Identification of Toxicants in Ballona Creek Sediments

Steve Bay

SCCWRP

Established 1969

SQO Implementation

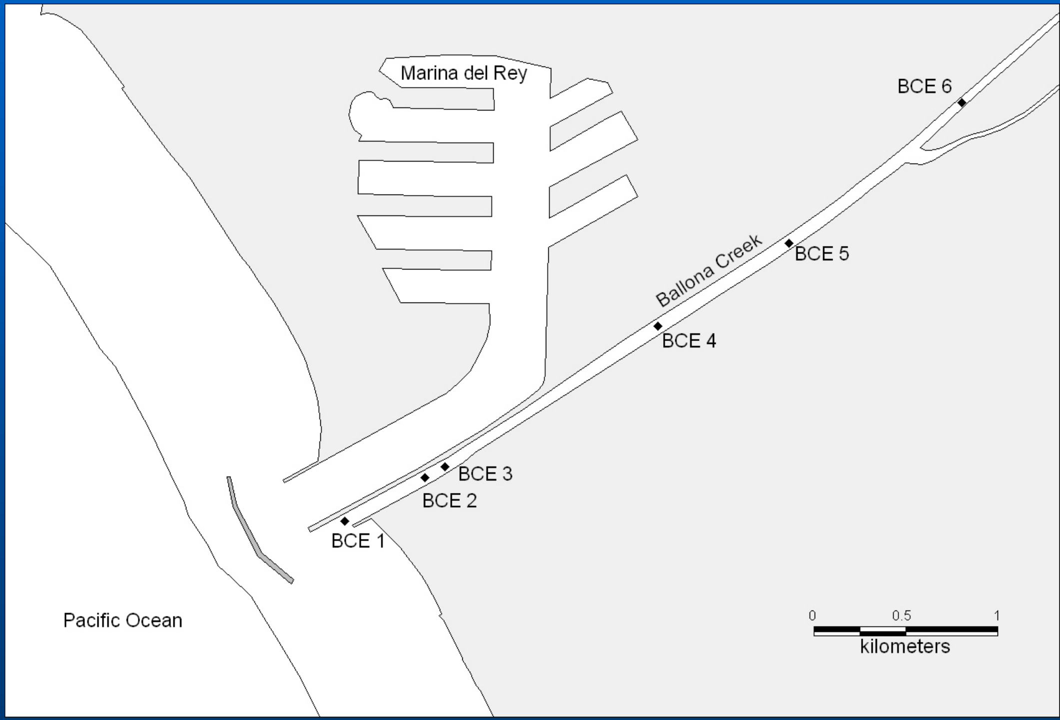
- Sediment quality assessment is not the only information needed to manage sediments
  - Doesn’t determine the cause of poor sediment quality
- Cause of the impacts (stressor) must be determined to guide management
  - Identify sources
  - Establish contaminant concentration and loads to protect sediment quality
- Stressor identification can assist in process
  - Ballona Creek Estuary example

Ballona Creek Estuary

- **Ballona Creek Estuary listed as impaired for multiple sediment contaminants**
  - **Metals: cadmium, copper, silver, lead, zinc**
  - **Organics: DDTs, PCBs, chlordane, PAHs**

Ballona Creek Estuary Special Study

- **Sediment contaminant limits may not be accurate**
  - **Based on Sediment Quality Guidelines**
  - **Current use pesticides not evaluated**
- **Special study designed to address data gaps**
  - **Collaboration with City of LA Watershed Protection Div. and EMD**
  - **SCCWRP Toxicology and Chemistry Departments**



Study Design

- **Update and expand sediment quality assessment**
  - **Spatial and temporal patterns in chemistry & toxicity**
  - **Investigate current use pesticides**
- **Identify cause of sediment toxicity**
  - **Laboratory Toxicity Identification Evaluation (TIE)**
- **Confirm Toxicity Identification**
  - **Chemistry:toxicity relationships**
- **Evaluation of TMDL targets (concentrations)**
  - **Toxicity thresholds for sediment contaminants**

2007 Chemistry and Toxicity

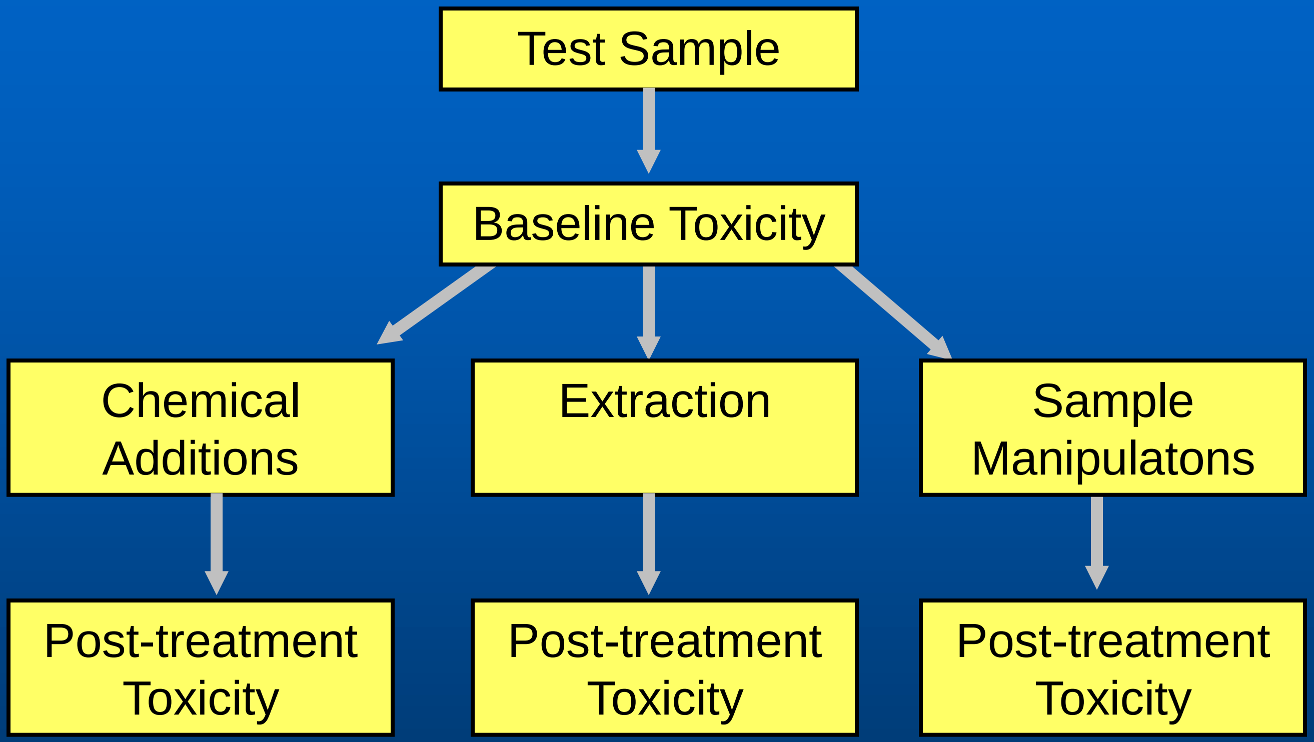
Parameter	Target	BCE1	BCE2	BCE3	BCE4	BCE5	BCE6
Amphipod %Surv.		89	3	0	16	18	8
Cadmium (mg/kg)	1.2	0.5	1.6	1.8	0.5	0.4	0.3
Copper (mg/kg)	34	18	55	117	14	16	13
Lead (mg/kg)	46.7	30.3	52.1	66.7	11.3	15.2	4.9
Silver (mg/kg)	1.0	0.6	1.4	1.6	0.2	0.3	nd
Zinc (mg/kg)	150	89	228	430	103	107	58
DDTs (ug/kg)	1.6	5.3	5.8	5.3	1.1	1.2	nd
Chlordane (ug/kg)	0.5	5.1	5.1	6	nd	nd	nd
PCBs (ug/kg)	22.7	nd	43	39	nd	82	nd
PAHs (ug/kg)	4022	nd	nd	nd	nd	nd	nd

Sediment toxicity widespread and of high magnitude

TMDL target exceedances show little relationship to toxicity

TIE Site

Toxicant Identification Evaluation (TIE)
Conceptual Approach



Contaminant-specific treatments applied to sample

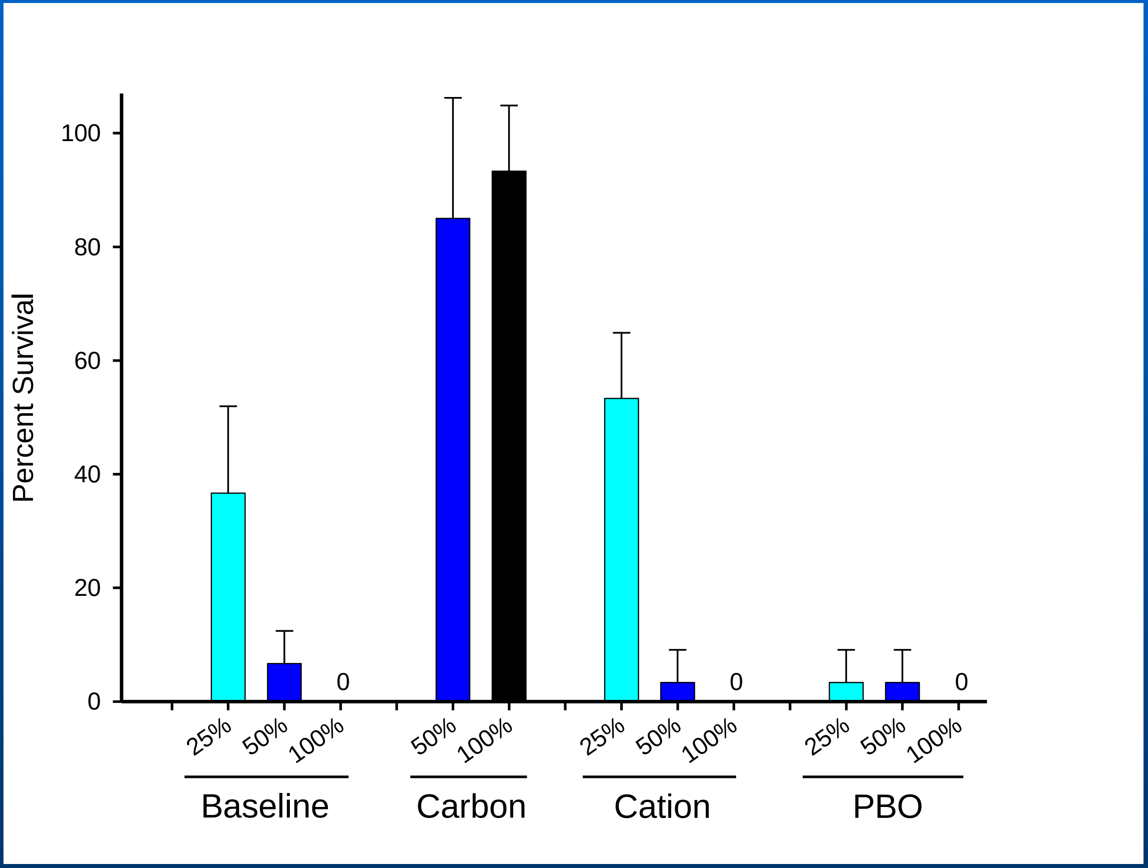
Changes in toxicity following sample treatments indicates type of toxicant

TIE Treatments

Treatment	Matrix	Purpose
EDTA	Water	Chelation of cationic metals (e.g. Zn, Cu)
Sodium thiosulfate (STS)	Water	Reducing agent for oxidizers (e.g. chlorine); reduces toxicity of some metals
C-18 column extraction	Water	Removal of non-polar organics
Cation exchange column extraction	Water	Removal of cationic metals
Coconut carbon	Sediment	Binding of organic contaminants
Cation exchange resin	Sediment	Binding of cationic metals
Piperonyl butoxide (PBO)	Water/ Sediment	Inhibits pesticide metabolism. Renders organophosphorus pesticides non-toxic; increases toxicity of pyrethroid pesticides

2007 Station 2: Sediment TIE

Amphipod Survival



Reduction of toxicity with carbon suggests organics

Increase of toxicity with PBO suggests pyrethroids

TIE Summary: 2007/08

Amphipod Survival: Sediment

	BCE2		BCE4	BCE5
Treatment	2007	2008	2007	2008
Piperonyl Butoxide Addition	Reduced Survival	Reduced Survival	Reduced Survival	Reduced Survival
Cation Exchange Resin	Slight Increase	No Effect	Slight Increase	No Data
Coconut Carbon	Increased Survival	No Effect	No Data	No Data

TIE response pattern consistent with pyrethroids for all samples

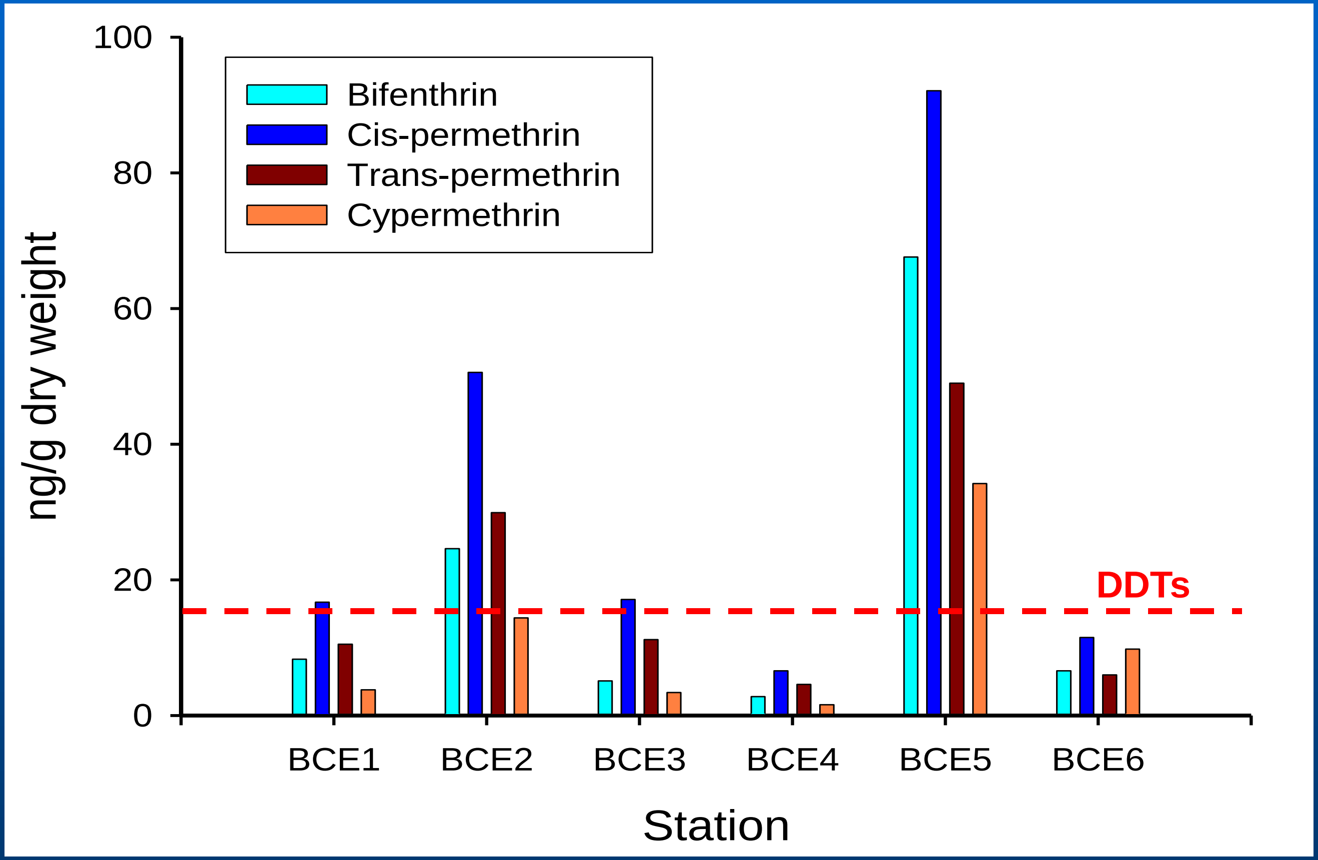
Role of metals and other organics is uncertain

Results are often not definitive

Chemistry Confirmation

- **Do sediment chemistry results support toxicant identification?**
  - **Sediment concentrations of pyrethroids and other contaminants**
  - **Estimate toxic units**
- **Are the contaminants bioavailable?**
  - **Pore water analysis using passive samplers**
  - **Compare to water effect thresholds**

Pyrethroid Pesticides June 2008



Multiple pyrethroids detected at every station

Relatively high concentrations

Fipronil also detected

Toxic Units

- **Toxic units (TUs) estimate potential for toxicity from specific chemicals**
  - **Strong toxicity expected when TU ≥ 1**

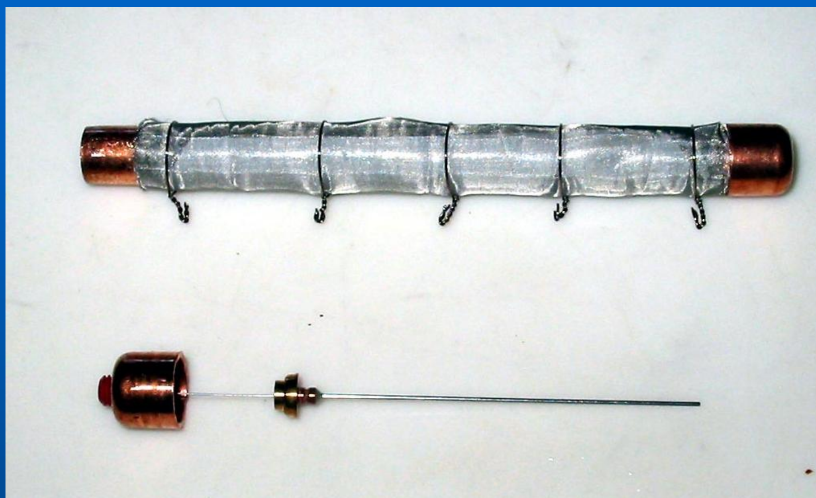
$$\text{TU} = \frac{\text{Sediment concentration } (\mu\text{g/g oc})}{\textit{E. estuarius} \text{ LC}_{50} \ (\mu\text{g/g oc})}$$

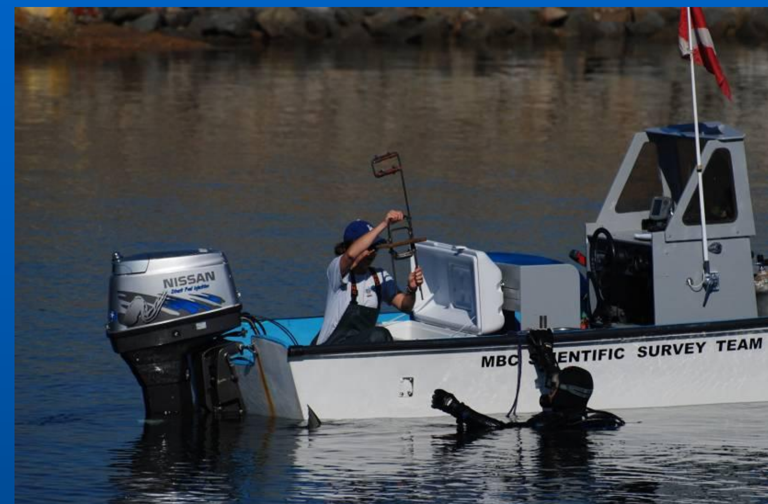
Pyrethroid	*E. estuarius* LC$_{50}$ (µg/g OC)
Bifenthrin	1.03
Cypermethrin	1.41
Permethrin	17.9

	BCE1	BCE 2	BCE 3	BCE 4	BCE 5	BCE 6
June 2008						
Bifenthrin	1.8	2.0	0.9	0.9	3.8	1.9
Cypermethrin	0.6	0.9	0.4	0.4	1.4	2.1
Permethrin	0.4	0.4	0.3	0.2	0.4	0.3

Pyrethroid concentrations sufficient to cause toxicity at every station

Quantifying Bioavailable Contaminants





Expose SPME fibers to contaminated sediment in field

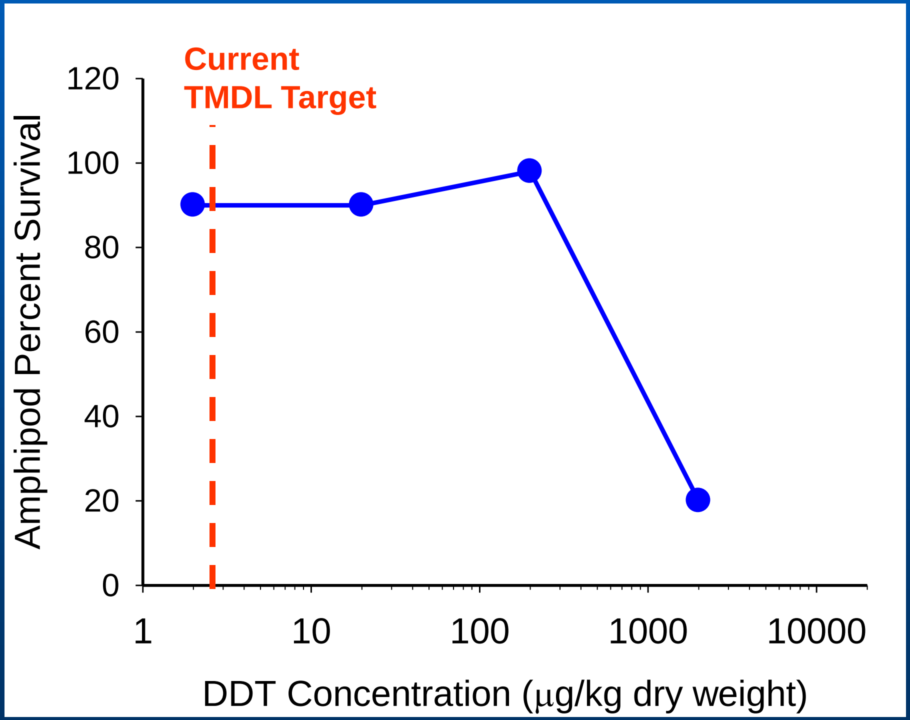
Measure fibers directly by ECD or MS (ECNI-MS)

Compute “bioavailable” porewater concentration (C_w)

- **Compare to water effect thresholds**

TMDL Target Evaluation

- **What concentrations of sediment contaminants are toxic to amphipods?**
  - **Spiked sediment studies using Santa Monica Bay sediment**
  - **Provides confirmation of TIE results by TU calculation**
  - **Can be used to refine TMDL targets**



Summary

- **Stressor identification is a critical component of sediment quality assessment**
  - **Provides essential information for management decisions**
- **Multiple approaches are needed**
  - **TIEs**
  - **Advanced chemical analysis**
  - **Dose-response relationships**
- **Opportunity to improve effectiveness of TMDLs and other management programs**

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