

LESSONS LEARNED FROM
THE UC DAVIS BIOSENTINEL
MERCURY MONITORING PROGRAM:
Feedback Tool for Watershed Management



**Part of the CBDA
Fish Mercury Project**



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UC DAVIS

Biosentinel Mercury Monitoring

Using small, young fish as localized, time-sensitive measures of methylmercury exposure

- Key element of the CalFed Mercury Strategy
- Techniques refined by UC Davis since 1985



- A consistent, fish-based measure of exposure, after MeHg has diffused out of the sediments, and is unambiguously moving into the food web

Biosentinel Mercury Monitoring

Using small, young fish as localized, time-sensitive measures of methylmercury exposure

- Key element of the CalFed Mercury Strategy
- Techniques refined by UC Davis since 1985



- Spatial patterns to a local scale
- Interannual trends and variability
- Within-year seasonal trends
- Performance measures for restoration and remediation

Large Wetland Restorations Underway



**Yolo
Bypass**

*Sacramento
River*

and

**North
Delta**

**Napa-
Sonoma
Marsh**

**Suisun
Marsh**

**McCormack
Williamson
Tract**

**Petaluma
Marsh**

*San Pablo
Bay*

*Grizzly
Bay*

*Suisun
Bay*

*Honker
Bay*

**Dutch
Slough**

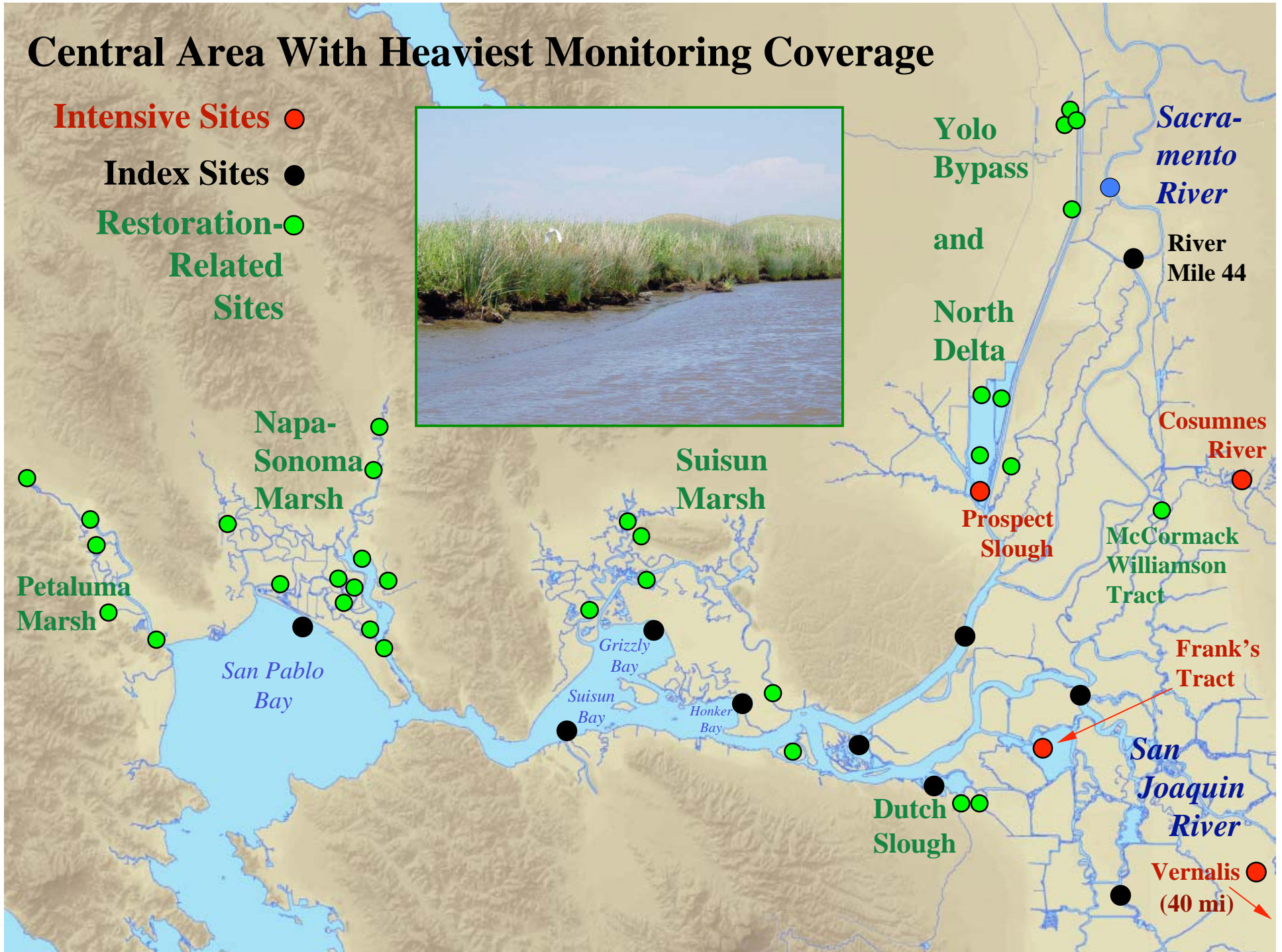
*San
Joaquin
River*

Central Area With Heaviest Monitoring Coverage

Intensive Sites ●

Index Sites ●

Restoration-Related Sites ●



Yolo Bypass

Sacramento River

River Mile 44

North Delta

Cosumnes River

Napa-Sonoma Marsh

Suisun Marsh

Prospect Slough

McCormack Williamson Tract

Petaluma Marsh

San Pablo Bay

Grizzly Bay
Suisun Bay
Honker Bay

Frank's Tract

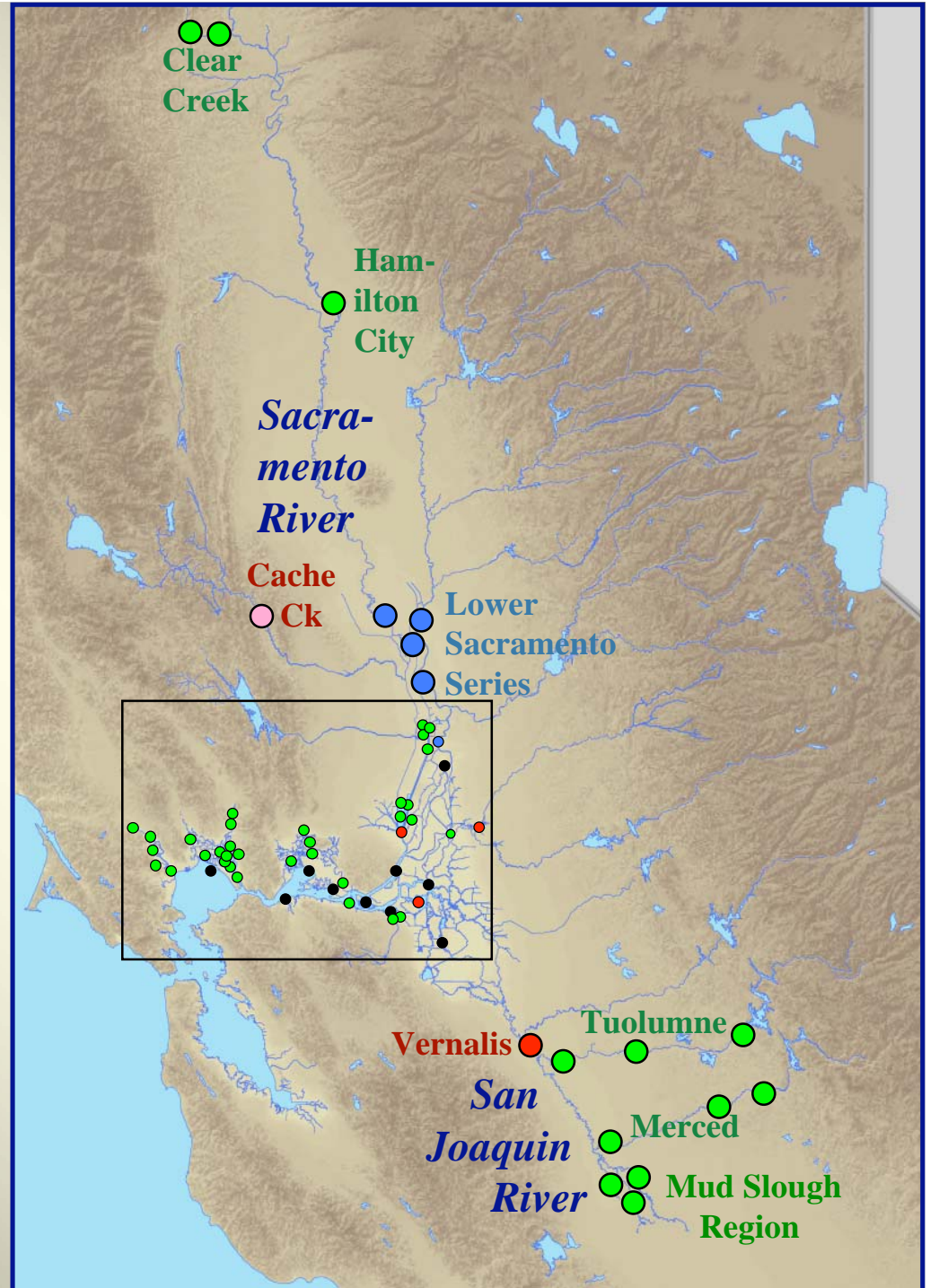
San Joaquin River

Dutch Slough

Vernalis (40 mi)

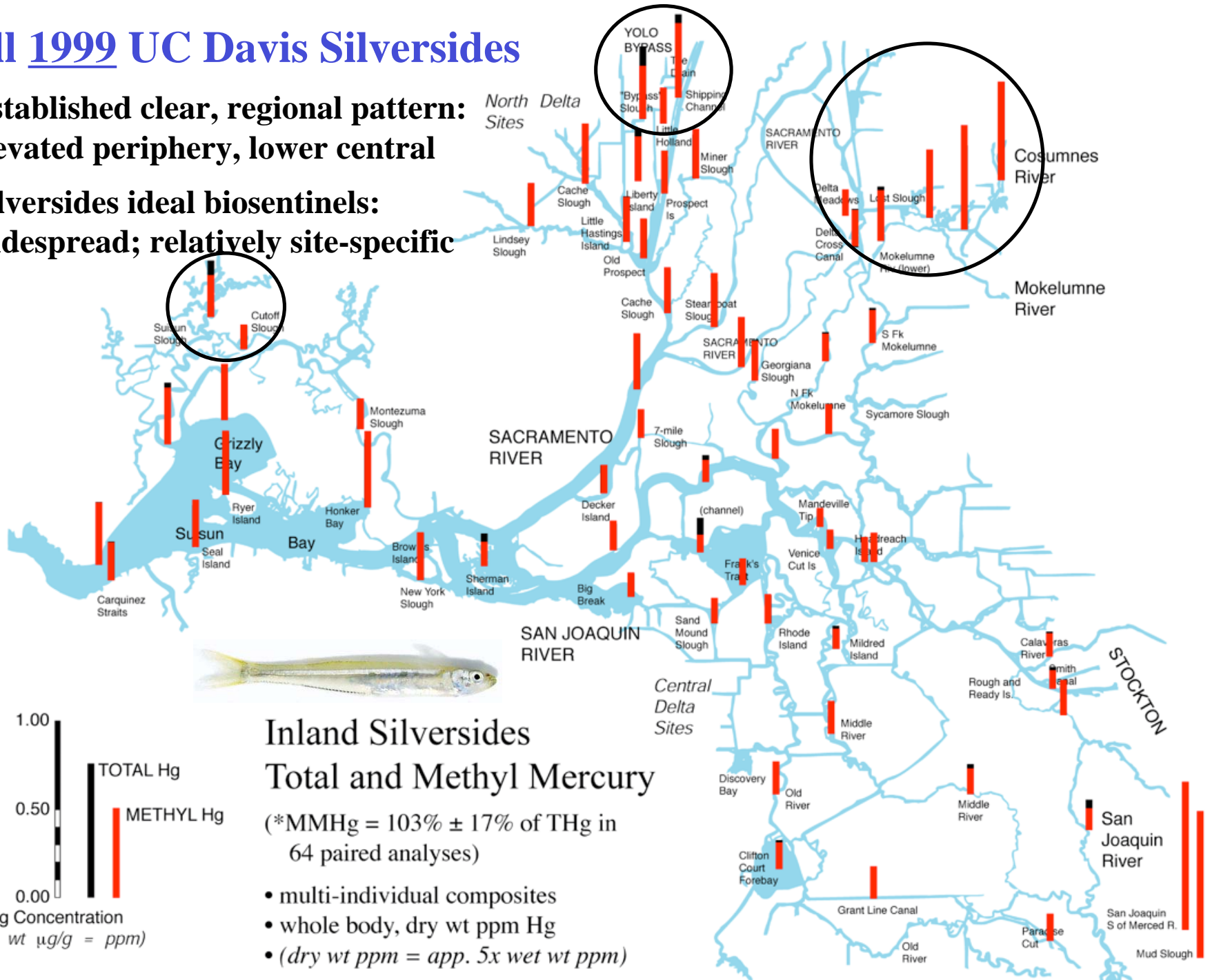
Entire Biosentinel Monitoring Region

- Over 3,000 individual small fish analyses/yr
- Feedback to restoration and watershed managers draws from entire program



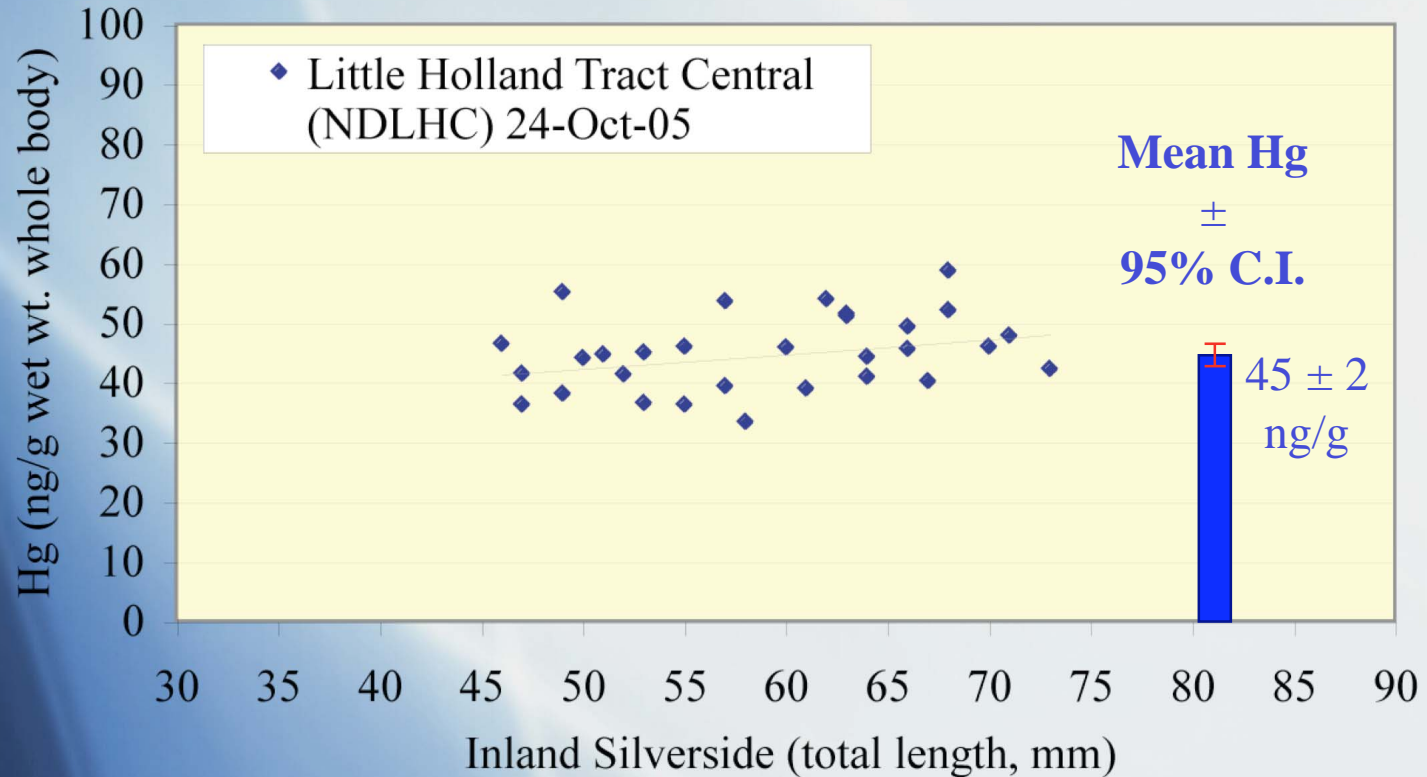
Fall 1999 UC Davis Silversides

- Established clear, regional pattern: elevated periphery, lower central
- Silversides ideal biosentinels: widespread; relatively site-specific



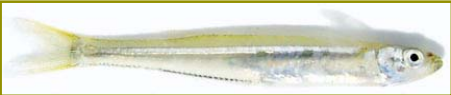
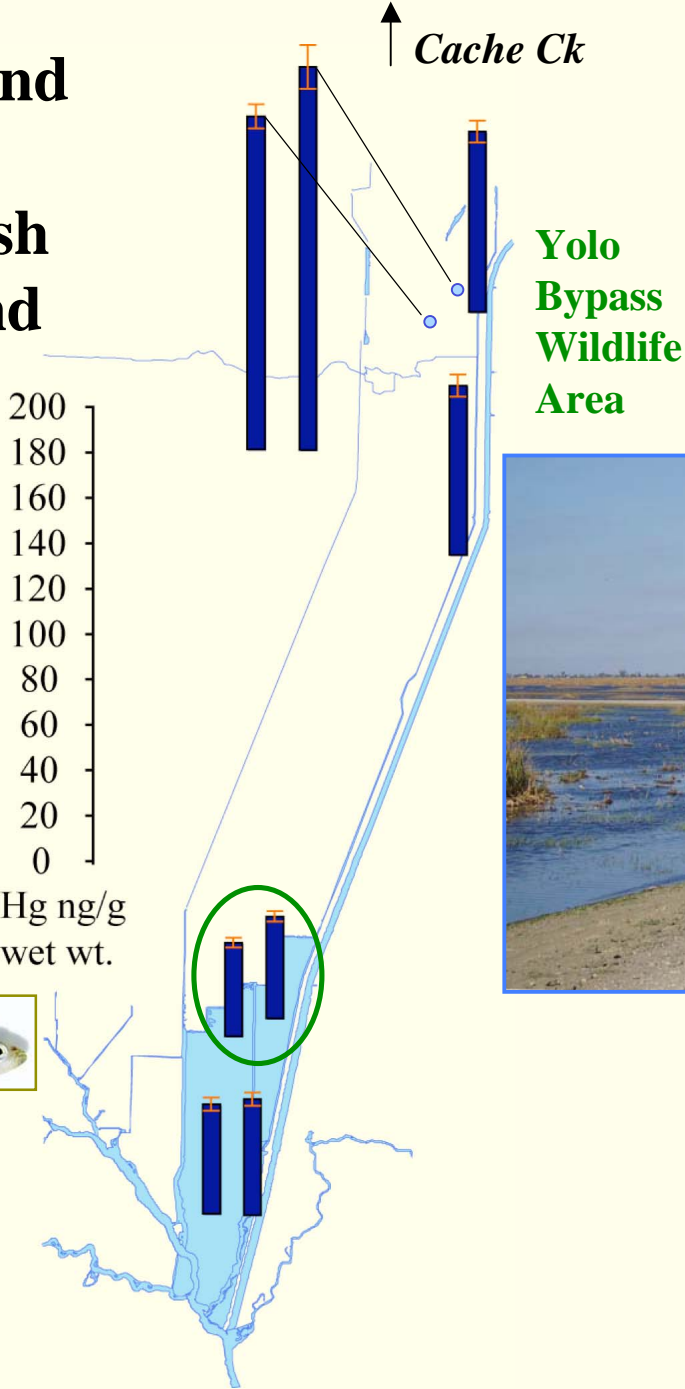
Multiple Individual Fish Analyses (n = 30)

- Within pre-defined size ranges with consistent Hg

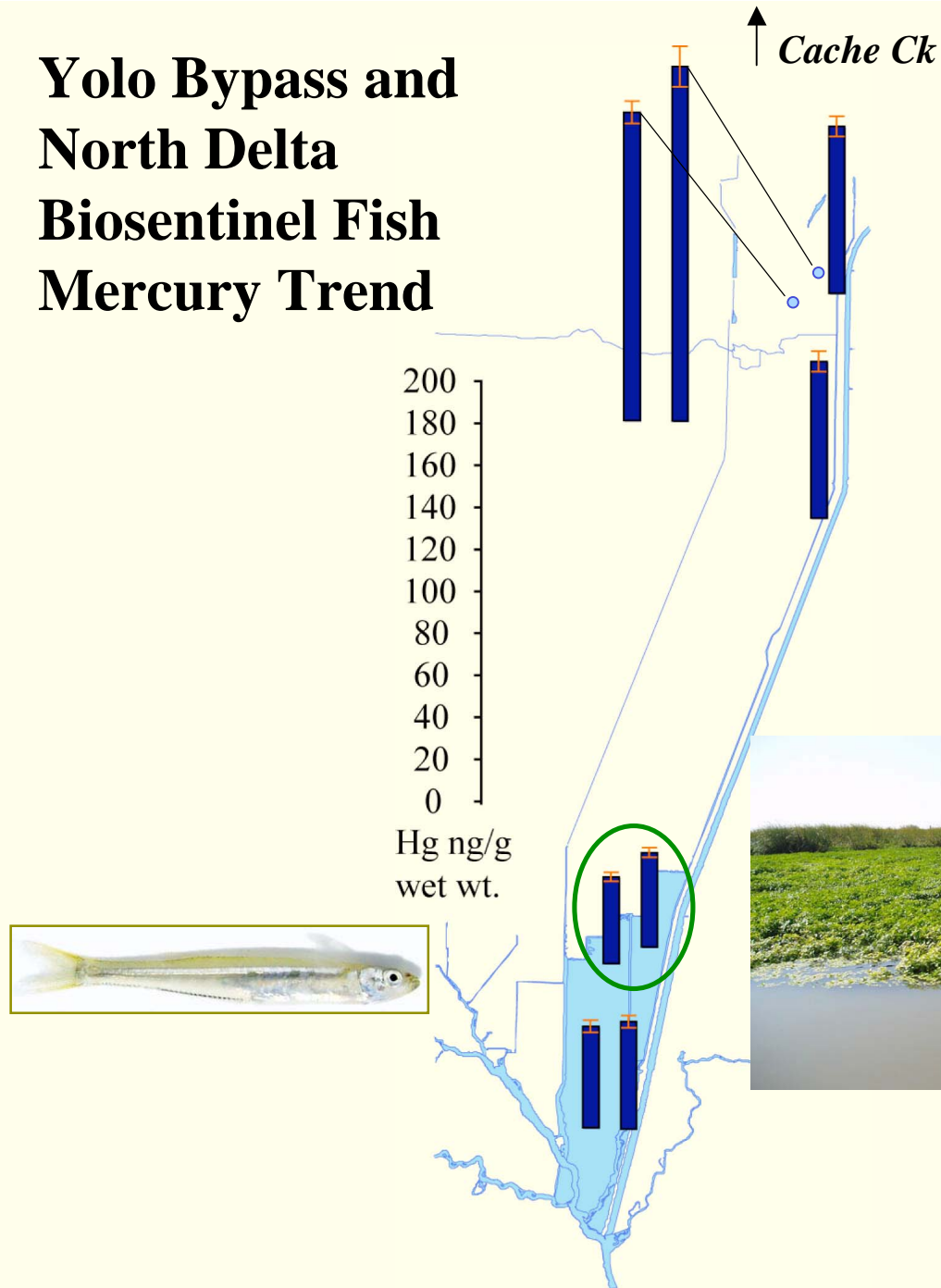


- Strong statistical power
- Detailed individual information

Yolo Bypass and North Delta Biosentinel Fish Mercury Trend



Yolo Bypass and North Delta Biosentinel Fish Mercury Trend



- A recurring theme:
Hot spots in some upland, episodically-flooded wetlands;
Often not seen in daily-flooded, tidal wetlands
- Mercury in North Delta flooded marshes *low*



Seasonal Studies: 2006

(selected data)



200
150
100
50
0
ng Hg/g
(wet wt)

- Historically high flood flows, winter rain runoff

Yolo Bypass
(Toe Drain)

Prospect
Slough

Sacra-
mento
River

May-06

Feb-06

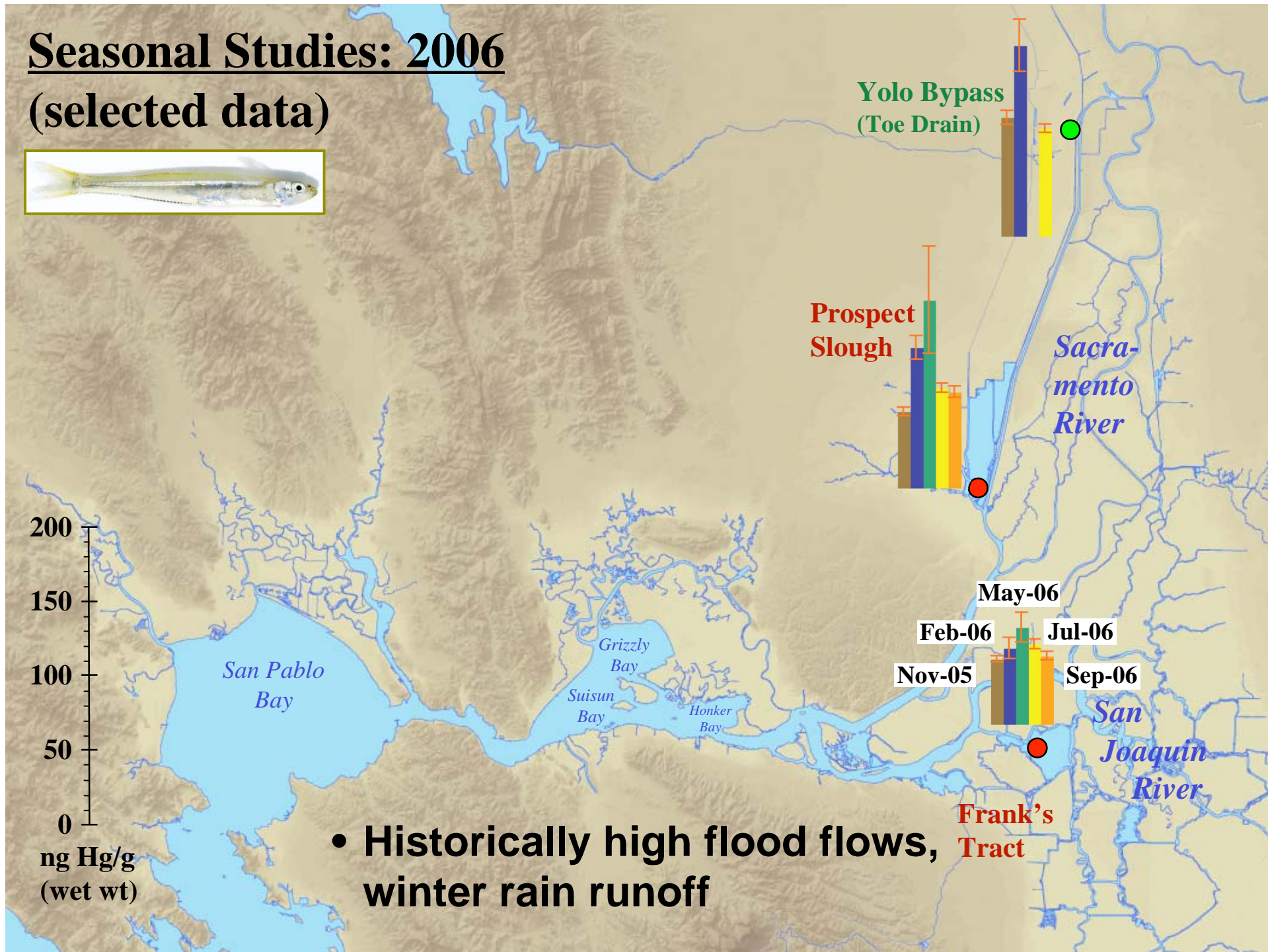
Jul-06

Nov-05

Sep-06

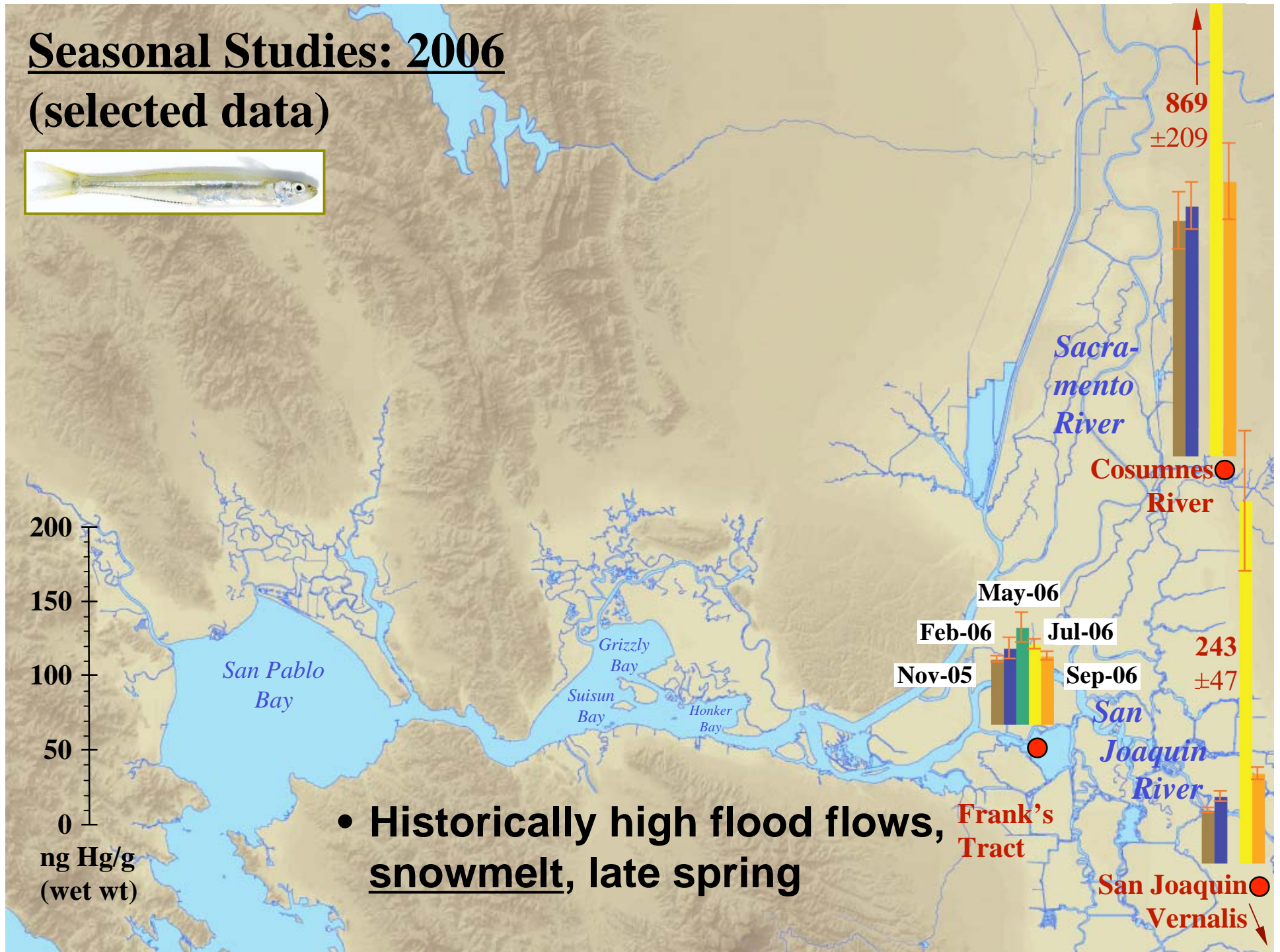
Frank's
Tract

San
Joaquin
River



Seasonal Studies: 2006

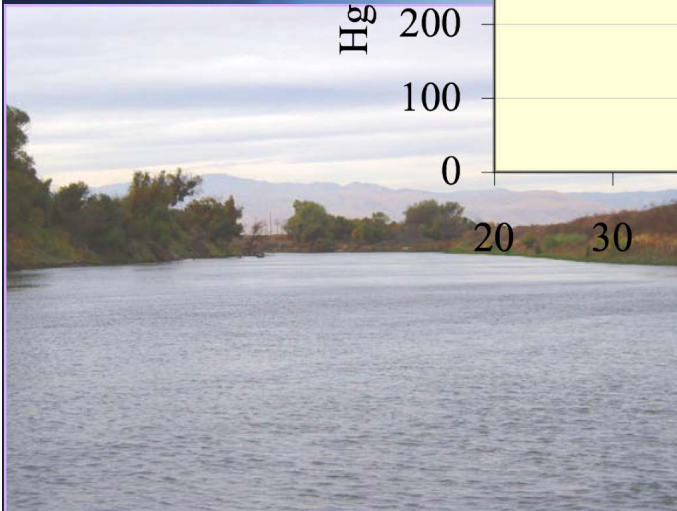
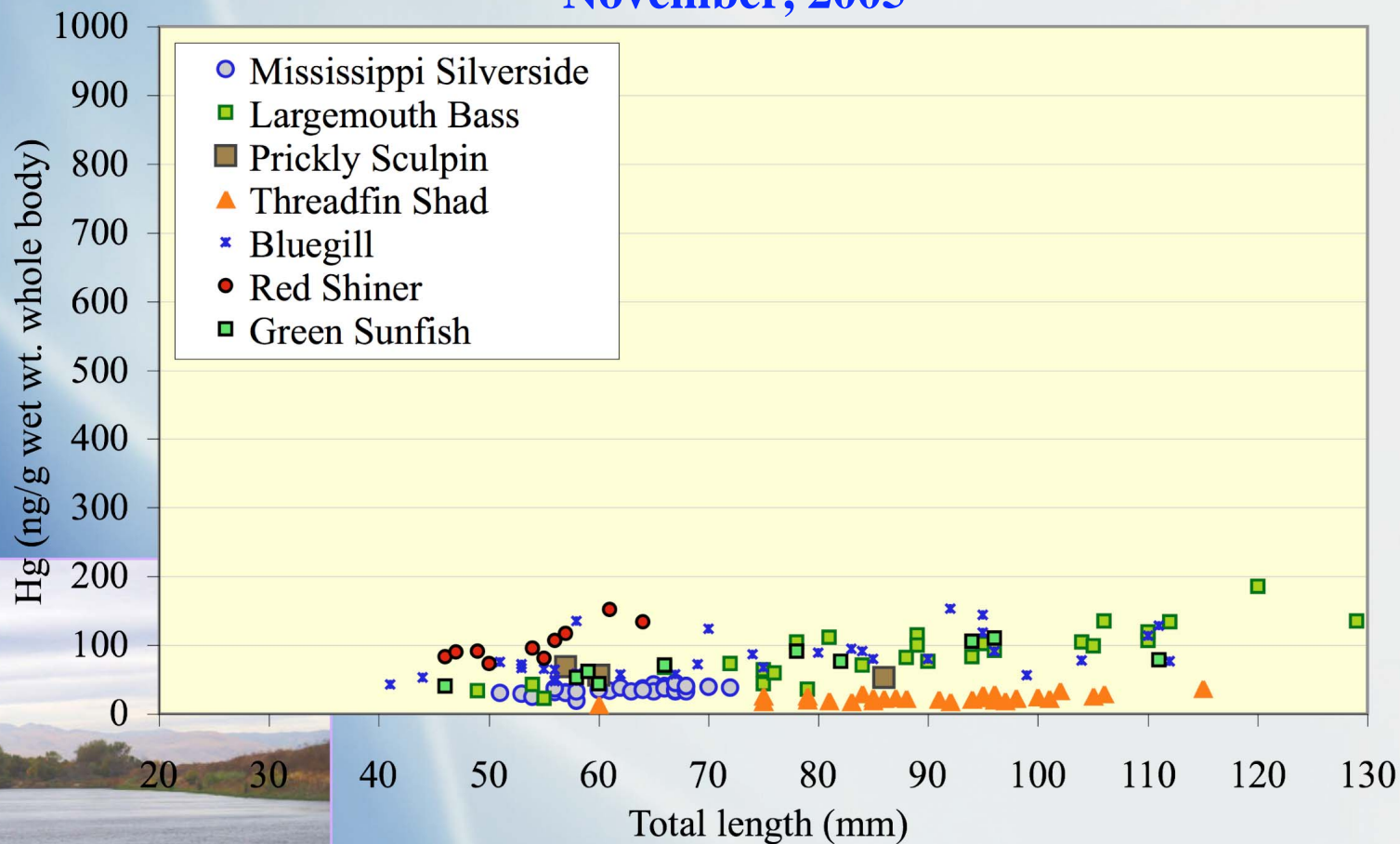
(selected data)



Intensive Sites, Multiple Species Data

San Joaquin River at Vernalis

November, 2005

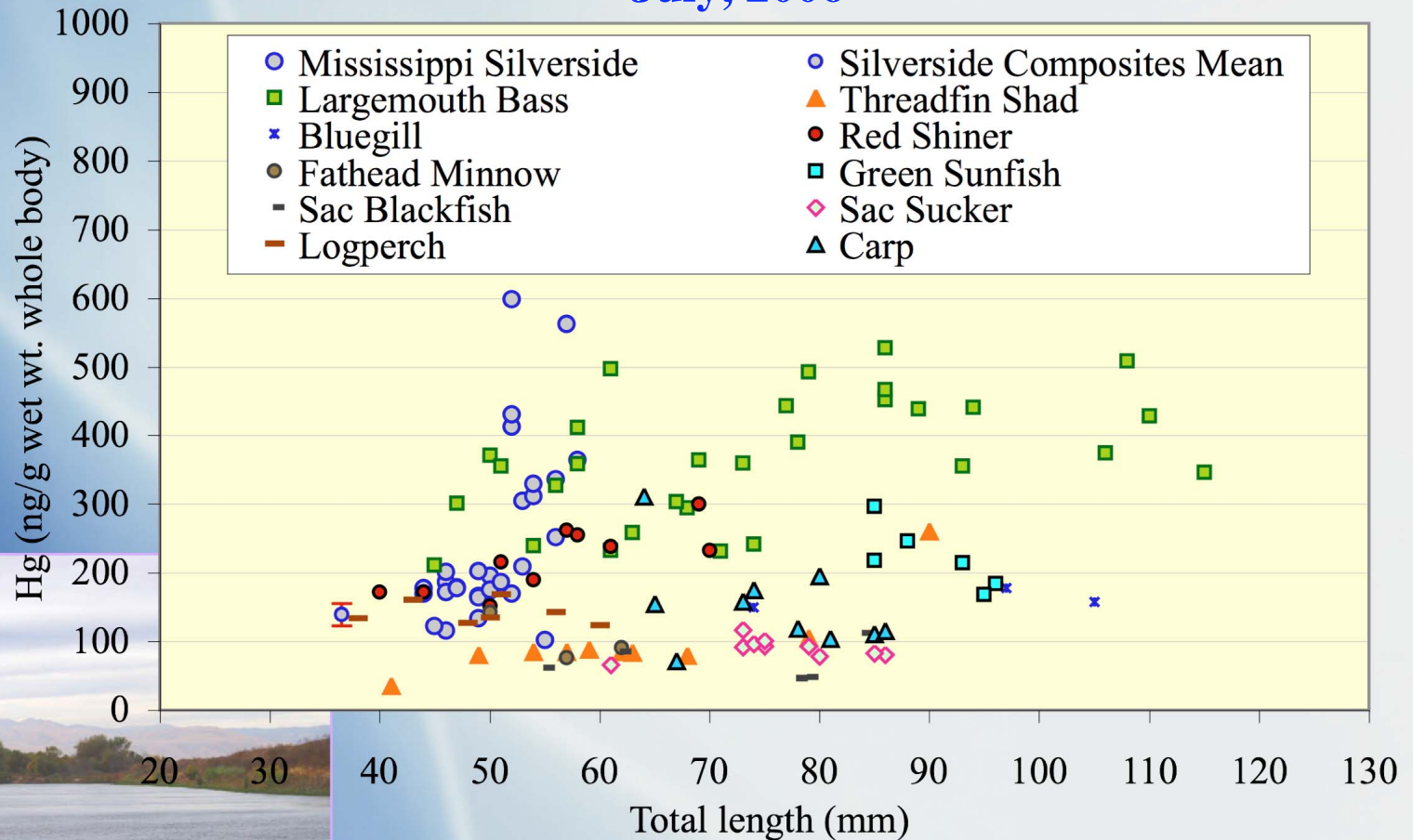


- **November, 2005: All species uniformly low to moderate in Hg**

Intensive Sites, Multiple Species Data

San Joaquin River at Vernalis

July, 2006

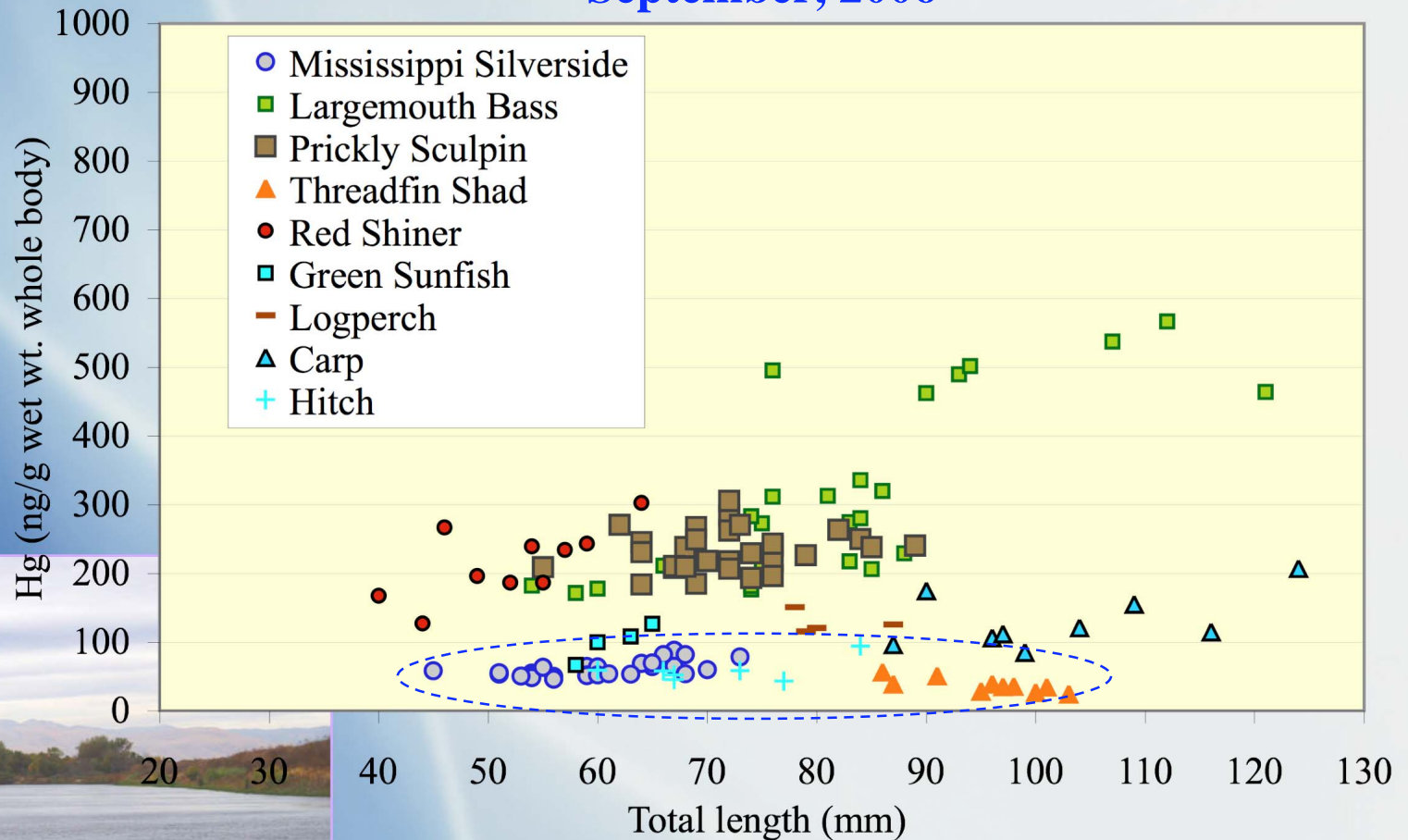


- **In July, following major flooding upstream, all species up dramatically**

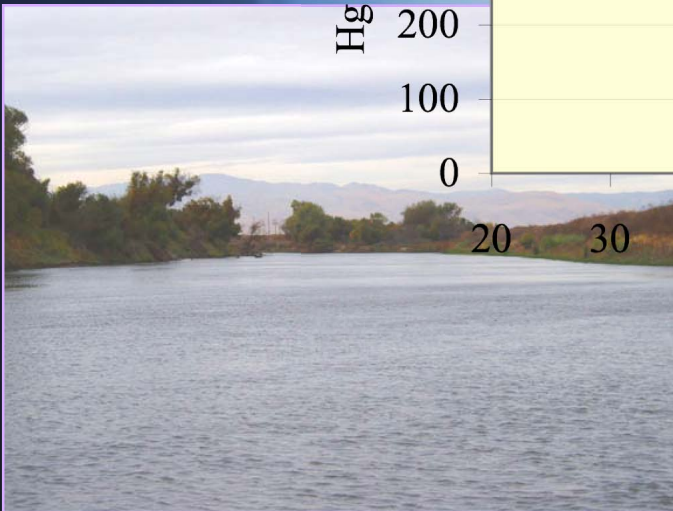
Intensive Sites, Multiple Species Data

San Joaquin River at Vernalis

September, 2006



- **By September, new-cohort species down, indicating reduced exposure; other species stayed elevated 12+ mo**



Seasonal Studies



- Massive spike concentrations after large flooding, July 2006
- New data from 2007, after drought season, no flooding

200
150
100
50
0
ng Hg/g
(wet wt)

- App. 10-fold decline, year-on-year, July

869
±209

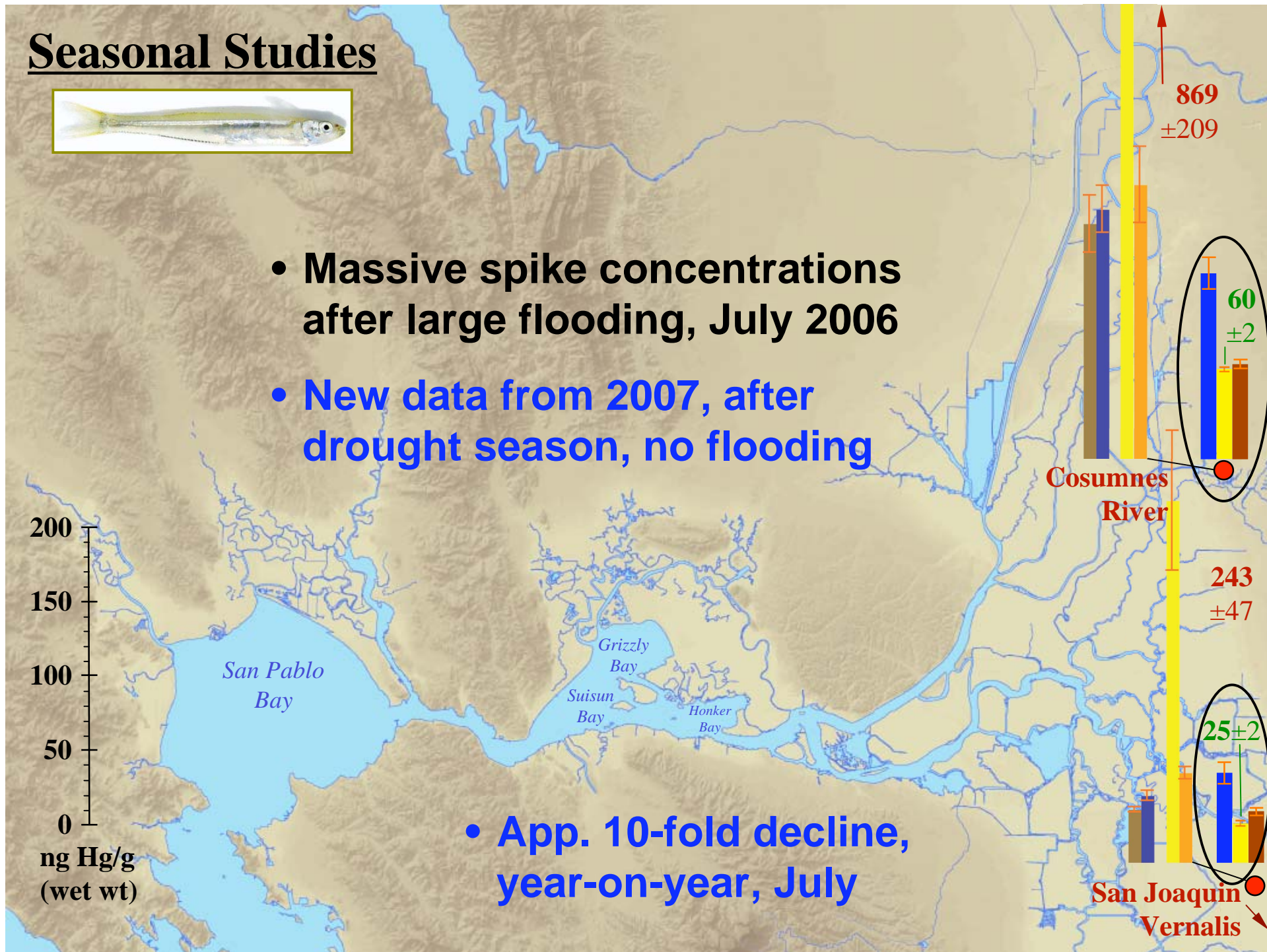
Cosumnes River

60
±2

243
±47

25±2

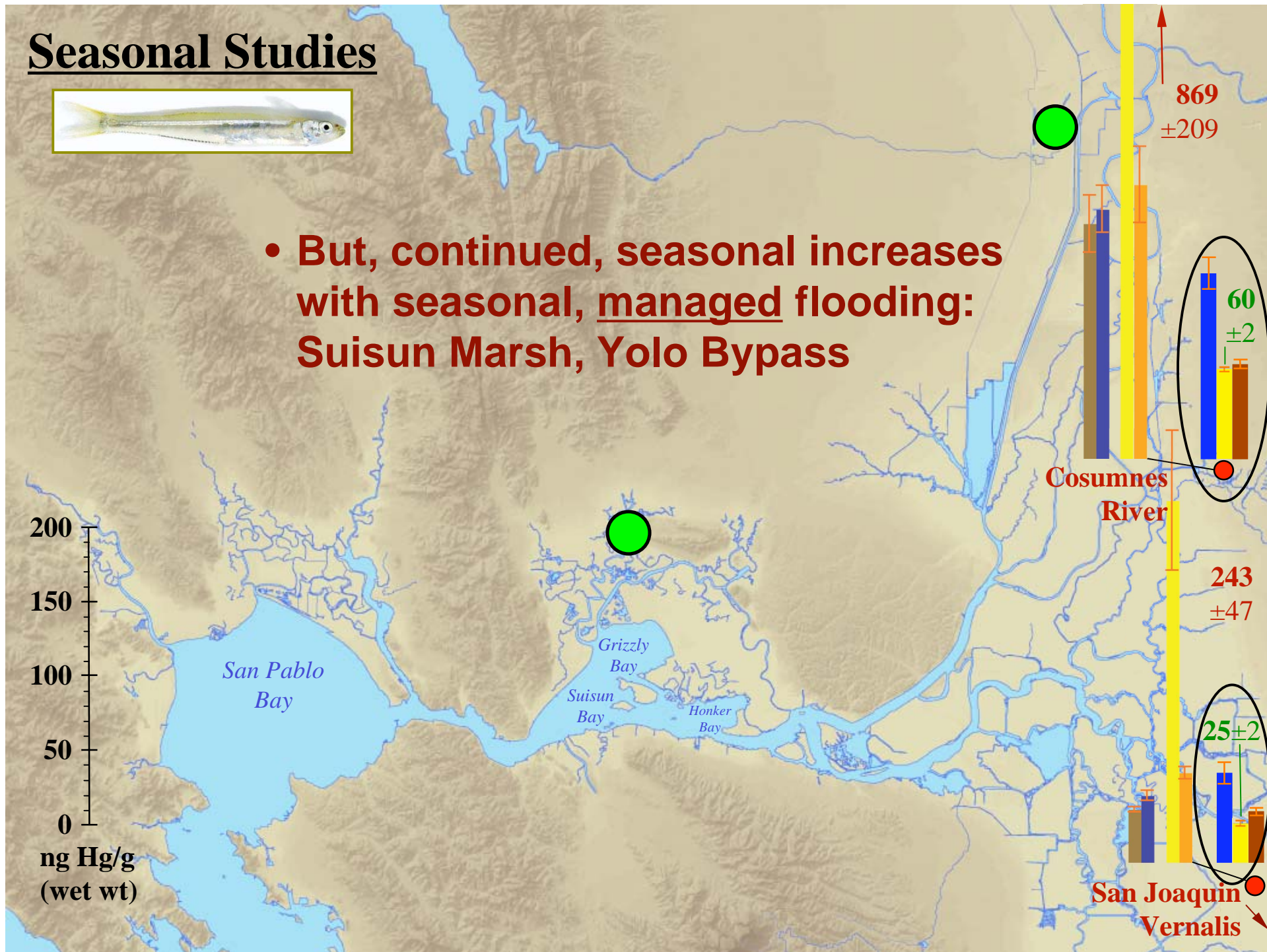
San Joaquin Vernalis



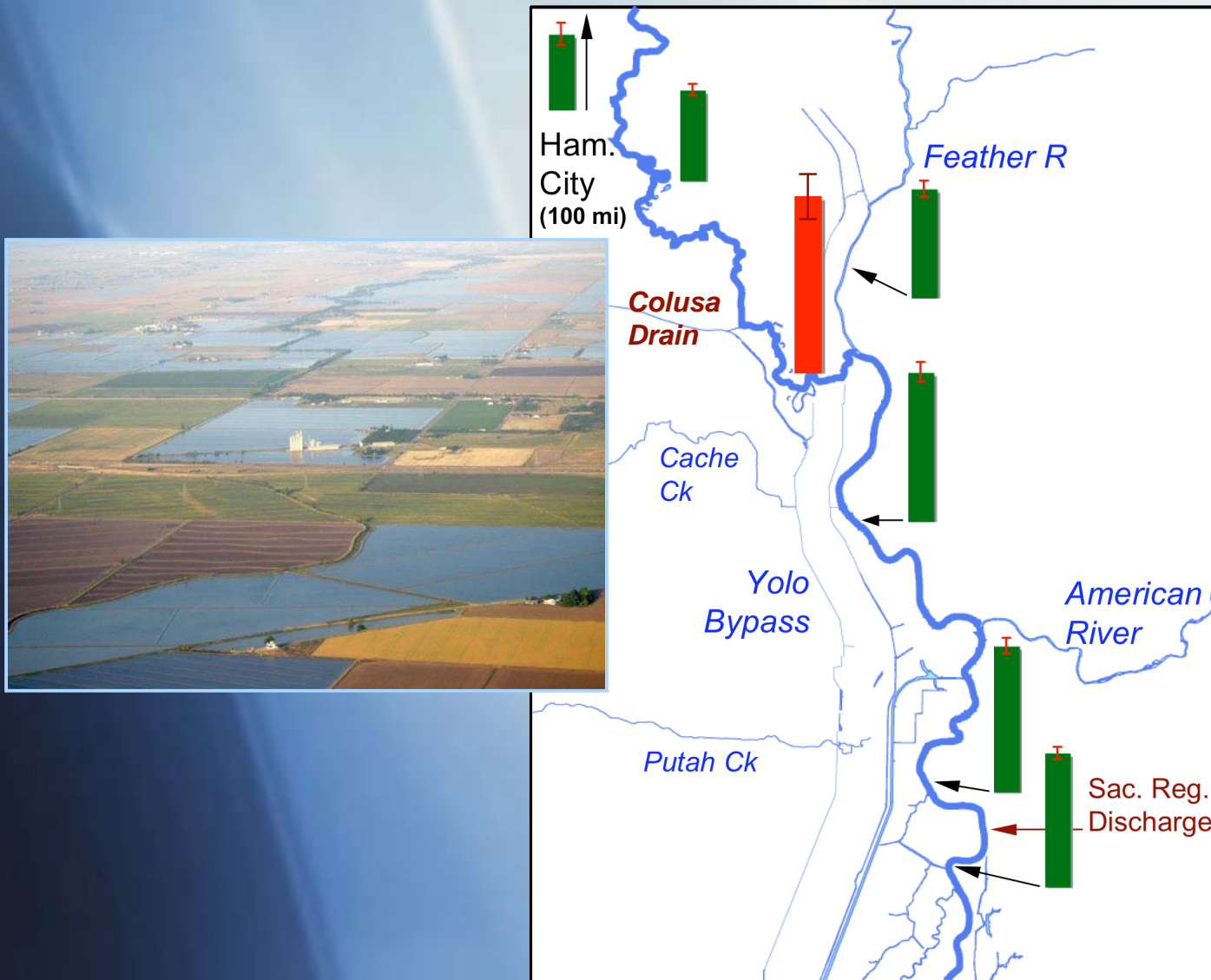
Seasonal Studies



- But, continued, seasonal increases with seasonal, managed flooding: Suisun Marsh, Yolo Bypass



Biosentinels for source identification: Sacramento River sculpin series (*Fall 2006*)



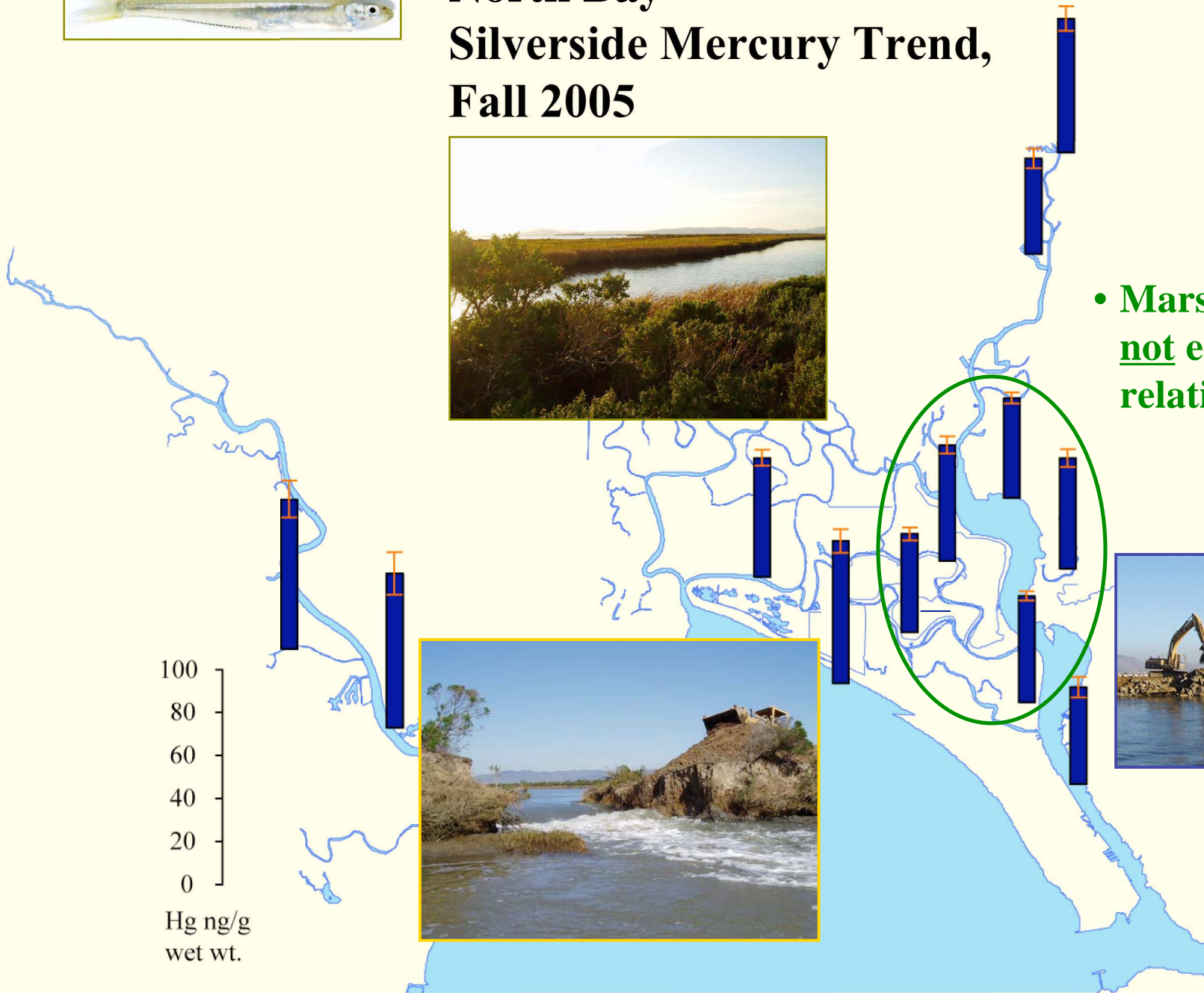
- Sculpin data suggest Colusa Drain as a source of MeHg
- Colusa Drain contains water from fields that are seasonally flooded--for waterfowl management and rice farming

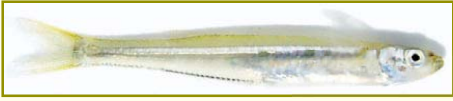


North Bay Silverside Mercury Trend, Fall 2005

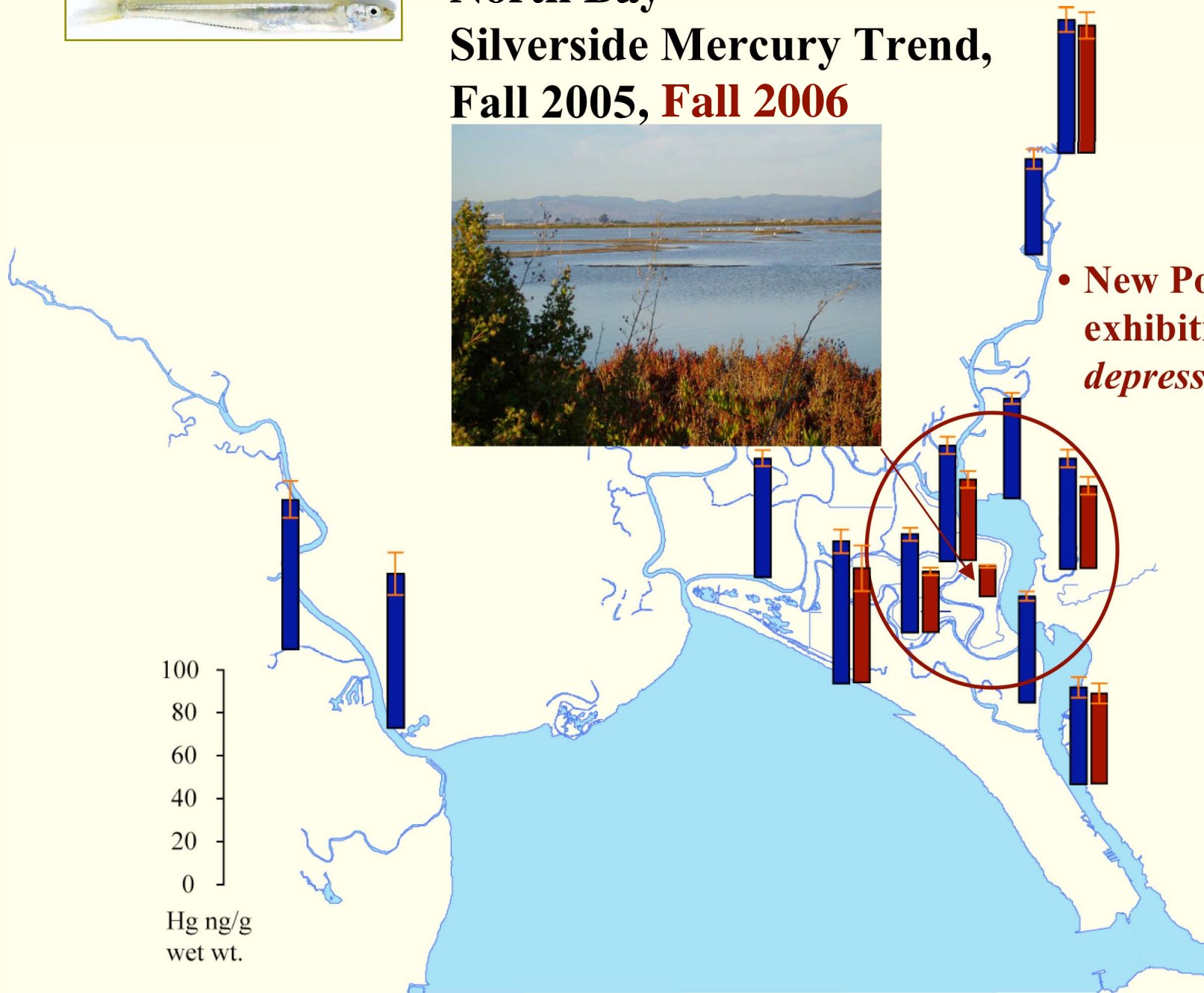


• Marsh area not elevated, relatively





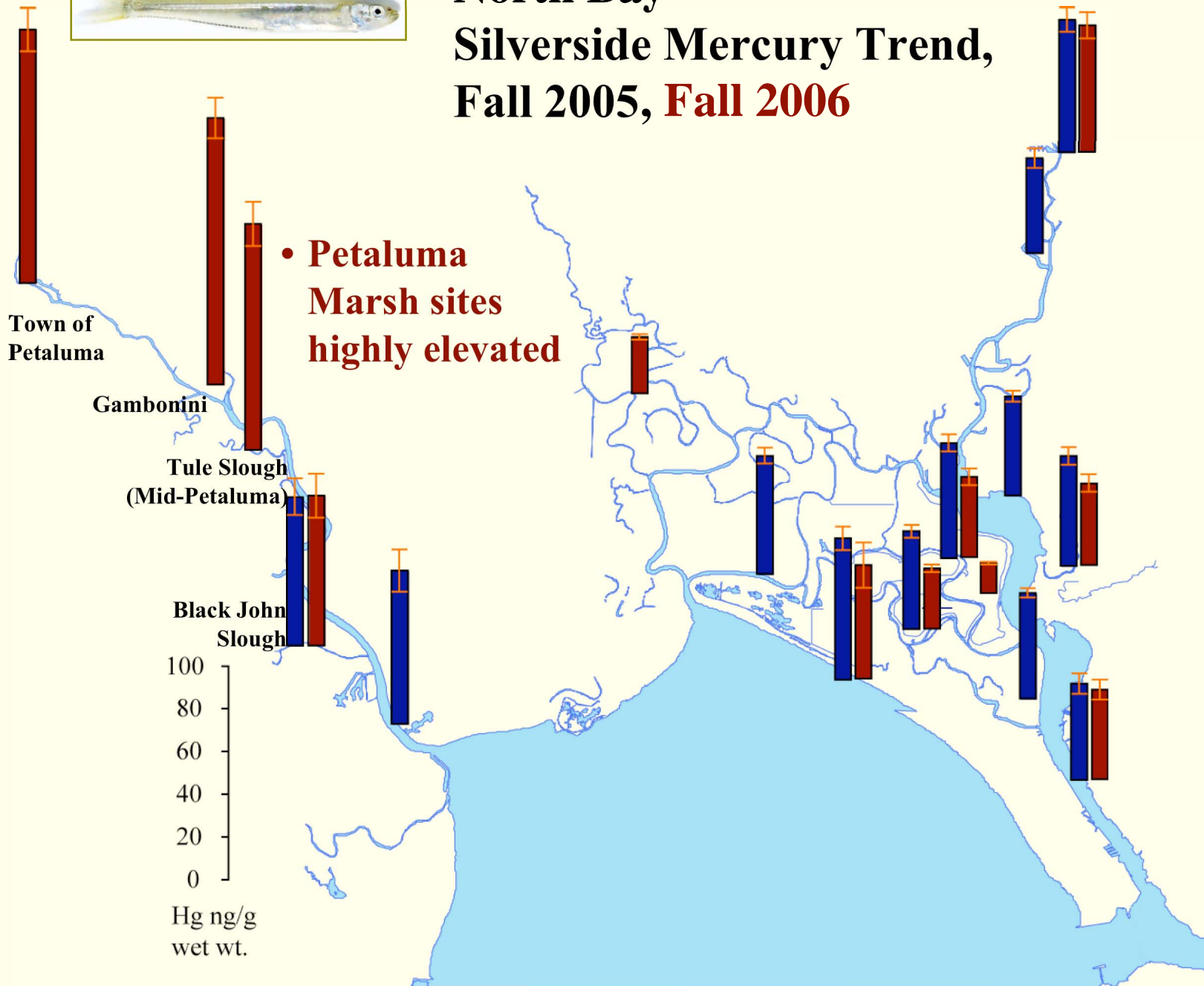
North Bay Silverside Mercury Trend, Fall 2005, **Fall 2006**



- **New Ponds 4-5 etc.**
exhibiting MeHg depression effect

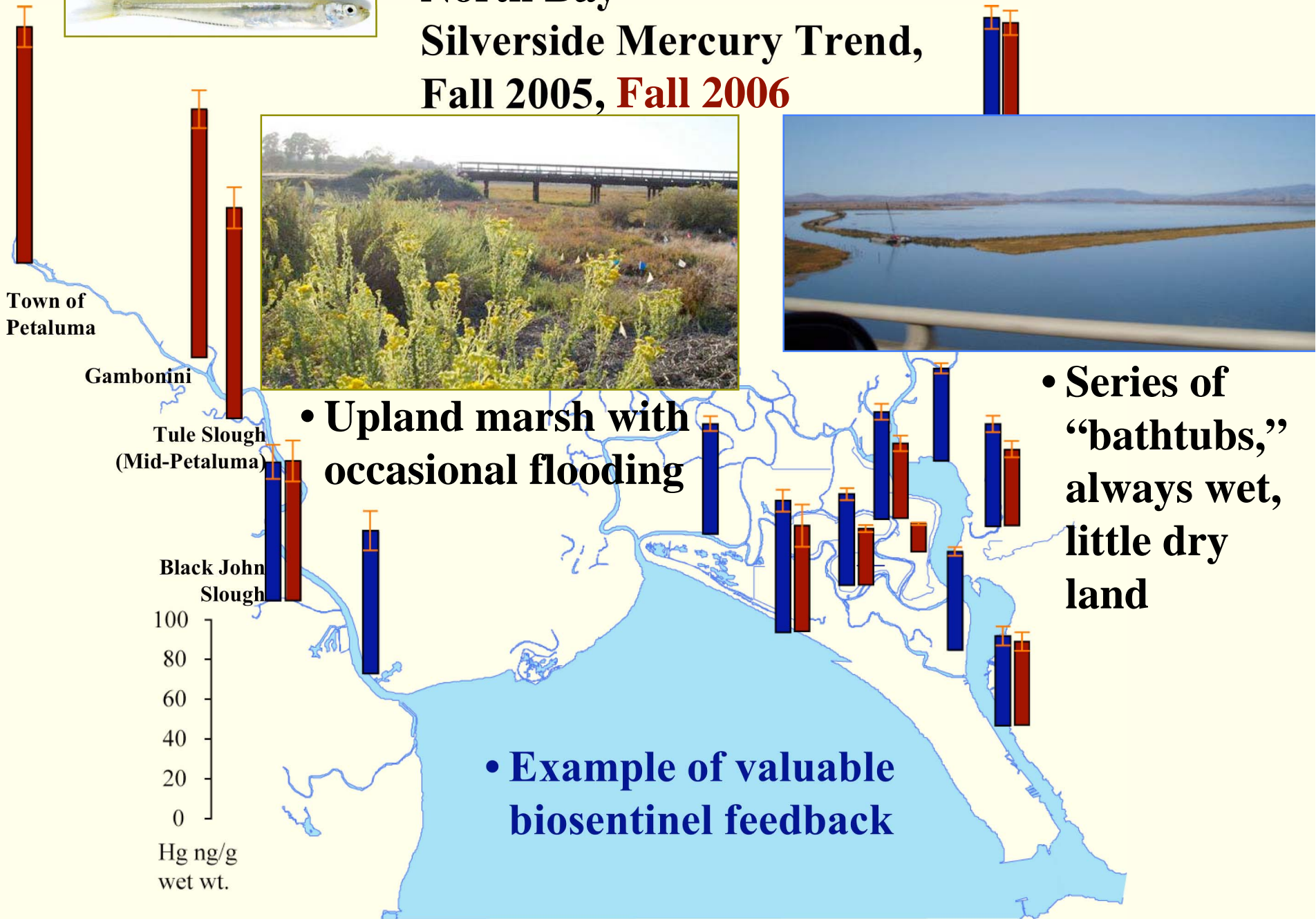


North Bay Silverside Mercury Trend, Fall 2005, Fall 2006





North Bay Silverside Mercury Trend, Fall 2005, Fall 2006

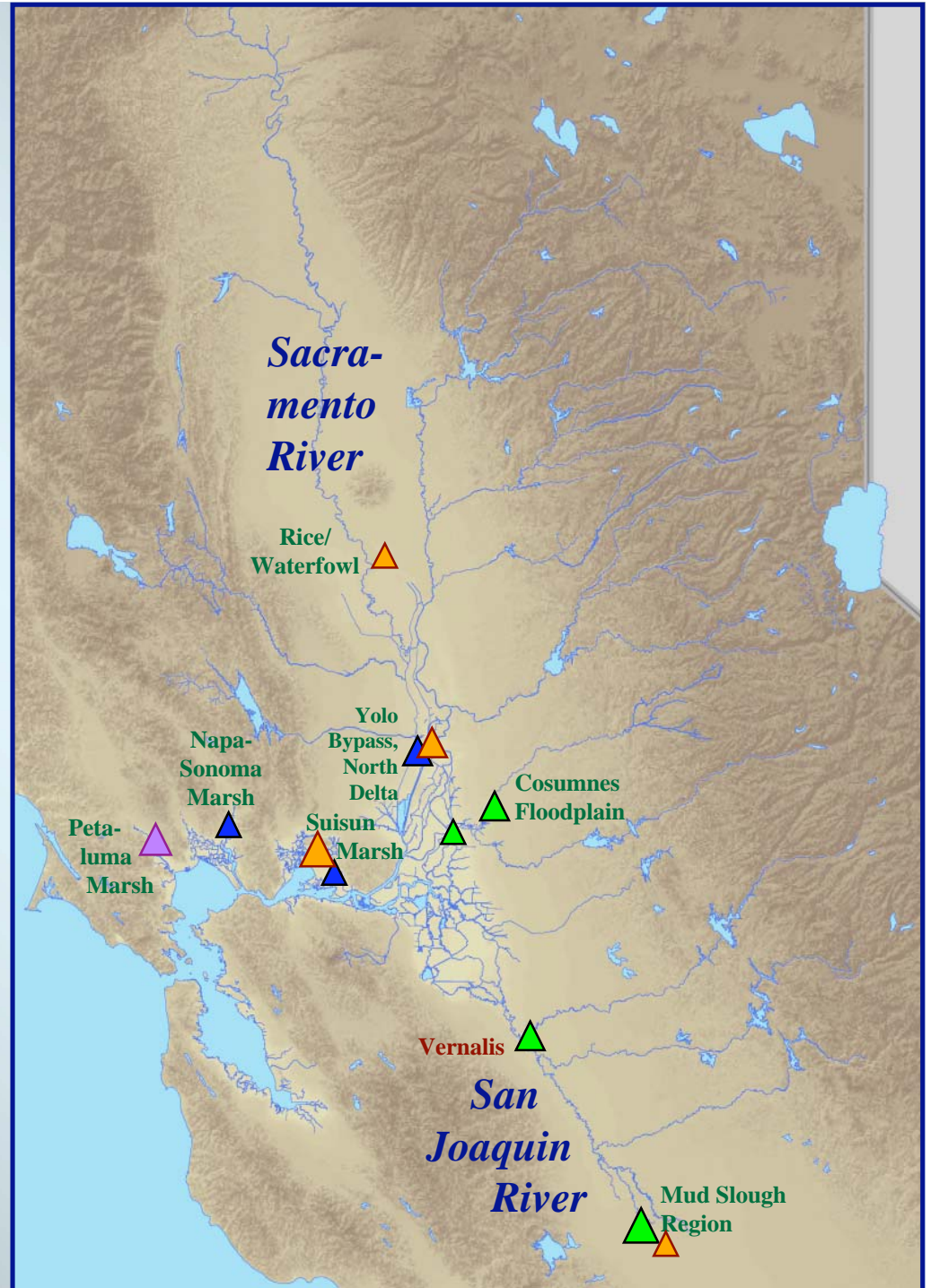


Conclusions

Main cases of highly elevated exposure all appear to have been associated with some form of episodic flooding:

- ▲ Winter, rain-runoff flooding
- ▲ Spring, snow-runoff flooding
- ▲ Episodic tidal flooding
- ▲ Managed flooding (summer/fall)

* Some may have realistic management solutions



Implications for Watershed Managers

Episodic flooding identified as the single most important factor leading to highly elevated MeHg exposure for fish.

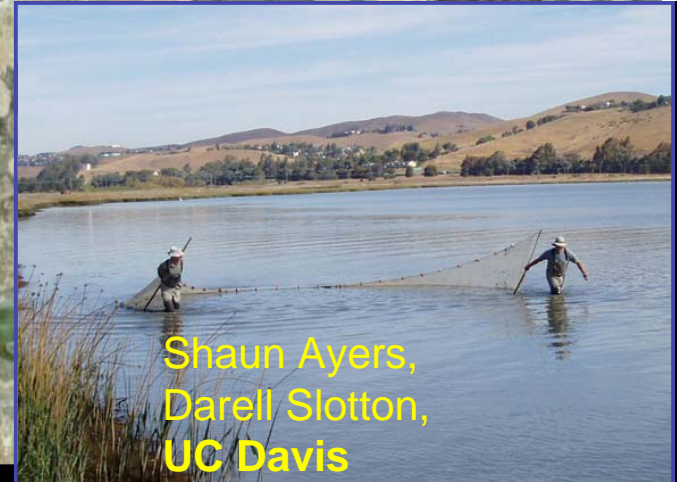
Presence of a Hg loading source tends to increase exposure.

Watershed flooding can impact large parts of the system.

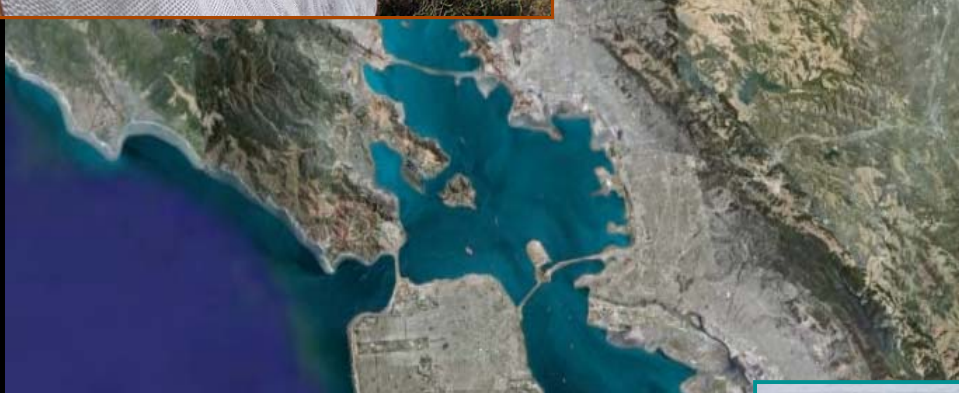
Toxicologically-significant changes in exposure can occur between years, and also seasonally.

Some major wetland areas are apparently *not* relative hot spots of MeHg exposure, including the Napa-Sonoma Marsh and much of the tidal Delta tule marsh and SAV zones.

A regional program of small fish biosentinel mercury monitoring has great value for watershed managers



Shaun Ayers,
Darell Slotton,
UC Davis



New, Expanded RMP Small Fish Program. Collaboration: SFEI, UC Davis, and others



Gretchen Gehrke,
Joel Blum (not pictured)
University of Michigan

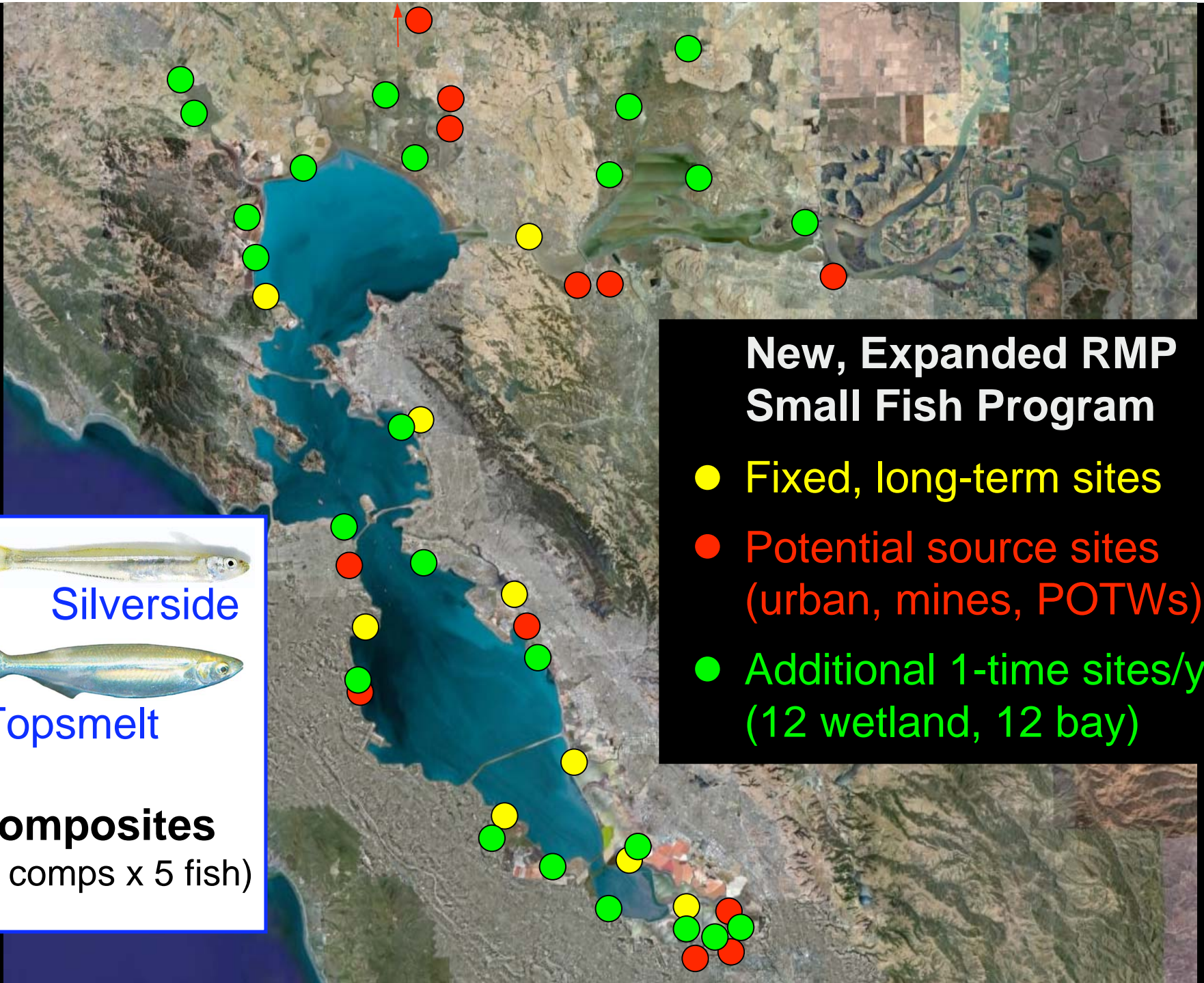


(Plus others)



Katie Harrold,
Ben Greenfield
(not pictured)

SFEI



New, Expanded RMP Small Fish Program

- Fixed, long-term sites
- Potential source sites (urban, mines, POTWs)
- Additional 1-time sites/yr (12 wetland, 12 bay)



Silverside



Topsmelt

Composites

(4 comps x 5 fish)