Sediment Quality Changes in the Strait of Georgia 1997-2006

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Sediment Quality Assessment: Strait of Georgia Region

The Washington State Department of Ecology (Ecology) conducted a sediment quality survey in the embayments of the southern Strait of Georgia in 2006 as part of the Puget Sound Assessment and Monitoring Program (PSAMP), recently renamed the Puget Sound Ecosystem Monitoring Program (PSEMP).

Potentially toxic chemicals entering Puget Sound can bind to suspended particulate matter in the water column and eventually be deposited into the sediments at the bottom of the Sound. This process tends to cleanse the water column, but also results in greater toxics exposure for the marine organisms living in or on the bottom. Therefore, it is important to monitor this exposure route as a major source of toxicological risks.

The Strait of Georgia monitoring region includes Boundary/Semiahmoo, Bellingham, Samish, Fidalgo, and Padilla Bays (Figure 1).

Sediment samples were collected during June of 2006 at 40 randomly selected locations throughout the 387-km^2 study area. The upper layers of each sample were analyzed to determine:

1. Concentrations of potentially toxic chemicals.
2. Degree of response in laboratory tests of toxicity.
3. The condition of the sediment-dwelling invertebrates (*benthos*) living in each location.

These three elements, called the Sediment Quality Triad, are combined as Ecology's Sediment Quality Triad Index (SQTI) to characterize geographic patterns and spatial extent of sediment quality degradation.

Ecology also compared these 2006 results with data collected in 1997 from a previous study in the Strait of Georgia to determine whether sediment quality had changed since then.

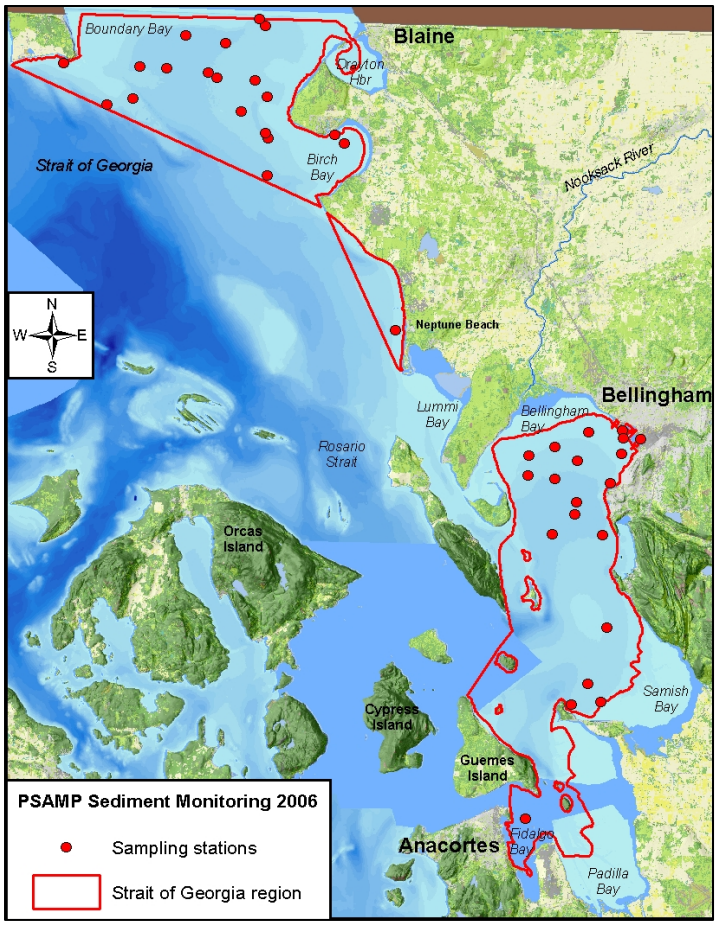

Figure 1. PSAMP (now PSEMP) Strait of Georgia region and locations of the 40 randomly selected sediment stations sampled in 2006.

Study Objectives

The objectives of this study were to:

1. Assess the current status of sediment quality in the region.
2. Determine the degree and nature of any trends in sediment quality over time.
3. Compare the extent of sediment quality degradation in the southern Strait of Georgia with other regions of Puget Sound and the entire Sound.

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What Did We Find?

Sediment Conditions in the southern Strait of Georgia in 2006 and compared to 1997

This study evaluated measures of exposure (chemical contamination), response (toxicity), and adverse biological effects (benthic invertebrates). Some measures indicated improvements in sediment quality on a region-wide scale, while some indicated no change, and a few measures declined (Table 1).

Chemical Analysis and Sediment Contamination

Chemical contaminant concentrations were compared to Washington's Sediment Quality Standards (SQS). Chemical concentrations above SQS values have been determined to cause adverse effects on benthic invertebrates.

- No samples in 2006 had chemical contaminant concentrations exceeding SQS, compared to 15% of samples in 1997.
- *Mercury:* Mercury is of particular interest because of the history of contamination from the former chlor-alkali plant in Bellingham Bay. Although mercury concentrations did decline slightly from 1997 to 2006 in Bellingham Bay, region-wide the levels did not change. Other studies have documented substantial reductions in mercury contamination in Bellingham Bay and the Whatcom Waterway since the 1970s.
- *Other metals:* Levels of some metals decreased significantly, others increased significantly, and some remained the same from 1997 to 2006.
- *PAHs:* Concentrations of low molecular weight polycyclic aromatic hydrocarbons (LPAH) increased from 1997 to 2006, but high molecular weight PAH (HPAH) levels did not change.
- *PCBs:* For the most part, PCBs were not detected or were so low as to not be measurable.

Sediment Toxicity

The toxicity of the sediments was evaluated in three laboratory tests performed with invertebrates: amphipod survival, sea urchin egg fertilization, and sand dollar embryo development (2006 only).

The different toxicity tests measure different biological responses to exposure to sediments or sediment porewater.

- Toxicity was indicated in at least one of the tests in 7 of the 40 samples in 2006. Those samples represented about 18% of the region.
- Compared to 1997, toxicity results were mixed. More samples in 2006 had toxic responses in the amphipod survival test than in 1997, while the reverse was true in the sea urchin fertilization test.
- A more sensitive species of amphipod was used in 2006 than in 1997, which could account for at least some of the increase in toxic responses. The same species of sea urchin was used in both years.

Table 1. Summary of region-wide changes from 1997 to 2006 in individual parameters measured in sediments of the southern Strait of Georgia.

Improvements
Decrease in metals: Cadmium, Silver, Tin
Decrease in contaminants exceeding state standards
Increase in benthic invertebrate diversity measures
No change
Metals: Arsenic, Copper, Mercury, Nickel
High Molecular Weight PAHs*
Mixed trends
Toxicity
Deterioration
Increase in metals: Chromium, Lead, Selenium, Zinc
Increase in Low Molecular Weight PAHs*
Decrease in benthic invertebrate abundance, species
Increase in adversely affected benthic communities
Overall decrease in % of high-quality sediments and increase in % of intermediate-quality sediments

*Polycyclic Aromatic Hydrocarbons

Benthic Invertebrate Communities

Benthic invertebrates – the small animals which live in or on the sediment – are important because they are near the base of the food chain which leads up to salmon and, eventually, people and orcas. Adverse effects, suggesting reactions to environmental stress, are indicated by relatively low abundance and diversity of organisms, decreased abundance of stress-sensitive species, and increased abundance of stress-tolerant species.

- In all, 19 of the 40 stations (48%) sampled in 2006 had adversely affected benthos. Those stations represented about 44% of the area of the region.
- The proportion of the study area with adversely affected benthos increased from 15% in 1997 to 44% in 2006.
- The declines in benthic community health seem not to coincide with the trends in sediment chemistry or toxicity. The benthos respond to complex interactions of natural physical and chemical factors, as well as anthropogenic (human-caused) factors. Other factors not measured in this survey, such as dissolved oxygen, pH, contaminants of emerging concern, or long-term natural cycles, may have affected the benthos.

Sediment Quality Triad Index (SQTI)

The SQTI combines the chemistry, toxicity, and benthic community results into a classification of sediment quality on a 4-level scale from high to degraded sediment quality, depending on the numbers of triad elements degraded (Figure 2).

- The proportion of the study area with high quality sediments (no triad elements degraded) decreased from 76% in 1997 to 56% in 2006 (Figure 2).
- Correspondingly, intermediate quality sediments (1-2 triad elements degraded) increased from 24% to 44% of the study area.
- None of the study area indicated degradation in all three triad elements in either year.
- Even though the chemistry element of the Sediment Quality Triad improved from 1997 to 2006, and there was no effective change in the toxicity element, the deterioration in benthic community health drove the shift from high to intermediate sediment quality.
- Some of these trends have been seen in other regions of Puget Sound. Ecology will continue to monitor sediment quality over time in both this region and the other regions to determine if these trends persist.

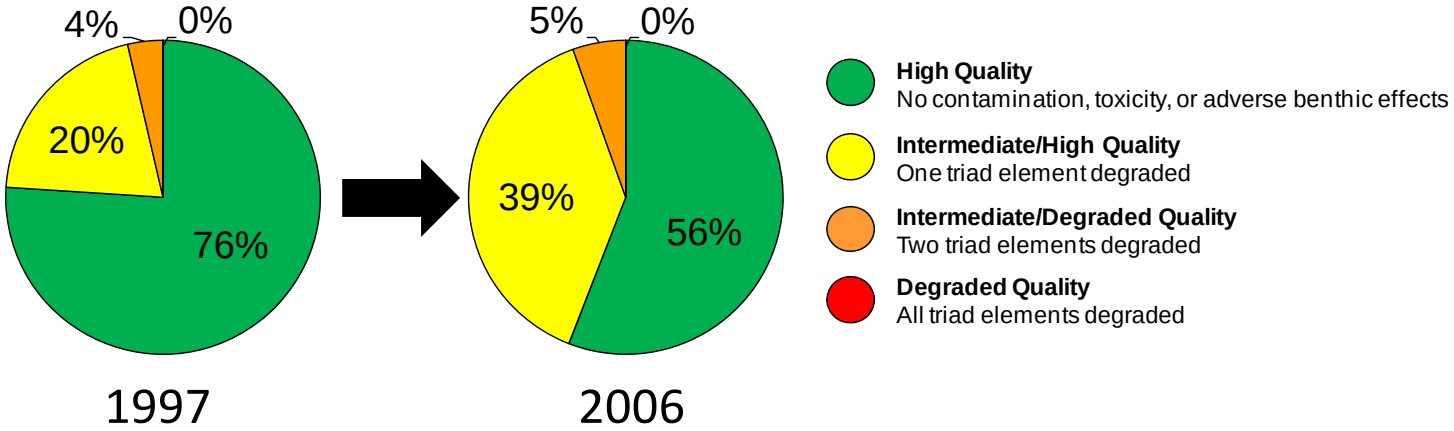

Figure 2. Overall sediment quality in the southern Strait of Georgia, as determined by the SQTI. Percentages of the total survey area are shown. Region-wide, the proportion of high quality sediment decreased from 1997 to 2006 and the proportion of intermediate quality sediment increased.

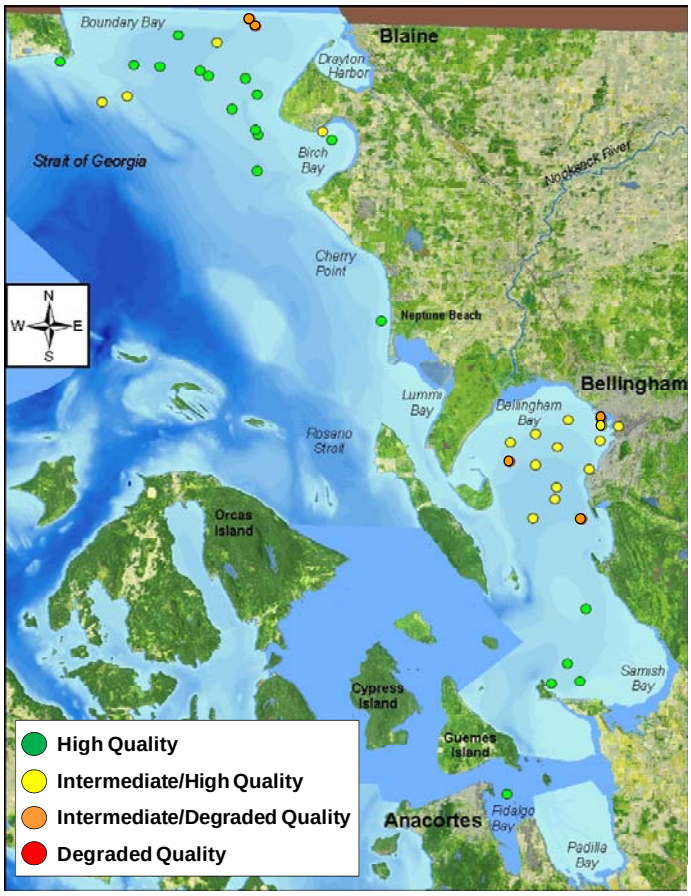

Figure 3. SQTI results in the southern Strait of Georgia in 2006. Note the pattern of greater degradation closer to urban areas, improving toward the outer bays and the strait.

Spatial Patterns

- Contaminant concentrations were generally highest in inner Bellingham Bay, especially near or within Whatcom Waterway, near the former Georgia-Pacific chlor-alkali pulp mill. The degree of contamination decreased southward out of Bellingham Bay into Samish Bay.
- The geographic patterns of where benthic invertebrate communities were adversely affected did not change from 1997 to 2006, but the number of samples with adversely affected benthos in those areas increased.
- There were no notable geographic patterns in sediment toxicity.
- Sediment conditions tended to be more degraded close to population centers (Bellingham, Blaine), improving to high quality in rural bays (Figure 3).

Comparisons with other P.S. regions

Ecology currently surveys sediment throughout Puget Sound in 8 regions over a 10-year rotating cycle and in 6 urban bays over a 6-year cycle. These surveys are designed to enable comparisons of sediment quality over time and at bay-wide, region-wide, and sound-wide scales. Baseline sediment quality was established in surveys conducted in 1997-2003. The current regional assessment cycle will be completed in 2014.

- In regions that included industrialized harbors, chemical contamination was a greater contributor to sediment degradation than in regions that were more rural.
- Chemical contamination and toxicity in the Strait of Georgia region were similar to those in non-urban areas of Puget Sound.
- Benthic community health varies widely across the regions. The proportions of samples and area with adversely affected benthos in the Strait of Georgia were toward the low end of the range in 1997 but in the middle of the range in 2006.
- Similar patterns of changes over time in sediment chemistry, toxicity, and benthos have been found in other bays and regions resampled so far.
- Sediment quality (SQTI) category percentages in the Strait of Georgia region were similar to those for Puget Sound as a whole and for the South Sound region.

More information on Ecology's marine sediment monitoring program is available on the web at www.ecy.wa.gov/programs/eap/psamp/index.htm.

This paper is based on the report:

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

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