

## Sediment Quality in the Bays and Inlets of the San Juan Islands, Eastern Strait of Juan de Fuca, and Admiralty Inlet (2002-2003)

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### Sediment Quality Assessment of Three Puget Sound Monitoring Regions

During 2002 and 2003, the Washington State Department of Ecology (Ecology) conducted a sediment quality survey in the bays, coves, and inlets of the San Juan Islands, eastern Strait of Juan de Fuca, and Admiralty Inlet. This survey was part of the Puget Sound Assessment and Monitoring Program (PSAMP).

Sediment samples were collected at 90 stations: 30 in each of three PSAMP monitoring regions (Figure 1). Survey objectives were to (1) measure levels of chemical contaminants and sediment toxicity, and (2) determine the condition of sediment-dwelling invertebrate communities (known as the *benthos*).

Using the *Sediment Quality Triad* of indicators (Long et al., 2004), Ecology determined the number and percent of stations and the size (km<sup>2</sup>) and percent of the study area with high, intermediate, or degraded sediment quality for each region.

### Chemical Contamination

Laboratory analyses were performed for over 120 chemicals and sediment properties. Two samples out of the 90 collected had chemicals higher than (exceeding) Washington State Sediment Quality Standards (SQS)



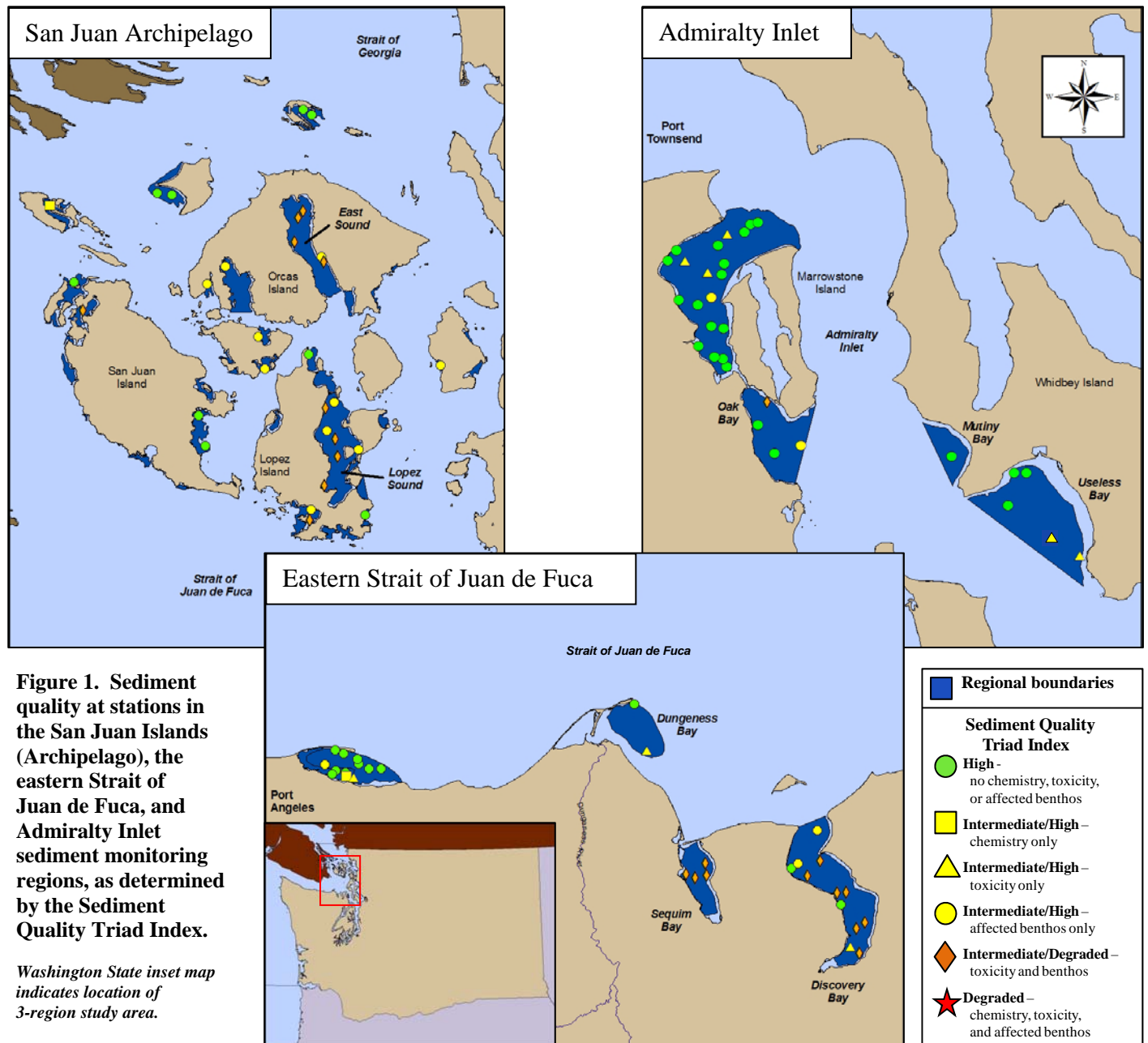
Sediment sampling in the eastern Strait of Juan de Fuca  
Photo by C.M. Eaton, Bio-Marine Enterprises

### Summary of Findings

- ❖ Sediment chemistry, toxicity, and invertebrate communities were evaluated at 90 stations in the San Juan Islands, the eastern Strait of Juan de Fuca, and Admiralty Inlet.
- ❖ Highest sediment quality was measured in Admiralty Inlet (69% of area).
- ❖ The majority of the sediments measured in the San Juan Islands and the eastern Strait of Juan de Fuca (70 and 72% of each area, respectively) were of intermediate quality.
- ❖ No sediments were of degraded quality in any of the three regions.
- ❖ The 1997-2003 eight-region, Puget Sound-wide sediment quality data baseline is complete.
- ❖ Periodic re-evaluation of embayment, regional, and Puget Sound-wide sediment quality provides information on change over time, useful in adaptive management.

(Figure 1). The concentration of di-n-butylphthalate exceeded the SQS in one sample from Prevost Harbor in the San Juan Islands (2.7 km<sup>2</sup>, 3.3% of that region). The concentration of fluoranthene exceeded the SQS value in one sample from Port Angeles Harbor in the eastern Strait of Juan de Fuca (0.9 km<sup>2</sup>, 1.4% of that region).

Mean Effects Range Median (ERM) and SQS quotients were low, ranging from 0.02 - 0.24 and 0.02 - 0.37, respectively. These indices are calculated for each sample to account for the presence and concentrations of selected chemicals. The indices, which range from < 0.1 - > 4.0 in Puget Sound, signify low potential for chemical-induced toxicity. They suggested no clear spatial patterns of chemical contamination within or among the three regions.



## Sediment Toxicity

Four toxicity tests were run on each sediment sample: the amphipod 10-day survival test in solid phase sediments, the sea urchin fertilization and Microtox<sup>®</sup> bioluminescence tests in sediment pore water extracts, and the echinoderm larval abnormality/mortality test in sediment/water elutriates.

There were 30 samples (33% of total) in which at least one toxicity test response was statistically significant (Figure 1). These samples represented a total of 80 km<sup>2</sup> or about 38% of the total study area. Both the percent of stations and area affected by toxicity were highest in the eastern Strait of Juan de Fuca (47% and 59%, respectively), lower in the San Juan Islands (33% and 33%, respectively), and lowest in Admiralty Inlet (20% and 23%, respectively). Sediment toxicity generally occurred most frequently in Sequim and Discovery Bays and in East Sound. Port Townsend, Oak Bay, Dungeness Bay, Port Angeles, and many of the small bays and coves off the southern San Juan Islands were among those areas with the least toxic sediment.

## Sediment-Dwelling Invertebrates

The total abundance and number of species of benthos differed considerably among the 90 stations, indicating a wide variety of community and habitat types. Total abundance differed by two orders of magnitude among stations, with as few as 16 animals in one sample and over 1000 in others. The numbers of species were most variable within the San Juan Islands, ranging from 2 to 199, but on average were considerably lower than in the other two regions.

Among the 90 stations, benthos were classified as *adversely affected* in 37 stations: 20 in the San Juan Islands, 14 in the eastern Strait of Juan de Fuca, and 3 in Admiralty Inlet (Figure 1). *Adversely affected* indicates lower total abundance and number of species, higher numbers of stress-tolerant species, and lower numbers of stress-sensitive species as compared with average values for Puget Sound benthos.

Adversely affected benthos were found throughout all or most of East Sound, Lopez Sound, Sequim Bay, and Discovery Bay. Unaffected assemblages were apparent throughout most or all of Port Angeles, Dungeness Bay, Port Townsend, Useless Bay, and Mutiny Bay.

## The Sediment Quality Triad Index

The chemistry, toxicity, and benthos data were compiled using the Sediment Quality Triad Index (Long et al., 2004) to classify the overall sediment quality at each station (Table 1).

*High quality* sediments were most prevalent in the Admiralty Inlet region (48 km<sup>2</sup>, 69% of the study area).

*Intermediate quality* sediments were dominant in the San Juan Islands and eastern Strait of Juan de Fuca (57 and 44 km<sup>2</sup>; 70 and 72% of the respective study areas).

None of the sediments were classified as *degraded*.

Stations classified as *intermediate/degraded*, the poorest quality encountered in this survey, represented 49% and 33% of the eastern Strait of Juan de Fuca and San Juan Islands regions, respectively, as compared to 5% of the Admiralty Inlet region.

Therefore, the data indicated that sediment quality was highest in Admiralty Inlet, poorer in the San Juan Islands, and poorest in the eastern Strait of Juan de Fuca.

**Table 1. Estimated incidence and spatial extent of degraded sediments in the 2002-2003 PSAMP monitoring regions, as measured with the Sediment Quality Triad Index.**

Sediment Quality Triad Index Category	Incidence		Spatial extent	
	No. (%) of stations		km <sup>2</sup> (%) of study area	
<b>San Juan Islands</b>	30	(100)	81	(100)
High	9	(30)	24	(30)
Intermediate/high	11	(37)	30	(37)
Intermediate/degraded	10	(33)	27	(33)
Degraded	0	(0)	0	(0)
<b>Eastern Strait of Juan de Fuca</b>	30	(100)	62	(100)
High	12	(40)	18	(28)
Intermediate/high	7	(23)	14	(23)
Intermediate/degraded	11	(37)	30	(49)
Degraded	0	(0)	0	(0)
<b>Admiralty Inlet</b>	30	(100)	69	(100)
High	22	(73)	48	(69)
Intermediate/high	7	(23)	18	(26)
Intermediate/degraded	1	(3)	4	(5)
Degraded	0	(0)	0	(0)

**High quality** = No parameters impaired

**Intermediate/high quality** = One parameter impaired (chemistry, toxicity, or benthos)

**Intermediate/degraded quality** = Two parameters impaired (chemistry, toxicity, and/or benthos)

**Degraded quality** = Three parameters impaired (chemistry, toxicity, and benthos)

## Completion of PSAMP's Puget Sound Sediment Quality Baseline

The 2002-2003 data have been merged with previously collected (1997-1999) data. This completes an eight-region, Puget Sound-wide baseline sediment quality data set collected for the PSAMP Sediment Component.

Using the Sediment Quality Triad Index, estimates of the spatial extent of sediment quality degradation have been calculated from these baseline data. This was done for each of the eight Puget Sound regions, five geographic/anthropogenic-use strata, and Puget Sound-wide.

## The Sediment Quality Triad Index as a Management Tool

The Sediment Quality Triad Index values provide environmental managers and scientists with a unique *effectiveness monitoring* tool. This tool can be used to estimate the spatial extent (km<sup>2</sup>) of sediment quality degradation at three increasing geographic scales: (1) embayment, (2) region, and (3) Puget Sound-wide.

These estimates characterize the cumulative effects of natural and human-influenced toxic input to water and sediments, as well as source control and cleanup activities, occurring in the eight Puget Sound monitoring regions or other selected areas.

Re-evaluation of sediments on a chosen cycle (e.g., 5-10 years) will allow evaluation of change in sediment quality over time. Adaptive management strategies can then be developed and implemented to facilitate improvement in sediment quality for selected embayments, regionally, and Puget Sound-wide.

## References

Long, E., M. Dutch, S. Aasen, and K. Welch, 2004. Sediment Quality Triad Index in Puget Sound. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-008. [www.ecy.wa.gov/biblio/0403008.html](http://www.ecy.wa.gov/biblio/0403008.html).



Ecology staff sampling sediments in the San Juan Islands  
Photo by C.M. Eaton, Biomarine Enterprises



Olympic Mountains, Eastern Strait of Juan de Fuca  
Photo by C.M. Eaton, Bio-Marine Enterprises

### This paper is a summary of the report:

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General information and all data generated for this report can be accessed from Ecology's Marine Sediment Monitoring website: [www.ecy.wa.gov/programs/eap/psamp/index.htm](http://www.ecy.wa.gov/programs/eap/psamp/index.htm)

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