

Urban Waters Initiative 2008: Sediment Quality Changes in Commencement Bay Since 1999

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A New Initiative for Urban Bays

The *Urban Waters Initiative* (UWI) is a multi-agency program established in 2007 to keep toxic chemicals out of several of Washington's urban waterbodies—Elliott Bay/Lower Duwamish Waterway, Commencement Bay, and Spokane River. Keeping toxics out of the water improves water quality and prevents contamination or re-contamination of sediments. The UWI is led by the Washington State Department of Ecology (Ecology).

Assessments of sediment quality are one measure of the response of the receiving system to engineering and policy changes that are being made to improve conditions in these urban waterbodies. Ecology scientists sampled the sediments of Commencement Bay during June of 2008 as a part of this initiative.

Surface sediment samples were taken at 30 randomly selected locations in both the bay and the adjoining waterways (Figure 1). The samples were analyzed for sediment chemistry, sediment toxicity, and community composition of benthic (bottom-dwelling) organisms. These three indicators were then combined into Ecology's Sediment Quality Triad Index to classify sediments from high quality to degraded (see page 2).

The sampling design and methods were the same as those developed for the Puget Sound Assessment and Monitoring Program (PSAMP) Sediment Component, allowing comparison of data between the two programs. Furthermore, 25 of the 30 stations were the same locations sampled by PSAMP in 1999, enabling us to examine whether and how conditions have changed over the past decade. In the mid-2000s, considerable cleanup activity was accomplished in the Hylebos, Middle, and Thea Foss Waterways and begun offshore of Ruston.



Mt. Rainier from the Blair Waterway. (T. Putnam photo)

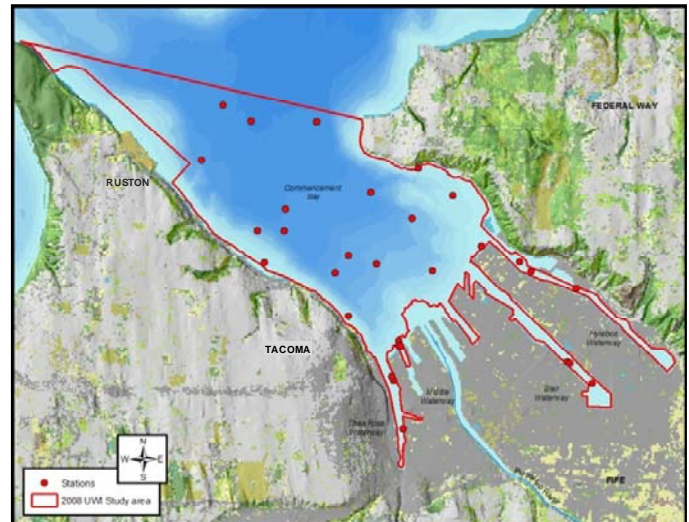


Figure 1. Thirty random sediment stations sampled in Commencement Bay in 2008 and 1999.

Sediment Study Objectives

The objectives of this study were to:

1. Assess the current conditions in the area, particularly the overall extent of sediment degradation.
2. Determine the degree and nature of any changes in sediment quality over time.
3. Compare the extent of sediment quality degradation in Commencement Bay with regional and Puget Sound-wide levels of degradation, to add a larger-scale perspective to the conditions in the bay.

What Did We Find?

Sediment Conditions in Commencement Bay - 2008

Chemical Contamination

- At eight of the 30 stations (27% of stations), representing an estimated 16% of the total study area, sediments were chemically contaminated, as indicated by chemical concentrations being higher than Washington State Sediment Quality Standards (SQS). The SQS are sediment chemical concentration levels determined to divide likely from unlikely adverse impacts on benthic invertebrates.
- Most stations not meeting SQS did so for one or two chemicals in any given sample, but two stations at either end of the Thea Foss Waterway had more than 10 chemicals not meeting SQS.
- For the eight stations at which sediment chemical concentrations were higher than the SQS, 20 of 41 chemicals failed to meet the standards:
 - ❖ Bis(2-ethylhexyl)phthalate (2 stations).
 - ❖ Butylbenzylphthalate (3 stations).
 - ❖ Mercury (1 station).
 - ❖ Copper (1 station).
 - ❖ 14 Polycyclic aromatic hydrocarbons (PAH) (2 stations).
 - ❖ Total PCB Aroclors (1 station).
 - ❖ Hexachlorobenzene (1 station).
- Contaminant concentrations were generally highest in the Thea Foss and Hylebos Waterways and lowest in the outer bay.



Sediment sampling in Commencement Bay. (C. Eaton photo)

- Some newer types of contaminants, such as pharmaceuticals, personal care products, and perfluorinated chemicals, were not included in this survey.

Sediment Toxicity

- Based on the results of two complementary toxicity tests (amphipod acute survival test and test of sea urchin egg fertilization) conducted on all 30 samples, no toxicity was recorded. Therefore, the incidence and spatial extent of toxicity was zero, according to those tests.

Benthic Invertebrate Communities

- Twelve of the 30 stations (40%) and an estimated 35% of the study area had adversely affected benthic invertebrate communities, as indicated by relatively low total abundance, diversity, and abundance of stress-sensitive species, and increased abundance of stress-tolerant species.
- While some of the adversely affected benthic communities were in the waterways, several were in the central-southeast portion of the bay.

Sediment Quality Triad Index (SQTI)

This study evaluated measures of exposure (chemical contamination), response (toxicity), and adverse biological effects (benthic invertebrates). The SQTI combines these measures into a 4-level scale from high to degraded sediment quality.

Figure 2 shows the 2008 SQTI results for Commencement Bay. Overall, approximately 61% of the study area was found to have high sediment quality, none had fully degraded sediment, and the remainder of the area was intermediate in quality.

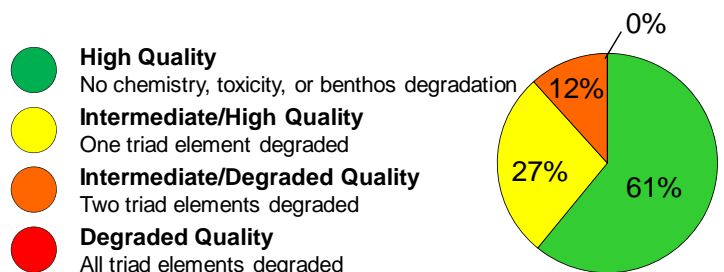


Figure 2. Overall sediment quality in Commencement Bay in 2008, as determined by the Sediment Quality Triad Index. Percentages of the total survey area are shown.

Comparison to 1999 Conditions

Many measures indicated improvements in sediment quality on a bay-wide scale, while some indicated no change, and a few measures declined (Table 1).

Table 1. Summary of bay-scale changes from 1999 to 2008 in individual parameters measured in Commencement Bay sediment.

<p>Improvements</p> <p>Metals: Arsenic, Copper, Lead, Mercury, Nickel, Silver, Tin, Zinc</p> <p>Most LPAHs¹</p> <p>Most HPAHs²</p> <p>Benthic Communities in Waterways</p>
<p>No change</p> <p>Metals: Cadmium, Chromium</p> <p>LPAH: Acenaphthylene</p> <p>HPAH: Benzo(b)fluoranthene</p> <p>Polychlorinated biphenyls (PCBs)</p> <p>Toxicity</p>
<p>Deterioration</p> <p>Bis(2-ethylhexyl)phthalate³</p> <p>Benthic Communities in Central-S.E. Bay</p>

¹ Low Molecular Weight Polycyclic Aromatic Hydrocarbons

² High Molecular Weight Polycyclic Aromatic Hydrocarbons

³ A common plasticizer; also known as DEHP

Sediment Contamination

- **Metals:** Levels of most metals, including arsenic, copper, lead, and mercury, decreased significantly. There were no significant changes in levels of cadmium or chromium.
- **PAHs:** Concentrations of most polycyclic aromatic hydrocarbons (PAH) decreased. Acenaphthylene and benzo(b)fluoranthene levels did not change.
- **PCBs:** Most PCB congeners and Aroclors were detected only in the waterways and were about the same levels as previously.
- **Phthalates:** Bis(2-ethylhexyl)phthalate levels increased. Where detected, butylbenzylphthalate levels were higher than the SQS, both years.
- **Comparison to sediment quality standards:** The number of chemicals not meeting their respective SQS remained about the same.
- The number of stations not meeting the SQS changed slightly (from 7 to 8), but the proportion of area affected increased substantially. This is because contamination improved in the waterways but worsened in the south-central bay.

Sediment Toxicity

- The incidence and spatial extent of sediment toxicity, based on two complementary tests, remained about the same, decreasing insubstantially from one station representing 0.5% of the study area in 1999 to none (0% of the area) in 2008.

Invertebrate Communities

- Benthic invertebrate community health improved in the waterways from 1999 to 2008 but worsened in the south-central portion of the bay.
- The total number of stations with adversely affected benthos decreased slightly (from 13 to 12), but the area affected increased substantially.
- Although it is not possible to determine causes in this study, there may have been some natural changes in the bay which affected the benthos.

Sediment Quality Triad Index

- Sediment quality, as measured by the SQTI, improved for 6 of the 25 stations (24%) sampled in 1999, remained the same for 13 of 25 stations (52%), and declined for 6 of 25 stations (24%).
- All of the improvements were at stations in the waterways. There was some deterioration at stations in the central-southeast bay.

Comparison to Conditions 30 Years Ago

In the late 1970s to early 1980s, the National Oceanic and Atmospheric Administration (NOAA) studied Commencement Bay extensively as part of the Marine EcoSystems Analysis (MESA) Puget Sound project. Many of the sampling and analytical methods of MESA were sufficiently similar to those of the UWI to warrant comparing the data.

Chemical contamination of the sediments in 2008 was a fraction of that in 1978-1981. The incidence of contamination by one or more chemicals relative to NOAA sediment quality guidelines was 12/27 or 44% of stations in the MESA data from the early 1980s. In 1999, the incidence of contamination relative to the NOAA sediment quality guidelines was 6/25 or 24%, and in 2008 it was 4/30 or 13%, a downward trend. PAH and metals contamination decreased substantially.

Comparisons at Different Spatial Scales

The 2008 Commencement Bay study area lies within the PSAMP Sediment Component's Central Region and within the marine portion of the Puget Sound Partnership's South Central Action Area (Figure 3). Those areas, in turn, lie within the entire Puget Sound sampling area. This nested series of sampling areas enables assessment of sediment quality at multiple geographic scales using the SQT_I.

- Sediment quality category proportions in Commencement Bay in 2008 (Figure 4b) were similar to those for all Puget Sound (Figure 4d).
- The proportion of area with high sediment quality in Commencement Bay was lower in 2008 (Figure 4b) than in 1999 (Figure 4a), reflecting the deteriorated benthic community health and increased chemical contamination in the central-southeast portions of the bay.
- The proportion of area with intermediate sediment quality in Commencement Bay in 2008 (Figure 4b) was higher than in the Central Region in 1998-1999 (Figure 4c), reflecting how industrialized Commencement Bay is, compared to the Main Basin of the Sound.

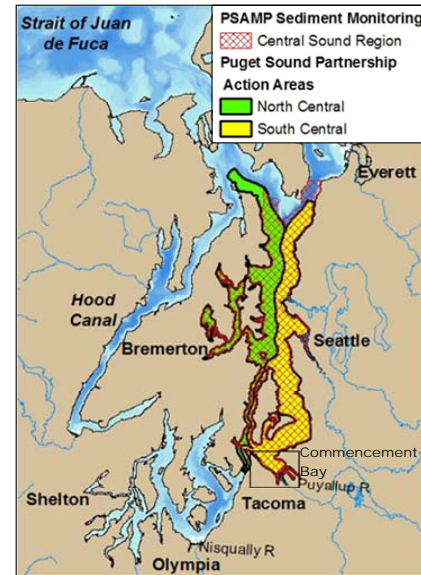


Figure 3. Overlap of the PSAMP Central Region and the marine portion of the PSP South Central Action Area. The location of Commencement Bay is indicated.

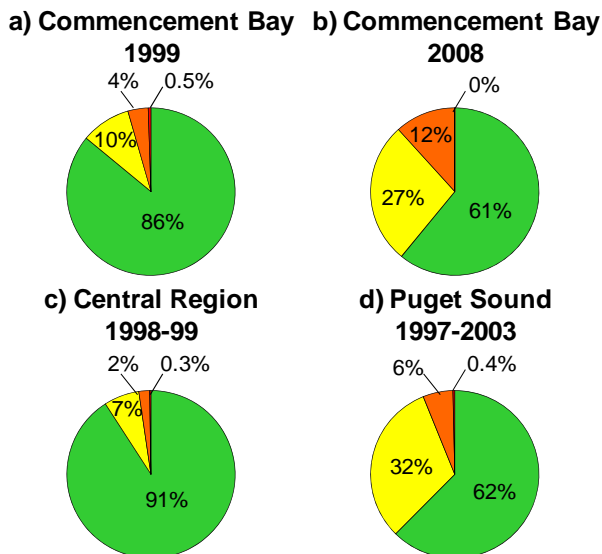


Figure 4. Overall sediment quality, as determined by the Sediment Quality Triad Index. Percentages of the total survey area are shown.

Relevance to the PS Partnership

The UWI sediment monitoring program is a new tool for use by the Puget Sound Partnership (PSP), environmental managers, and other stakeholders. Results from this survey, together with the existing PSAMP sediment monitoring work, provide information addressing key components of the PSP Action Agenda, including:

- *Status-and-trends monitoring.*
- *Effectiveness monitoring.*
- *Multivariable indicators.*
- *Coordinated regional monitoring.*
- *Sound science.*
- *Communication.*

Other UWI Sediment Monitoring

Bay-scale sediment monitoring will be expanded to Bellingham Bay in 2010, Budd Inlet in 2011, and Port Gardner/Everett Harbor in 2012. Ecology also sampled sediment in Elliott Bay in 2007 and in the Bainbridge Basin (Sinclair/Dyes Inlets) in 2009. A report on the Elliott Bay UWI study is available at www.ecy.wa.gov/biblio/0903039.html. Data from the Bainbridge Basin are being analyzed.

This paper is based on the report:

Partridge, V., S. Weakland, E. Long, K. Welch, and M. Dutch, 2010. Urban Waters Initiative, 2008: Sediment Quality in Commencement Bay. Washington State Department of Ecology. Publication No. 10-03-019. www.ecy.wa.gov/biblio/1003019.html

General information and all data generated for this report is available from Ecology's Marine Sediment Monitoring website: www.ecy.wa.gov/programs/eap/psamp/index.htm