Characterizing Sediment Contamination and Potential Ecological Effects in Six Tributaries of the San Francisco Bay Estuary

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Overview

Statement of Relevance

This study, conducted in the winter of 2004-2005, was one of the first Bay Area urban creek studies to characterize bedded sediment contaminant concentrations (including pyrethroids) in the lower reaches of six tributaries around the San Francisco Estuary and to evaluate the potential for sediment toxicity.

Background

The change in pesticide regulations in the State resulted in the decline in sales of water-soluble organophosphate pesticides such as diazinon and chlorpyrifos during the period of 1999-2003. During this time the sales of the more hydrophobic pyrethroid pesticide have increased. As a result several water toxicity studies in tributaries around the San Francisco Estuary have observed a decline in the frequency of toxic hits (SFEI 2003, CEP-2005).

The RMP's-Status and Trends Monitoring Program has demonstrated a seasonal difference in the frequency of sediment toxicity seen in the Estuary. Between 1993 and 1999 52% of the sediment toxicity samples collected during the winter sampling period (February) were toxic to amphipods while only 15% of the samples collected during the summer sampling period (August) were toxic.

With the increased usage of more hydrophobic pesticides, and to address possible sources of the pronounced sediment toxicity observed during the winter in the Estuary, the following questions arise:

- Are regulated and emerging contaminants of concern detected in sediments of tributaries around the San Francisco Estuary?
- Are sediments in those tributaries contributing to the in-bay toxicity?

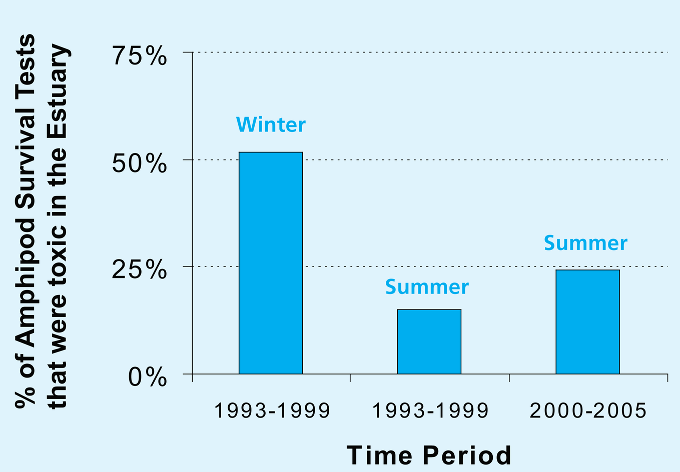


Figure 1. Seasonal differences in the percentage of toxic hits to amphipods in RMP Status and Trends sediment toxicity tests conducted in the San Francisco Estuary (1993 and 2005). Since 2000 the RMP only sampled the Estuary during the summer.

Goal

The purpose of this study was to characterize sediment contamination, and the potential for sediment toxicity to freshwater and estuarine amphipods in tributaries in different regions of the San Francisco Estuary.

Study Design

Two stations were selected in six tributaries that represent varying degrees of urban and agricultural land-use practices around the Estuary. In general, tributaries in the north drain mixed urban, rural, and agricultural land-use types. Tributaries in the south drain primarily highly urbanized regions with varying degrees of heavy industry.

The stations were located in the lower reaches of each tributary with an "upper" station in the freshwater region and the "lower" station within tidal reach. An effort was made to find stations that may have been sampled in other studies and that had enough fine-grained sediments to sample.

Tributaries included:

Northern Estuary: Suisun Creek, Napa River, Petaluma River,

Southern Estuary: San Mateo Creek, Coyote Creek, San Lorenzo Creek

Stations Field sampling occurred twice during the winter of 2004-2005.

Samples were collected after the first rain of the winter in order to capture the potential effects of dry season pesticide usage (November - 2004). The second sampling occurred in late spring (April - 2005), after the winter rain and coinciding with resumption of pesticide applications in urban and agricultural settings. *Table 3*

Bedded surface sediments (~2cm) were collected targeting recently deposited sediments for toxicity and chemical analyses. A suite of California Toxics Rule priority pollutants, sediment grain-size, total organic carbon, and additional emerging pollutants of concern (including pyrethroids and polybrominated diphenyl ethers (PBDEs)) were characterized in the upstream stations for each tributary

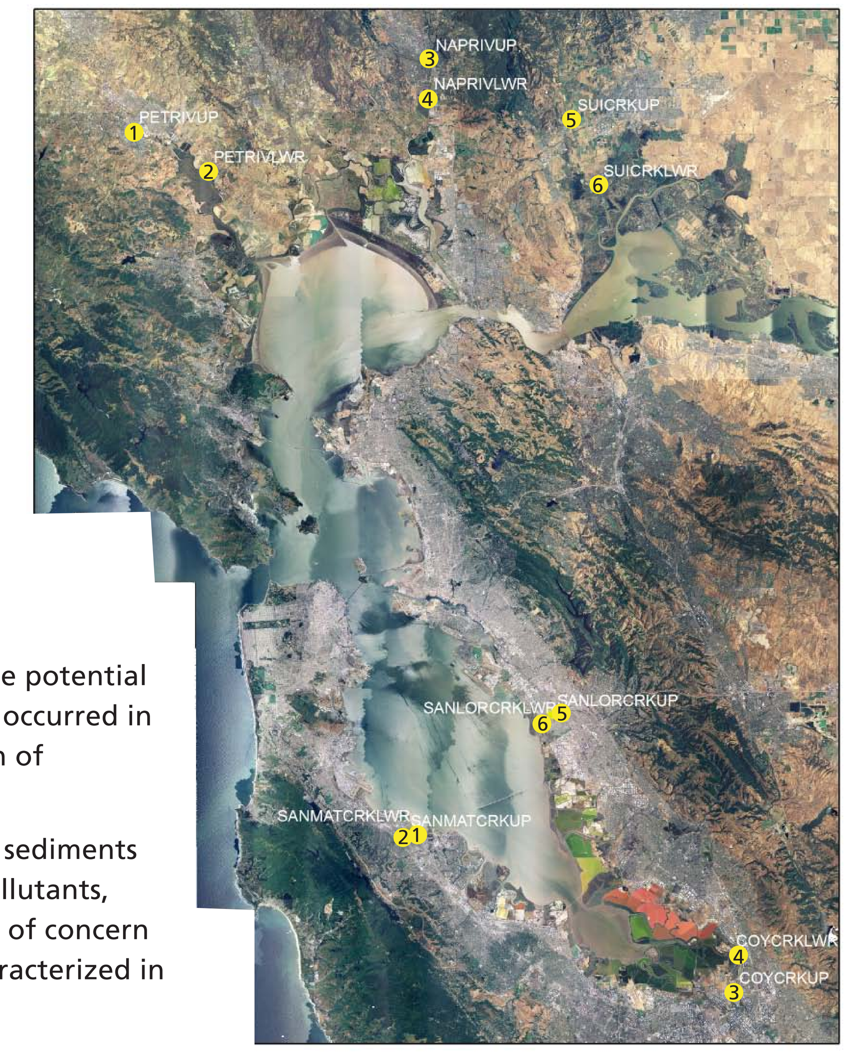
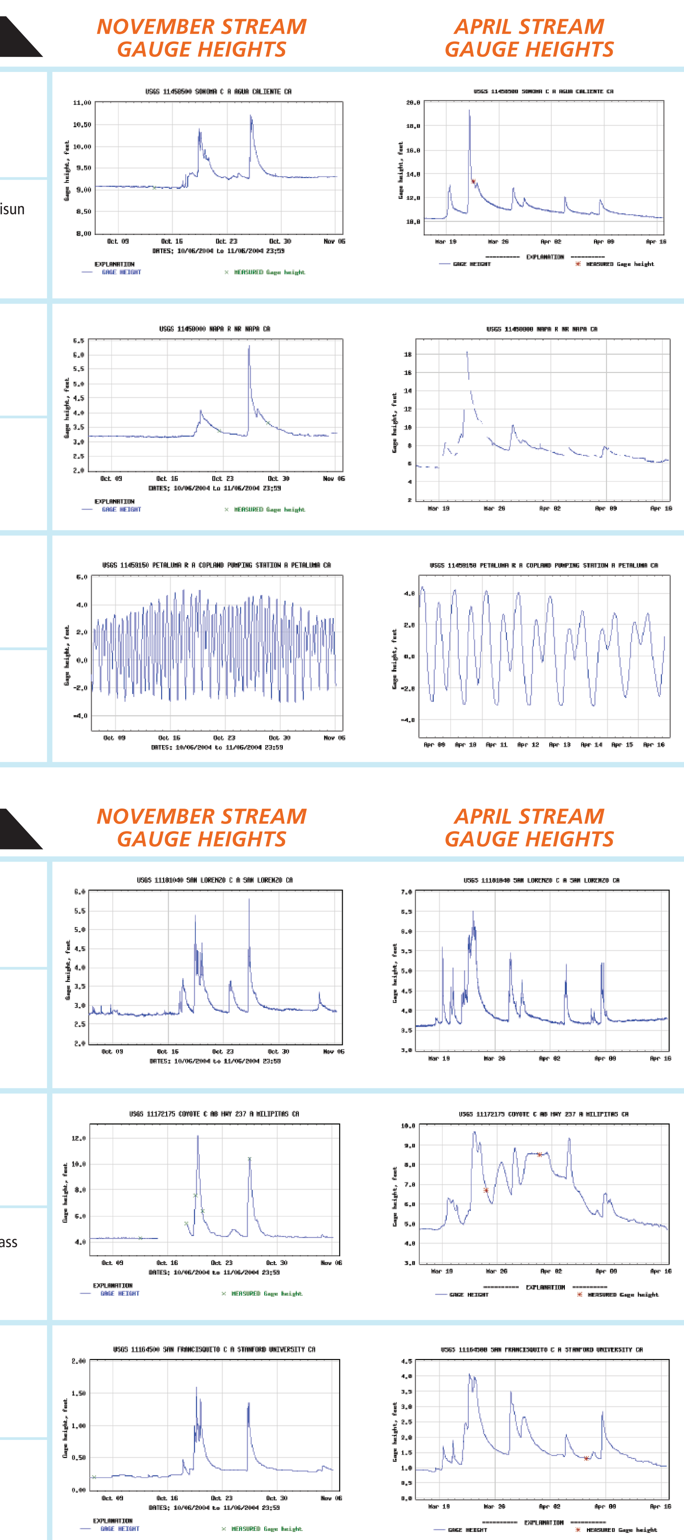


TABLE 3 Station information and stream gauge heights near the time of sampling (USGS website).

North Bay Tributaries
Suisun Creek Upper: (fresh water) (Rockville Rd and Willotta Dr. Suisun City, CA) Sampled the quieter, upstream portion of the Creek. Date Sampled: 11/3/2004 and 4/19/2005
Suisun Creek Lower: (tidal) (Chadbourne Rd. creek overpass just past Jacksnipe Rd. Suisun City, CA) Sampled the downstream side of the overpass. Date Sampled: 11/3/2004 and 4/19/2005 NAD84 Latitude: 37.5741; Longitude: 122.3065
Napa River Upper: (fresh water) (1st Street at Copia. Napa, CA) Sampled River below the Northwest corner of parking lot. Date Sampled: 11/2/2004 and 4/19/2005 NAD84 Latitude: 38.3021; Longitude: 122.2816
Napa River Lower: (tidal) (John F. Kennedy Park downstream of town. Napa, CA) Sampled off of wharf. Date Sampled: 11/2/2004 and 4/19/2005 NAD84 Latitude: 38.2655; Longitude: 122.2835
Petaluma River Upper: (fresh water/tidal) (East Washington St. and Weller. Petaluma, CA) Date Sampled: 11/2/2004 and 4/20/2005 NAD84 Latitude: 38.2357; Longitude: 122.6371
Petaluma River Lower: (tidal) (Gilardi's Lakeville Marina. Lakeville, CA) Date Sampled: 11/2/2004 and 4/20/2005 NAD84 Latitude: 38.1977; Longitude: 122.5476

South Bay Tributaries
San Lorenzo Creek Upper: (fresh water) (Via Bregani and Madeline. San Lorenzo, CA) Date Sampled: 11/3/2004 and 4/20/2005 NAD84 Latitude: 37.6820; Longitude: 122.1431
San Lorenzo Creek Lower: (tidal) (Via Murieta and Via Sorrento. San Lorenzo, CA) Date Sampled: 11/3/2004 and 4/20/2005 NAD84 Latitude: 37.6753; Longitude: 122.1542
Coyote Creek Upper: (fresh water) (Murphy Ranch Rd. and Technology Dr. Milpitas, CA) Date Sampled: 11/1/2004 and 4/18/2005 NAD84 Latitude: 37.4183; Longitude: 122.9303
Coyote Creek Lower: (tidal) (RMP station BW10, N. McCarthy Blvd./ just over the overpass heading south from Dixon Landing Rd. Milpitas, CA) Date Sampled: 11/1/2004 and 4/18/2005 NAD84 Latitude: 37.4534; Longitude: 121.9248
San Mateo Creek Upper: (fresh water) (in Gateway Park, 3rd Ave. San Mateo, CA) Date Sampled: 11/4/2004 and 4/18/2005 NAD84 Latitude: 37.5696; Longitude: 122.3178
San Mateo Creek Lower: (tidal) (3rd Ave. and J. Hart Clinton Drive. San Mateo, CA) Sampled under the creek overpass. Date Sampled: 11/4/2004 and 4/18/2005 NAD84 Latitude: 37.5741; Longitude: 122.3065



Sampling and Sample Handling

Sample collection, sample handling, and laboratory methods were the same as those employed by the RMP Status and Trends program and/or compliant with the Surface Water Ambient Monitoring Program (SWAMP) protocols. Methods for collection of field samples and sample handling are further outlined in the RMP's Field Operations Manual (SFEI 2001).

STUDY PARTICIPANTS AND TARGET PARAMETERS

Project Management, Logistics, Information Management	Ms. Sarah Lowe[1], Ms. Cristina Grosso, Mr. John Ross, Ms. Amy Franz, Mr. Predrag Stevonovich, and Mr. Donald Yee San Francisco Estuary Institute (SFEI), Oakland, CA
Logistics	Mr. Paul Salop, Mr. Bryan Bemis, and Ms. Basia Hajduczek Applied Marine Sciences (AMS), Livermore, CA
Sediment Trace Organic Chemistry PAHs, Alkylated PAHs, PCBs, Synthetic Biocides including: Chlordanes, HCHs, Cyclopentadienes, Pyrethroids	Dr. Dave Crane, Mr. Abdu Mekebri and Mr. Loc Nguyen California Dept. of Fish & Game, Water Pollution Control Laboratory (CDFG-WPCL), Rancho Cordova, CA
Sediment Trace Element Chemistry, & Ancillary Sediment Characteristics Ag, Al, As, Cd, Cu, Hg, meHg, Mn, Ni, Pb, Se, Zn; Grain-size, Total Organic Carbon, Total Nitrogen	Dr. Colin Davies and Ms. Elizabeth Madonick Brooks-Rand Ltd. (BRL), Seattle, WA Dr. Russ Flegal and Ms. Genine Scelfo UC Santa Cruz (UCSCDET), Santa Cruz, CA
Sediment Toxicity Testing 10-day amphipod tests	Mr. Brian Anderson,[1] and Mr Bryn Phillips Marine Pollution Studies Lab (UCD-MPSL), Granite Canyon, CA

PARAMETER LIST

For the full list, please see envelope to right

Sample Analyses

Sediment chemistry: The full RMP list of sediment contaminants, plus pyrethroids was performed in the upstream samples to characterize contaminant inputs into the Estuary. Similarly sediment samples from the inter-tidal downstream stations were collected, but these chemistry samples were archived.

If the downstream sediments were toxic, then the same list of contaminants were measured in the archived sediments.

Sediment Toxicity, Grain size and TOC analyses were performed in all samples.

Sediment toxicity tests included the 10-d growth and survival protocol for *Hyalella azteca* for sediments collected in upstream reaches, and the 10-d survival protocol for *Eohaustorius estuarius* for sediment collected in the downstream reaches.

Chemistry and Toxicity Results

Of the six tributaries sampled the San Mateo Creek Upper station was toxic in both November and April and had the highest concentrations of PAHs, PCBs, Pyrethroids, methyl-mercury, nickel, and zinc. *Figures 1-5*

San Mateo Creek showed sediment toxicity to amphipods at both the Upper (freshwater) and Lower (inter-tidal) stations sampled in both November and April. The San Lorenzo Creek Upper station sediment was toxic in November while the Coyote Creek Upper station was toxic in April. *Figure 1*

Pyrethroids were present in sediment from all tributaries in the November samples with San Mateo Creek Upper station being the only location where 4 of the six measured pyrethroids were found above detection limits of 2 μg/kg. Bifenthrin was the only pyrethroid detected in all six tributaries at least once while permethrin was detected in three tributaries in the November samples. This finding is consistent with other studies conducted in the region (Weston, 2006). Cyfluthrin and cypermethrin were detected only at the San Mateo Creek Upper station in November. Esfenvalerate and lamda-cyhalothrin were below detection in all samples. *Figure 2*

The legacy contaminants, including PCBs and DDTs, were detected in all samples. The San Mateo Creek Upper station had the highest Sum of DDTs concentration in November (122 μg/kg: six times higher than the average concentrations seen in this study). In April, San Mateo Creek and San Lorenzo Creek Upper stations had elevated Sum of DDTs concentrations of 37 and 45 μg/kg respectively. *Figure 3*

PBDE concentration were higher in the April samples, and were detected in all tributaries in April, with the highest concentration found at the San Lorenzo Creek Upper station. *Figure 4*

Figure 1. Sediment Toxicity

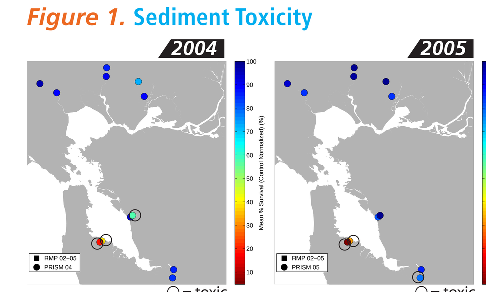


Figure 2. Pyrethroids

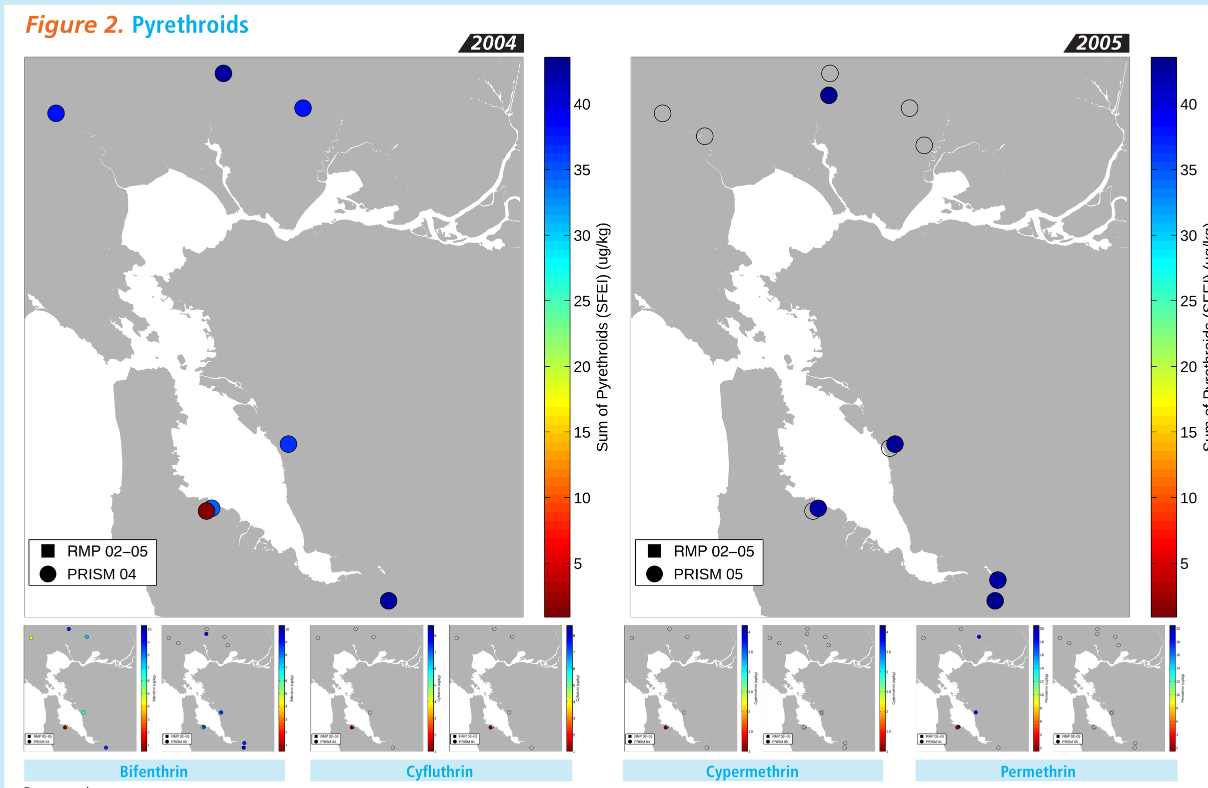


Figure 3. Legacy Organics

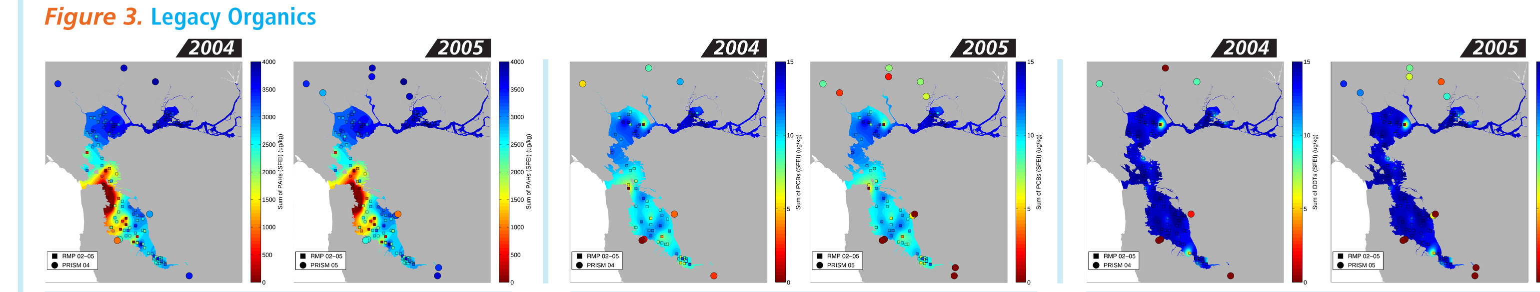


Figure 4. PBDEs

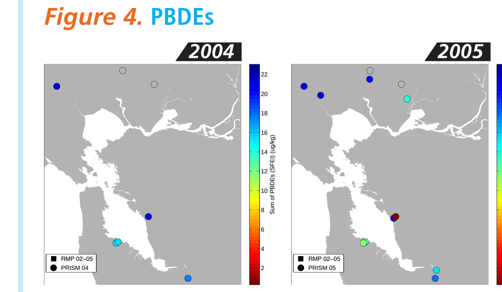


Figure 5a. Nickel Zinc

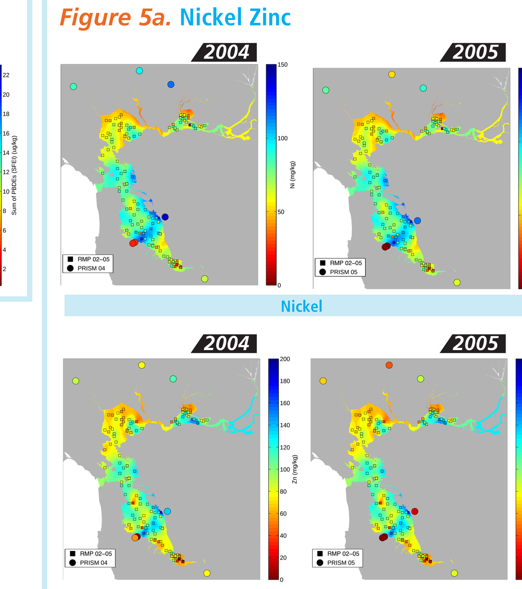
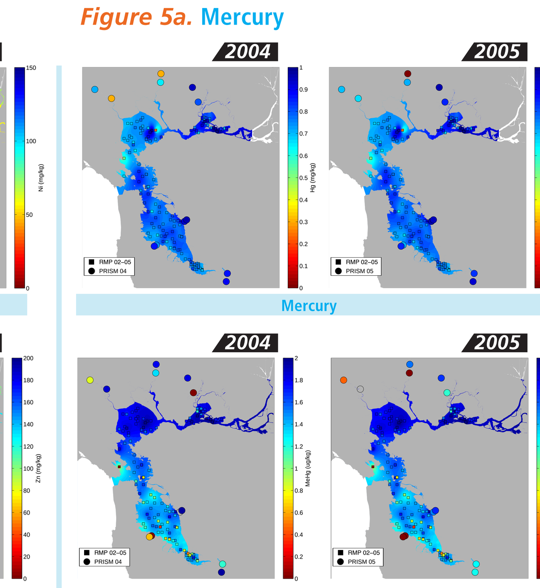


Figure 5a. Mercury



Conclusions

This study characterized sediments from Bay Area tributaries for priority pollutants, potential to cause toxicity to amphipods, grain-size, total organic carbon, and additional emerging pollutants of concern (including pyrethroids and PBDEs). Sampling and analytical methodologies were comparable to the RMP-Status and Trends program and provides a base-line, "snap-shot" of pyrethroid concentrations in urban tributaries in 2004-2005 when sales of those pesticides are still on the rise.

Of the six tributaries studied, San Mateo Creek was toxic to both freshwater and estuarine amphipods during both sampling events, and had the highest contaminant concentrations for important legacy and emerging contaminants.

Pyrethroids were present in detectable concentrations in all tributaries studied, but of the six pyrethroids measured only bifenthrin and permethrin were found in more than one tributary.

Contaminant levels in sediments of this study were generally higher at the Upper, freshwater stations as compared to the Lower, inter-tidal stations indicating that sediment contamination is higher the tributaries than in the Estuary itself.

The more urban/industrial South Bay tributary sediments were more toxic in amphipod tests and tended to have higher concentrations of measured contaminants (including: PAHs, PCBs, DDTs, pyrethroids, PBDEs, methyl-mercury) than the North Bay mixed urban/rural tributaries.

Project Funding Sources

- Pesticide Research and Identification of Source & Mitigation (PRISM Grant: 041355520)
- San Francisco Estuary Institute's - Regional Monitoring Program for Water Quality in San Francisco Estuary (RMP) - Episodic Toxicity Program 2004

PRISM Project Title: INVESTIGATIONS OF SOURCES AND EFFECTS OF PYRETHROID PESTICIDES IN WATERSHEDS OF THE SAN FRANCISCO BAY ESTUARY

Project Director: Sarah Lowe (SFEI)

Project Co-PI: Brian Anderson (UC Davis-MPSL)

Project Grant Manager: Susan Gladstone (SWRCB)

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References

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More Information

The final PRISM Report presenting this field study and including two additional projects: a sensitivity study to determine lethal concentrations (LC50) of targeted contaminants to E. estuaries, and a summary of the pyrethroid TIE tools developed by UC-Davis MPSL (presented in the Pyrethroids session at this conference by Bryn Phillips (Wednesday Oct 25th, 11AM) will be available in early 2007. For more information please contact Sarah Lowe at sarahl@sfei.org.

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