

SedNet – Venice 6-9 April 2011

PCB-induced changes of a benthic community and expected ecosystem recovery following in situ sorbent amendment

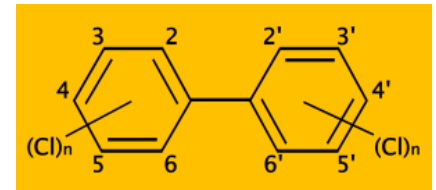
Elisabeth Marie-Louise Janssen

Janet K. Thompson, Samuel N. Luoma, Richard G. Luthy



Outline

- **Study site and concept**
- **Benthic community surveys**
- **Sediment chemistry**
- **Sediment remediation: in-situ amendment**
- **Biodynamic modeling**



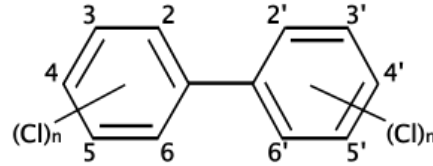
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Study site

Hunters Point California



Polychlorinated biphenyls (PCBs)



Ecological risk

Fish consumption advisories

San Francisco Bay

WARNING

Information about fish you, your family or friends catch in San Francisco Bay

Pregnant women Breastfeeding women Children under 6 years	Other Adults
1 MEAL A MONTH	2 MEALS A MONTH
Do not eat more than one meal of SF Bay fish a month	Do not eat more than 2 meals (1 pound) of SF Bay fish a month
Do not eat striped bass over 27 inches long	Do not eat striped bass over 35 inches long
NO shark	
For all San Francisco Bay fish except salmon, herring, smelt, and anchovies.	

EAT SAN FRANCISCO BAY FISH SAFELY

Vertical text on the right side: 警告事項 LAPATAIGA BABALA 816199U

Vertical text on the left side: AVISO FAKATOKANGA LUJU YI

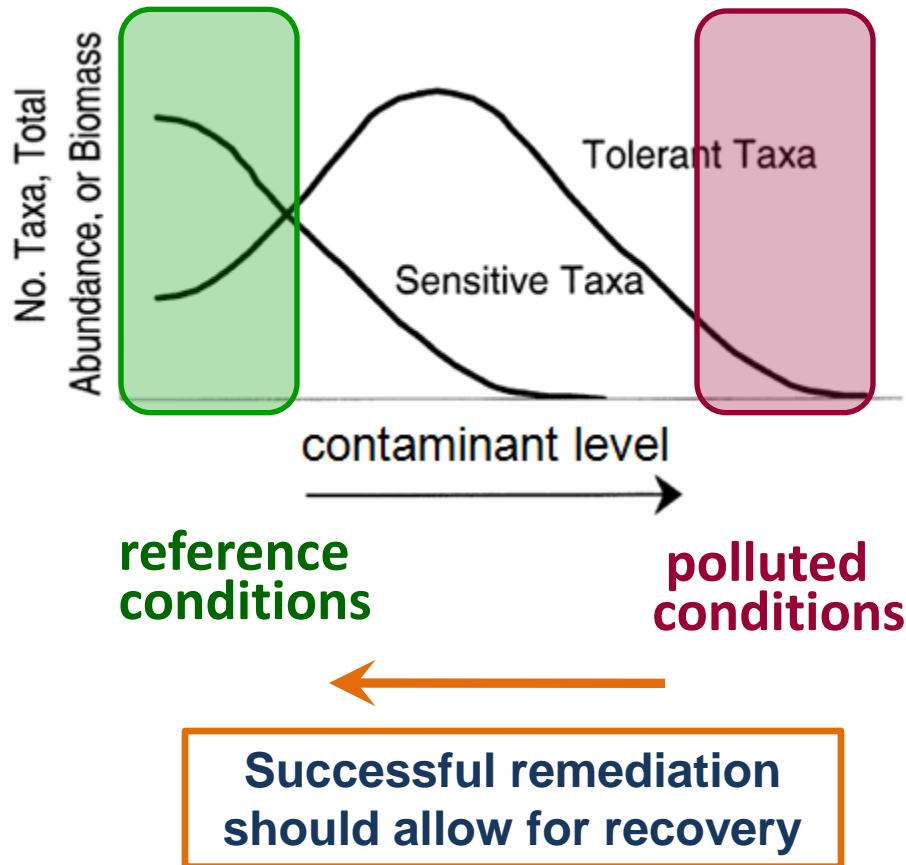
EPA 823-R-97-006,1998

Fisher et al. Aquat Toxicol (45) 1999; Murdoch et al. ES&T (16) 1997; Landrum et al. Aquat Toxicol and Haz Ass (12) 1989

Concept

Benthic response to sediment pollution & remediation

Pearson et al. *Mar Ecol Prog Ser* (12), 1978



Trait-based Ecol. Risk Assessment

Horne et al.

Arch Environ Contam Toxicol (37), 1999

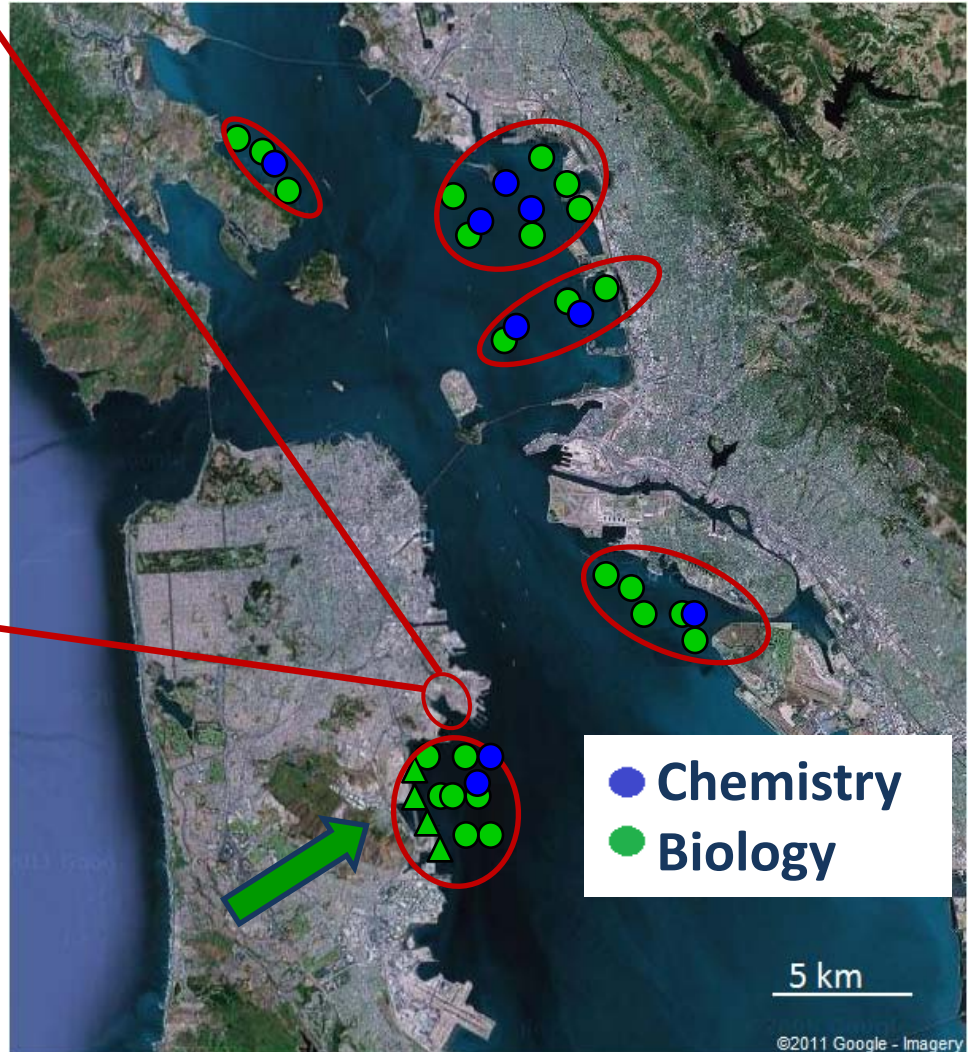
Relative abundances [%]

	Reference	Polluted *
Subsurface	56.30 %	16.75 %
Surface	42.90 %	83.13 %
Carnivores	0.80 %	0.12 %

* PCBs (56ppm), Hg (15 ppm)

Study site

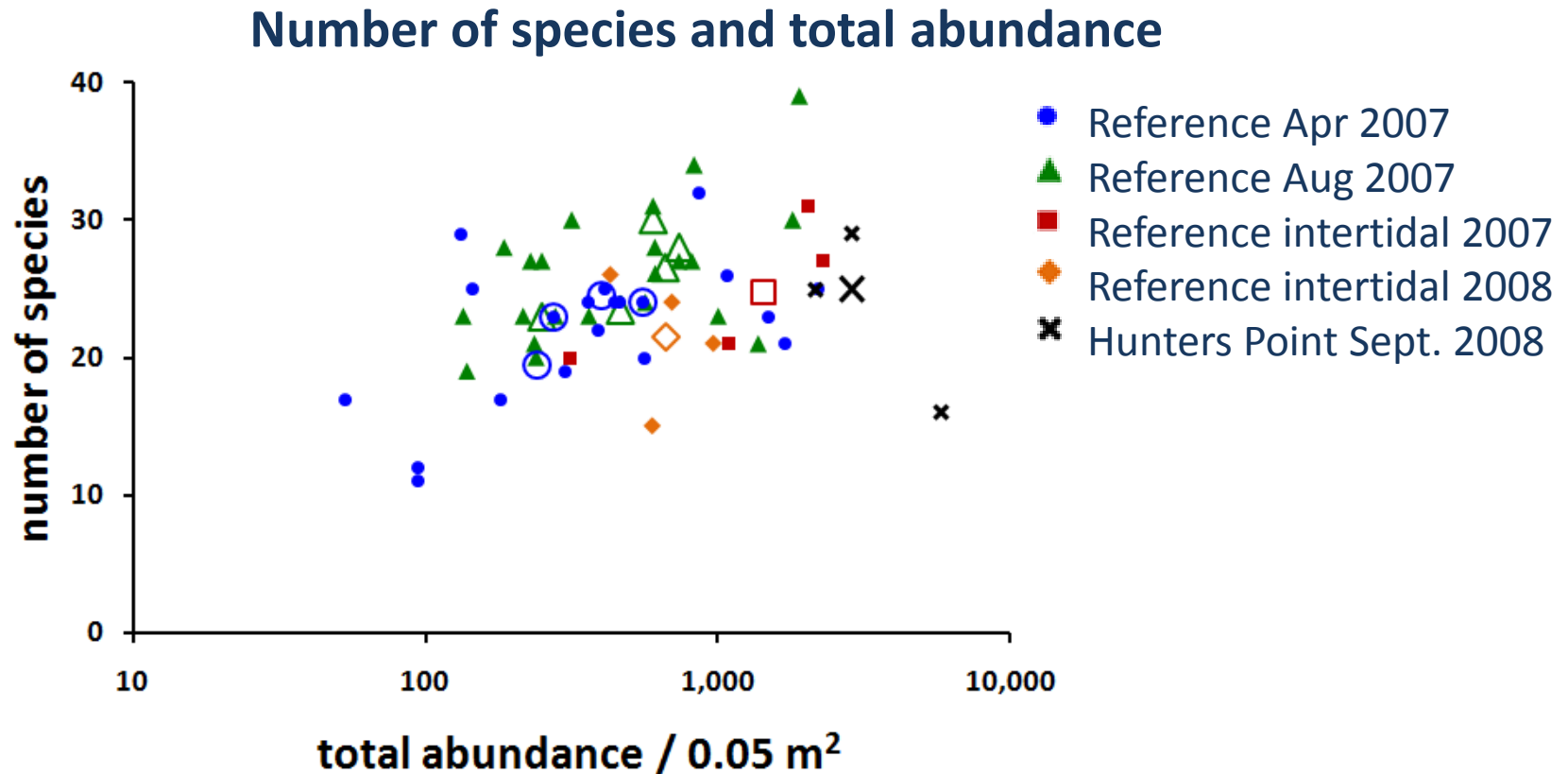
Hunters Point and reference sites in Central S.F. Bay



USGS, Dr. Janet Thompson



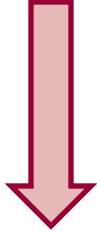
Benthic community surveys



- **Shannon-Wiener Diversity Index:** HP (1.87)
Reference (2.09 to 2.89), intertidal (1.84 to 2.0),
- **Dominant species:** more species with abundance >1% at ref. sites
- **Multi-Dimensional Scaling:** Hunters Point clusters separately
(stress >0.10)

Benthic community survey

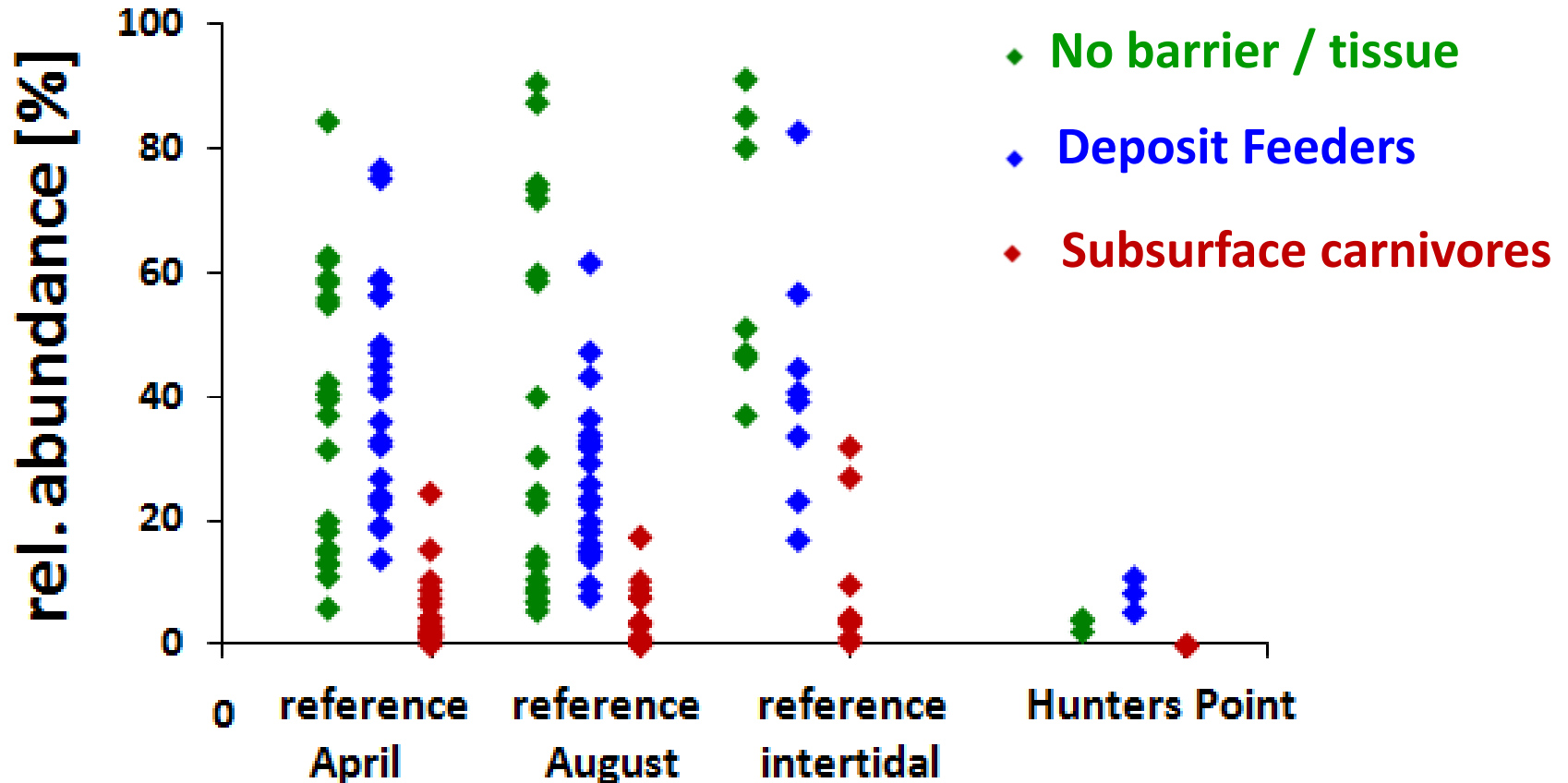
Analysis by functional traits

Feeding	Reproduction	Position	exposure
Surface/subsurface carnivores	Egg layers	No barrier Tubed w/ tissue	 more less
Surface/subsurface deposit feeders	Brooders	Tubed w/ chitin	
Surface & filter feeders	Pelagic larvae	Chitin barrier	
		Shell barrier	
Filter feeders		Cuticle	

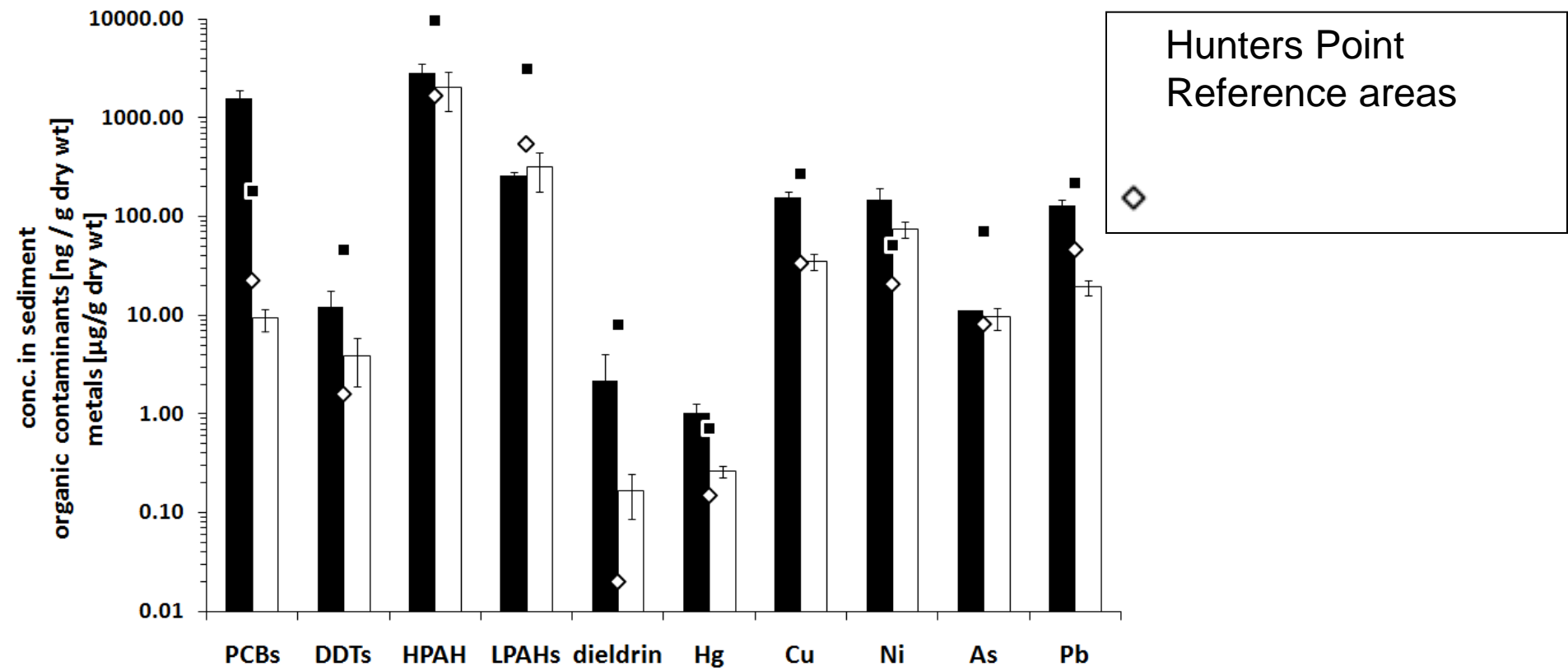
- ANOVA tests with square root transformed relative abundances

Benthic community survey

Significant differences of benthic community

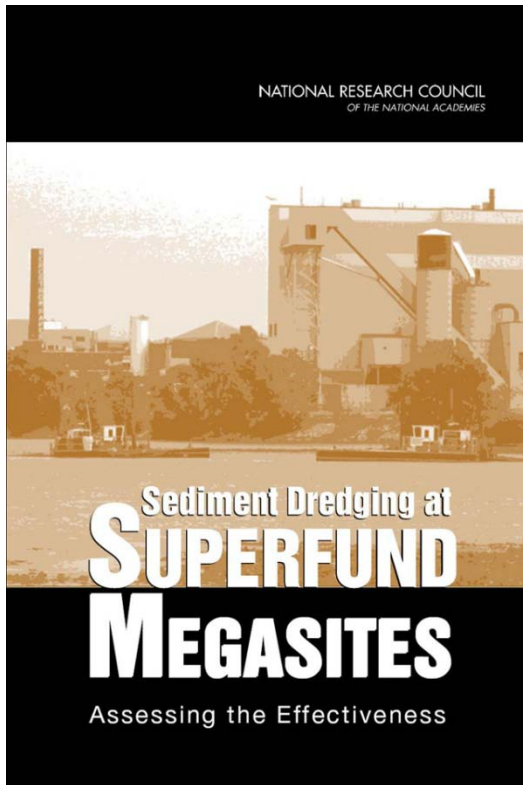


Hunters Point is depauperate in benthic organisms experiencing high exposure to contaminated sediment.



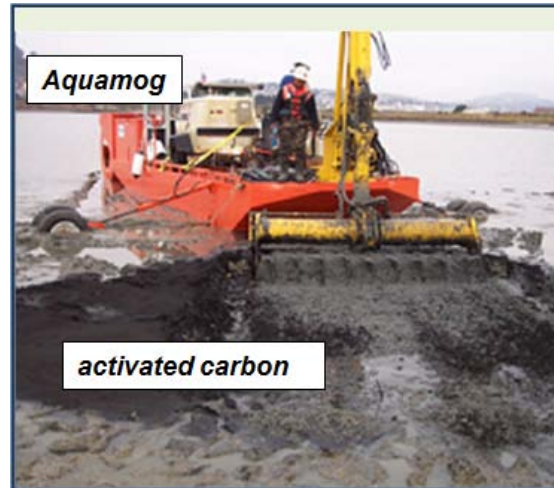
Sediment remediation

Sediment dredging - limited success



National Academies Press, 2007

In Situ sorbent amendment



Roto-vator: Aquatic Environ., Inc.



Injector: Compass Environ., Inc.

Mixing 3.4% activated carbon into upper 30 cm

Cho et al. *Mar Environ Res* (64), 2007 and *ES&T* (43), 2009

Sediment remediation

Concept: In Situ sorbent amendment

Observation:

PCBs accumulate in coal/charcoal/coke more strongly bound & less bioavailable

Hypotheses:

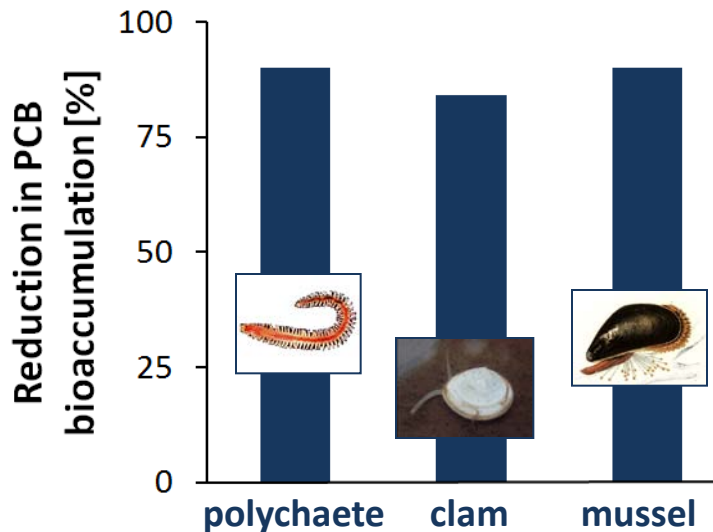
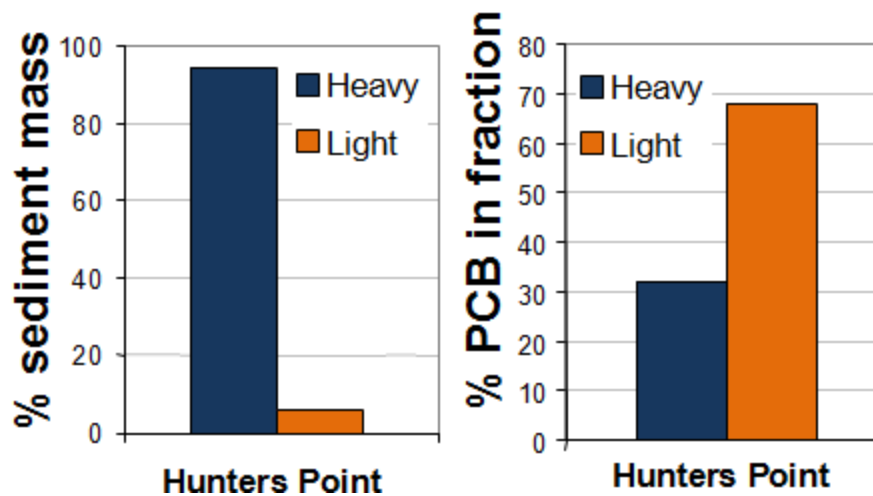
Bioavailability can be changed by adding sorbent carbonaceous particle

PCB bioaccumulation can be reduced by up to 80 to 90%.

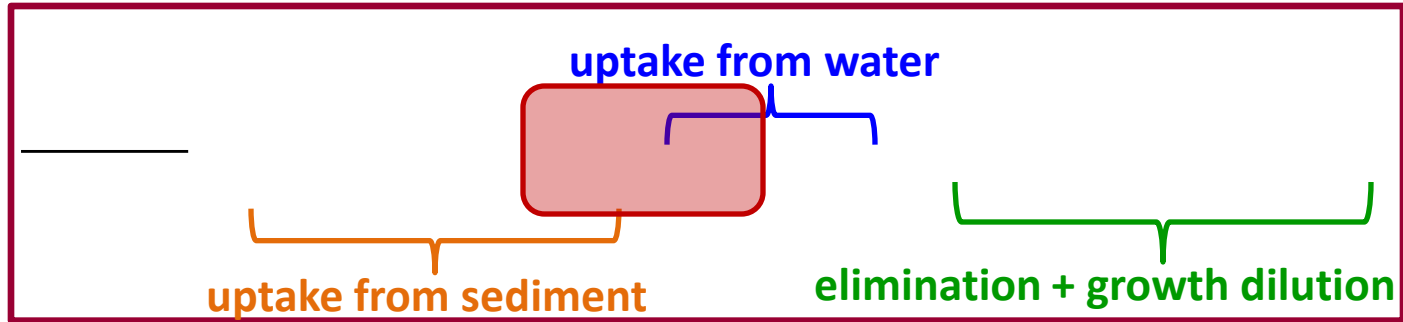
Promising but yet novel technique

Ghosh et al., *ES&T* (37) 2011

Ghosh, Zimmerman & Luthy, *ES&T* (37) 2003; McLeod et al., *ES&T* (42) 2008; Janssen et al., *ES&T* (44) 2010



Biodynamic Modeling



IR = Ingestion rate
 C_{sed} = Concentration in sediment
 AE = Assimilation efficiency

C_w = Concentration in water
 k_w = Aqueous uptake rate constant

k_e = Elimination rate constant
 k_g = Growth rate constant

Björk and Gilek, *Aquat Toxicol* (38) 1997, McLeod et al., *ES&T* (42) 2008, Tomaszewski et al. *Water. Res* (42) 2008, Janssen et al., *ES&T* (44) 2010

Surface & Filter



Deposit



Filter

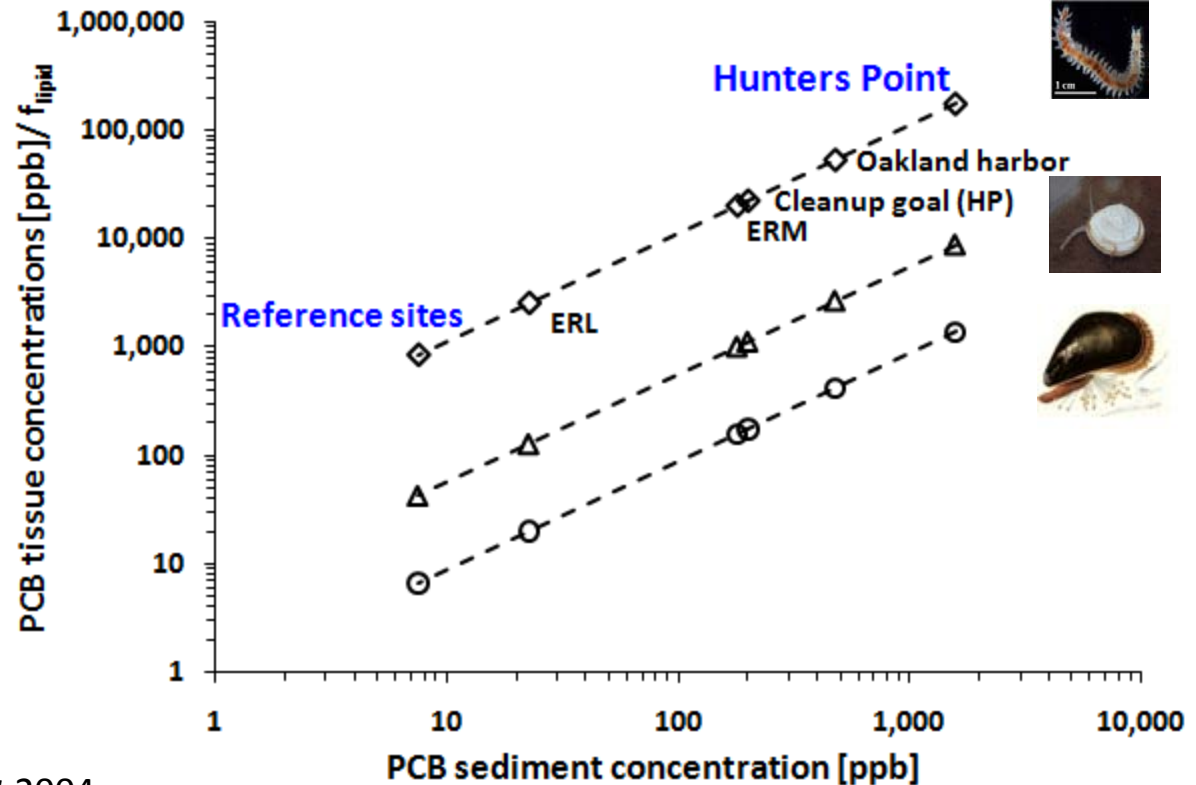


Biodynamic Modeling

PCB tissue concentrations relative to sediment concentration

Levels of PCB pollution

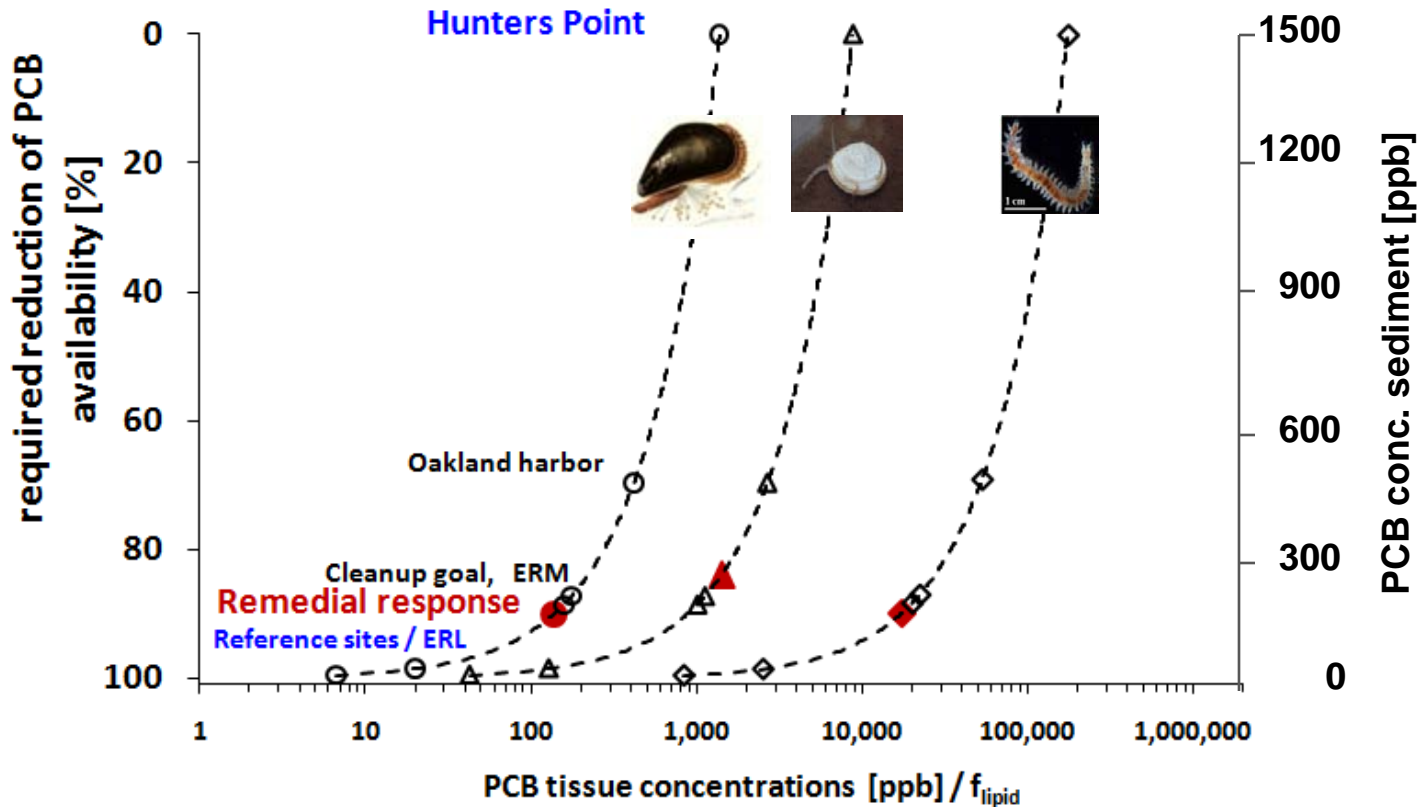
	S
Hunters Point	1570
Oakland Harbor (hot spot)	476
Clean-up goal	200
ERM	180
ERL	23
Reference sites	9



Battelle, Validation Study Hunters Point 2004;
 McFarland et al. Report in Oakland Harbor
 Deepening Project, 1994; Brajas Feasibility Study
 Hunters Point, 2008; Long et al. Environ Manag
 (19), 1995; San Francisco Estuary Institute online
 database

Biodynamic Modeling

Remedial success of in situ AC-amendment
- reduced PCB bioavailability (AE) -



Reduction in PCB availability will comply with cleanup goal.

Thank you



Conclusions

Functional ecology

- identifies changes in benthic community and affected species
- highly exposed species are significantly less abundant

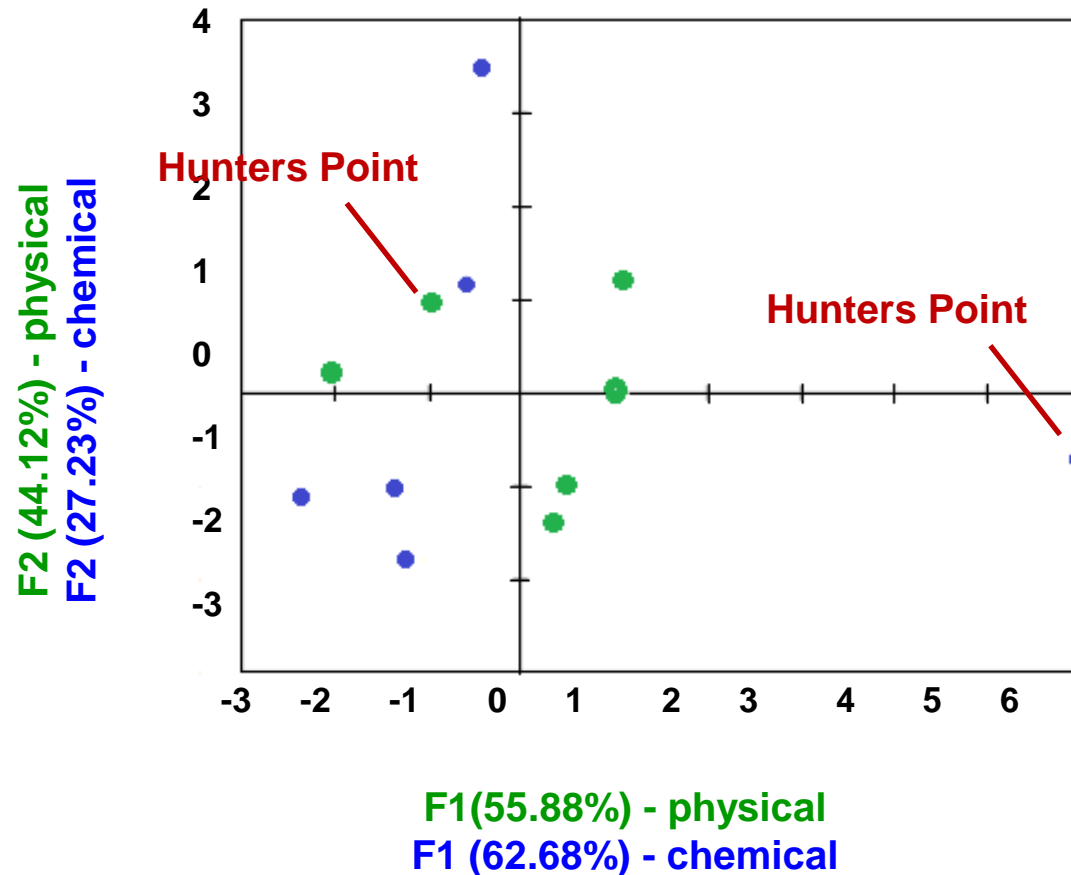
Biodynamic model

- links dietary routes and exposure
- predicts exposure scenarios
- translates changes in bioavailability to terms (sediment concentrations) that can be compared to cleanup goals

Sediment Chemistry

Principal Component analysis

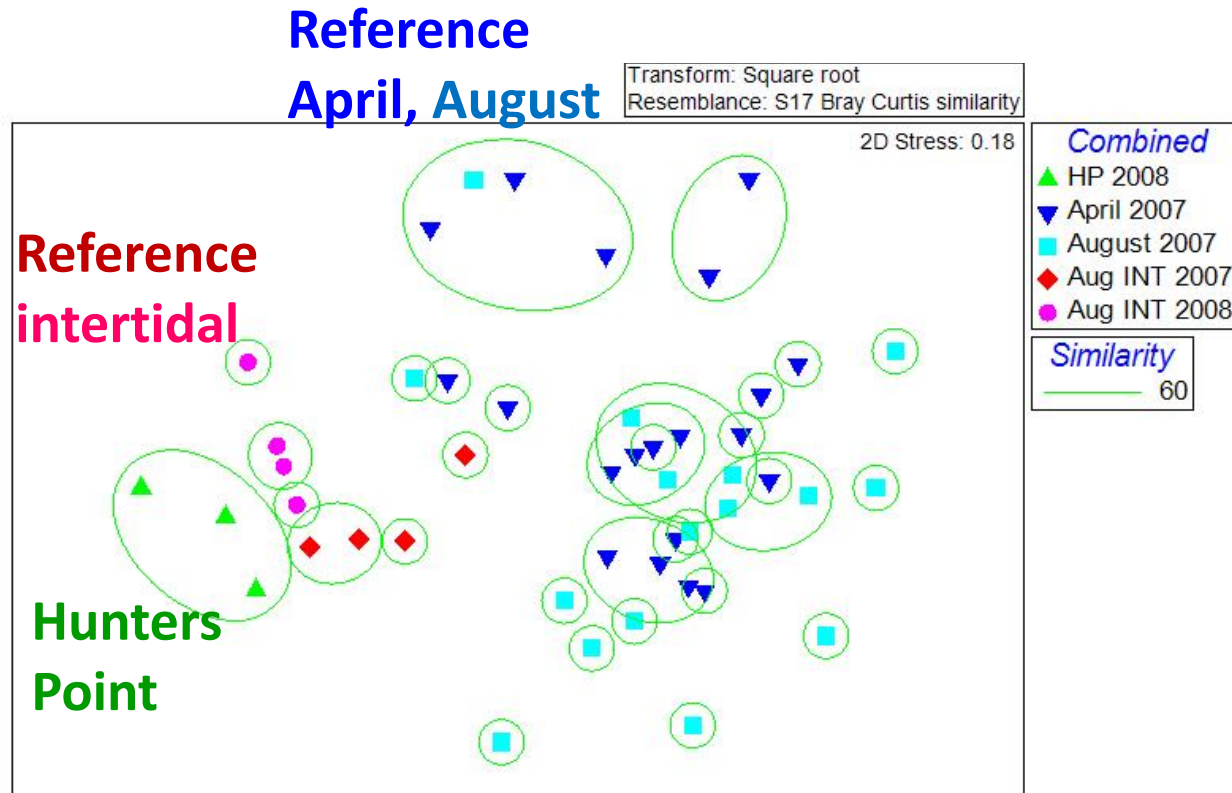
comparing **physical habitat (green)** and **chemical pollutants (blue)**



Sediment chemistry differentiates Hunters Point from the reference sites
Physical parameters are **similar** at Hunters Point and the reference sites

Benthic community surveys

Parametric Multi-Dimensional Scaling
using Bray Curtis Dissimilarities



Hunters Point clusters separately from the reference sites.