Biomagnification, oceanographic processes, and the distribution of toxic contaminants in Puget Sound's pelagic food web

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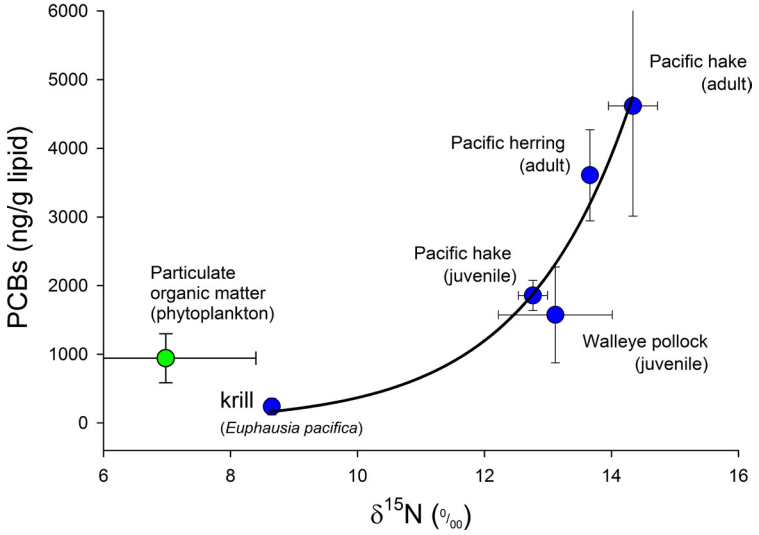
Puget Sound's pelagic food web is characterized by high concentrations of polychlorinated biphenyls (PCBs) in its apex predators, including killer whales (*Orcinus orca*; Ross et al. 2000) and harbor seals (*Phoca vitulina*; Ross et al. 2004), and in the pelagic fish and invertebrate prey that make up the base of this food web (West et al. 2008, O'Neill and West 2009, West et al. 2011a, 2011b). In a 2010 central Puget Sound study, PCBs increased exponentially with trophic level, from primary producers (phytoplankton, represented as particulate organic matter) through primary consumers (krill, *Euphausia paci ica*), secondary consumers (juvenile forms of predatory pelagic fish), and tertiary consumers (adult Pacific hake, *Merluccius productus).* PCB concentration in this range of species varied from approximately 300 to over 5000 ng/g lipid weight (Figure, data from West et al. 2011a, 2011b). High PCB levels in particulate organic matter suggest PCBs concentrate at the base of the pelagic food web as these contaminants enter surface waters. This notion of a direct pelagic food web pathway challenges the paradigm that particulate PCBs sink quickly, accumulate primarily in sediments, and enter pelagic biota primarily via a benthic-to-pelagic food web linkage (or via resuspension).

Puget Sound exhibits five characteristics that may increase the availability of PCBs for uptake by pelagic biota:

- strong stratification related to high freshwater inputs may slow the sinking rate of PCB-laden particles, resulting in their aggregation at the density gradient, where particulates may stimulate grazing by microplankton,
- abundant pelagic micro-grazers promote remineralization and recycling of organic material in surface waters, which competes with the benthic-pelagic coupling,
- deep, fjord-like basins support vertically migrating macrozooplankton such as krill, which intercept and feed on sinking particles; krill break up particles during feeding and reduce their sinking rate, promoting retention of particle-bound PCBs in mid- and surface waters,
- a relatively long pelagic food chain, including vertically migrating zooplankton, increases the probability of pelagic biomagnification, and
- a complex microbial community, characterized notably by abundant and potentially increasing populations of positively buoyant heterotrophs like Noctiluca scintillans, may increase recycling of biota-bound PCBs in surface waters.

Elliott Bay is a particularly suitable area to test these concepts because it is deep enough to support resident populations of vertically migrating macrozooplankton, it regularly exhibits strong density-stratification, and it receives some of the greatest inputs of PCBs of any location in Puget Sound. A comparison of Elliott Bay biota with those from a shallower, less stratified yet similarly PCB-contaminated embayment such as Sinclair Inlet could provide valuable information regarding best actions to reduce PCBs in Puget Sound's pelagic food web.



Biomagnification model of PCBs in the pelagic food web of the Puget Sound's central basin. Mean PCB concentration (ng/g lipid, 95% confidence intervals) in six pelagic species or groups representing a wide range of trophic levels. Trophic levels represented by the abundance of the rare but stable isotope of nitrogen, ^{15}N, expressed as a ratio to its more abundant ^{14}N isotope, measured in whole bodies of the organisms. Particulate organic matter, representing primary producers, were size-selected plankton samples targeting phytoplankton blooms, and were dominated by centric and pennate diatoms and dinoflagellates. Consumer groups were Pacific krill (*Euphasia pacifica*), Pacific herring (*Clupea pallasii*), Pacific hake (*Merluccius productus*), and walleye pollock (*Theragra chalcogramma*).

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