Mercury and the South Bay Salt Pond Restoration Project

By

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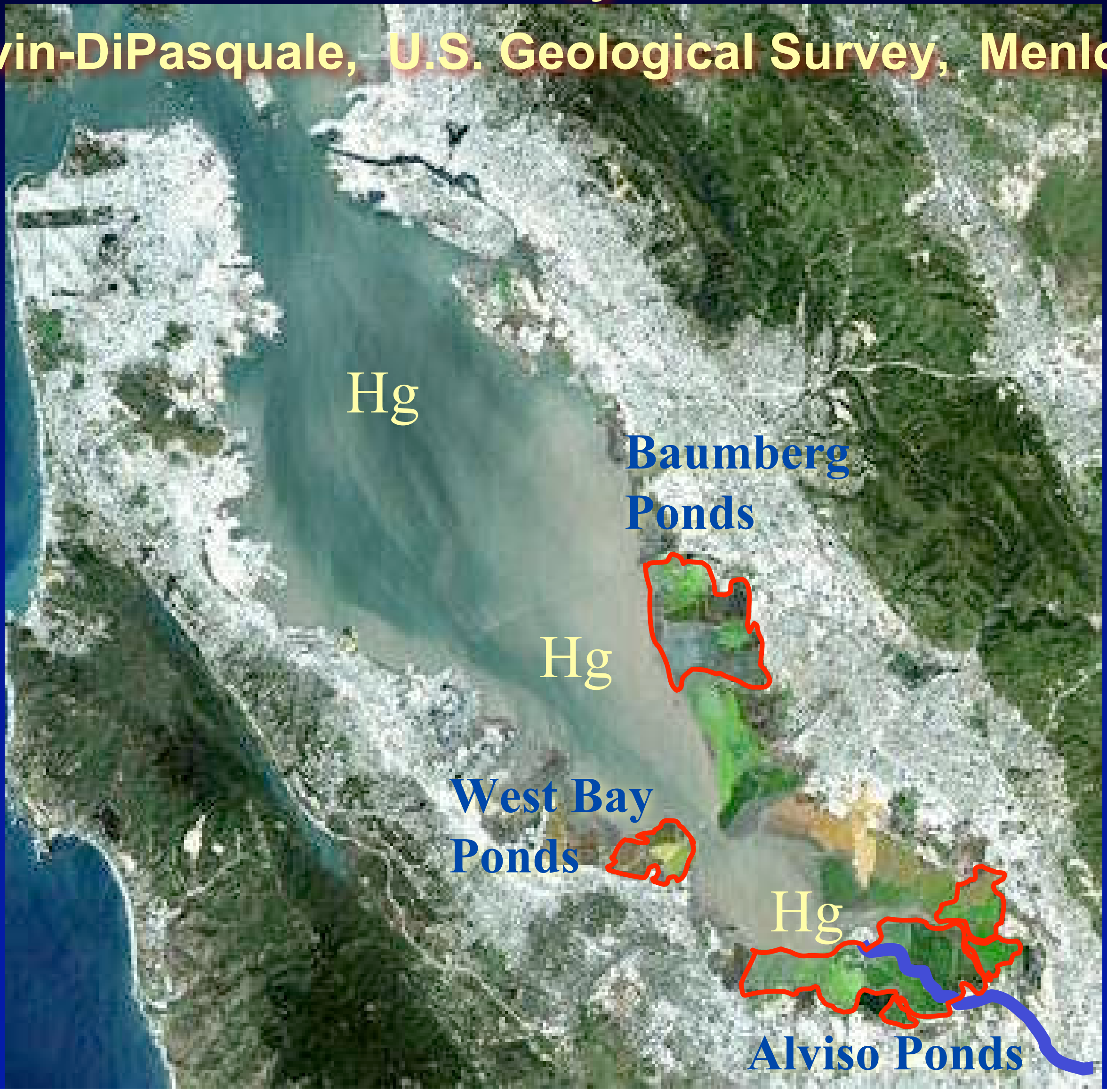


Presentation

➢ What Do We Know?

- ♦ Hg species concentrations in water, sediments and some biota
- ♦ Wetlands are active zones of MeHg production

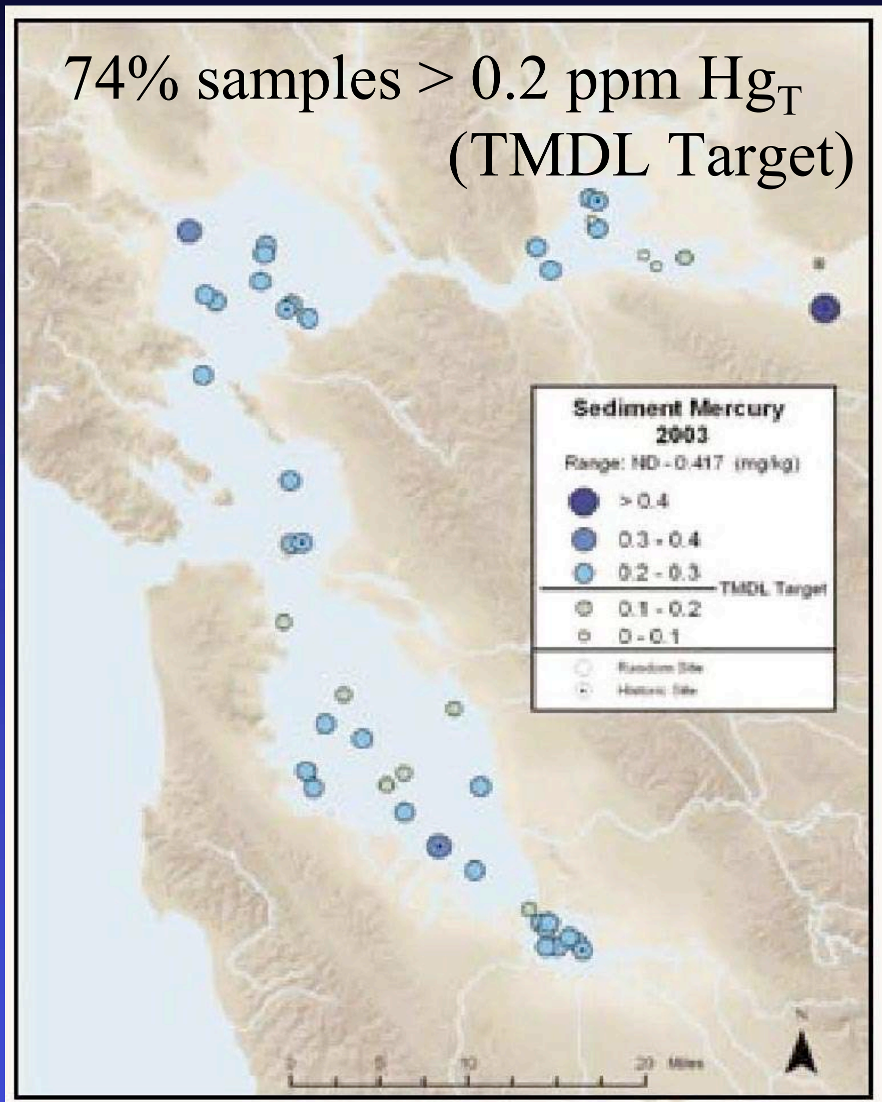
➢ What Don't We Know?

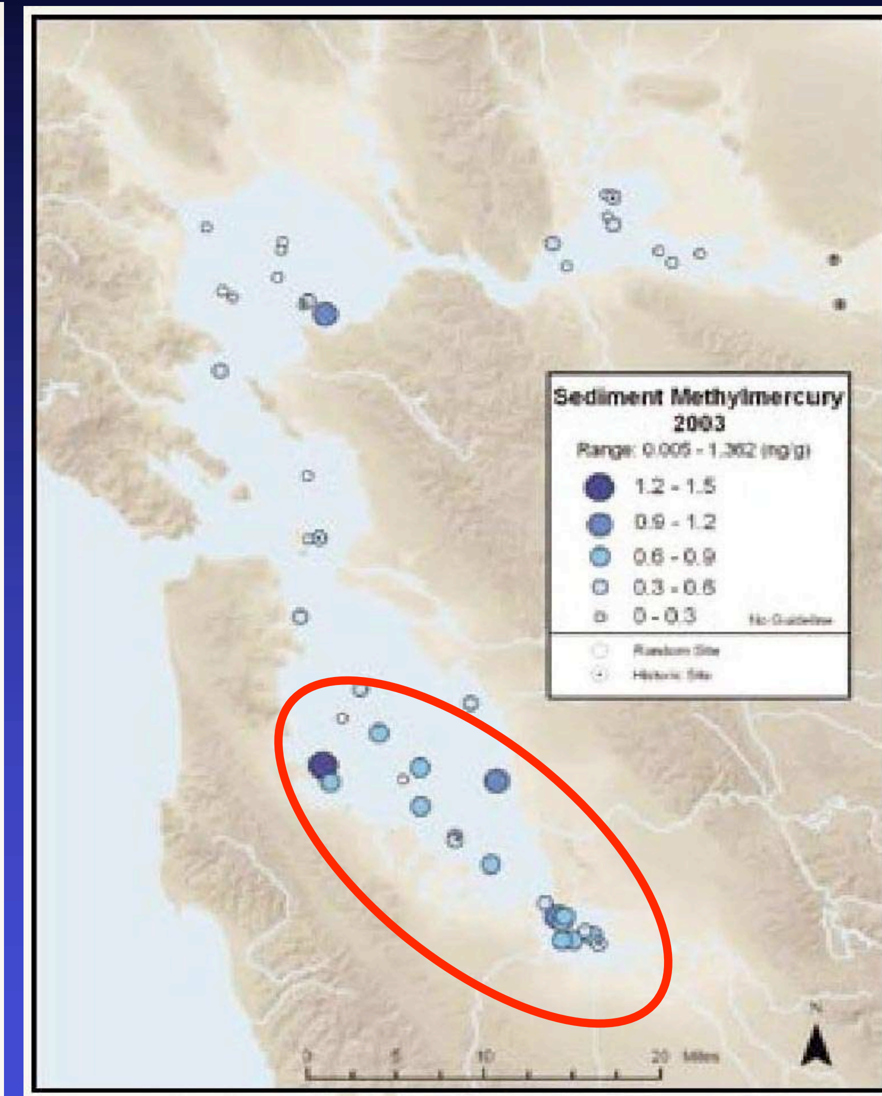
- ♦ Extent of the "Hg Problem" at the Ecosystem Level
- ♦ Habitat specific Processes Controlling:
  Hg-methylation, Hg- transport or bioaccumulation

➢ What Are The Implications for SBSP Restoration?

- ♦ Potential for enhanced 'reactive' Hg(II) mobilization → MeHg production → bioaccumulation
- ♦ Limited 'Window of Opportunity' to mitigate Hg problems → design considerations

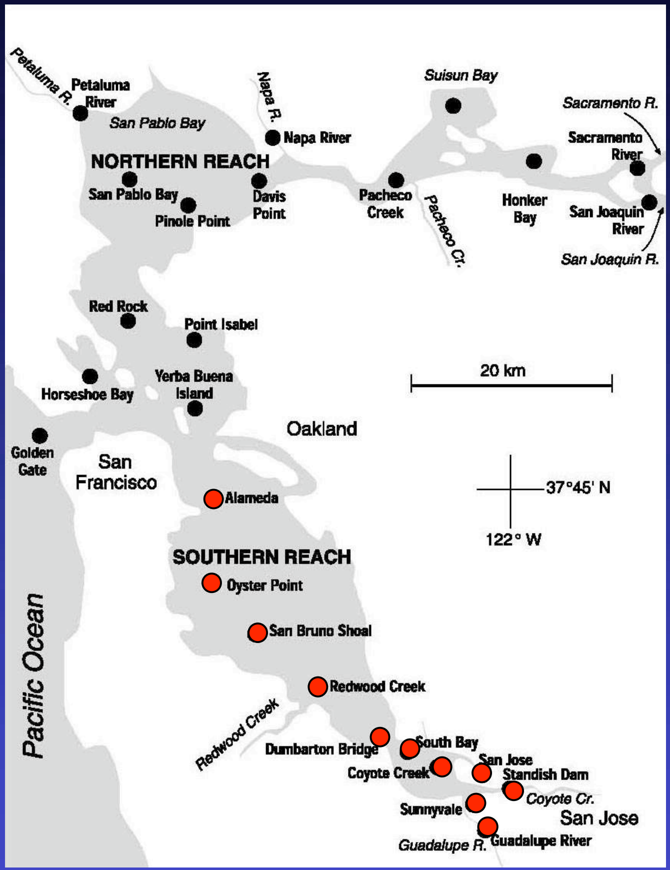
Mercury in Sediment - SFB

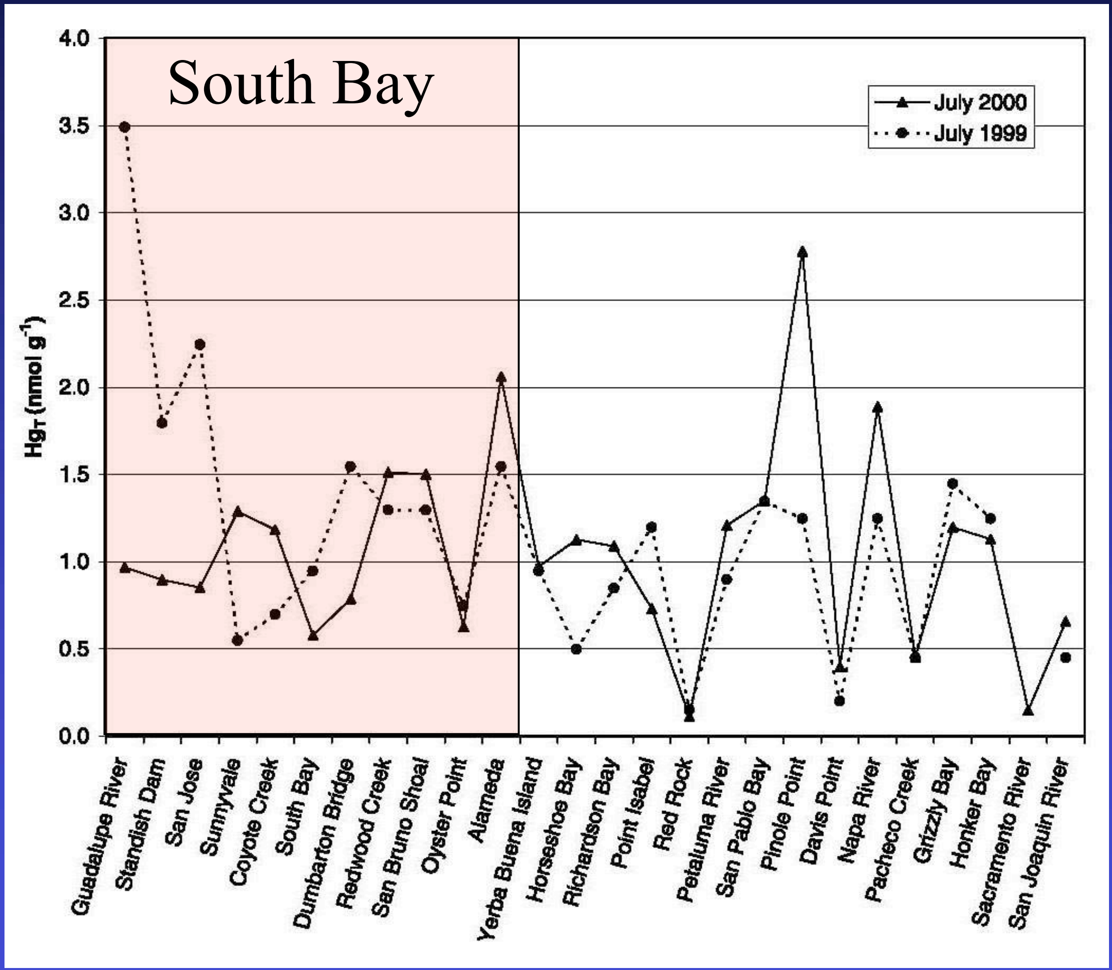




Source: Pulse of the Estuary 2005
Data: Regional Monitoring Program

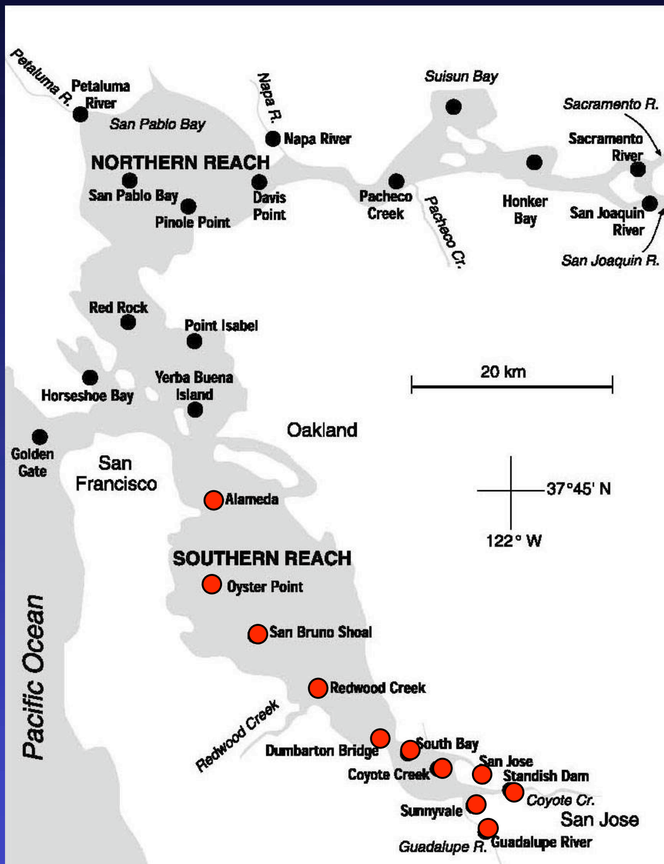
Total Mercury in Sediment - SFB

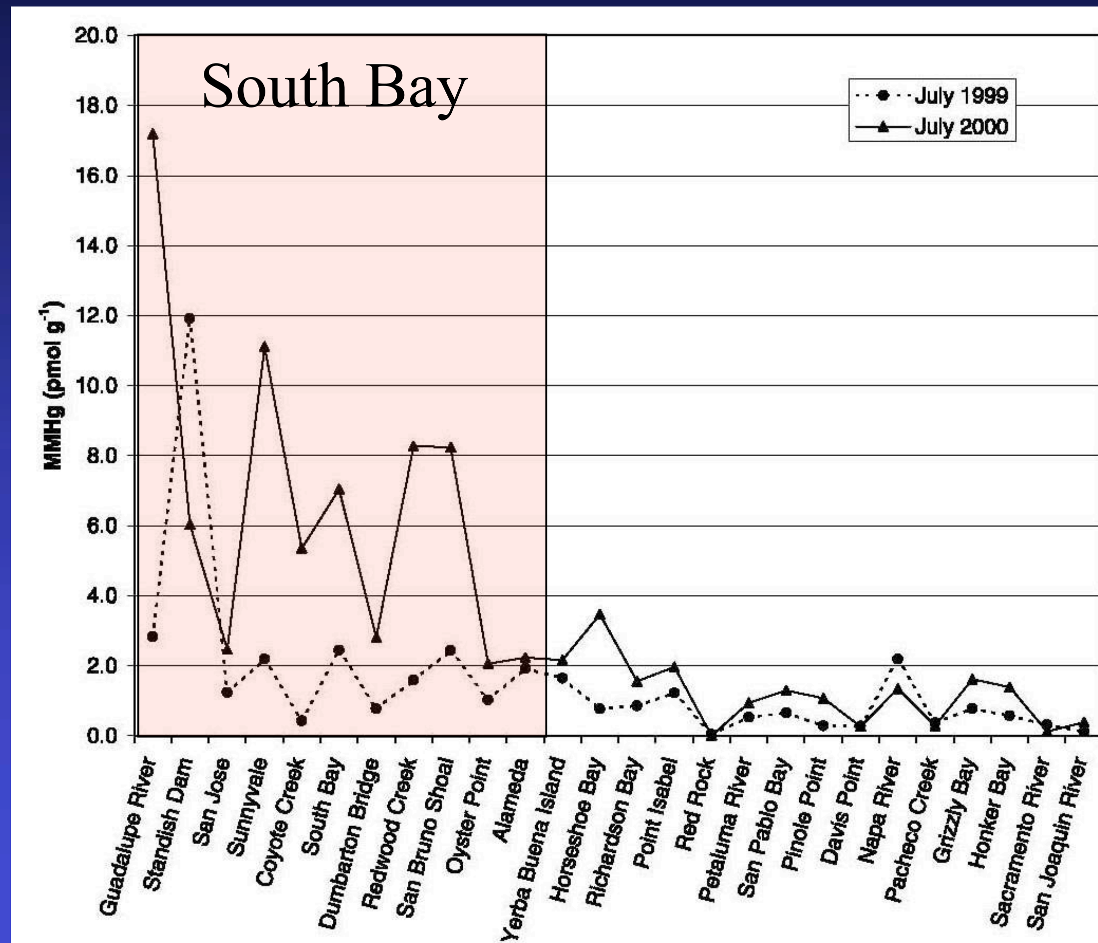




Source: Conaway et al. 2003, Marine Chemistry, v. 80 p. 199–225

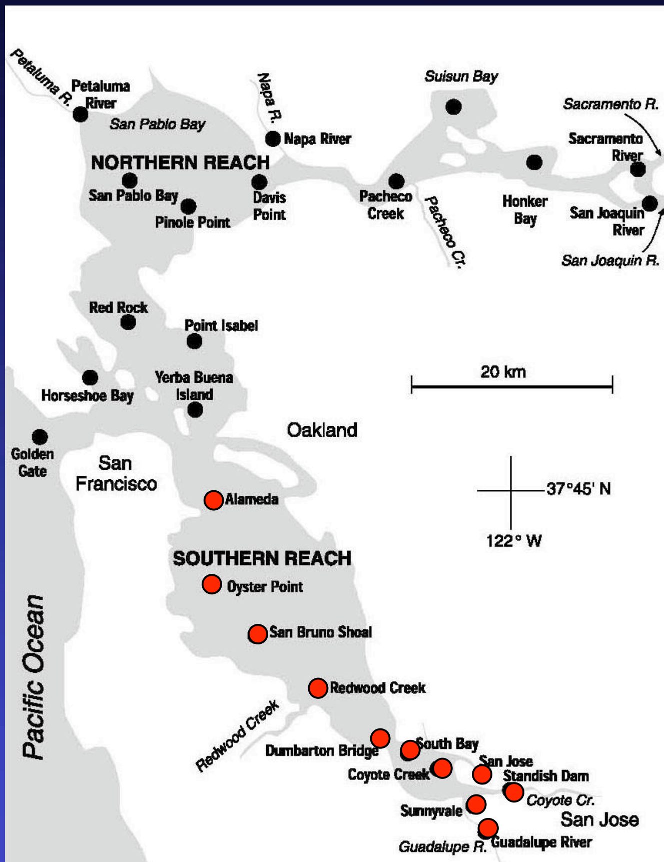
Methylmercury in Sediment - SFB

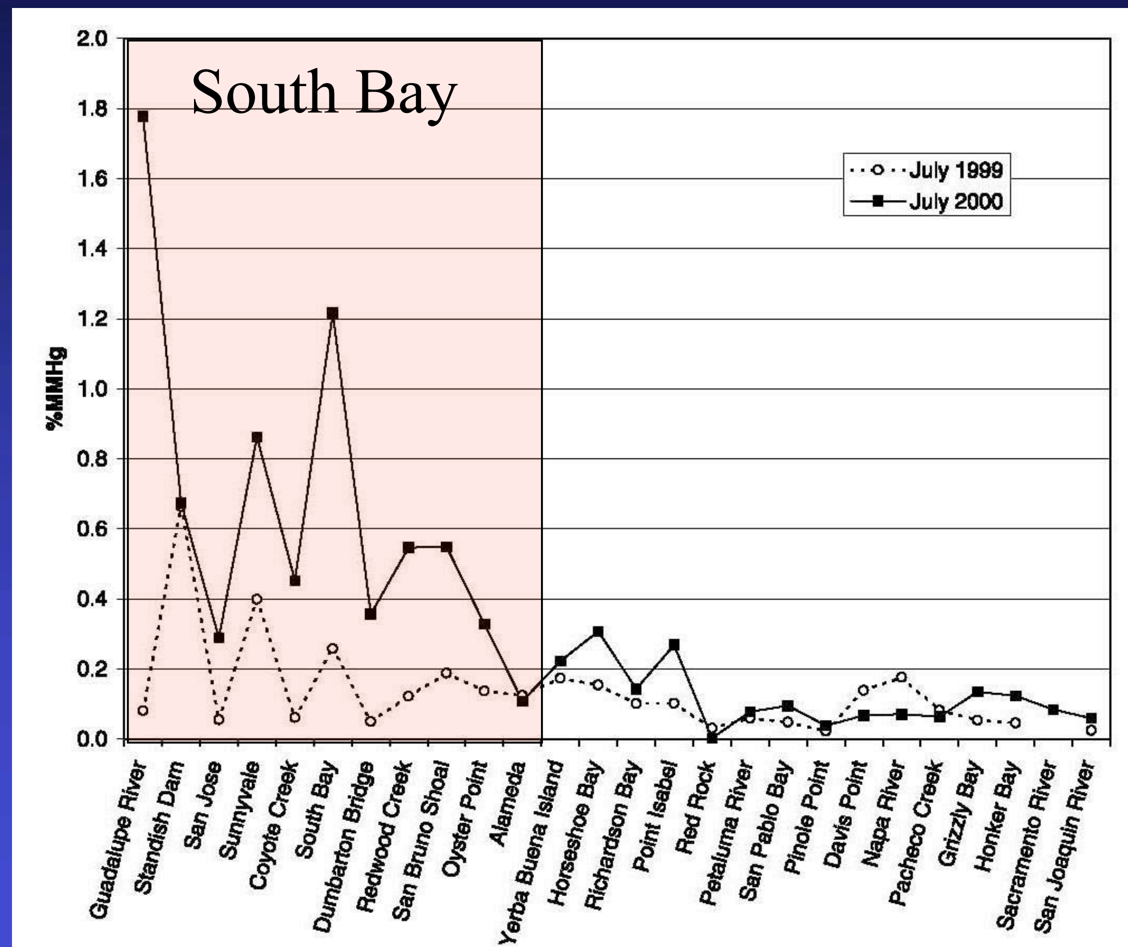




Source: Conaway et al. 2003, Marine Chemistry, v. 80 p. 199–225

% Methylmercury in Sediment - SFB

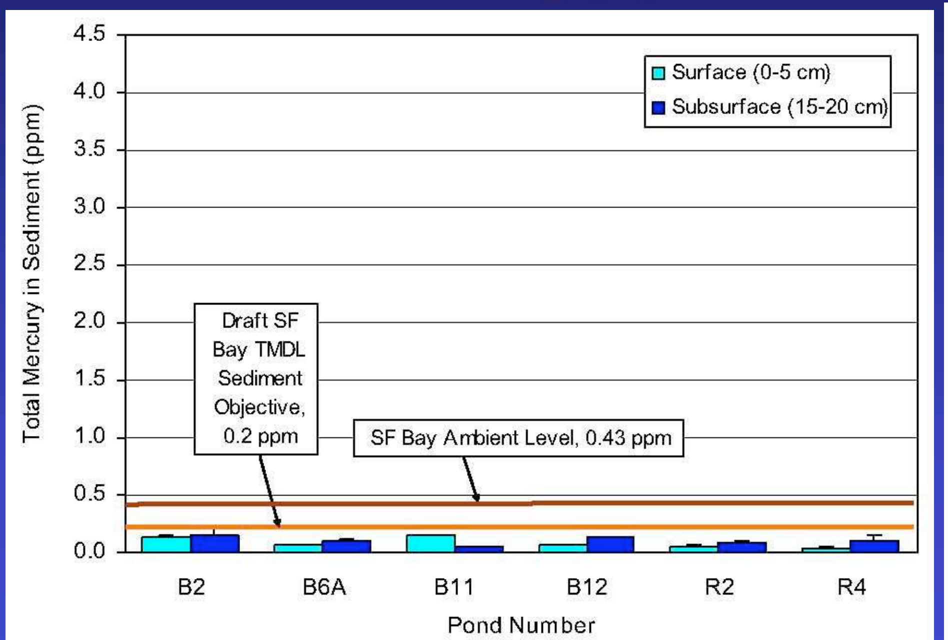




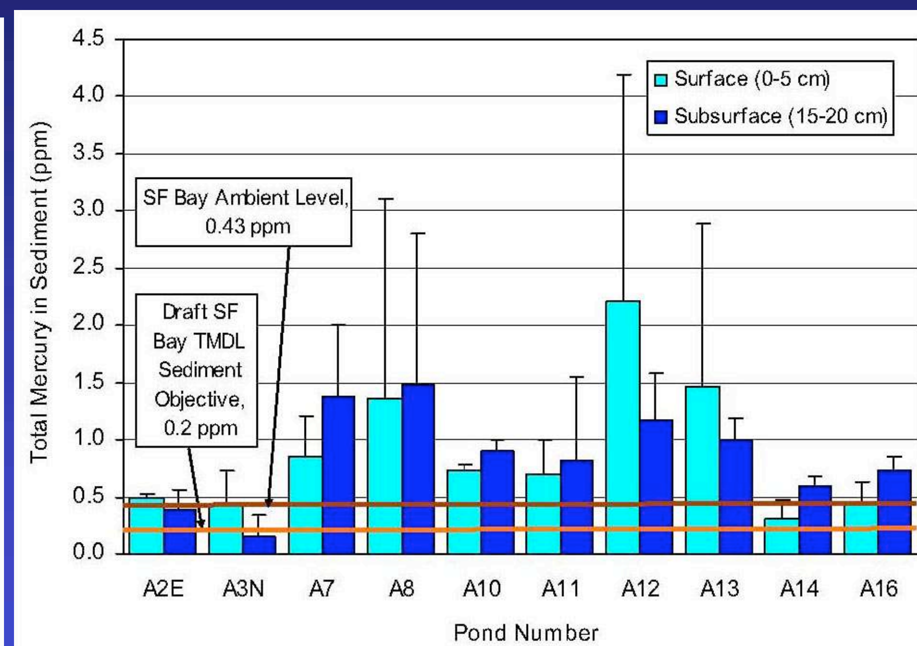
Source: Conaway et al. 2003, Marine Chemistry, v. 80 p. 199–225

Total Mercury in Salt Ponds Sediment

Baumberg/ Eden Landing (B) and Redwood/West Bay (R) Ponds



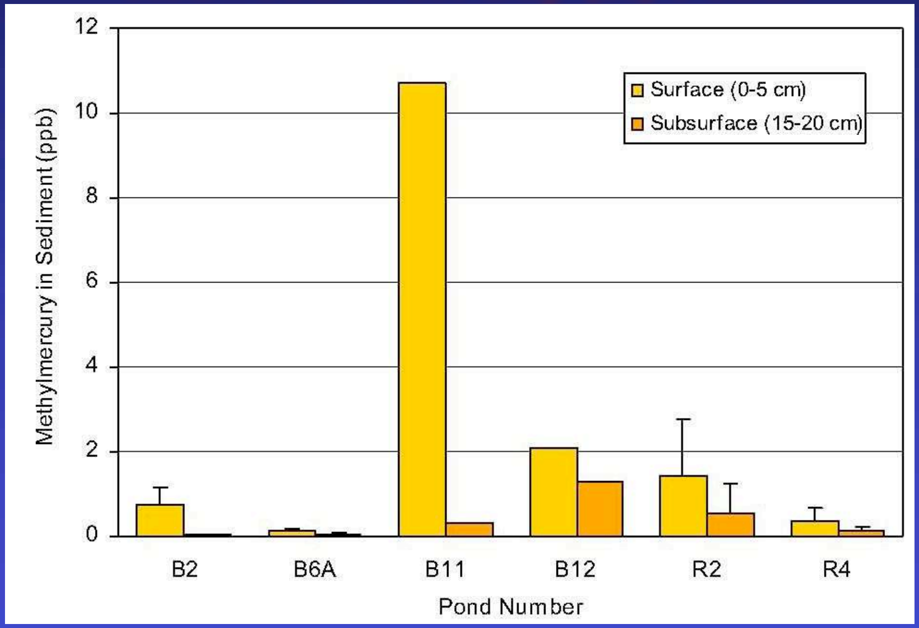
Alviso Ponds



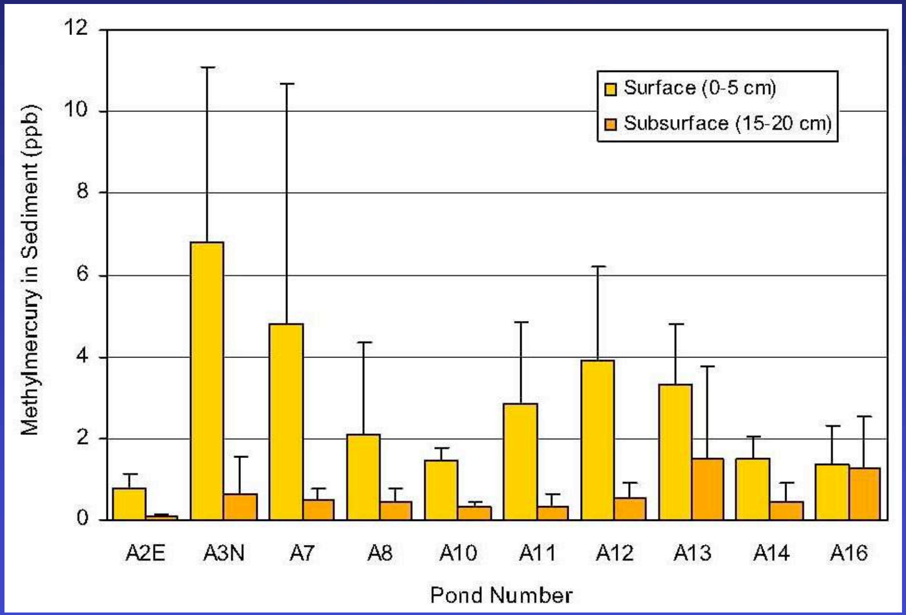
Source: Beutel et al., Mercury Technical Memo, 2004
Data: Keith Miles et al., USGS - WERC

Methylmercury in Salt Ponds Sediment

Baumberg/ Eden Landing (B) and Redwood/West Bay (R) Ponds



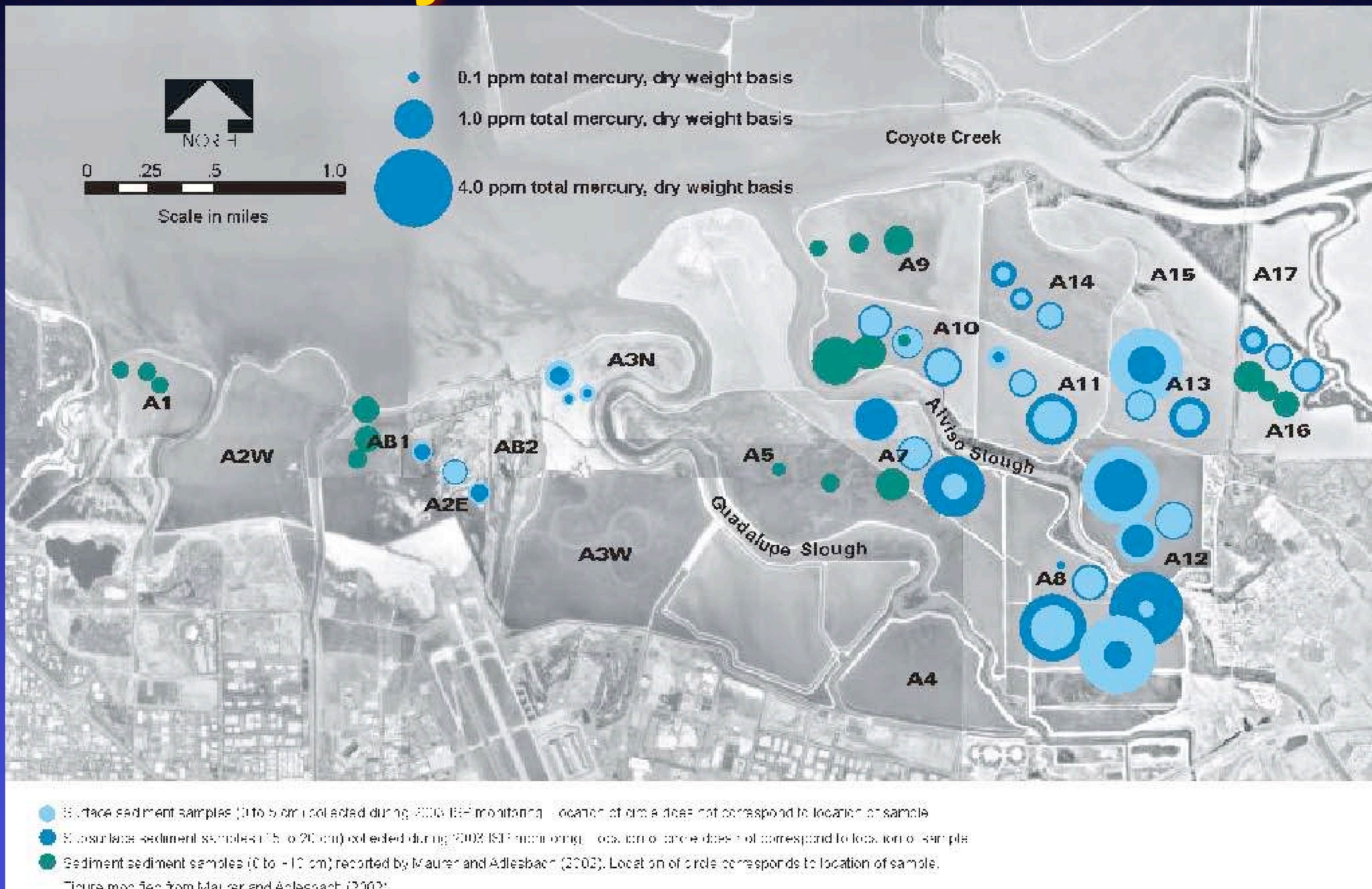
Alviso Ponds



Source: Beutel et al., Mercury Technical Memo, 2004

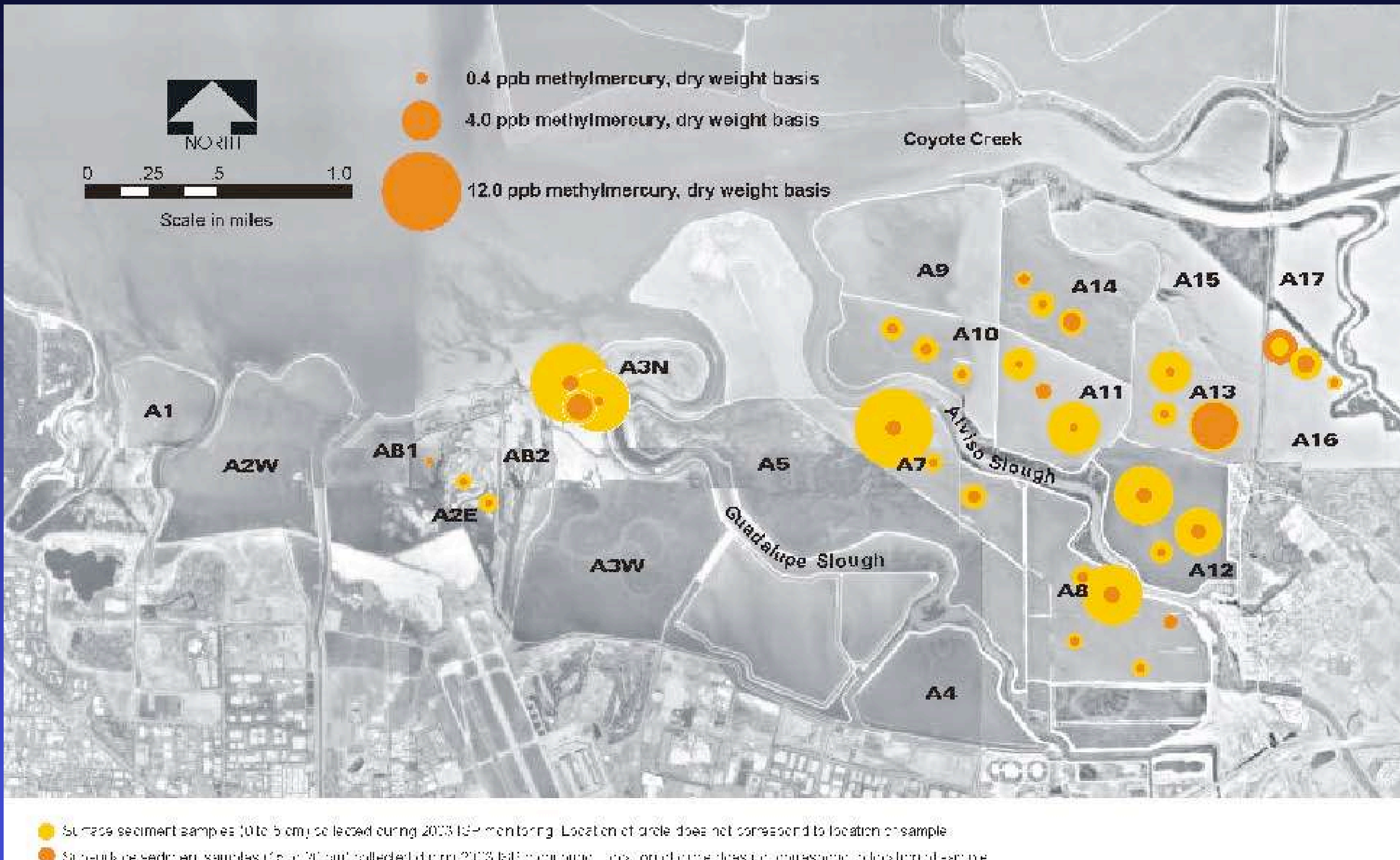
Data: Miles et al., USGS - WERC

Total Mercury in Alviso Ponds Sediment



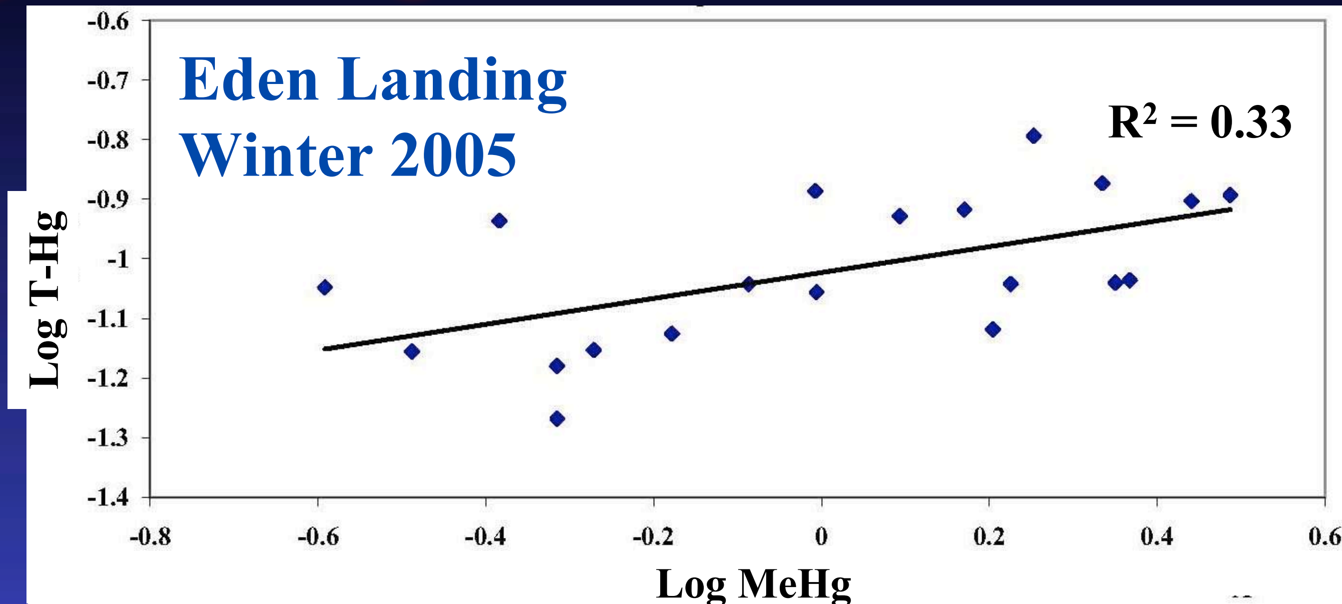
Source: Beutel et al., Mercury Technical Memo, 2004

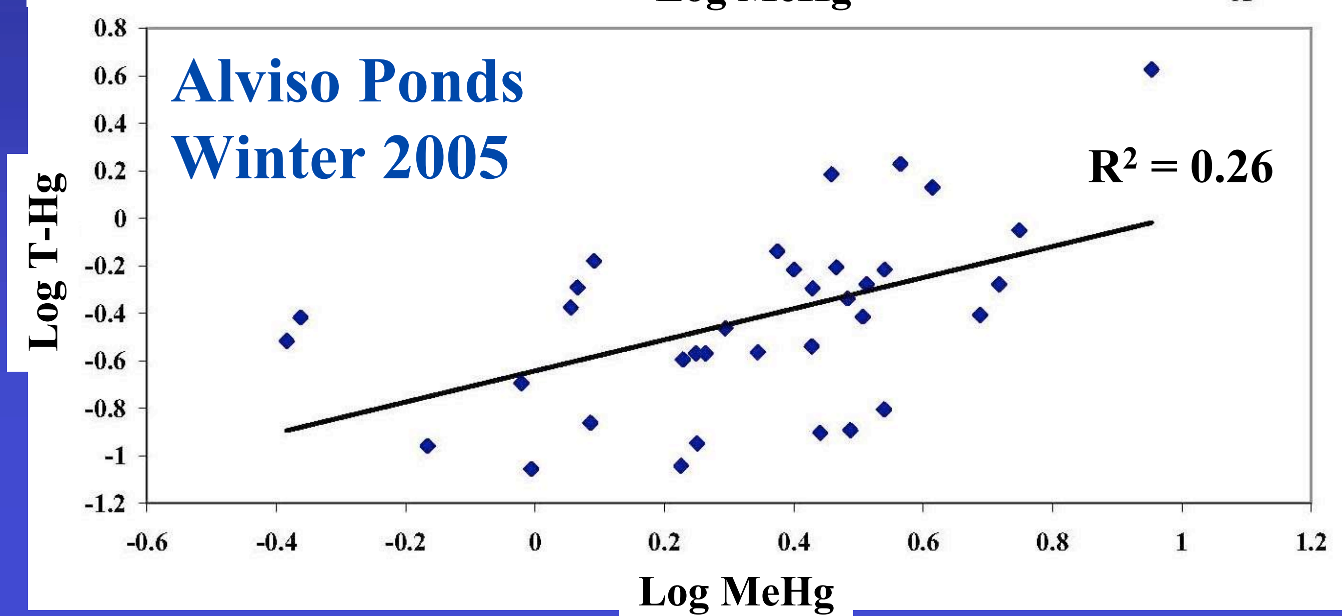
Methylmercury in Alviso Ponds



Source: Beutel et al., Mercury Technical Memo, 2004

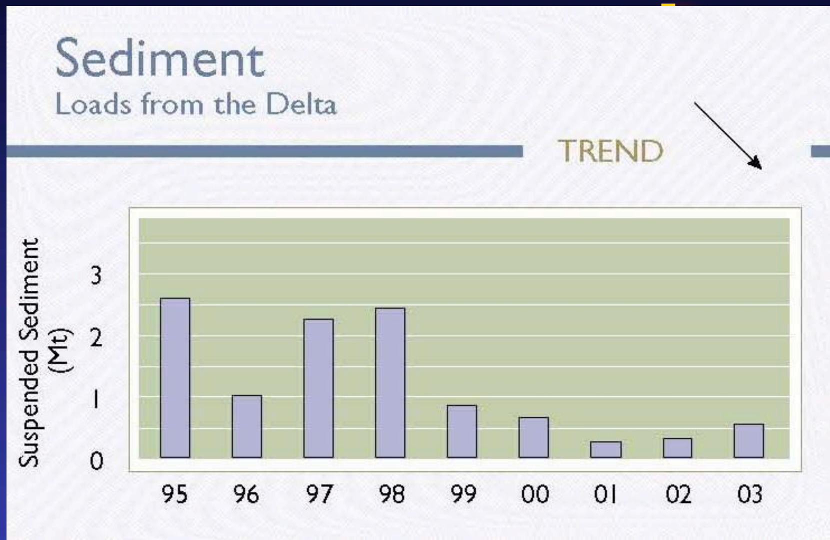
T-Hg vs MeHg in Salt Ponds Sediment

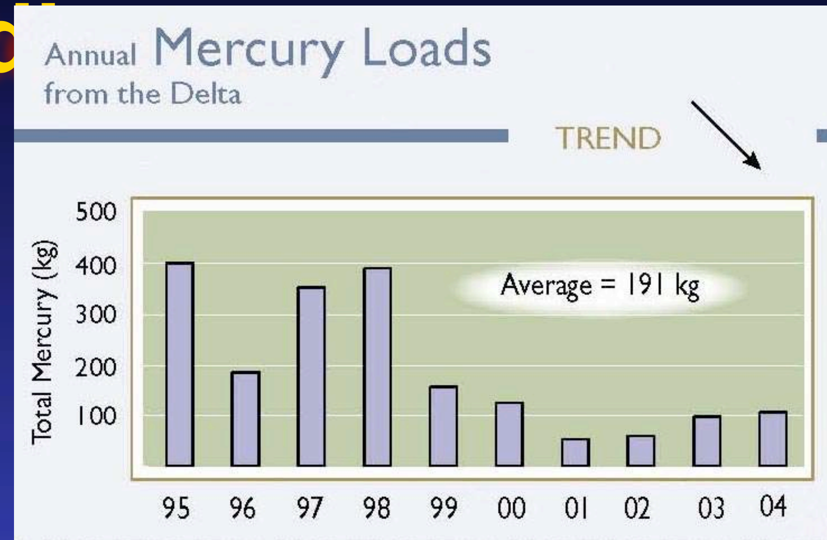


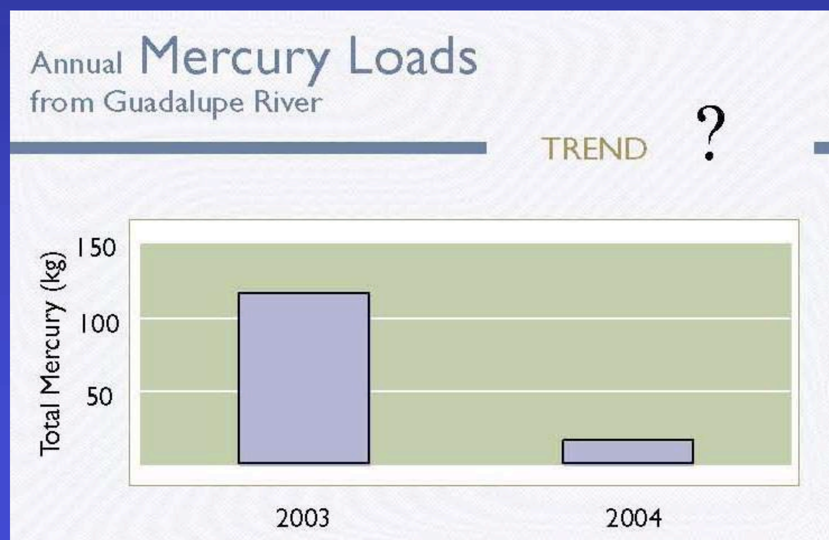


Source: Miles et al., USGS - WERC, 2005

Sediment Associated Mercury Loads



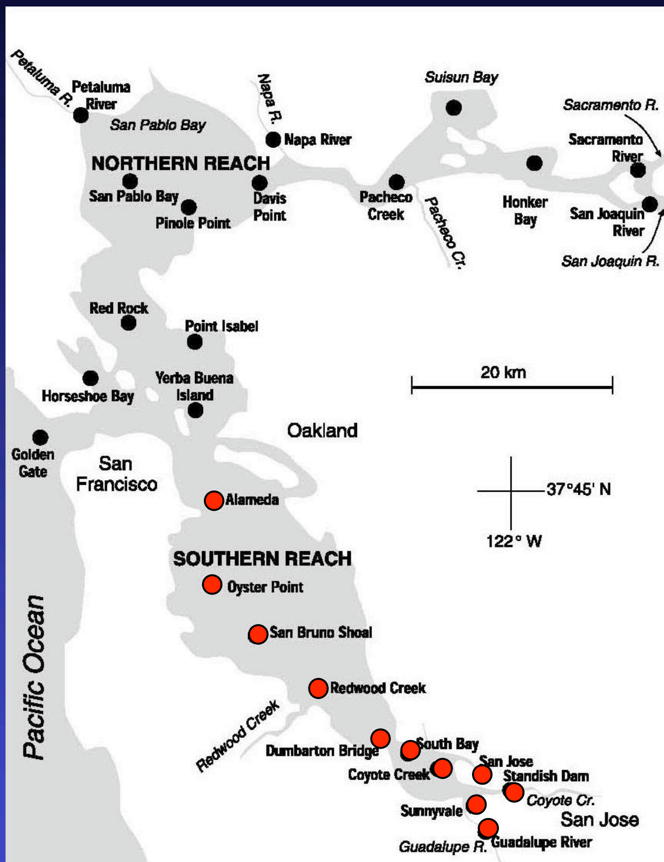


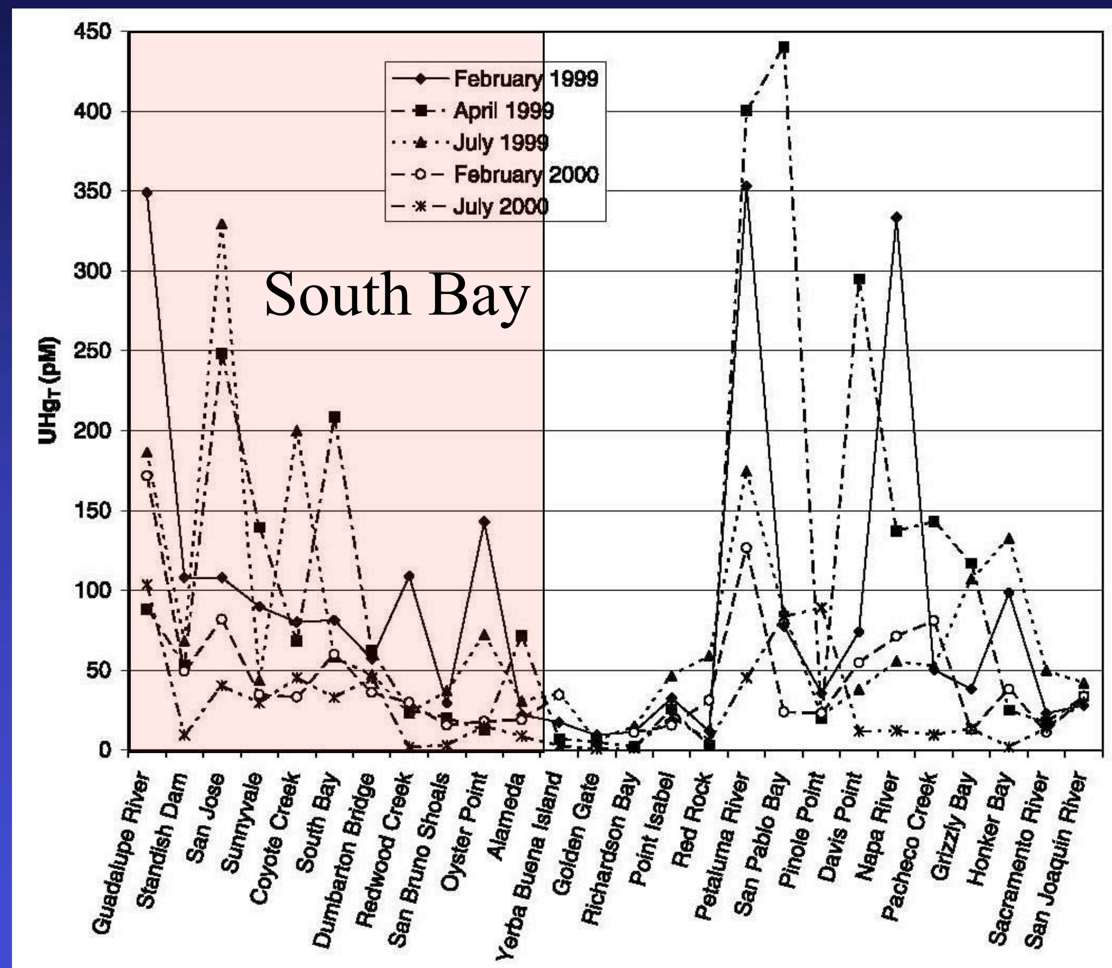


Source: Pulse of the Estuary 2005

Data: RMP, USGS, SFEI (Lester McKee)

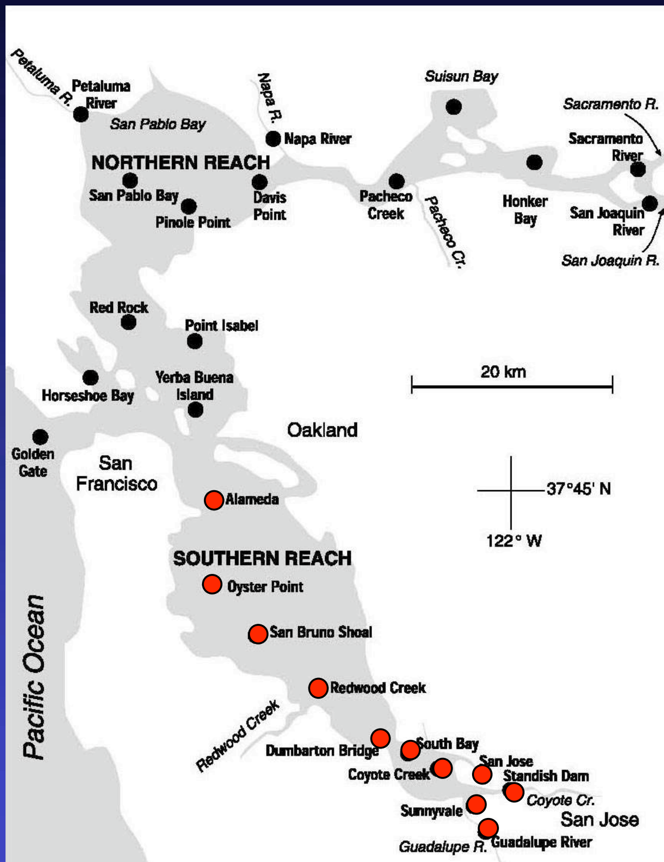
Unfiltered Total Hg in Water - SFB

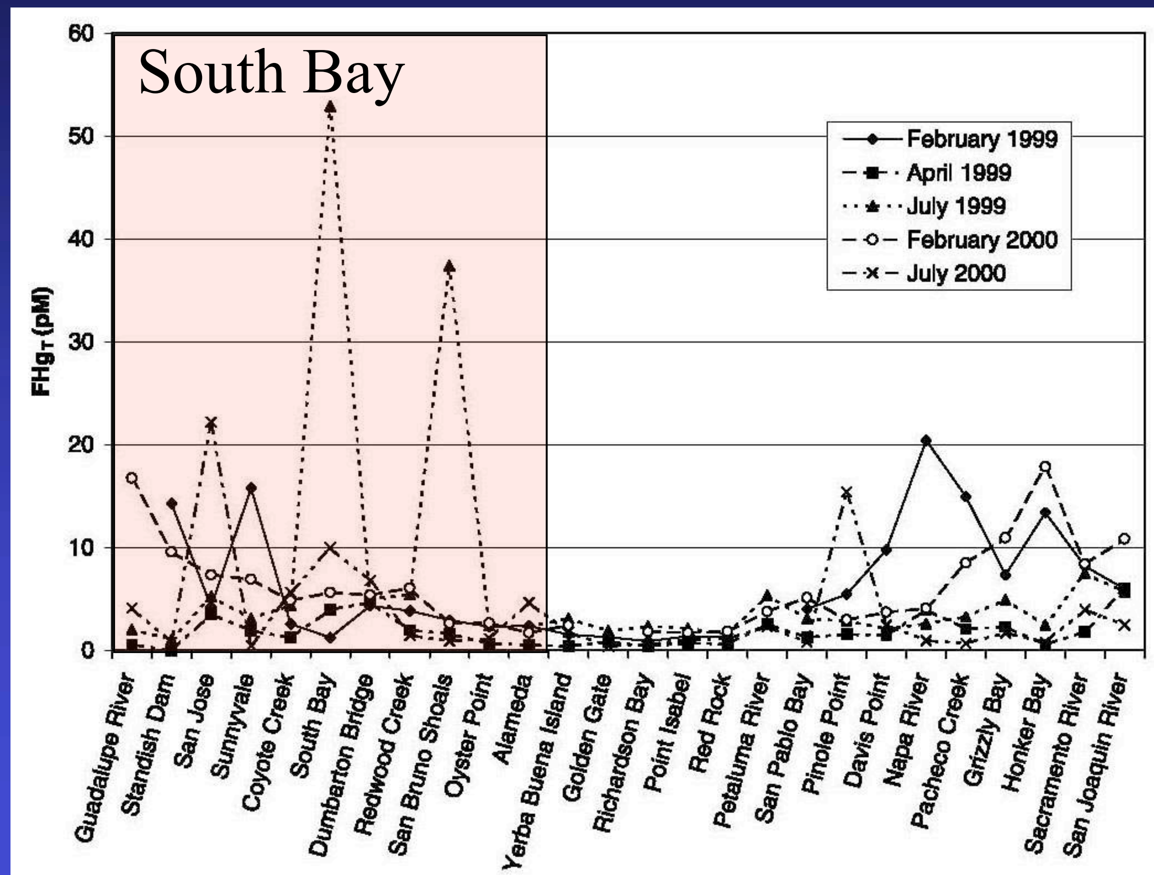




Source: Conaway et al. 2003, Marine Chemistry, v. 80 p. 199–225

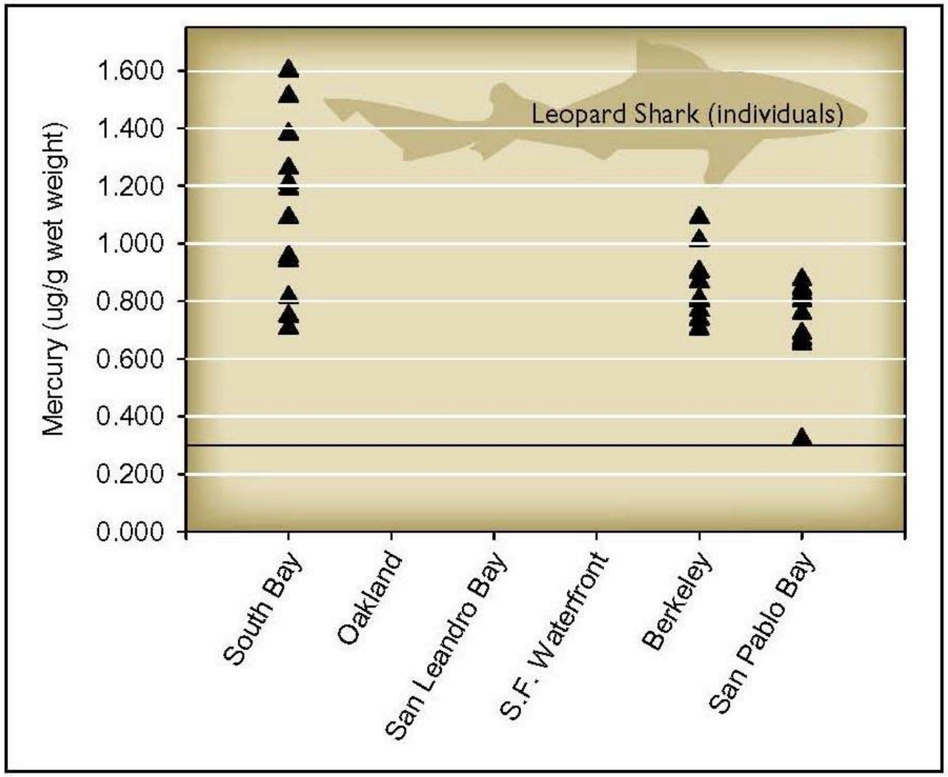
Filtered Total Hg in Water - SFB

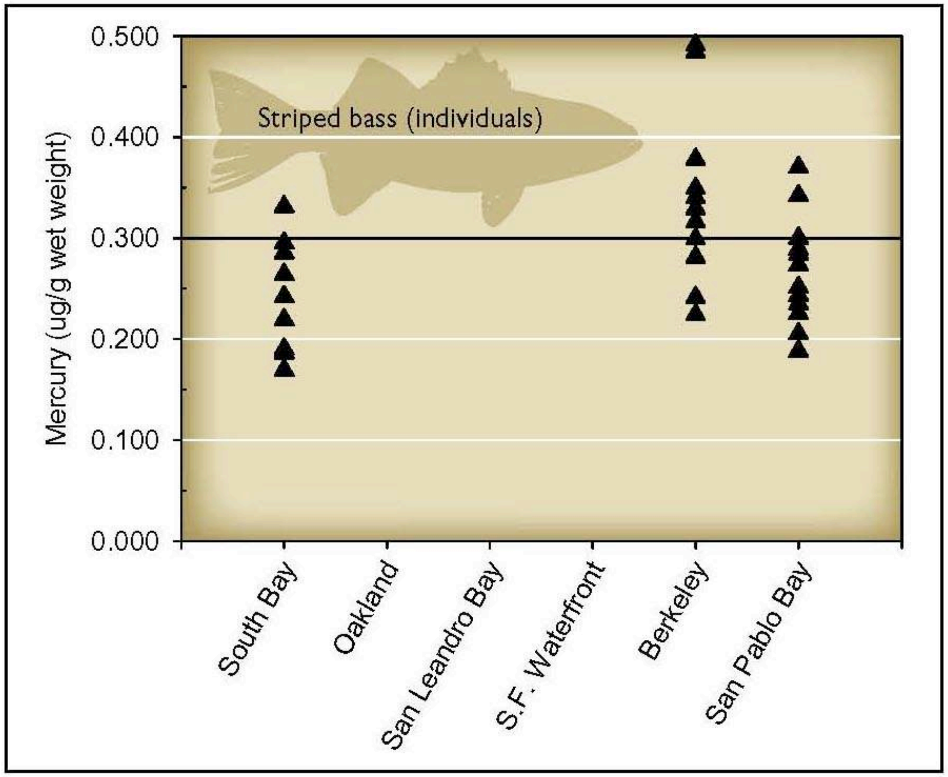




Source: Conaway et al. 2003, Marine Chemistry, v. 80 p. 199–225

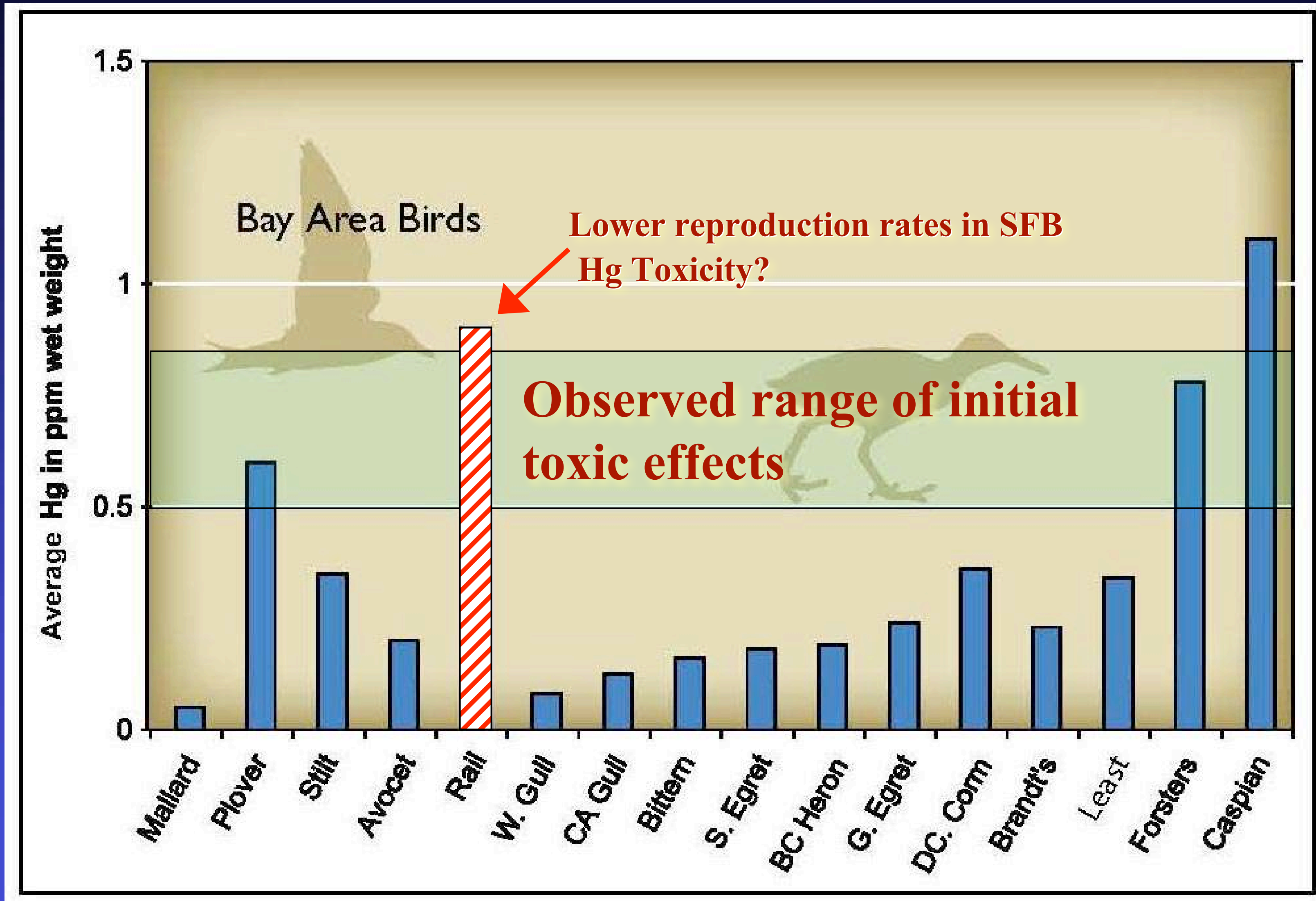
Mercury in Fish





Source: Pulse of the Estuary 2005
Data: RMP???

Mercury in Birds Eggs - SFB

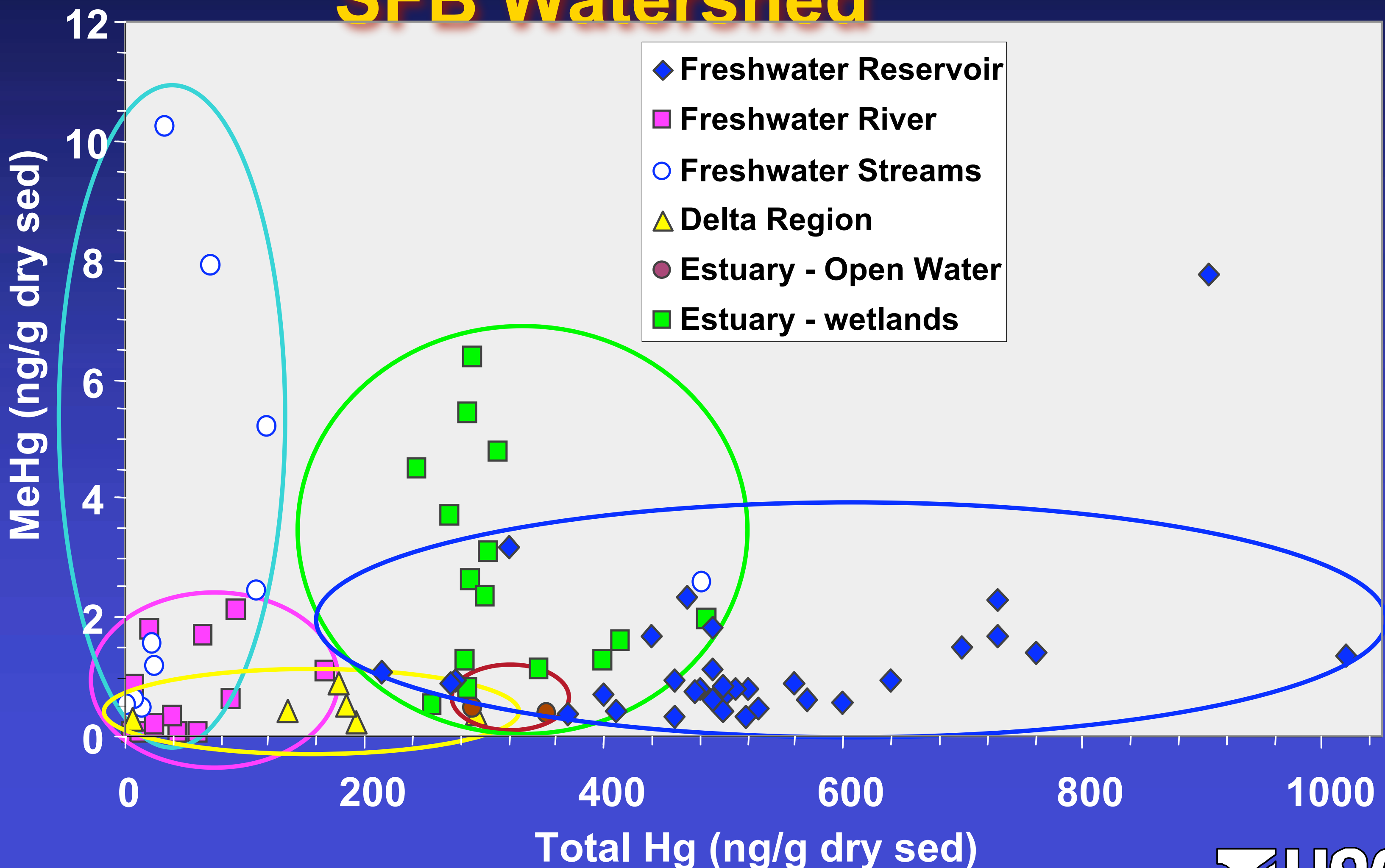


Source: Pulse of the Estuary 2005

Data: USFWS; Schwarzbach & Adelsbach, 2003

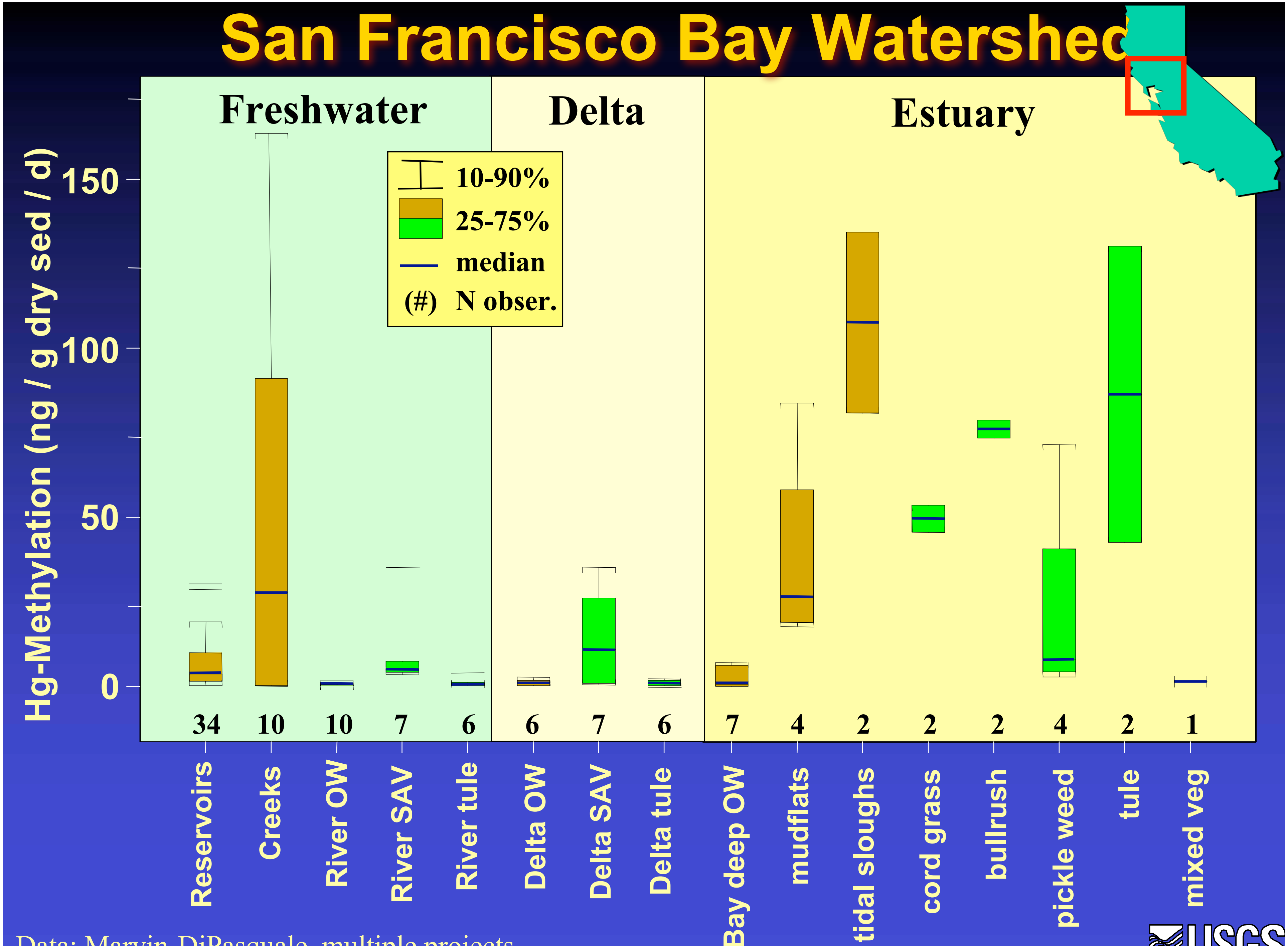
MeHg Production: Habitat Type Matters!

SFB Watershed



Data: Marvin-DiPasquale, multiple projects

San Francisco Bay Watershed

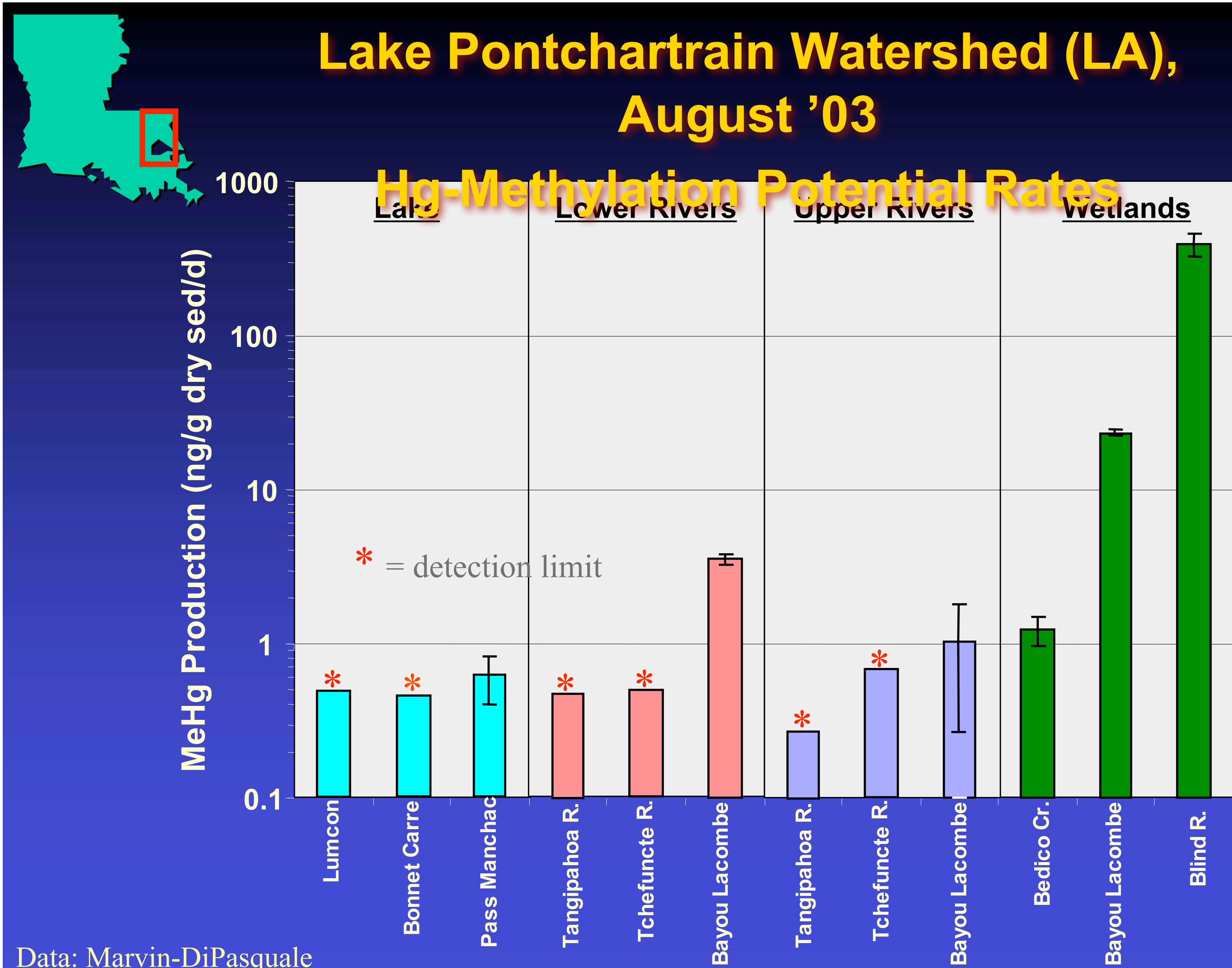


Data: Marvin-DiPasquale, multiple projects

USGS

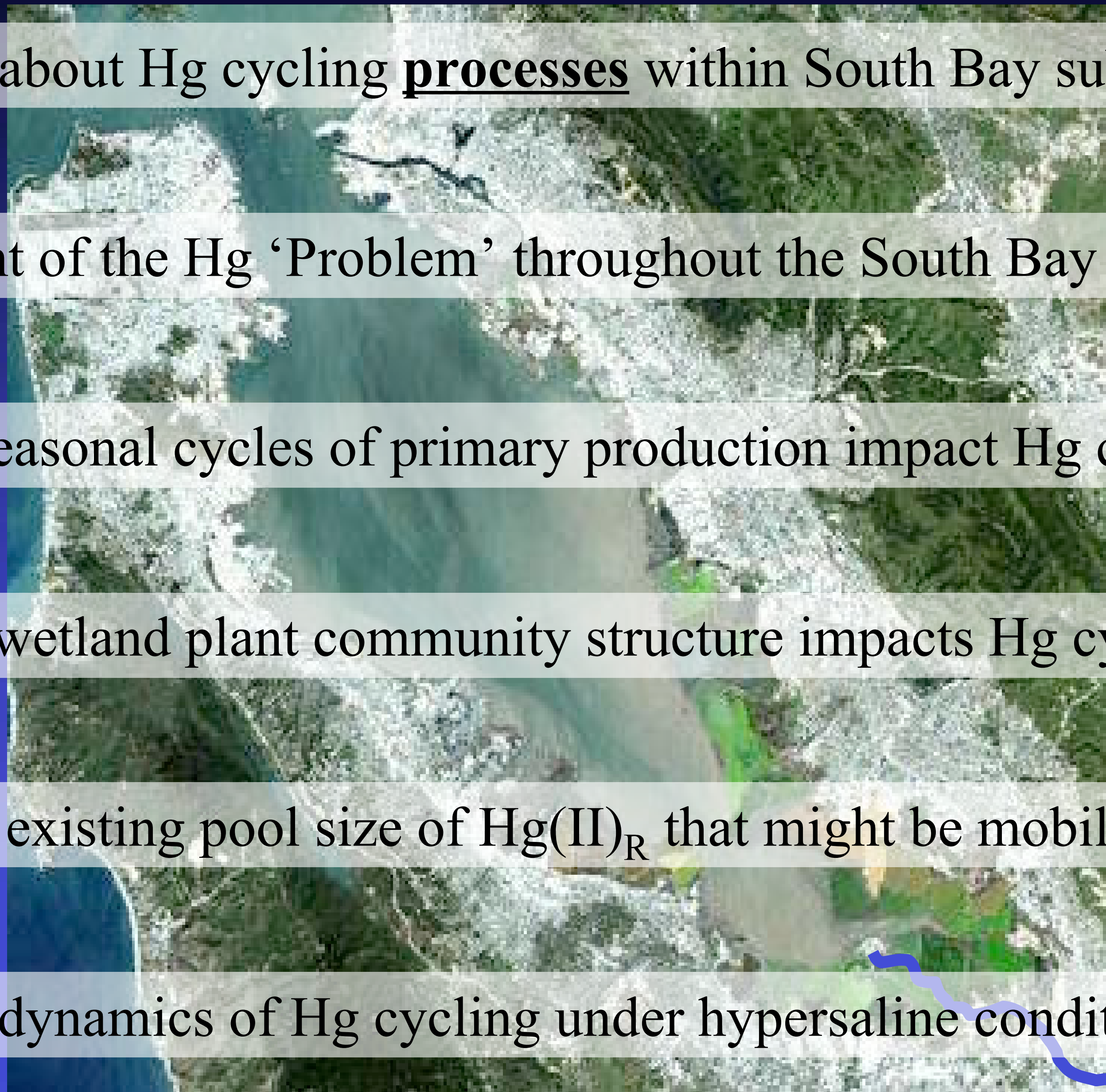
Lake Pontchartrain Watershed (LA), August '03

Hg-Methylation Potential Rates



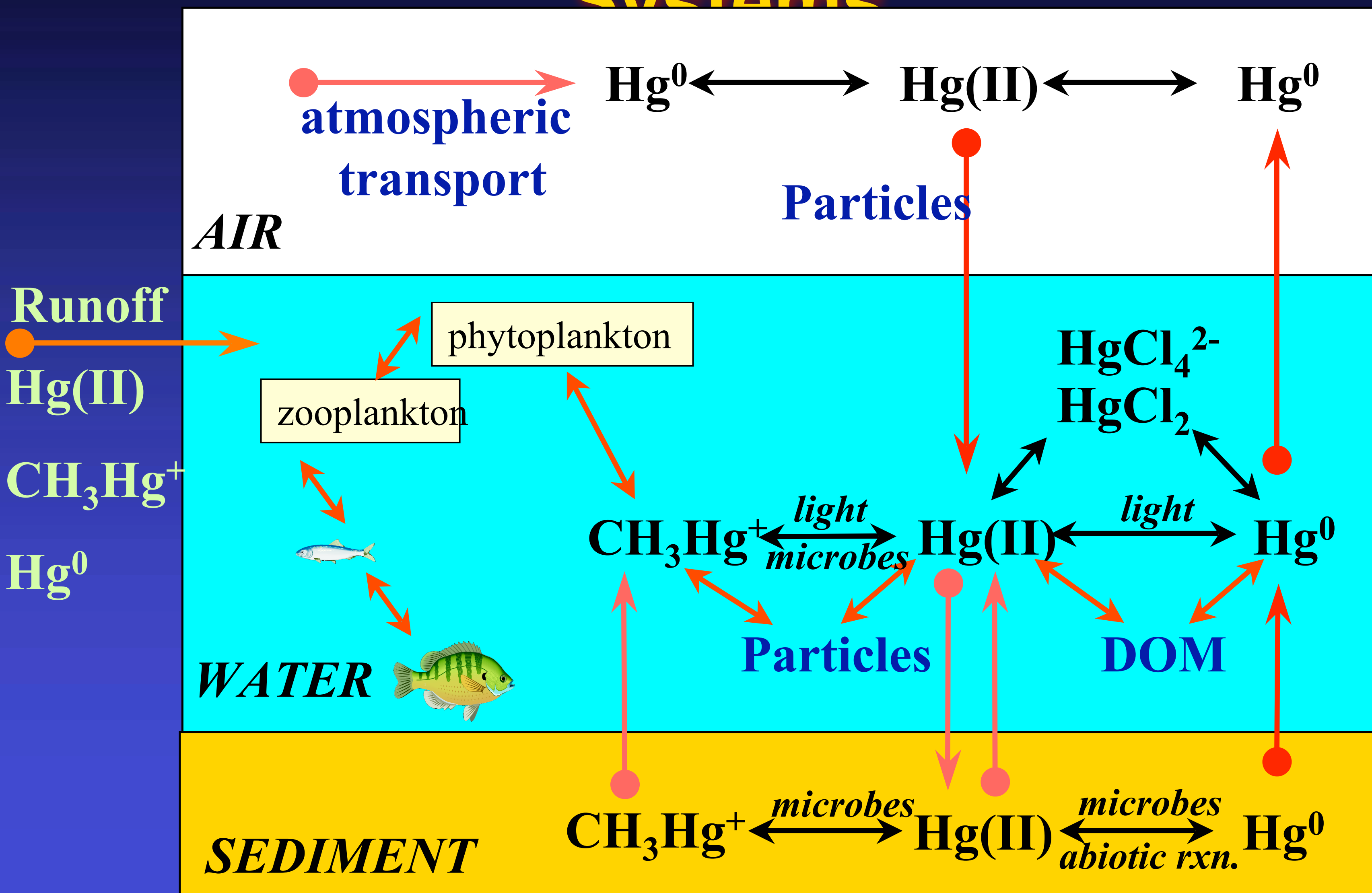
Data: Marvin-DiPasquale

What Don’t We Know?



- ✓ Specifics about Hg cycling **processes** within South Bay sub-habitats
- ✓ The extent of the Hg ‘Problem’ throughout the South Bay food web
- ✓ How seasonal cycles of primary production impact Hg cycling
- ✓ How wetland plant community structure impacts Hg cycling
- ✓ The existing pool size of $Hg(II)_R$ that might be mobilized
- ✓ The dynamics of Hg cycling under hypersaline conditions

The Mercury Cycle in Aquatic Systems



What Controls MeHg Production?

In simplest terms:

Gross MeHg Production
– Gross MeHg Degradation *

Net MeHg Production

What Controls NET MeHg Production?

MICROBIAL ACTIVITY

Hg(II)-Methylating &
MeHg-Degrading

- community composition
- electron donors (org-C)
- electron acceptors
  (e.g. Fe^{3+}, SO_4^{2-}, NO^{3-})
- pH and redox (E_h)
- temperature

MERCURY AVAILABILITY

Reactive-Hg(II) and MeHg

- amount of total-Hg or MeHg
- complexation w/ DOM
- binding to particles
- pH and redox (Eh)
- sulfur and iron chemistry
- salinity (Cl^-)
- chemical form: (HgS, HgS_2^{2-}
  , $HgCl_2$, $HgCl_4^{2-}$, etc…)

USGS

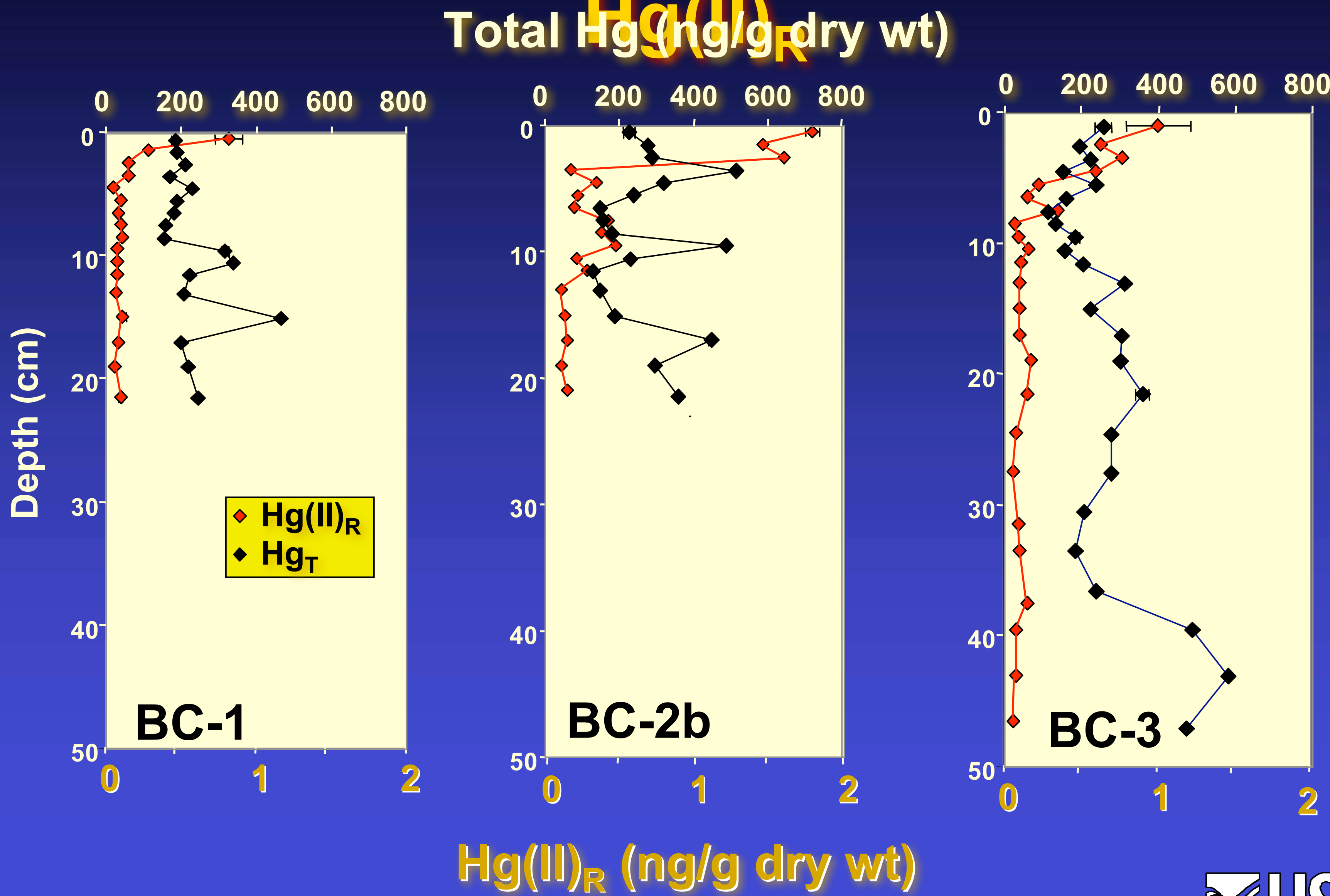
Hot Spot or Not?: $MP = K \times Hg(II)_R$

Reactive Hg(II) Concentration

Hg(II)-Methylating Bacteria Activity (K)	Low	High
Low	***Low*** **MeHg Production**	***Moderate*** **MeHg Production**
High	***Moderate*** **MeHg Production**	***High*** **MeHg Production**

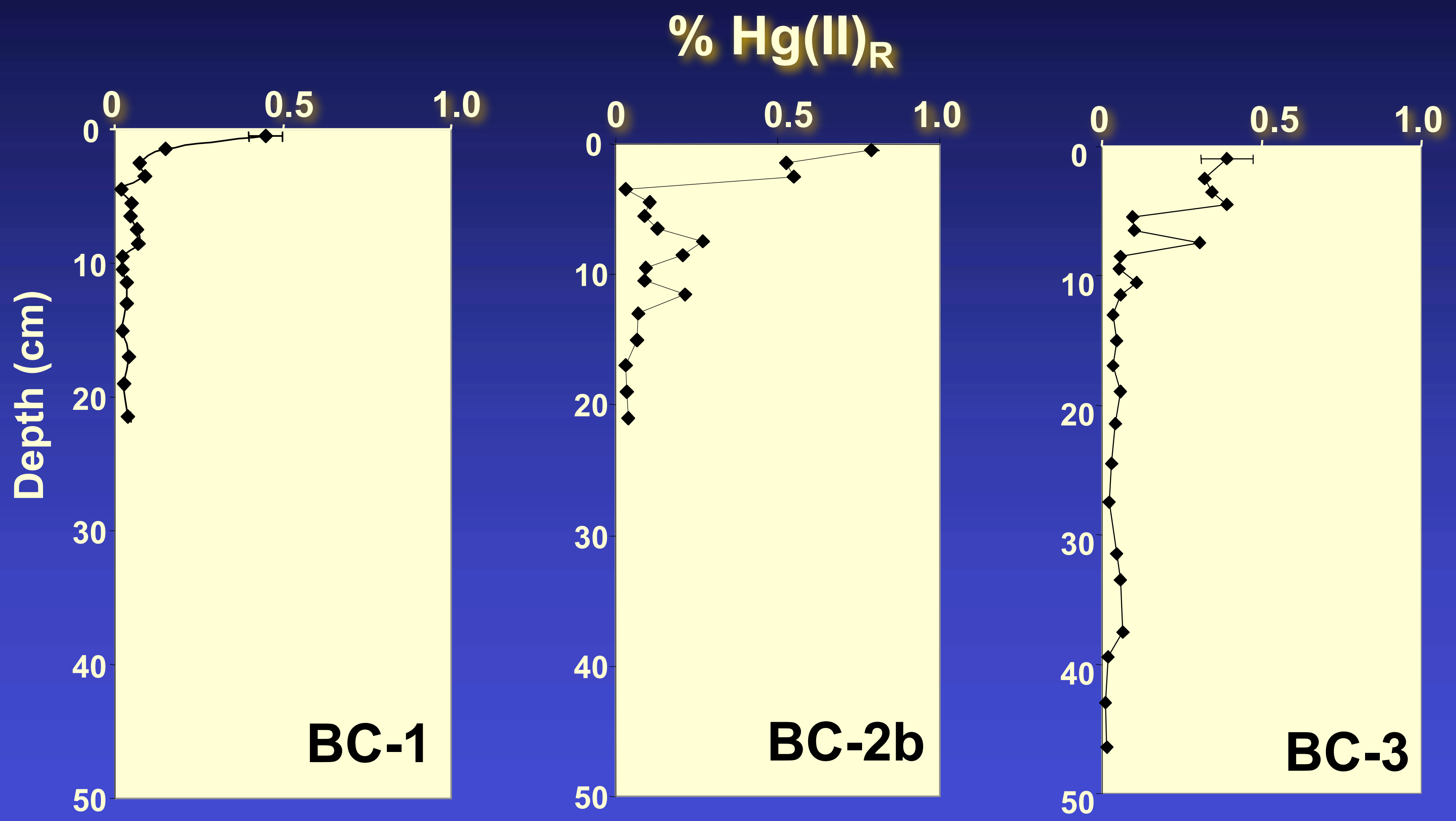
USGS

San Pablo Bay (Sept. '04) – Hg_T & $Hg(II)_R$



USGS

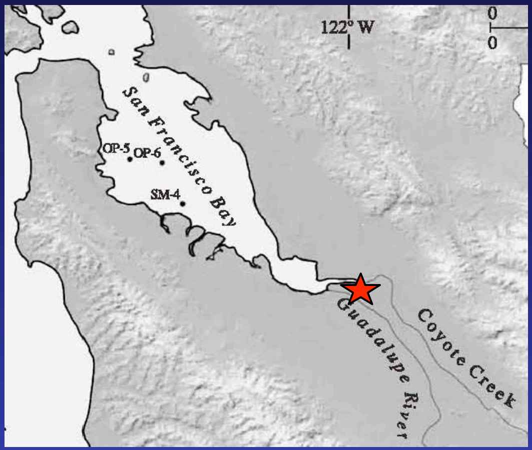
San Pablo Bay (Sept. ’04) – Percent $Hg(II)_R$

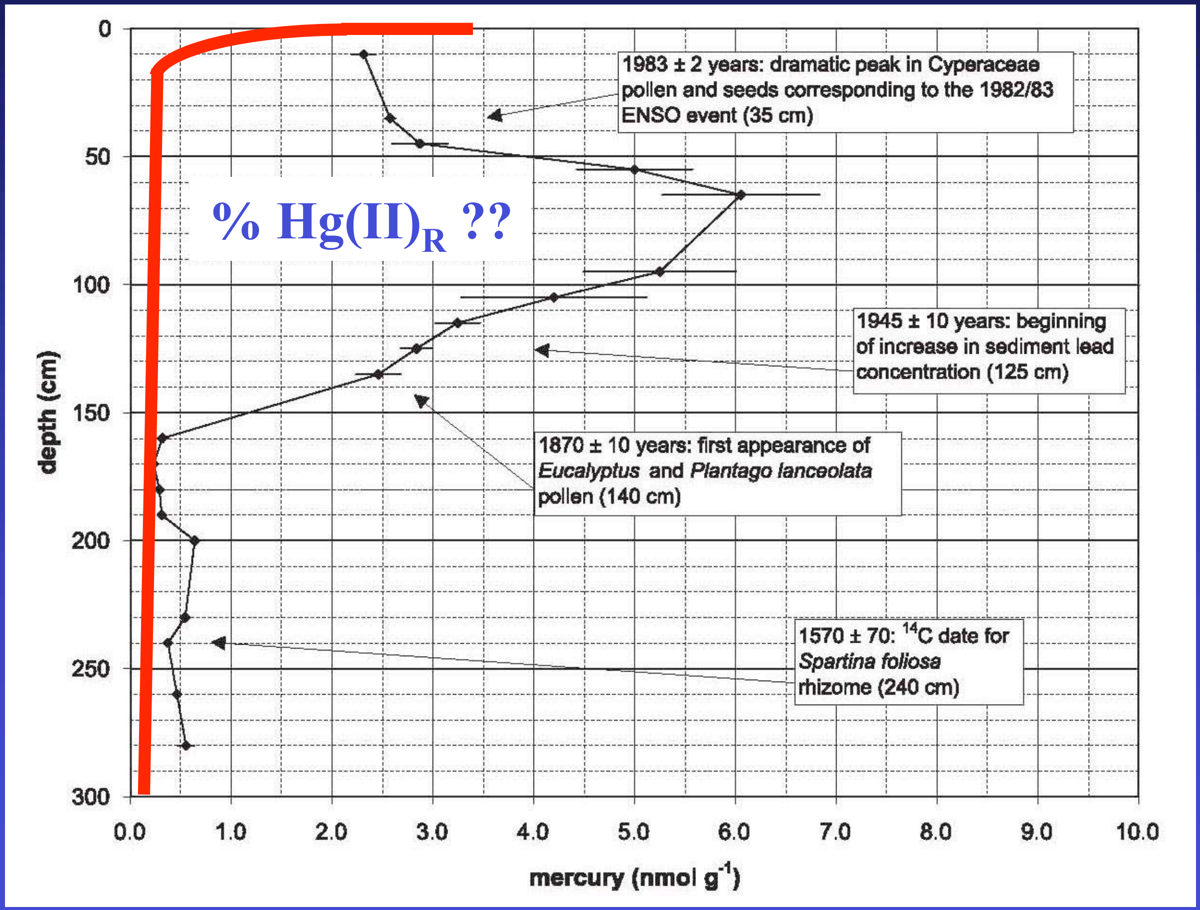


USGS

Mercury in Wetland Sediment

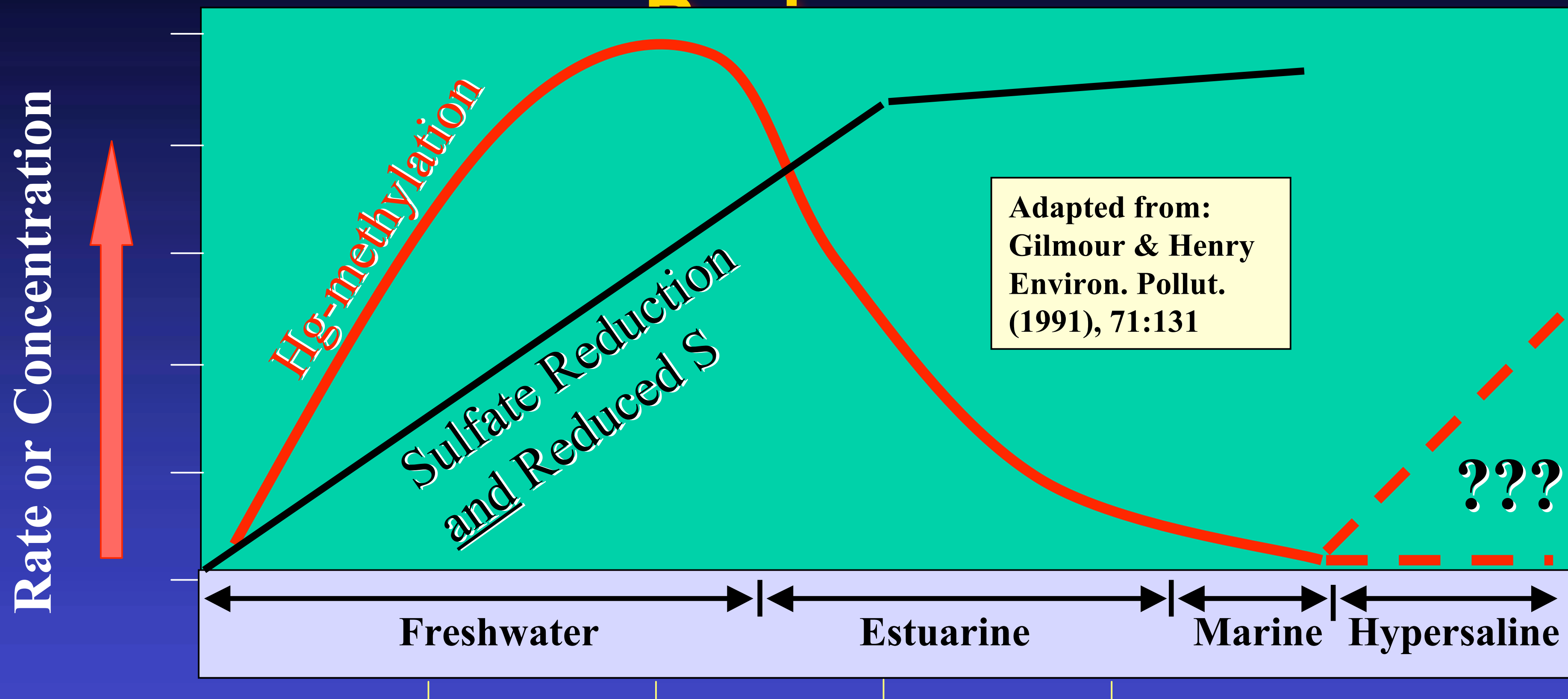
Triangle Marsh – Dated Core





Source: Conaway et al. 2004, Marine Chemistry, v. 90 p. 175–184

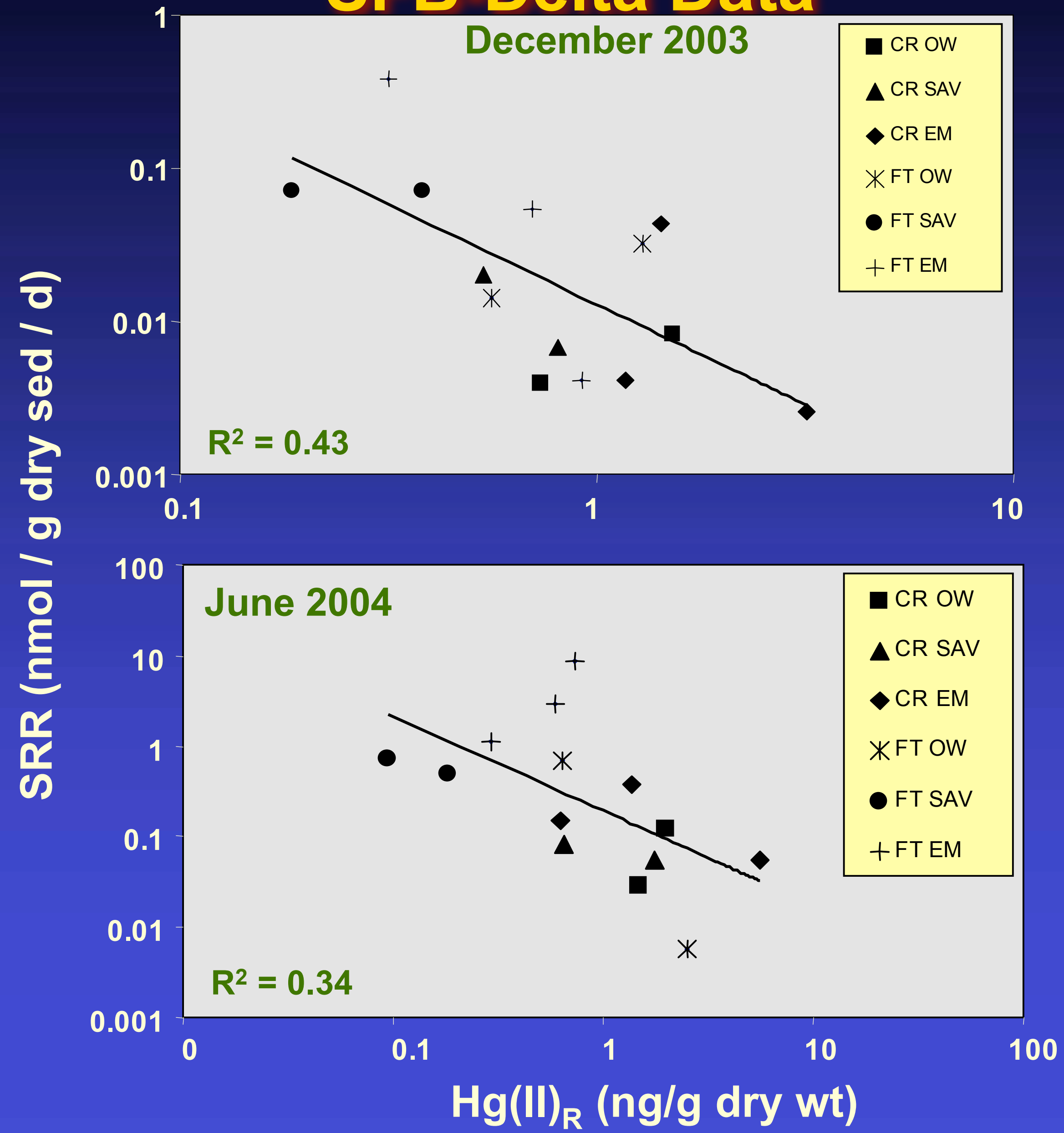
Hg-Methylation Activity Across Salinity



Low SO_4^{2-} & Cl^-
Low Sulfate Reduction
Low Reduced-S
Dominant: HgS & $HgCl_2$ (neutral)

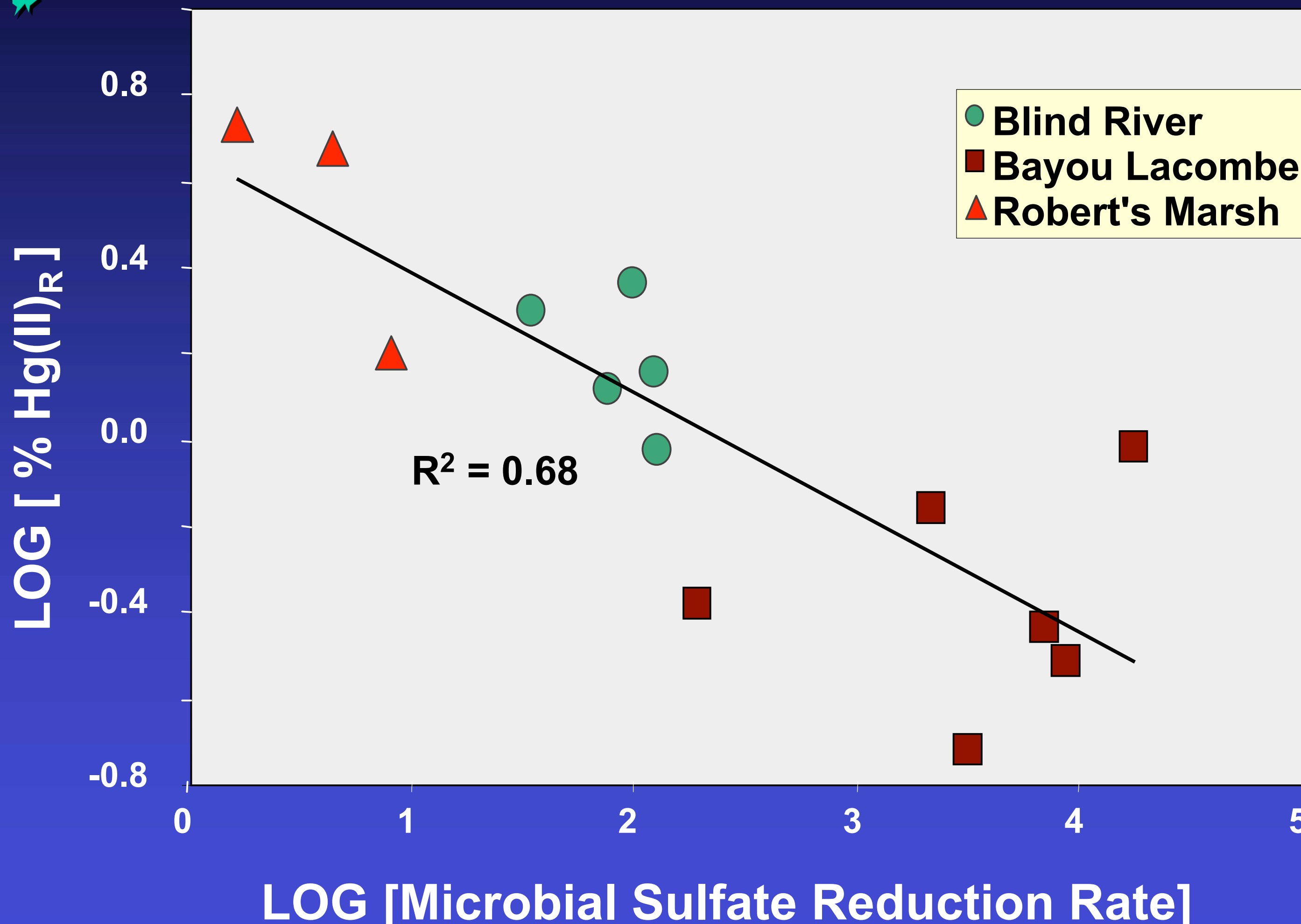
High SO_4^{2-} & Cl^-
High Sulfate Reduction
High Reduced-S
Dominant: HgS_2^{2-} & $HgCl_4^{2-}$ (charged)

Sulfate Reduction: A Control on $Hg(II)_R$?
SFB-Delta Data

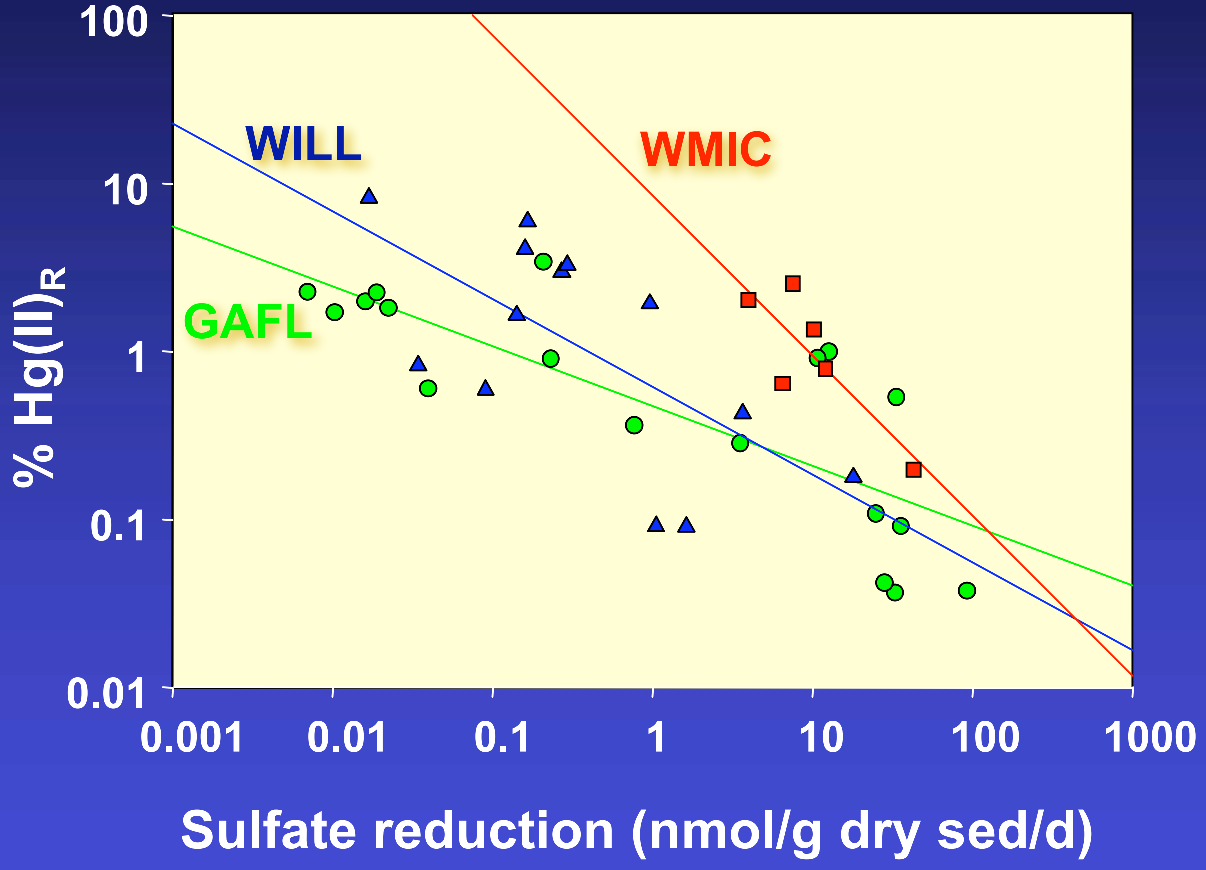


Sulfate Reduction: A Control on $Hg(II)_R$?

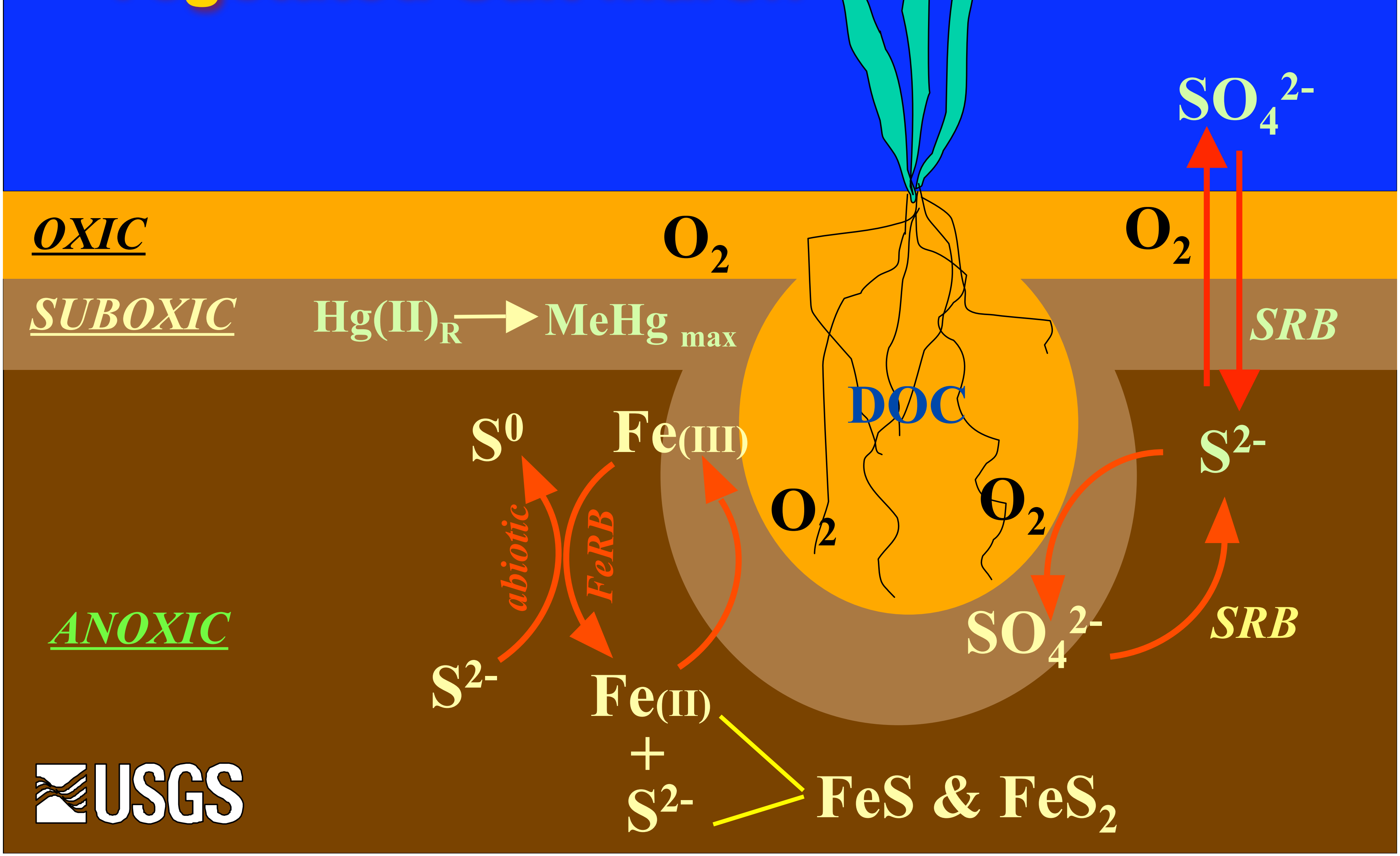
Louisiana Wetlands, April '04, surface 0-2 cm



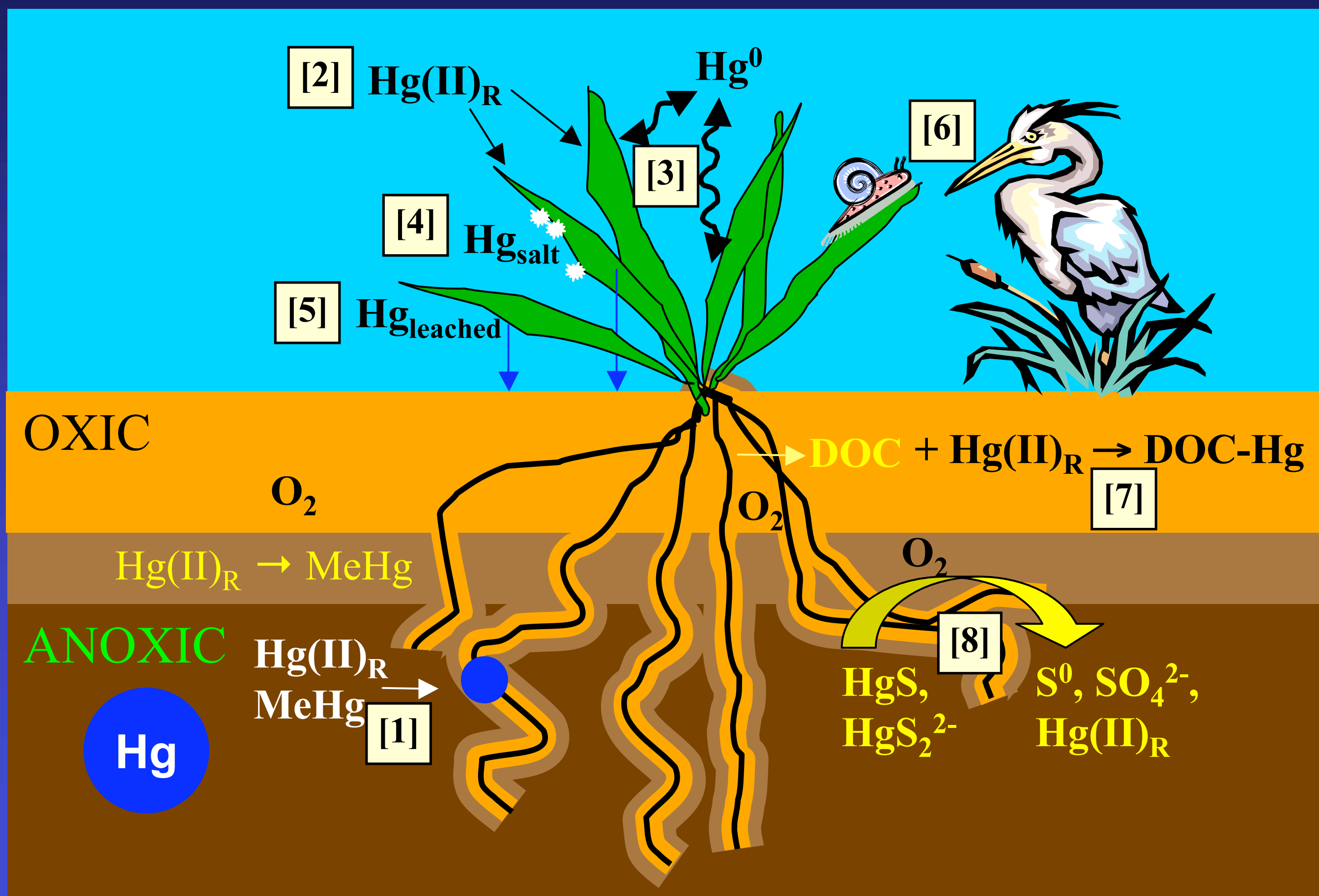
Sulfate Reduction: A Control on $Hg(II)_R$?
Stream & River Data from 3 National Regions
USGS-NWAQA Mercury Topical Study



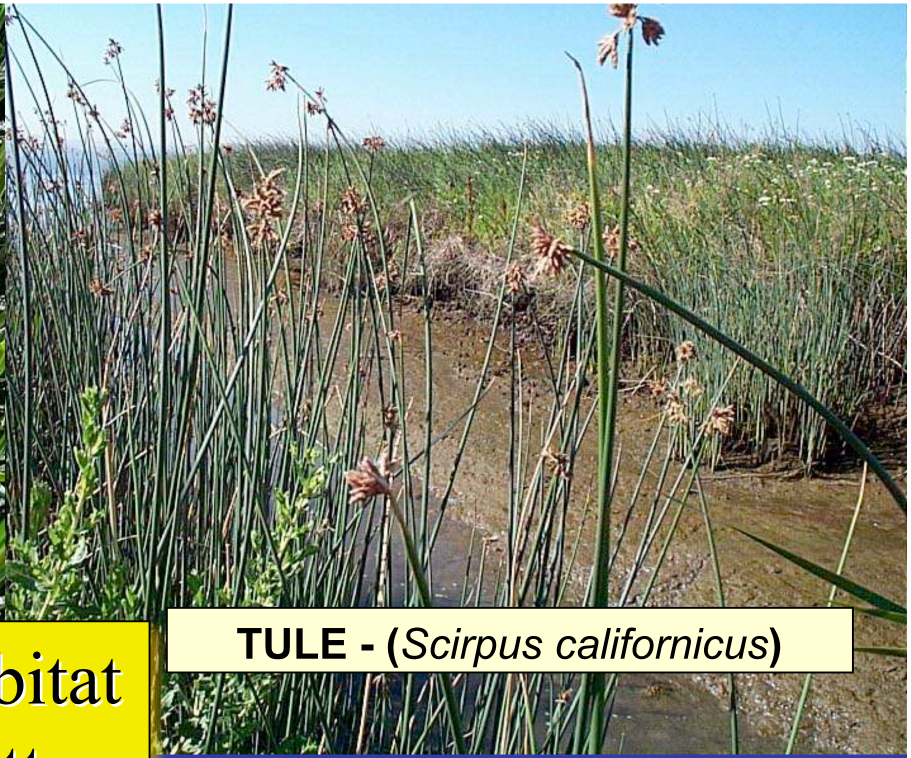
Conceptual Model: Vegetated Salt Marsh

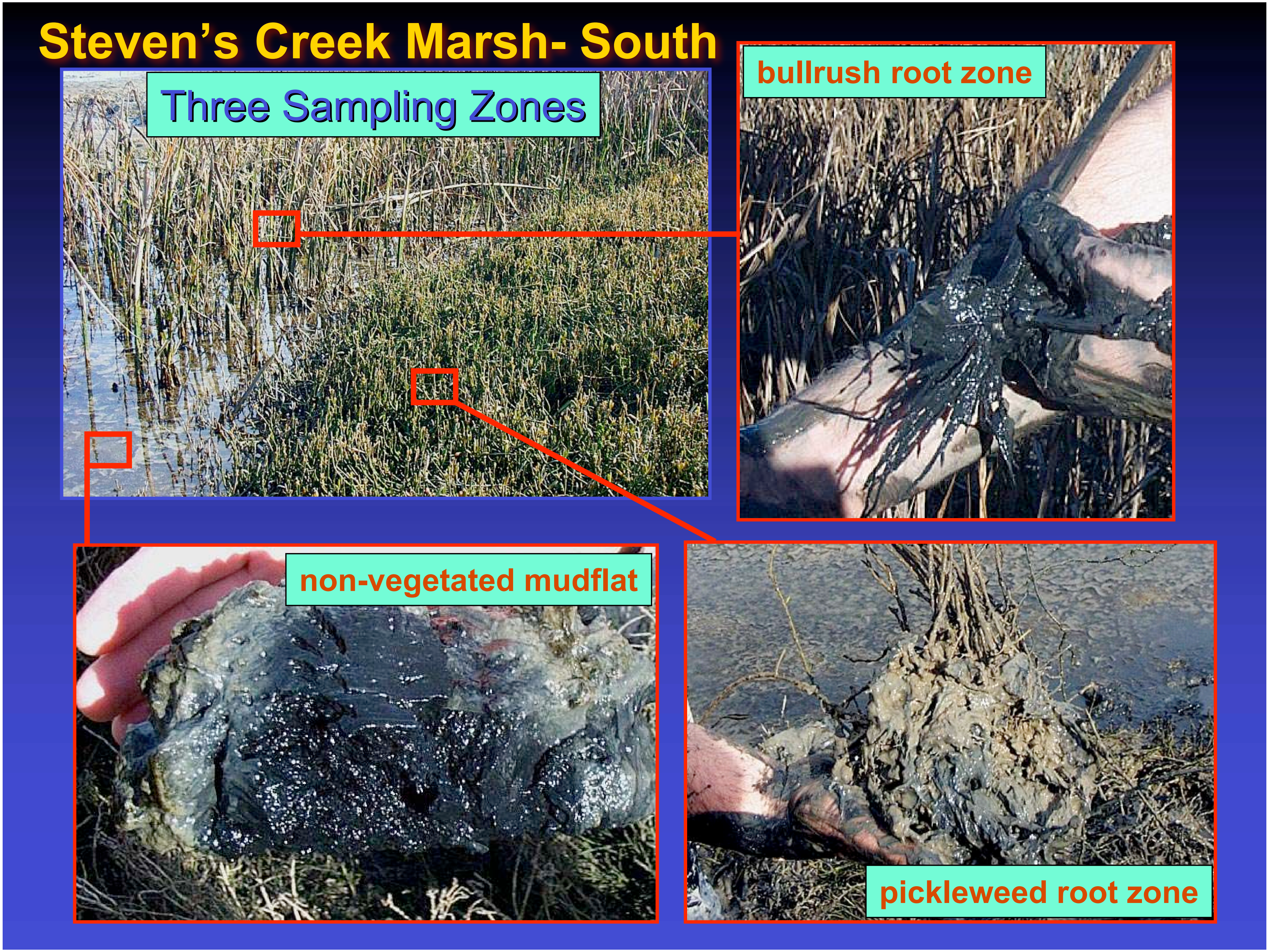


Wetland plants can alter Hg pools and fluxes in MANY ways.



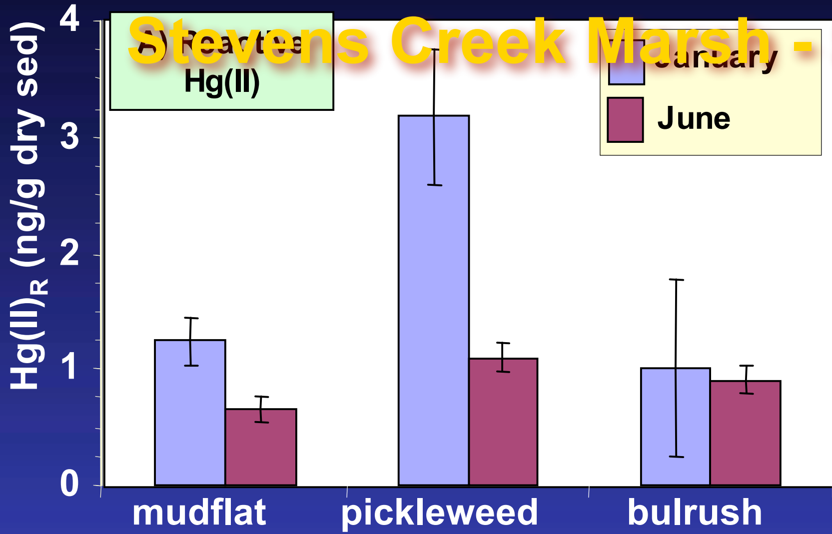
Habitat Matters

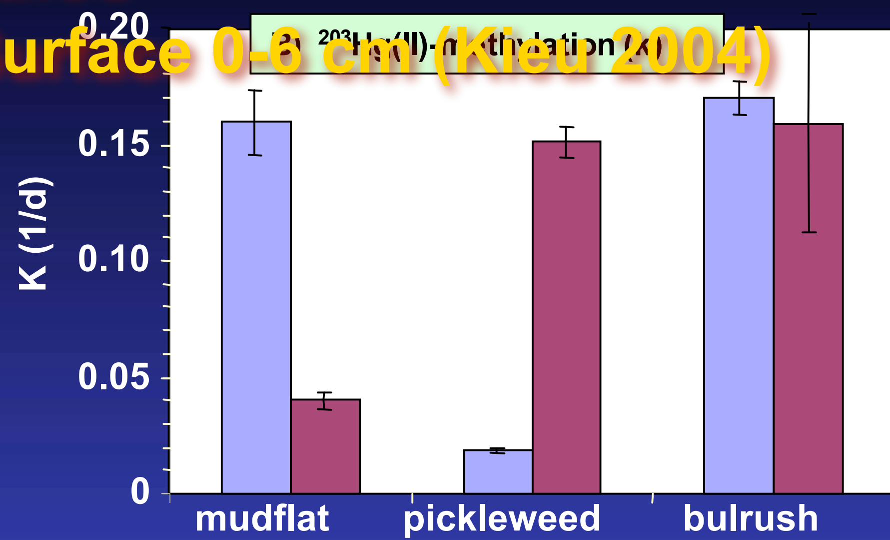


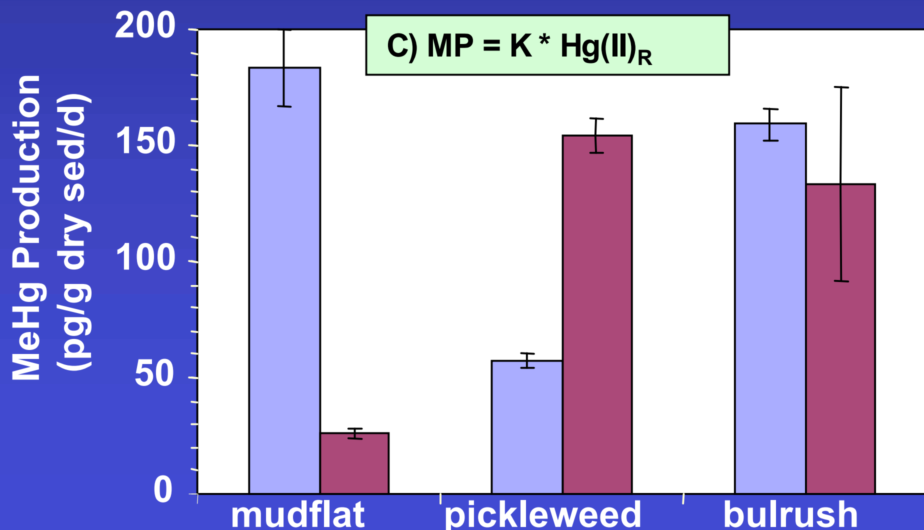

Steven's Creek Marsh- South
Three Sampling Zones
bullrush root zone
non-vegetated mudflat
pickleweed root zone

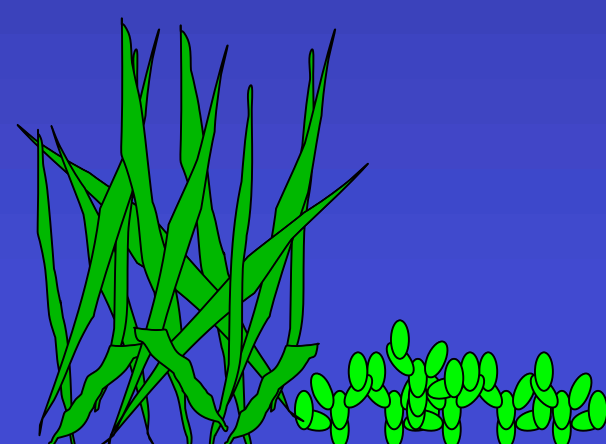
Vegetation Affects Hg Cycling Over Small Spatial Scales

Stevens Creek Marsh - Surface 0-6 cm (Kieu 2004)



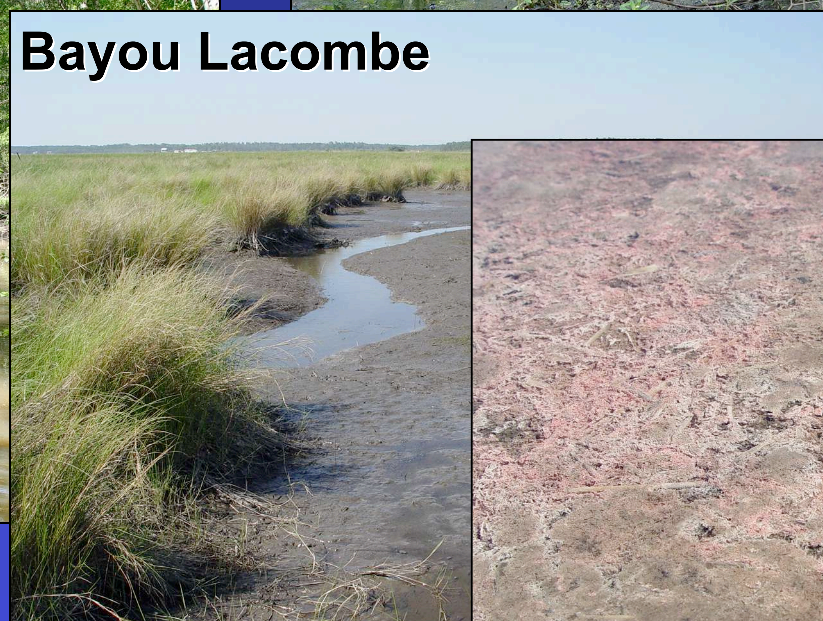




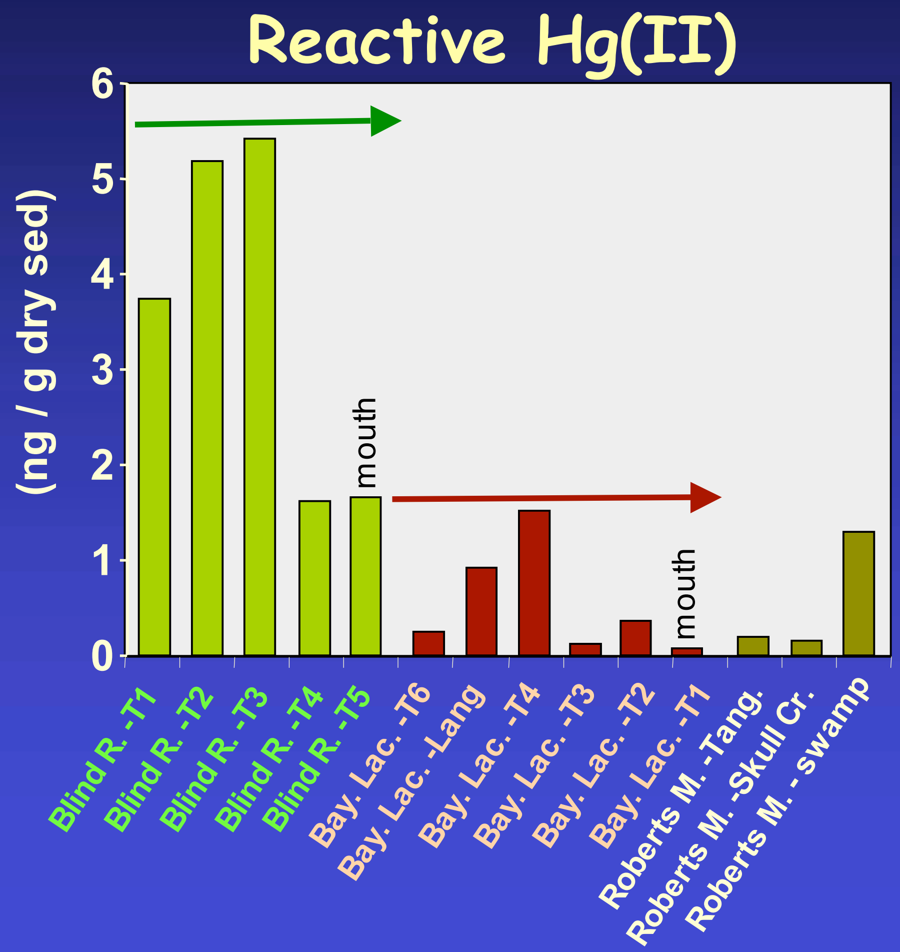


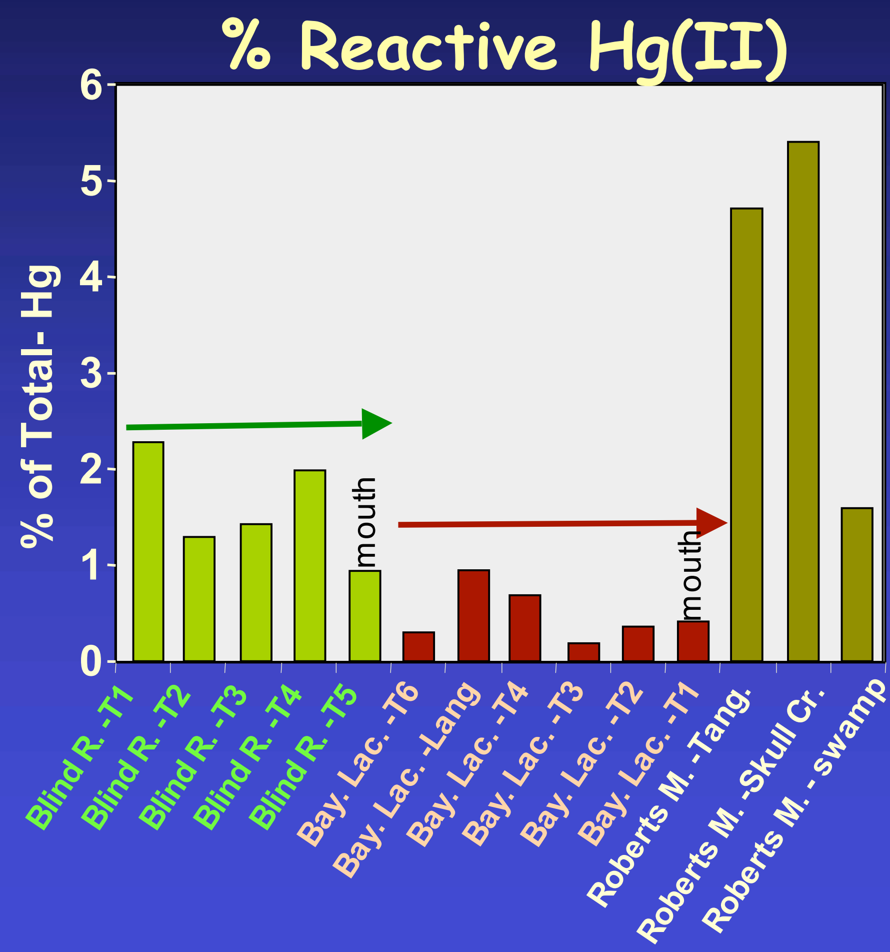
Mudflat Bulrush Pickleweed

Louisiana Wetlands (April '04)



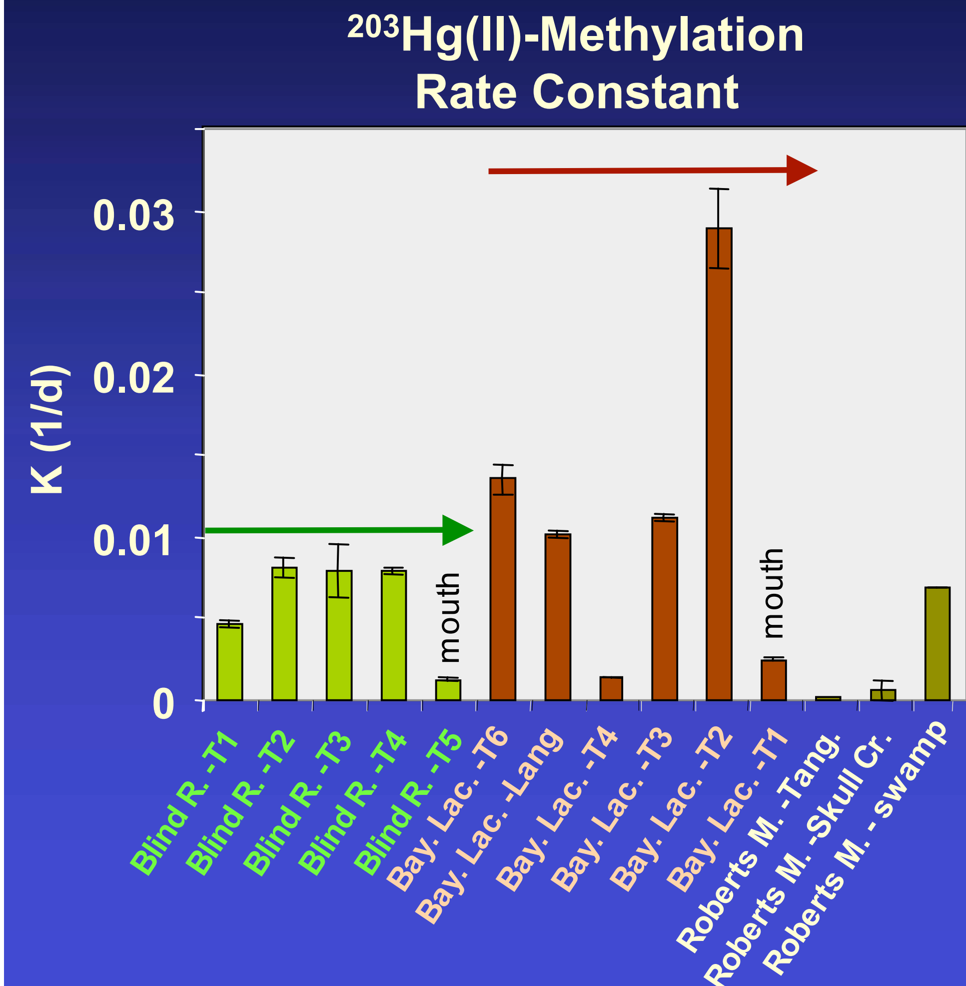
Reactive Hg(II): Louisiana Wetlands, April '04
(surface 0-2 cm interval)

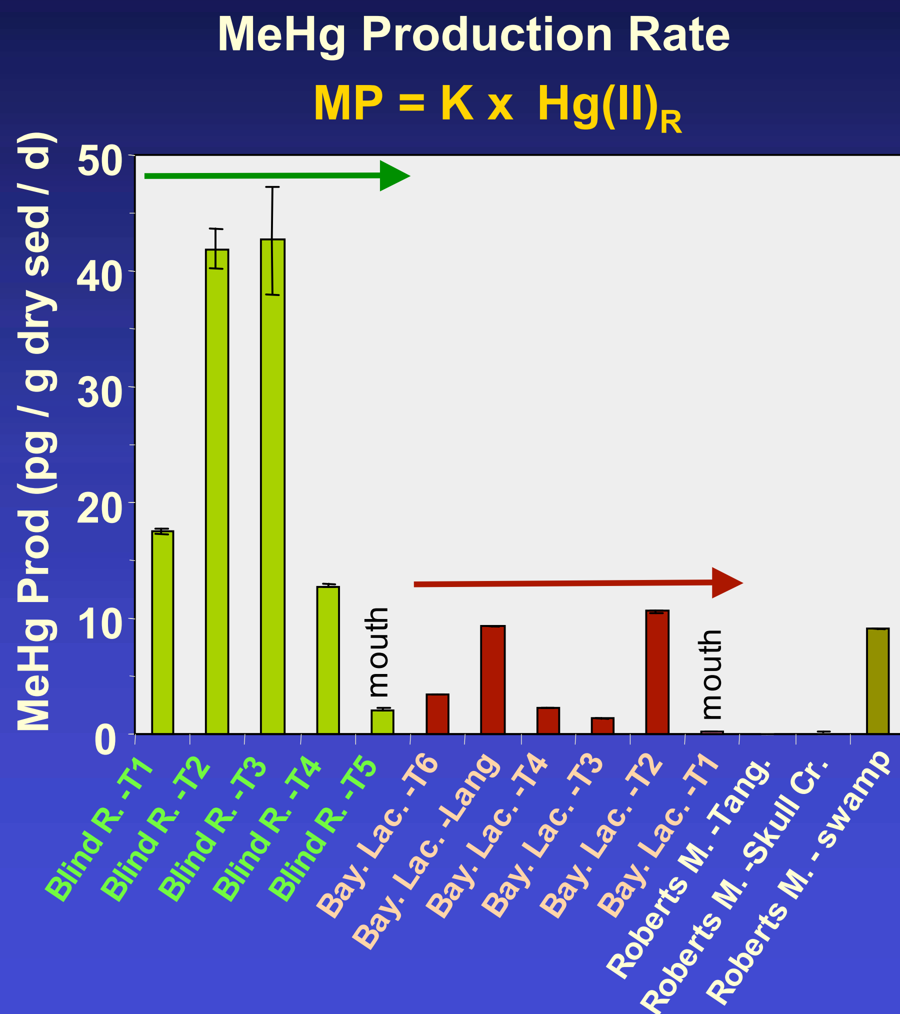




USGS

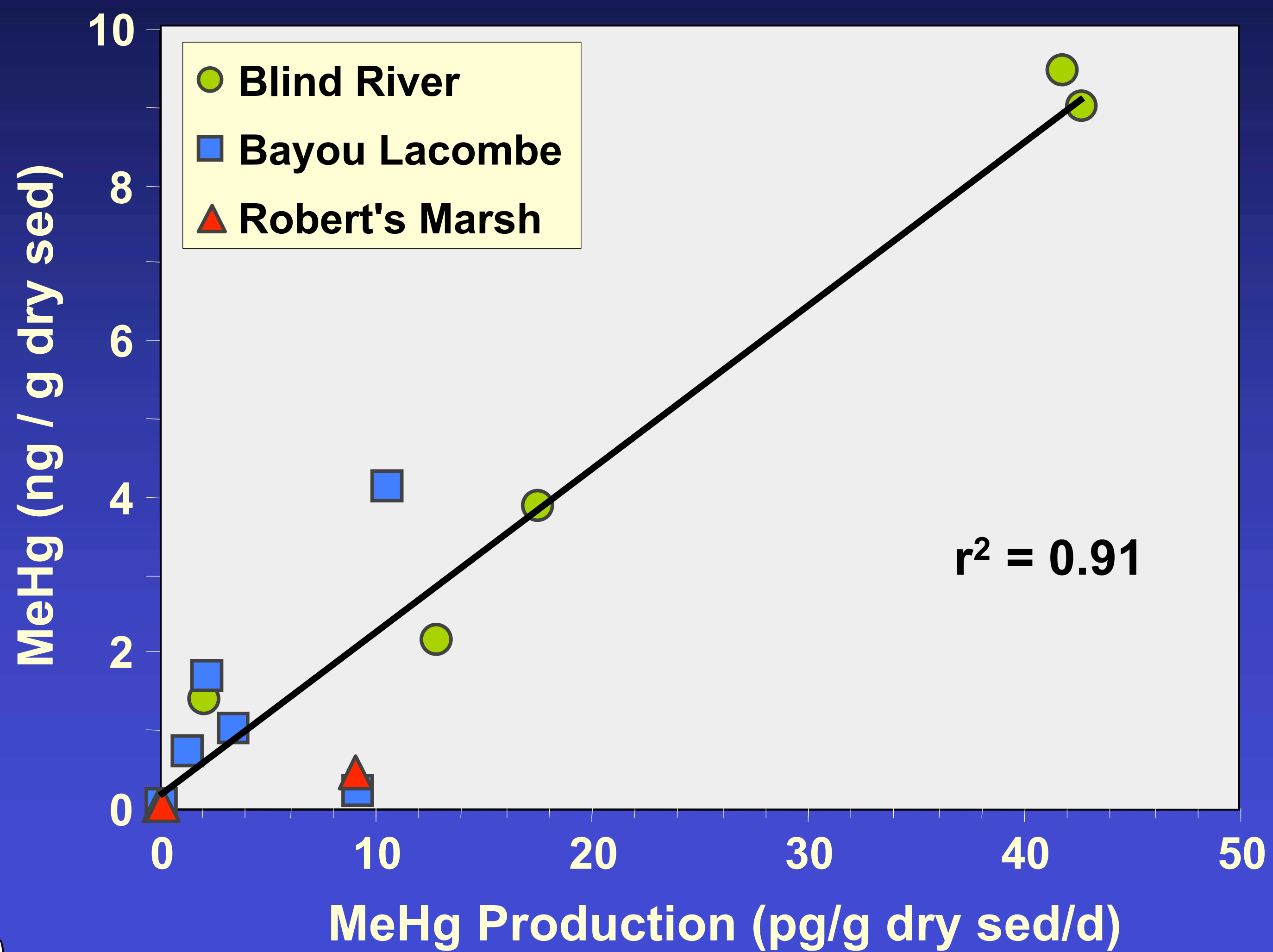
MeHg Production: Louisiana Wetlands, April '04
Dry Sediment Rates (surface 0-2 cm interval)





USGS

MeHg Production based on REACTIVE Hg(II) vs MeHg concentration (dry wt.)



$$MP = K * Hg(II)_R$$

Key Questions

- What are the current trends wrt MeHg production ($Hg(II)_R$ S, and Fe chemistry) with increasing salinity in the ponds (is there an optimum)?

- How will these parameters change as we convert the salt ponds to tidal wetland and managed ponds?

- How does Hg currently cycle under the target wetland conditions? (i.e. What is the background?)

- How will deepening Alviso Slough impact $Hg(II)_R$ concentrations in the ponds and in South SFB? And for how long?

USGS

Take Home Message

- South SFB & Salt Ponds have elevated Hg in sediments, water and biota (top preditors)
- Limited understanding of the specific underlying processes involved in Hg cycling in this Bay region
- MeHg Production is a function of microbial activity and availability of reactive Hg(II)
- MeHg production / degradation rates vary widely (but predictably) among and within ecosystem sub-habitats
- Plants can have multiple and substantial effects on Hg cycling.
- Reactive-Hg(II) varies with sediment chemistry (organics, redox, …) and is a small fraction of Hg_T ($\leq$ 5%)
- ***Wetland Restoration:*** **Success will depend on understanding the controls on Hg cycling in various sub-habitats that comprise the project area**

USGS