

Time trends of three major classes of toxic contaminants in two indicator fish species from Puget Sound



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- PCBs have declined significantly in herring from the low-development basin; they are still elevated in the more-developed central and south Puget Sound basins.
- PCBs have increased or decreased in English sole from 10 index sites.
- PBDEs primarily declined or remained static in herring and English sole in Puget Sound.

Two classes of persistent environmental contaminants, polychlorinated biphenyls (PCBs) and polybrominated diphenylethers (PBDEs) have been monitored in two indicator fish species, English sole (*Parophrys vetulus*) and Pacific herring (*Clupea pallasii*) since 1994 in Puget Sound. English sole, a common and abundant flatfish that reflects sediment contaminant conditions, are currently sampled biennially at ten index sites, ranging from highly developed habitats such as the Seattle waterfront and Tacoma's City Waterway, to less developed habitats in Hood Canal and northern Puget Sound (Southern Strait of Georgia). Pacific herring are a small-bodied, open-water planktivore that reflect contaminant conditions in the pelagic food web. Herring results are summarized for four distinct stocks in southern (Squaxin), central (Port Orchard/Madison), and northern (Semiahmoo and Cherry Point) Puget Sound.

The rate of change of PCBs and PBDEs was modeled by regressing the contaminant concentration of tissue composite samples against time (year), with up to three biological covariates (fish size, tissue lipid concentration, and sex ratio). Rate of change was a significant factor in 18 of the 28 regression models ($p > 0.05$, Table); time explained moderate amounts of contaminant variability (partial r^2 from 0.11 to 0.41) in 13 regressions, and time was a low or trivial factor in five regressions (partial $r^2 < 0.10$; Table). Ten regressions were not significant ($p > 0.05$), indicating no change in contaminants over the monitored time period. Semiahmoo and Cherry Point herring exhibited moderate declines in PCBs (-4.0% and -2.3%), whereas herring from the other two stocks exhibited no change (Squaxin), or a weak decline (Port Orchard, -1.1%). The PCB decline in herring from Port Orchard, however, is indistinguishable from the normal, low variability observed in the analytical method, and so should be interpreted with caution. PCBs increased in English sole from two highly developed sites (Seattle Waterfront, 3.6%; Tacoma City Waterway, 6.2%), two moderately

	Basin ^a	Land Development	PCBs ^b			PBDEs ^c		
			n	Year Range	Rate (%)	n	Year Range	Rate (%)
<i>Pacific Herring</i>								
Cherry Point	NPS	low	40	94-14	-2.3	36	94-14	-4.3
Semiahmoo	NPS	low	85	99-14	-4.0	47	01-14	-8.1
Port Orchard	CPS	high	116	99-14	-1.1	78	01-14	-7.0
Squaxin	SPS	medium	115	99-14	NC	73	01-14	-4.5
<i>English Sole</i>								
Str. Georgia	NPS	low	55	97-15	NC	33	05-15	NC
Vendovi Is.	NPS	low	55	97-15	NC	36	05-15	-7.2
Everett	WB	medium	55	97-15	7.1	34	05-15	5.9
Hood Canal	HC	low	57	97-15	2.8	41	98-15	-3.2
Eagle Harbor	CPS	medium	31	98-15	2.9	19	05-15	NC
Duwamish River	CPS	high	26	07-15	NC	26	07-15	NC
Seattle Waterfront	CPS	high	56	97-15	3.6	35	05-15	-3.7
Bremerton	CPS	high	52	97-15	NC	37	98-15	-4.0
Tacoma City Wway	CPS	high	56	97-15	6.2	31	05-15	NC
Anderson Is.	SPS	low	57	97-15	3.6	36	05-15	NC

^a oceanographic basins as follows: NPS (north Puget Sound), CPS (Central Puget Sound), SPS (south Puget Sound), HC (Hood Canal), and WB (Whidbey Basin)

^b estimate of total PCBs based on an algorithm using 17 selected congeners; Lauenstein, G. G. and A. Y. Cantillo, Eds. (1993). Sampling and analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects. 1984-1992. Silver Spring, MD, National Oceanic and Atmospheric Administration Technical Memorandum NOS ORCA 71.

^c sum of detected values of 11 selected PBDE congeners

Rate of change of two contaminant groups in benthic English sole and pelagic Pacific herring over various time periods from 1994 to 2015, and across a wide range of land development levels. Bolded rates indicate moderately significant changes (partial $r^2 \geq 0.10$, < 0.42); unbolded rates are statistically significant but weak (partial $r^2 < 0.10$). NC indicates no significant change.

developed sites (Eagle Harbor, 2.9%; Everett, 7.1%), and two low-development sites (Anderson Island, 3.6%; Hood Canal, 2.8%). PCBs remained static in English sole from the Strait of Georgia and Vendovi Island. PBDEs declined moderately to strongly in all four herring stocks, with rates ranging from -4.3% to -8.1%. PBDEs declined moderately in English sole from Seattle Waterfront (-3.7%), Bremerton (-4.0%), Vendovi Island (-7.2%), and Hood Canal (-3.2%). Five other sites showed no change in PBDEs, and PBDEs increased in English sole from one site, Everett (+5.9%).

These results indicate that although PCBs have declined in herring from the low-development basin, they are still problematic in the more developed central and south Puget Sound, and in English sole from several sites throughout the sound. PCBs appear to persist, especially in the urbanized pelagic food web, despite prohibitions against their production and use. PBDEs declined or remained static widely in both species (except for English sole from one site), suggesting that source controls and mitigation efforts for PBDEs have been somewhat successful.

RECOMMENDED CITATION

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