

White-Puyallup Watershed Freshwater Fish Contaminant Monitoring Program 2024 Results



Environmental Assessment Program

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Abstract

The White-Puyallup watershed is a major tributary of the Puget Sound Basin and is formed by the White, Puyallup, and Carbon rivers. This river system has been extensively surveyed for toxics in water and anadromous or marine fish, but resident freshwater fish have received little attention. In 2024, we collected resident fish species from seven sites across the river system. Fish were analyzed for PBDE and PCB congeners, and results were compared to Washington Department of Health (DOH) consumption screening levels and Washington Department of Ecology (Ecology) water quality standards. Fish tissue PCB concentrations exceeded Ecology's water quality standard for carcinogenic contaminants at all sites but did not exceed DOH fish consumption screening levels. PBDE tissue concentrations did not exceed DOH consumption screening levels but were significantly elevated at sites within the lower river system. The widespread presence of PCBs in fish tissues indicates that additional source assessment work is needed to identify background sources of PCBs within the watershed. These survey results will be used in Ecology's Water Quality Assessment and shared with DOH for further evaluation.

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Background

The White-Puyallup watershed is located in the Puget Sound Basin and drains approximately 1,056 square miles from the glaciers of Mount Rainier through the Cascade Foothills and Puget Sound Lowlands to its terminus in Commencement Bay. The watershed consists of over 1,287 linear miles of rivers and streams, of which three major rivers, White, Puyallup, and Carbon, converge to flow into the Puget Sound. The headwaters and upper reaches of these river systems lie within forest lands with little to no urbanization (Figure 1). The lower reaches of the river system traverse through densely populated areas before flowing into Commencement Bay near Washington State's third largest city, Tacoma.

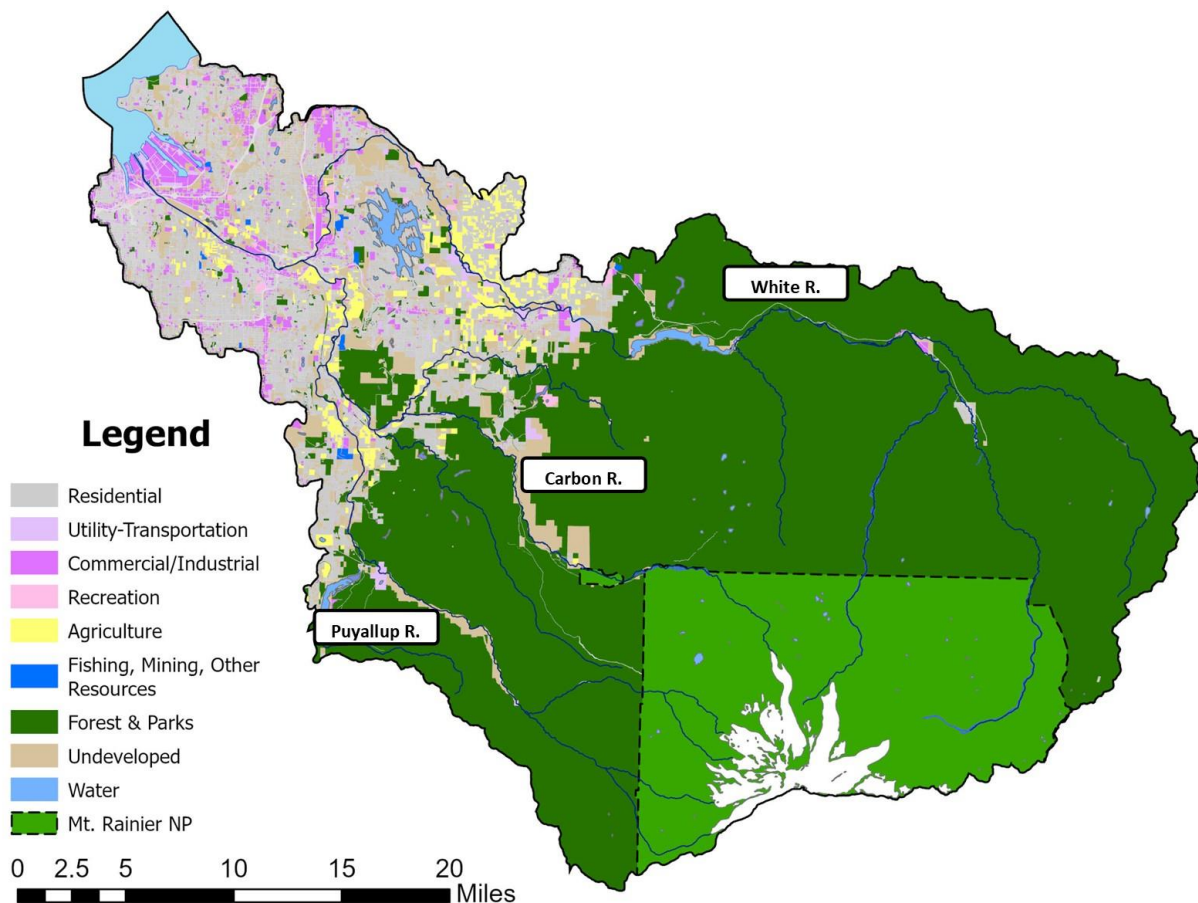


Figure 1. Land use map for the White-Puyallup Watershed.

The river system is of economic and ecological importance, hosting numerous salmonid species including Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*) salmon, steelhead and rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*). The shores and waters of the rivers are also of cultural importance to the Puyallup Tribe of Indians.

and Muckleshoot Indian Tribe, whose usual and accustomed areas and ancestral lands encompass these rivers.

Previous surveys of marine fish species and juvenile Chinook salmon in the White-Puyallup watershed have shown accumulation and potential impacts of toxic chemicals, specifically polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs). Juvenile Chinook residing in the Puyallup River estuary and nearshore habitat were shown to have tissue concentrations of PBDEs and PCBs that exceed fish health thresholds known to cause adverse sublethal effects (O'Neill et al. 2015). Further surveys of juvenile Chinook stomach contents and livers from Commencement Bay found PCBs at concentrations which could cause decreased growth rates and suppress immune function (Stehr et al. 2000).

Additionally, English sole (*Parophrys vetulus*), Dungeness crab (*Metacarcinus magister*), and mussels (*Mytilus trossulus*) surveyed within Commencement Bay between 2006 and 2017 had tissue concentrations which exceeded Ecology's water quality standards for PCBs in fish tissue. These exceedances have led to parts of Commencement Bay being listed as impaired on the Environmental Protection Agency (EPA) 303(d) list. Portions of the Thea Foss, Blair, and Hylebos waterways, which make up part of the Puyallup River estuary, are included within these impairment listings.

While anadromous and marine fish species from the White-Puyallup watershed have been surveyed for contaminants extensively, there has been no comprehensive survey of contaminants in resident fish species within the watershed's major tributaries. This is a data gap in the state's inventory of contaminants in freshwater fish given the watershed's size and importance to the densely populated Puget Sound Region.

To address this data gap, Ecology's Freshwater Fish Contaminant Monitoring Program (FFCMP) surveyed resident fish within the Puyallup, White, and Carbon rivers in the summer of 2024. Standard collection methods, processing, and analysis methods were used (Seiders and Sandvik 2020; Bednarek and White 2024) to determine tissue concentrations of PBDEs and PCBs in resident fish species. Multiple sites across the watershed were selected to evaluate geographic differences in fish tissue concentrations. Results from this survey were compared to Ecology's Water Quality Standard for PCBs and the Washington State Department of Health (DOH) consumption screening levels for PBDEs and PCBs. This report summarizes the results from the 2024 survey and compares the results to statewide resident fish tissue results.

Methods

In 2024, FFCMP sampled freshwater fish from seven sites in the White-Puyallup watershed for analysis of PBDEs and PCBs. Three sites were located along the White River (lower, middle, and upper), two sites along the Puyallup River (lower and upper), and one site each within the Carbon River and Lake Tapps Flume (Figure 2). Site selection was designed to collect fish from

urbanized and non-urbanized areas of the river system, and leverage site accessibility and pre-existing collection opportunities.

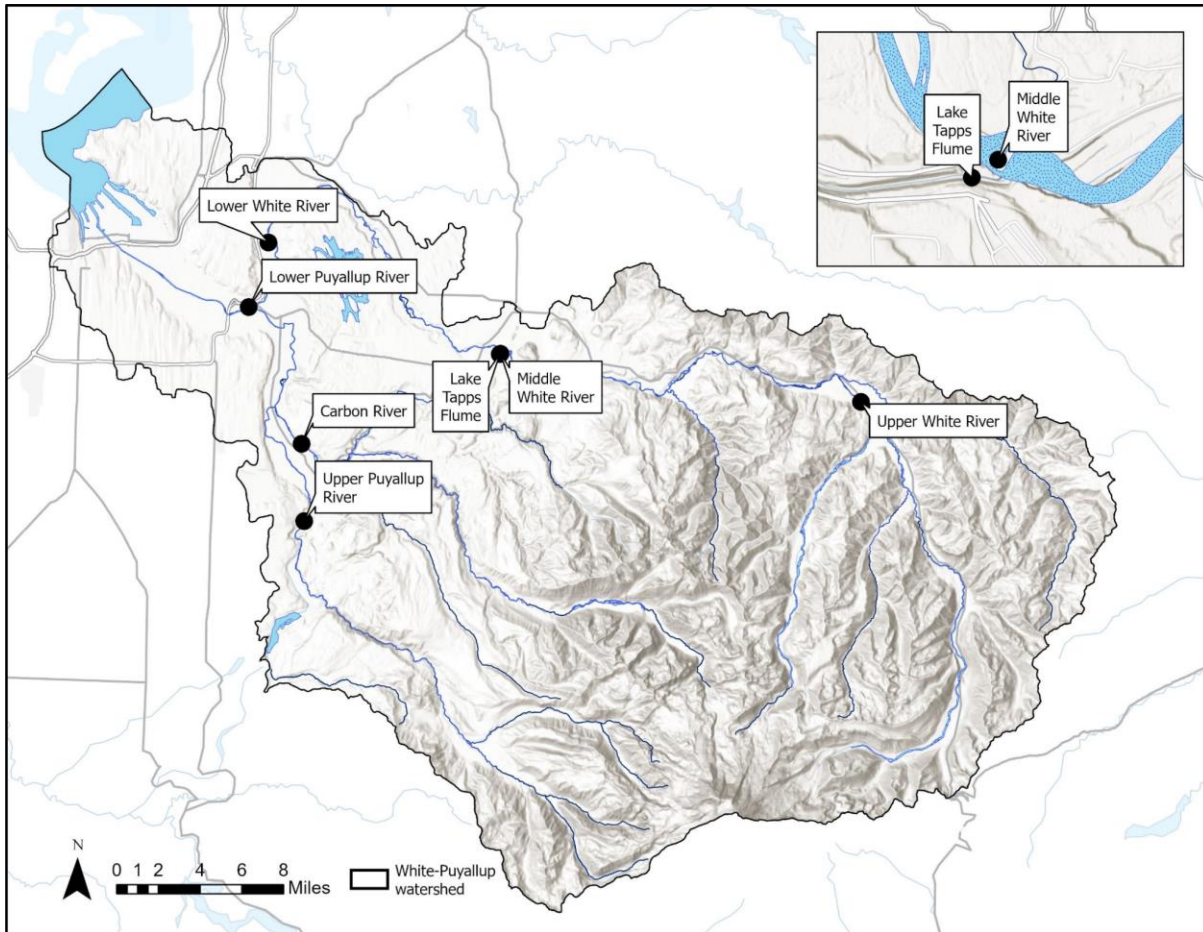


Figure 2. Map of fish collection locations within the White-Puyallup watershed.

We sampled fish from June to August 2024 to avoid disturbing spawning runs of Spring and Fall Chinook. Two species of resident fish were collected: mountain whitefish (*Prosopium williamsoni*) (n=173) and rainbow trout (*O. mykiss*) (n=12). Numerous other fish species were observed, including sculpin spp., juvenile sucker spp., lamprey spp., bull trout (*Salvelinus confluentus*), Chinook salmon (*Oncorhynchus tshawytscha*), cutthroat trout (*O. clarkii*), and steelhead trout (*O. mykiss irideus*). Mountain whitefish and rainbow trout were selected for collection due to their abundance and prevalence across the study area.

Backpack electrofishing equipment and seine nets were used to collect fish. Backpack electrofishing was the primary means of fish collection due to limited success with seine nets. Once collected, each fish was weighed and measured in the field, then wrapped in aluminum foil and stored on ice until being frozen upon returning from the field (Ecology 2018a).

Fish were composited by site based on length, with 3 – 7 fish in each sample. Skin-on fillets were collected from each fish, homogenized, and composited based on Ecology SOPs (Ecology

2018b and Ecology 2018c). Representative scales were collected from each fish and sent to the Washington Department of Fish and Wildlife's fish aging laboratory for aging analysis. Table A-1 summarizes fish composite data for each site.

Fish tissue samples were analyzed for PBDEs, PCBs, and lipids at accredited laboratories using methods specified in the project's quality assurance project plan (QAPP) (Bednarek and White 2024). Manchester Environmental Laboratory (MEL) performed the PBDE and percent lipid analyses by methods SW8270E and SOP730009, respectively. SGS AXYS analyzed samples for PCB congeners by method 1668C. MEL validated PCB results at the Stage 2B level, which includes review of sample receipt conditions, data completeness, and sample- and instrument-related QC results.

PBDE and PCB tissue concentrations were compared to Washington's water quality standards and DOH consumer screening values for informational purposes only. Washington water quality standards include tissue exposure concentrations for carcinogenic contaminants (TEC_c). DOH uses screening levels rooted in similar human health risk equations. The exceedance of these thresholds does not imply the impairment status of waterbodies or that fish are not safe to eat. Results will be evaluated by Ecology's water quality assessment process as outlined in Policy 1-11 (Ecology 2018d). Fish consumption guidance will be provided by DOH upon evaluation of data.

PBDE and PCB congener results were summed to determine total PBDE/PCB concentrations. Results qualified as non-detects based on reporting limits, and laboratory blanks were excluded from sums. PCB congener results less than or equal to 5 times (5x) the laboratory blank concentration were censored due to blank contamination to prevent interpretation of false positives.

PBDE and PCB results were explored for potential relationships with composite mean length, weight, age, and percent lipid. Due to weak and variable relationships between these variables and PBDE/PCB concentrations, results were not lipid-normalized for further data analyses. A Kruskal-Wallis non-parametric hypothesis test was used to compare geographic trends in total PBDE and PCB congeners across sites. Where significant differences were found, a pairwise comparison was performed using a Dunn Test with Benjamin-Hochberg adjusted p-values. Non-detects and replicates were not included in the testing groups.

Results

Measurement Quality Objectives

Fish collection goals were met for all sites, though species were limited to mountain whitefish except at the upper White River site where rainbow trout were also collected. In total, 185 fish were collected and composited into 35 samples. Two composite samples were split after homogenization and submitted as field duplicates. In total, 37 samples were analyzed for PBDEs, PCBs, and lipids. Table A-1 summarizes the species and number of fish per composite.

Three individual fish were analyzed as their own samples due to the lack of similar size groupings for compositing.

Table 1 summarizes the rates of non-detects, results qualified as estimates, and results censored due to method blank contamination for PBDE and PCB analysis. Several PCB results were qualified as estimates due to the exceedance of field duplicate control limits. Estimated results were deemed acceptable and included in data analyses and total PBDE/PCB sums.

Table 1. Rates of non-detects, estimates, and method blank censored results.

Parameter	Non-detect (%)	Estimate (J) (%)	Method Blank Censored (%)
PCBs	22.0	33.8	2.4
PBDEs	75.3	14.8	0

J = The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample.

Result accuracy and precision were deemed acceptable based on the results from labeled recovery and internal standards, ongoing precision and recovery samples, and lap duplicates. Certified reference material (CRM) was extracted and analyzed with each batch of PCB samples. CRM samples met criteria with some exceptions. Data were not qualified based on CRM results.

Detection and reporting limits met method quality objectives as outlined in the QAPP. Results were compared to method blanks using 5x the concentration detected in the blank to censor results. Results which were less than or equal to 5x the method blank concentration were censored and not included in sums of total PBDEs and PCBs. No PBDE results were censored due to method blanks, and only 2.4% of PCB results were method blank censored.

Laboratory Results

Fish tissue results from the White-Puyallup watershed are summarized in Table 2 and outlined by site in Table A-1. PBDEs and PCBs were detected in all fish tissue samples. The highest concentrations of PBDEs and PCBs were detected at the lower Puyallup River site, with mean concentrations of 8.84 µg/kg and 4.32 µg/kg, respectively. The lowest concentrations were measured at the upper White River site, where mean concentrations were 0.259 µg/kg and 2.02 µg/kg (Figure 3).

Table 2. Summary of fish tissue results.

Parameter	Minimum	Median	Max	Detection Frequency (%)
Total PCBs (µg/kg)	0.72	2.60	7.27	100
Total PBDEs (µg/kg)	0.07	1.79	25.71	100
Lipids (%)	1.79	4.64	6.87	100

BDE-47 and BDE-99 were the most commonly detected PBDEs, making up between 74% and 100% of the total PBDE concentration. Four PBDEs, BDE-71, BDE-183, BDE-191, and BDE-209, were not detected in any sample. PCB penta- and hexa- homologs were found at the highest concentrations in tissue samples and made up between 18% and 46.5% of the total PCB concentrations. Eight PCB congeners were not detected in any sample: PCB-03, PCB-07, PCB-112, PCB-142, PCB-145, PCB-161, PCB-169, and PCB-186.

Lipid concentrations varied between fish composites and sites with no clear correlation to fish length or weight. Linear regression was used to explore correlations between percent lipid and total PBDE and total PCB concentrations. No significant correlation existed between these contaminants and lipids.

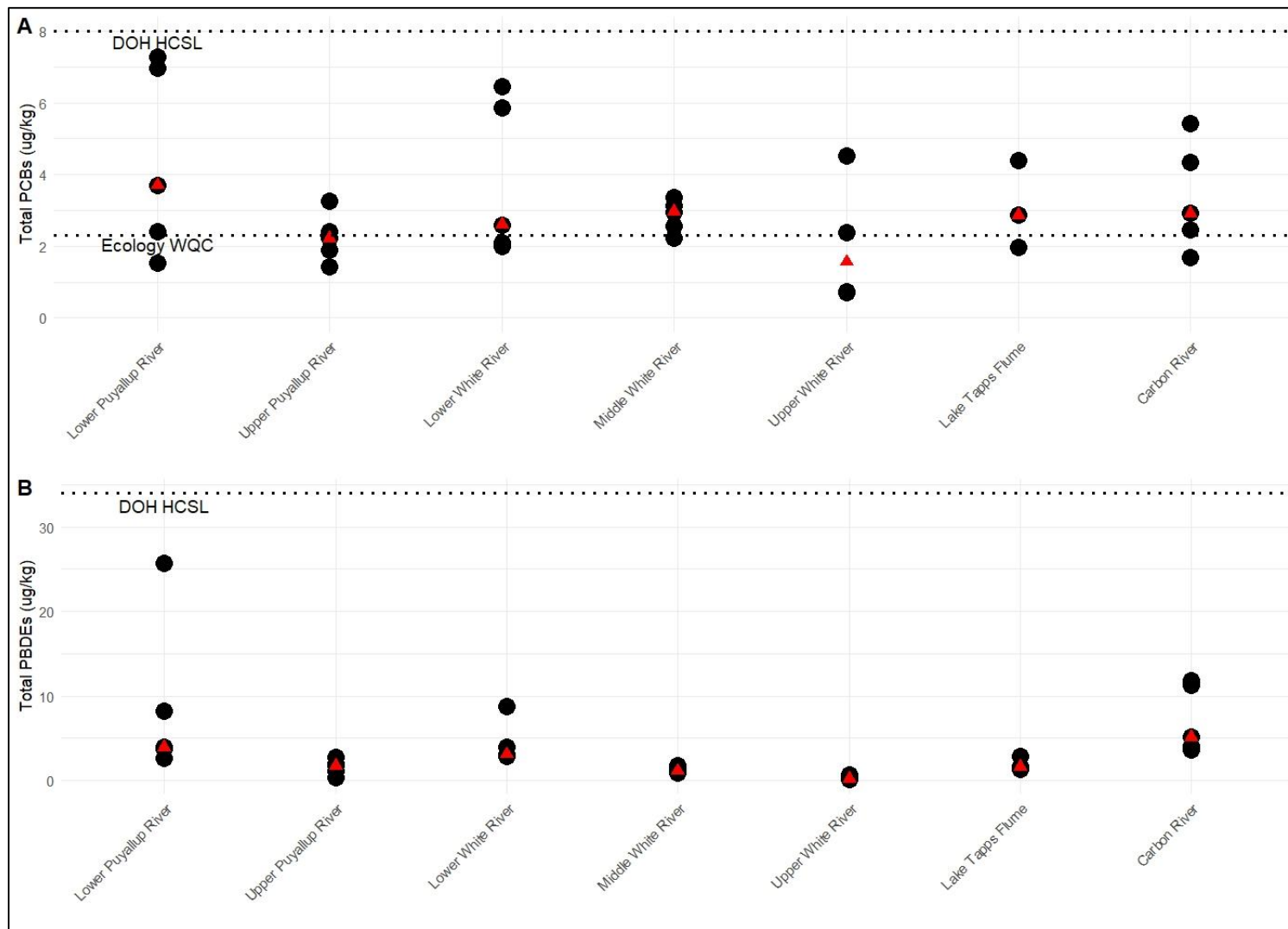


Figure 3. Mountain whitefish composite total PCB (A) and PBDE (B) concentrations by site.

Black dots represent composite concentrations for total PCBs and PBDEs. Red triangles represent site median composite concentrations. DOH HCSL = Washington State Department of Health — Consumption Screening Level; Ecology WQC = Water Quality Criterion.

Human Health Standards Comparison

PCBs were found at levels that exceed Washington's water quality standards for carcinogenic contaminants ($10 \times \text{TEC}_c$) at all sites Figure 3A. Median site concentrations (red triangles) are used to assess exceedances of water quality standards using the $10 \times \text{TEC}_c$ threshold. Median composite concentrations for total PCBs exceeded water quality standards at the following sites: lower Puyallup River, lower White River, middle White River, Lake Tapps Flume, and Carbon River. These exceedances may lead to new 303(d) listing after assessment by Ecology's Water Quality Program. Median PCB concentrations did not exceed the TEC_c at upper White River and upper Puyallup River sites.

PCB and PBDE concentrations did not exceed DOH's screening levels at any site (Figure 3 A and B). Two individual fish collected at the lower Puyallup River site had total PCB concentrations near the DOH screening level ($8 \mu\text{g}/\text{kg}$). PCB and PBDE results will be provided to DOH for further assessment.

Fish Health

Based on results from this study, adverse effects on resident fish health from PBDE and PCB exposure should be considered. While the adverse effect thresholds are often species-specific, mountain whitefish are in the same family as juvenile Chinook which are known to be sensitive to many toxic chemicals. One of 35 samples of mountain whitefish had PBDE levels exceeding the adverse effect threshold for juvenile Chinook.

We don't expect growth or mortality effects on resident fish based on PCB concentrations found in White-Puyallup watershed fish, but reproductive effects could be present. Adverse reproductive effects are estimated to begin occurring in up to 13% of fish at whole-body PCB concentrations of as little as $1 \mu\text{g}/\text{kg}$ (Berninger and Tillitt 2019). Fillet concentrations, which we measured, are typically half as high as whole-body concentrations, meaning that all sites had mean PCB fillet concentrations that could potentially impact fish reproduction to some degree.

More studies are needed to fully understand the potential effects of toxics on fish health in the White-Puyallup watershed. Future studies should include whole-body tissue sampling. PCB concentrations in water should also be measured to determine if water quality standards for aquatic life uses are being met.

Geographical Trends

Fish age, length, weight, and lipid concentrations did not differ significantly between sites. This is important when comparing geographical trends in tissue concentrations, as differences in these metrics can bias results of the geographical analysis. Comparisons between sites were only made for mountain whitefish as rainbow trout were only collected at one site.

Geographical trends differed for total PCBs and PBDEs. No significant differences were found between the 7 sites for total PCBs ($P = 0.539$). A significant difference was found between

sites for total PBDEs ($P=0.00027$). A pairwise comparison of sites for total PBDEs demonstrated significant differences between sites in the lower and upper river system. Site comparisons with significant differences are shown in Table 3.

Table 3. Statistical comparison of total PBDE concentrations ($\mu\text{g/kg}$) in fish tissue from the White-Puyallup Watershed.

Site 1	Site 2	Site 1 Median	Site 2 Median	p-value	Adjusted p-value	Effect Size
Carbon River	Middle White River	5.145	1.122	0.0030	0.02	0.83
Carbon River	Upper Puyallup River	5.145	1.718	0.0063	0.03	0.83
Carbon River	Upper White River	5.145	0.316	0.0001	0.00	0.82
Lower Puyallup River	Middle White River	3.942	1.122	0.0115	0.04	0.83
Lower Puyallup River	Upper White River	3.942	0.316	0.0006	0.01	0.82
Lower White River	Upper White River	3.079	0.316	0.0017	0.01	0.82

The geographical trend for PBDEs between lower and upper river sites may represent the impacts of higher urbanization on tissue concentrations in the lower Puyallup, White, and Carbon rivers. The lack of geographical trends for PCBs indicates that sites across the three river systems demonstrate similar levels of fish tissue contamination.

Age and Length Trends

Fish age and length were compared to total PBDE and PCB concentrations to explore potential trends in tissue concentrations across age and size. Linear regression did not identify any statistically significant trends between age, length, and tissue concentration for either PBDEs or PCBs. While no significant trend was observed, most fish greater than two years of age or larger than 245 mm had PCB levels greater than Washington's water quality standard of $2.3 \mu\text{g/kg}$ (Figure 4). This demonstrates that mountain whitefish residing in the river system over 2 years accumulate levels of PCBs which exceed Ecology's water quality standard.

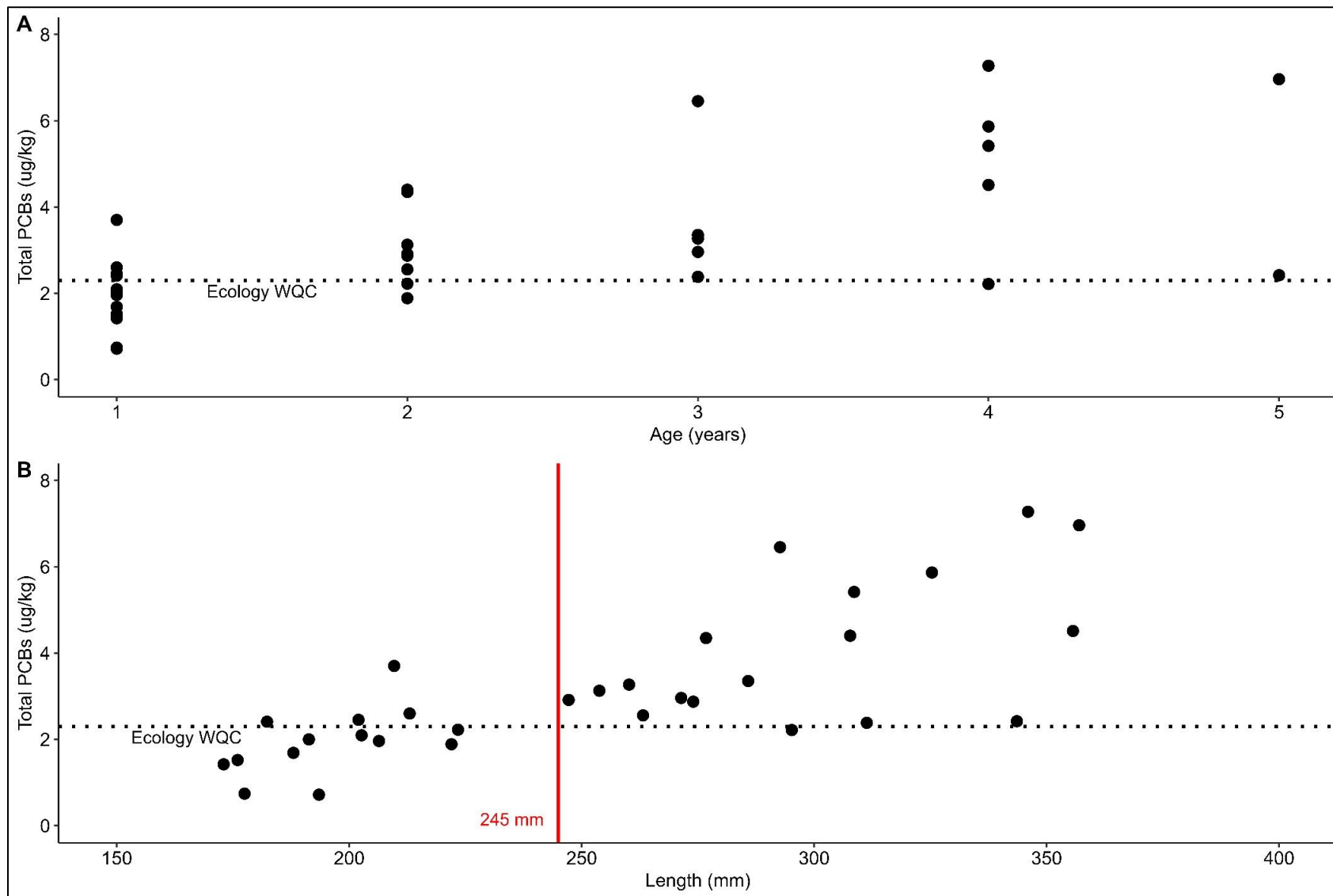


Figure 4. Comparison of mountain whitefish composite age and length to PCB tissue concentration.

Statewide Comparison

Fish tissue concentrations of PBDEs and PCBs collected from the White-Puyallup watershed were compared to statewide fish tissue results from 2001 to 2024 using cumulative frequency distributions. PCB concentrations in the White-Puyallup watershed ranged from the 10th to 40th percentile of statewide fish tissue results (0.7 – 7.3 µg/kg), while PBDE concentrations ranged from the 2nd to 83rd percentile (0.7 – 25.7 µg/kg) (Figures 5A and 5B). These results show that while PCB concentrations exceeded water quality standards at each site, these concentrations were on the lower end of what is seen across the state. A few tissue samples had high levels of PBDEs in comparison to statewide results but were below the DOH screening level.

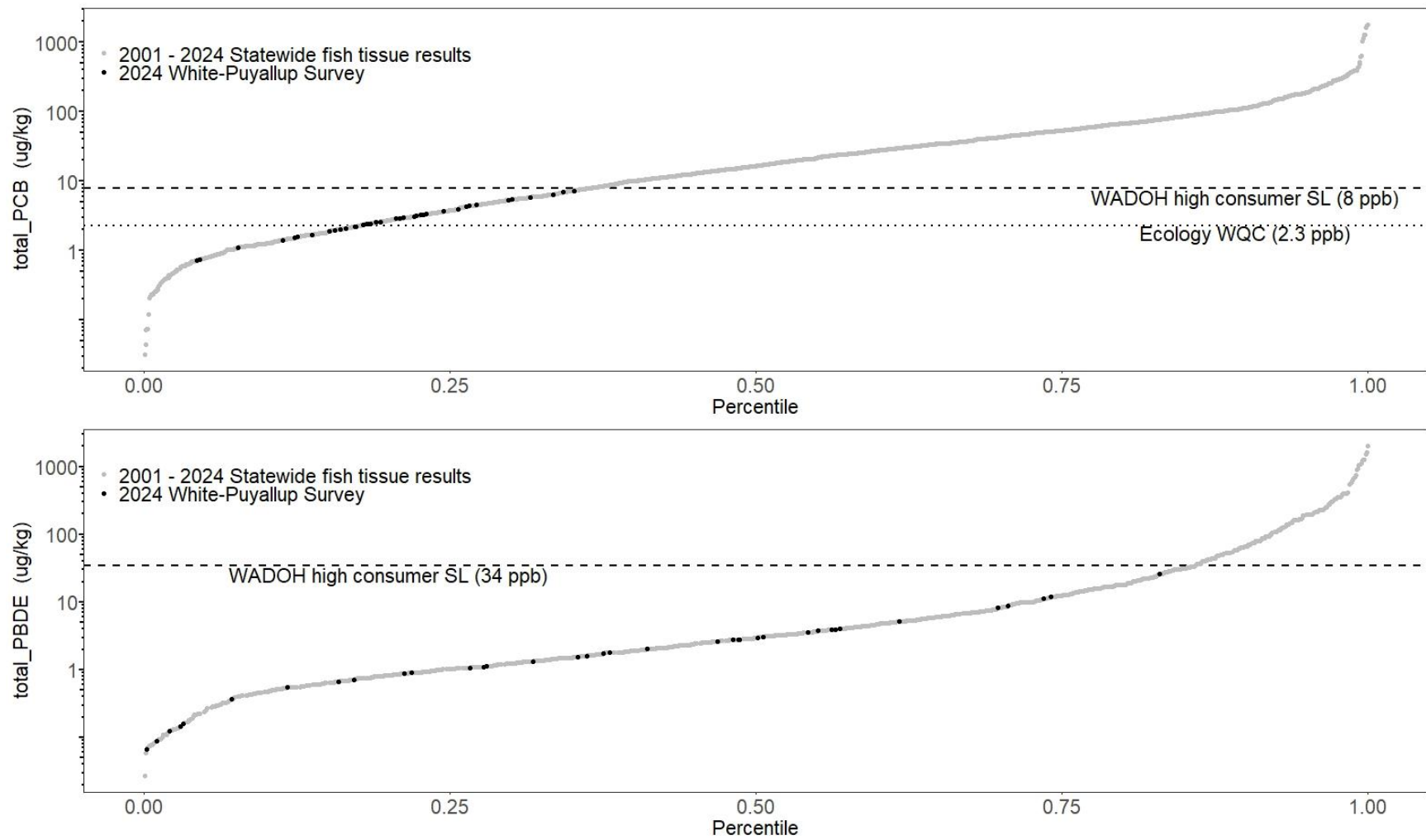


Figure 5. Cumulative frequency distribution of 2024 White-Puyallup PCB (A) and PBDE (B) results compared to statewide results with Ecology water quality standard and DOH consumer screening limits.

Conclusions

Results of this 2024 study support the following conclusions:

- Resident fish tissue samples from all sites in the White, Puyallup, and Carbon rivers had PCB levels higher than Ecology's water quality standards. However, when compared to statewide levels, these PCB concentrations were in the lower to mid-range (10th to 40th percentile).
- PCB and PBDE levels in fish tissue did not exceed the screening levels used by Washington Department of Health.
- There is strong evidence that PBDE concentrations in fish tissue were higher in lower river sites compared to upper river sites within the White, Puyallup, and Carbon rivers.

Recommendations

Results of this 2024 study support the following recommendations:

- Begin long-term monitoring of the White-Puyallup watershed to develop trends in PCB and PBDE concentrations in fish tissue.
- Evaluate water for PCB concentrations to see if aquatic life uses are being met.
- Use these 2024 results in Ecology's upcoming Water Quality Assessment.
- Assess potential PCB sources at sites within the upper river system and characterize background sources to the watershed.
- Evaluate strategies to reduce PCB inputs to the watershed to reduce impacts to human health and aquatic life.

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Appendix A.

A-1. Fish Measurement Information and Chemical Concentrations for Composite Samples.

Site	Species	n	Mean Length (mm)	Length Range (mm)	Mean Weight (g)	Mean Age (years)	Lipids (%)	Total PBDE (µg/kg)	Total PCB (µg/kg)
Carbon River	MWF	5	188	186–192	60	1	4.38	3.57	1.69
Carbon River	MWF	5	202	198–206	71	1	4.65	4.02	2.45
Carbon River	MWF	5	247	239–251	149	3	5.1	5.15	2.91
Carbon River	MWF	4	277	265–293	204	3	5.48	11.24	4.35
Carbon River	MWF	5	309	303–320	303	4	5.59	11.84	5.42
Lower Puyallup River	MWF	3	182	178–190	61	1	5.54	3.94	2.41
Lower Puyallup River	MWF	3	210	204–213	80	1	3.26	3.74	3.7
Lower Puyallup River	MWF	1	346	346	430	4	4.64	8.19	7.27
Lower Puyallup River	MWF	1	357	357	470	5	5.37	25.71	6.96
Lower Puyallup River	MWF	4	176	171–178	47	1	3.01	2.64	1.52
Upper Puyallup River	MWF	5	173	157–180	45	1	4.61	0.36	1.42
Upper Puyallup River	MWF	4	222	186–244	112	2	5.36	2.02	1.89

Site	Species	n	Mean Length (mm)	Length Range (mm)	Mean Weight (g)	Mean Age (years)	Lipids (%)	Total PBDE (µg/kg)	Total PCB (µg/kg)
Upper Puyallup River	MWF	5	260	249–275	184	3	5.83	1.08	3.27
Upper Puyallup River	MWF	5	295	278–309	263	4	4.83	1.72	2.22
Upper Puyallup River	MWF	5	344	320–369	404	5	3.94	2.76	2.42
Lower White River	MWF	3	191	181–200	63	1	3.01	2.79	2
Lower White River	MWF	3	203	201–205	76	1	3.32	3.08	2.09
Lower White River	MWF	3	213	209–217	88	1	3.89	3	2.6
Lower White River	MWF	3	293	285–299	240	3	4.68	3.97	6.45
Lower White River	MWF	3	325	304–360	379	4	4.82	8.78	5.87
Middle White River	MWF	5	223	187–249	109	2	3.66	0.9	2.22
Middle White River	MWF	5	254	250–257	154	2	4.8	1.56	3.13
Middle White River	MWF	5	263	259–269	170	2	5.55	1.12	2.55
Middle White River	MWF	5	271	270–273	182	3	4.93	1.79	2.96
Middle White River	MWF	5	286	274–304	216	3	4.07	1.11	3.35
Upper White River	MWF	4	178	170–183	53	1	1.79	0.07	0.74
Upper White River	MWF	4	194	187–199	74	1	5.26	0.09	0.72
Upper White River	MWF	3	311	300–324	315	3	6.61	0.54	2.38
Upper White River	MWF	3	356	325–394	538	4	6.87	0.67	4.51

Site	Species	n	Mean Length (mm)	Length Range (mm)	Mean Weight (g)	Mean Age (years)	Lipids (%)	Total PBDE (µg/kg)	Total PCB (µg/kg)
Upper White River	RBT	7	146	141–155	34	1	2.88	0.16	1.11
Upper White River	RBT	1	266	266	212	4	2.61	0.13	1.57
Upper White River	RBT	3	341	320–364	378	4	2.29	0.15	3.14
Lake Tapps Flume	MWF	5	206	195–220	80	1	3.36	1.33	1.96
Lake Tapps Flume	MWF	5	274	261–285	196	2	2.68	1.6	2.87
Lake Tapps Flume	MWF	4	308	292–335	300	2	4.21	2.79	4.4

n = number of fish per composite

MWF = Mountain whitefish

RBT = Rainbow Trout