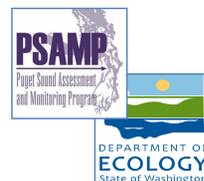


Polybrominated Diphenyl Ethers (PBDEs) in Puget Sound Sediments (2004-2011)

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I. Introduction

Polybrominated diphenyl ethers (PBDEs) are a class of brominated hydrocarbons which have been in wide commercial production and use since the early 1970s. They are used as flame retardant additives in plastics, foams, textiles, adhesives, coatings, and other household and commercial products.

Structurally similar to polychlorinated biphenyls (PCBs), PBDEs are now known to break down and enter the ecosystem. PBDEs have been classified as Persistent Bioaccumulative Toxics (PBTs), and the Washington State Chemical Action Plan for PBDEs calls for baseline monitoring in Puget Sound.

II. Study Questions

- Are PBDEs present in Puget Sound sediments?
- If PBDEs are present in Puget Sound sediments, which ones have measurable concentrations, where are they located, and in what concentrations are they found?

III. Sampling Locations

The Washington State Department of Ecology's Marine Sediment Monitoring Team has measured PBDE levels in Puget Sound sediments since 2004 as part of the Puget Sound Assessment and Monitoring Program (PSAMP) and Ecology's Urban Waters Initiative (UWI). Locations included ten long-term monitoring stations and randomly selected stations from five monitoring regions and five urban bays.

IV. Methods

Sediment Collection

Sediments were collected with a 0.1m² stainless steel double vanVeen grab sampler. The top 2 to 3 cm were analyzed for grain size, TOC, toxicity, and chemistry (including PBDEs).

Chemical Analyses

Sediments were tested for the presence of 5-13 PBDE congeners using USEPA methods 3545 (extraction), 3620 and 3665 (clean-up), and 8270 (Capillary Gas Chromatography/Mass Spectrometry in Select Ion Mode (GC/MS-SIM)).

V. Summary of PBDE concentrations in Puget Sound Sediments

Results from monitoring efforts are summarized and presented in Table 1 and Figures 1 and 2.

Patterns seen in these data include:

- BDE-47, -99, -209, and -49 were detected in most or all study areas, and in 68, 33, 30, and 15%, respectively, of the stations sampled. Concentrations are highest in urban bays.
- BDE-209 was most frequently detected and had the highest concentrations in urban bays, including Bellingham Bay, Everett Harbor, Elliott Bay/Lower Duwamish, Sinclair Inlet, Commencement Bay, and Budd Inlet; and in parts of the Central Basin and South Puget Sound.
- BDE-209 concentrations increased at most long-term monitoring stations between 2005 and 2010 (Figure 2).
- BDE-66, -71, -100, -153, -154, -183, -184, and -191 were detected in <5% of all stations.
- BDE-138 was never detected at these stations.
- With the exception of BDE-209 and -47, BDE concentrations were generally below 1 ppb.
- BDE-184 and -191 were only detected in the Strait of Georgia; possibly a contaminant signal from the Fraser River.

Table 1. Number and % of stations with detected levels of PBDE congeners.

Sampling Year	Study area	Number of Stations Sampled	Number of Stations with Detected Levels of each PBDE Congener														
			BDE 47	BDE 49	BDE 66	BDE 71	BDE 99	BDE 100	BDE 138	BDE 153	BDE 154	BDE 183	BDE 184	BDE 191	BDE 209		
2004	Hood Canal	30	15	NA	NA	NA	9	1	NA	0	0	0	0	NA	NA	NA	NA
2005	Puget Sound Temporal (10 ³ reps)	24	5	1	1	14	2	0	0	0	0	0	0	NA	NA	NA	16
2006	Strait of Georgia	40	28	0	0	0	14	0	0	2	1	0	6	5	0	0	1
2007	Whidbey Basin	40	22	2	0	0	4	0	0	0	1	0	0	0	0	0	1
2007	Elliott Bay	30	24	14	0	0	13	1	0	0	1	1	0	0	0	0	8
2008/2009	Central Sound	80	46	14	0	0	30	3	0	0	0	2	0	0	0	0	30
2008	Commencement Bay	30	28	4	0	0	22	5	0	5	4	1	0	0	0	0	21
2009	Bainbridge Basin	33	15	10	0	0	6	0	0	0	0	0	0	0	0	0	6
2010	Puget Sound Temporal (10 ³ reps)	25	10	0	0	9	5	0	1	3	0	0	0	0	0	0	19
2010	Bellingham Bay	30	28	3	0	0	11	0	0	0	0	0	0	0	0	0	17
2011	South Puget Sound	43	27	4	0	0	8	1	0	0	0	1	0	0	0	0	8
2011	Budd Inlet	30	23	1	0	0	8	1	0	0	1	1	0	0	0	0	9
Total:			446	305	67	1	148	19	0	8	11	6	6	5	135		
Percent of stations with detected congeners:			68.4	15.0	0.2	0.2	33.2	4.3	0.0	1.8	2.5	1.3	1.3	1.1	30.3		

VI. Summary/Conclusions

- A PBDE baseline has been established for sediments at 10 long-term stations, 5 monitoring regions, and 5 urban bays in Puget Sound.
- PBDEs were detected in sediments from all of the study areas. Only BDE-47, -49, -99, and -209 were detected regularly and at higher levels in urban locations.
- Levels of BDE-209 increased at long-term stations over a five-year period. These stations will be retested in 2015 to determine whether this trend persists.

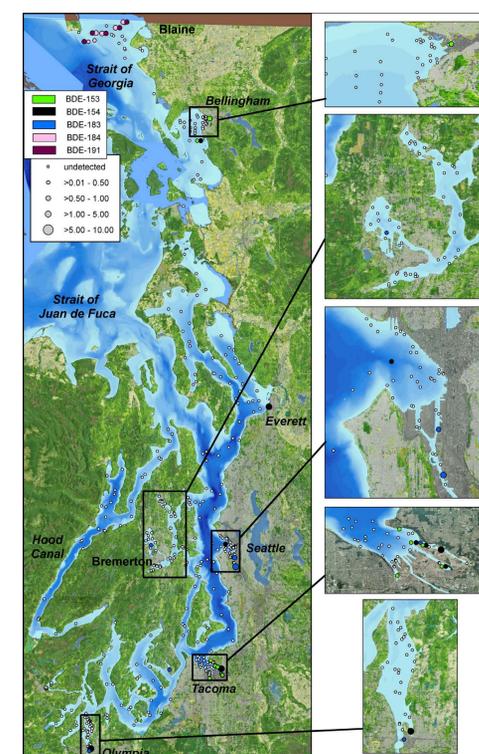
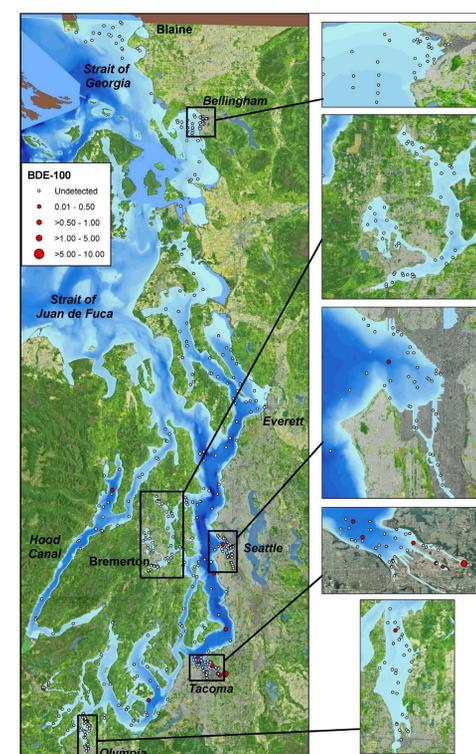
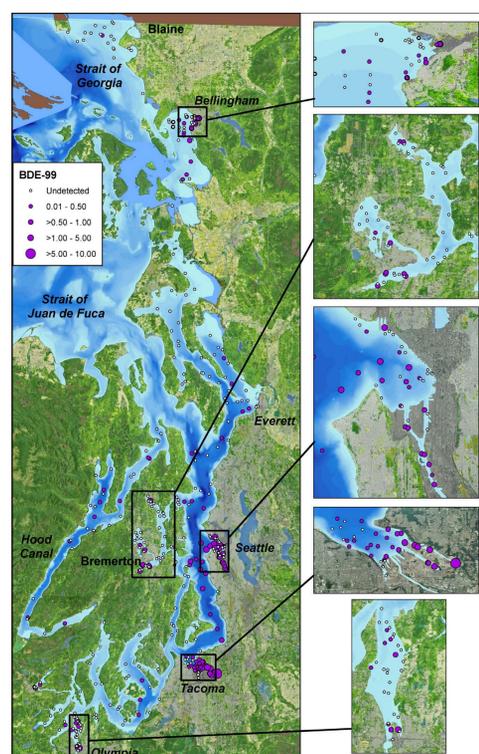
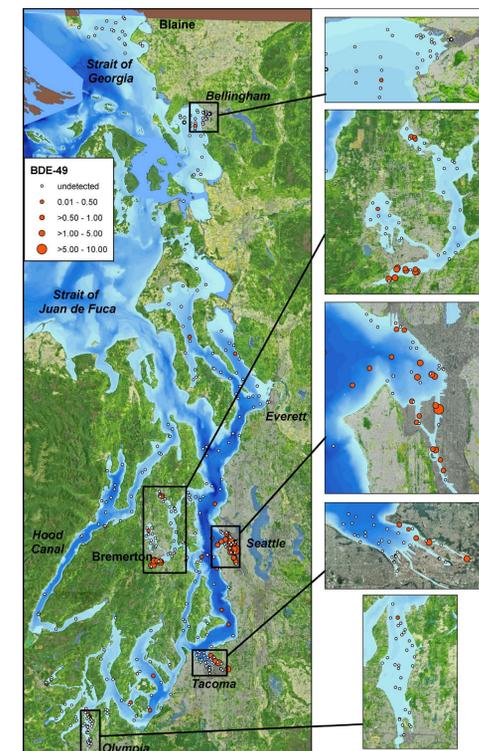
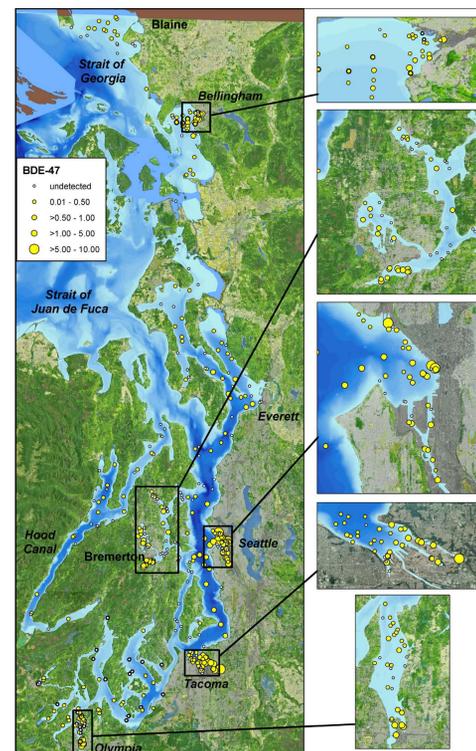
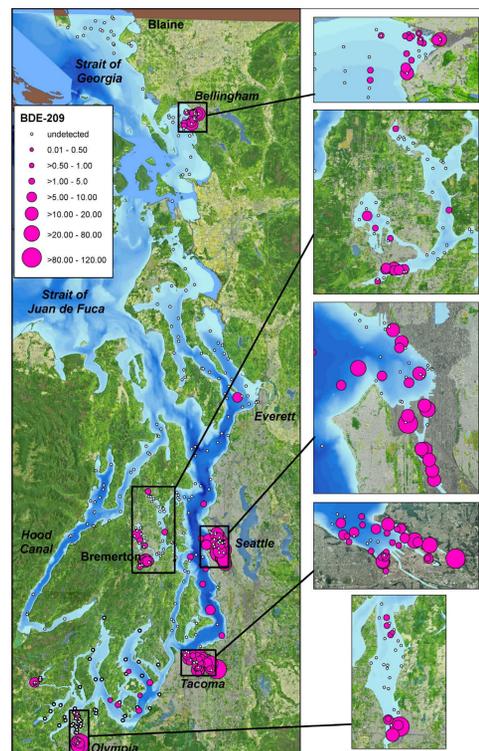


Figure 1. Concentrations (ppb dry weight) of PBDE congeners detected at Puget Sound sediment monitoring stations.

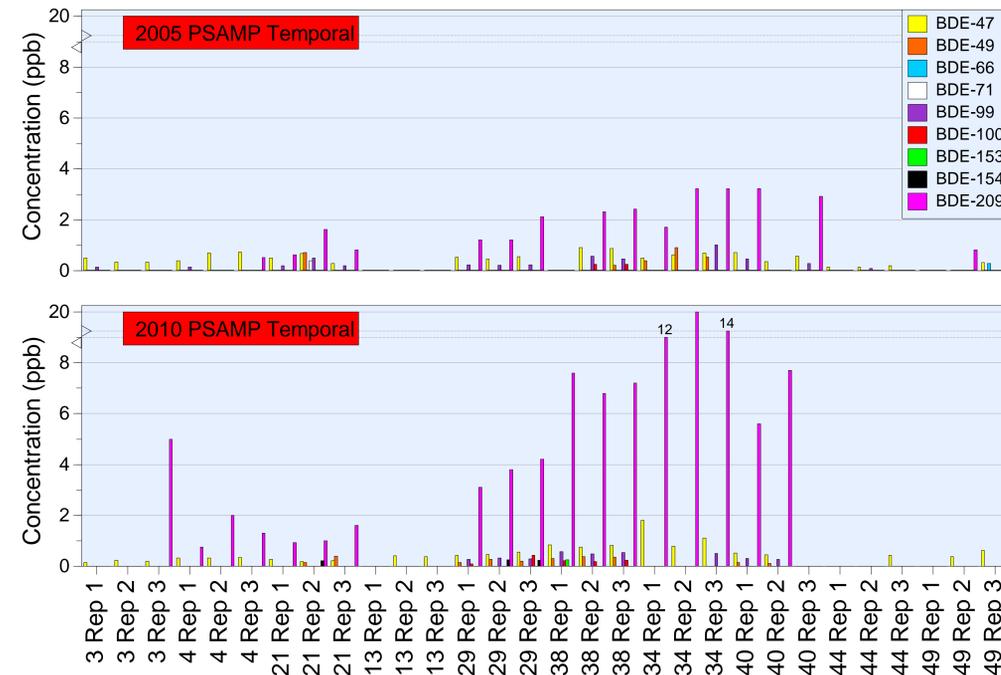


Figure 2. Concentrations (ppb dry weight) of PBDE congeners detected at Puget Sound long-term sediment monitoring stations sampled in 2005 and 2010.