Using transplanted mussels to assess contaminants in Puget Sound's nearshore habitats

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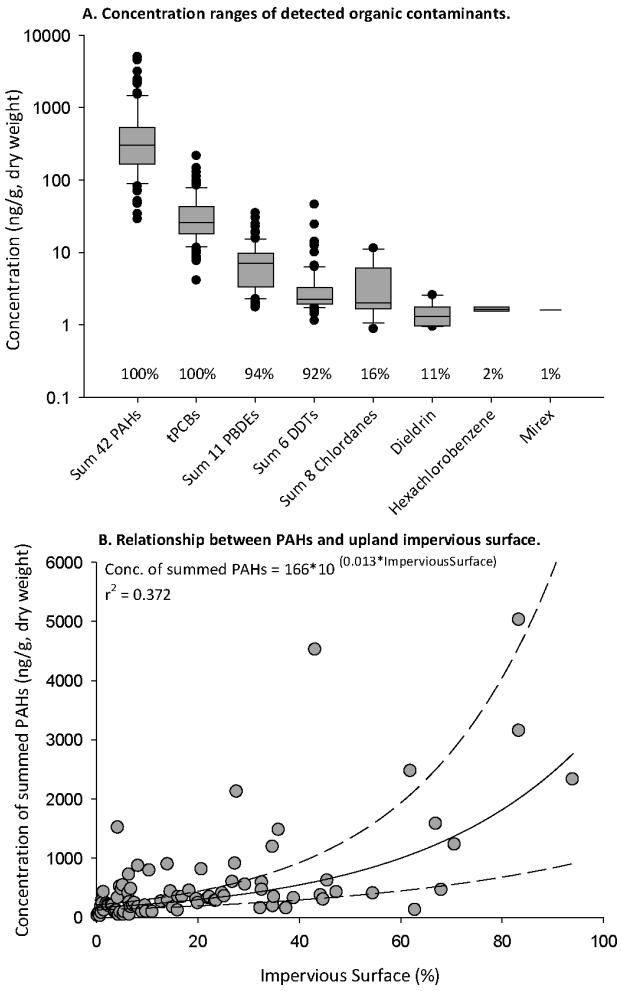
- Our findings suggest toxic contaminants are entering the nearshore food web of the Puget Sound, especially along shorelines adjacent to highly urbanized areas; polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and dichlorodiphenyltrichloroethanes (DDTs) were the most abundant organic contaminants measured in mussels.
- There were significant positive correlations between upland watershed land development and nearshore levels of PAHs, PCBs, PBDEs, DDTs, lead, copper, and zinc.

Understanding the sources, fate, and transport of contaminants in the Puget Sound nearshore marine food web improves our ability to mitigate the harm pollution causes to the biota residing in our nearshore environments. In the winter of 2012/13 the Washington Department of Fish and Wildlife (WDFW), with the help of other state, county and city agencies, tribes, non-governmental organizations (NGOs), and citizen science volunteers, conducted the first synoptic, Puget Sound-wide assessment of toxic contaminants in nearshore biota, using bay mussels *(Mytilus trossulus)* as the indicator species. Since wild mussels were not available in all areas, transplanted mussels taken from a relatively uncontaminated aquaculture source in Penn Cove, Whidbey Island, were used for this pilot study.

Polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and dichlorodiphenyltrichloroethanes (DDTs) were the most abundant organic contaminants measured (Figure A). PAHs and PCBs were detected in mussels from every site and the highest concentrations were observed in four of the Puget Sound's most urbanized embayments: Elliott Bay, Salmon Bay, Commencement Bay, and Sinclair Inlet. PBDEs and DDTs followed a similar pattern, though lower in overall concentration. Lead, copper, zinc, cadmium, mercury, and arsenic were also detected in low levels at all of the study sites. There were significant positive correlations between upland watershed land development (impervious surface) and nearshore levels of PAHs (Figure B), PCBs, PBDEs, DDTs, lead, copper, and zinc. PAH analyte pattern analysis in mussels (not shown for brevity) suggested the majority of nearshore sites were dominated by pyrogenic sources; however, atypical patterns at a few locations suggested petroleum sources may have contributed a larger proportion in those areas. In addition, PCB congener-ratio analysis suggested urban embayments in the central Puget Sound are sources of PCBs for non-urban areas.

These findings suggest toxic contaminants are entering the nearshore food web of the Puget Sound, especially along shorelines adjacent to highly urbanized areas. The nearshore contaminant patterns observed in this study support patterns observed in previous mussel monitoring studies in the Puget Sound, where higher concentrations ("hotspots") were found in areas of high urbanization (Kimbrough et al., 2008; Mearns 2001; Puget Sound Action Team, 2007). This pattern is also seen in studies of benthic and pelagic fish and shellfish in the Puget Sound (Carey et al., 2014; West et al., 2001) confirming the role of urbanization as a major source of pollution to our marine waters.

As a result of the success of this pilot study, a new, collaborative mussel monitoring program has emerged in Puget Sound. This new program is principally funded through Stormwater Action Monitoring, but includes a number of other sponsoring entities including many who participated in the pilot study. In addition, hundreds of WDFW and NGO citizen science volunteers continue to provide critical field support during mussel deployment and retrieval along the greater Puget Sound coast. Data from the latest round of mussel monitoring (2015/16) is currently being analyzed and a final report will be released in the summer of 2017. The next deployment of mussels will occur in the winter of 2017/18. Groups interested in participating in Washington State's mussel monitoring are encouraged to contact the lead author of this study at WDFW.



(A) concentrations of organic contaminants detected in mussels and % of sites where contaminants were detected; (B) concentration of 42 summed PAHs in mussels increased with % impervious surface ($p < 0.0001$), dots represent sites, solid curve is a regression, dotted curves are 95% confidence intervals.

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