Sediment Toxicity in the San Francisco Estuary: Understanding Impacts in a Challenging Environment

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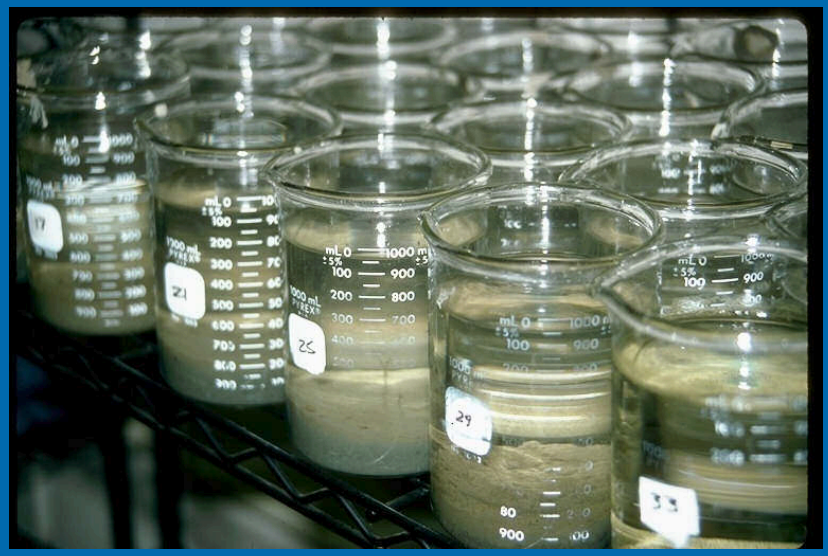
Background

- High incidence of toxicity in lab tests since the Status and Trends Program began in 1993.
- Magnitude of toxicity is often moderate
- Management decisions require identification of contaminants of concern
- Stressor identification is a key element of the State Water Resources Control Board's SQOs program

What's Killing Amphipods in Laboratory Toxicity Tests?



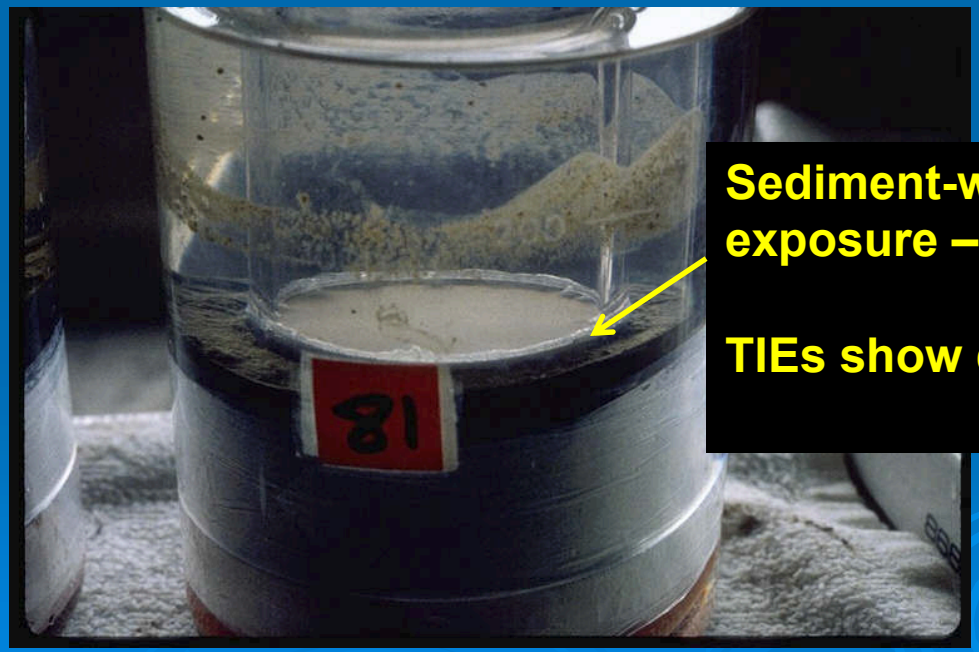
- Benchmark Species for State SQO program
- Free burrower
- Euryhaline
- Relatively tolerant of wide range of grain sizes
- Responsive to contaminants

SF Bay Datasets Show Moderate Toxicity and Moderate Concentrations in Chemical Mixtures

Mytilus galloprovincialis

Normal larva

Abnormal larva



Sediment-water interface exposure –

TIEs show divalent cations

Do we have confidence in our indicators?

BPTCP: Hunt et al. 1998 . and

Hunt, J.W., B.S. Anderson, B.M. Phillips, J. Newman, R. Tjeerdema, R. Fairey, H.M. Puckett, M.Stephenson, R.W. Smith, C.J. Wilson, and K.M. Taberski. 2001. Evaluation and use of sediment toxicity reference sites for statistical comparisons in regional assessments. Environ Toxicol Chem. 20: 1266-1275.

Among protocols recommended:

- ✓ ***Eohaustorius estuarius*** **- Whole sediment**
- ✓ ***Mytilus galloprovincialis*** **- Sediment Water Interface**

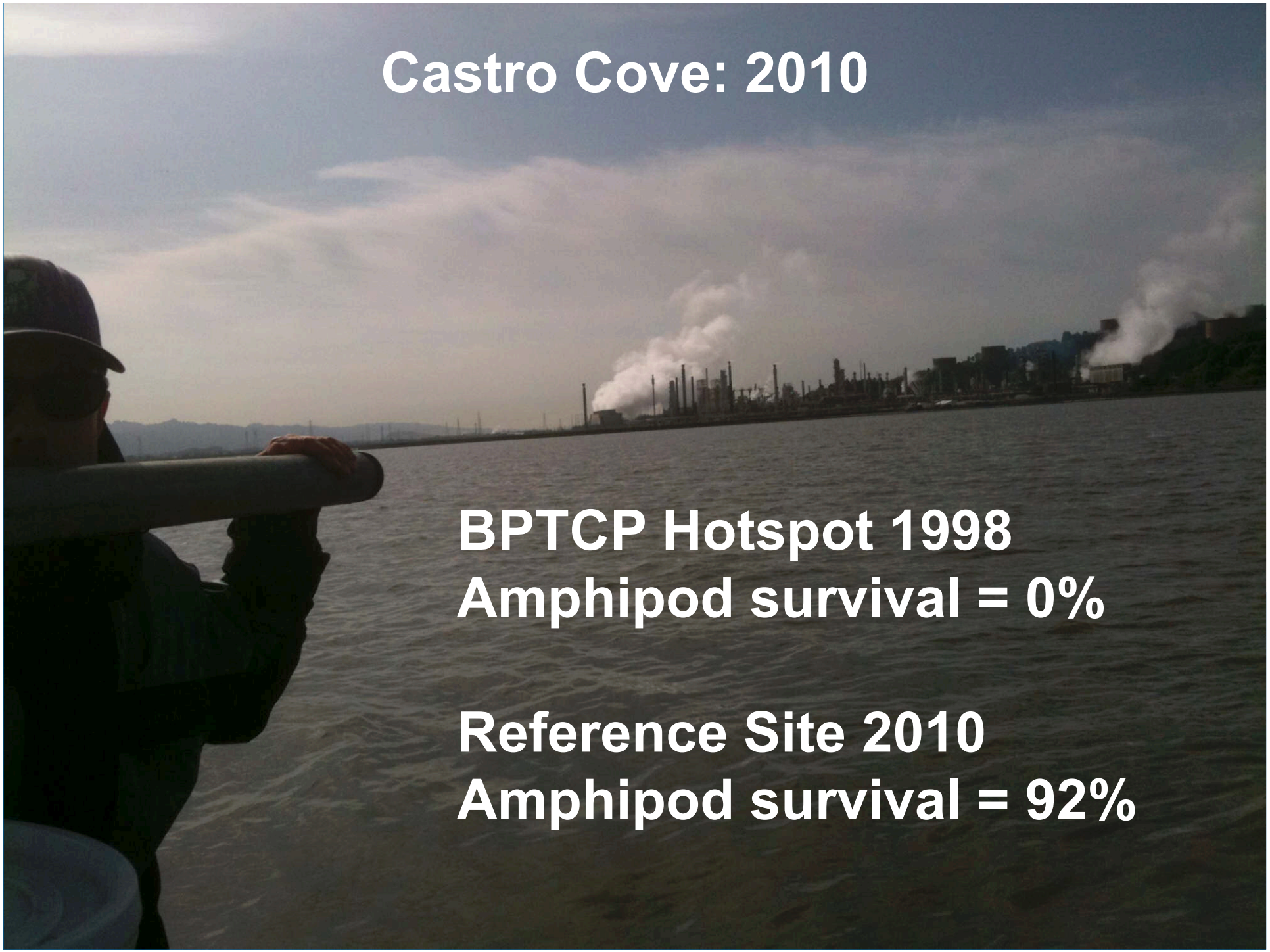
SWRCB SQO: Greenstein, D, Bay, S, Anderson, BS, Chandler, GT, Farrar, JD, Keppler, C,, Phillips, BM, Ringwood, A, Young, D. 2008. Comparison of methods for evaluating acute and chronic toxicity in marine sediments. Environ Toxicol Chem. 27(4) :933-942

Among protocols recommended:

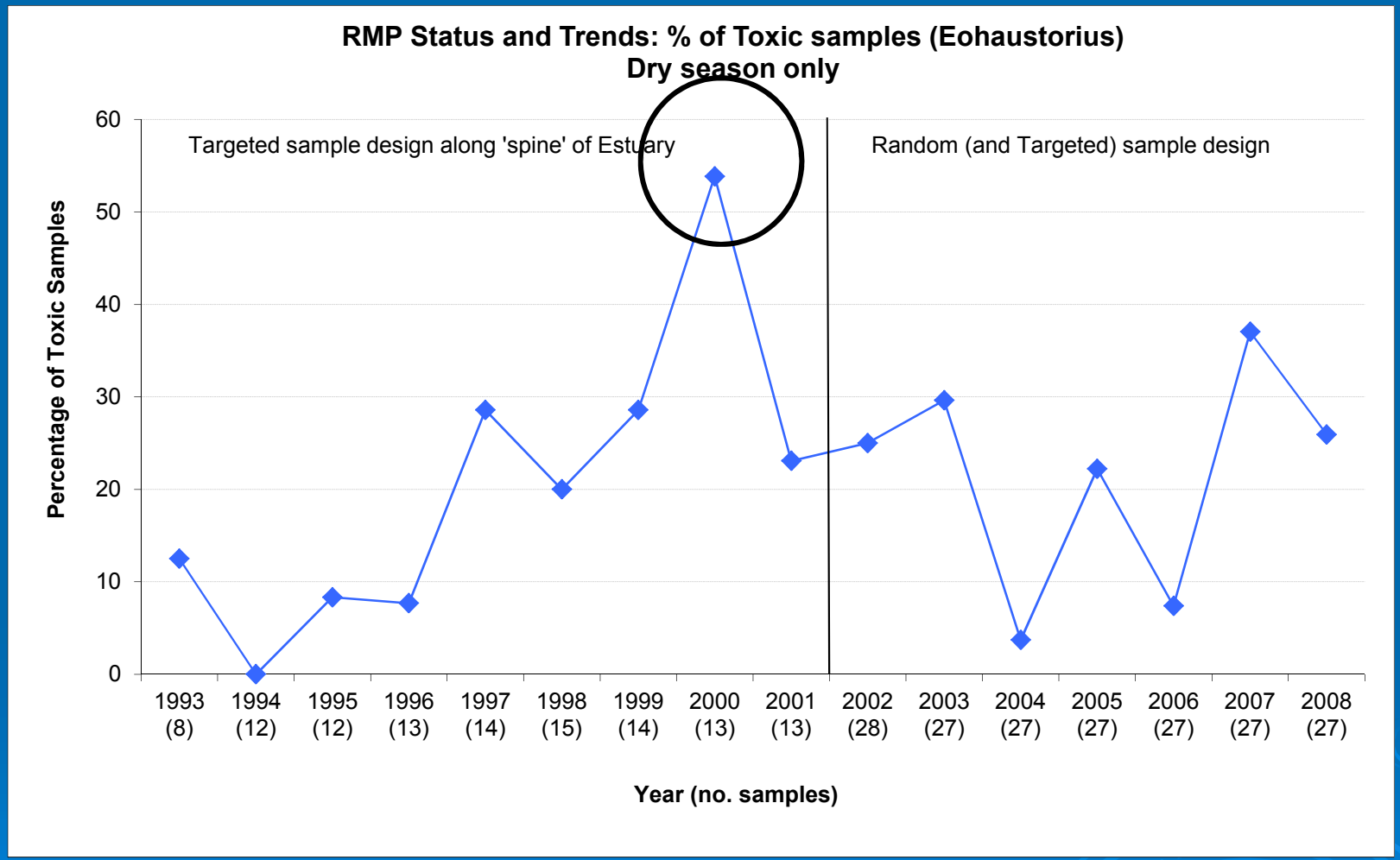
- ✓ ***Eohaustorius estuarius and M. galloprovincialis - SWI***

A Changing Environment: Hotspots and Reference Sites

	Amphipod Survival		
	BPTCP (1995 or 1997)	Phillips et al 2008	Phillips et al. 2010
Mission Creek	19%	48%	
San Leandro Bay	65%	76%	
Islais Creek	0%	64%	
Castro Cove	0%	88%	92%
Paradise Cove	81%		67%

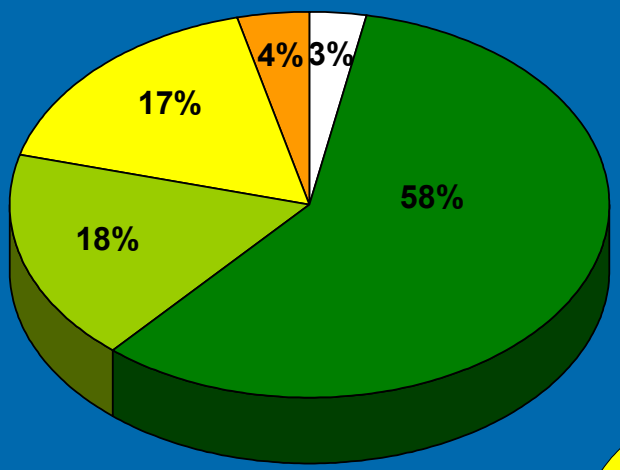

Castro Cove: 2010
BPTCP Hotspot 1998
Amphipod survival = 0%
Reference Site 2010
Amphipod survival = 92%

Amphipod Survival Over the Years

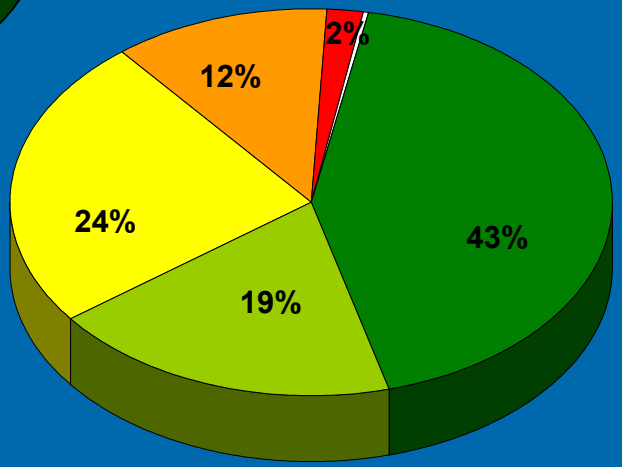


NOAA/EMAP 2000 = 32/48 stations tested with *Eohaustorius* were toxic (67%)

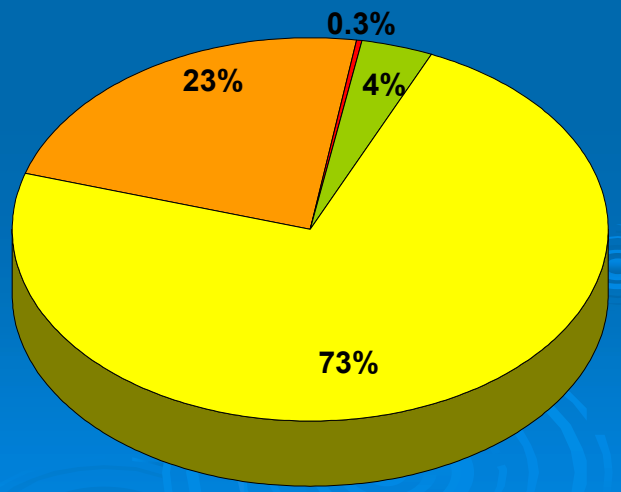
Regional Condition



North
139 km^2



South
135 km^2



San Francisco Bay
1020 km^2

- Unimpacted
- Likely Unimpacted
- Possibly Impacted
- Likely Impacted
- Clearly Impacted
- Inconclusive

A Challenging Environment

- "Levels of agreement among experts using best professional judgment to assess mesohaline and tidal freshwater benthic macrofaunal condition in the San Francisco Estuary and Delta "

- **Freshwater to brackish salinity habitats = 29% to 38% correlation among benthic ecology experts (Thompson et al. 2010)**

- **Brackish to marine habitats = 92% correlation among experts (Weisberg et al. 2008)**

“On Tuesday when it hails and snows,
The feeling on me grows and grows
That hardly anybody knows
If those are these or these are those”

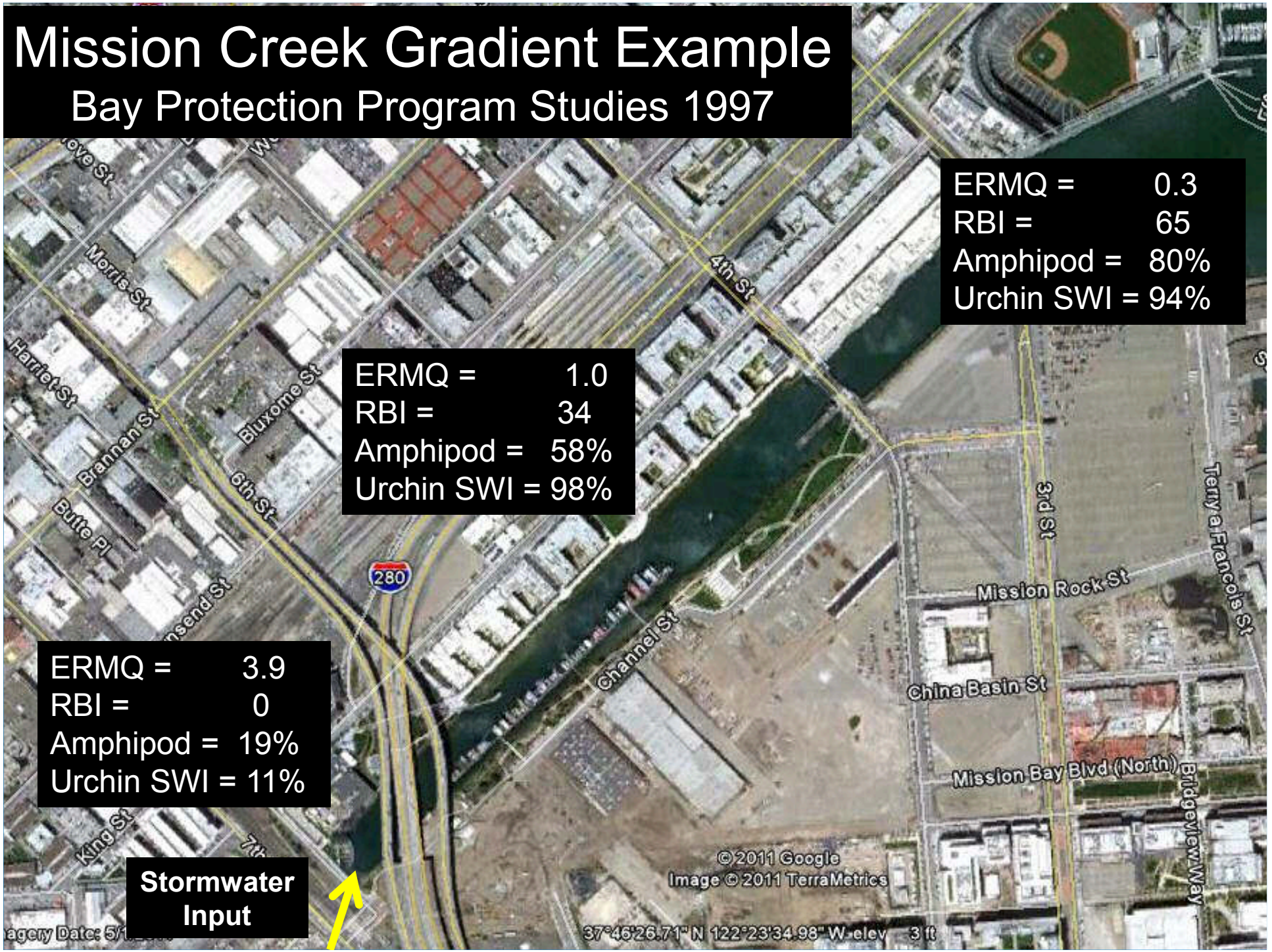
W. T. Pooh

“Don’t bother trying to figure out what’s going on in San Francisco Bay”

Rick Swartz

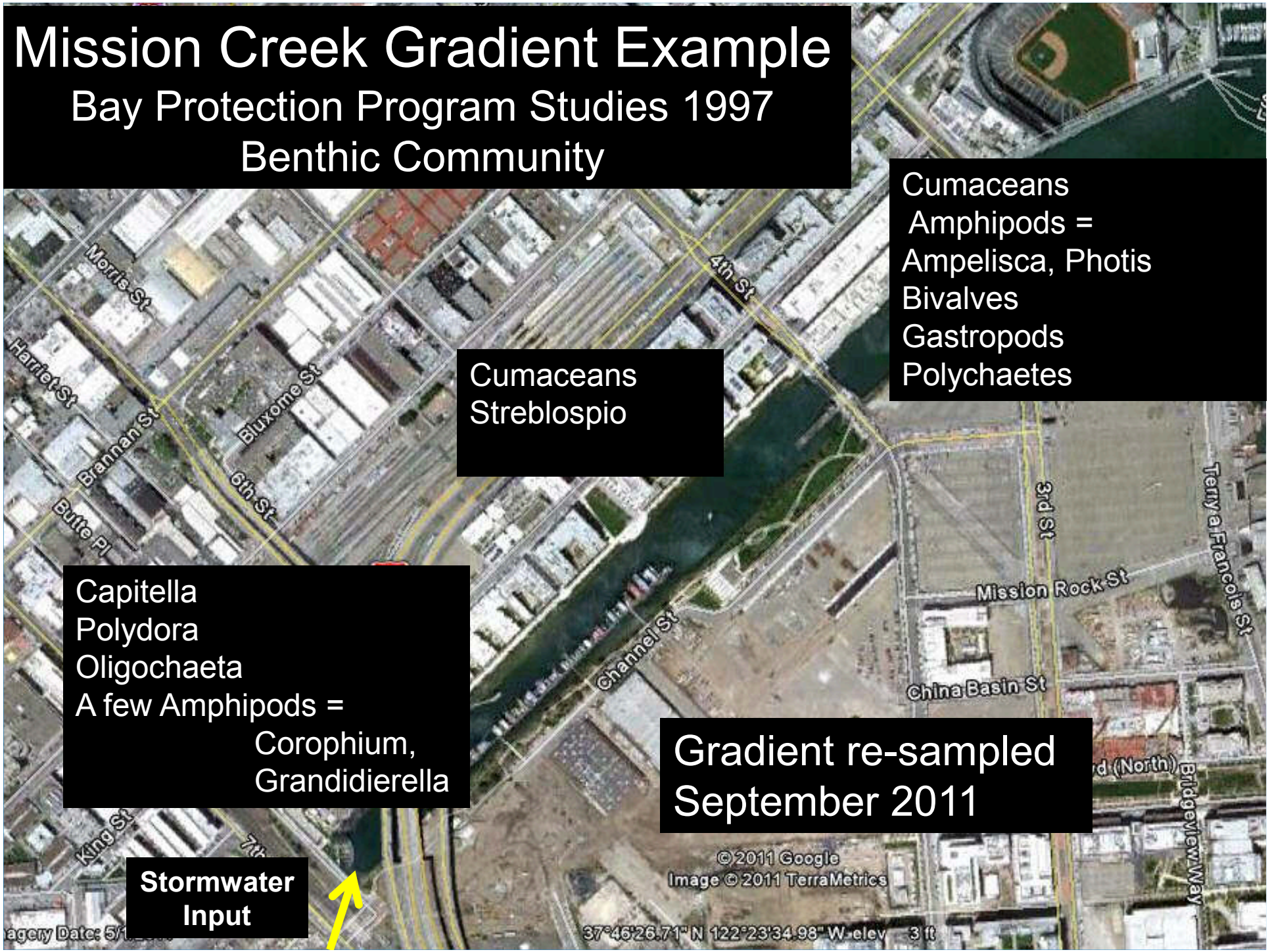
Mission Creek Gradient Example

Bay Protection Program Studies 1997

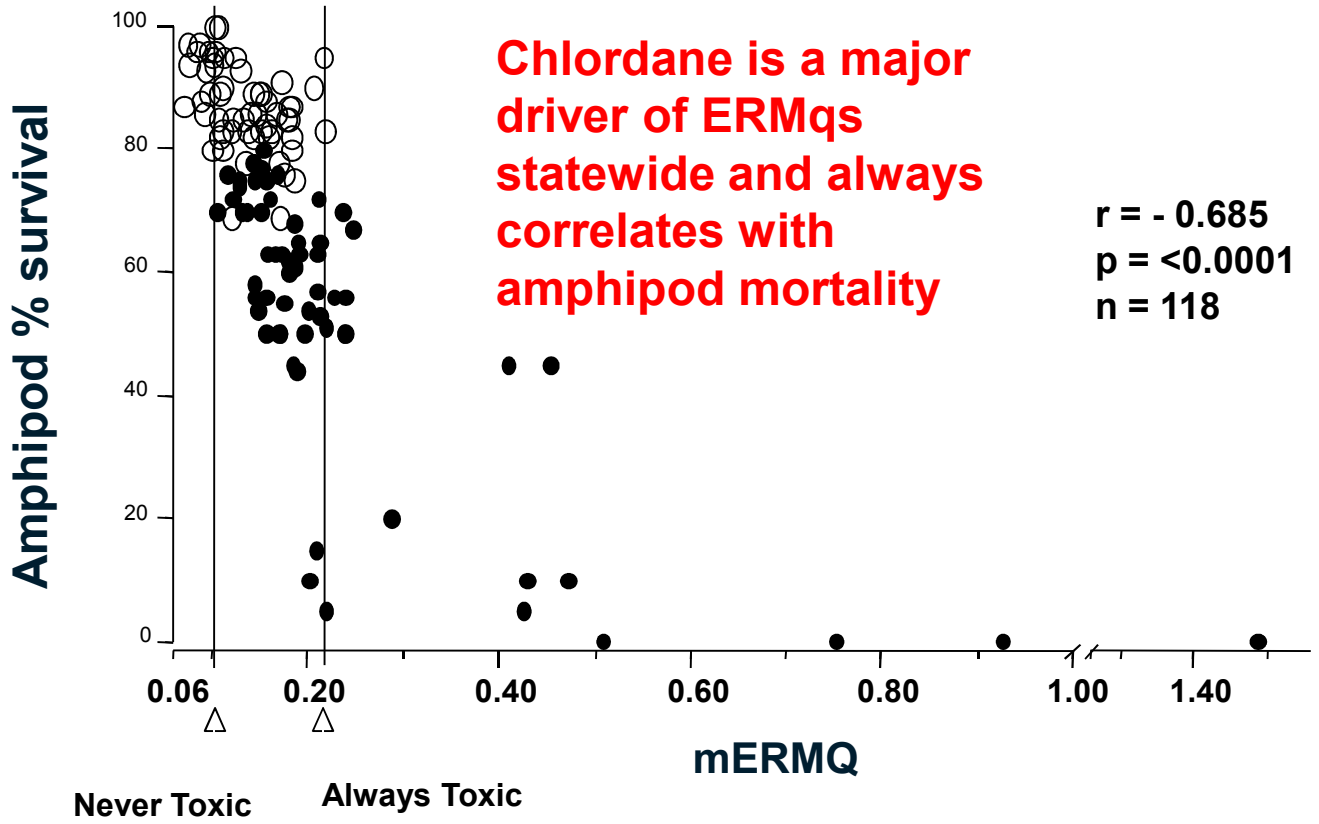


Mission Creek Gradient Example

Bay Protection Program Studies 1997
Benthic Community



Amphipod response vs. contaminant mixtures



Chlordane is a major driver of ERMqs statewide and always correlates with amphipod mortality

r = - 0.685
p = <0.0001
n = 118

● toxic ○ nontoxic

Thompson et el. 1999

Dose-Response Information for *E. estuarius*

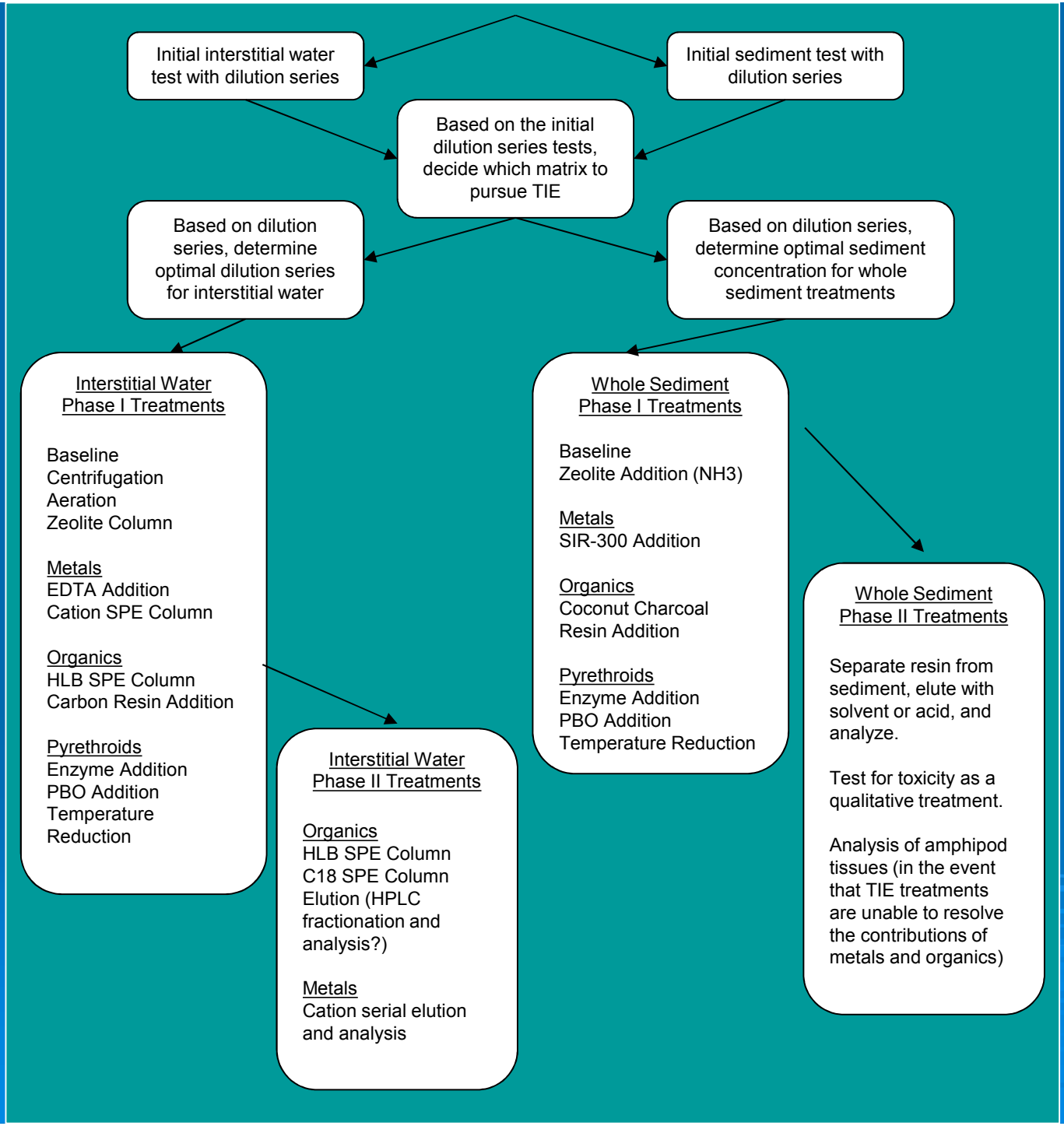
- **Cis chlordane LC50 > 13,400 ng/g** — **Greenstein et al., 2010**
- **Trans chlordane LC50 > 31,400 ng/g** — **Phillips et al., 2010**

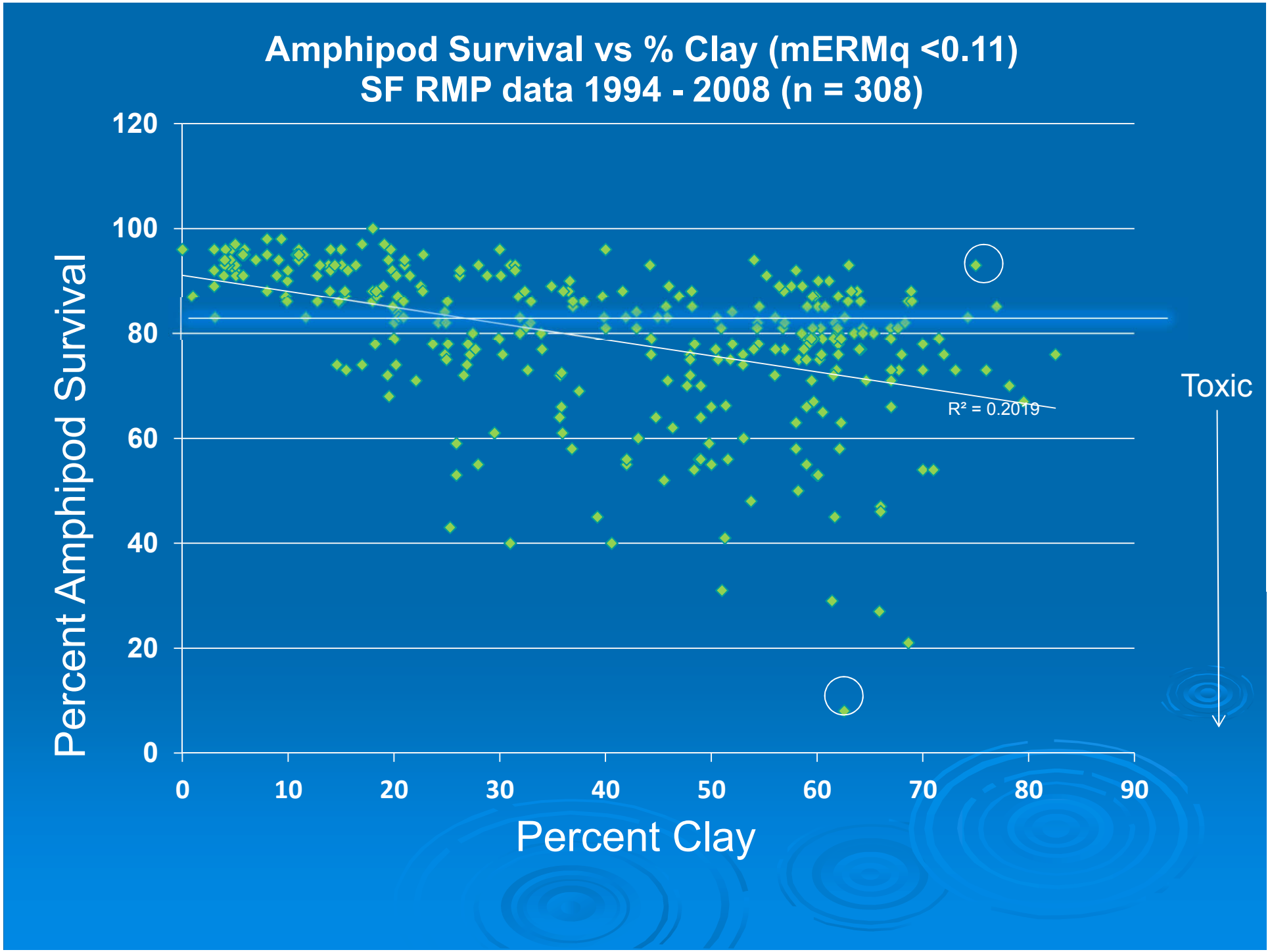
- 4 pyrethroids
- 5 organochlorine pesticides + Total DDT and Arochlor 1254
- 1 organophosphate pesticide
- 5 PAHs + Total PAHs
- 4 Metals (not likely responsible for *E. estuarius* mortality)

SFEI Sediment Stressor ID and TIE Workshop April 2010

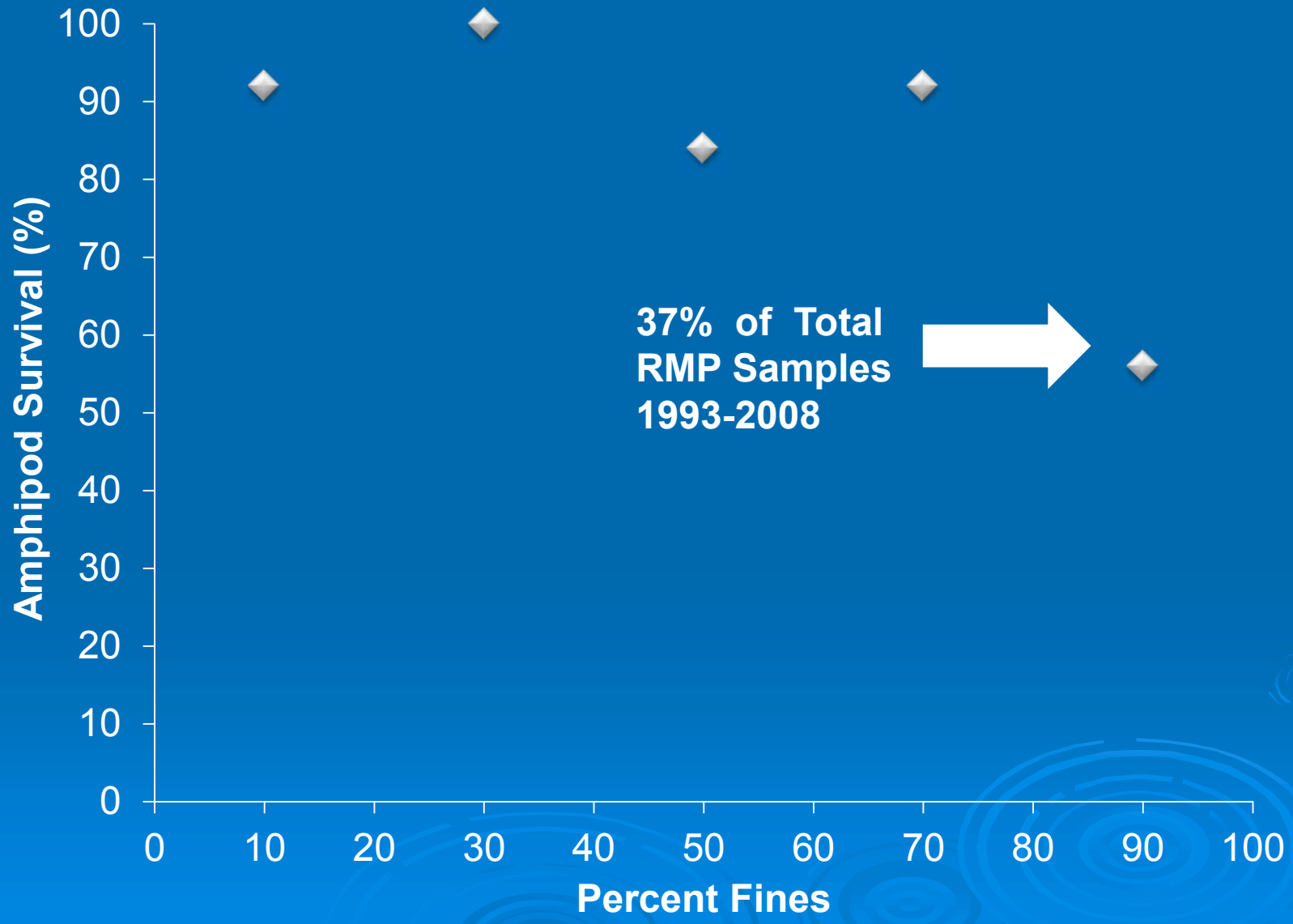
- Attended by regional, state, and national sediment TIE experts
- Consensus opinion is that we're on the right track building on EPA/WERF whole sediment and IW TIE methods
- Prioritized contaminant and non-contaminant stressors of concern
- Expanded on flow-chart of TIE procedures
- SFEI-led effort is the only "formal" program in the country

TIE Flow Chart of Procedures




Amphipod Survival vs % Clay (mERMq <0.11)
SF RMP data 1994 - 2008 (n = 308)
Percent Amphipod Survival
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Percent Clay
R² = 0.2019
Toxic

E. estuarius **mean 10d survival in mixture of 75 µm-sieved reference sediment (= silt+clay) + sand (MPSL unpublished data).**



Conclusions

- San Francisco Estuary is a challenging environment
- Evidence suggest sediment toxicity patterns are variable at specific sites
- Moderate toxicity persists at Status and Trends stations
- A combination of approaches is required to answer basic questions about sediment toxicity: dose-response data, traditional TIEs, genomic TIEs (use Mission Creek to evaluate methods)
- Non-contaminant factors require more work