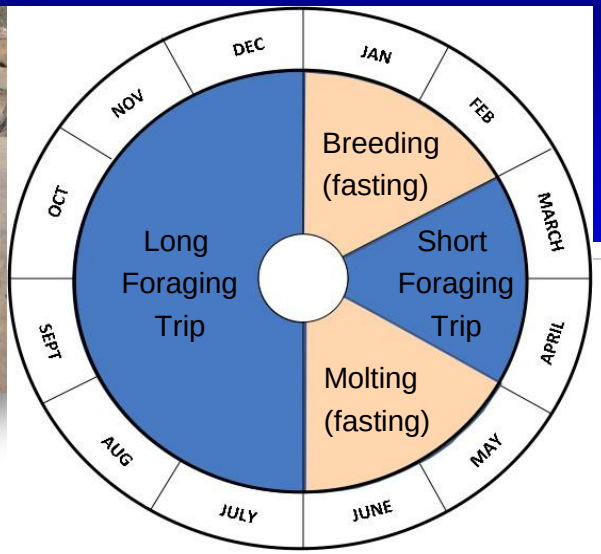
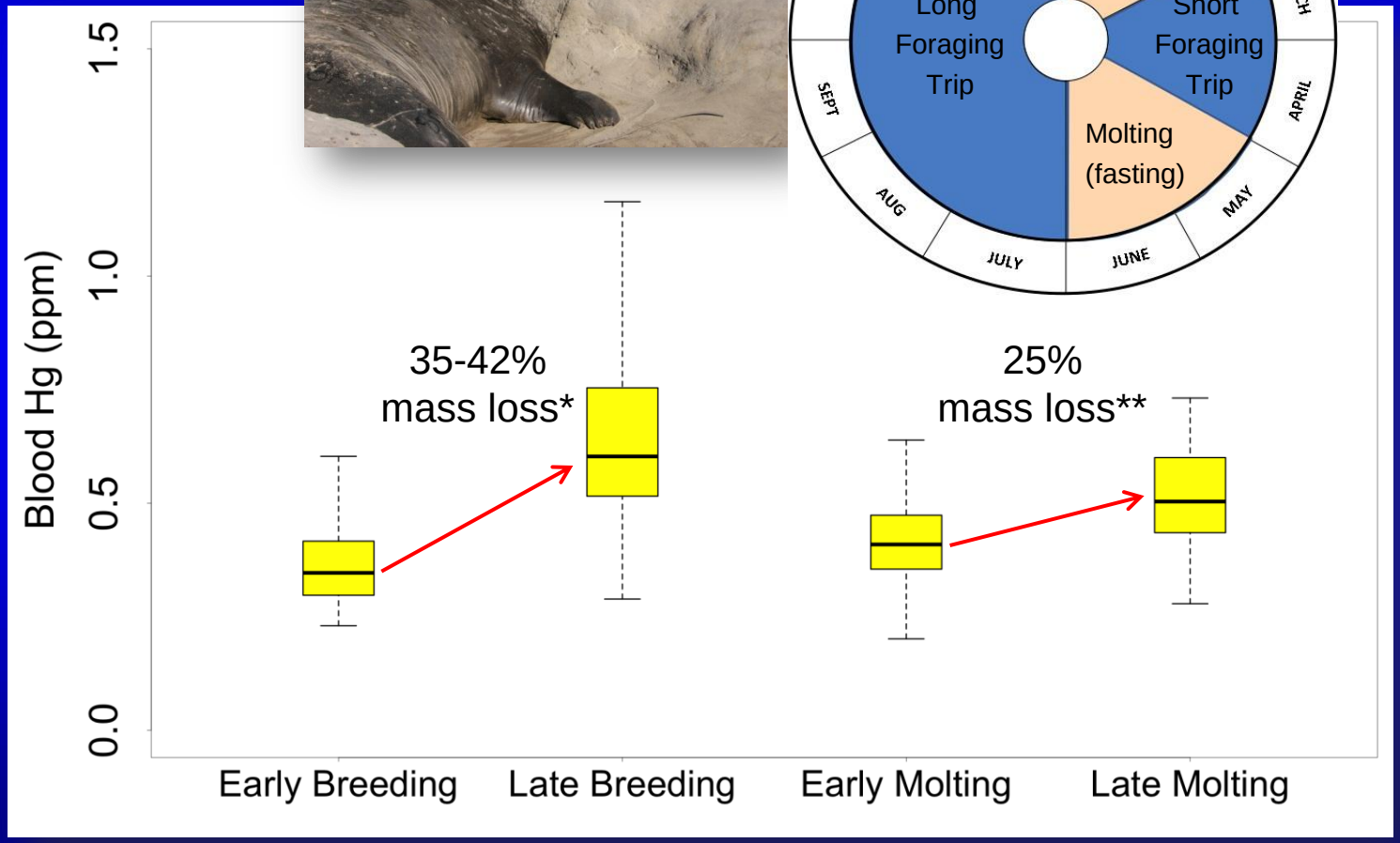


USGS science for a changing world

Ackerman et al. 2011

Mercury in Elephant Seals at Año Nuevo





Sarah Peterson, PhD Candidate, UC Santa Cruz, Dan Costa's Lab

**Costa et al. 1986, *Crocker et al. 2001; **Worthy et al. 1992*

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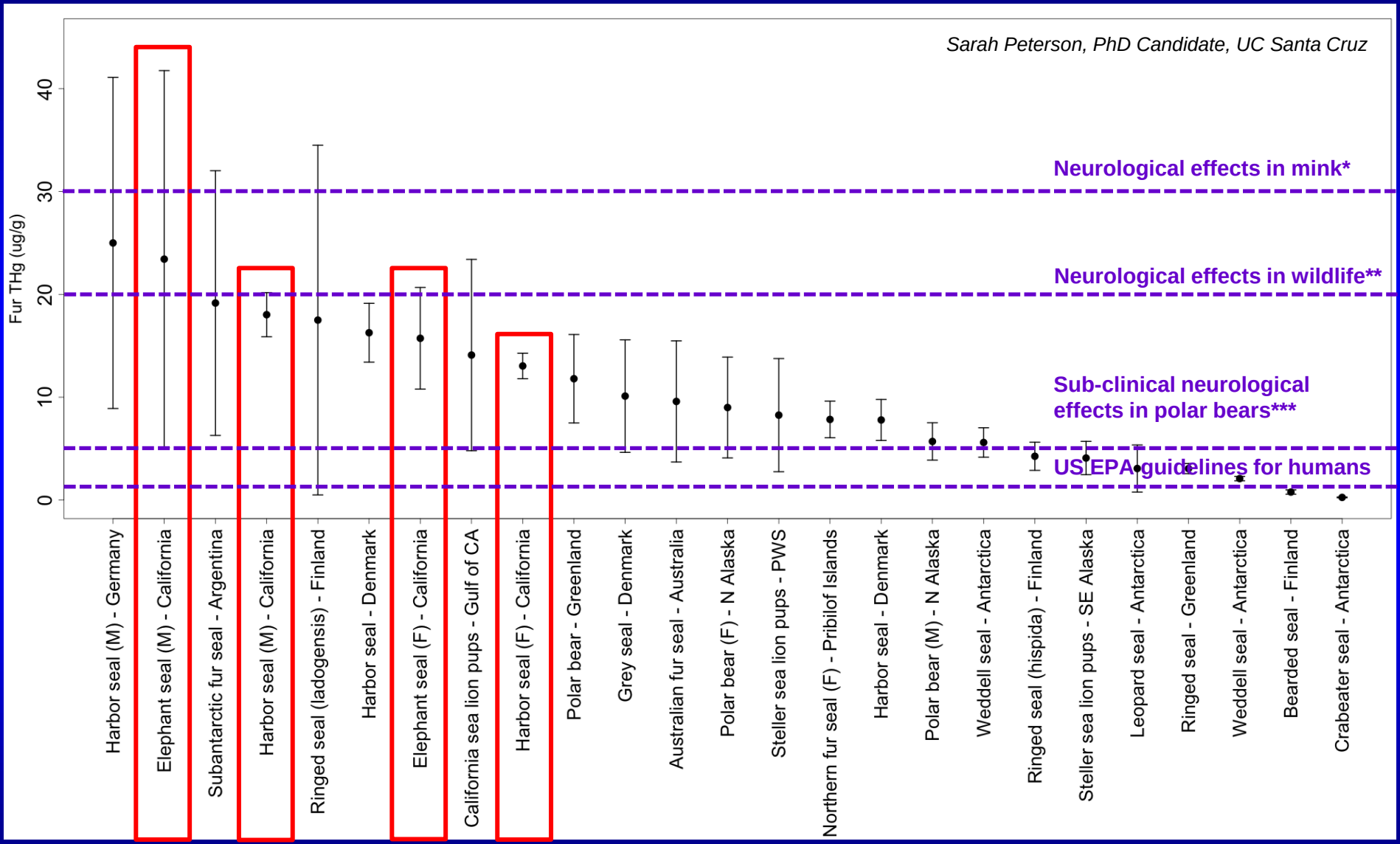
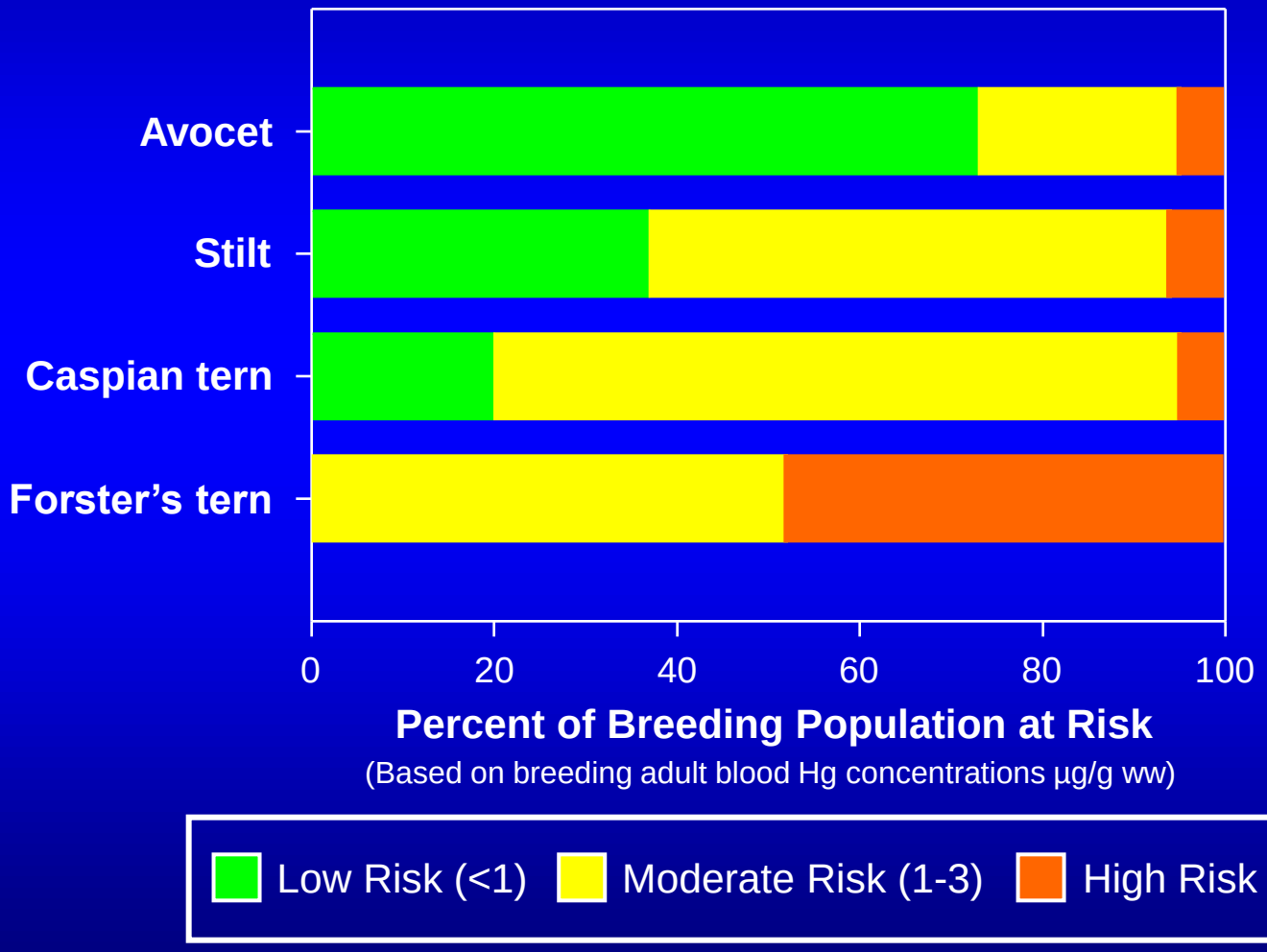
Marine Mammal Mercury Exposure along Coast



Wenzel et al 1993, Fossi et al 1997, Brookens et al 2007, Medvedev et al 1997, Aubail et al 2011, Elorriaga-Verplancken et al 2008, Dietz et al 2011, Bacher 1985, Cardona-Marek et al 2009, Castellini et al 2012, Gray et al 2008, *Basu et al 2007, ** Thompson et al 1996, ***Basu et al 2009

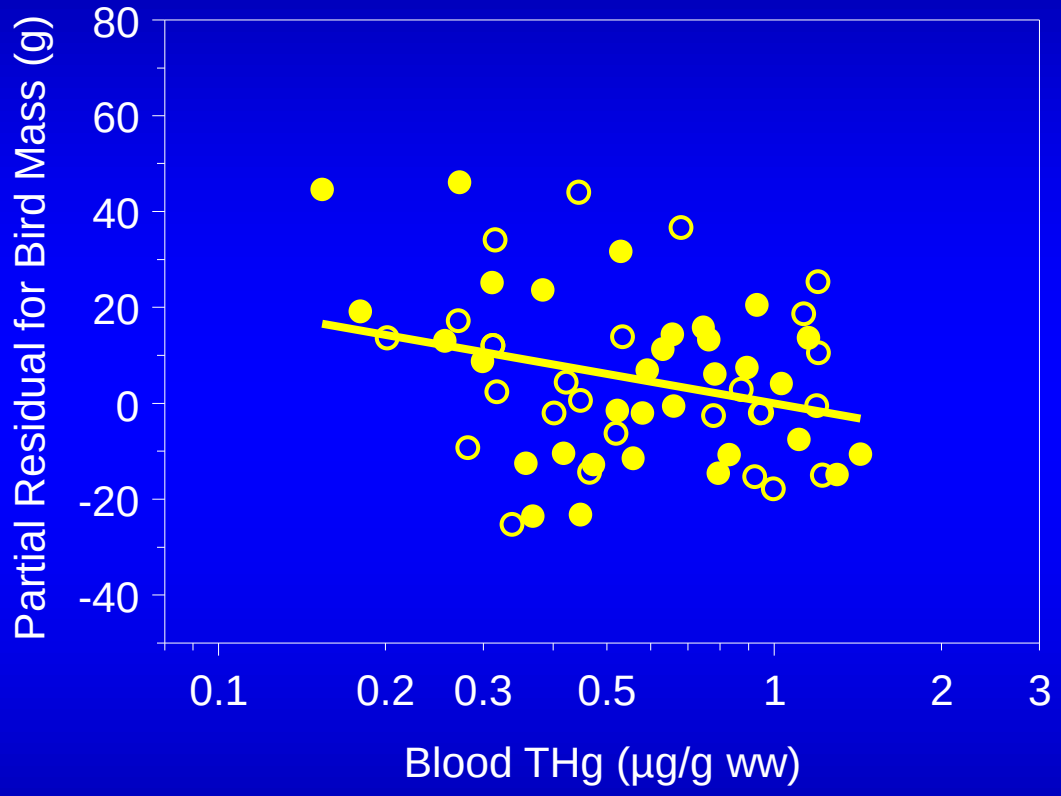
Percent of Breeding Population at Risk to Mercury Toxicity



USGS science for a changing world

Eagles-Smith et al. 2009

Mercury in Endangered Clapper Rails: Reduced Body Mass



Females
Males

Body Mass Loss Of:

20-22g

5-6% for males

6-7% for females

USGS science for a changing world

Ackerman et al. 2012

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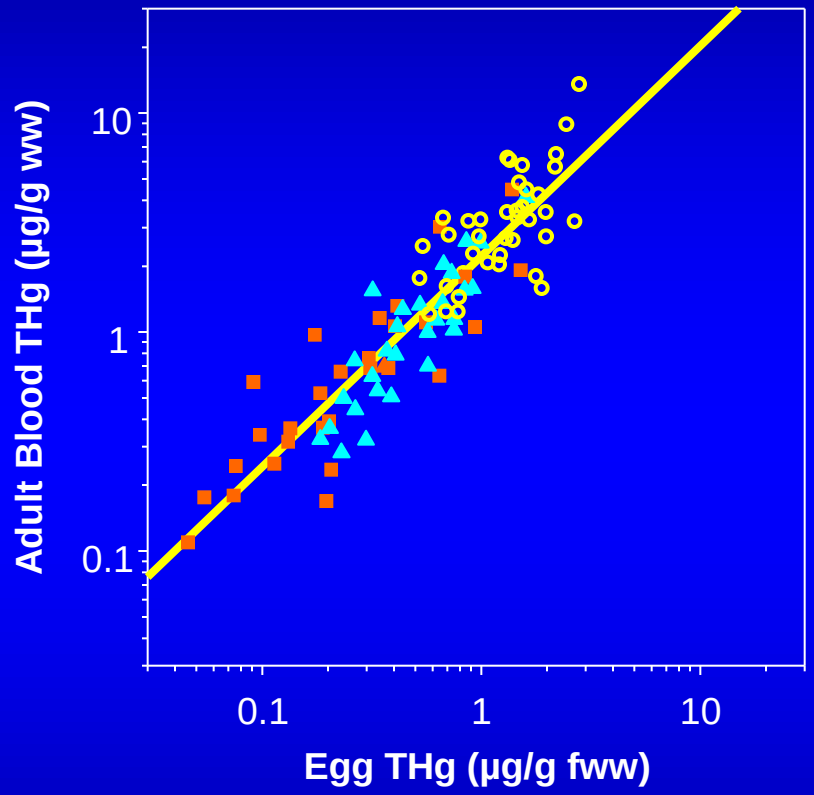
Maternal Transfer of Mercury



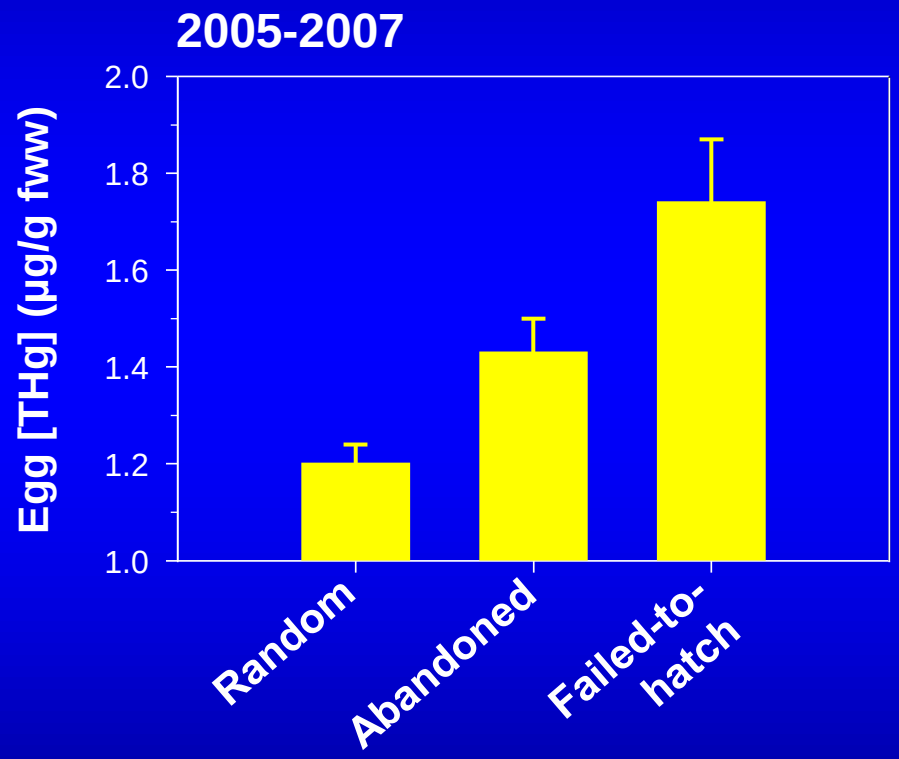
P<0.0001
R^2=0.83
N=99 clutches & parents

- Terns
- Stilts
- Avocets

Ackerman, USGS unpublished

USGS science for a changing world

Mercury Highest in Failed-to-Hatch Tern Eggs



P*<0.001

$F_{2,341}$=13.58

N=52 failed eggs in successful nests

*Statistically controlled for effects of colony site and year

Ackerman, USGS unpublished

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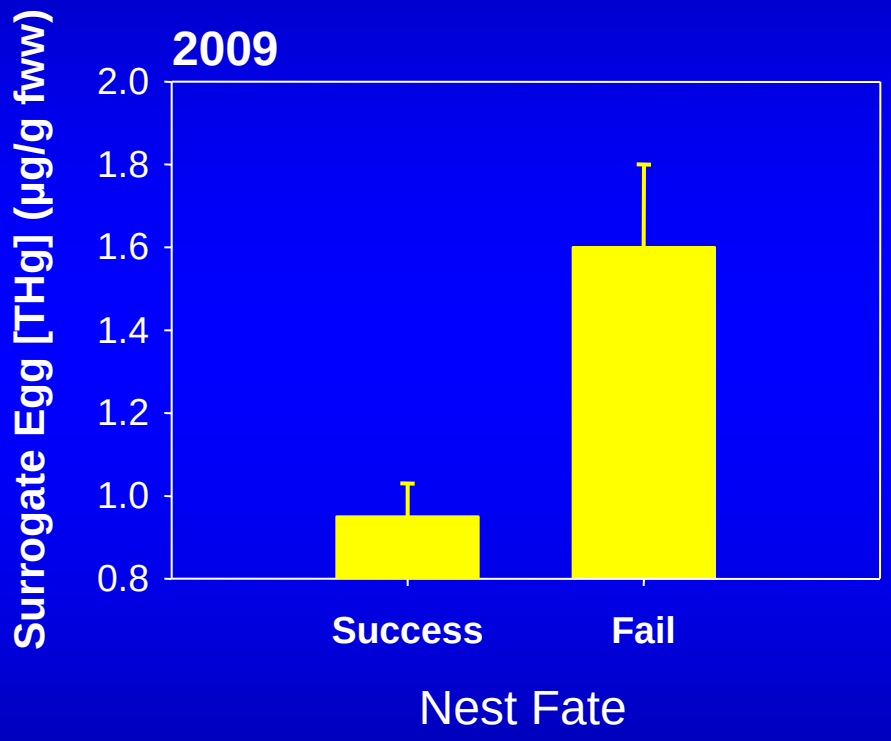
Mercury Highest in Random Eggs Collected from Nests that Subsequently Failed



P*<0.0004

$F_{1,81}$=13.79

N=24 failed eggs in successful nests

*Statistically controlled for effects of colony site

Ackerman, USGS unpublished

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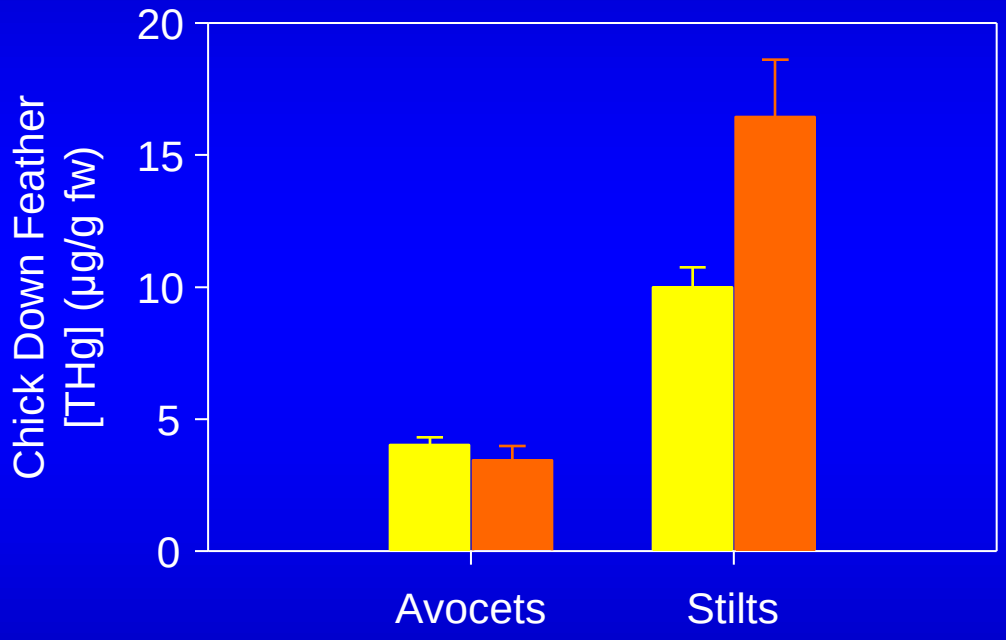
Effects of Mercury on Shorebird Chick Mortality at Hatching



Newly Hatched

Live chicks

Dead chicks

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Ackerman et al. 2008

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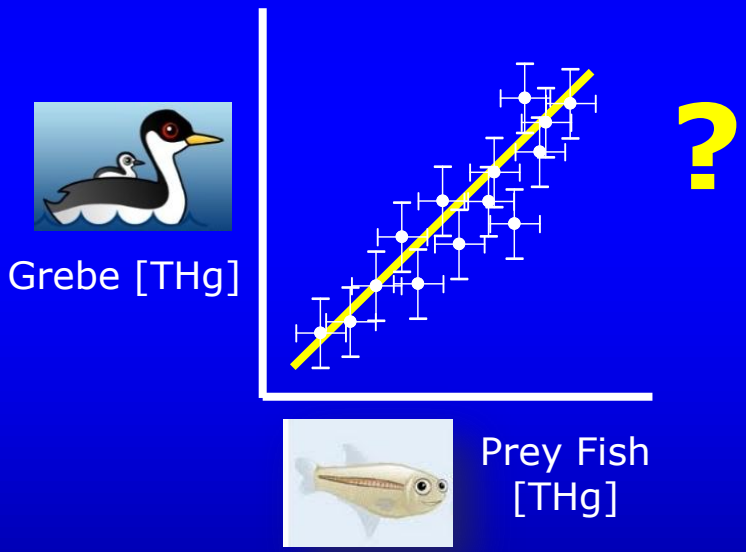
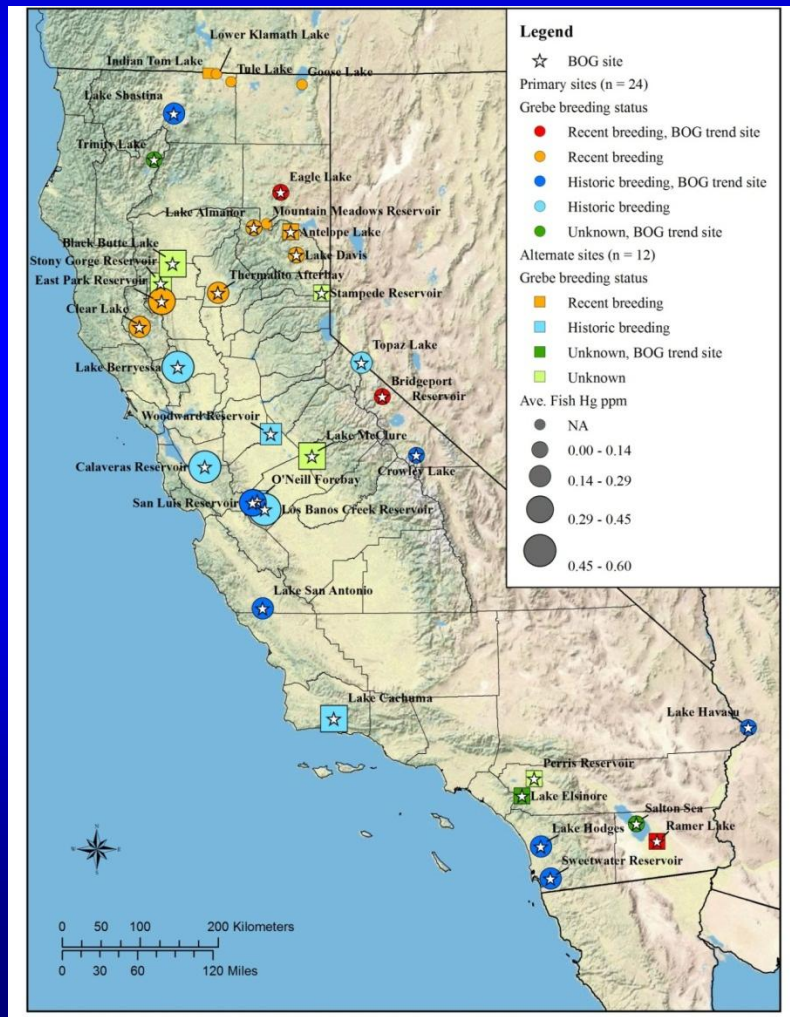
Current BOG Research on California Wildlife

-Incorporate Mercury Risk to Wildlife into BOG Monitoring
-Using Biomagnification Factors from Prey Fish to Grebes





USGS science for a changing world

Summary

- Hg is prevalent in California wildlife throughout regions
- Location and timing are main drivers of Hg exposure
- Many wildlife have Hg levels near or exceeding known toxicity levels
- Hg shown to currently be impairing reproductive success of birds nesting in SF Bay
- Mercury monitoring programs should include wildlife sampling; bird eggs and blood are most useful tools