Ecology's Urban Waters Initiative – Assessing Changes in Sediment Quality in Urban Bays

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I. Initial Findings - Metals in Elliott Bay - Changes 1998 to 2007

- Decreases in copper, lead, mercury, silver, and tin concentrations in statistical analyses paired by station.
- Increases in zinc and selenium concentrations in statistical analyses paired by station.
- No significant change in spatial extent of contamination exceeding Washington State Sediment Quality Standards in paired statistical comparisons not weighted by area represented by sample sites.
- Changes in distribution of some metals contamination in study area.
- Changes in metals concentrations are occurring primarily at harbor sites representing relatively little area.

II. Introduction

As part of Ecology's Urban Water's Initiative, current and 5-year follow-up monitoring are being conducted in urban bays in Puget Sound to assess the extent of sediment contamination, changes over time, and the long-term effectiveness of collective toxics management efforts bay-wide.

Data collected will be analyzed to:

- Provide a current "bay-scale" sediment quality assessment.
- Compare with historical data to indicate whether bay-scale sediment quality is improving, deteriorating, or remaining unchanged over time.
- Evaluate the effectiveness of collective source control and cleanup actions.

Results can be used as performance measures in adaptive management strategies developed for Puget Sound.

III. Study Design

The Elliott Bay/Lower Duwamish study area is "nested" within a larger scale sediment monitoring sampling frame developed for the Puget Sound Assessment and Monitoring Program (PSAMP) (Figures 1 and 2).

PSAMP uses a probability-based sampling design with unequal weighting to assess sediment quality at region- and sound-wide scales in Puget Sound (Figure 2).

Sediment chemistry, toxicity, and sediment-dwelling invertebrates are sampled to characterize the spatial extent of degraded sediment quality.

Thirty stations in the Elliott Bay/Lower Duwamish study area were sampled in 1998, providing baseline data. These stations were resampled in 2007 (Figure 2).

Similarly, thirty previously sampled stations will be resampled in Commencement Bay and associated waterways in 2008, and 5 years later.

IV. What questions can we answer?

- Spatial extent of sediment contamination in study area = ?
- Proportion of study area exceeding WA State sediment management standards = ?
- Has spatial extent changed?
- Have proportions exceeding sediment quality standards changed?
- Have concentrations changed?

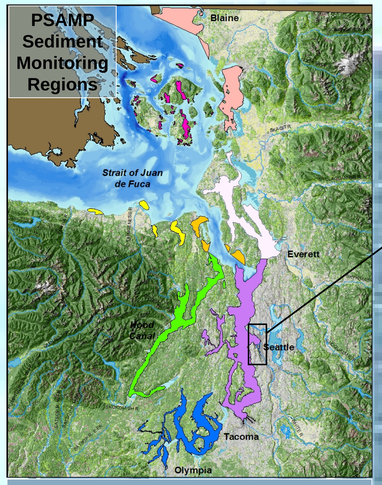

Figure 1. Elliott Bay/Lower Duwamish study area within the PSAMP Central Puget Sound Sediment Monitoring Region.

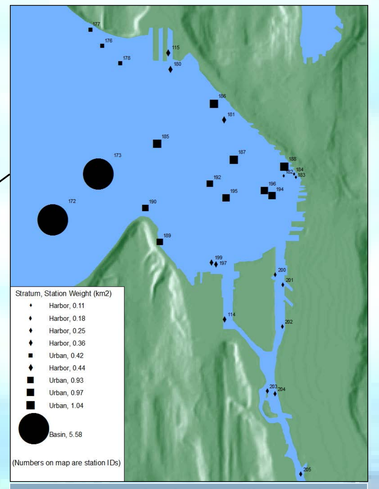

Figure 2. Sample sites in Elliott Bay/ Lower Duwamish indicating relative weights.

V. Analysis Methods

- Sediment metals concentrations were compared to Washington State Sediment Quality Standards (SQS).
- Mean of SQS-normalized values (mean SQS quotient) was calculated.
- Cumulative distribution functions (CDF) of sample results, weighted by amount of area represented, were generated to describe the distributions of contamination within the study area (example in Figure 3).
- Spatial extent of contamination exceeding SQS was compared between 1998 and 2007 (Table 1).
- CDFs were compared between years to assess change in distribution of metals concentrations within the study area, weighted according to amount of area represented (Table 2).
- Paired-sample analyses of 1998 and 2007 concentrations by station, not weighted by amount of area represented, were performed (Table 2).

Table 1. Spatial extent (km^2) of metals contamination in Elliott Bay/Lower Duwamish in 1998 and 2007.

Metal	Spatial extent of sediment contamination above SQS (km^2)		Has spatial extent changed significantly? (two-proportion test, alpha = 0.05)
	1998	2007	
Arsenic	0.32	0.28	No
Cadmium	0.00	0.00	No
Chromium	0.00	0.00	No
Copper	0.00	0.00	No
Lead	0.00	0.00	No
Mercury	4.96	3.68	No
Nickel	NA	NA	--
Selenium	NA	NA	--
Silver	0.00	0.00	No
Tin	NA	NA	--
Zinc	0.25	0.18	No

Table 2. Statistical comparisons of 1998 and 2007 metals concentrations, paired by station and unpaired.

Parameter	Paired comparisons not weighted by unequal probabilities (Peto-Prentice test, sign test, alpha = 0.05)	Unpaired comparison of CDFs (Rao test, Wald-Scott test, alpha = 0.05)
Mean metals SQS quotient	Decrease	No change
Arsenic	No change	Increase overall, but decrease in upper range
Cadmium	No change	No change
Chromium	No change	No change
Copper	Decrease	No change
Lead	Decrease	Decrease not significant at α=0.05 (significant at α=0.10)
Mercury	Decrease	Decrease not significant at α=0.05
Nickel	No change	No change
Selenium	Increase	Increase in both detected values and number of non-detects
Silver	Decrease	Decrease
Tin	Decrease	Decrease
Zinc	Increase	No change

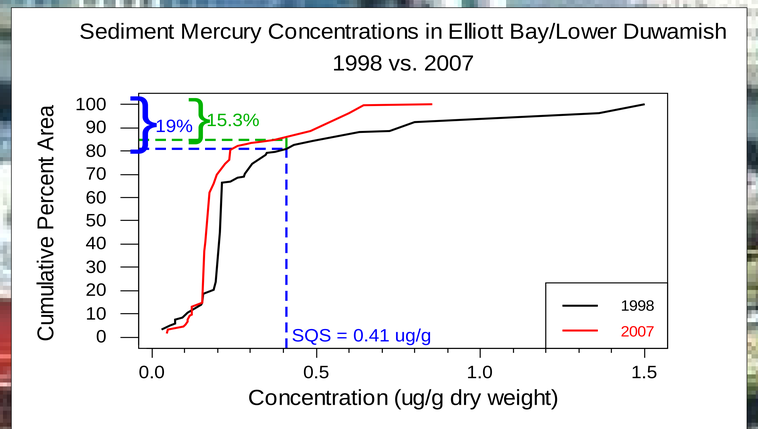

Figure 3. Cumulative distribution functions showing spatial extent of mercury contamination in Elliott Bay/Lower Duwamish in 1998 and 2007. The graph also indicates the change in percent of area exceeding the Washington State Sediment Quality Standard (SQS) for mercury.

VI. Conclusions to date

Sediment metals concentrations have changed significantly at some stations. But most of those stations represented small proportions of the total study area, so that the changes are not detected in comparisons of spatial extent of contamination. Increasing the sample size and developing methods for incorporating paired results in CDF comparisons will improve the ability to detect change.

General information and all data generated during this survey can be accessed from Ecology's Marine Sediment Monitoring website: http://www.ecy.wa.gov/programs/eap/mar_sed/msm_intr.htm

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