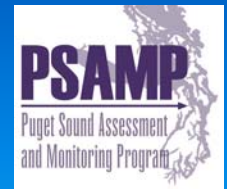


# Polybrominated Diphenyl Ethers (PBDEs) in Puget Sound Sediments

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## I. Findings

- Congeners BDE-47 and -99, and BDE-209, primary components of the commercial penta- and deca-BDE products, are accumulating in the sediments throughout Puget Sound.
- BDE-47 was found at most stations, with highest concentrations at stations near urban/industrial areas and depositional locations.
- BDE-99 and -209 were only found near urban/industrial areas and in sediment depositional areas.
- BDE-209 was the congener found in highest concentrations.
- BDE-47 and BDE-99 were two of the four most prevalent congeners measured in tissues from five Puget Sound fish species.
- As in the sediments, fish tissue concentrations were higher from stations in urban/industrial areas.

## II. Introduction

Polybrominated diphenyl ethers (PBDEs) are a class of brominated hydrocarbons which have been in wide commercial production and use since the early 1970s as flame retardant additives in plastics, foams, textiles, adhesives, coatings, and other household and commercial products. Structurally similar to polychlorinated biphenyls (PCBs), it is now known that PBDEs break down and enter the ecosystem. PBDEs have been classified as Persistent Bioaccumulative Toxics (PBTs), and the WA State Interim Chemical Action Plan for PBDEs calls for baseline monitoring in Puget Sound.

## III. PBDEs in Hood Canal

In June 2004, congeners BDE-47, -99, -100, -153, and -154 were measured in sediments from 30 randomly selected stations throughout Hood Canal. These congeners are predominant in commercially available penta-BDE mixtures, and their levels in the environment have been measured worldwide. Of 180 measured values, 17% were detected, while 83% were undetected. Congeners BDE-47 and -99 were detected in 17 and 10 of 30 samples, respectively, while BDE-100 and -153 were each detected in 1 of 30 samples. Congener BDE-154 was not detected (Figure 1).

## IV. PBDEs in Puget Sound

In April 2005, the 5 penta-BDE congeners measured in 2004 (above); BDE-209, the primary congener in commercial deca-BDE mixtures; and BDE-49, -66, -71, -138, -183, and -184 were measured at ten PSAMP temporal stations located throughout Puget Sound. Of 422 measured values, 16% were detected, while 83% were undetected. As in Hood Canal, BDE-47 and -99 were detected most frequently. Congener BDE-47 was detected at all 10 stations; while BDE-99 was detected at 5 stations, including the deep, depositional Shilshole Bay (sta. 29) and Point Pully (sta. 38) stations, and the stations near urban/industrial areas including Port Gardner (sta. 21), Sinclair Inlet (sta. 34), and the Thea Foss Waterway (sta. 40). Congener BDE-209 was also detected at these 5 stations, and at the station in Budd Inlet (sta. 44). Congeners BDE-49, -66, -71, and -100, were detected at 3, 1, 2, and 1 station(s), respectively. Congeners BDE-138, -153, -154, -183, and -184 were not detected in any samples (Figure 2).

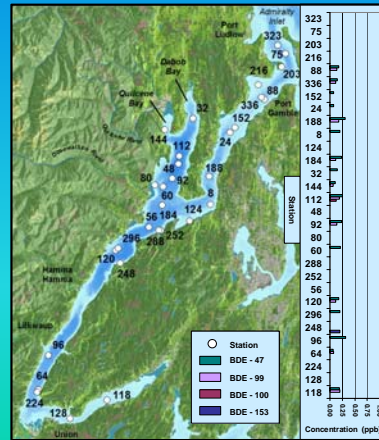


Figure 1. Concentrations (ppb dry wt) of PBDE congeners detected at 30 PSAMP sediment monitoring stations collected from Hood Canal in June, 2004. (Congener BDE-154 was included in the analysis, but not detected in any sample.)

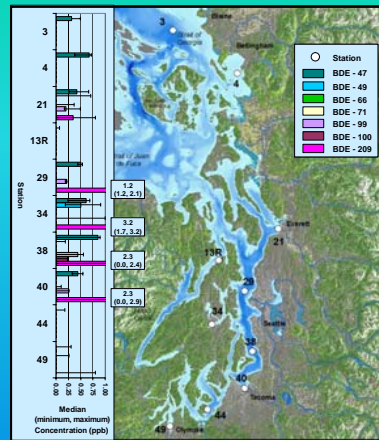


Figure 2. Concentrations of PBDE congeners detected at 10 PSAMP long-term sediment monitoring stations collected from Puget Sound in April, 2005. (Congeners BDE-138, -153, -154, -183, -184 were included in the analysis, but not detected in any sample.)

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](http://www.ecy.wa.gov/programs/eap/mar_sed/msm_intr.htm)

## V. PBDE concentrations in sediments nationally and worldwide

Comparison of the Puget Sound sediment PBDE data with data from the San Francisco estuary and various European and Asian marine surveys indicated that BDE-47, -99, and -209 were the prevalent congeners found to be accumulating in marine and estuarine sediments worldwide. Levels of BDE-209 in Puget Sound were the lowest of all eight surveys, while BDE-47 and -49 were only lower than levels in three of the other surveys (Figure 3).

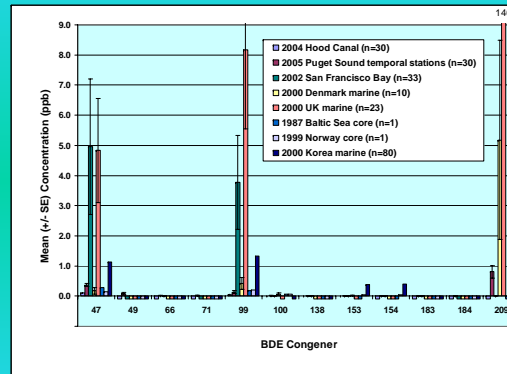


Figure 3. Mean (+ standard error) concentration (ppb) of 12 BDE congeners measured in marine sediments worldwide. Congeners measured, but below detection limits, were set to zero. Bars extending below the x axis represent congeners not measured or reported. (Data compiled from Oros, et al. 2005; Hites, et al. 2004; Christensen and Platz, 2001; and Allchin and de Boer, 2001.)

## VI. PBDE concentrations in Puget Sound fish

Eleven of the 12 congeners measured in the sediments were also measured in tissue from 5 species of fish collected from Puget Sound by O'Neill and West, Washington Department of Fish and Wildlife. Of these, seven were detected in the fish tissue, while four (BDE-71, -138/166, -183, and -209) were usually below method detection limits. (Figures 4 a-c). All species accumulated BDE-47 in the highest concentrations, while -49 was relatively high in the herring and Chinook samples. Congeners BDE-99 and -100 were relatively high in all species except the Quillback Rockfish. Congeners BDE-66, -153, and -154 were present, but relatively low in all five species. Levels of PBDEs in English Sole muscle tissue were highest in and near urban/industrial bays and decreased in more rural areas (Figure 4a). Levels of PBDEs in herring tissue were highest in southern stocks and lowest in the most northern stocks (Figure 4b). Whether high or low, proportions of the various BDE congeners appeared to remain consistent within species between locations.

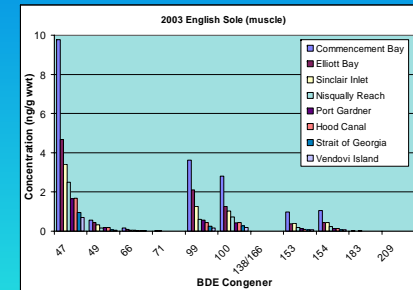


Figure 4a. Concentration (ng/g wet weight) of 11 BDE congeners measured in English Sole collected from various locations in Puget Sound. Congeners measured, but below detection limits, were set to zero. (Data from S. O'Neill and J. West, Washington Department of Fish and Wildlife.)

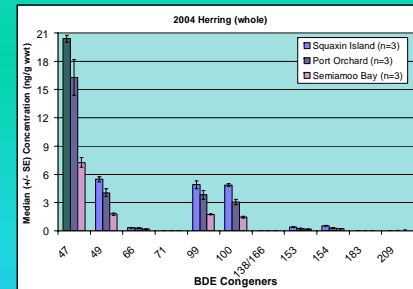


Figure 4b. Median (+ standard error) concentration (ng/g wet weight) of 11 BDE congeners measured in herring from various locations in Puget Sound. Congeners measured, but below detection limits, were set to zero. (Data from O'Neill and West, Washington Department of Fish and Wildlife.)

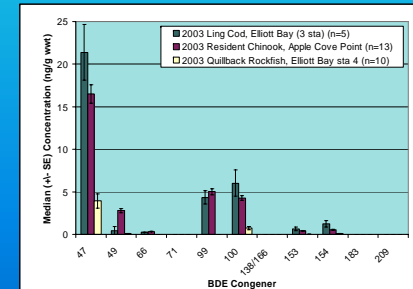


Figure 4c. Median (+ standard error) concentration (ng/g wet weight) of 11 BDE congeners measured in Ling Cod, resident Chinook salmon (Blackmouth, subadults), and Quillback Rockfish from various locations in Puget Sound. Congeners measured, but below detection limits, were set to zero. (Data from O'Neill and West, Washington Department of Fish and Wildlife.)