Tidal Marsh Restoration Design and Management

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RMP MeHg Forum, 17 Dec 2013

TBI

Management Question

What do we know about designing and managing marsh restoration projects to reduce the risk of mercury impairment (i.e., elevated MeHg in the food web)?

Hypotheses

It is possible to design or manage restored marshes to reduce methylmercury exposure in vertebrate end points.

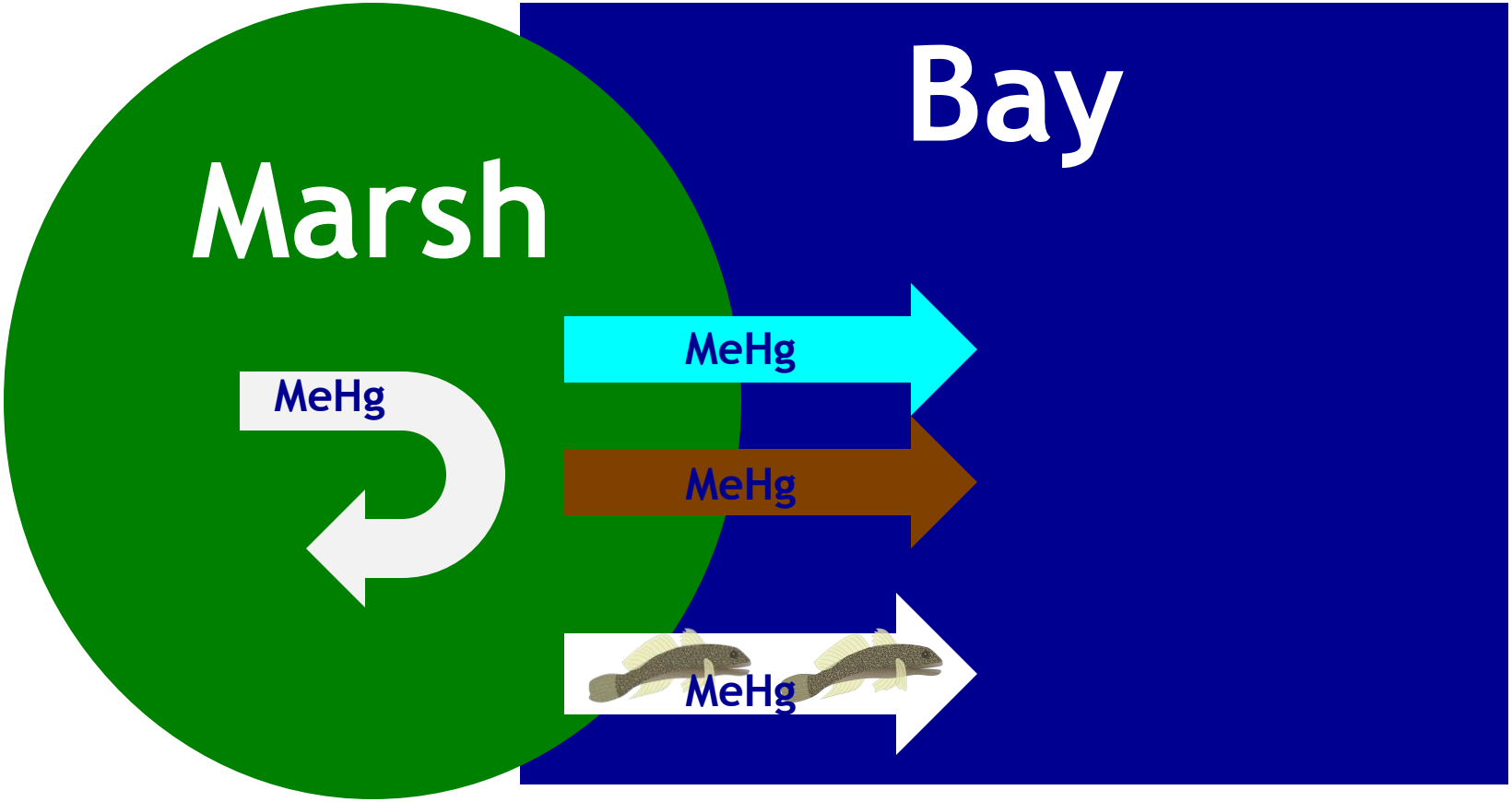
We do not yet have sufficient information to design tidal marsh restoration projects to reduce methylmercury exposure.

But we know enough to have some ideas…

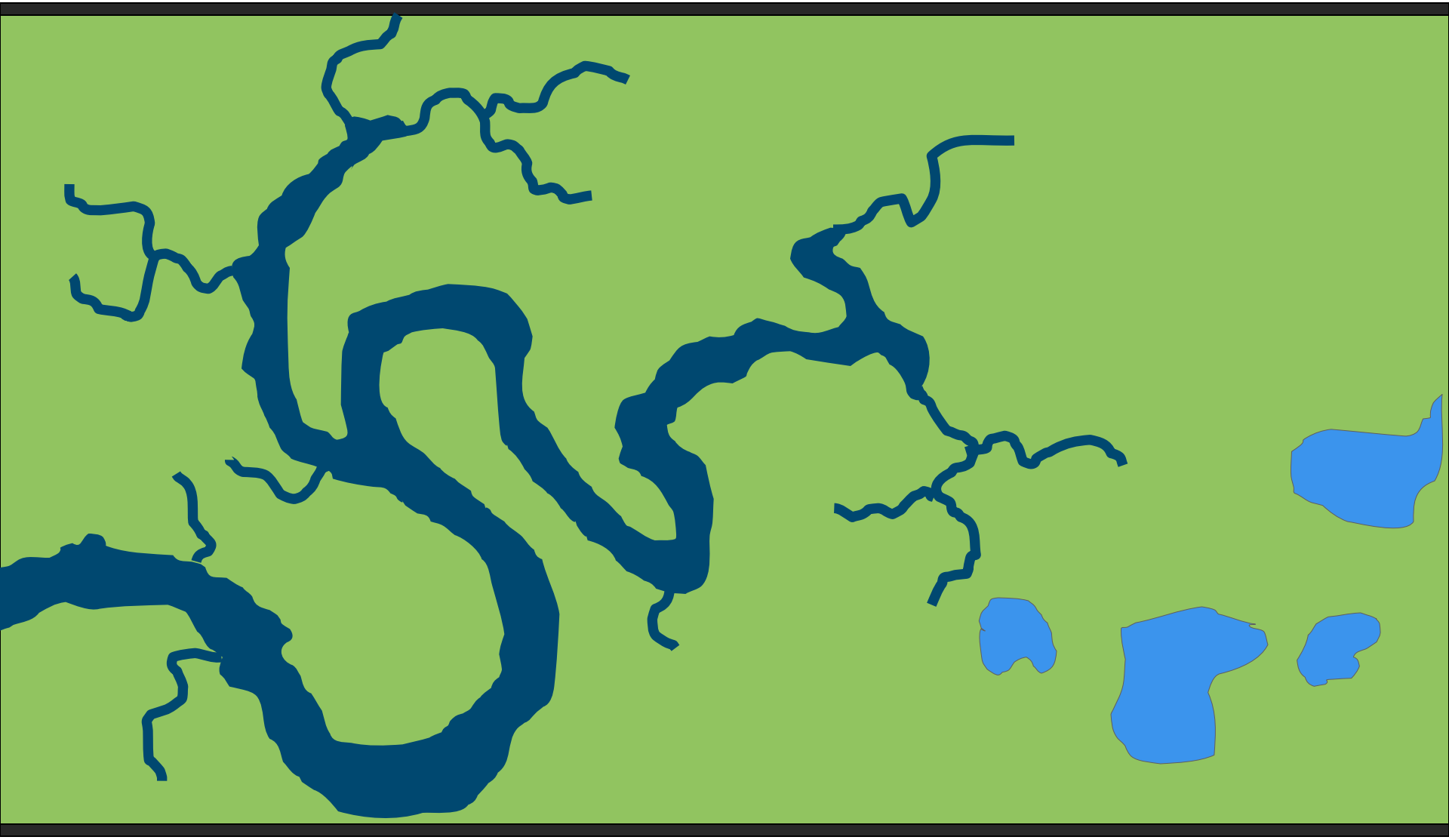
Science in its Infancy

- No studies to answer this question
- Very few related studies of tidal marsh
- Enough to generate hypotheses
- Testing and monitoring needed before becoming design elements or restoration recommendations

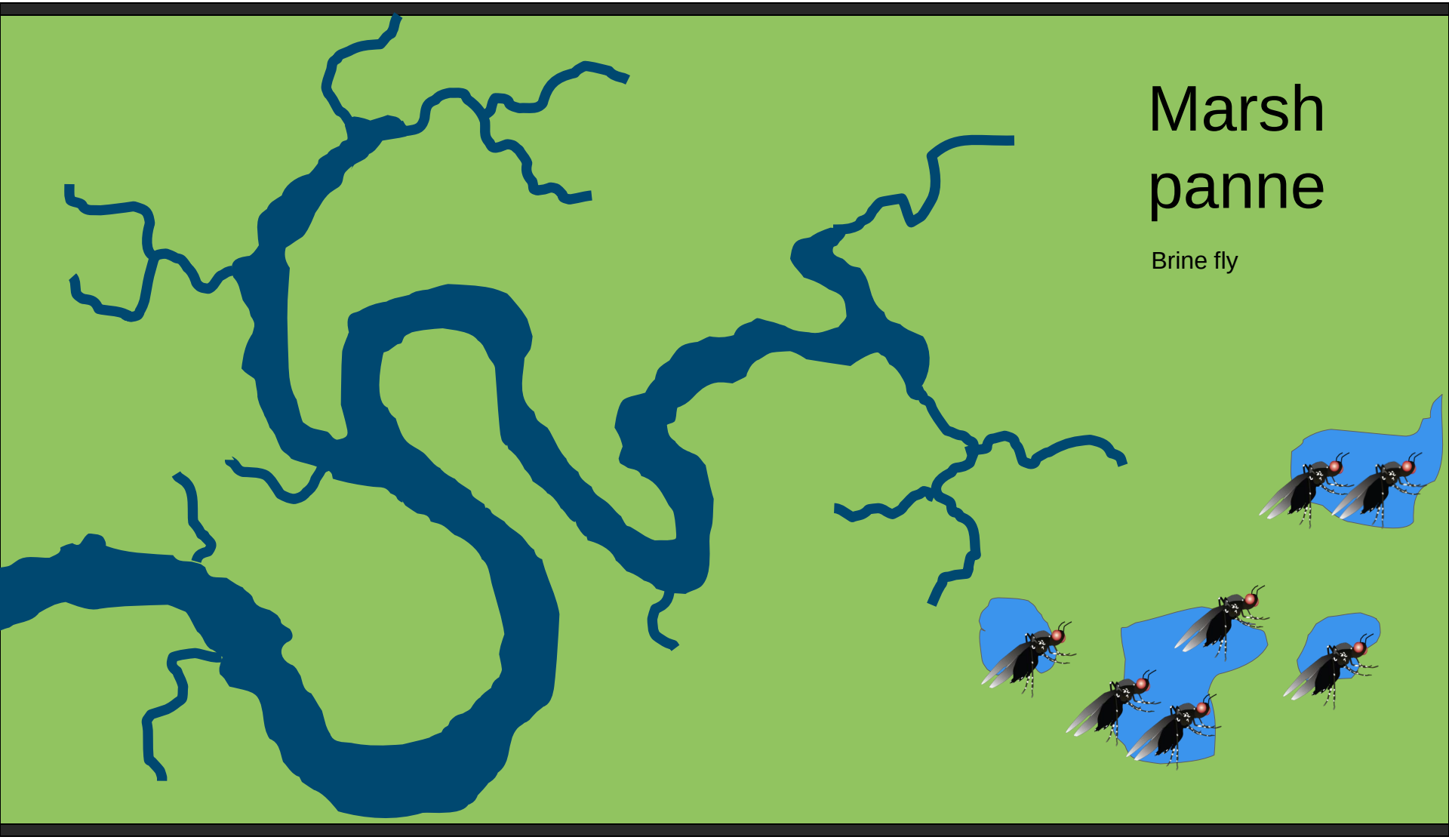
Concern about Methylmercury and Wetland Restoration



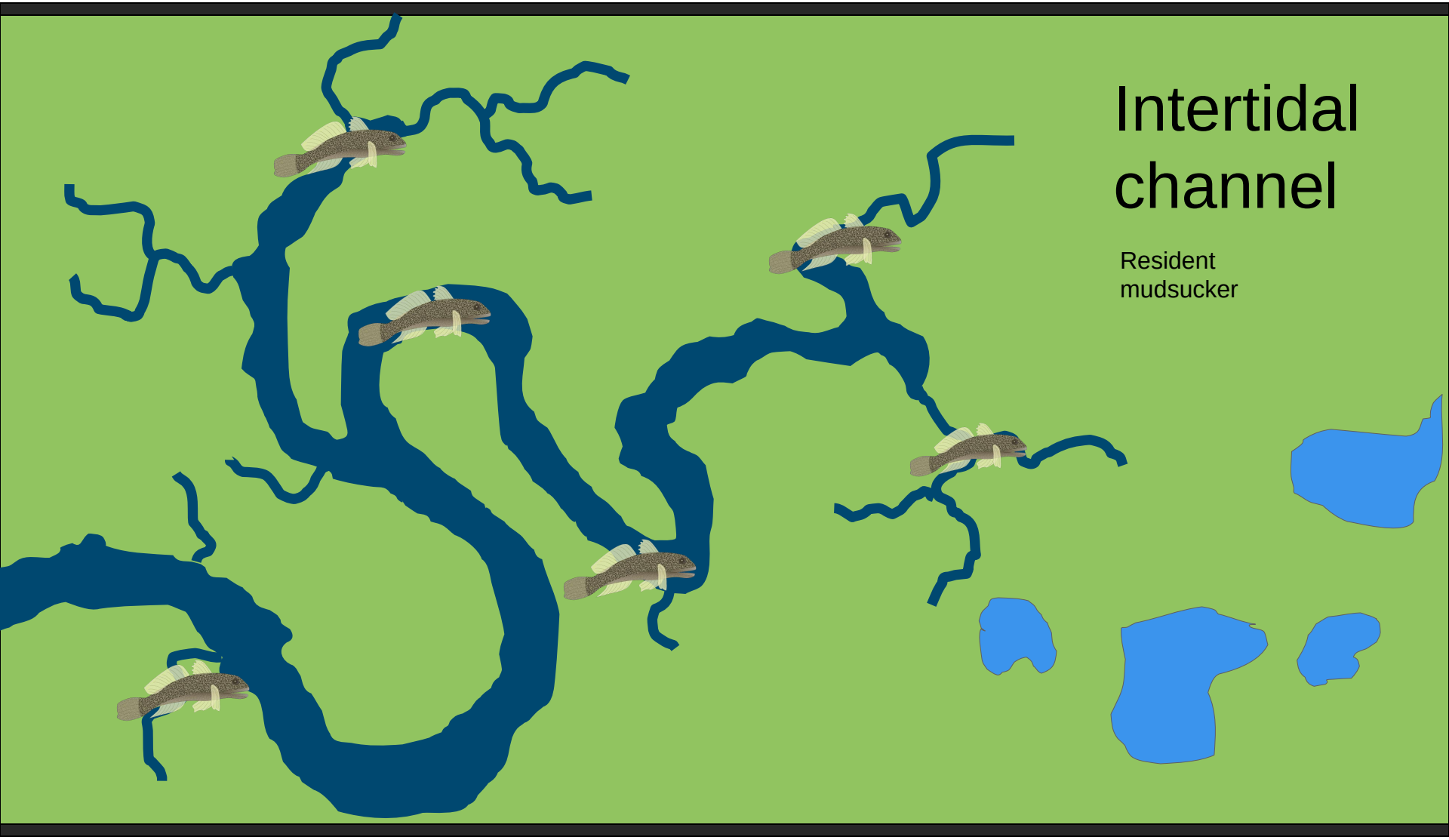
Tidal Marshes Have Discrete Habitats where Hg Cycling and Bioaccumulation May Differ



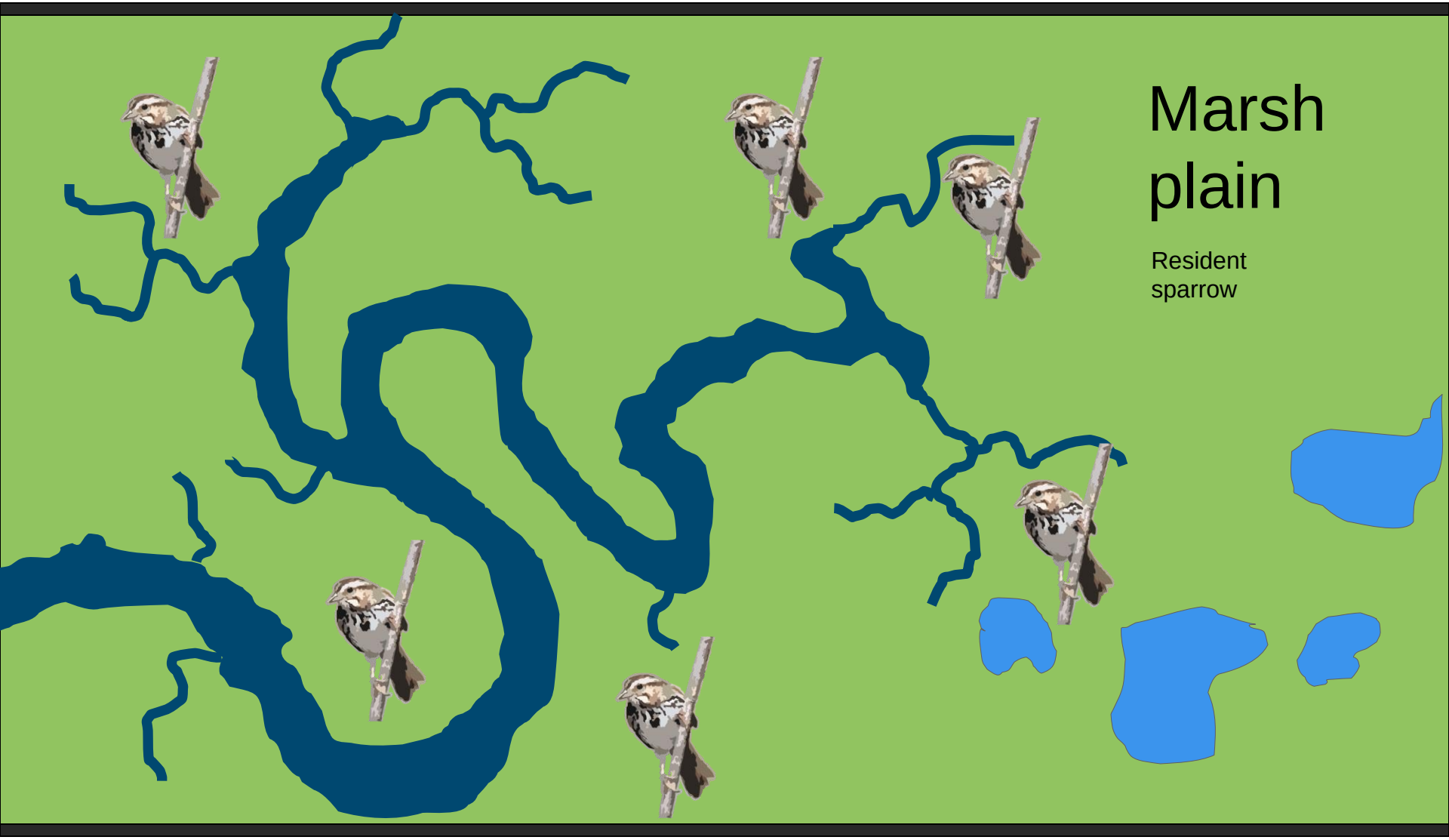
Match Each Habitat to a Biosentinel



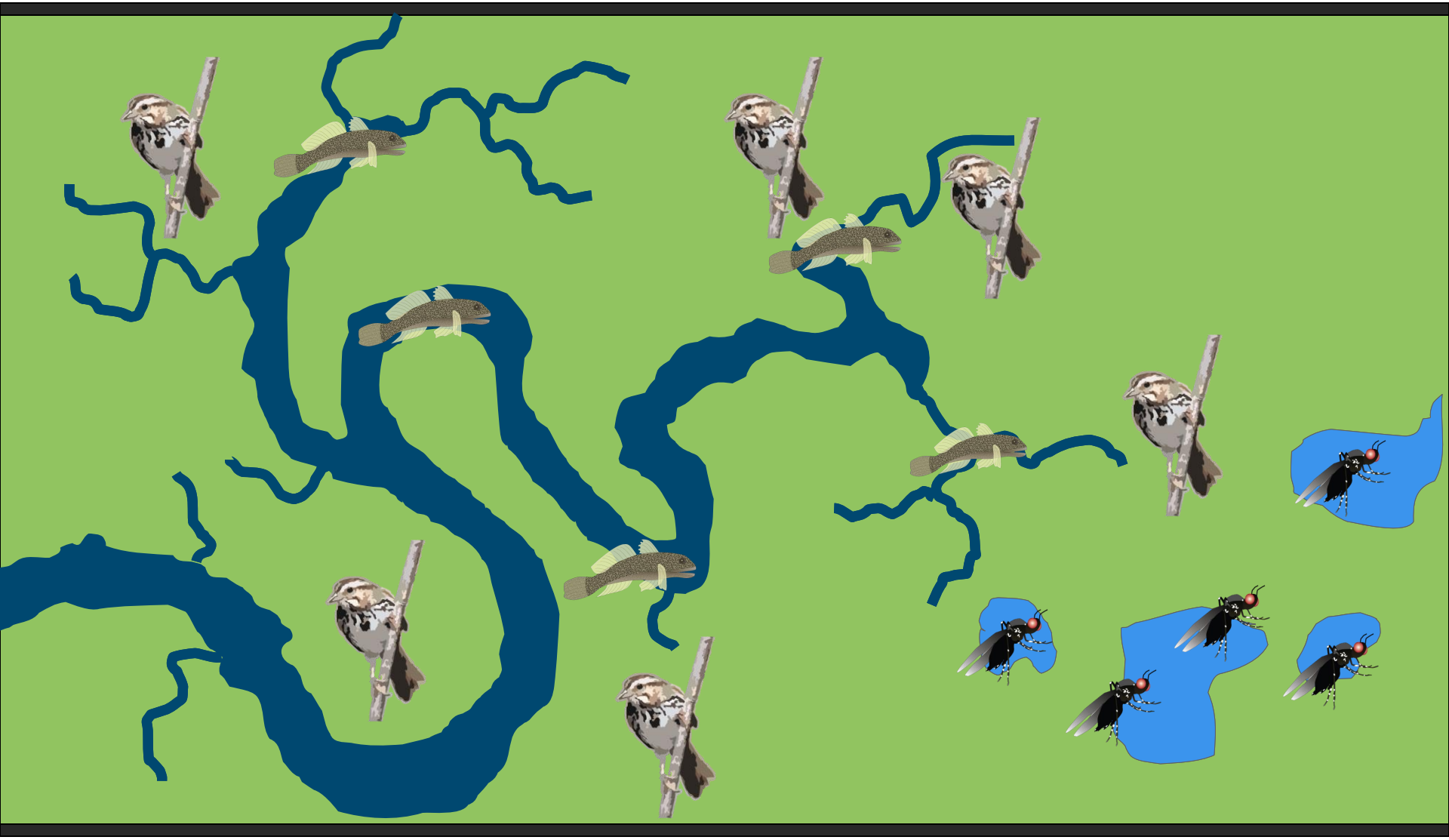
Match Each Habitat to a Biosentinel



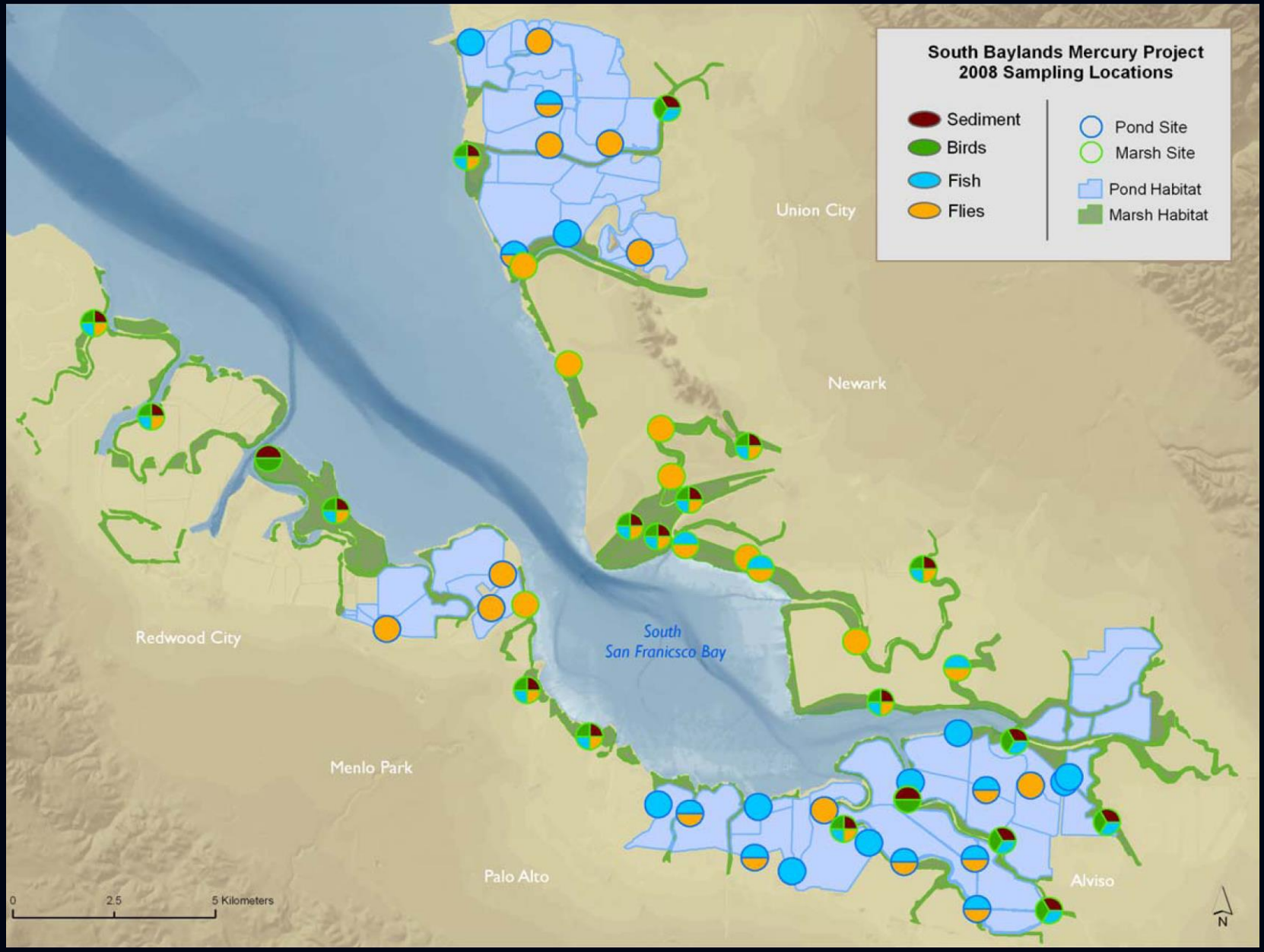
Match Each Habitat to a Biosentinel

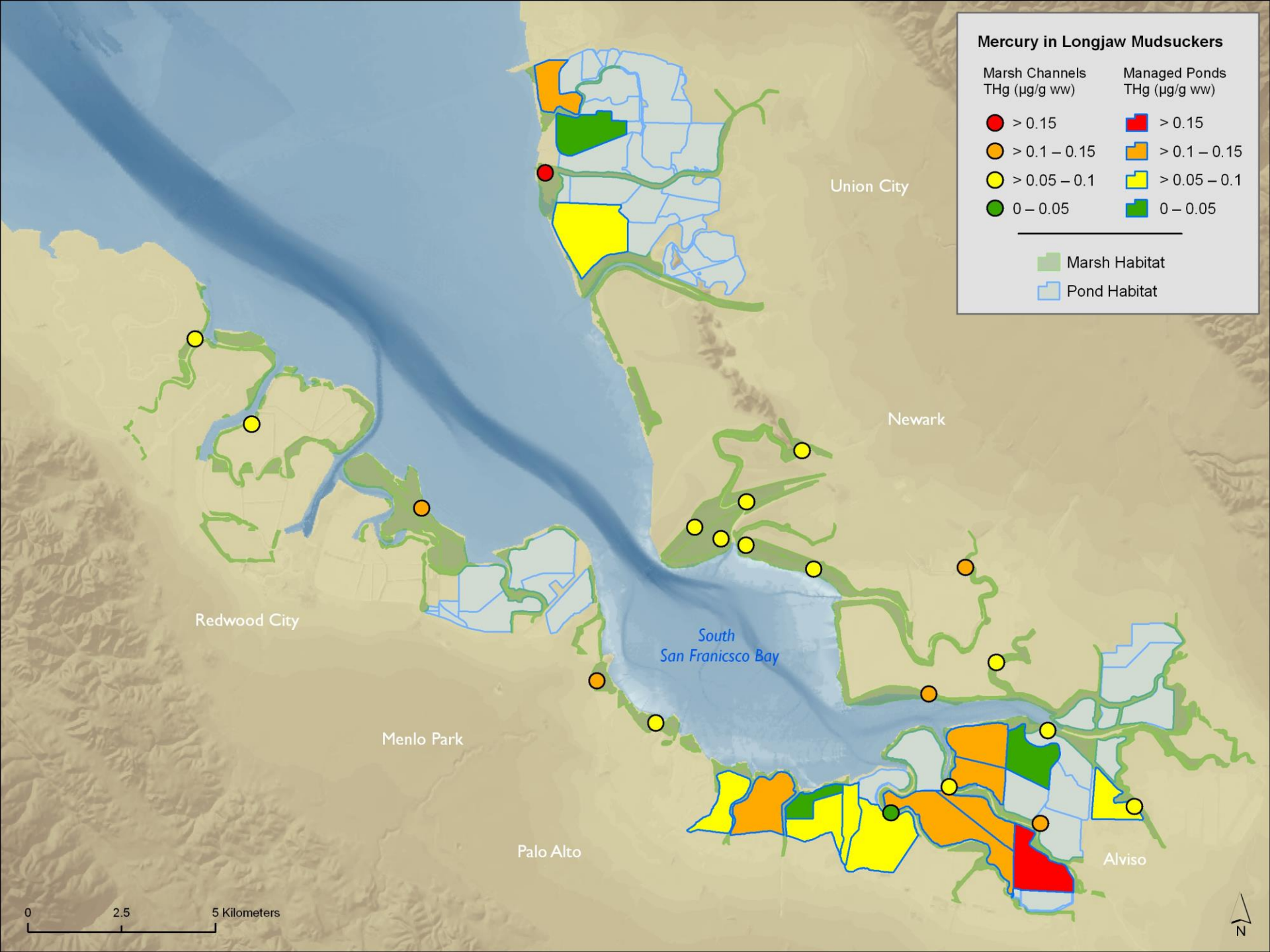


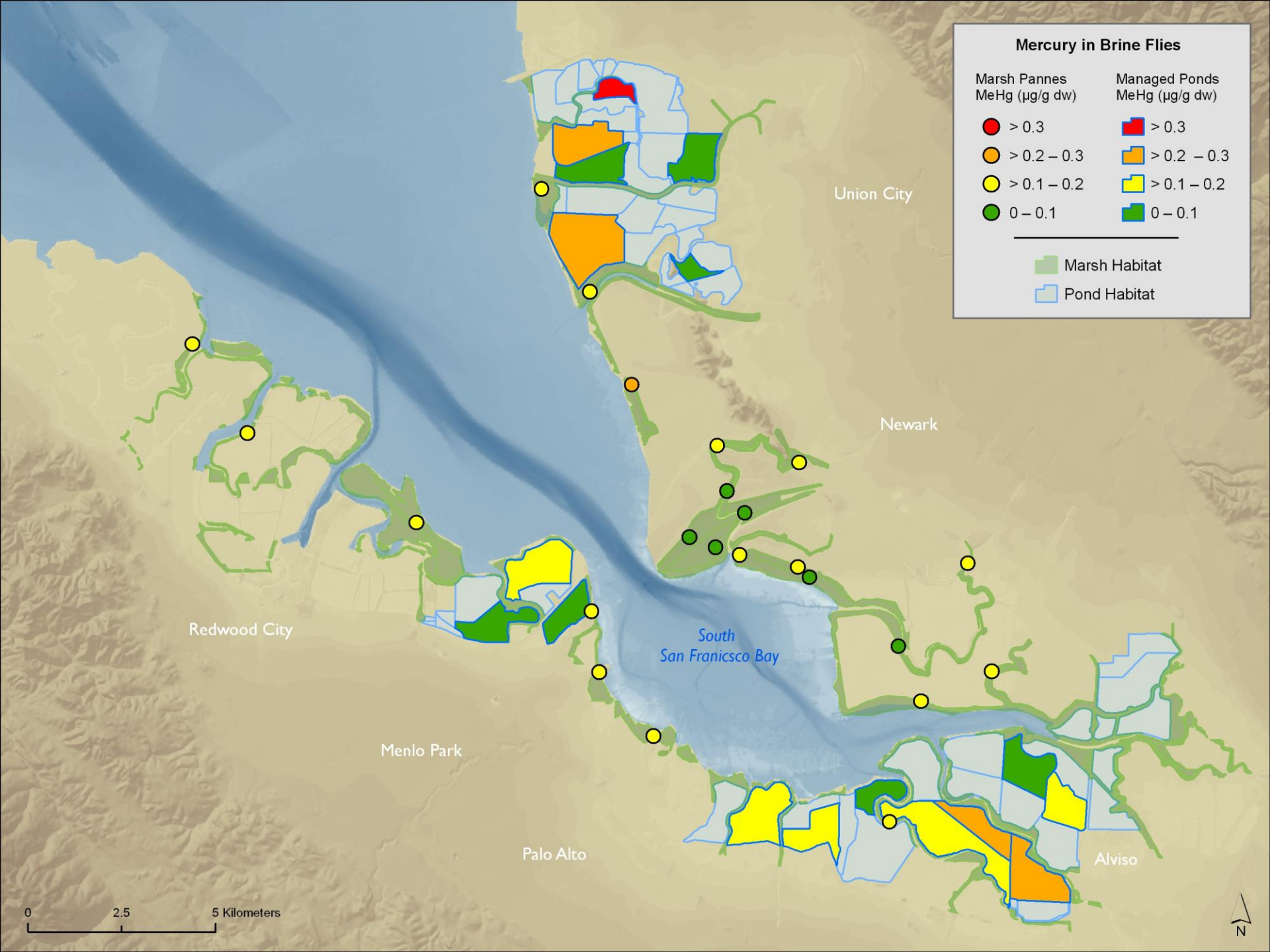
Toolkit of Biosentinels for Tidal Marsh Questions

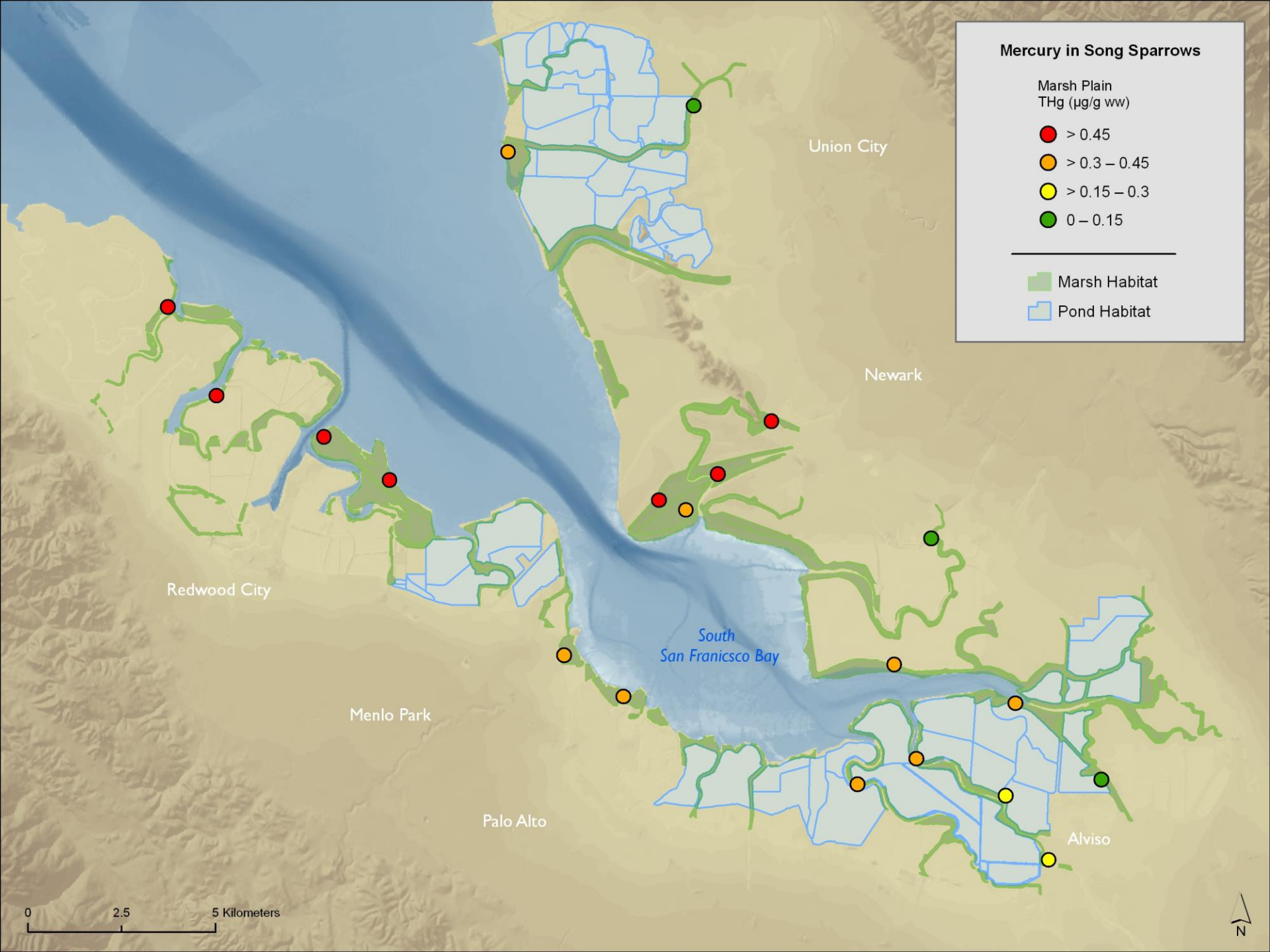


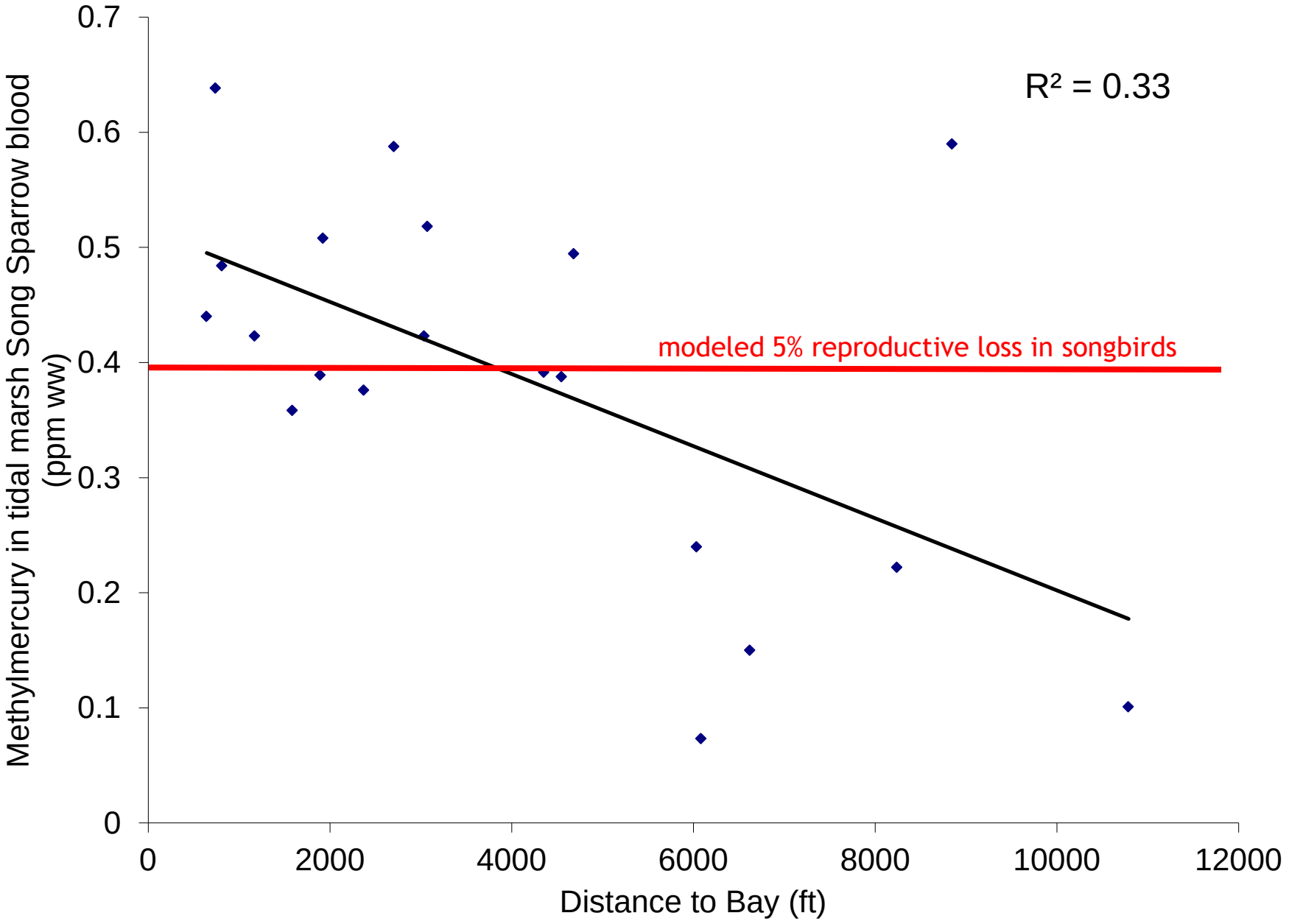
GRTS Survey of South Bay Wetlands




Mercury in Longjaw Mudsuckers
Marsh Channels THg (µg/g ww)
> 0.15
> 0.1 – 0.15
> 0.05 – 0.1
0 – 0.05
Managed Ponds THg (µg/g ww)
> 0.15
> 0.1 – 0.15
> 0.05 – 0.1
0 – 0.05
Marsh Habitat
Pond Habitat
Union City
Newark
Redwood City
South San Franicsco Bay
Menlo Park
Palo Alto
Alviso
0
2.5
5 Kilometers
N


Mercury in Brine Flies
Marsh Pannes MeHg (µg/g dw)
> 0.3
> 0.2 – 0.3
> 0.1 – 0.2
0 – 0.1
Managed Ponds MeHg (µg/g dw)
> 0.3
> 0.2 – 0.3
> 0.1 – 0.2
0 – 0.1
Marsh Habitat
Pond Habitat
Union City
Newark
Redwood City
South San Franicsco Bay
Menlo Park
Palo Alto
Alviso
0
2.5
5 Kilometers
N


Mercury in Song Sparrows
Marsh Plain
THg (µg/g ww)
> 0.45
> 0.3 – 0.45
> 0.15 – 0.3
0 – 0.15
Marsh Habitat
Pond Habitat
Union City
Newark
Redwood City
South
San Franicsco Bay
Menlo Park
Palo Alto
Alviso
0
2.5
5 Kilometers
N


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Methylmercury in tidal marsh Song Sparrow blood (ppm ww)
R² = 0.33
modeled 5% reproductive loss in songbirds
0
2000
4000
6000
8000
10000
12000
Distance to Bay (ft)

Conceptual Model
Factors Affecting Hg Risk

Mercury Risk

Higher Risk

Lower Risk

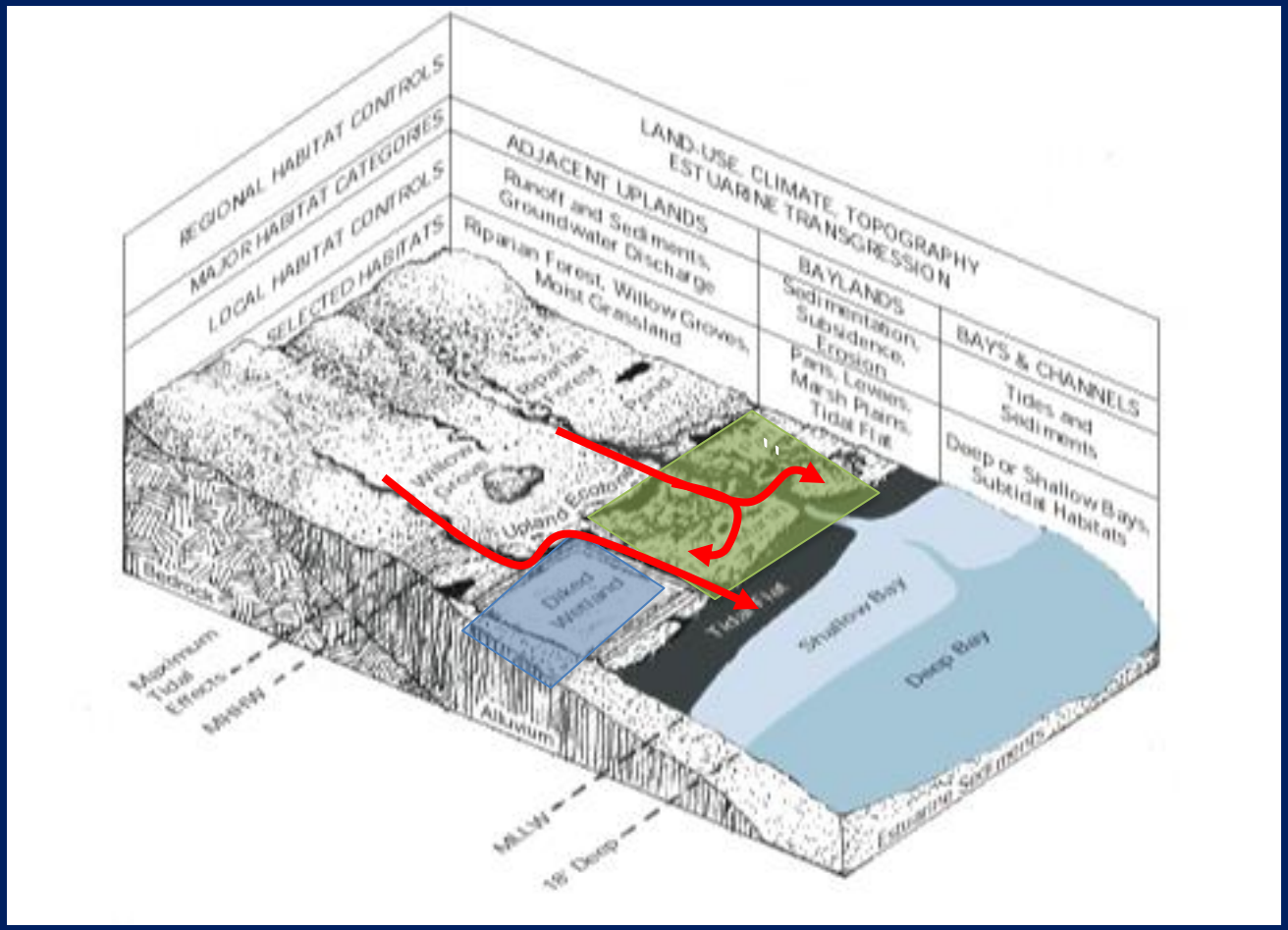
Low — Salinity (distance to Bay) — *High*

Low — THg legacy — *High*

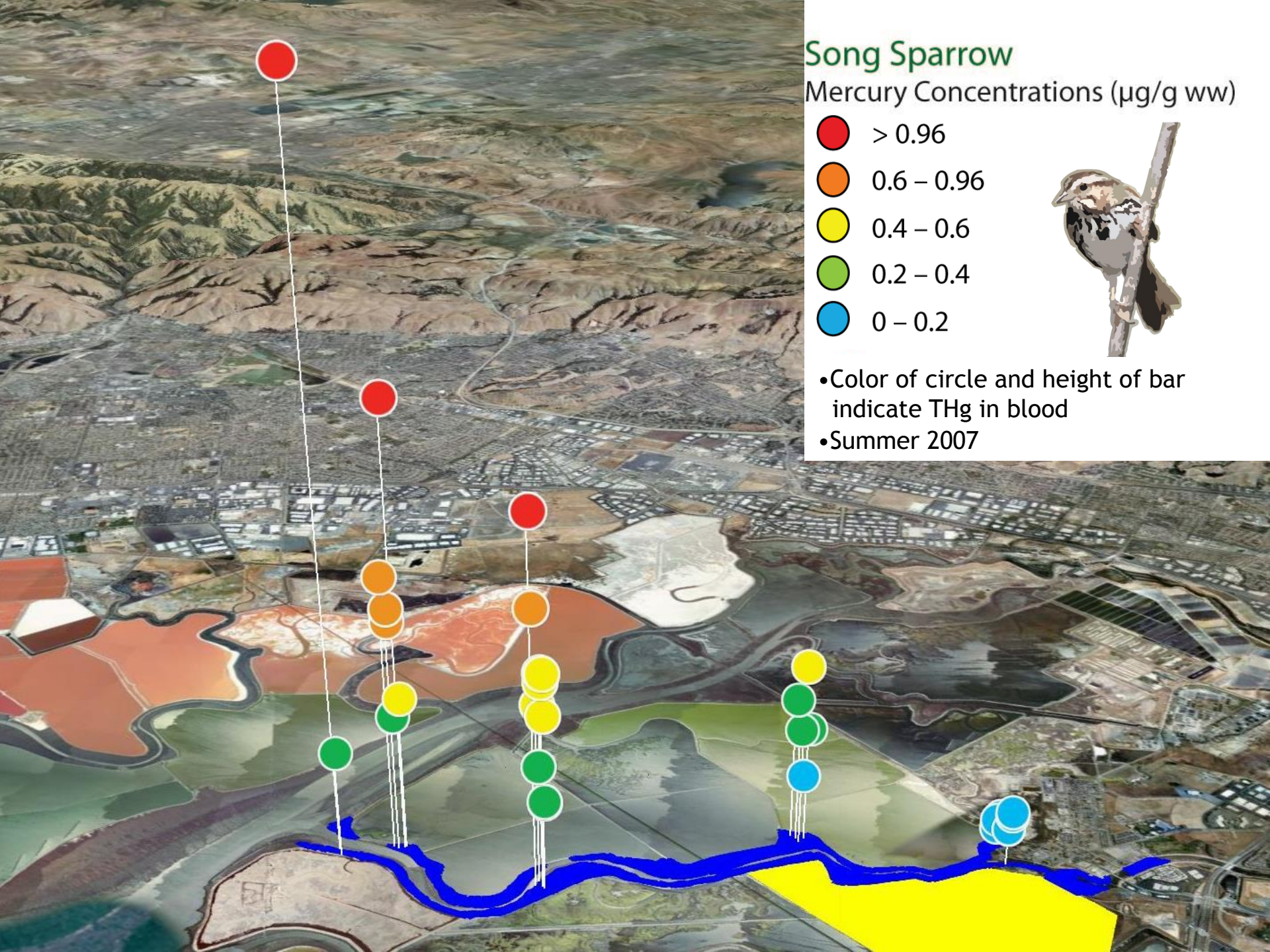
Low — Freq. of wetting/drying cycles — *High*

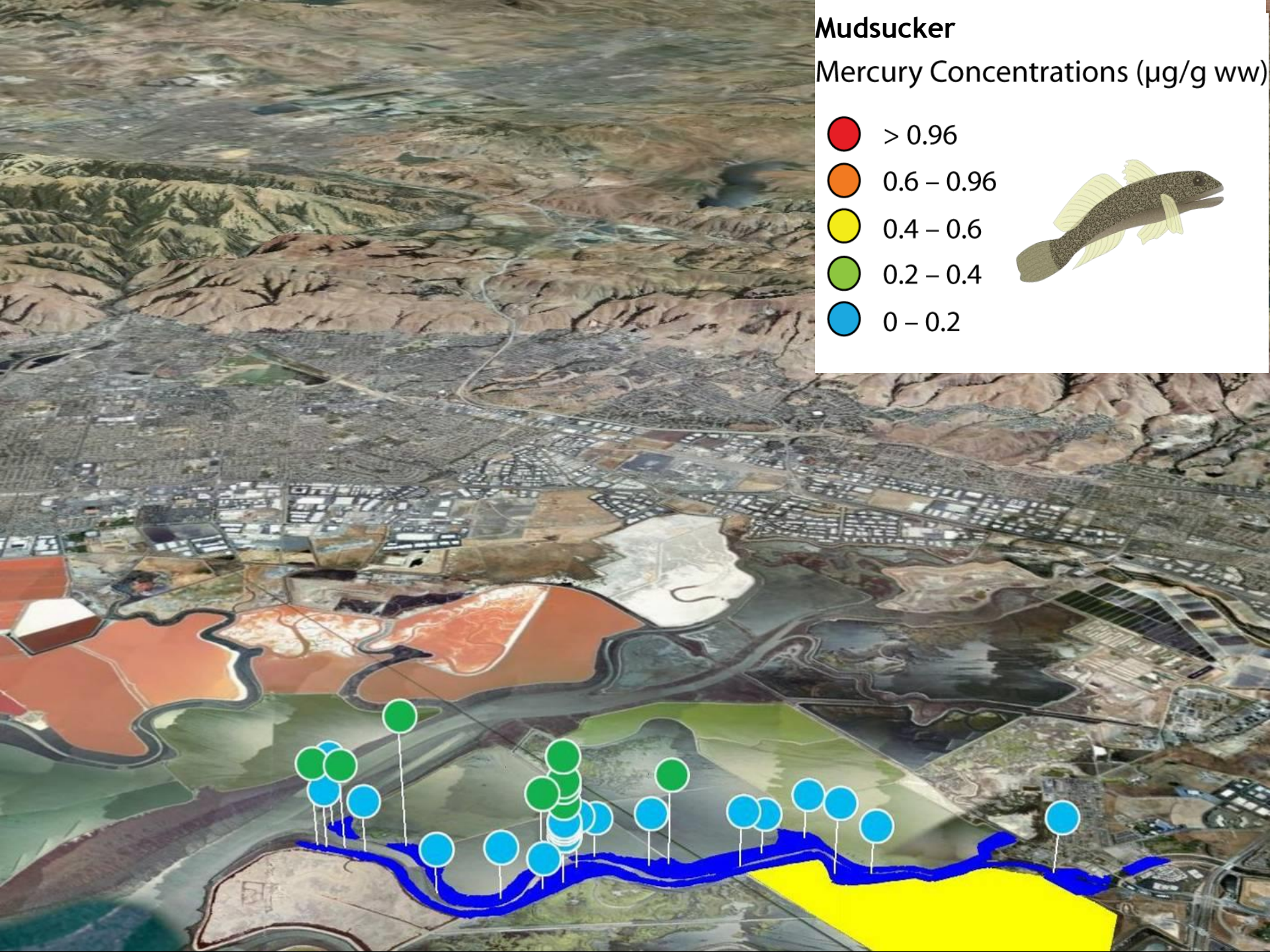
Many channels, few pannes — Topography — *Few channels, many pannes*

Restore Fresh to Saline Marsh Gradients



- Many co-benefits
- Potential co-problems: Nutrients and contaminants

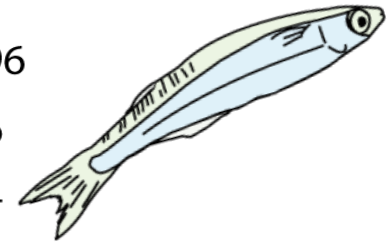

Song Sparrow
Mercury Concentrations (µg/g ww)
> 0.96
0.6 – 0.96
0.4 – 0.6
0.2 – 0.4
0 – 0.2
•Color of circle and height of bar indicate THg in blood
•Summer 2007

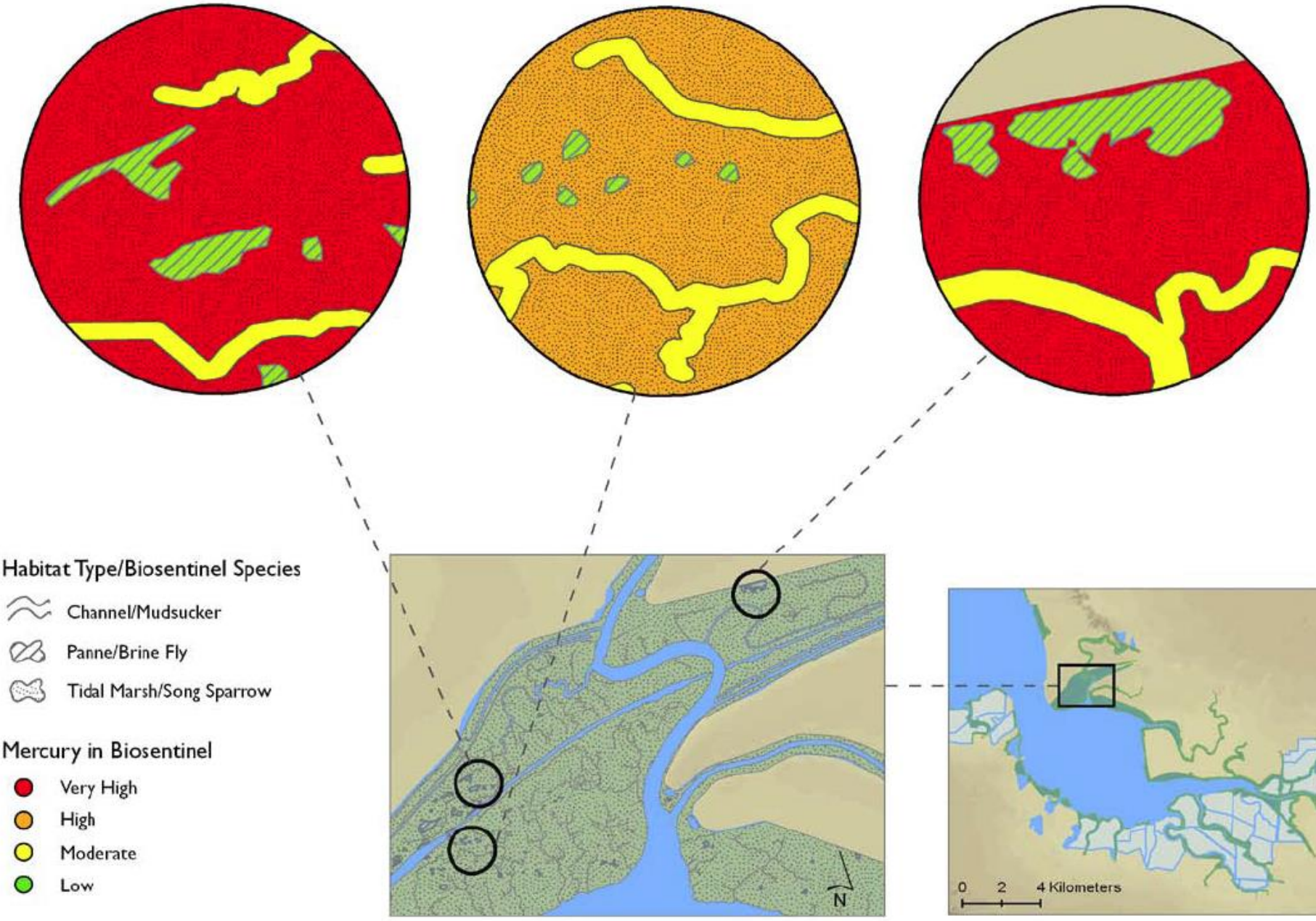

Mudsucker
Mercury Concentrations (µg/g ww)
> 0.96
0.6 – 0.96
0.4 – 0.6
0.2 – 0.4
0 – 0.2

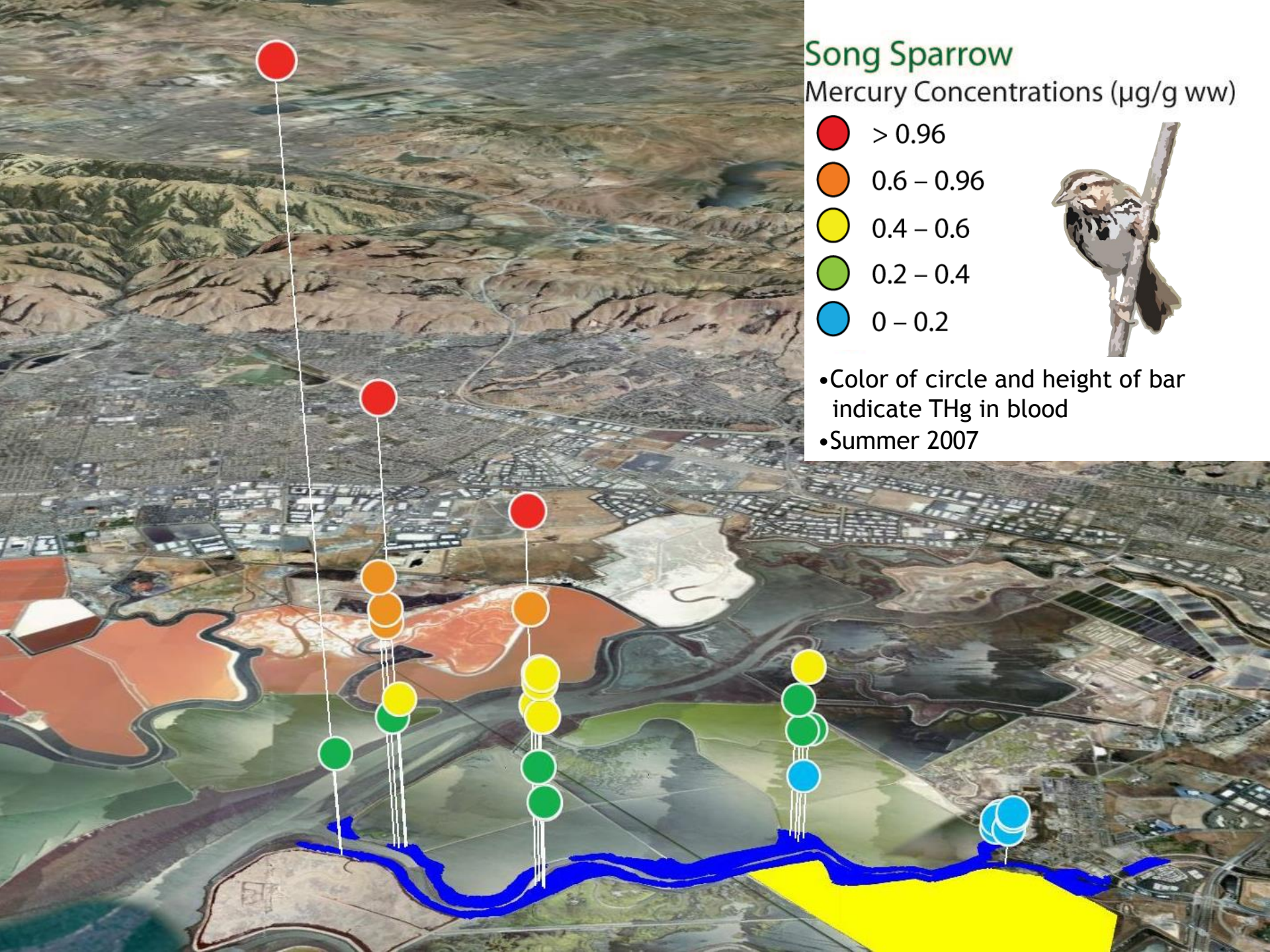
Mississippi Silversides

Mercury Concentrations (µg/g ww)

- > 0.96
- 0.6 – 0.96
- 0.4 – 0.6
- 0.2 – 0.4
- 0 – 0.2




Habitat Type/Biosentinel Species
Channel/Mudsucker
Panne/Brine Fly
Tidal Marsh/Song Sparrow
Mercury in Biosentinel
Very High
High
Moderate
Low
N
0 2 4 Kilometers
Marshes near Newark Slough
South San Franicsco Bay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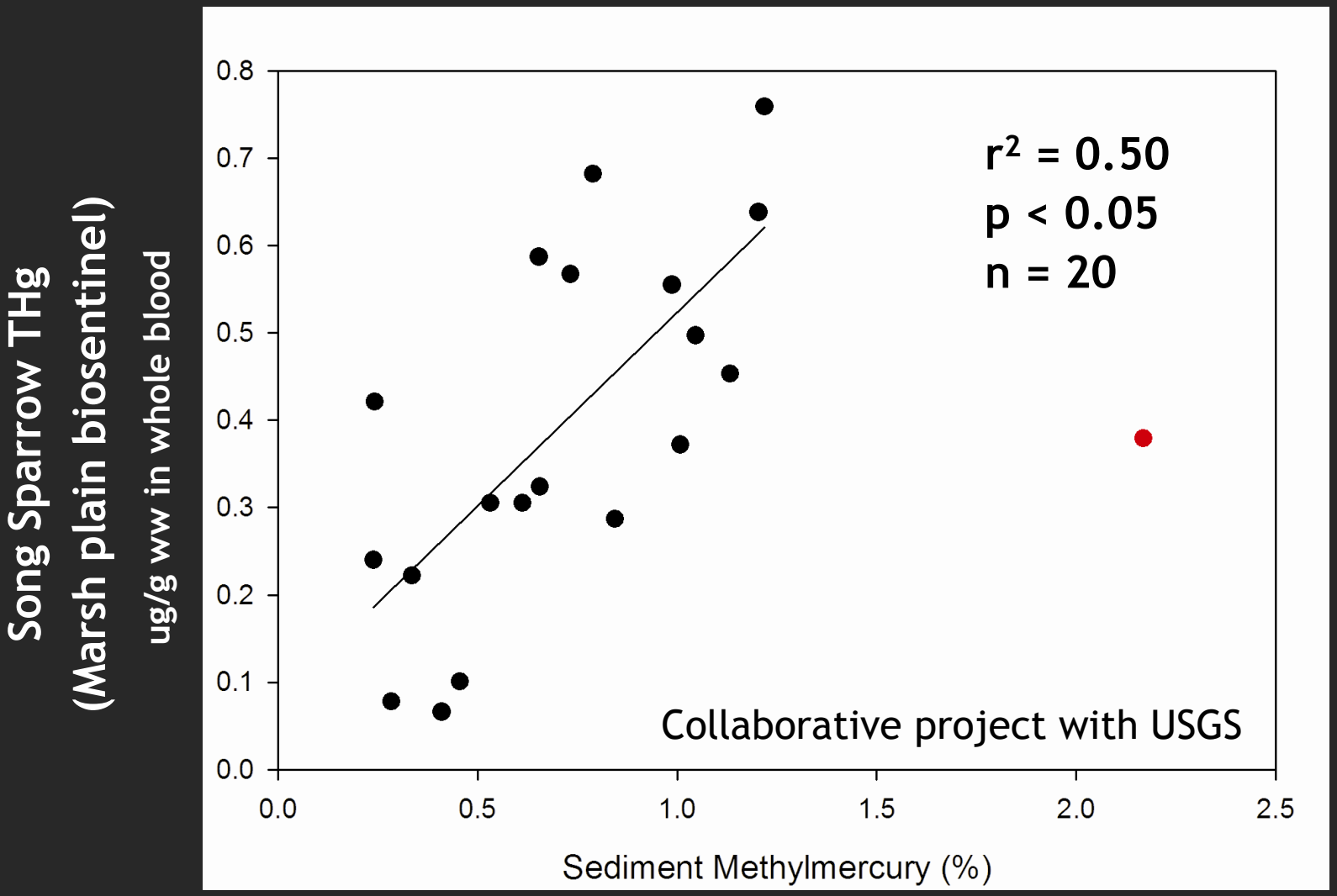
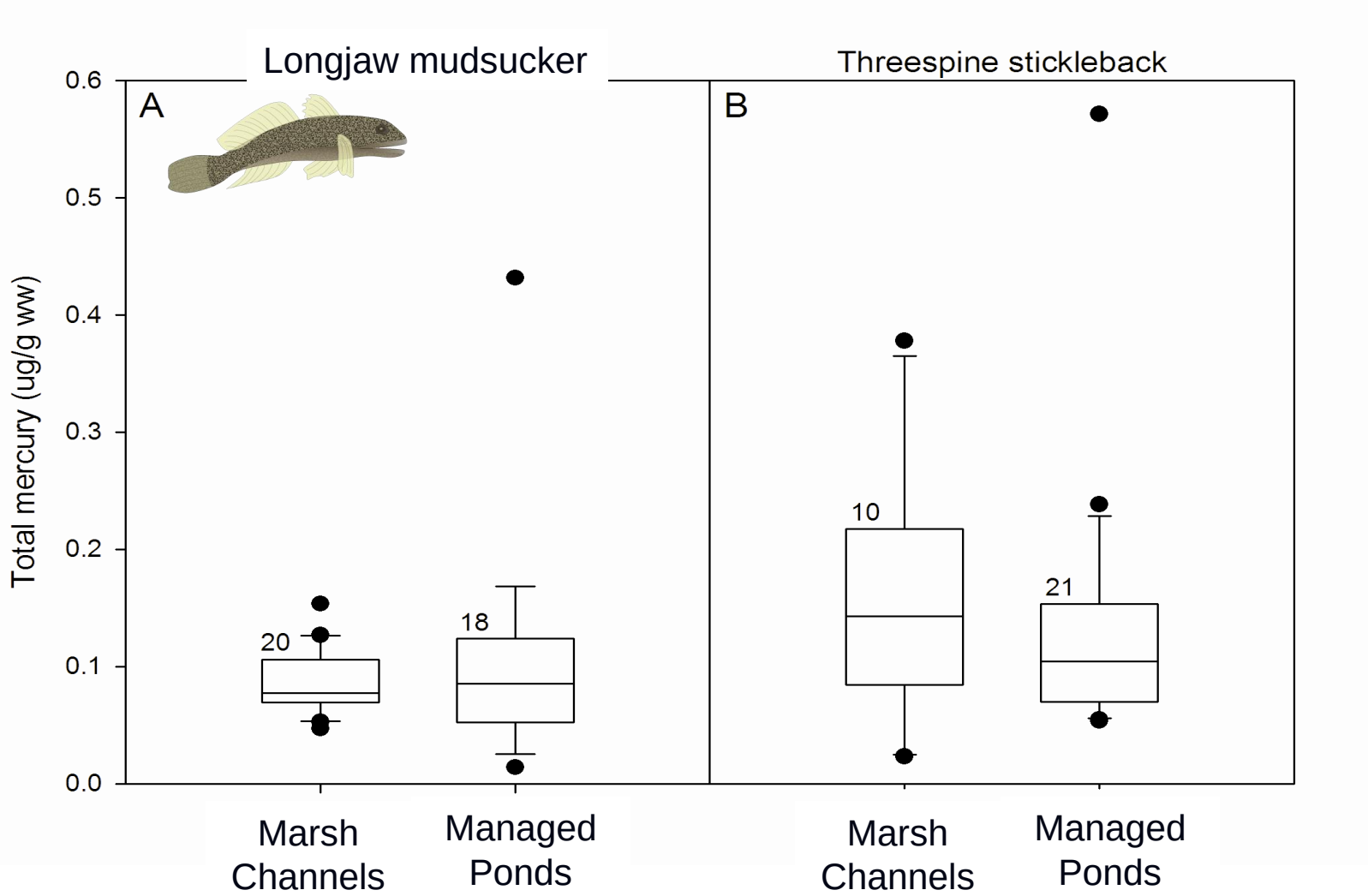
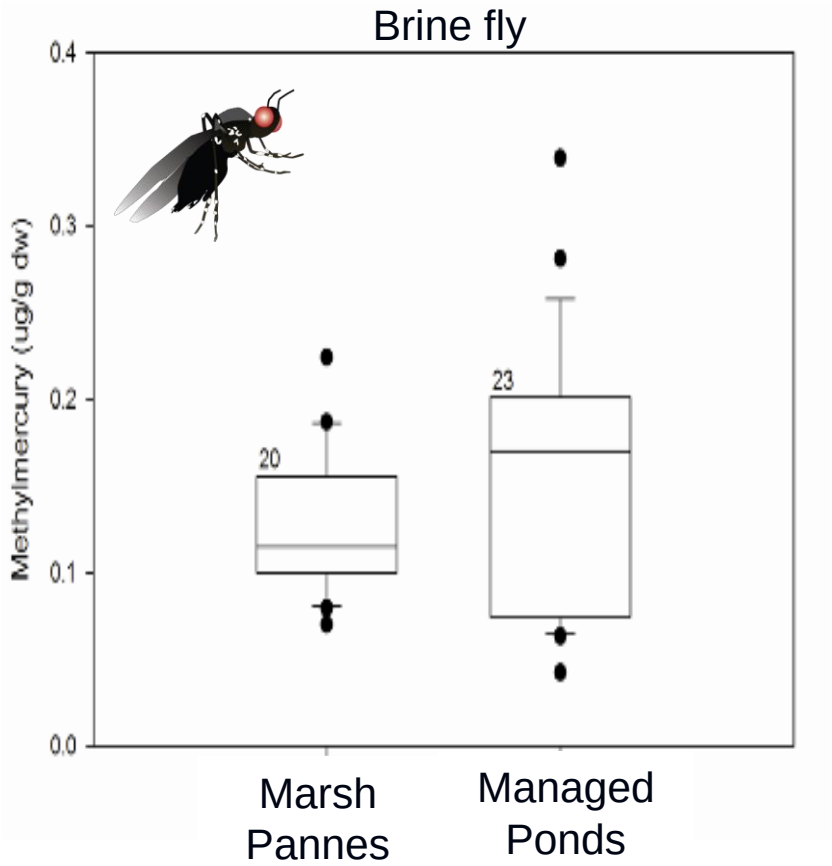
Strong relationship between biosentinels and methylmercury in their habitat



MeHg Exposure Similar in Ponds and Marshes



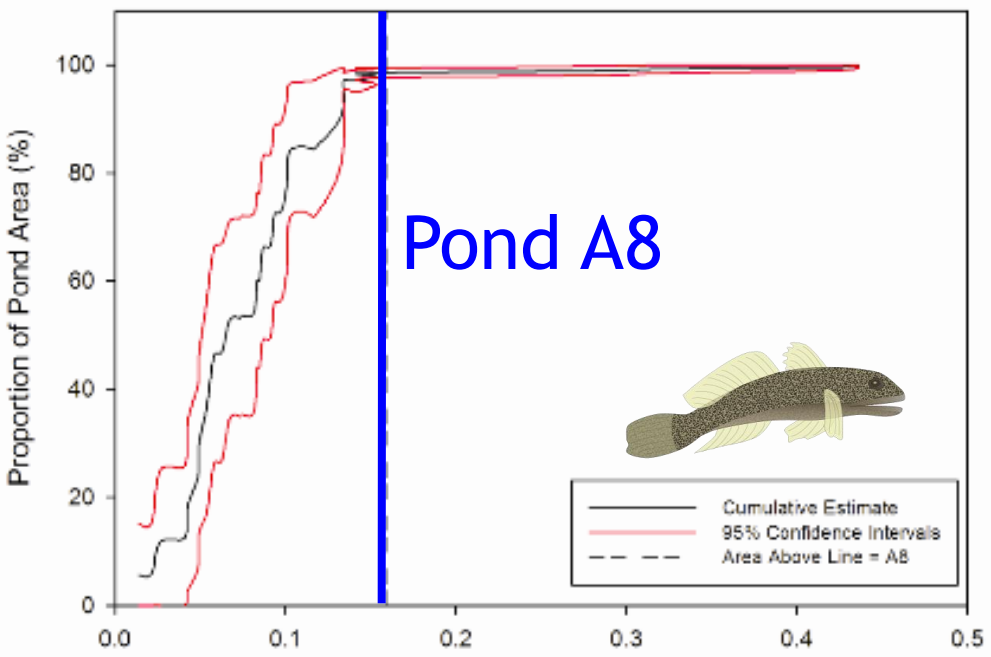
MeHg Exposure Similar in Ponds and Marshes

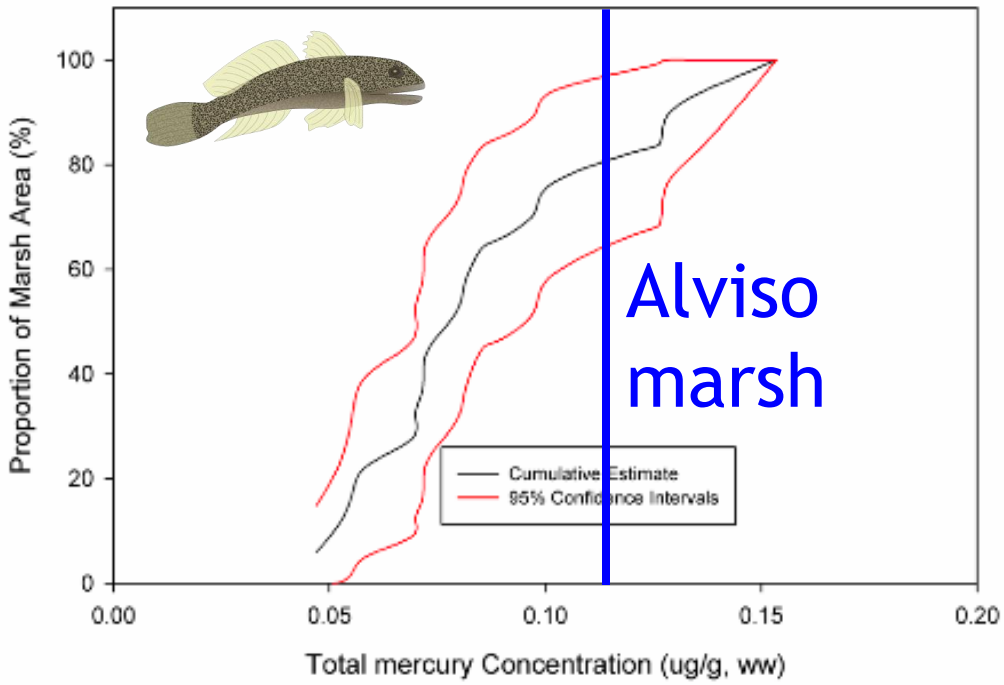


Where and what is restored matters

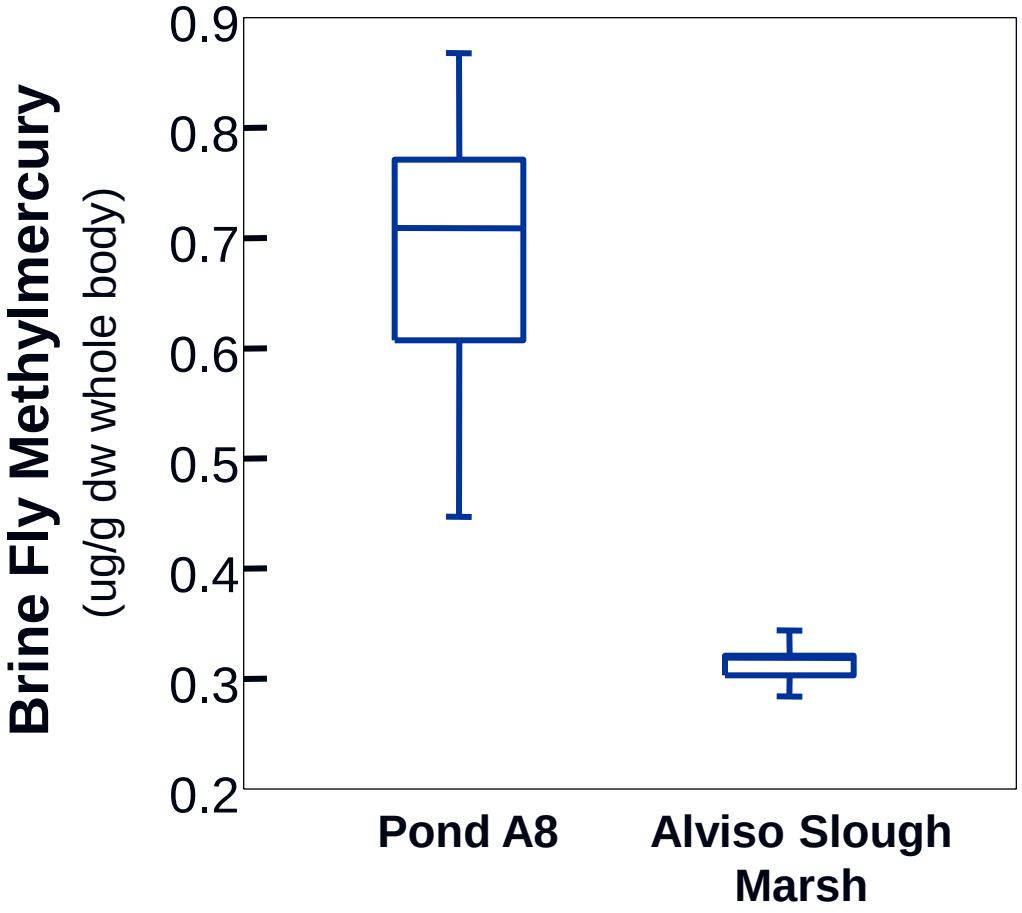
Question: Convert pond to marsh?

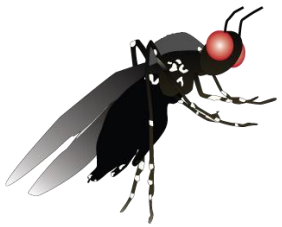
- **What is the mercury condition before?**
- **What is it likely to be after?**





Higher Mercury in Pond A8 than Adjacent Marsh



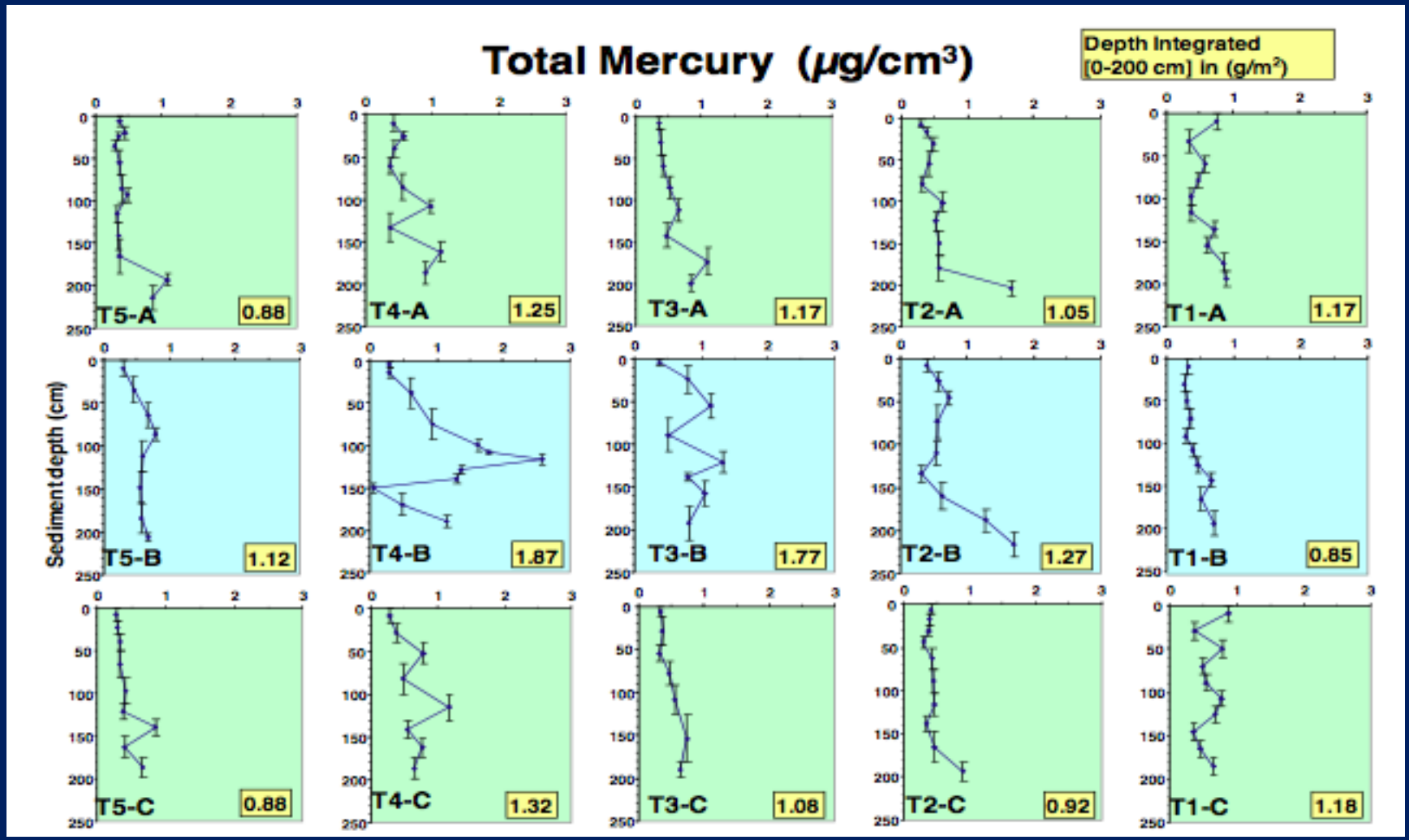


$p < 0.05$
Summer 2007
Composites

Localized Hot Spots

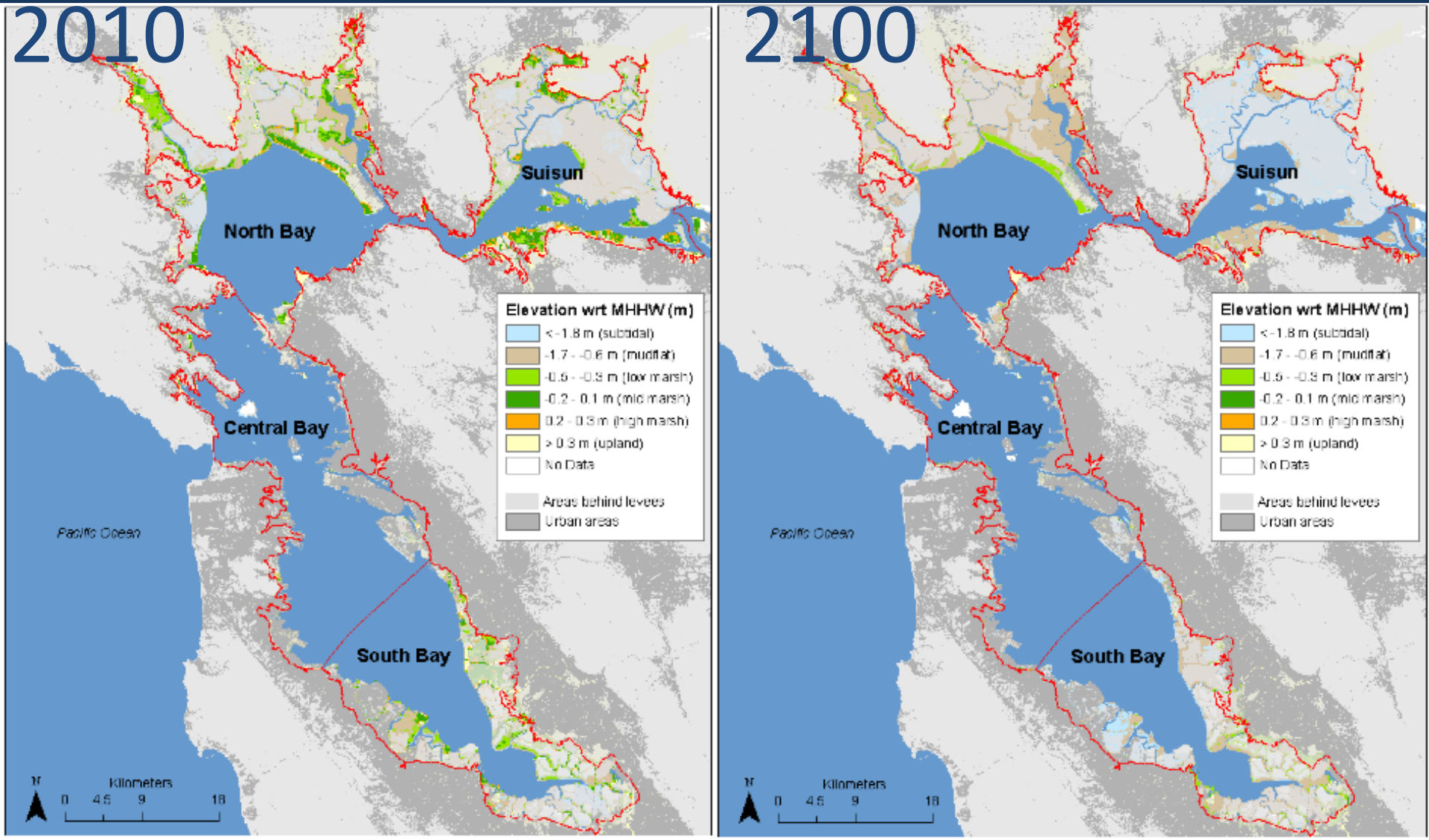
- Engineered Solutions (activated carbon?, etc.)
  - Need experiments
- Dredge or cap contaminated sediment
- Don’t restore to tidal influence

Marshes provide a valuable sequestration service

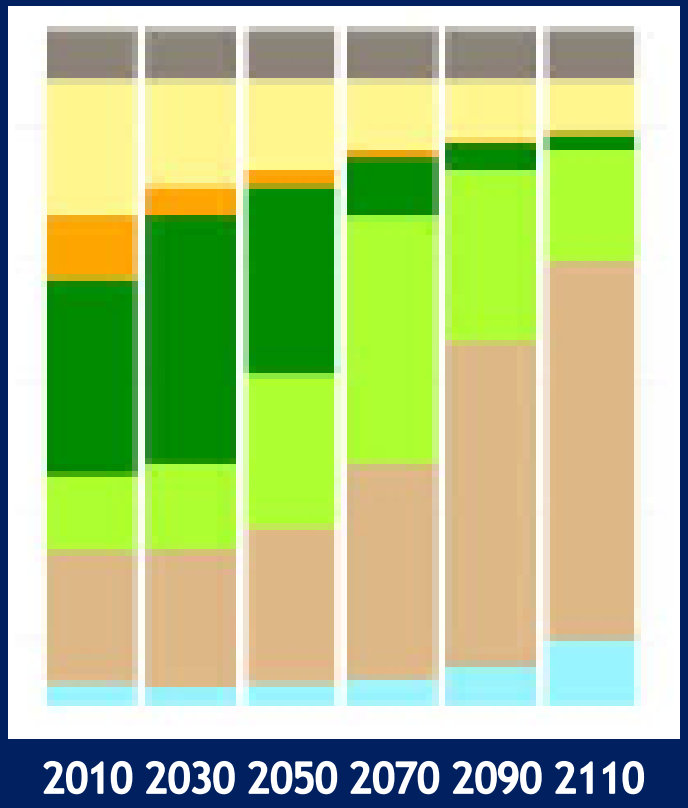


Marvin-DiPasquale and Cox 2007

Eroding Marshes -> Remobilized Contaminants?



Probable significant loss of mid and high marsh starting mid-century



	% Loss 2050	% Loss 2110
No Data		
Upland		
High Marsh	45 %	95 %
Mid Marsh	25 %	> 95 %
Low Marsh		
Mudflat		
Subtidal		

Stralberg et al. 2011

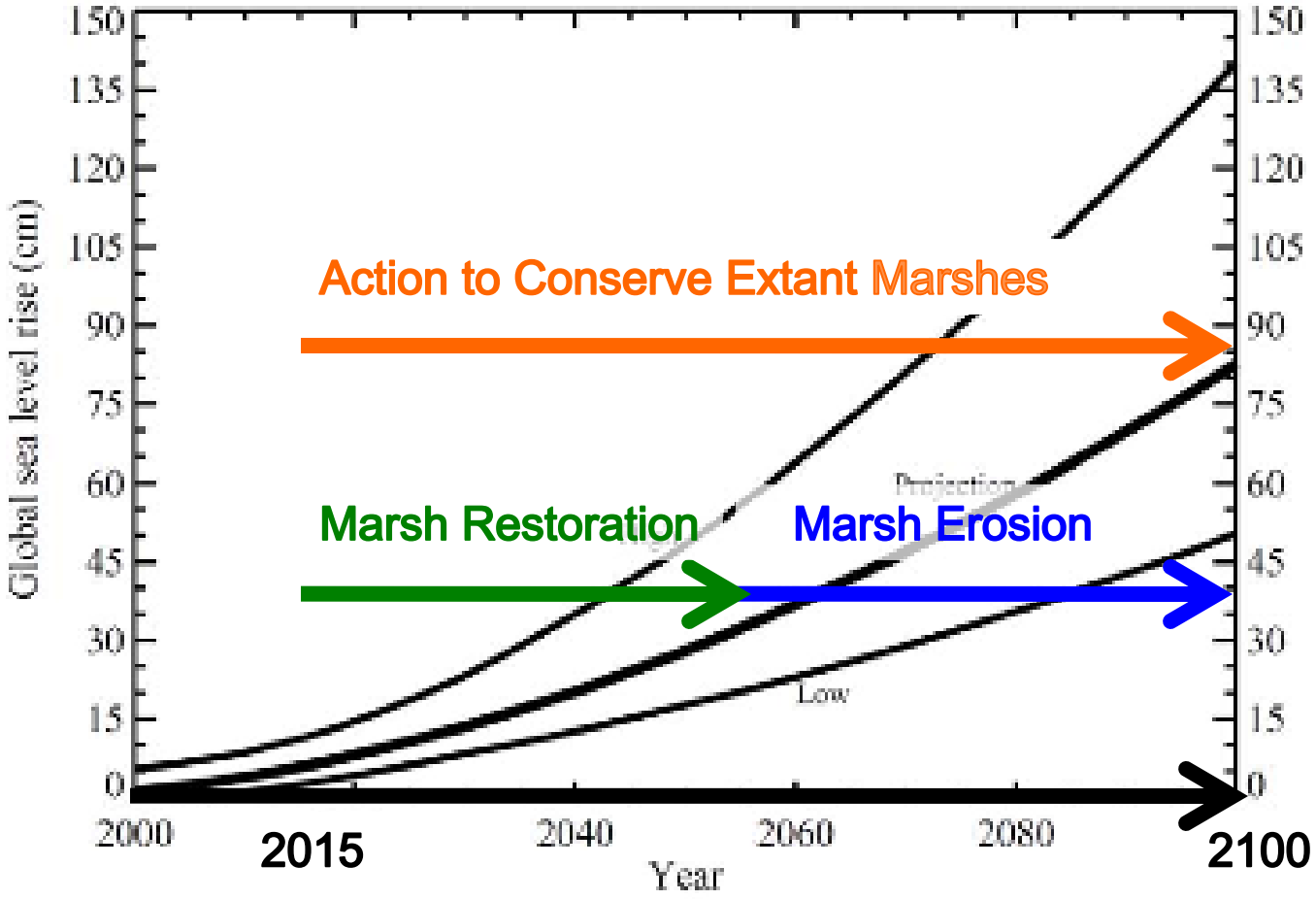
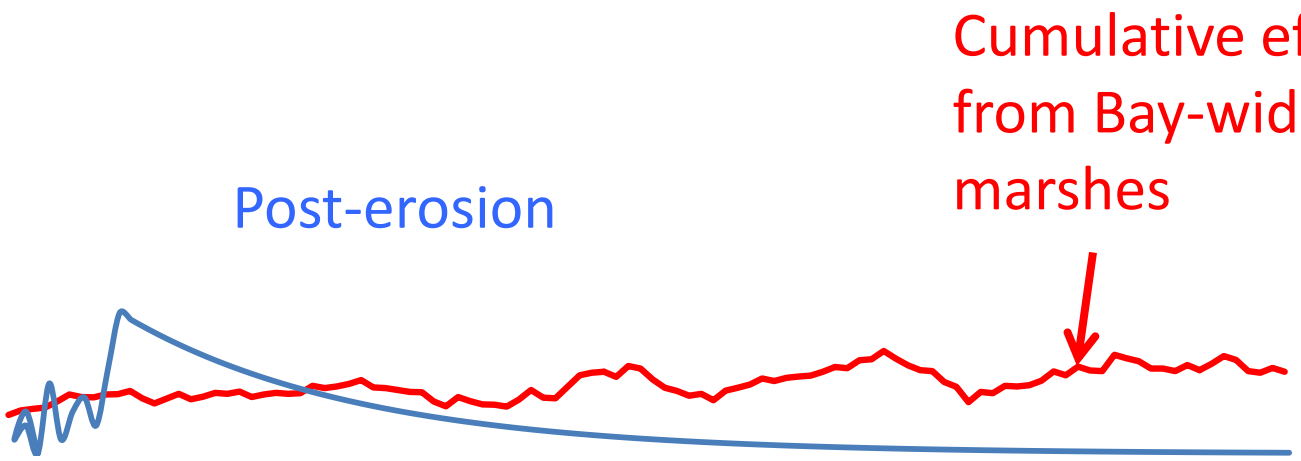


FIGURE 5.6 Range of committee projections for the sum of all individual components of global sea-level rise.

NRC 2012

Preventing erosion of extant marshes may be a high leverage action for water quality

Regional Response



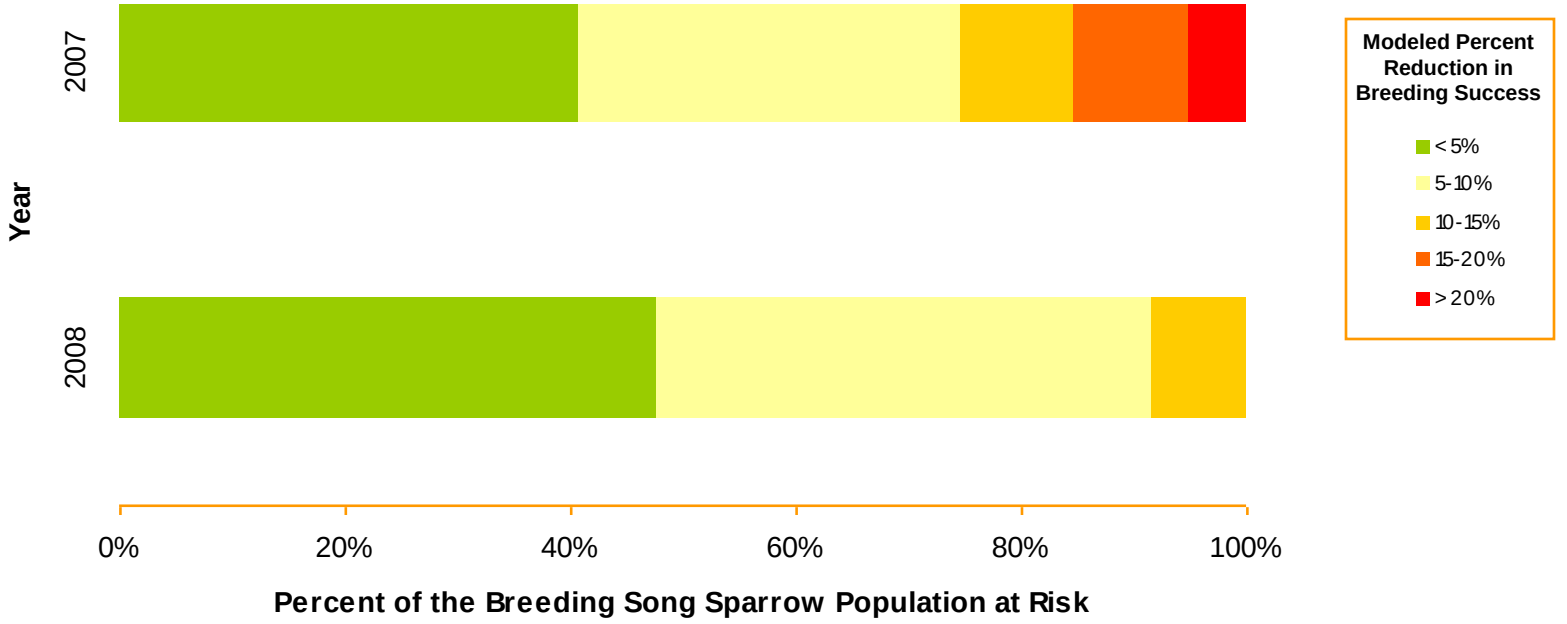
SF Estuary Endemic Birds and Mammals

- Tidal Marsh

Clapper Rail	*Rallus longirostris obsoletus*	San Francisco Bay
Common Yellowthroat	*Geothlypis trichas sinuosa*	San Francisco Bay
Song Sparrow	*Melospiza melodia samuelis*	San Pablo Bay
	M. m. pusillula	San Francisco Bay
	M. m. maxillaris	Suisun Bay
Ornate shrew	*Sorex ornatus sinuosus*	San Pablo Bay
Wandering shrew	*Sorex vagrans halicoetes*	South San Francisco Bay
Salt marsh harvest mouse	*Reithrodontomys raviventris raviventris*	San Francisco Bay
	R. r. halicoetes	San Pablo and Suisun Bays
California vole	*Microtus californicus paludicola*	San Francisco Bay
	M. c. sanpabloensis	San Pablo Bay

- Bay

> Half of Tidal Marsh Sparrow Population at Risk for Reproductive Loss due to MeHg



May get worse as sea level rises and salinities increase

What can we do?

- Conserve extant marshes
- Restore to fully tidal
- Restore fresh to saline gradient
- Work to understand variation among pannes & within marsh plains
- Restore in the right places; consider before and after

Thank You