Mercury Bioaccumulation and Effects on Avian Reproduction

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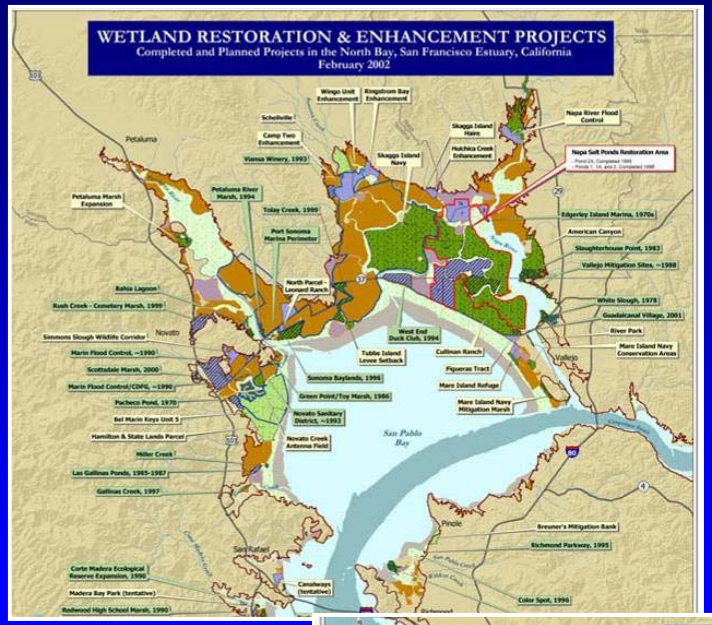


Extensive Wetland Restoration Along San Francisco Bay Margins

Wetlands are known Methyl Hg producers:

- How will restoration efforts alter Methyl Hg dynamics in Bay and Delta?
- Implications for wildlife?

Wildlife Sensitive to Methyl Mercury Toxicity

- Central nervous system effects
  - Altered behavior
  - Impaired vision, hearing, and motor skills
- Endocrine effects
- Reduced breeding effort
- Embryo death
- Embryo deformities
- Chick death

Forster's Tern Nest

MeHg Reduces Reproductive Success

Objectives

1. Spatial and temporal patterns in adult mercury
2. Space use and foraging patterns
3. Spatial and temporal patterns in egg and chick mercury
4. How do bird mercury concentrations relate to effects and toxicological risk?

Species Studied

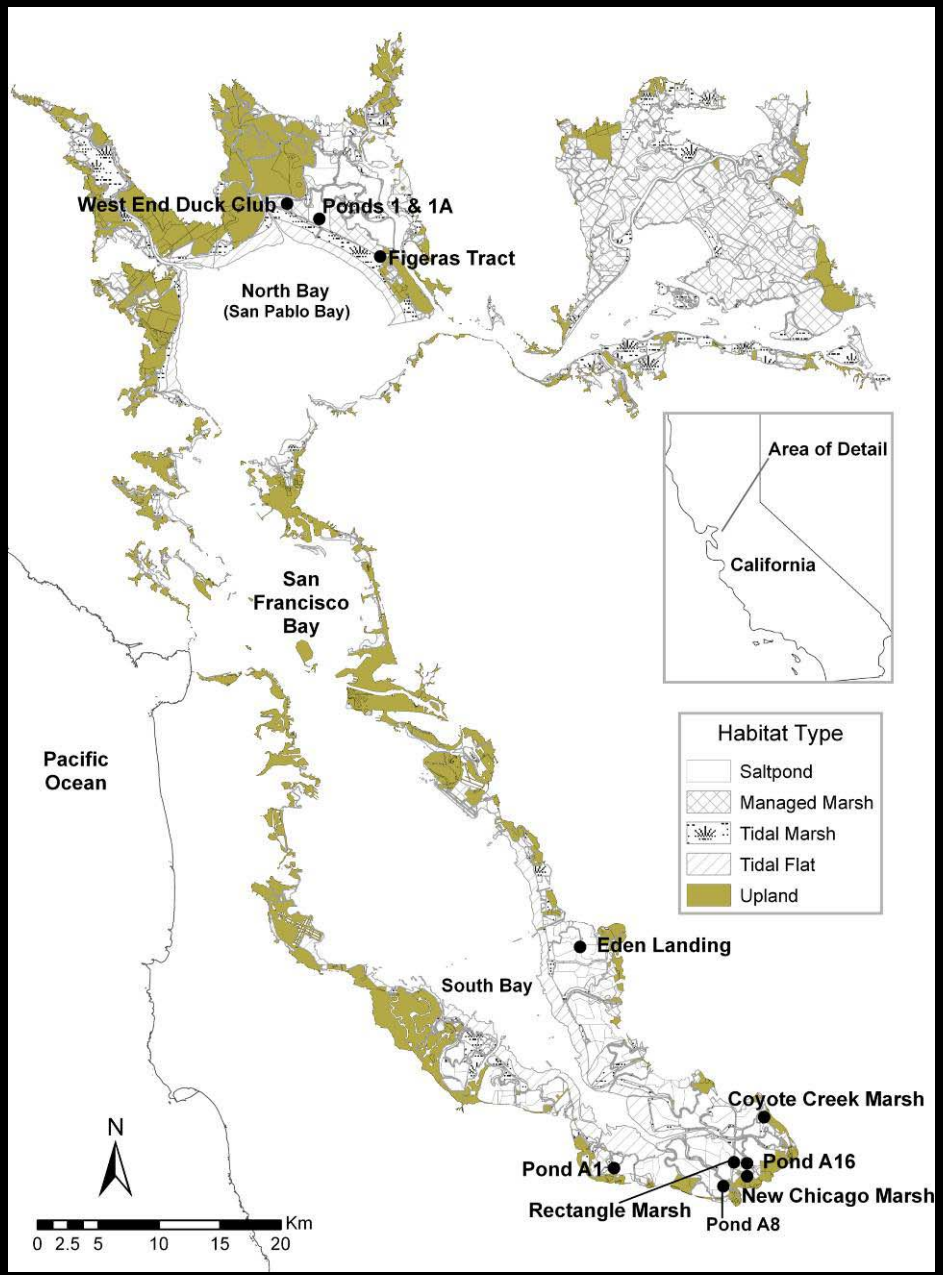
Littoral Foragers – eat insects & crustaceans

- American avocets
- Black-necked stilts

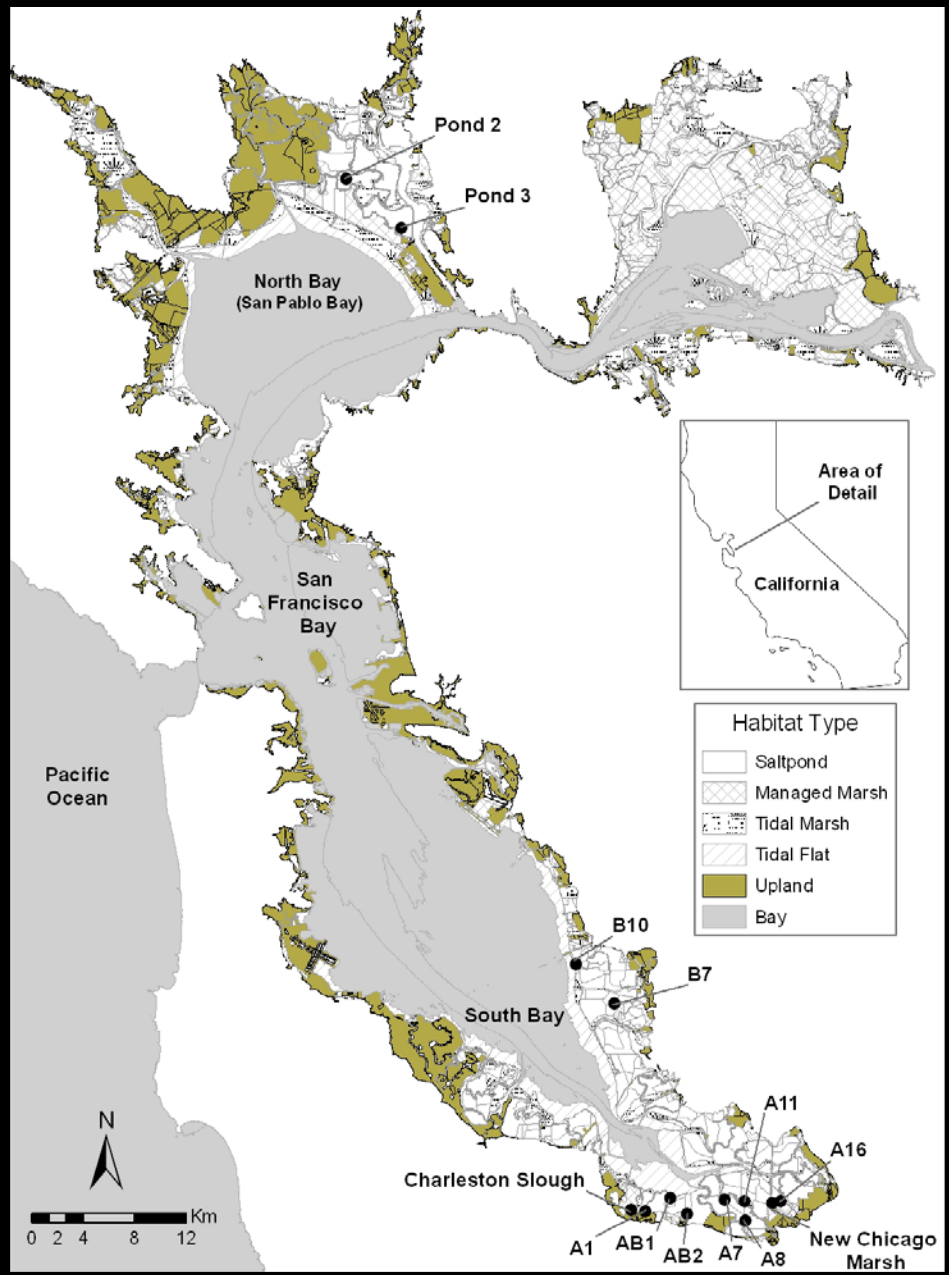
Obligate Piscivores – eat fish

- Forster's terns
- Caspian terns

Avocets & Stilts



Forster's Terns



Methods: Adult Birds

- **Birds Captured**

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- **Whole blood drawn**

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- **Released**
- **Mercury Analyzed at USGS Davis Field Station Mercury Lab**

Methods: Eggs and Chicks

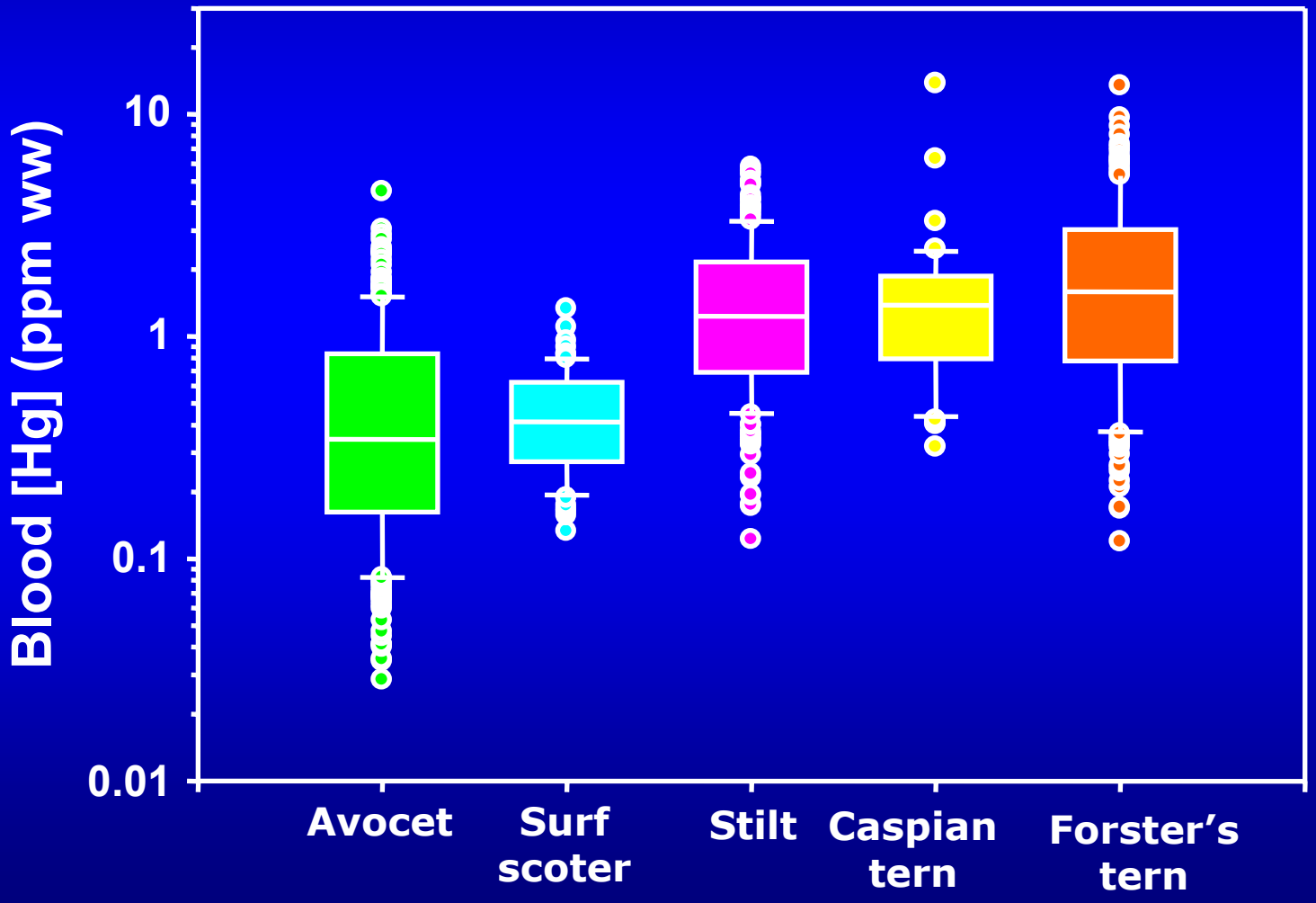
- **Nests and chicks monitored**

Results Outline

1. Large-scale patterns in bird mercury concentrations
2. Small-scale patterns in bird mercury concentrations
   - Site: differences among ponds
   - Time: season and chick age
3. Percent of bird populations at toxicological risk to mercury

Bird Mercury Concentrations

1. Mercury differed among species



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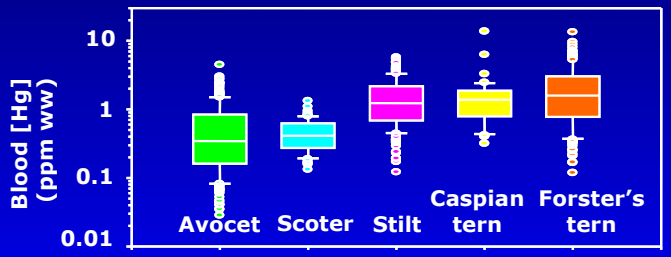
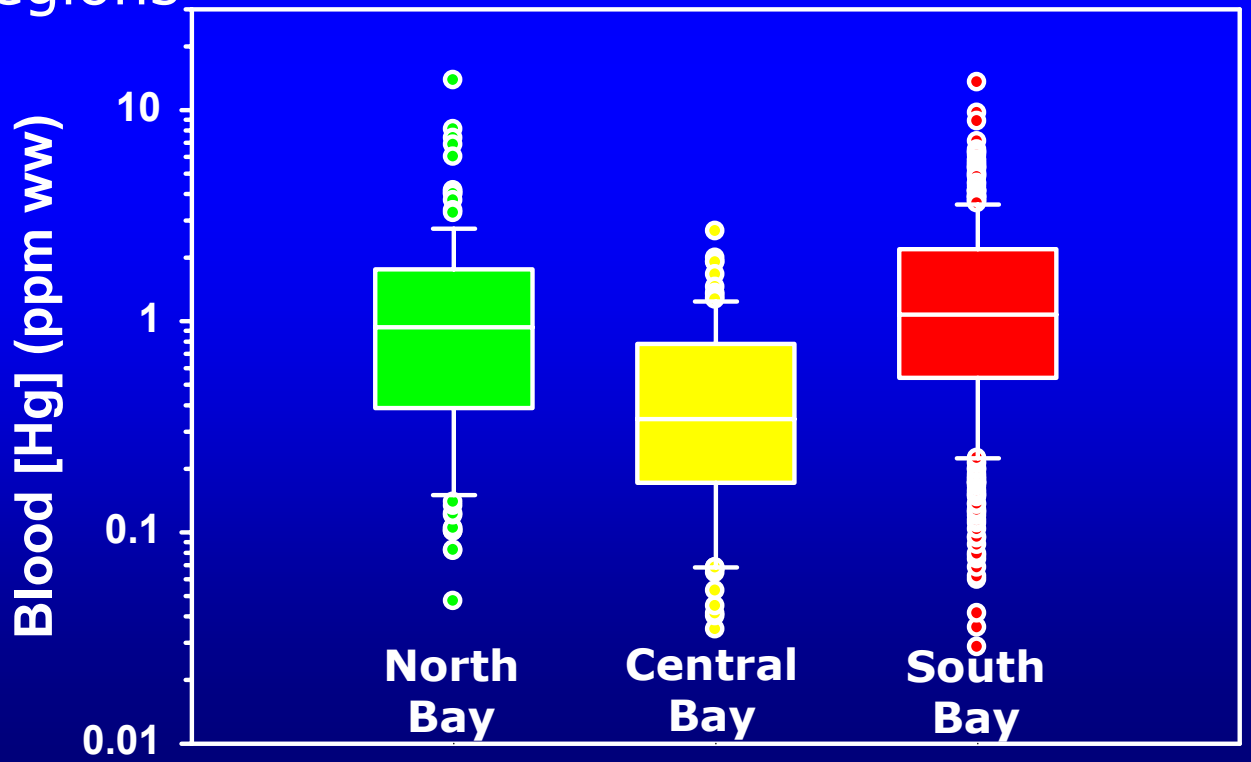


P<0.0001

2. Mercury concentrations differed among regions



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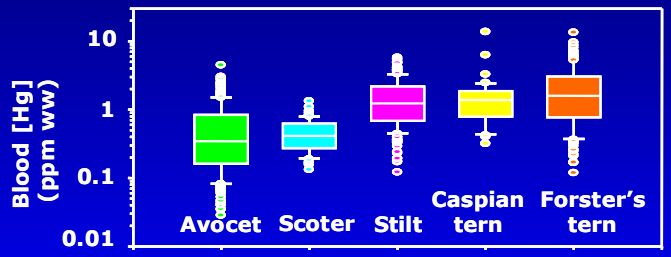

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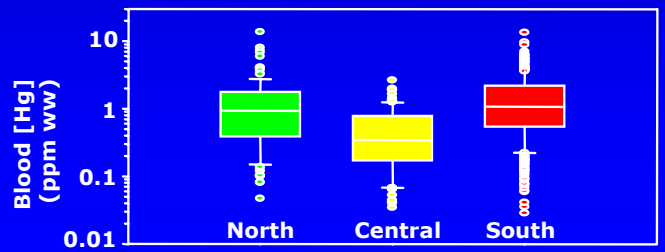

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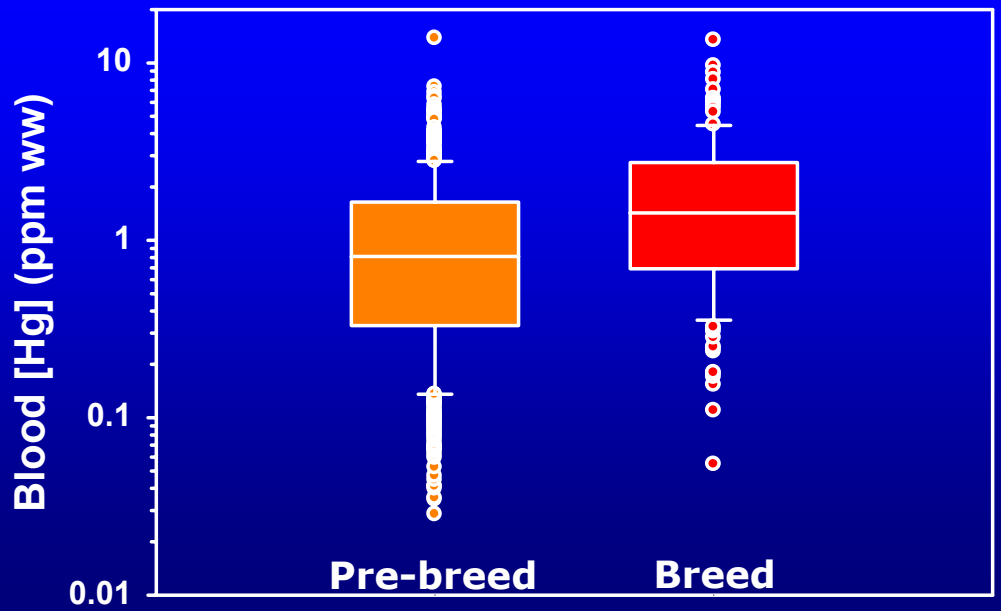
3. Mercury differed by breeding status



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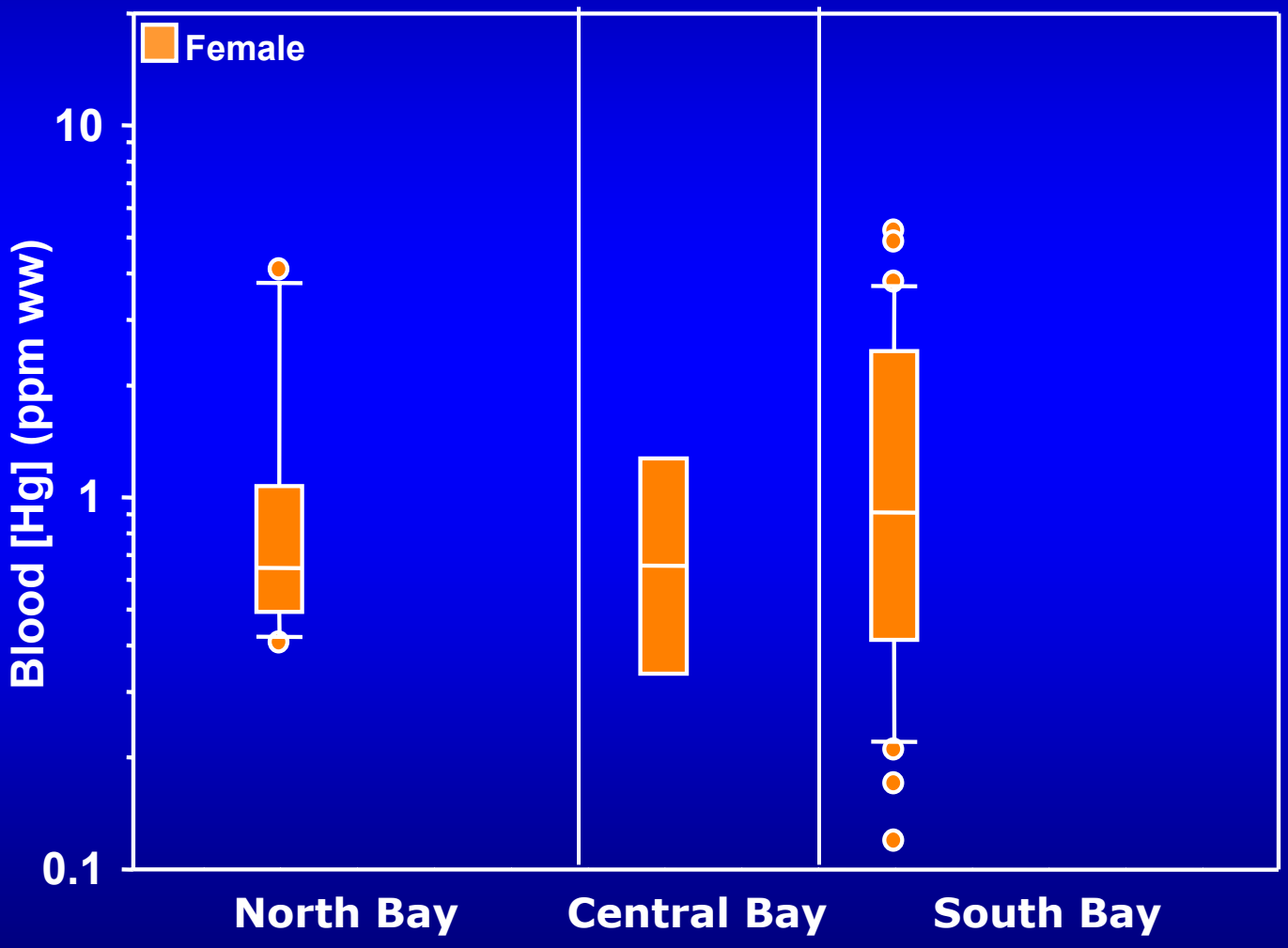
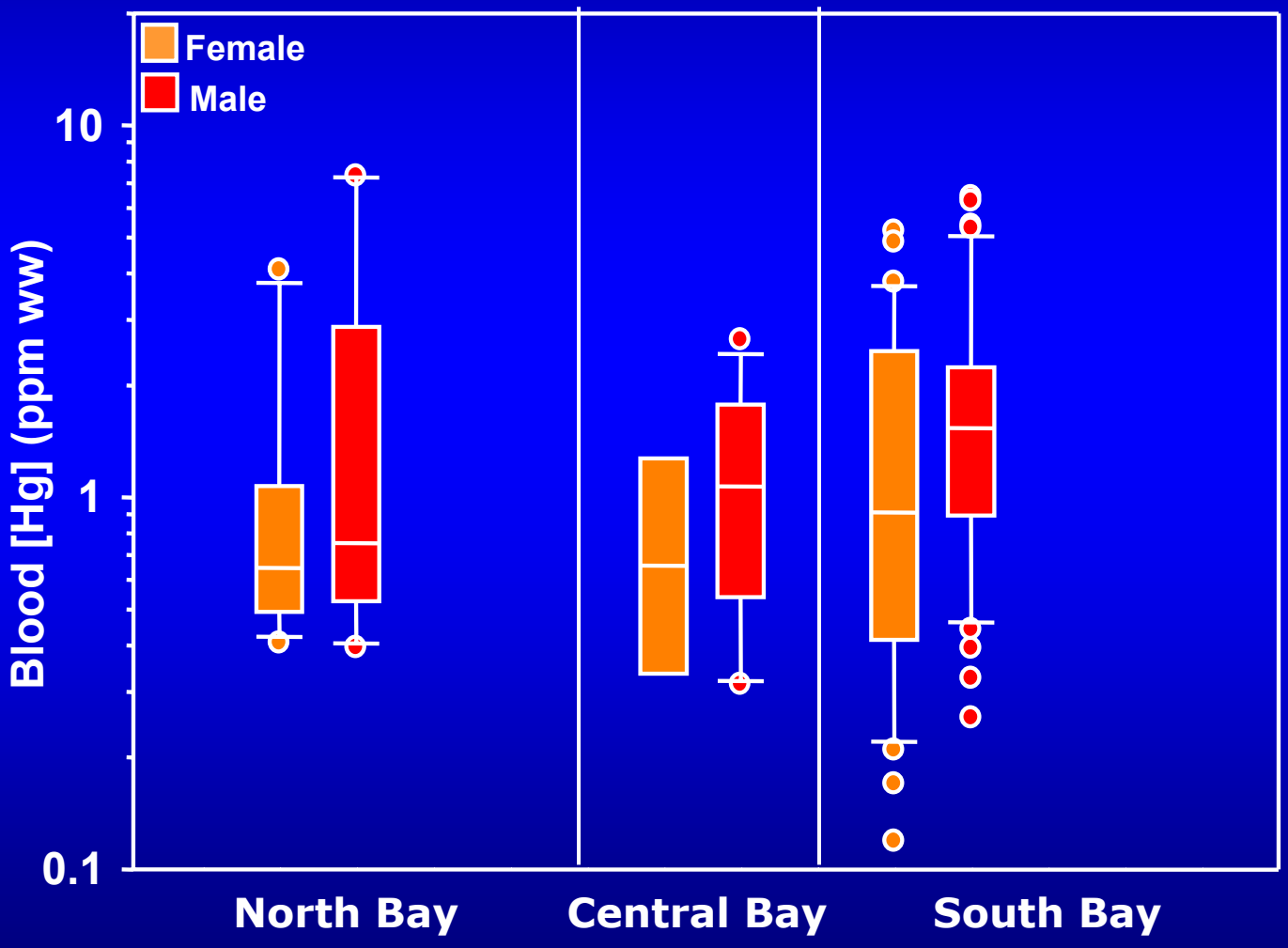
Forster's Terns



North Bay > Central Bay < South Bay (P = 0.03)

Forster's Terns

Male Hg > Female Hg
(P = 0.003)



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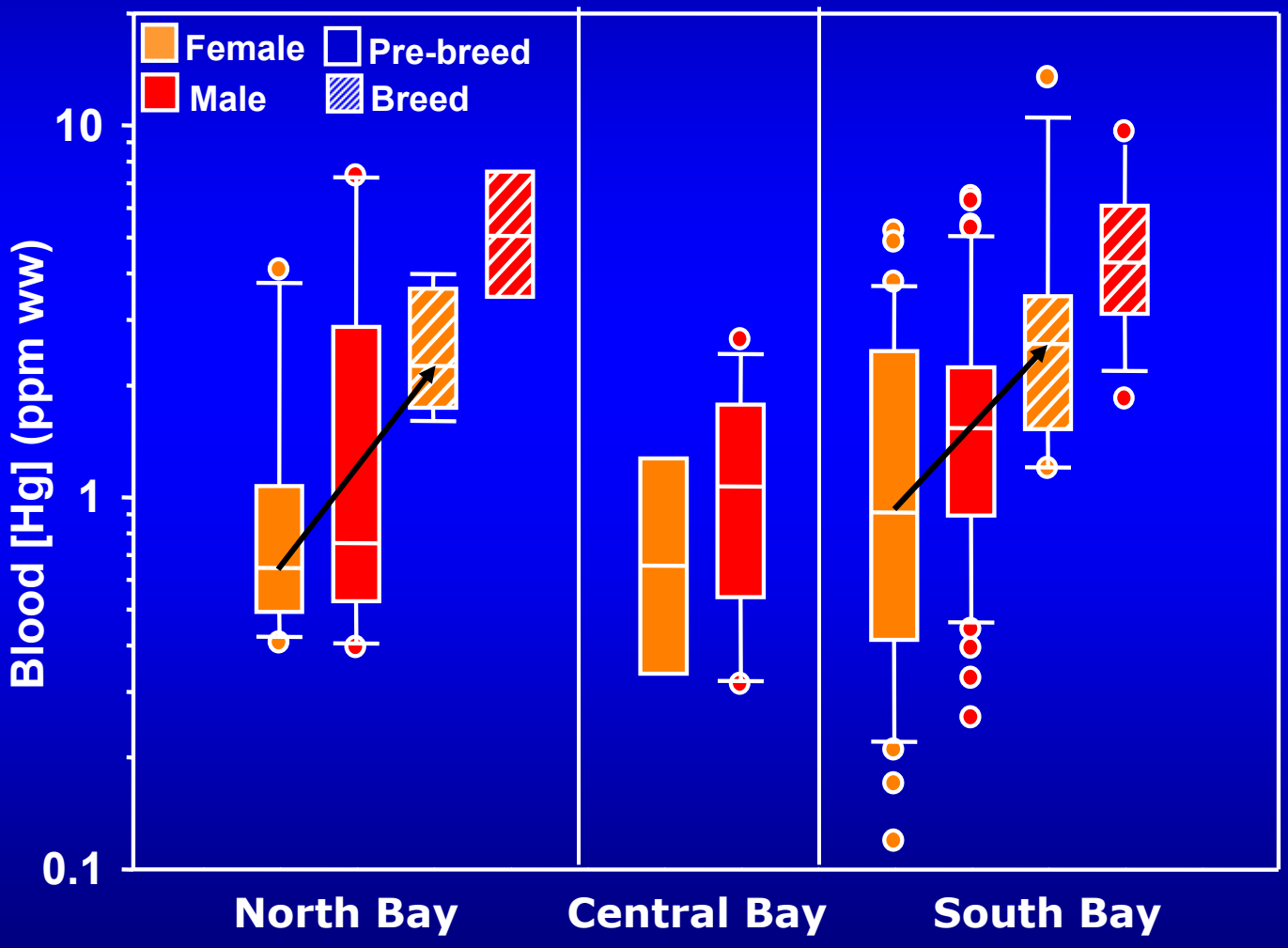
Male Hg > Female Hg (P = 0.003)

Breeding > Pre-breeding (P < 0.0001)



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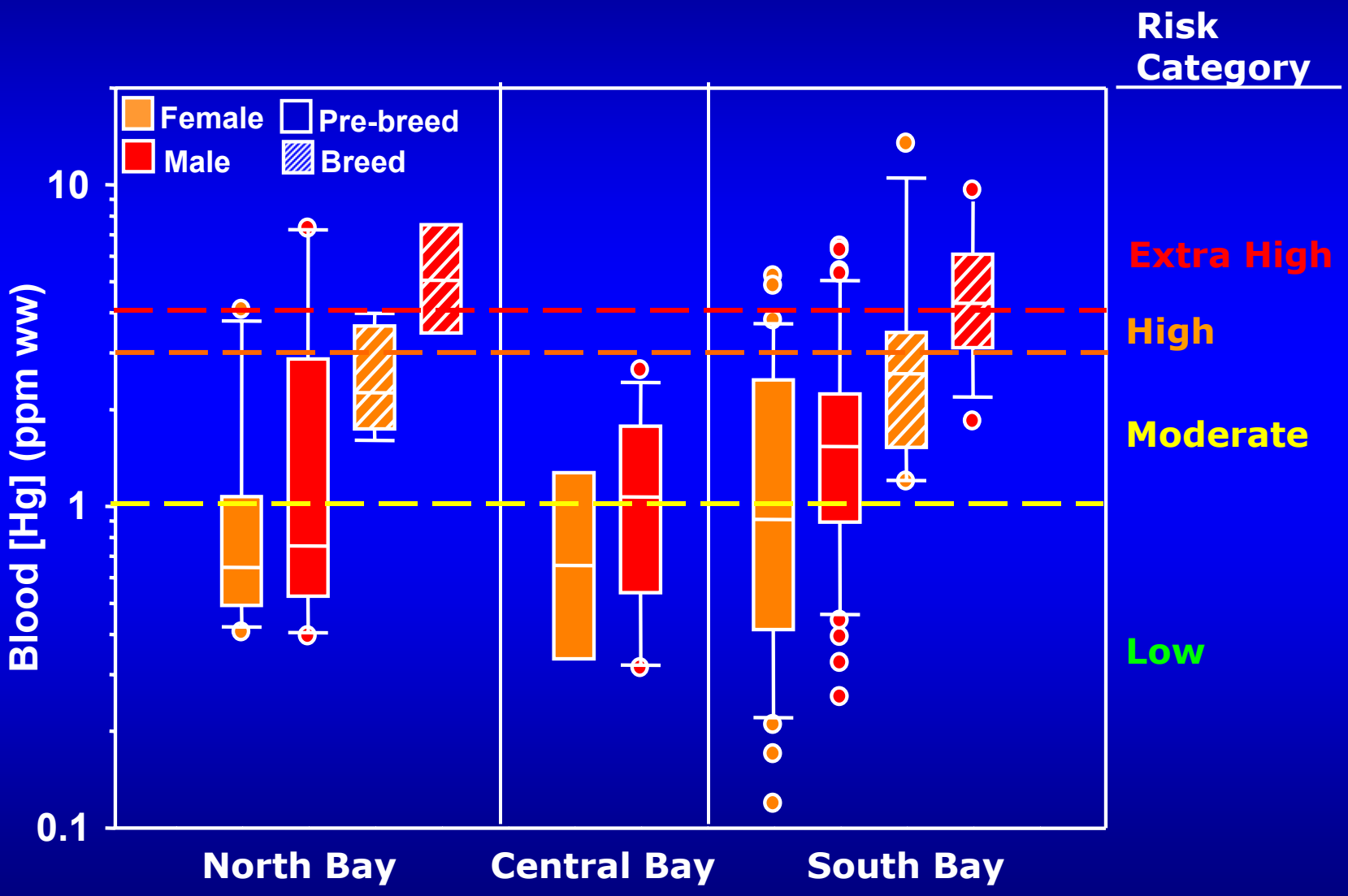

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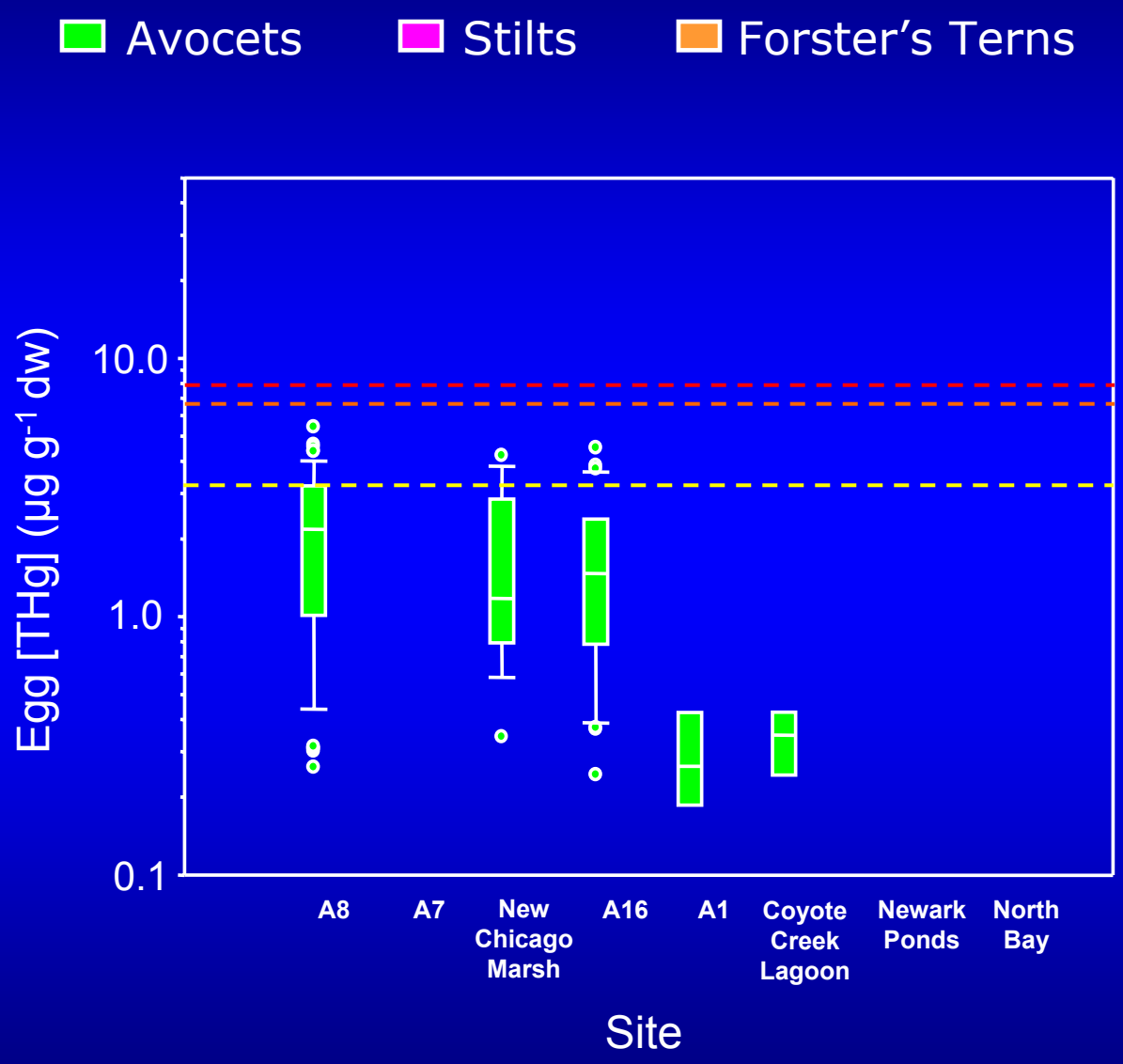
Mercury by Site: Eggs



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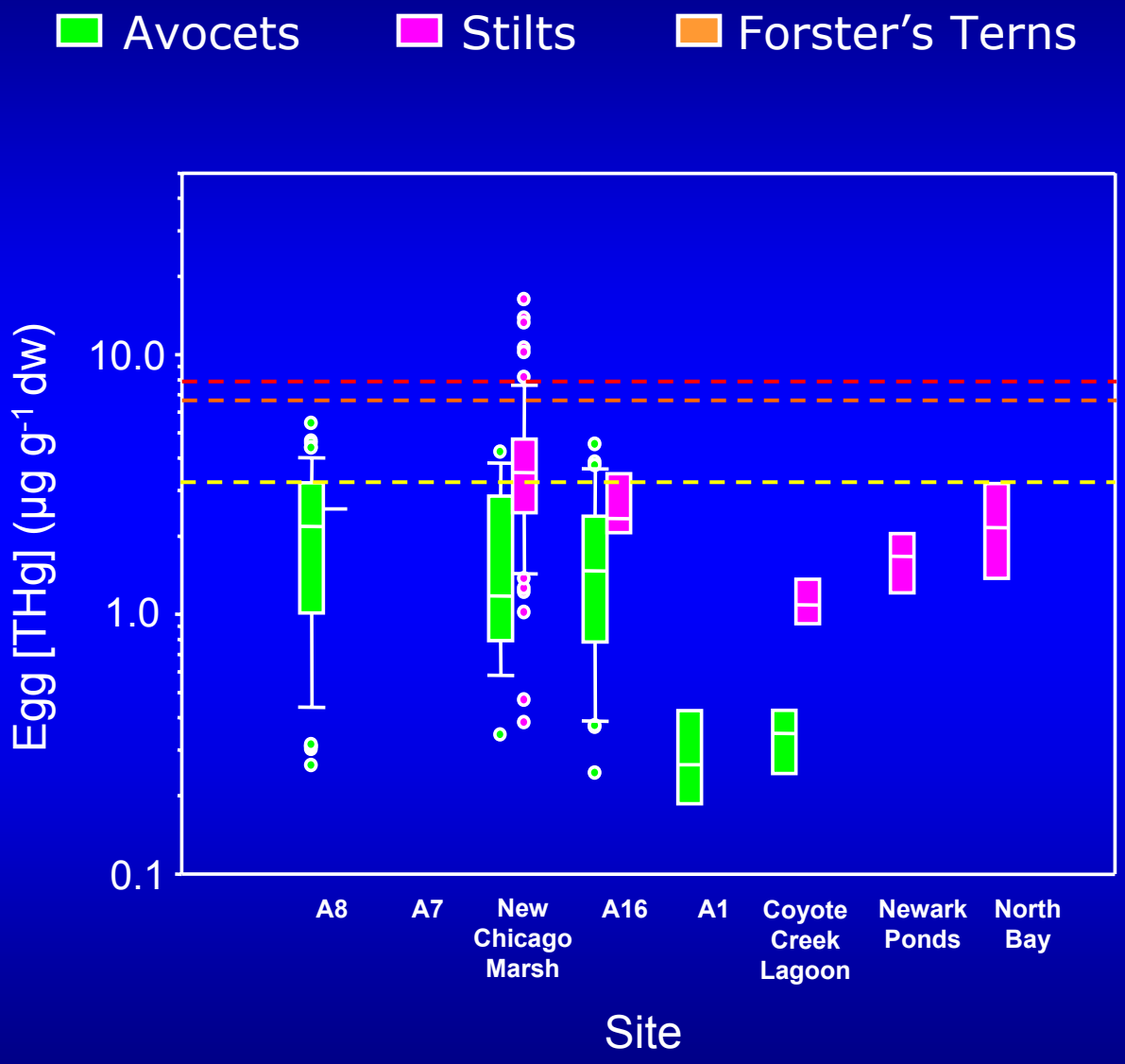

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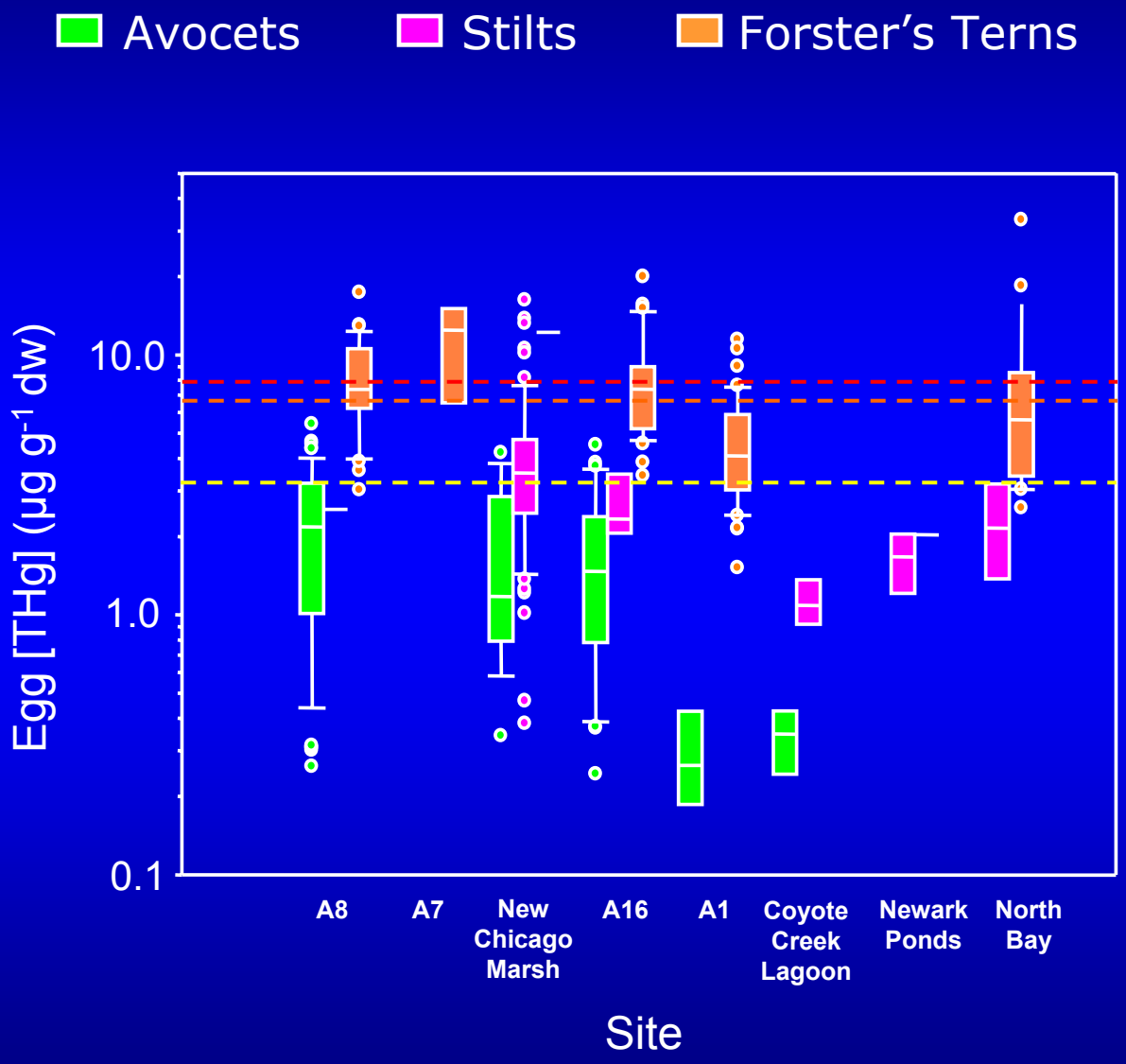

Why Do Bird Mercury Concentrations Differ Among Species and Sites?

- **Bird space & habitat use**
- **Bird-specific diet**
- **Bird prey mercury concentrations (aquatic invertebrates & fish)**
  - **at specific foraging sites**

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Avocets 2005

South
San Francisco Bay

Stilts 2005

South

San Francisco Bay

Telemetry Locations and Core Areas

Eden Landing 50% UD

New Chicago Marsh 50% UD

Habitat Types

Saltpond

Managed Marsh

Tidal Marsh

Tidal Flat

Upland

Forster's Terns 2005

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- West Alviso Locations
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Habitat Type
- Saltpond
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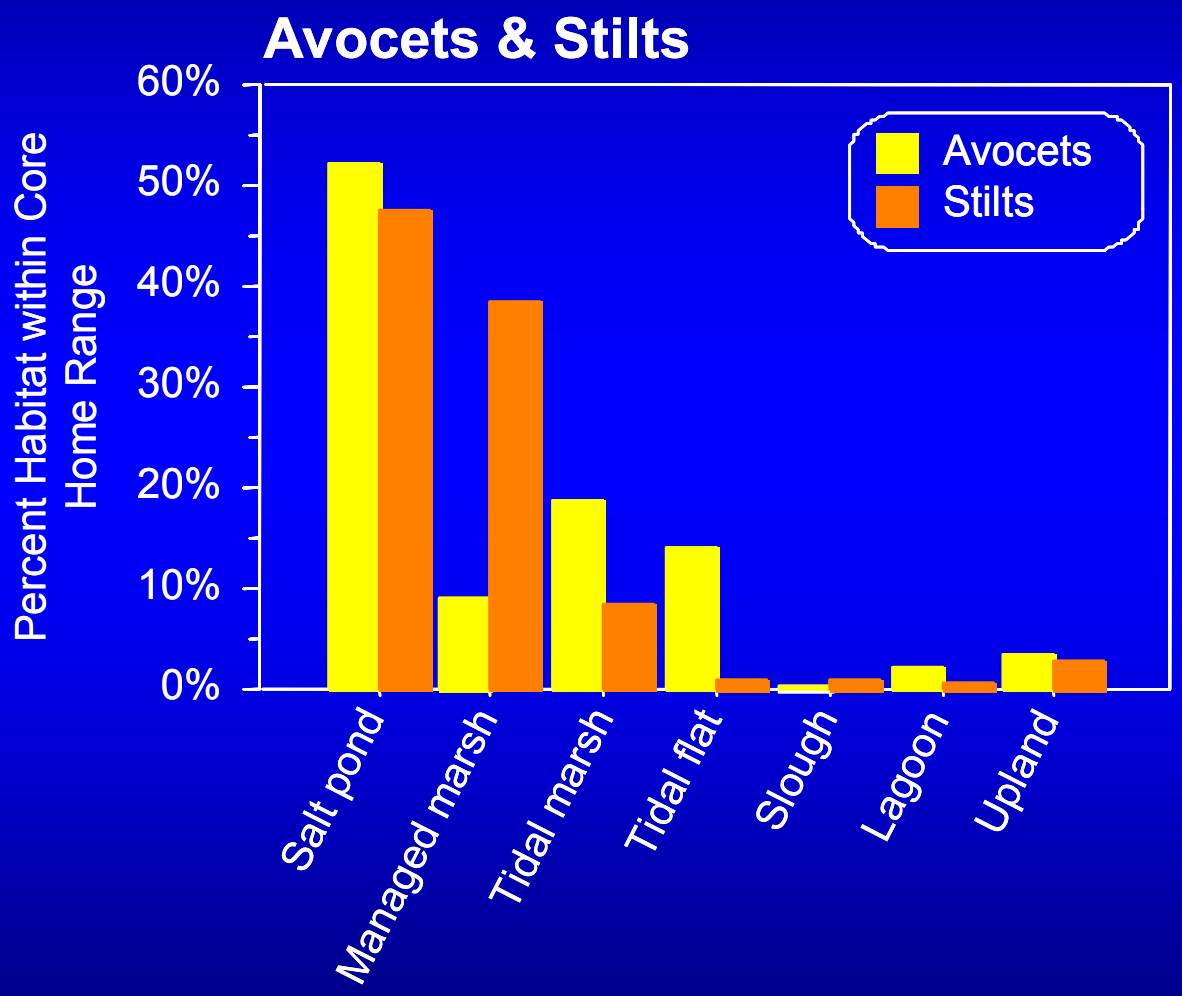
- Bay

Habitat Use by Adult Birds



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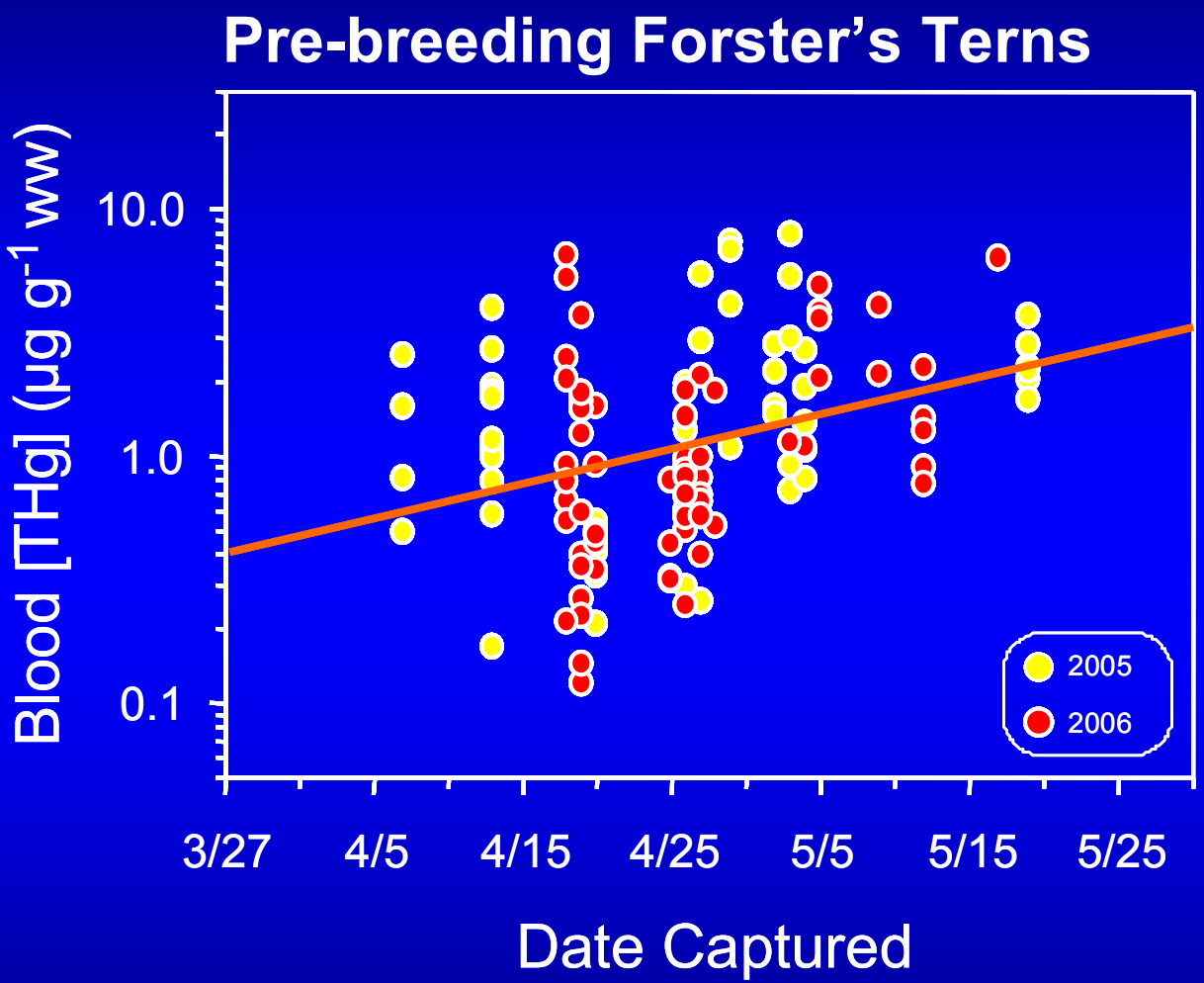

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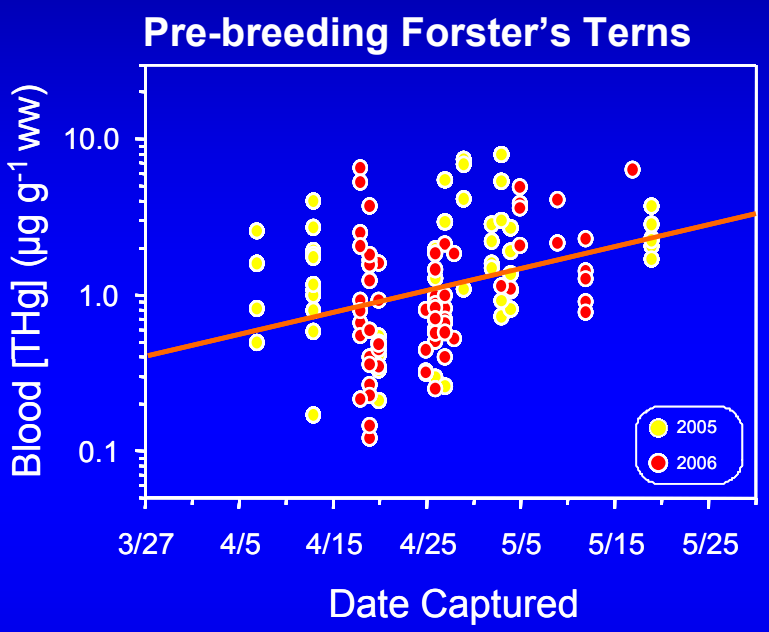
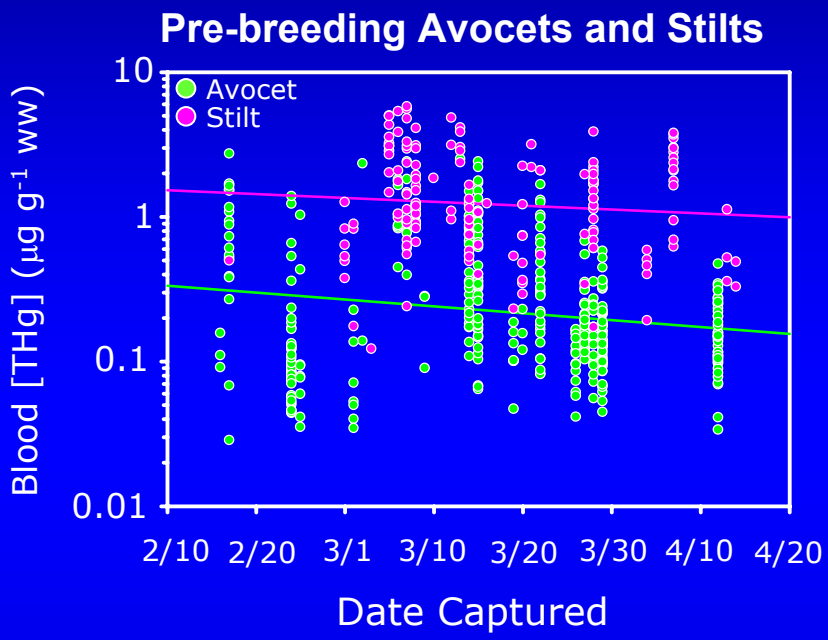
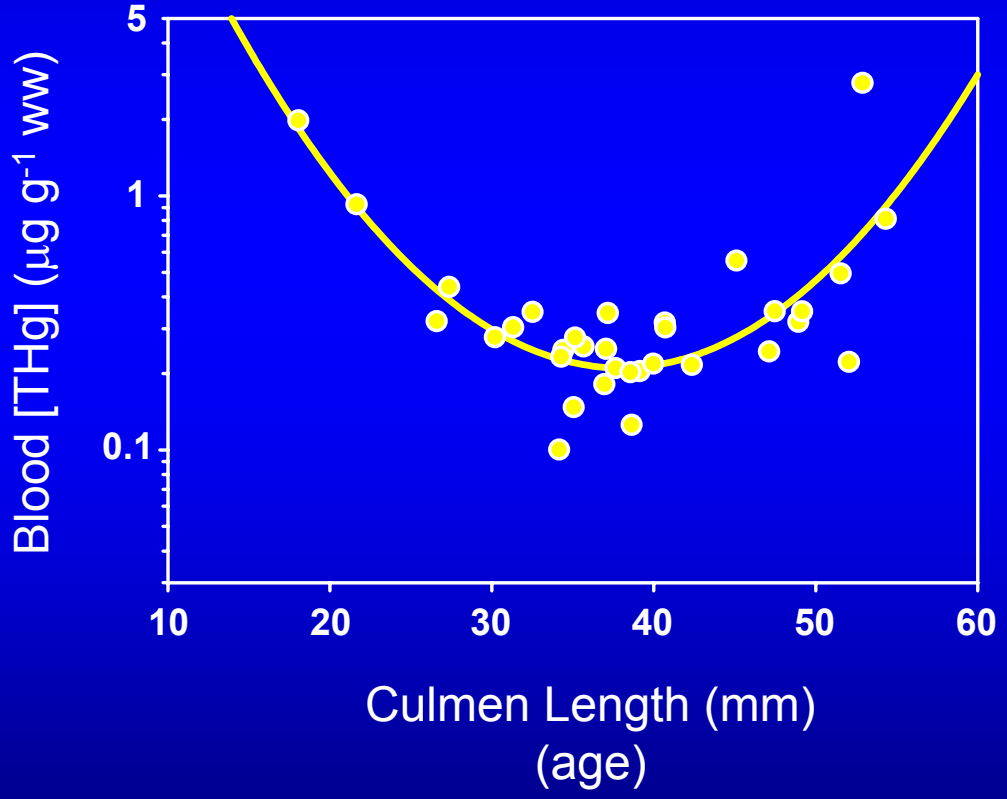




Mercury as Chicks Age: Stilts

- **New Chicago Marsh**



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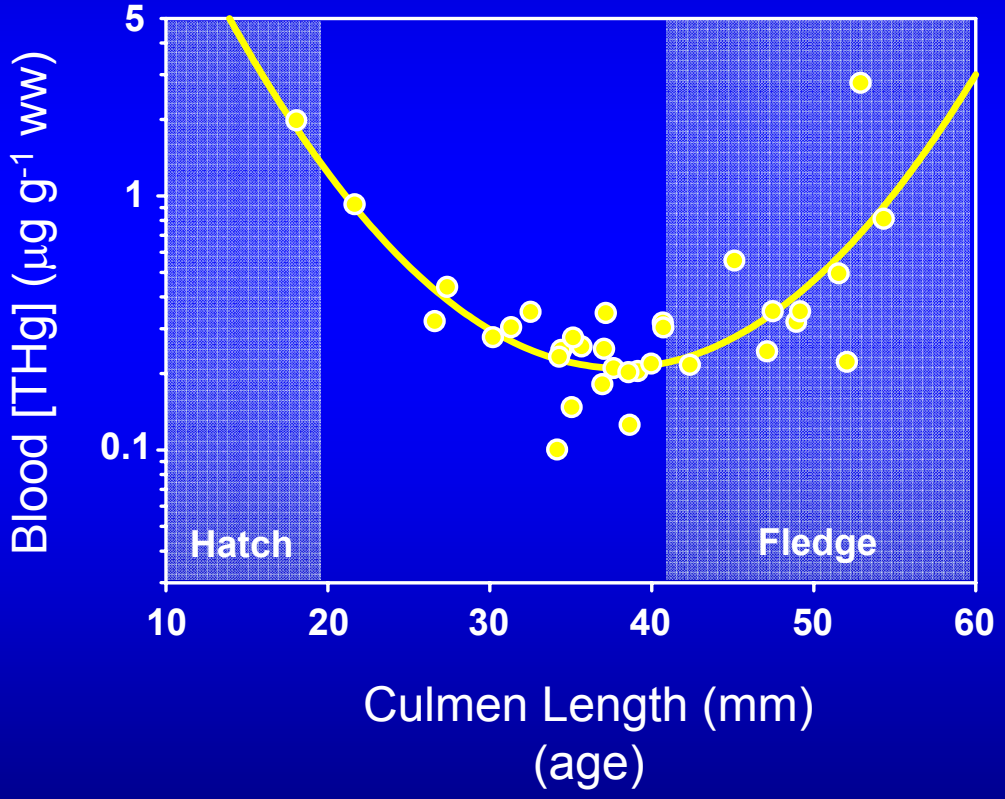

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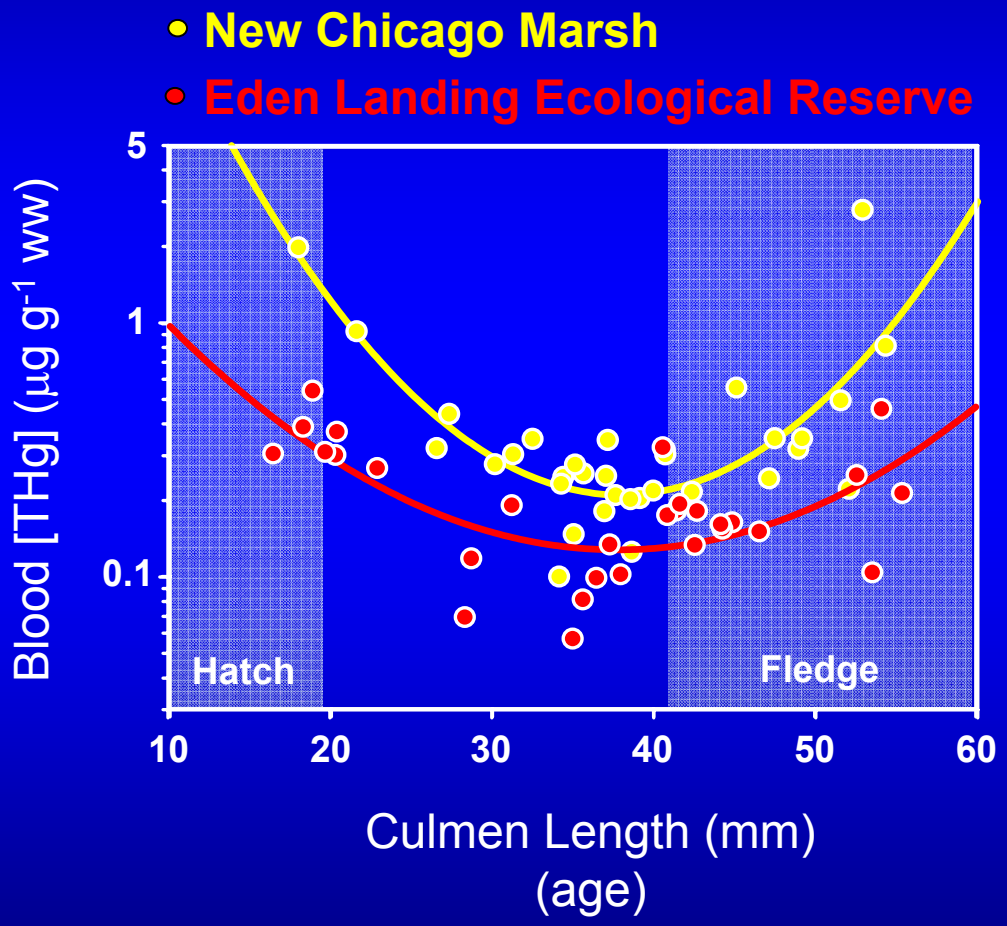
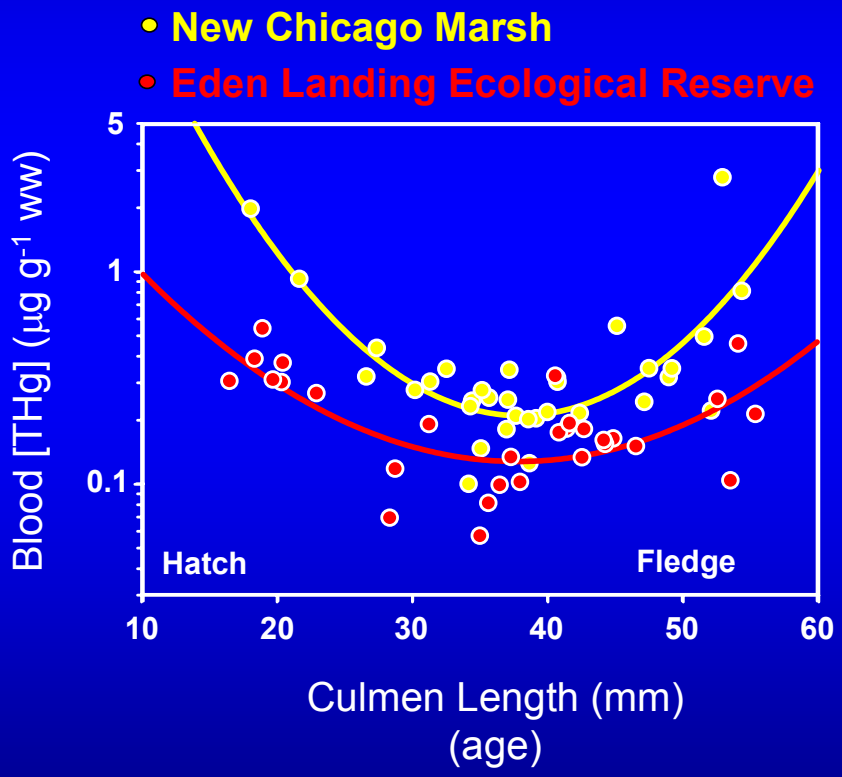
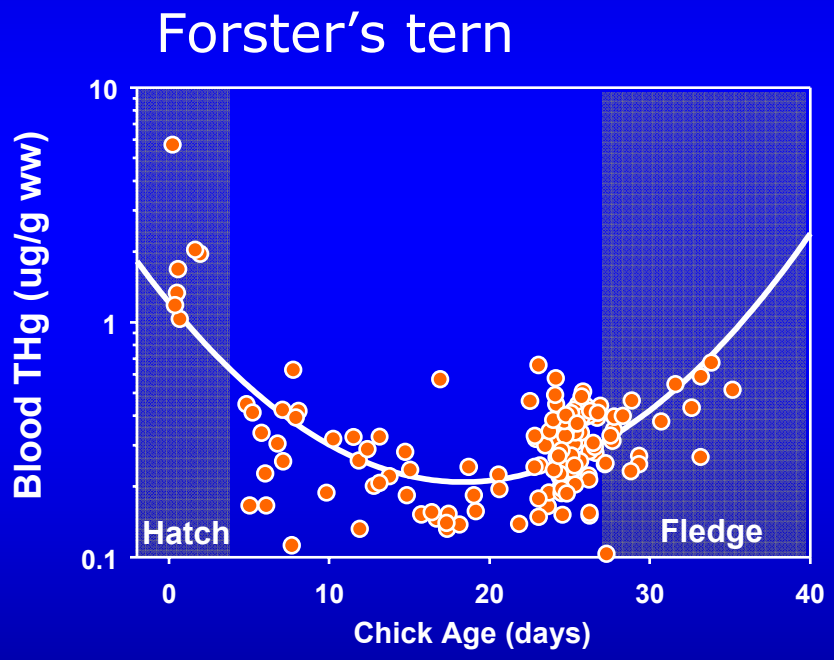


Mercury as Chicks Age: Stilts and Terns





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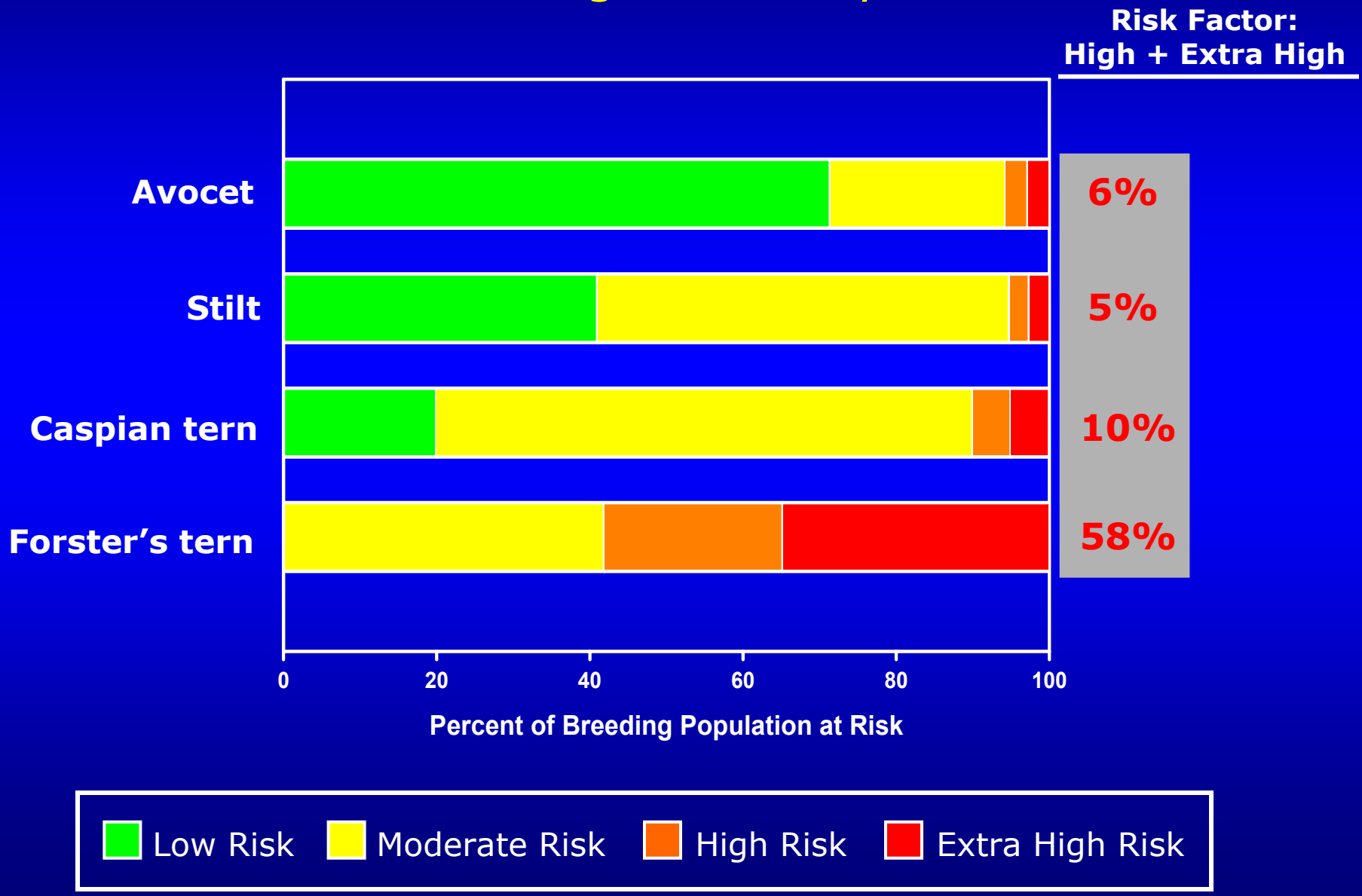
What Does this Mean for Birds? Risk Factor Analysis

Based on Evers et al. 2004 (common loon) & Heinz and Hoffman 2003 (mallard)

Risk Category	Hg Concentration (ppm)		Impact
	Blood (ww)	Eggs (dw)	
Low	<1	<3.2	Undocumented; Minimal Effects
Moderate	1–3	3.2–6.8	Potential Effects; Reduced Egg Hatchability
High	3–4	6.8–8	Documented Effects: Molecular, Cellular, Behavioral, Potential Population Effects
Extra High	>4	>8	Documented Effects at Population Level

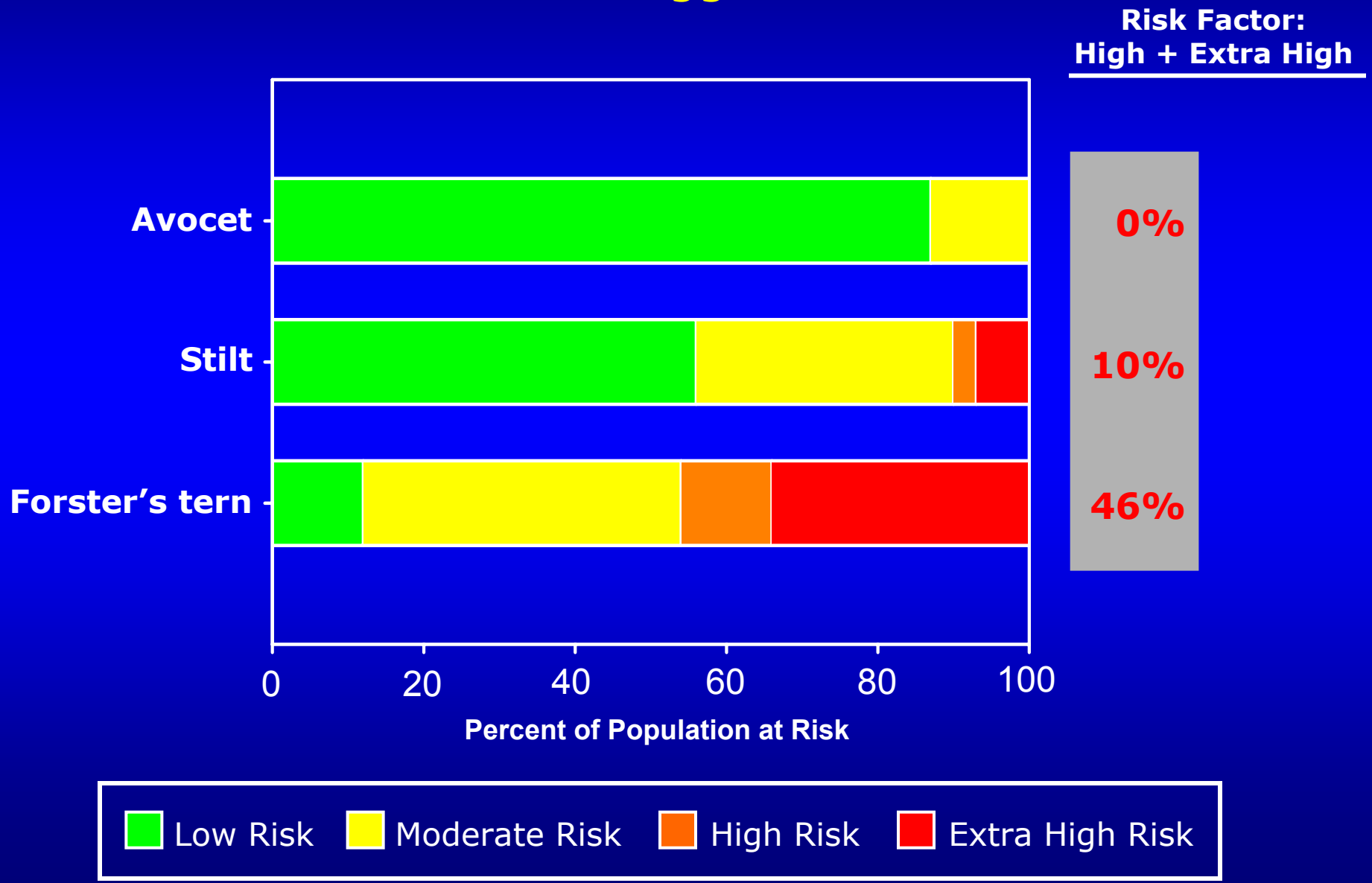
Percent of Population at Risk

Breeding Birds Only



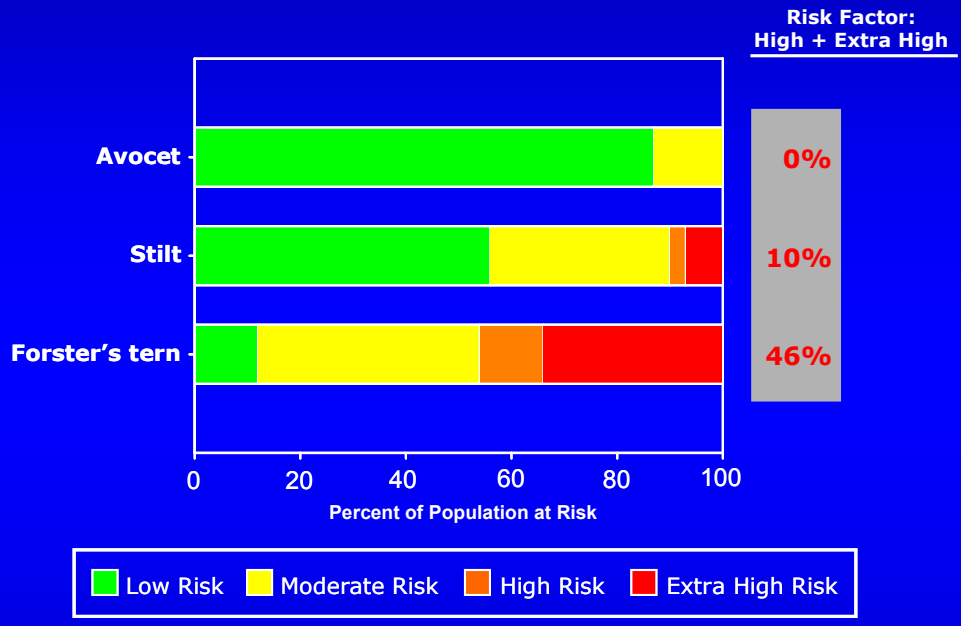
Percent of Population at Risk

All Eggs



Percent of Population at Risk
Cautions for Interpretation

- Based on surrogate species
  - Loon and Mallards
- Differences in species sensitivities?
- Interactions with selenium and other contaminants



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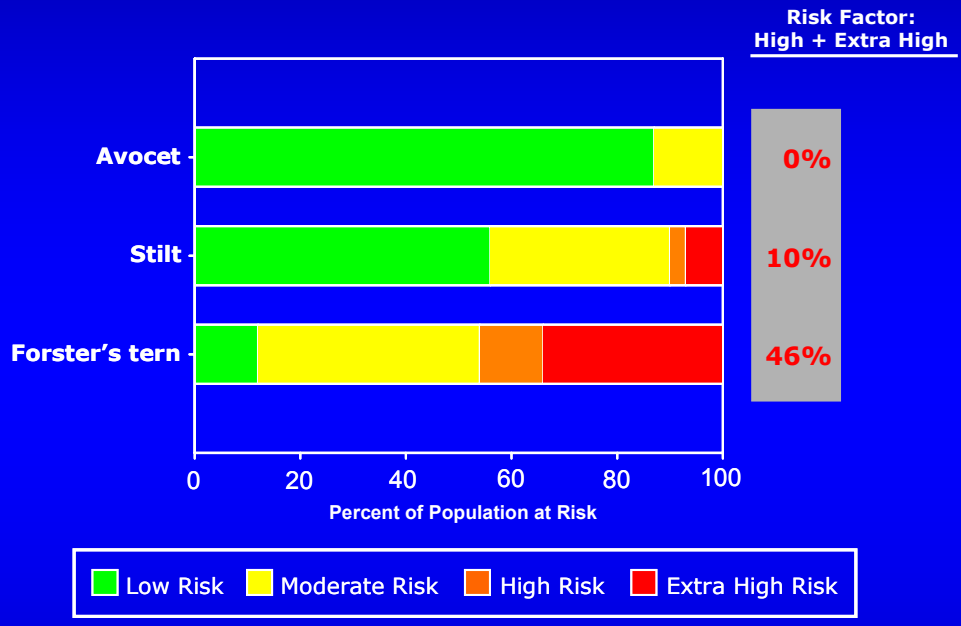
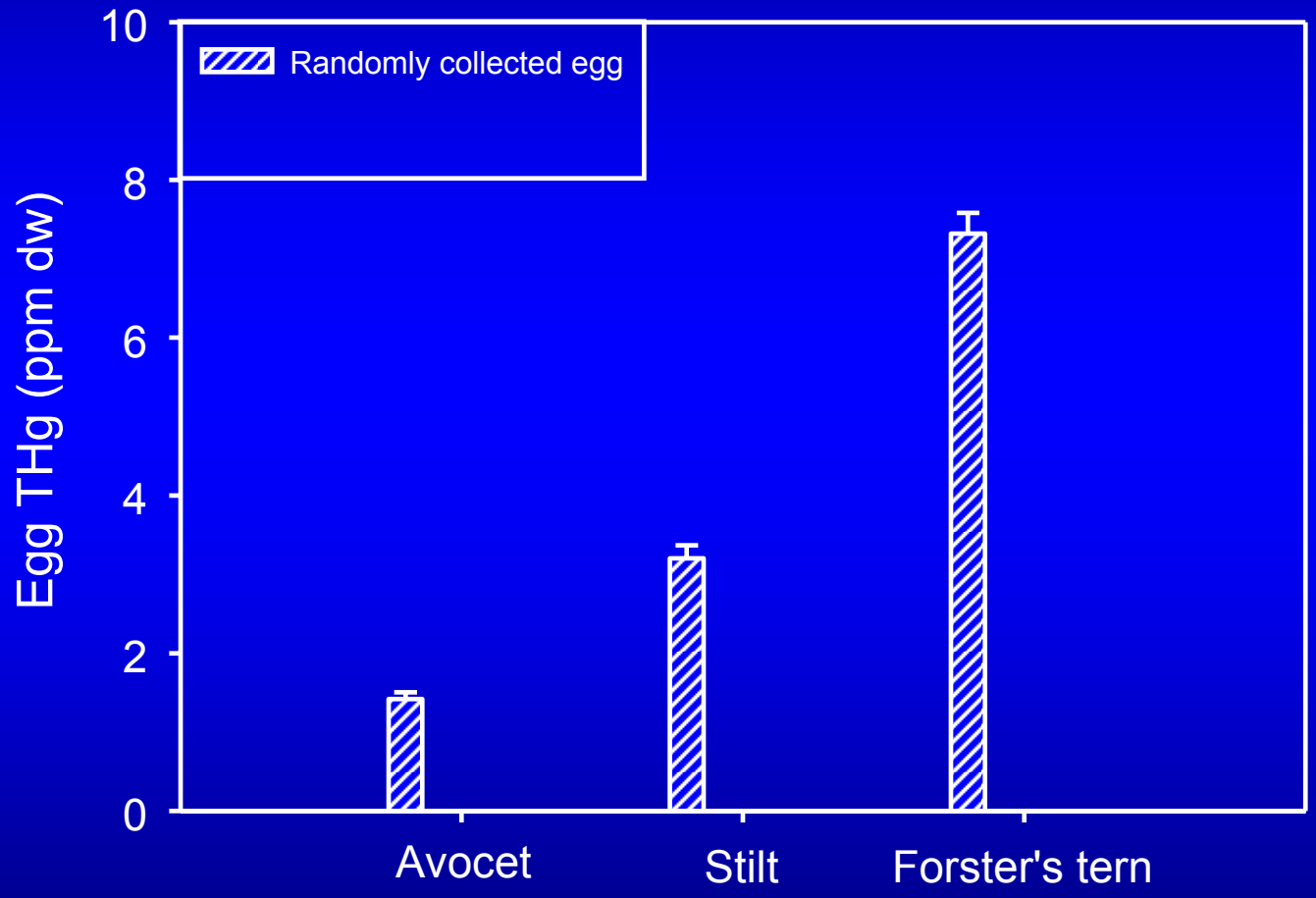


Need to quantify effects for SF Bay species

Egg Hg and Hatchability



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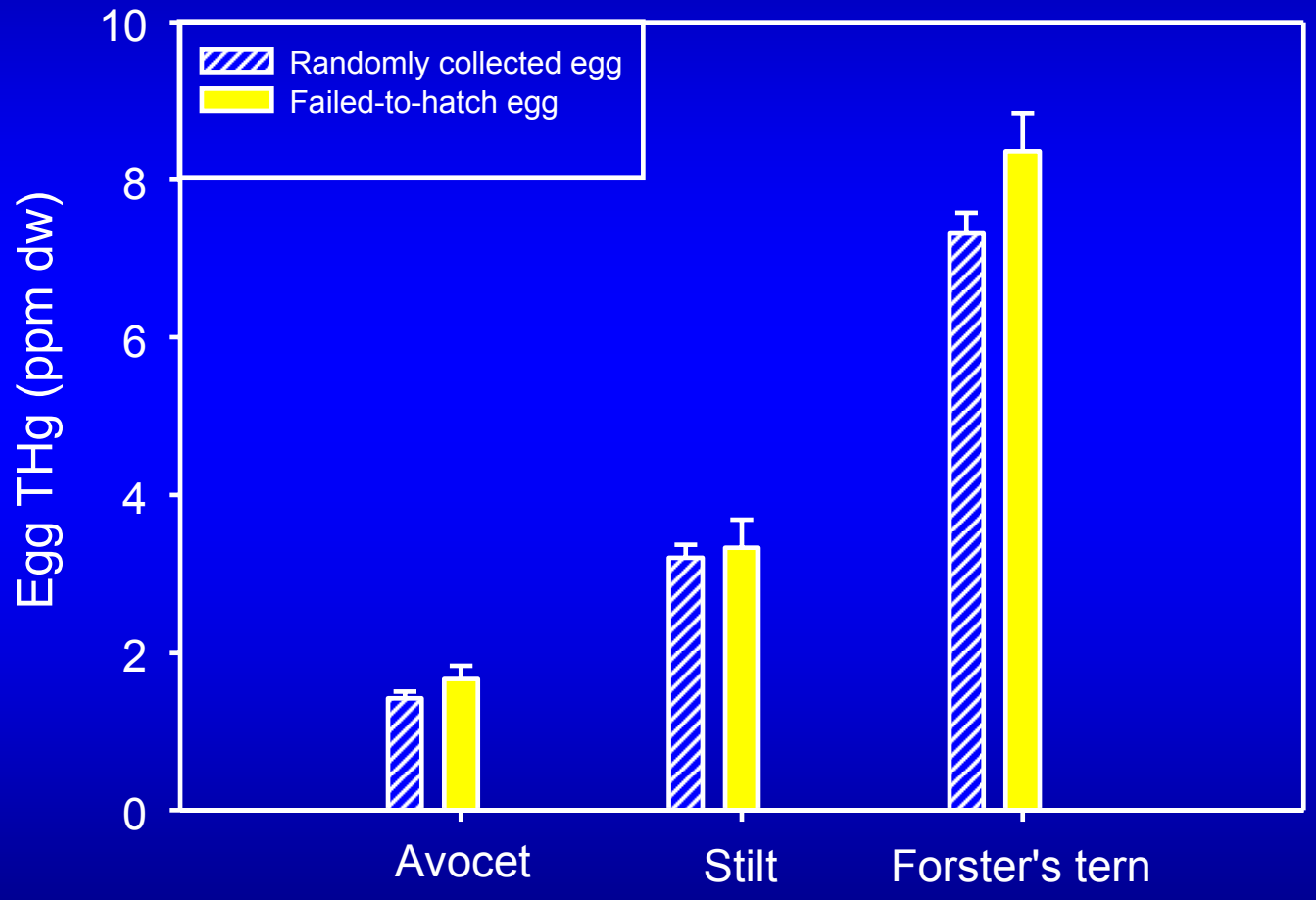

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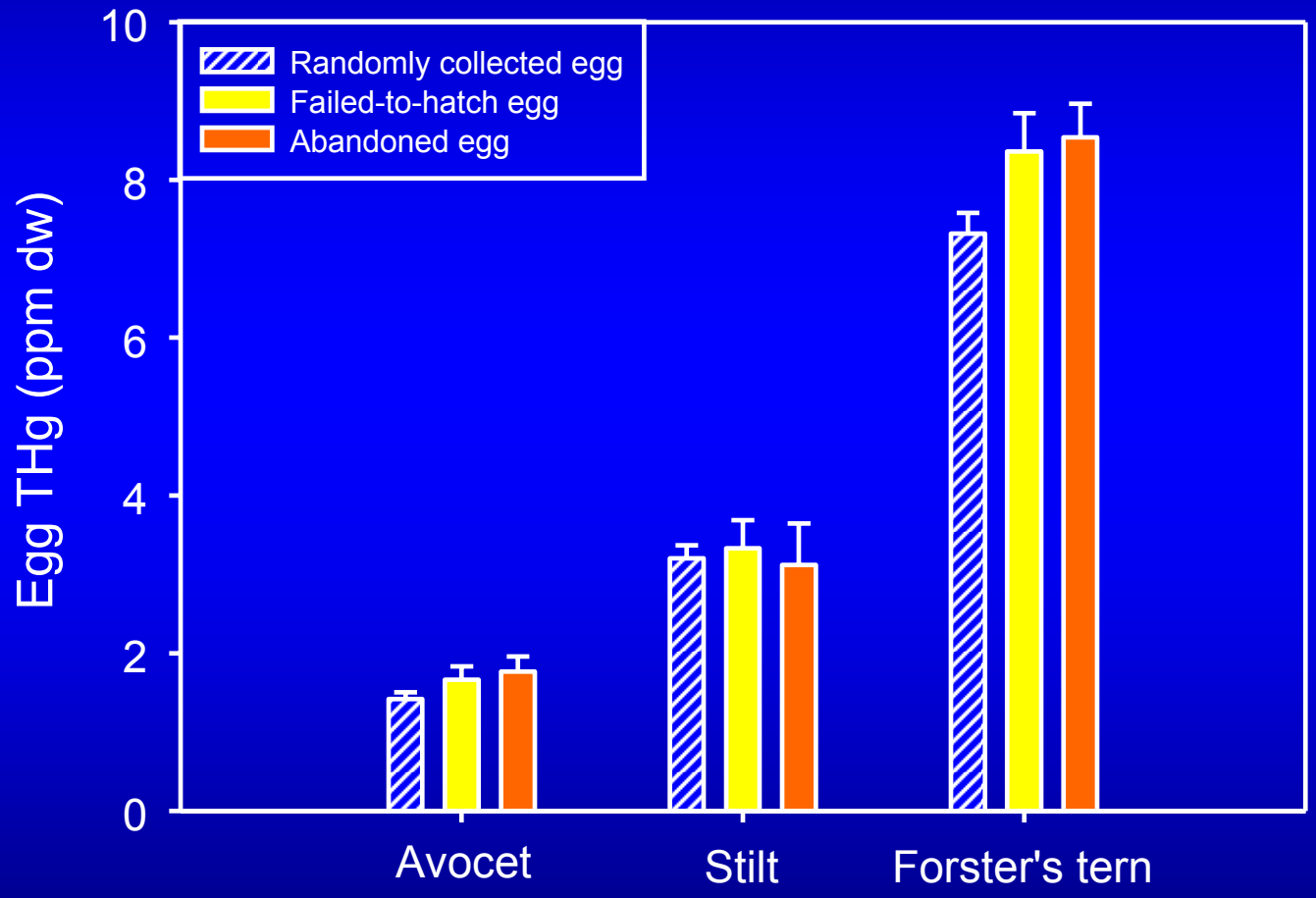

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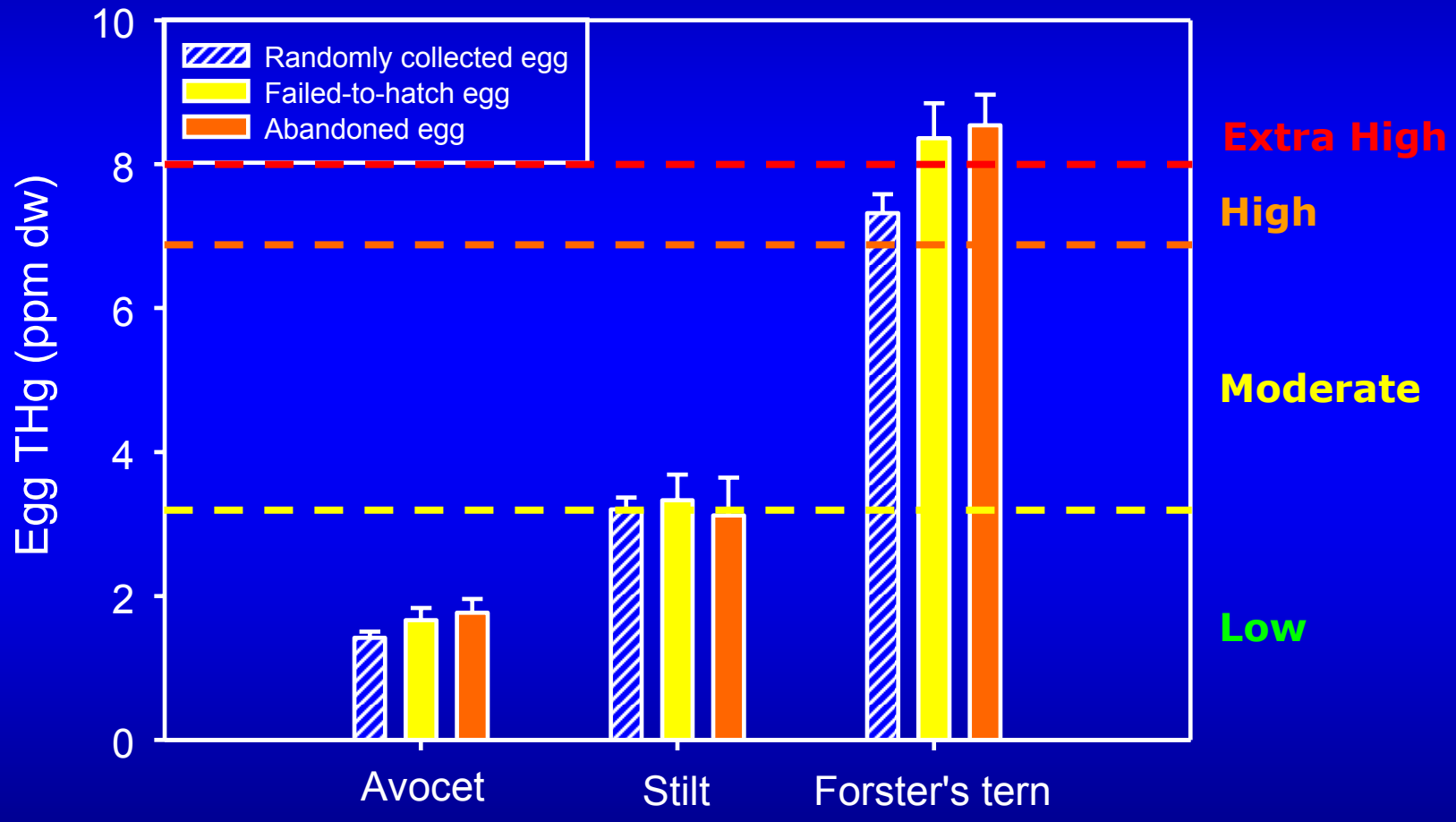

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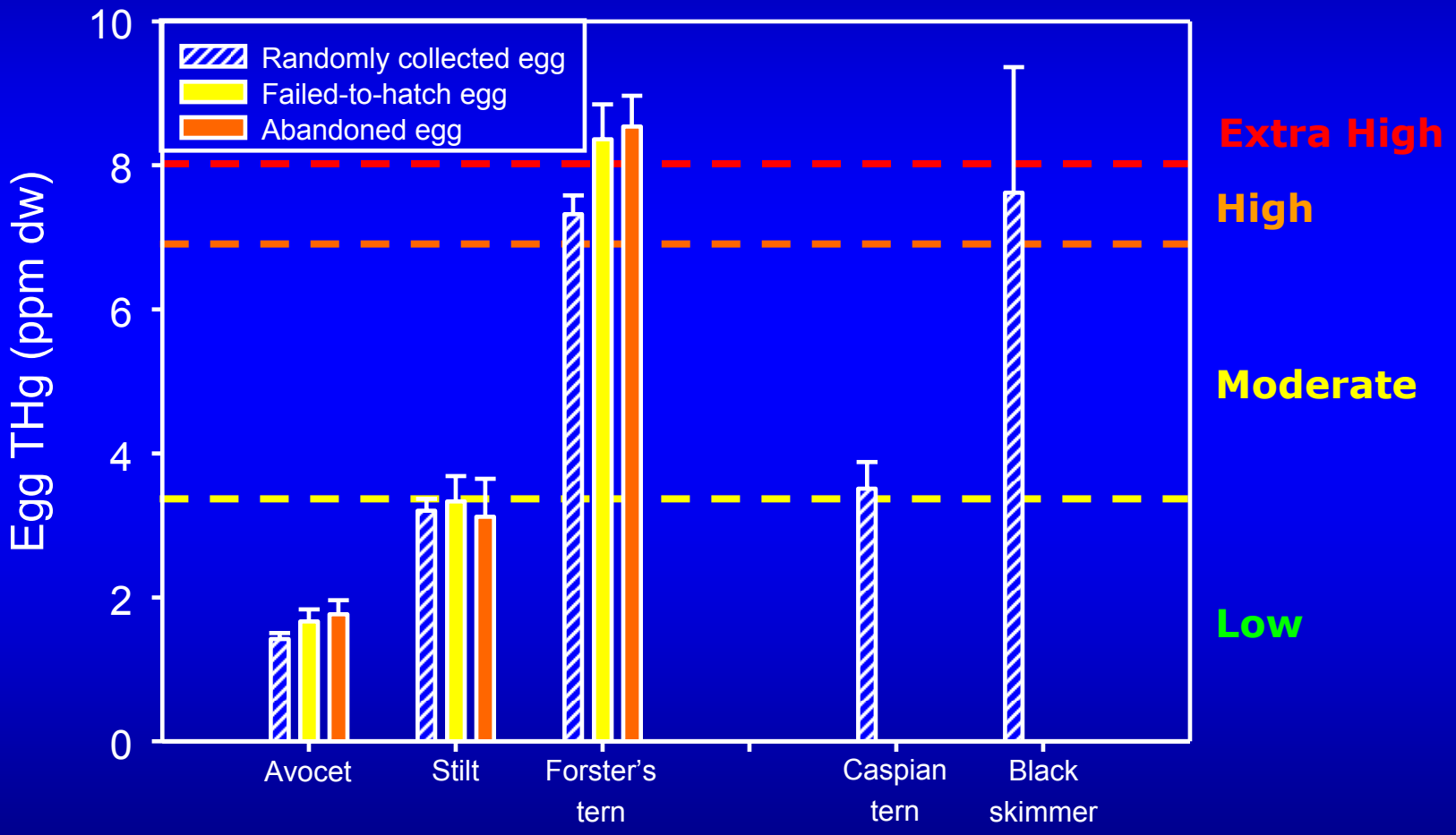

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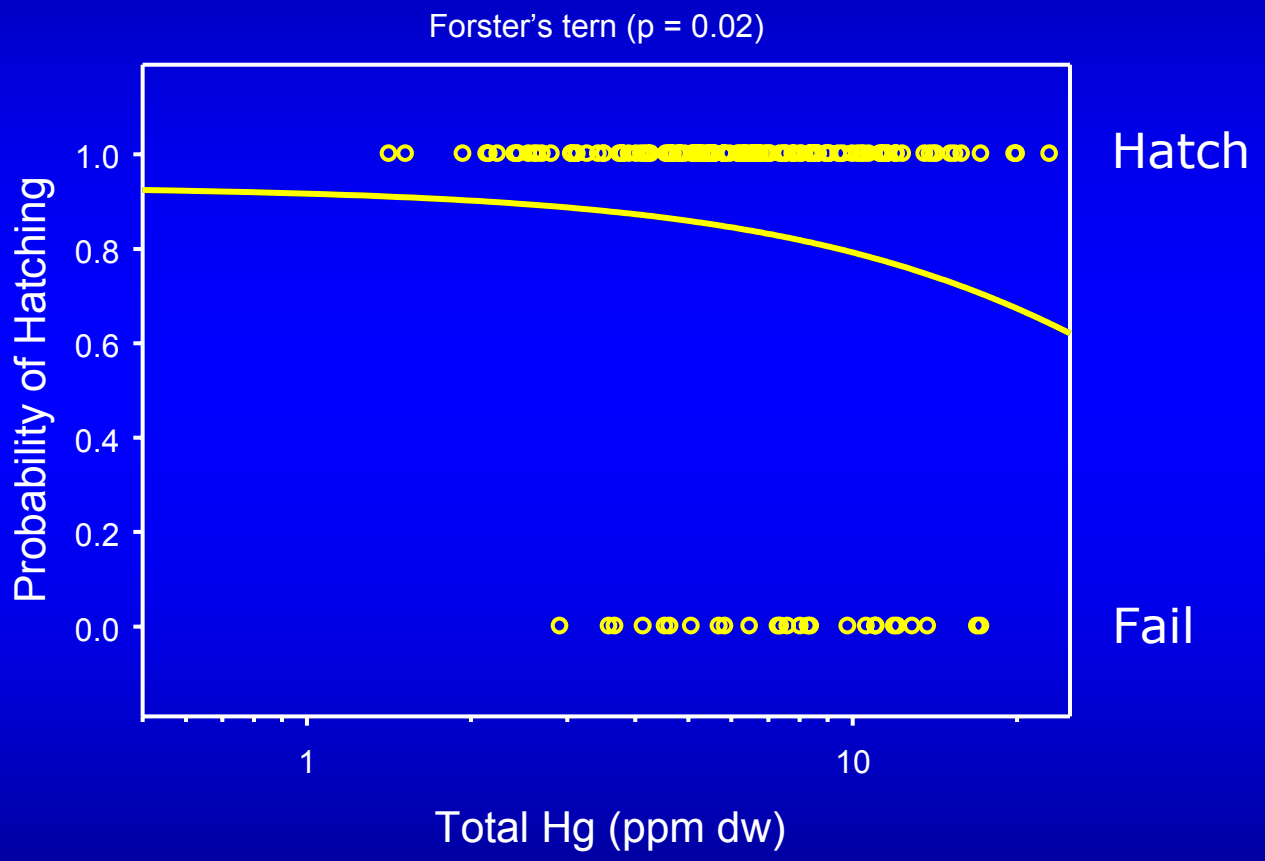

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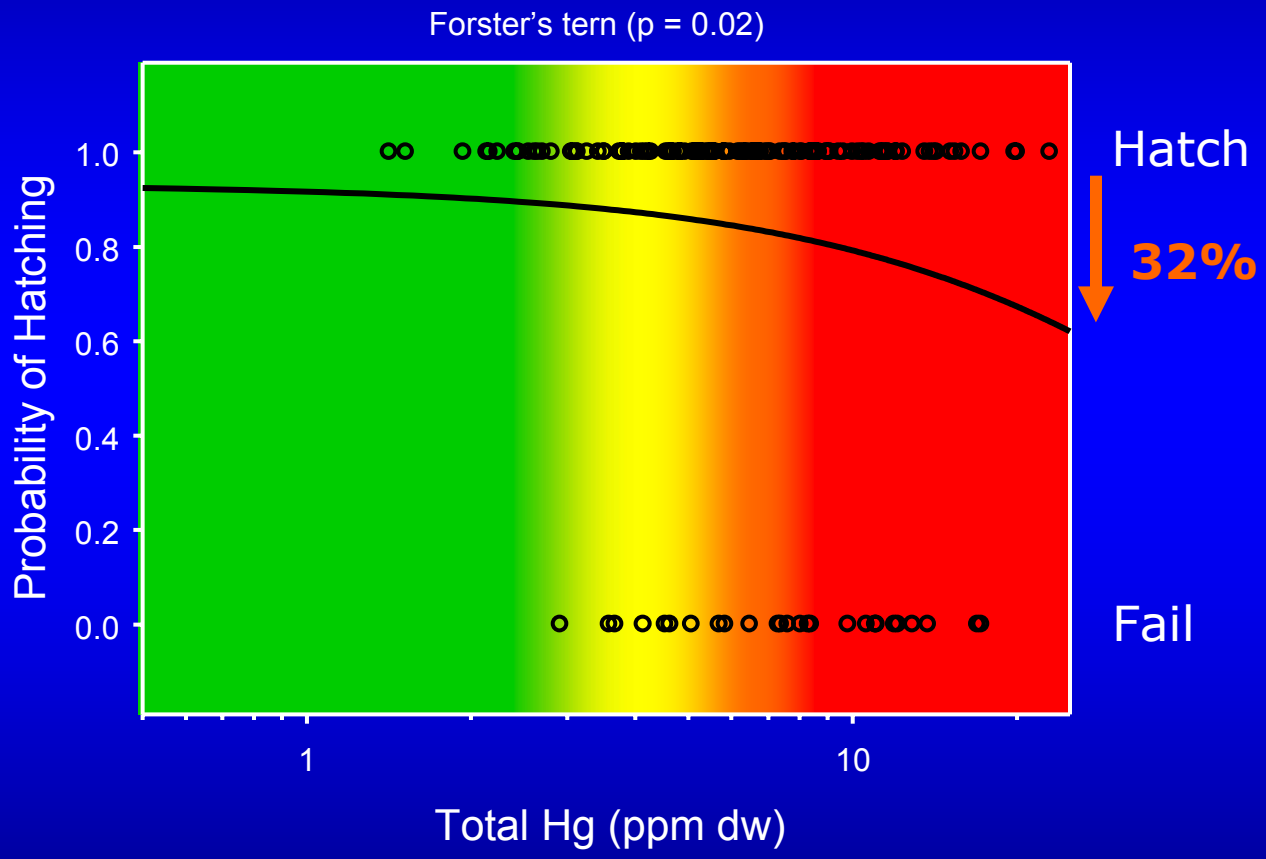
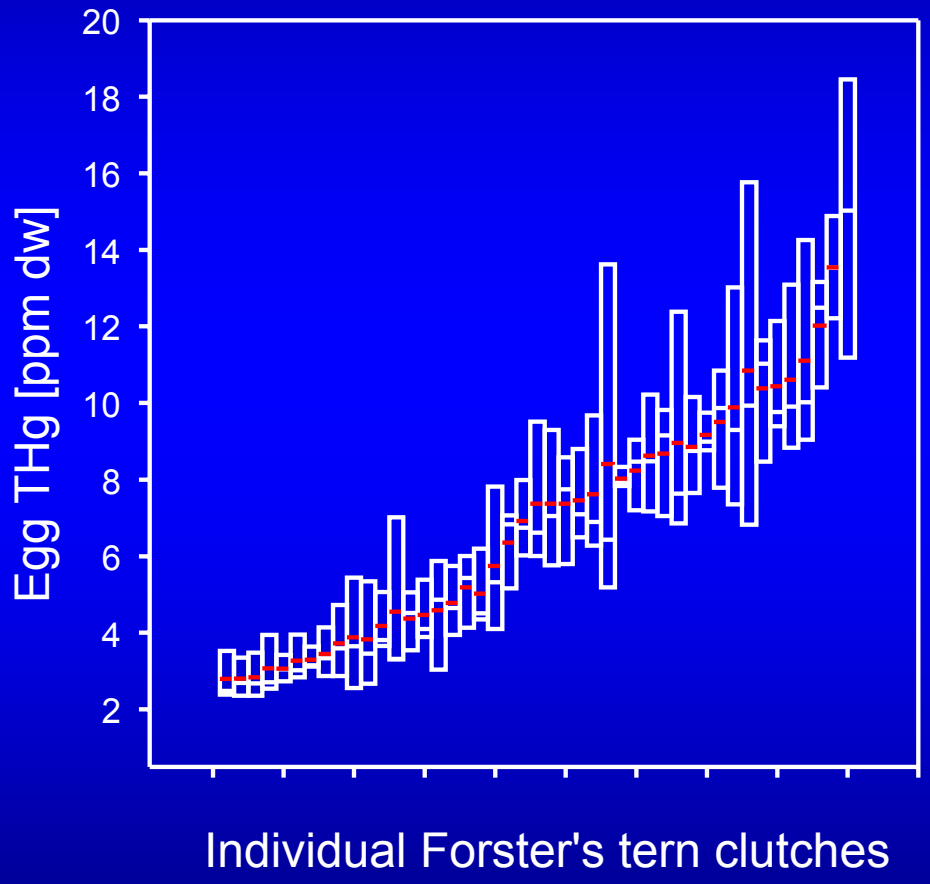


Within-clutch Mercury Variability



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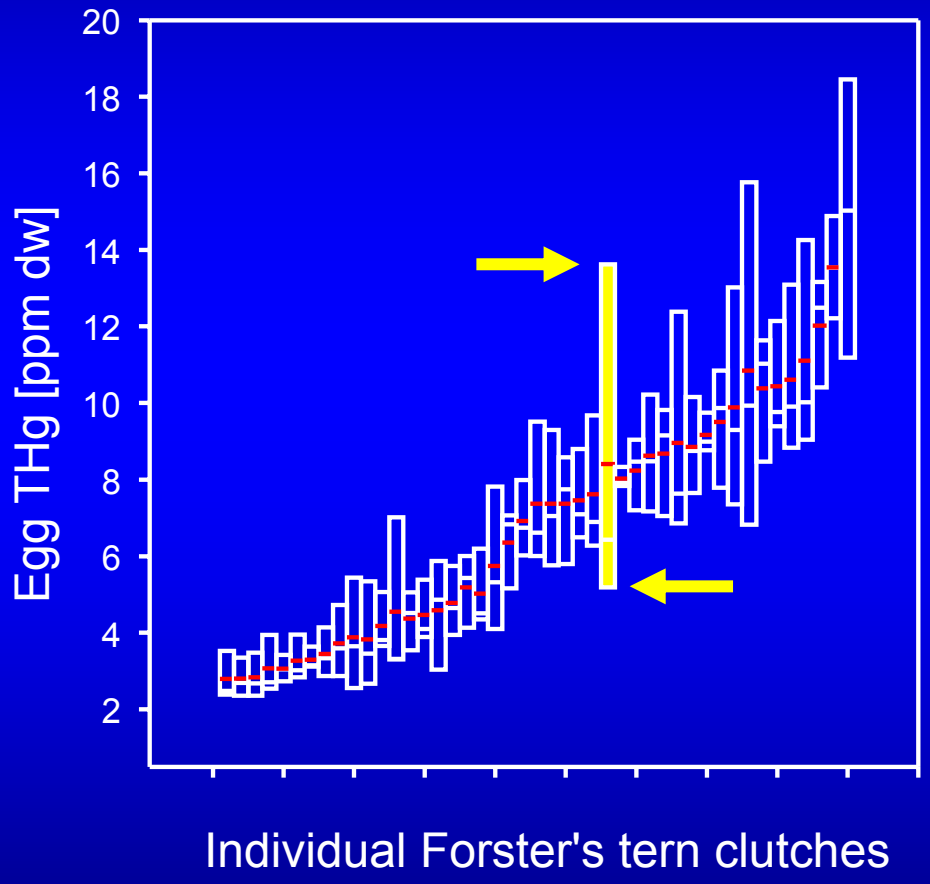

Individual Egg Microsampling Technique

1. Egg drilling

2. Albumin microsampling

3. Egg sealing

4. Egg replacement and monitoring

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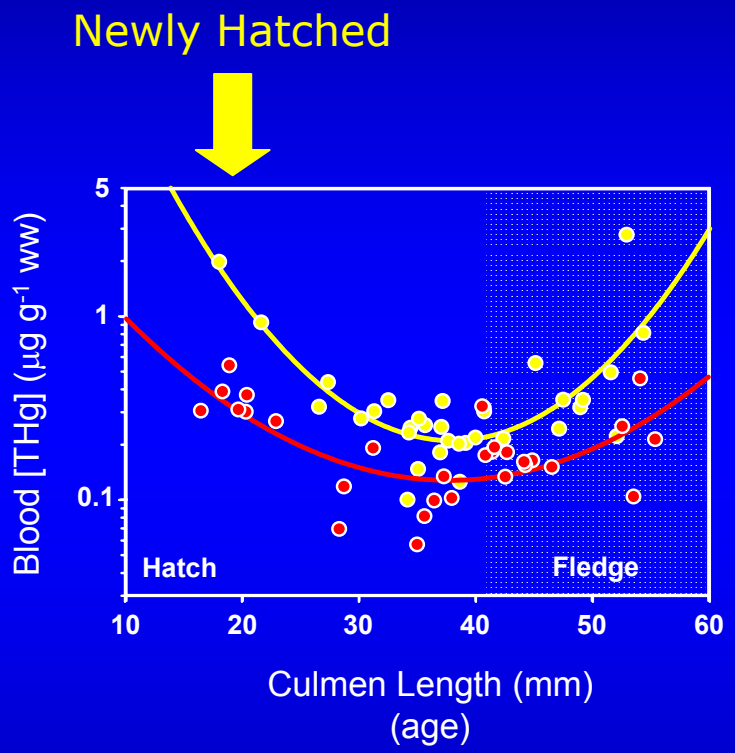
Species	# of eggs drilled	% of drilled eggs hatched	% of control eggs hatched in same nest
AMAV	93	97% (N=90)	91% (N=85)
BNST	14	100% (N=14)	93% (N=13)
FOTE	33	85% (N=28)	91% (N=30)

Chick Survival: Stilts & Avocets



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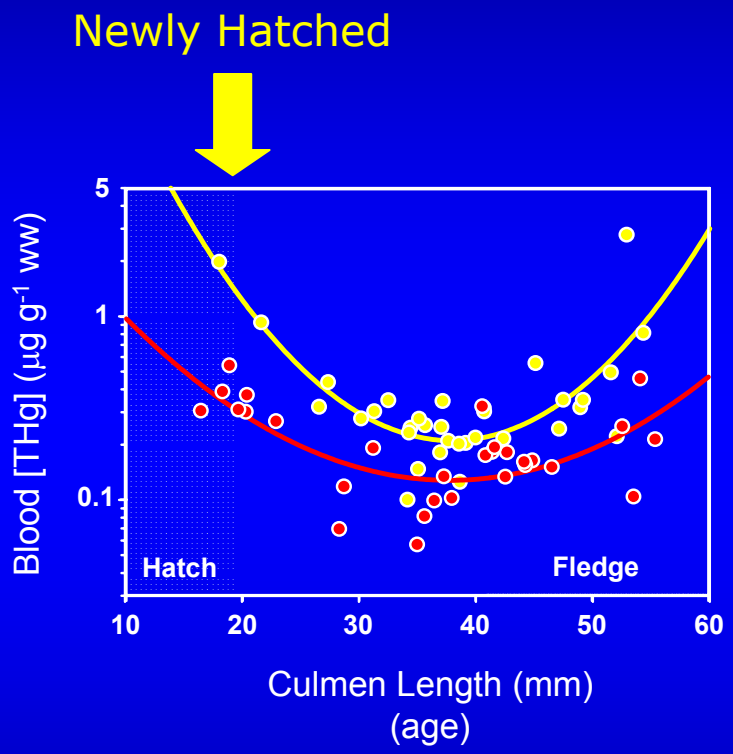
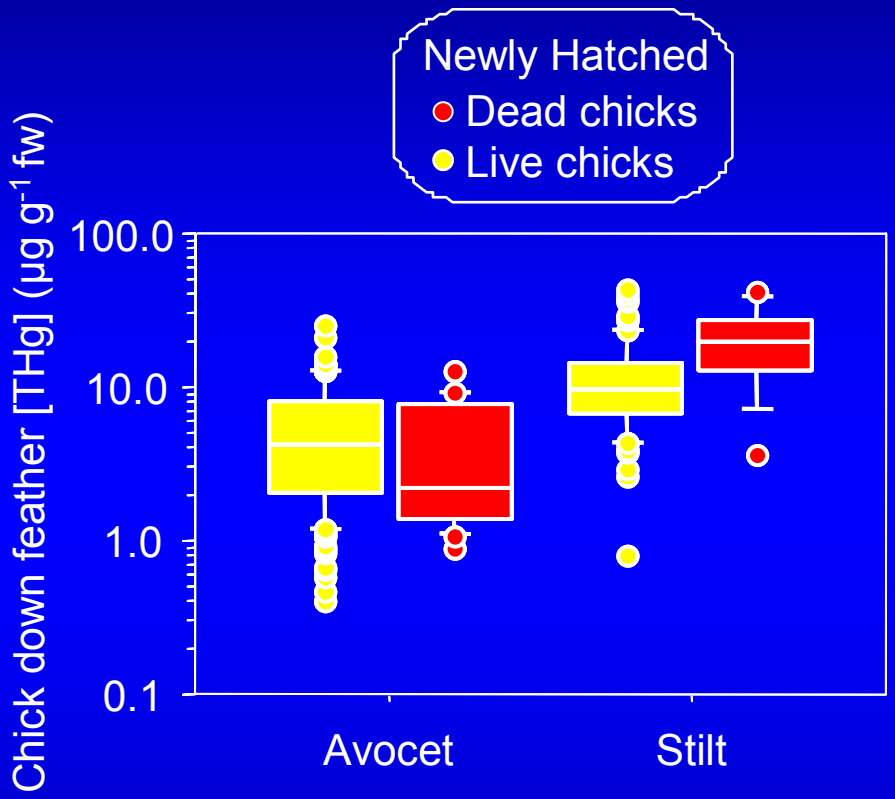
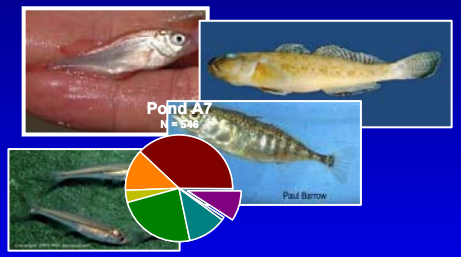




Bird Eggs as Mercury Biomonitoring Tools



Trophic Transfer

Maternal Transfer

Fail-to-Hatch

Hatch

Survive

Mortality

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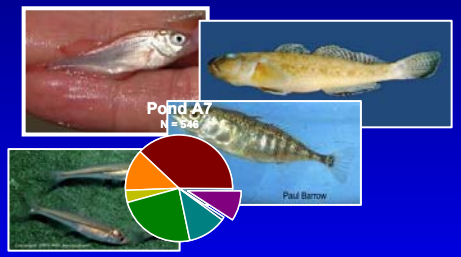

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