PBDE Flame Retardants in Washington Rivers and Lakes: Concentrations in Fish and Water, 2005-06

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PBDE Flame Retardants in Washington Rivers and Lakes: Concentrations in Fish and Water, 2005-06

by
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Waterbody Number: Statewide

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Glossary of Acronyms and Units

Acronyms

BAF	bioaccumulation factor
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EST	Environmental Sampling Technologies
MS/MSD	matrix spike/matrix spike duplicate
PBDE	polybrominated diphenylether
PBT	persistent, bioaccumulative toxin
PCB	polychlorinated biphenyl
QC	quality control
RPD	relative percent difference
SPMD	semipermeable membrane device
TOC	total organic carbon
TSS	total suspended solids
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
WSTMP	Washington State Toxics Monitoring Program
ww	wet weight

Units

mg/Kg	milligrams per kilogram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ng/Kg	nanograms per kilogram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)

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Abstract

The Department of Ecology analyzed polybrominated diphenyl ether flame retardants (PBDEs) in freshwater fish and water samples collected statewide during 2005-06. This was done in response to increasing PBDE levels in the environment and concern about potential adverse human health effects from fish consumption. The goal was to establish baseline conditions that could be used to evaluate the effectiveness of the *Washington State PBDE Chemical Action Plan* and other efforts to reduce PBDE inputs to the environment.

Data were obtained on concentrations of PBDE-47, -49, -66, -71, -99, -100, -138, -153, -154, -183, -184, -190, and -209 in approximately 120 fish fillet samples, 23 whole fish samples, and 16 water samples, representing 32 waterbodies. The results are used to evaluate the environmental distribution and accumulation of PBDEs in Washington rivers and lakes.

Total PBDE concentrations appear to be less than 10 ug/Kg (parts per billion, wet weight) in fish fillets from most Washington rivers and lakes. Certain fish species from several large waterbodies – Palouse River, Columbia River, Lake Washington, Snohomish River, Cowlitz River, and Snake River – have total PBDE concentrations in the 10 – 200 ug/Kg range. PBDEs in fish from watersheds with minimal human disturbance are at or below the limit of detection. High PBDE levels are found throughout the Spokane River, exceeding 1,000 ug/Kg in some cases.

Acknowledgements

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- Staff at the Department of Ecology's Manchester Environmental Laboratory analyzed samples for this project. Special thanks to Dolores Montgomery who was primarily responsible for the PBDE analyses.

- The following people assisted with fish collection or provided fish samples for this project:
  - Washington Department of Fish and Wildlife: Marc Divens, Marc Petersen, Steve Caromile, David Low, and field staff.
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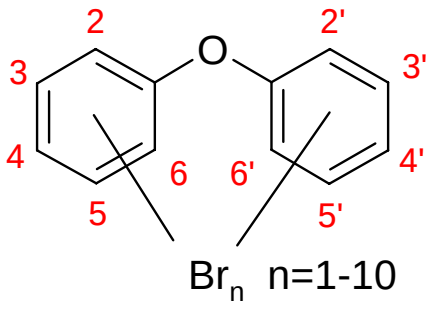
Introduction

Background on Polybrominated Diphenyl Ethers

Polybrominated diphenyl ethers (PBDEs) are a subgroup of brominated organic compounds that function as flame retardants in resins and plastics used in furniture (foam cushions), carpet padding, electronics enclosures, wire and cable insulation, adhesives, textile coatings, and other applications. PBDEs have been a high volume production chemical with the bulk of its world-wide usage taking place in North America.



Polybrominated Diphenyl Ether (PBDE)

Figure 1. General Structure of Polybrominated Diphenyl Ethers

Environmental release of PBDEs has occurred during production, use, and disposal of final treated products – through direct discharge, volatilization, incineration, landfills, wastewater treatment plants, and other sources. First reported in 1981, these compounds are now ubiquitous in the environment (Hites, 2004). The highest PBDE concentrations have generally been found in North America, where levels are 10 or more times greater than in Europe or Japan (Hites, 2004).

Unlike classical pollutants such as DDT, PCBs, and dioxin, PBDE levels have been increasing in environmental samples. This phenomenon has been reported across a range of media including aquatic sediments, fish, bird eggs, seal blubber, and human tissues (Norén and Mieronyté, 2000; She et al., 2002; Luross et al., 2000). Figure 2, for example, shows the contrasting trend in the levels of PBDEs versus dioxin and PCB TEQs[1] in human breast milk samples from Sweden, analyzed between 1972 and 1996.

In the Pacific Northwest, Rayne et al. (2003) demonstrated that total PBDE concentrations in Columbia River mountain whitefish have increased by an order of magnitude since 1992 (Figure 3). These samples were collected about 30 miles above the Washington border at Genelle, British Columbia (between Trail and Castlegar). Rayne et al. concluded the doubling period for PBDEs in Columbia River whitefish was 1.6 years between 1995 and 2000.

[1] Toxicity Equivalence: a measure of the combined toxicity of dioxin-like compounds.

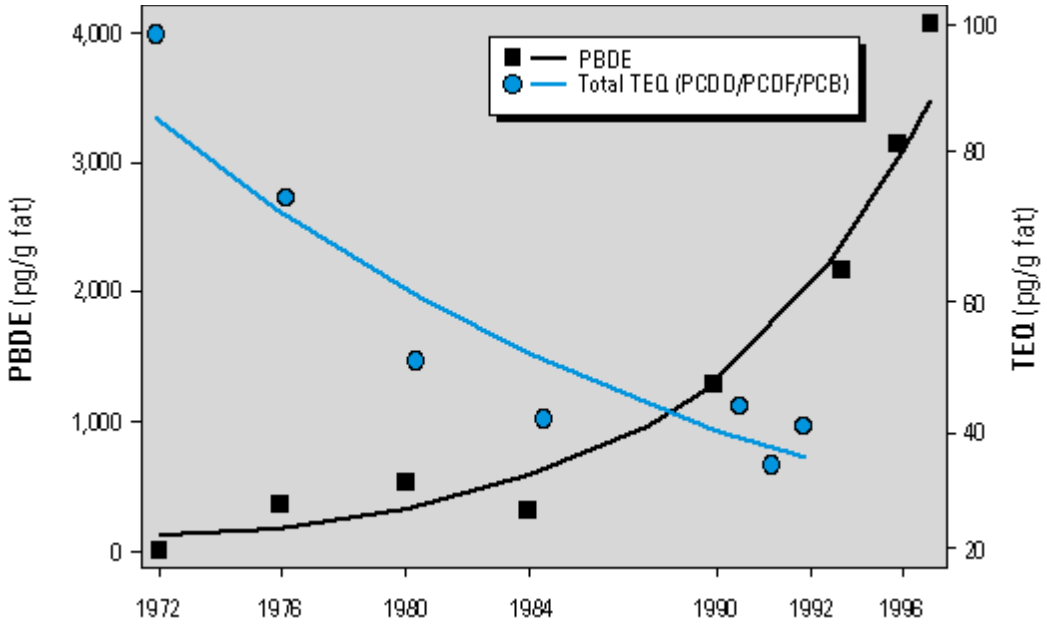


Figure 2. PBDEs vs Total TEQs in Human Breast Milk, Sweden 1972-1996 (Norén and Mieronyté, 2000).

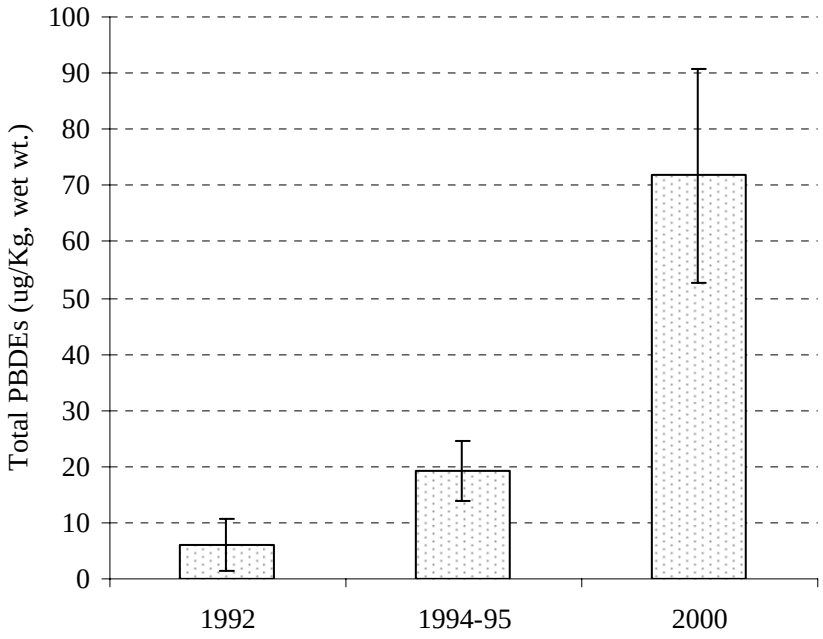


Figure 3. Time-Trend of Total PBDE Concentrations in Columbia River Mountain Whitefish Collected at Genelle, British Columbia (based on muscle tissue data in Rayne et al., 2003).

Three main types of PBDEs are used in consumer products: Penta-BDE, Octa-BDE, and Deca-BDE. The most common use of Penta-BDE is in flexible polyurethane foam in furniture. Typical end products containing Octa-BDE are housings for fax machines, as well as computers, automobile trim, telephone handsets, and kitchen appliance castings. Octa is used in wire and cable insulation, coatings and adhesive systems, and fabric coatings, as well as housings for computers and other equipment. These products can contain 10-20% PBDEs by weight. (Ecology and WDOH, 2006)

Deca-BDE is used in a variety of polymer systems such as high-impact polystyrene, nylon, polypropylene, low-density polyethylene, rubber, polyester, and epoxy. It is also used in wire and cable insulation of all types, coatings, and adhesive systems, including back-coatings for fabrics. Deca-BDE formulations make up 10 to 27% of the product by weight. Deca-BDE is not used in clothing. (Ecology and WDOH, 2006)

The individual compounds (congeners) that predominate in commercial products are PBDE-47, -99, -100, -153, -154, -183, and -209 (Table 1). PBDE -47 and -99 account for the greatest percentage of residues found in environmental samples.

Table 1. Primary Congeners in Commercial PBDE Products

Congener	Chemical Name	% of Total in Commercial Mixtures		
		Penta-BDE	Octa-BDE	Deca-BDE
PBDE-47	2,2',4,4'-tetrabromodiphenyl ether	27		
PBDE-99	2,2',4,4',5-pentabromodiphenyl ether	43		
PBDE-100	2,2',4,4',6-pentabromodiphenyl ether	9.8		
PBDE-153	2,2',4,4',5,5'-hexabromodiphenyl ether	8.5	6.7	
PBDE-154	2,2',4,4',5,6'-hexabromodiphenyl ether	9.3	9.3	
PBDE-183	2,2',3,4,4',5,6'-heptabromodiphenyl ether		44	
- -	octabromodiphenyl ethers (3 compounds)		34	
PBDE-209	2,2'3,3',4,4',5,5',6,6'-decabromodiphenyl ether			>98

The Washington State Department of Ecology (Ecology) has identified PBDEs as persistent, bioaccumulative toxins (PBTs). Ecology and the Washington State Department of Health (WDOH) have prepared a *Washington State PBDE Chemical Action Plan* identifying steps the state may take to reduce the threat of PBDEs in the environment (Ecology and WDOH, 2006).

The *Chemical Action Plan* has detailed information on use, environmental occurrence, toxicity, and regulations pertaining to PBDEs. Briefly, the primary concern revolves around the observation that PBDE concentrations in human tissues have been doubling every two to five years. If this rate were to continue, the levels could reach those known to cause adverse effects in laboratory rodents. PBDEs have been linked to neurotoxicity, impaired thyroid function, fetal toxicity, endocrine effects, and tumor generation in animal studies.

Penta-BDE is generally more toxic than Octa-BDE, and both are much more toxic than Deca-BDE. Industry voluntarily ceased manufacture of Penta- and Octa-BDEs in December 2004. The use of Deca-BDE however is anticipated to increase. Deca-BDE has been shown to break down in the environment to more toxic and bioaccumulative forms of PBDEs (Ecology and WDOH, 2006). Industry holds there is no convincing evidence of this phenomenon.

Diet is a major source of the PBDE body burden in humans, and fish have the highest PBDE levels among different types of food (Schecter et al., 2004). As of 2005, there was not much data on PBDE levels in Washington freshwater fish, and no data on the levels in surface water. There are currently no state or federal fish tissue or water quality criteria for PBDEs.

Goals and Objectives of the Statewide PBDE Survey

In view of the limited data that had been collected and the potential for adverse human health effects, the Washington State Legislature provided funding for Ecology's Environmental Assessment Program to conduct a statewide survey of PBDEs in selected rivers and lakes to better determine the current level of contamination. The Statewide PBDE Survey was conducted during 2005-06.

The goal of the survey was to establish baseline conditions that could be used in the future to evaluate the effectiveness of the *Washington State PBDE Chemical Action Plan* and other efforts to reduce PBDE inputs to the environment.

Specific objectives were to:

1. Measure PBDE concentrations in fish fillets from 20 waterbodies, three species each.
2. Measure PBDE concentrations in one water column sample representative of 10 of the fish collection sites.
3. Assess seasonal changes in PBDE levels at six of the water sampling sites.
4. Rank the waterbodies in terms of PBDE contamination.
5. Identify spatial, species, and temporal patterns in the environmental distribution and accumulation of PBDEs.

Some of the fish tissue data evaluated as part of the Statewide PBDE Survey were obtained through the Washington State Toxics Monitoring Program (WSTMP; www.ecy.wa.gov/programs/eap/toxics/wstmp.html) and through a focused survey of chemical contaminants in Spokane River fish (Serdar and Johnson, 2006), both also conducted by Ecology's Environmental Assessment Program. The timing, field procedures, and chemical analysis methods for all three efforts were the same.

Study Design

Waterbodies where Ecology collected samples for the Statewide PBDE Survey are shown in Figure 4. The survey focused primarily on waterbodies that drain large areas and are a significant fisheries resource. Ten rivers or impoundments and ten lakes were selected to represent a range of land use types including urban, agricultural, and forested (Table 2). An attempt was made to distribute the sampling effort equitably across the state.

There was an emphasis on the Columbia River system, not only due to its size and importance, but also because of the reports of rapidly increasing PBDE levels in upper Columbia River fish, as previously described. Two rivers, the Queets and Methow, and two lakes, Ozette and Bead, were selected as likely representing present-day background for PBDEs, given their location and surrounding land use. The Lake Ozette fish tissue data used in the present report are based on samples analyzed by Ecology through the WSTMP in 2004.

An effort was made to collect at least three species from each waterbody. Gamefish were preferentially taken, with other less sought after species such as carp, suckers, or pikeminnow retained when needed to obtain the target sample size. Where possible, the samples included both predators and bottom feeders to cover a range of trophic levels. The fish were collected during August – November 2005. The lipid (fat) content of many species represents a reservoir for PBDEs and is generally highest at this time (EPA, 2000a).

Fillets were analyzed for all species. Each sample typically consisted of composited fillets from four to five individual fish; a few samples were two or three fish composites. Limited numbers of whole-body composites were also analyzed. Whole fish is probably a worst-case sample for PBDEs. A total of 63 fillet samples and five whole fish samples were analyzed for the Statewide Survey.

Water column concentrations of PBDEs were estimated for 10 of the rivers and lakes, as indicated in Figure 4. Because PBDEs have very low water solubility, a passive sampling technique using a standardized semipermeable membrane device (SPMD) was employed to concentrate sufficient PBDE residues for measurement.

An SPMD consists of a tubular, layflat, low-density polyethylene (LDPE) membrane containing a thin film of a high-molecular weight lipid (triolein). The LDPE tubing mimics a biological membrane by allowing selective diffusion of hydrophobic organic compounds into the lipid. SPMDs sequester the dissolved, readily bioaccumulative form of a chemical and provide lower detection limits than traditional water sampling techniques. Studies on other halogenated compounds such as PCBs have shown that concentrations determined from SPMDs are comparable to other, more elaborate, low-level sampling methods such as solid-phase and liquid-liquid extraction (Ellis et al., 1995; Rantalainen et al., 1998; Hyne et al., 2004). Details of SPMD theory, construction, and application can be found at wwwaux.cerc.cr.usgs.gov/spmd/spmd_overview.htm.

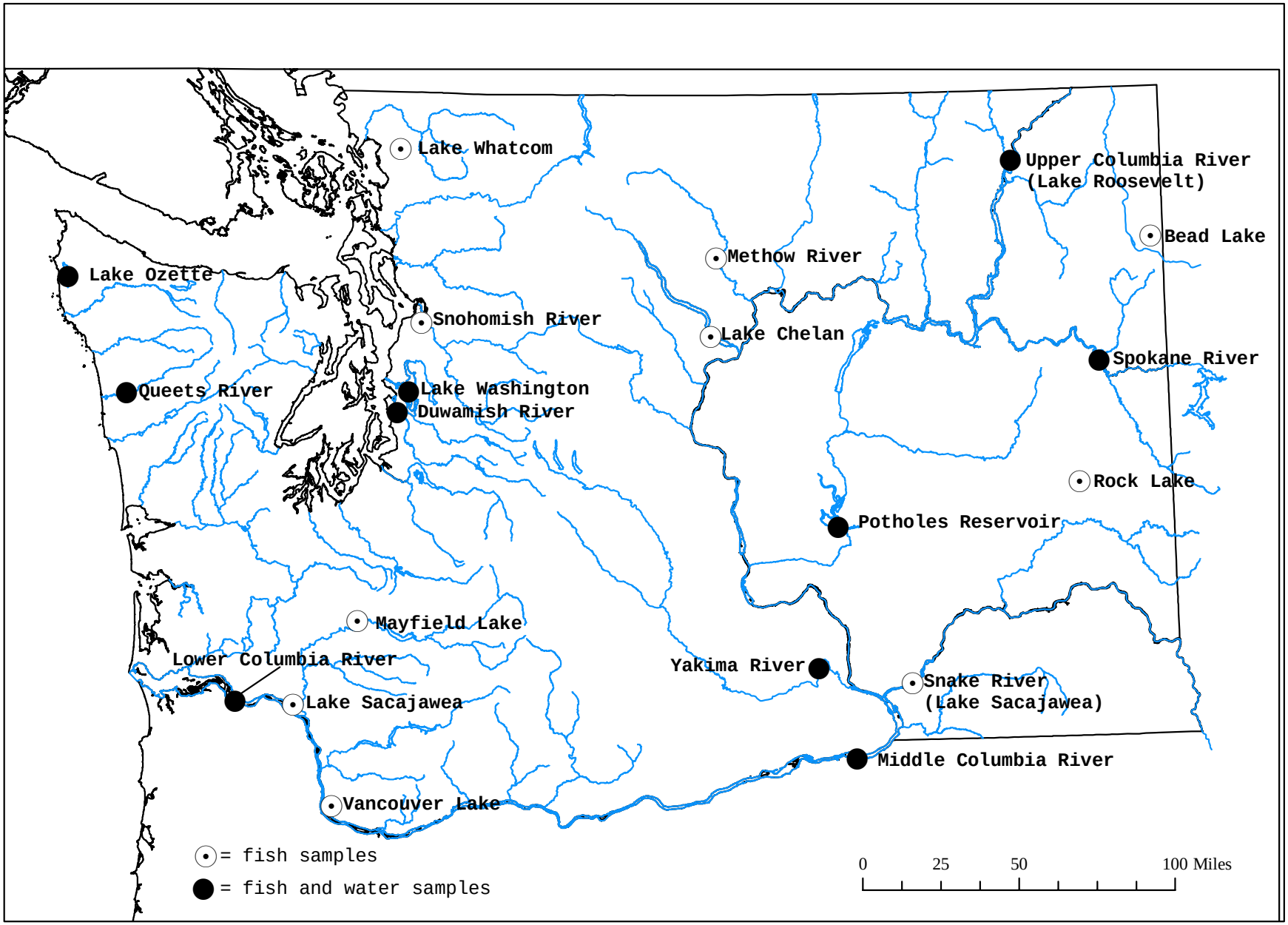


Figure 4. Rivers and Lakes Sampled During Ecology's 2005-06 Statewide PBDE Survey

Table 2. Rivers and Lakes Sampled During Ecology's 2005-06 Statewide PBDE Survey

Waterbody	Fish Samples	Water Samples	WRIA*	County	Drainage Area (sq. miles)	Predominant Land Use
Rivers/Impoundments						
Spokane River	x	x†	54	Spokane	5,200	urban
Lower Columbia River	x	x†	25	Cowlitz	256,900	urban
Snohomish River	x		7	Snohomish	1,720	urban
Duwamish River	x	x†	9	King	483	urban
Snake River	x		33	Walla Walla	108,500	agriculture
Yakima River	x	x†	37	Benton	6,120	agriculture
Middle Columbia River	x	x	31	Benton	2,214,000	agriculture
Upper Columbia River	x	x	58	Stevens	64,500	forested
Methow River**	x		48	Okanogan	1,772	forested
Queets River**	x	x†	21	Jefferson	143	forested
Lakes						
Lake Washington	x	x†	8	King	472	urban
Vancouver Lake	x		28	Clark	39	urban
Lake Sacajawea	x		26	Cowlitz	6	urban
Lake Chelan	x		47	Chelan	924	agriculture
Rock Lake	x		54	Whitman	523	agriculture
Potholes Reservoir	x	x	41	Grant	4,551	agriculture
Lake Whatcom	x		1	Whatcom	56	forested
Mayfield Lake	x		26	Cowlitz	1,400	forested
Bead Lake**	x		62	Pend Oreille	9	forested
Lake Ozette**	x	x	20	Clallam	78	forested

*WRIA = Water Resource Inventory Area
†Collected August-September 2005 and March-April 2006, otherwise August-September 2005 only
**Background site for present study

One five-membrane SPMD array was deployed at each of the 10 sites for approximate one month during August – September 2005. For the six sites indicated in Table 2, a second set of SPMDs was deployed during March – April 2006 to assess the magnitude of seasonal changes in PBDE levels due to runoff or other factors.

All fish and SPMD samples were analyzed for PBDE-47, -49, -66, -71, -99, -100, -138, -153, -154, -183, -184, -190, and -209. The fish samples were also analyzed for percent lipids. Water samples for total suspended solids (TSS) and total organic carbon (TOC), as well as field measurements of temperature and specific conductivity, were taken to characterize water quality at each SPMD site.

This study was conducted according to a Quality Assurance Project Plan (Johnson and Seiders, 2005).

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Methods

Field Procedures

Fish Samples

Fish were collected by electro-shocking, gill net, dip net, or hook & line. Specimens retained for analysis met Washington Department of Fish and Wildlife (WDFW) size limit restrictions or, in their absence, were judged large enough to be retained for consumption. The latitude and longitude of the sampling sites were recorded from a GPS receiver or taken from USGS quad maps. Detailed information on sampling methods and site locations for all of Ecology's 2005 PBDE fish samples is provided in Appendix A-1.

Fish selected for analysis were killed by a blow to the head. Each fish was given a unique identifying number and its length and weight recorded. The fish were individually wrapped in aluminum foil, put in plastic bags, and placed on ice for transport to Ecology headquarters, where the samples were frozen pending preparation of the tissue samples. Chain-of-custody was maintained.

Appendix B has the data on length, weight, age, and sex of each fish analyzed for PBDEs by Ecology in 2005. The accepted common and scientific name for each species are listed in Appendix C.

SPMD Samples

Deployment and retrieval procedures for SPMDs followed the guidance in Huckins et al. (2000). Standard SPMDs (91 x 2.5 cm thin-walled, layflat polyethylene tube containing 1 mL triolein) and the stainless steel canisters (16.5 x 29 cm) and carriers that hold the membranes during deployment were obtained from Environmental Sampling Technologies (EST), St. Joseph, MO (www.est-lab.com/index.php).

EST spiked the membranes with 0.2 ng each of PCB-4 and PCB-29 for use as Performance Reference Compounds (PRCs). PRCs are analytically non-interfering compounds with moderate to relatively high fugacity (escape tendency). The loss rate of PRCs is proportional to the uptake of target compounds. PRC loss rates in the field are used to derive an exposure adjustment factor to calibrate for the effects of water velocity, biofouling, and temperature on SPMD sampling rates. A high rate of PRC loss translates into a lower calculated water column concentration for target compounds because the chemical residues in the SPMD represent a larger volume of water, and vice versa. PCB-4 and -29 are not found in significant amounts in commercial PCB mixtures or environmental samples. The spiking solutions were prepared by the Ecology Manchester Laboratory.

The SPMDs were preloaded onto the carriers by EST in a clean room and shipped in solvent-rinsed metal cans under argon atmosphere. Five SPMDs were used in each canister, with one canister per sampling site. The SPMDs were kept frozen until deployed.

On arriving at the sampling site, the cans were pried open, carriers slid into the canisters, and the device anchored and tethered in place. Because SPMDs are potent air samples, the procedure was done as quickly as possible, typically a minute or less. Field personnel wore nitrile gloves and did not touch the membranes.

The SPMDs were deployed for approximately 28 days. The retrieval procedure was essentially the opposite of deployment. Cans holding the SPMDs were sealed and shipped to EST for extraction. The SPMDs were kept at or near freezing and arrived at EST within 24 hours of retrieval. Chain-of-custody was maintained.

An Onset StowAway Tidbit was attached to each canister to monitor temperature. Grab samples were taken for TSS and TOC at the beginning, middle, and end of the deployment period. Conductivity was measured with a field meter. The latitude and longitude of each sampling site was recorded from a GPS receiver. Appendix A-2 has descriptions of the SPMD deployment sites.

Laboratory Procedures

Fish Tissue

Fish tissue samples were prepared following the guidance in EPA (2000a). Techniques to minimize potential for sample contamination were used. People preparing the samples wore non-talc nitrile gloves and worked on heavy-duty aluminum foil or a polyethylene cutting board. The gloves and foil were changed between samples and the cutting board cleaned between samples, as described below.

The fish were thawed enough to remove the foil wrapper and rinsed with tap water, then deionized water to remove any adhering debris. The entire fillet from one or both sides of each fish (depending on its size) was removed with stainless steel knives and homogenized in a Kitchen-Aid or Hobart commercial blender. The fillets were skin-off for catfish, and scaled with skin-on for other species, as recommended by EPA (2000a). Whole fish samples were homogenized in the Hobart blender without scaling. The sex of each fish was recorded and hard structures (scales, otoliths, opercles, dorsal, and/or pectoral spines as appropriate for each species) saved for aging. Fish ages were determined by John Sneva and Lucinda Morrow of the WDFW.

Four to five individual fish were used for each composite sample. To the extent possible, the length of the smallest fish in a composite was no less than 75% of the length of the largest fish. The composites were prepared using equal weight aliquots from each fish. The pooled tissues were homogenized to uniform color and consistency, using a minimum of three passes through the blender. The homogenates were placed in 4-oz. glass jars with Teflon lid liners, cleaned to EPA (1990) quality assurance / quality control specifications.

Cleaning of resecting instruments, cutting boards, and blender parts was done by washing in tap water with Liquinox detergent, followed by sequential rinses with tap water, deionized water, and pesticide-grade acetone. The items were then air dried on aluminum foil in a fume hood before use.

The tissue samples were refrozen for shipment with chain-of-custody record to the Ecology Manchester Laboratory. The samples were stored frozen at Manchester until analyzed.

Chemical Analysis

All project samples were analyzed at the Ecology Manchester Laboratory following the methods shown in Table 3.

Table 3. Laboratory Procedures for Ecology 2005-06 PBDE Samples

Sample Matrix	Analysis	Sample Prep Method	Analytical Method
Fish tissue	PBDEs	EPA 3540	EPA 8270
"	Lipids	extraction	EPA 608.5
SPMDs	PBDEs	dialysis/GPC	EPA 8270
"	PCB-4,-29	"	EPA 8082
Whole water	TSS	N/A	EPA 160.2
"	TOC	N/A	EPA 415.1

The fish tissue samples were analyzed following Manchester Laboratory's standard operating procedure for PBDEs. The samples were extracted with methylene chloride/acetone by EPA SW-846 Method 3540 then solvent exchanged to iso-octane. The extracts were analyzed by capillary gas chromatography with mass spectral detection (GC/MS/MS) following EPA SW-846 Method 8270.

The SPMD samples were extracted (referred to as dialysis) at EST. Prior to extraction, the membranes were spiked with a PBDE surrogate compound (decachlorobiphenyl). The extracts were cleaned up by gel permeation chromatography (GPC). EST's dialysis and GPC methods are documented in standard operating procedures on file at Ecology Headquarters. EST ampoulized the extracts and shipped them to Manchester Laboratory. Manchester analyzed the extracts by EPA SW-846 Method 8270.

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Data Quality

Manchester Laboratory prepared written case narratives assessing the quality of the data collected for this project. The reviews include a description of analytical methods and an assessment of holding times, tuning, initial and continuing calibration verification (CCV) and degradation checks, method blanks, matrix spike/matrix spike duplicate (MS/MSD) recoveries, laboratory control samples (LCS), surrogate recoveries, laboratory duplicates, and standard reference materials (SRM). The reviews and the complete Manchester data reports are available on request.

An overview of data quality for all of Ecology's 2005-06 PBDE samples – Statewide Survey, WSTMP, Spokane River Study fish samples, and SPMD samples – follows.

Fish Tissue Samples

Relatively few problems were encountered in analyzing PBDEs in fish tissue. All samples were analyzed within method holding times. No target compounds were detected in the method blanks.

Instrument tuning and calibration were within quality control (QC) limits, except that results for PBDE-66 in the Statewide PBDE Survey samples were rejected (REJ flag) due to high CCV recoveries. PBDE-66 was infrequently detected in other sample sets and is not a major constituent or breakdown product of PBDE flame retardants.

Selected samples were spiked with PBDE target compounds to assess bias due to matrix effects and provide an estimate of precision. MS/MSD recoveries were within established QC limits of 50-150%. The relative percent difference (RPD) between MS/MSDs was $\leq$40% for most samples. All MS/MSDs for PBDE Survey samples had poor recoveries of PBDE-66, and all sample results for this congener were rejected. All spike recoveries of PBDE Survey sample number 512007 (Duwamish River largescale sucker fillet) were affected by unknown constituents in the matrix. A re-analysis gave the same outcome. All results for PBDE-49, -71, -47, -99, -100, and -66 in this sample were therefore rejected, and results for other PBDE compounds were qualified as estimates (J flag). Six other samples slightly exceeded QC limits for the MS/MSD as shown in Table 4. Results for these compounds were qualified as estimates.

Decachlorobiphenyl was spiked into all samples as a PBDE surrogate for estimating the recovery of target compounds. Recoveries fell within QC limits of 50-150% except 171% in sample number 024741 (Potholes Reservoir lake whitefish) and 33% in sample number 512015 (Mid Columbia River channel catfish). PBDE results for these samples were qualified as estimates.

Table 4. Fish Tissue Samples Outside QC Limits for Matrix Spikes and Matrix Spike Duplicates

Project	Sample No.	PBDE					
		49	99	100	138	184	209
PBDE Survey	522022	- -	- -	MS 167% MSD 240%	- -	- -	- -
"	522025	- -	- -	- -	- -	- -	MS 31% MSD 32%
WSTMP	514705	- -	RPD 32% MSD 32%	RPD 50% MSD 47%	- -	- -	- -
"	524717	- -	- -	MS 44% MSD 49%	- -	- -	- -
"	54756	MS 170% MSD 173%	- -	- -	- -	- -	- -
Spokane River	494256	- -	MS 44%	- -	- -	- -	- -
"	494246	- -	- -	- -	MS 45%	MS 49%	- -

A standard reference material – National Institute of Standards and Technology (NIST) SRM #1946, Lake Superior Fish Tissue – was extracted with each batch of WSTMP samples. PBDE concentrations are not certified in this material, but NIST provides reference values for congeners -47, -99, and -153 (Stapleton et al., 2004a). The recoveries achieved by Manchester are shown in Table 5.

Table 5. PBDE Recoveries in NIST Standard Reference Material #1946

Project	Sample Batch	PBDE		
		47	99	153
WSTMP	#1	83-85%	87-92%	65-67%
"	#2	81-94%	93-112%	41-49%
Reference Value (ug/Kg)	- -	31	19.4	5.1

No data qualifiers were assigned due to the somewhat low recovery of PBDE-153 in WSTMP batch #2 since the SRM values are not certified, and recoveries in matrix spikes and LCS samples did not indicate a problem with this analyte.

As previously noted, the PBDE data used for Lake Ozette fish in the present report were collected by the WSTMP in 2004. The results for Lake Ozette sample 5084304 (northern pikeminnow) were rejected for use due to instrument problems during the analysis.

The precision of the PBDE data reported here can be gaged from results on duplicate (split) samples (Table 6). The duplicates were submitted blind to the laboratory. On average, the PBDE concentrations measured in duplicate samples agreed within 25%.

Table 6. Precision of Duplicate Sample Analyses (RPD) [other PBDEs not detected]

Species/Tissue	Sample Number	PBDE						
		47	49	66	99	100	153	154
Rainbow trout - fillet	5494230	49%	18%	29%	48%	50%	30%	29%
Mountain whitefish - fillet	5494235	24%	17%	20%	23%	21%	24%	18%
Mountain whitefish - fillet	6024749	9%	0%	4%	8%	9%	5%	12%
Cutthroat trout - fillet	5514705	11%	19%	ND	6%	2%	ND	ND
Common carp - fillet	5524717	3%	16%	ND	ND	4%	ND	9%
Smallmouth bass - fillet	6054756	0%	24%	ND	18%	4%	ND	ND
Northern pikeminnow-fillet	5522022	22%	57%	REJ	ND	17%	52%	33%
Largescale sucker - fillet	5512010	ND	ND	ND	ND	ND	ND	ND
Largescale sucker - whole	5494245	30%	60%	ND	52%	36%	21%	19%
Largescale sucker - whole	5494248	18%	29%	ND	ND	23%	32%	28%
Largescale sucker - whole	5494251	13%	6%	ND	ND	7%	8%	2%
	Mean RPD	18%	25%	18%	26%	17%	25%	19%

RPD = relative percent difference (range of duplicates as percent of mean)
ND = not detected
REJ = data rejected

SPMD Samples

The SPMD samples were analyzed within the one-year holding time established by Manchester Laboratory for sample extracts. Instrument tuning, calibration, internal standards, and matrix spikes were within QC limits. Surrogate recoveries were within acceptance limits except for sample number 394092 (Lake Washington, fall 2005) which had 43% recovery. All results for this sample were qualified as estimates. No PBDEs were detected in Manchester method blanks.

Because SPMDs sample vapors while being exposed to air, field blanks were used to assess chemical accumulation during deployment and retrieval. The field blank consisted of five membranes in an argon-filled stainless steel can. It was opened to the air for the average amount of time it took to open and place the SPMDs in the water. The blank was then resealed and refrozen. It was taken back into the field and opened and closed again to mimic the retrieval process. The blank was prepared, processed, and analyzed the same as deployed SPMDs.

There was one field blank for each sampling period. The total time each blank was exposed to air ranged from approximately one to two minutes. The field blank exposure site was the Queets River.

Several PBDEs were detected in the field blank for both the fall 2005 and spring 2006 deployments (Table 7). The concentrations were similar to those in EST's procedural blanks. All of the SPMD PBDE data in the present report were corrected for the field blank by subtracting that amount from the sample concentrations.

Table 7. PBDE Concentrations Detected in SPMD Field Blanks (ng/SPMD)

Sample Set:	Aug.-Sept. 2005		Mar.-Apr. 2006	
Sample No:	394095		164254	
PBDE-047	**18**		**13**	
PBDE-049	2	U	2	U
PBDE-066	2	U	5	U
PBDE-071	2	U	2	U
PBDE-099	**11**		**7.8**	
PBDE-100	**2.6**		**1.7**	J
PBDE-138	4	U	4	U
PBDE-153	**4.3**		**1.2**	J
PBDE-154	**1**	J	2	U
PBDE-183	**28**		4	U
PBDE-184	4	U	4	U
PBDE-191	4	U	4	U
PBDE-209	50	U	50	U

U = Not detected at or above reported quantitation limit
J = Estimated value

Two separate SPMD arrays were deployed in the Queets River and Spokane River during fall 2005 to provide estimates of variability (field + laboratory). The PBDE residues accumulated in the replicates compared closely, as shown in Table 8.

Table 8. PBDE Concentrations Measured in Replicate SPMDs from the August - September 2005 Deployments (ng/SPMD; field blank corrected)

Location:	Queets River		Spokane River	
Sample No:	394093	(rep.) 394094	404113	(rep.) 404114
PBDE-47	2 U	**7.9**	**523**	**572**
PBDE-49	2 U	2 U	**28**	**15**
PBDE-66	2 U	2 U	**12**	**12**
PBDE-71	2 U	2 U	2 U	2 U
PBDE-99	**4.0**	**11**	**213**	**225**
PBDE-100	2 U	2 U	**52**	**55**
PBDE-138	4 U	4 U	4 U	4 U
PBDE-153	4 U	4 U	**8.7**	**6.3**
PBDE-154	4 U	4 U	**9.2**	**8.3**
PBDE-183	4 U	4 U	4 U	4 U
PBDE-184	4 U	4 U	4 U	4 U
PBDE-191	4 U	4 U	4 U	4 U
PBDE-209	50 U	50 U	50 U	50 U
PCB-4 (% recov.)	22	42	40	30
PCB-29 (% recov.)	50	83	74	70

U = Not detected at or above reported quantitation limit

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Results[2] and Discussion

PBDE Concentrations in Fish Samples

Statewide PBDE Survey

During Ecology's Statewide PBDE Survey, fish were collected from 20 major rivers/ impoundments and lakes throughout Washington between June and November 2005. Three to four species were typically analyzed for each waterbody, one composite fillet sample for each species. The individual sample results are provided in Table 9.

[2] Data from this project are available electronically through the Ecology Environmental Information Management (EIM) database www.ecy.wa.gov/eim/index.htm. Search User Study ID, AJOH0048.

Table 9. PBDE Concentrations Measured in Composite Fish Fillets Collected During Ecology's Statewide Survey (ug/Kg, wet weight).

Waterbody	Date	Sample No.	Species	PBDEs														Lipids (%)
				47	49	66	71	99	100	138	153	154	183	184	191	209	Total	
Bead Lake	10/26/05	5514700	Burbot	0.50 U	0.50 U	0.50 U	0.22 U	0.22 U	0.22 U	1.0 U	0.50 U	0.50 U	1.0 U	1.0 U	1.0 U	6.2 U	0	0.4
Bead Lake	10/26/05	5514701	Kokanee	**1.1**	**0.27** J	0.47 U	0.47 U	**1.0**	**0.25** J	0.95 U	0.47 U	0.47 U	0.95 U	0.95 U	0.95 U	5.9 U	2.6	1.7
Bead Lake	10/26/05	5514702	Northern pikeminnow	**3.1**	**0.48** J	0.49 U	0.49 U	0.49 U	**0.50**	0.99 U	0.49 U	0.49 U	0.99 U	0.99 U	0.99 U	6.2 U	4.1	8.2
Bead Lake	10/26/05	5514703	Peamouth	**0.29** J	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	0.88 U	0.44 U	0.44 U	0.88 U	0.88 U	0.88 U	5.5 U	0.29	1.4
Bead Lake	10/26/05	5512000	Largescale sucker	**0.12** J	0.22 U	REJ	0.22 U	0.22 U	**0.19** J	0.44 U	0.44 U	**0.17** J	0.44 U	0.44 U	0.44 U	1.1 U	0.48	1.36
Ozette Lake	10/06/04	5084302	Cutthroat trout	0.48 U	NA	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	NA	NA	6.0 U	0	1.7
Ozette Lake	10/06/04	5084303	Largemouth bass	0.49 U	NA	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	NA	NA	6.1 U	0	0.67
Ozette Lake	10/06/04	5084305	Yellow perch	0.47 U	NA	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	NA U	NA	5.9 U	0	0.45
Duwamish River	08/31/05	5522018	Northern pikeminnow	**4.6**	0.20 U	REJ	0.20 U	0.20 U	**0.42**	0.40 U	**0.21** J	**0.37** J	0.40 U	0.40 U	0.40 U	1.0 U	5.6	2.2
Lake Chelan	10/06/05	5512001	Cutthroat trout	0.21 U	0.21 U	REJ	0.21 U	**0.14** J	0.21 U	0.42 U	0.42 U	0.42 U	0.42 U	0.42 U	0.42 U	1.1 U	0.14	1.3
Lake Chelan	10/05/05	5512002	Kokanee	0.22 U	0.22 U	REJ	0.22 U	**0.84**	0.22 U	0.43 U	**0.11** J	**0.078** J	0.43 U	0.43 U	0.43 U	1.1 U	1.0	1.2
Lake Washington	06/28/05	5512012	Largescale sucker	0.22 U	0.22 U	REJ	0.22 U	0.22 U	0.22 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	**0.56** J	0.56	2.4
Lake Washington	06/28/05	5512013	Largescale sucker	**22**	**0.30**	REJ	0.21 U	0.21 U	**6.5**	0.43 U	**0.45**	**2.2**	0.43 U	0.43 U	0.43 U	1.1 U	31	3.3
Lake Washington	06/28/05	5524717	Common carp	**39**	**6.75** J	0.48 U	0.48 U	0.48 U	**8.4** J	0.96 U	0.48 U	**1.2**	0.96 U	0.96 U	0.96 U	6.0 U	55	9.0
Lake Whatcom	10/12/05	5524729	Peamouth	**1.1**	**0.35** J	0.49 U	0.49 U	0.49 U	**0.46** J	0.97 U	0.49 U	0.49 U	0.97 U	0.97 U	0.97 U	6.1 U	2	2.1
Lake Whatcom	10/12/05	6024747	Cutthroat trout	**6.6**	**0.88** J	**0.33** J	0.48 U	**3.5**	**1.4**	0.97 U	**0.31** J	**0.26** J	0.97 U	0.97 U	0.97 U	6.0 U	13	2.8
Lake Whatcom	10/12/05	6024748	Yellow perch	**0.17** J	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.97 U	0.49 U	0.49 U	0.97 U	0.97 U	0.97 U	6.1 U	0.17	0.5
Lake Whatcom	10/12/05	6024750	Smallmouth bass	**3.5**	**0.38** J	0.49 U	0.49 U	**0.63**	**0.60**	0.99 U	**0.17** J	**0.11** J	0.99 U	0.99 U	0.99 U	6.2 U	5.4	2.4
Lake Whatcom	10/12/05	5522020	Brown bullhead	**0.35**	0.22 U	REJ	0.22 U	**0.69**	0.22 U	0.43 U	**0.11** J	**0.091** J	0.43 U	0.43 U	0.43 U	1.1 U	1.2	2.1
Lower Columbia R.	08/30/05	5524720	Peamouth	**7.1**	**0.78** J	0.50 U	0.5 U	0.50 U	0.50 U	1.0 U	**0.32** J	**0.23** J	1.0 U	1.0 U	1.0 U	6.2 U	8.4	1.6
Lower Columbia R.	08/30/05	6024738	Northern pikeminnow	**13**	**0.71** J	0.49 U	0.49 U	0.49 U	**2.6**	0.98 U	**0.19** J	**0.25** J	0.98 U	0.98 U	0.98 U	6.1 U	17	2.0
Lower Columbia R.	08/30/05	5512006	Largescale sucker	**25**	**0.12**	REJ	0.22 U	0.22 U	**4.6**	0.43 U	**0.53**	**0.70**	0.43 U	0.43 U	0.43 U	1.1 U	31	2.6
Mayfield Lake	09/15/05	5524721	Largemouth bass	**1.5**	0.48 U	0.48 U	0.48 U	**0.52**	0.48 U	0.97 U	0.48 U	0.48 U	0.97 U	0.97 U	0.97 U	6.0 U	2.0	0.9
Mayfield Lake	09/15/05	5524722	Northern pikeminnow	**1.9**	0.49 U	0.49 U	0.49 U	0.49 U	**0.41** J	0.98 U	0.49 U	0.49 U	0.98 U	0.98 U	0.98 U	6.1 U	2.3	1.5
Mayfield Lake	09/15/05	5524723	Yellow perch	**0.38** J	0.5 U	0.50 U	0.5 U	0.50 U	0.50 U	1.0 U	0.5 U	0.5 U	1.0 U	1.0 U	1.0 U	6.2 U	0.38	0.5
Mayfield Lake	09/15/05	5512008	Largescale sucker	**2.2**	0.22 U	REJ	0.22 U	0.22 U	**0.17** J	0.43 U	**0.08** J	**0.18** J	0.43 U	0.43 U	0.43 U	1.1 U	2.6	1.7
Methow River	10/20/05	5524724	Cutthroat trout	**1.4**	0.49 U	0.49 U	0.49 U	**0.71**	**0.45** J	0.98 U	0.49 U	0.49 U	0.98 U	0.98 U	0.98 U	6.1 U	2.6	2.4
Methow River	10/20/05	6024740	Mountain whitefish	**4.2**	0.49 U	**0.29** J	0.49 U	**5.2**	**1.4**	0.99 U	**0.21** J	**0.18** J	0.99 U	0.99 U	0.99 U	6.2 U	11	3.9
Middle Columbia R.	11/15/05	5512014	Yellow perch	0.22 U	0.22 U	REJ	0.22 U	0.22 U	0.22 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	1.1 U	0	0.56
Middle Columbia R.	11/15/05	5512015	Channel catfish	**11**	0.87 U	REJ	0.87 U	**5.4**	**3.3**	1.7 U	**0.74** J	**0.52** J	1.7 U	1.7 U	1.7 U	4.3 U	21	25
Middle Columbia R.	11/15/05	5512016	Largescale sucker	**8.2**	0.22 U	REJ	0.22 U	0.22 U	**1.8**	0.44 U	**0.18** J	**0.40** J	0.44 U	0.44 U	0.44 U	1.1 U	11	6.4
Spokane River	09/29/05	5494257	Bridgelip sucker	**59**	**0.90**	**0.29**	0.21 U	**0.46**	**10**	0.42 U	**2.5**	**2.8**	0.42 U	0.42 U	0.42 U	2.6 U	76	1.5
Spokane River	09/29/05	5494269	Rainbow trout	**182**	**6.7**	**5.3**	0.22 U	**172**	**39**	0.33 U	**7.5**	**5.1**	**0.25** J	0.43 U	0.43 U	1.1 UJ	417	2.1
Spokane River	09/29/05	5494271	Mountain whitefish	**443**	**13**	**14**	0.21 U	**449**	**111**	**0.25** NJ	**17**	**11**	**0.58**	**0.21** NJ	0.42 U	1.0 UJ	1059	3.6

Table 9 (cont.). PBDE Concentrations Measured in Composite Fish Fillets Collected During Ecology's Statewide Survey (ug/Kg, wet weight).

Waterbody	Date	Sample No.	Species	PBDEs													Lipids (%)
				47	49	66	71	99	100	138	153	154	183	184	191	209	Total	
Potholes Reservoir	10/25/05	6024741	Lake whitefish	**1.2** J	0.47 U	0.47 U	0.47 U	**0.67** J	0.47 U	0.95 U	0.47 U	0.47 U	0.95 U	0.95 U	0.95 U	5.9 U	1.9	17
Potholes Reservoir	10/26/05	6024742	Smallmouth bass	**0.41** J	0.44 U	0.44 U	0.44 U	**0.21** J	0.44 U	0.88 U	0.44 U	0.44 U	0.88 U	0.88 U	0.88 U	5.5 U	0.62	1.9
Potholes Reservoir	10/25/05	6024743	Walleye	**0.46** J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	1.0 U	1.0 U	6.2 U	0.46	1.7
Potholes Reservoir	10/25/05	5512009	Largescale sucker	**0.68**	0.22 U	REJ	0.22 U	0.22 U	0.22 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	1.1 U	0.68	8.1
Queets River	11/21/05	5522028	Mountain whitefish	0.42 U	0.42 U	REJ	0.42 U	0.42 U	0.42 U	0.84 U	0.84 U	0.84 U	0.84 U	0.84 U	0.84 U	2.1 U	0	2.2
Rock Lake	08/23/05	5524725	Brown trout	**0.31** J	0.48 U	0.48 U	0.48 U	**0.29** J	0.48 U	0.97 U	0.48 U	0.48 U	0.97 U	0.97 U	0.97 U	6.1 U	0.6	4.2
Rock Lake	08/23/05	5524726	Largemouth bass	**0.28** J	0.49 U	0.49 U	0.49 U	**0.30** J	0.49 U	0.98 U	0.49 U	0.49 U	0.98 U	0.98 U	0.98 U	6.1 U	0.58	1.0
Rock Lake	08/24/05	5524727	Yellow perch	**0.44** J	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.94 U	0.47 U	0.47 U	0.94 U	0.94 U	0.94 U	5.9 U	0.44	0.8
Rock Lake	8/23/2005	5512010	Largescale sucker	0.22 U	0.22 U	REJ	0.22 U	0.22 U	0.22 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	1.1 U	0	2.7
Sacajawea Lake	09/14/05	5514715	Grass carp	**0.56**	0.50 U	0.50 U	0.5 U	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	1.0 U	1.0 U	6.2 U	0.56	1.2
Sacajawea Lake	09/14/05	6024744	Largemouth bass	**0.71**	0.47 U	0.47 U	0.47 U	**0.15** J	0.47 U	0.95 U	0.47 U	0.47 U	0.95 U	0.95 U	0.95 U	5.9 U	0.86	1.0
Sacajawea Lake	09/14/05	5522019	Brown bullhead	**0.29**	0.22 U	REJ	0.22 U	**0.16** J	0.22 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	0.44 U	1.1 U	0.45	0.76
Snake River	11/14/05	5524730	Yellow perch	**0.40** J	**0.20** J	0.49 U	0.49 U	0.49 U	0.49 U	0.99 U	0.49 U	0.49 U	0.99 U	0.99 U	0.99 U	6.2 U	0.6	0.6
Snake River	11/14/05	5524731	Peamouth	**1.7**	0.49 U	0.49 U	0.49 U	0.49 U	**0.78**	0.98 U	0.49 U	0.49 U	0.98 U	0.98 U	0.98 U	0.98 U	2.5	1.8
Snake River	11/14/05	6024751	Common carp	**22**	**2.6** J	0.48 U	0.48 U	0.48 U	**5.5**	0.96 U	0.48 U	**0.43** J	0.96 U	0.96 U	0.96 U	6.0 U	30	5.4
Snake River	11/14/05	5522021	Largescale sucker	**4.0**	0.21 U	REJ	0.21 U	0.21 U	**0.27**	0.43 U	0.43 U	**0.25** J	0.43 U	0.43 U	0.43 U	1.1 U	4.5	4.0
Snohomish River	09/01/05	5524728	Cutthroat trout	**16**	**1.7** J	**0.48** J	0.49 U	**3.3**	**2.9**	0.99 U	**0.45** J	**0.35** J	0.99 U	0.99 U	0.99 U	6.2 U	26	3.6
Snohomish River	09/01/05	6024746	Northern pikeminnow	**7.3**	**0.37** J	0.47 U	0.47 U	0.47 U	**1.6**	0.94 U	**0.10** J	**0.20** J	0.94 U	0.94 U	0.94 U	**2.5** J	12	2.5
Snohomish River	09/01/05	6024745	Mountain whitefish	**13**	**0.82** J	**0.76**	0.48 U	**14**	**3.5**	0.97 U	**0.65** J	**0.47** J	0.97 U	0.97 U	0.97 U	6.1 U	32	4.1
Snohomish River	09/01/05	5512011	Largescale sucker	**8.5**	0.22 U	REJ	0.22 U	0.22 U	**1.5**	0.43 U	**0.20** J	**0.55** J	0.43 U	0.43 U	0.43 U	**0.62** J	11	2.4
Upper Columbia R.	10/20/05	5512003	Largescale sucker	**7.7**	0.22 U	REJ	0.22 U	0.22 U	**1.4**	0.44 U	**0.12** J	**0.58**	0.44 U	0.44 U	0.44 U	1.1 U	9.8	2.8
Upper Columbia R.	10/20/05	5512004	Rainbow trout	**0.92**	0.21 U	REJ	0.21 U	0.21 U	0.21 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	1.1 U	0.92	3.3
Upper Columbia R.	10/20/05	5512005	Walleye	**1.3**	0.22 U	REJ	0.22 U	**0.20** J	0.22 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	0.43 U	1.1 U	1.5	0.70
Upper Columbia R.	09/13/05	5522027	Lake whitefish	**10**	0.21 U	REJ	0.21 U	**5.4**	**1.7**	0.43 U	**0.56**	**0.52**	0.43 U	0.43 U	0.43 U	1.1 U	18	11
Vancouver Lake	12/05/05	5522026	Largescale sucker	**2.1**	0.21 U	REJ	0.21 U	0.21 U	0.21 U	0.42 U	0.42 U	**0.19** J	0.42 U	0.42 U	0.42 U	1.0 U	2.3	1.5
Yakima River	11/16/05	5512017	Common carp	**2.7**	0.22 U	REJ	0.22 U	0.22 U	0.22 U	0.43 U	0.43 U	**0.13** J	0.43 U	0.43 U	0.43 U	1.1 U	2.8	2.6
Yakima River	11/16/05	5522023	Largescale sucker	**20**	**0.82**	REJ	**0.21**	0.21 U	**5.9**	0.42 U	**0.45**	**1.3**	0.42 U	0.42 U	0.42 U	1.0 U	29	8.4
Yakima River	11/16/05	5522025	Smallmouth bass	**6.2**	**0.32**	REJ	0.22 U	**1.1**	**0.71**	0.43 U	**0.13** J	**0.18** J	0.43 U	0.43 U	0.43 U	1.1 UJ	8.6	1.1
Yakima River	11/16/05	5522022	Northern pikeminnow	**6.6**	**0.14** J	REJ	**0.22**	0.22 U	**1.8** J	0.44 U	**0.23** J	**0.42** J	0.44 U	0.44 U	0.44 U	**0.26** J	9.1	2.1

U = Not detected at or above reported quantitation limit
J = Estimated value
UJ = Not detected at or above reported quantitation limit. Quantitation limit is approximate.
REJ = Data rejected
NA = Not analyzed

Table 10 shows a statistical summary of the data. The reporting limit was used to calculate means and medians for non-detects. In these and subsequent tables and figures, the term *total PBDEs* refers to the sum of detected congeners.

Table 10. Statistical Summary of PBDE Data on Composite Fish Fillets Analyzed for Ecology's Statewide Survey (ug/Kg wet weight, parts per billion).

PBDE	No. of Samples	No. of Detections	Detection Frequency	Minimum	Median	Mean	90th %	Maximum
-47	63	53	84%	0.17	1.5	22	27	443
-49*	60	24	33%	0.14	<0.49	1.3	2.1	13
-66	36†	7	19%	0.29	<0.49	1.0	0.50	14
-71	63	2	3%	<0.21	<0.48	<0.45	<0.49	0.22
-99	63	24	38%	0.15	<0.49	17	4.0	449
-100	63	32	51%	0.17	1.0	5.1	6.4	111
-138	63	1	2%	0.25	<0.97	<0.90	<1.0	<1.0
-153	63	25	40%	0.10	<0.48	1.1	0.70	17
-154	63	31	49%	0.11	0.48	0.88	0.70	11
-183	63	2	3%	0.25	<0.97	<0.88	<1.0	<1.0
-184*	60	1	2%	0.21	<0.97	<0.91	<1.0	<1.0
-191*	60	0	0%	<0.42	<0.97	<0.91	<1.0	<1.0
-209	63	4	6%	0.26	<6.1	<5.3	<6.2	<6.2
Total PBDEs	63	59	86%	0	2.8	35	31	1,059

*these congeners not analyzed in Lake Ozette samples
†27 results rejected due to low matrix spike recoveries (see *Data Quality*)

Sixty-three fillet samples were analyzed in all. Reporting limits were in the range of 0.2 – 0.5 ug/Kg (parts per billion, wet weight basis), except 1 – 6 ug/Kg for PBDE-209. The higher reporting limits for PBDE-209 are due to its long retention time and thermal instability, leading to breakdown during analysis. As retention time become longer, the instrument response decreases.

Eighty-six percent of the fillet samples had at least one PBDE detected. The most frequently detected congeners (Figure 5) were PBDE-47 (84% of samples), PBDE-100 (51%), and PBDE-154 (49%). PBDE-49, -66, -99, and -153 were detected in 19 - 40% of the samples. Six percent of samples had detectable amounts of PBDE-209. PBDE-71, -138, -183, and -184 were infrequently detected (3% or less of samples). PBDE-191 was not found.

The occurrence of PBDE-209 is of particular interest, because unlike Tetra- and Octa-BDEs, it continues to be produced (Deca-BDE) and breaks down into lower, more toxics PBDEs. Due in part to analytical difficulties, PBDE-209 is infrequently detected in biological samples (Hites, 2004). PBDE-209 is poorly accumulated by fish (Dodder et al., 2002).

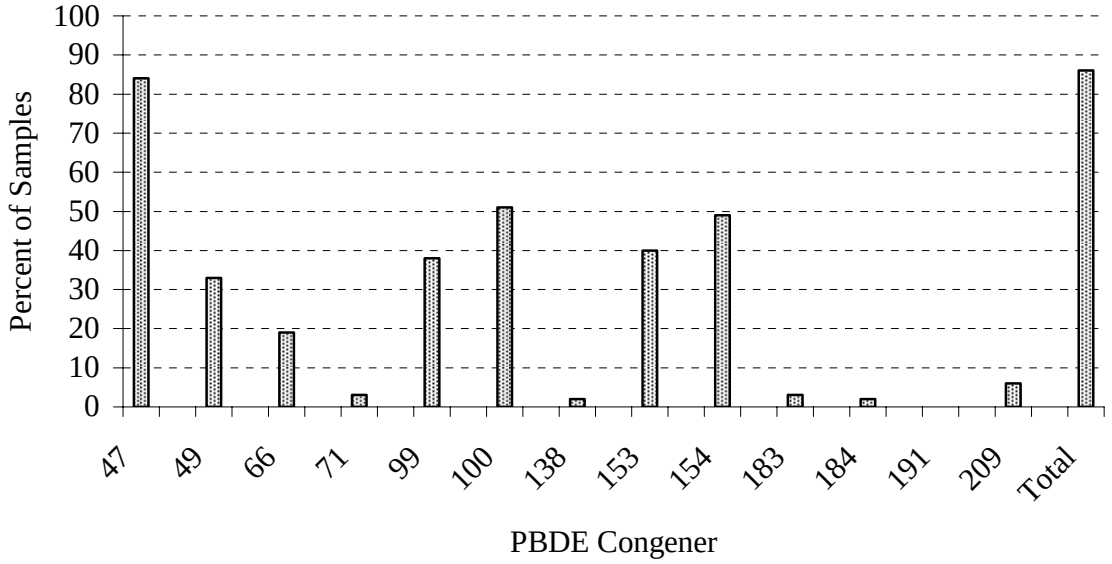

Figure 5. Detection Frequency of PBDEs in Fish Fillets Analyzed for Ecology's Statewide Survey (N = 63, except N =36 for PBDE-66)

Figure 6 shows 90th percentile values from the Statewide Survey. Total PBDE concentrations in the majority of fillets were less than 31 ug/Kg. Most samples had PBDE-47 concentrations less than 27 ug/Kg. The remaining compounds were generally present at or below 6 ug/Kg.

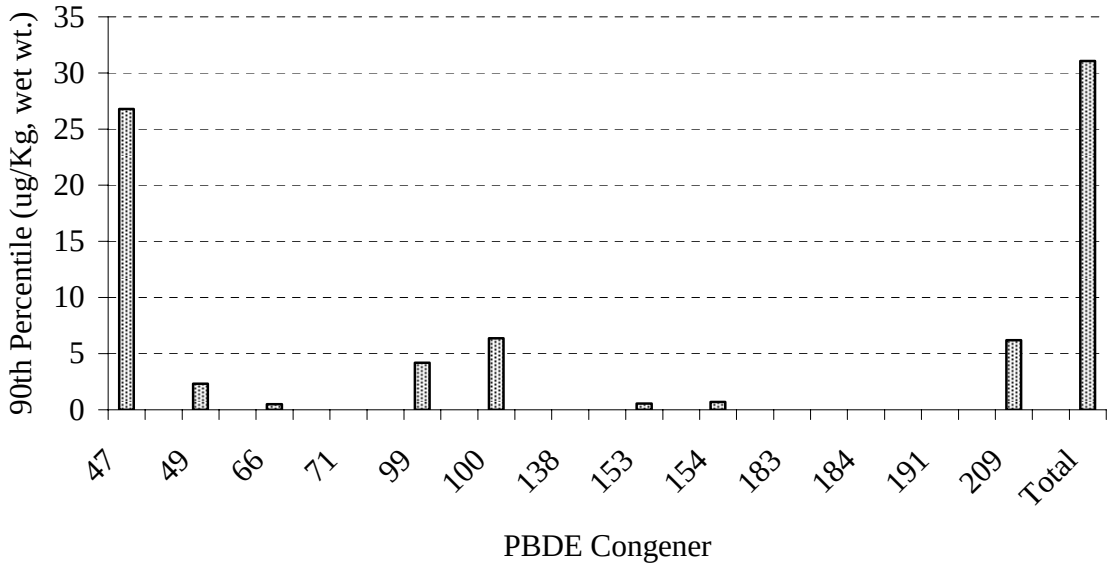

Figure 6. 90th Percentile Concentrations of PBDEs in Fish Fillets Analyzed for Ecology's Statewide Survey (N = 63, except N =36 for PBDE-66)

On average, PBDE-47 accounted for 68% of the total PBDE concentration in fish fillets, followed by PBDE-99 at 16% (Figure 7). PBDE-49, -100, and -154 averaged 3 – 9% of the total. Other PBDEs contributed 1% or less.

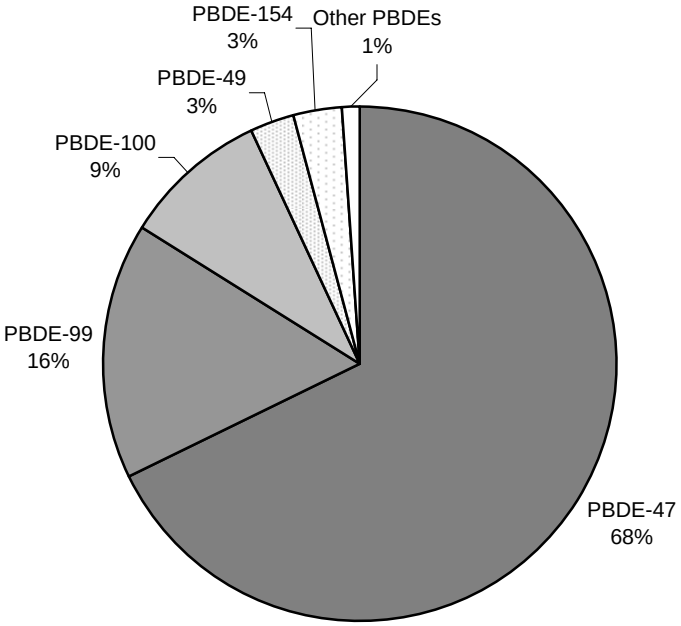

Figure 7. Average Contribution of Individual Congeners to Total PBDE Concentrations in Fish Fillets Analyzed for Ecology's Statewide Survey.

Figure 8 illustrates how total PBDE levels were distributed across the survey. Approximately 80% of the samples were clustered around 0 – 10 ug/Kg, with another approximately 15% in the vicinity of 20 - 30 ug/Kg. Four outliers had total PBDE concentrations ranging from 54 - 1,059 ug/Kg.

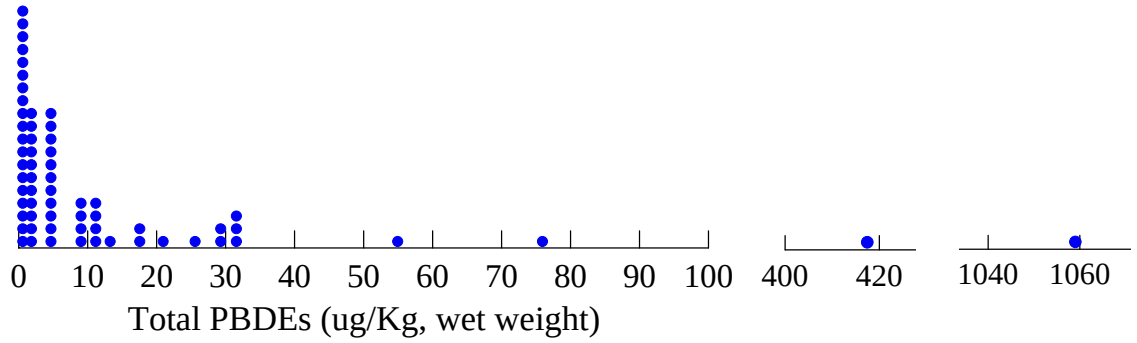

Figure 8. Histogram Showing Total PBDE Levels in Fish Fillets Analyzed for Ecology's Statewide Survey (Table 9 data)

Figure 9 plots the mean and range of the total PBDE concentrations for each waterbody. The highest concentrations were found in Spokane River fish where total PBDEs averaged 740 ug/Kg, an order of magnitude above other rivers and lakes. Bridgelip sucker, rainbow trout, and mountain whitefish were analyzed from this site, with concentrations of 76, 417, and 1,059 ug/Kg, respectively (Table 9). The second highest levels were recorded for Lake Washington where the three species analyzed averaged 29 ug/Kg. Additional data on PBDEs in Spokane River and Lake Washington fish are presented later in this report.

The next five waterbodies in order of decreasing total PBDE concentrations were the Snohomish River, Lower Columbia River, Yakima River, Middle Columbia River, and Upper Columbia River, at 20, 19, 12, 11, and 10 ug/Kg respectively. Concentrations appeared to increase going downstream in the Columbia.

The remaining 13 waterbodies had average total PBDE concentrations of 9.5 ug/Kg or less. Due to matrix interferences, previously described, useable data were only obtained on one sample from the Duwamish River (northern pikeminnow), and concentrations were relatively low at 5.6 ug/Kg total PBDEs.

PBDEs were not detected in fish from Lake Ozette or the Queets River, the two western Washington areas selected a priori as representing background conditions. Although concentrations for the survey's two eastern Washington background sites – Bead Lake and the Methow River – were relatively low, they were not among the least contaminated waterbodies, particularly the Methow, which averaged 7.0 ug/Kg total PBDEs.

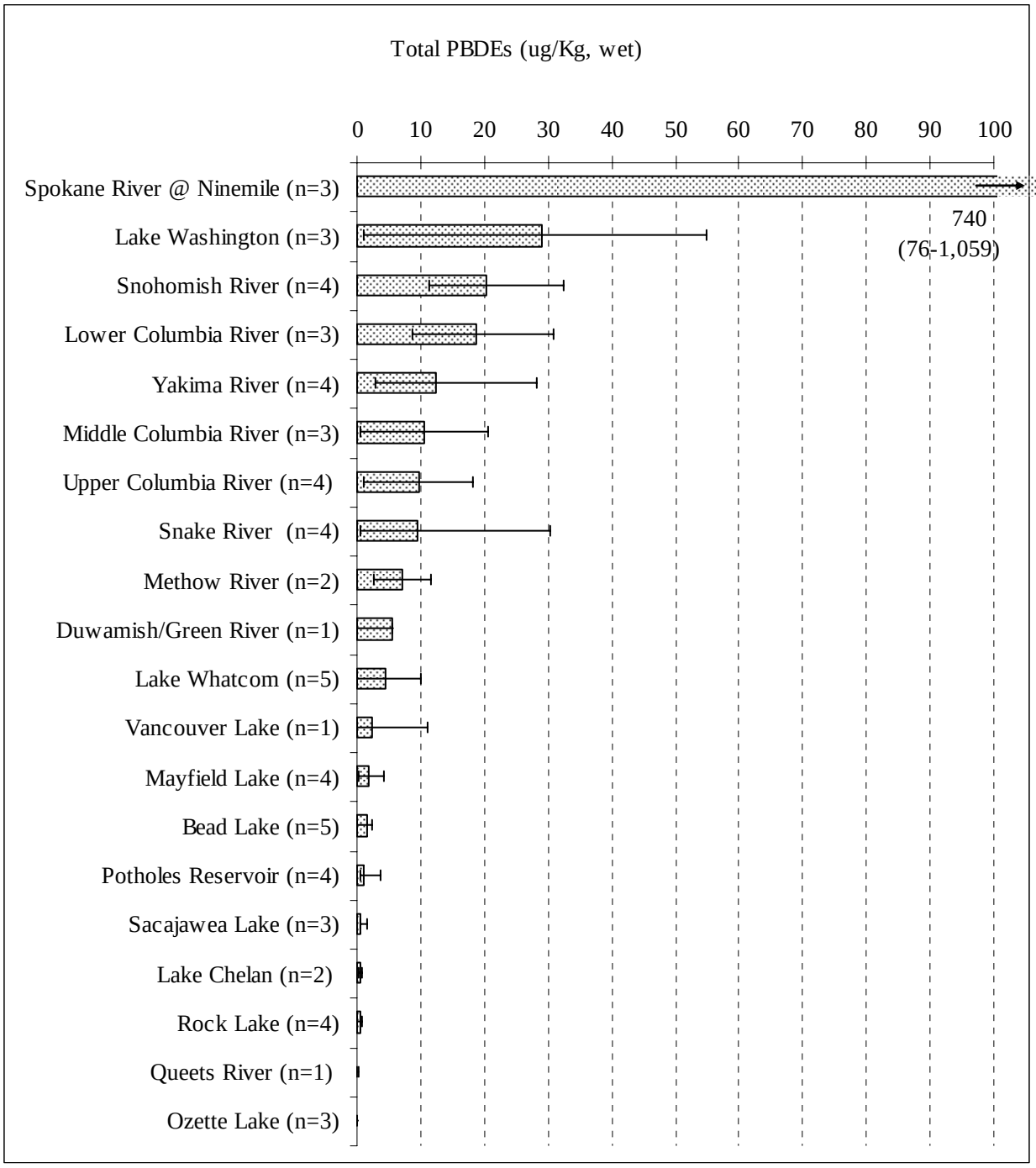

Figure 9. Mean and Range of Total PBDE Concentrations in Fish Fillets Analyzed for Ecology's Statewide Survey

1. Spokane River Study

Ecology conducted an intensive survey of chemical contaminants in Spokane River fish in 2005 (Serdar and Johnson, 2006). The objectives were to provide data to the Washington State Department of Health for an updated fish consumption advisory and to identify spatial and temporal trends in contamination. Composite sportfish fillets and whole largescale suckers were collected from six sites during August – November (Figure 10). PBDEs were included among the analytes.

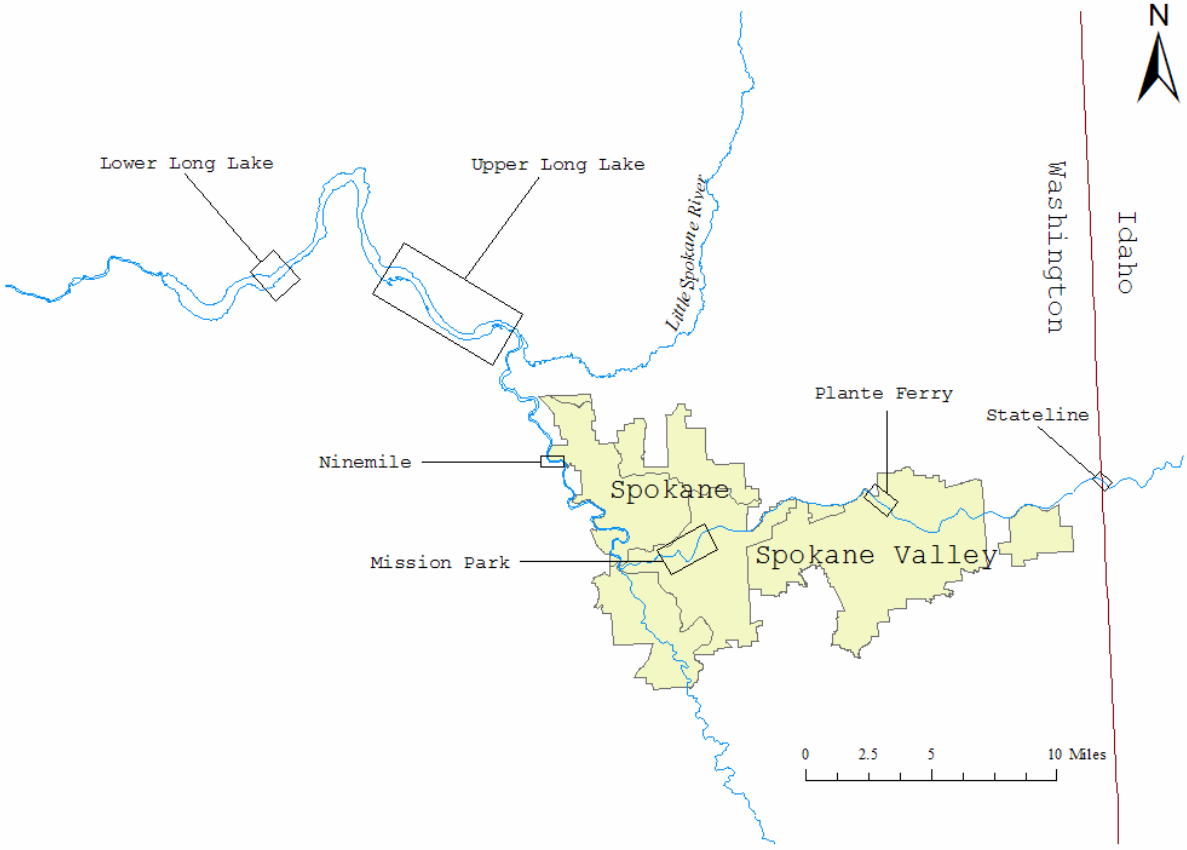

Figure 10. Locations of Spokane River Fish Samples Analyzed for PBDEs in 2005

The PBDE data from the Spokane River Study are summarized in Table 11. Figure 11 plots the data in downstream order beginning with the Stateline/Plante Ferry reaches and ending in lower Long Lake.

Total PBDEs in the Spokane River ranged from means of 30 – 1,059 ug/Kg in sportfish fillets and 95 – 572 ug/Kg in whole largescale suckers. Peak concentrations were observed in the Ninemile reach and in upper Long Lake. Concentrations appeared to decrease in lower Long Lake.

Table 11. Summary of PBDE Concentrations Measured in Spokane River Fish Analyzed by Ecology in 2005

Reach	Species	N* =	Total PBDEs (ug/Kg, ww)	
			Mean	Range
Fillet Samples				
Plante Ferry	Rainbow Trout	3	90	65 - 107
Mission Park	Rainbow Trout	3	30	27 - 32
"	Mountain Whitefish	3	368	355 - 391
Ninemile	Rainbow Trout†	3	418	292 - 564
"	Mountain Whitefish†	3	1,059	905 - 1,222
Upper Long Lake	Mountain Whitefish	3	175	161 - 198
"	Brown Trout	1	159	- -
"	Smallmouth Bass	1	42	- -
Lower Long Lake	Mountain Whitefish	6	122	56 - 228
"	Smallmouth Bass	3	57	34 - 92
Whole Body Samples				
Stateline	Largescale Sucker	3	198	169 - 214
Plante Ferry	Largescale Sucker	3	154	84 - 252
Mission Park	Largescale Sucker	3	95	90 - 98
Ninemile	Bridgelip Sucker	3	522	334 - 708
Upper Long Lake	Largescale Sucker	3	572	459 - 718
Lower Long Lake	Largescale Sucker	3	198	90 - 357

*Composites of 4-5 individual fish each, except lower Long Lake mountain whitefish were analyzed individually
ww – wet weight
†Some of these data were also reported as part of the Statewide Survey (Table 9)

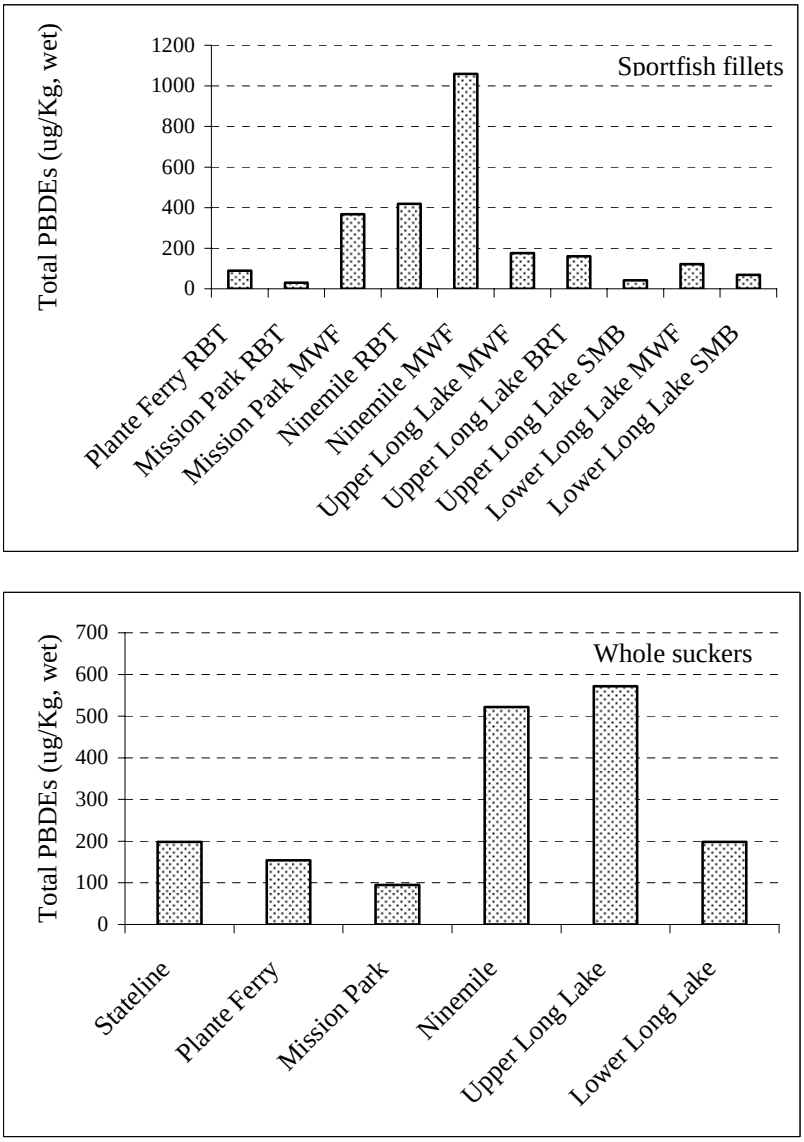

Figure 11. Mean Total PBDE Concentrations in Spokane River Composite Fish Samples Analyzed by Ecology in 2005 [RBT = rainbow trout MWF = mountain whitefish BRT = brown trout SMB = smallmouth bass]

All but a few of the Spokane fish samples substantially exceeded PBDE concentrations observed in other parts of the state. In most cases the concentrations were at least an order of magnitude higher. Substantially elevated PBDE levels appear to extend up to the Idaho border. These results suggest there is a major PBDE source(s) in the Ninemile area and that there also may be significant sources in Idaho. (Dams prevent upstream movement of fish between the Ninemile, Mission Park, and Plante Ferry/Stateline reaches.) Potential sources in Washington include the Spokane wastewater treatment plant, which discharges just above the Ninemile reach, and stormwater runoff from the city of Spokane.

As in the statewide data, PBDE-47, -99, and -100 were the major constituents in Spokane River fish, contributing approximately 56%, 23%, and 11%, respectively to the total PBDE concentrations (Figure 12). PBDE 209 was not detected.

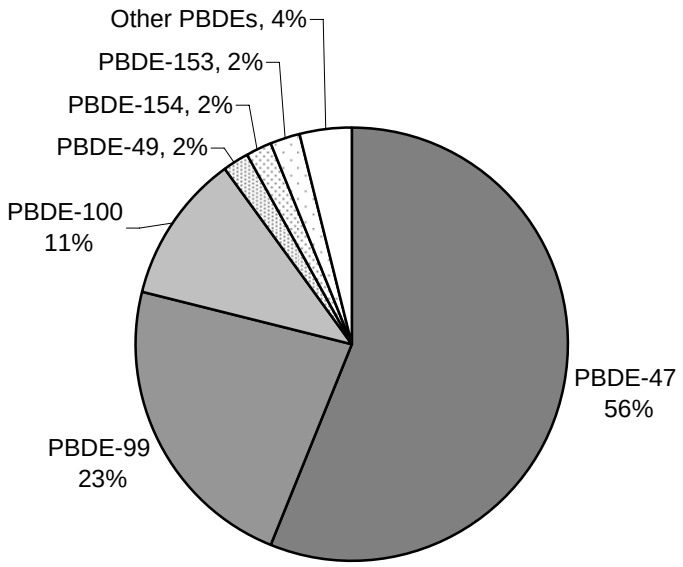

Figure 12. Average Contribution of Individual Congeners to Total PBDE Concentrations in Fillet and Whole Fish Samples Analyzed for Ecology's 2005 Spokane River Study.

2. Lake Washington Study

The Washington State Department of Health (WDOH) conducted a study in 2005 to obtain chemical contaminant data for use in updating the fish consumption advisory for Lake Washington (www.doh.wa.gov/ehp/oehas/eha_fish_adv.htm). PBDEs were included in the analyses but are not being evaluated for the advisory. The samples were analyzed at Ecology's Manchester Laboratory following the same methods used for Ecology's 2005 samples. PBDE-49 and -193 were not included among the WDOH target compounds.

The WDOH fish were collected over a lake-wide area during May – July. Forty-two composite fillets from six species were analyzed. Each composite consisted of pooled tissues from between three to five individual fish. Cutthroat trout and northern pikeminnow were analyzed by size class. Four composite carp fillets were also analyzed from nearby Green Lake.

The detection frequency and relative contribution of individual PBDE congeners to the total was similar to findings from the Statewide and Spokane River studies. PBDE-209 was not detected

in either the Lake Washington or Green Lake samples. The individual sample data are in Appendix D.

Table 12 summarizes the total PBDE data on Lake Washington and Green Lake. Concentrations ranged widely depending on the species and size class analyzed. Higher total PBDE concentrations were found in the larger size cutthroat and pikeminnow, averaging 88 and 86 ug/Kg, respectively. Small individuals of these species had order of magnitude lower concentrations. Substantially elevated PBDE concentrations were observed in some of the large cutthroat and pikeminnow samples, to 126 and 207 ug/Kg total PBDEs, respectively.

The four other species analyzed – yellow perch, black crappie, pumpkin seed, and rainbow trout (one sample only) – had low mean concentrations of 0.10 – 1.7 ug/Kg total PBDEs. Low PBDE concentrations were characteristic of Green Lake carp.

Table 12. Summary of PBDE Concentrations Measured in Composite Fillets from Lake Washington Fish Collected in 2005

Location/Species	Size Class (mm)	N* =	Total PBDEs (ug/Kg, ww)	
			Mean	Range
Lake Washington				
Cutthroat trout	>400	7	88	49 - 126
Cutthroat trout	300-400	3	31	17 - 45
Cutthroat trout	<300	4	9.1	3.8 - 15
Northern pikeminnow	>300	4	86	49 - 207
Northern pikeminnow	<300	3	8.8	5.0 - 15
Yellow perch	all	10	1.5	0 - 7.0
Black crappie	all	3	1.7	0.67 - 3.2
Pumpkin seed	all	7	0.10	0 - 0.71
Rainbow trout	all	1	0.93	- -
Green Lake				
Common carp	all	4	1.2	0 - 2.0

Source: WDOH unpublished data
* Composites of 3 - 5 individual fish
ww – wet weight

3. Washington State Toxics Monitoring Program

WSTMP is a routine fish tissue monitoring program initiated by Ecology in 2001. The goal is to investigate the occurrence and concentrations of toxic contaminants in fish and water samples from freshwater environments where contamination is suspected (www.ecy.wa.gov/programs/eap/toxics/index.html). WSTMP prepares annual reports of the data.

In 2005, WSTMP analyzed PBDEs in composite fish fillets from 12 waterbodies in addition to those included in the data set for the Statewide Survey. Most of these were small lakes, but two large waterbodies, the Palouse River and Cowlitz River, were also sampled. The detection

frequency and relative concentrations of individual PBDE congeners was similar to the statewide data, with the exception that PBDE-209 was not detected.

The PBDE concentrations measured in fish samples from these waterbodies are summarized in Table 13. For the most part, concentrations were at or below approximately 6 ug/Kg total PBDEs. Relatively high concentrations, however, were observed in the South Fork Palouse River and, to a lesser extent, in the Cowlitz River.

Table 13. Total PBDE Concentrations in Composite Fish Fillets Analyzed from Other Waterbodies Sampled by WSTMP in 2005

Location	County	Collection Date	Species	Total PBDEs (ug/Kg, wet)	Lipids (%)
South Fork Palouse River	Whitman	5/24	Northern pikeminnow	42	1.1
Lower Palouse River	"	6/23	Northern pikeminnow	7.5	2.0
North Fork Palouse River	"	6/9	Northern pikeminnow	6.9	2.9
Middle Palouse River	"	6/6	Smallmouth bass	4.3	0.53
Cowlitz River	Lewis	8/29	Mountain whitefish	24	6.8
"	"	8/29	Northern pikeminnow	18	1.8
"	"	8/29	Cutthroat trout	4.8	4.8
Merwin Lake	Clark/Cowlitz	11/1	Kokanee	5.7	1.5
"	"	11/1	Northern pikeminnow	5.6	2.1
Haven Lake	Mason	11/29	Cutthroat trout	3.5	1.3
"	"	11/29	Largemouth bass	2.8	2.3
"	"	11/29	Rainbow trout	1.6	0.96
Liberty Lake	Spokane	10/11	Smallmouth bass	3.3	1.8
Loon Lake	Stevens	10/26	Largemouth bass	2.1	1.4
Leland Lake	Jefferson	9/16	Largemouth bass	2.0	0.88
"	"	9/14	Yellow perch	0.98	0.54
"	"	9/14	Bluegill	0.96	0.79
"	"	9/14	Black Crappie	0.90	0.84
Rowland Lake	Klickitat	9/7	Largemouth bass	1.6	0.79
"	"	9/7	Bluegill	0.98	0.62
"	"	9/7	Yellow perch	0.98	0.66
Long Lake	Grant	8/24	Smallmouth bass	0.98	0.98
"	"	8/24	Walleye	0.79	1.3
Northwestern Lake	Klickitat	11/2	Rainbow trout	1.3	1.7
Stan Coffin Lake	Grant	9/6	Channel catfish	1.0	3.5
"	"	9/6	Largemouth bass	1.0	0.66
"	"	9/6	Yellow perch	0.98	0.38
Silver Lake	Cowlitz	9/22	Largemouth bass	0.82	0.69
"	"	9/22	Common carp	0.80	2.0
"	"	9/22	Bluegill	0.76	1.7

The single fish sample (northern pikeminnow) analyzed from the South Fork Palouse had a total PBDE concentration of 42 ug/Kg, which is toward the upper end of the statewide range. The South Fork is particularly influenced by urban pollution sources. Wastewater treatment plant discharges from Moscow, Idaho and Pullman have the potential to account for most of the total river flow during any month of the year (Pelletier, 1993). The three Cowlitz River fish samples had up to 24 ug/Kg total PBDEs, with an average concentration of 13 ug/Kg.

WSTMP also analyzed PBDEs in a large number of fish fillet samples collected during 2004. The quality of these data is uncertain as a number of problems were encountered during the analyses, including high matrix spike recoveries and poor precision in replicate samples. The total PBDE data from 2004 are provided for informational purposes in Table 14. The results tend to support findings from the more recent Statewide Survey with respect to elevated PBDE levels in the Columbia and Snake river systems.

WSTMP has some fish tissue data on PBDE-47, -99, -100, -154, -154 from 2001-2003. These samples were analyzed by a different method (ECD) and were judged too old to use in the present report. Total PBDE concentrations in the 2001-2003 samples did not exceed 10 ug/Kg (Seiders, 2003; Seiders and Kinney, 2004; Seiders et al., 2006).

Table 14. Total PBDE Concentrations in Composite Fish Fillets Analyzed by WSTMP in 2004 (see text for caveats on data quality)

Location	Species	Total PBDEs (ug/Kg, wet)	Lipids (%)
Columbia River, below Wells Dam	Mountain whitefish	80	4.9
Columbia River, above Beebee Bridge	Northern pikeminnow	18	2.4
"	Peamouth chub	4.4	1.4
Columbia River, below Rocky Reach Dam	Mountain whitefish	9.8	3.0
Columbia River, above Rock Island Dam	Walleye	22	2.6
"	Northern pikeminnow	11	1.8
"	Peamouth chub	6.2	2.3
Columbia River, below Wanapum Dam	Mountain whitefish	50	6.9
Snake River, below Lower Monumental Dam	Channel catfish	26	7.2
Snake River, below Clarkston	Peamouth chub	12	1.9
"	Mountain whitefish	9.4	2.0
"	Largemouth bass	2.5	0.7
Snake River, near Central Ferry	Channel catfish	14	13.1
"	Peamouth chub	2.1	2.2
"	Largemouth bass	0.47	0.7
"	Yellow perch	0	0.5
Skagit River, RM 11-12	Cutthroat trout	14	3.1
"	Peamouth chub	3.7	1.6
"	Mountain whitefish	1.4	1.4
Pend Oreille River, RM 56-77	Northern pikeminnow	11	2.5
Black Lake near Olympia	Rainbow trout	4.8	1.9
Cascade Lake, Orcas Island	Kokanee salmon	2.2	4.1
"	Largemouth bass	0.39	1.0
"	Rainbow trout	0	0.7
Chehalis River, near Montesano	Northern pikeminnow	2.7	0.6
"	Cutthroat trout	0.92	4.0
Chehalis River, near Aberdeen	Chinook salmon	0	3.6
Entiat River, above Entiat Falls	Rainbow trout	0.99	2.8
Mountain Lake, Orcas Island	Kokanee salmon	0.75	3.7
Quinault River, at Tahola	Chinook salmon	0.42	3.5
Queets River, above Clearwater Bridge	Chinook salmon	0.28	2.8
Lake Ozette	Cutthroat trout	0	1.7
"	Largemouth bass	0	0.7
"	Yellow perch	0	0.5

RM – river mile

4. EPA National Lakes Study

EPA conducted a National Study of Chemical Residues in Lake Fish Tissue to estimate the distribution of selected persistent, bioaccumulative, and toxic chemicals in fish from lakes and reservoirs in the lower 48 states (www.epa.gov/waterscience/fishstudy/overview.htm). EPA worked with partner agencies, including Ecology, over a four-year period (2000-2003) to collect fish from 500 lakes and reservoirs selected randomly from an estimated 147,000 target lakes and reservoirs. One predator species and one bottom-dwelling species were collected from each waterbody. Each sample was a composite of five adult fish of similar size. Fillets were analyzed for predators, and bottom-dwellers were analyzed whole.

PBDEs were analyzed in selected samples only. The analysis included 46 individual congeners, analyzed by Axys Analytical Services in Sidney, B.C. following EPA Method 1614 (Brominated Diphenyl Ethers in Water, Soil, Sediment and Tissue by HRGC/HRMS). The detailed PBDE data for EPA's Washington lakes are in Appendix E. The nationwide data were not available as of this writing.

Ecology collected fish from 14 lakes for the EPA study; PBDEs were analyzed for six of the them. The total PBDE concentrations measured in these samples are shown in Table 15. Elevated concentrations of 24 ug/Kg were observed in whole fish samples from the Pend Oreille River and Lake Wallula (Columbia River impoundment above McNary Dam). Fillets from brown trout and smallmouth bass collected from the same sites had considerable lower concentrations of 1.6 – 7.5 ug/Kg. Total PBDE concentrations in fish fillets from other lakes were 4.0 ug/Kg or less.

Table 15. EPA Data on PBDEs in Fish from Washington Lakes (unpublished data from the EPA National Study of Chemical Residues in Lake Fish Tissue)

Location	County	Collection Date	Species/Tissue	Total PBDEs (ug/Kg, wet)	Lipids (%)
Lake Wallula (Col. R.)	Benton/Walla Walla	8/27/03	Smallmouth bass - fillet	7.5	1.6
"	"	11/6/02	Largescale sucker - whole	24	6.0
Pend Oreille River	Pend Oreille	7/23/02	Largescale sucker - whole	24	6.1
"	"	7/23/02	Brown trout - fillet	1.6	1.1
Calligan Lake	King	7/17/02	Rainbow trout - fillet	4.0	2.4
Patterson Lake	Okanogan	8/26/03	Largemouth bass - fillet	2.0	1.6
Buffalo Lake	"	7/24/02	Largemouth bass - fillet	1.1	3.7
Lake Nahwatzel	Mason	9/4/03	Largemouth bass - fillet	0.9	1.1

Figure 13 shows the average congener contribution for predator and bottom-dwelling species in the EPA national data. The same congeners were responsible for the bulk of the residues as in Ecology's 2005 samples. Table 16 compares results of Ecology's Statewide Survey with the EPA national data.

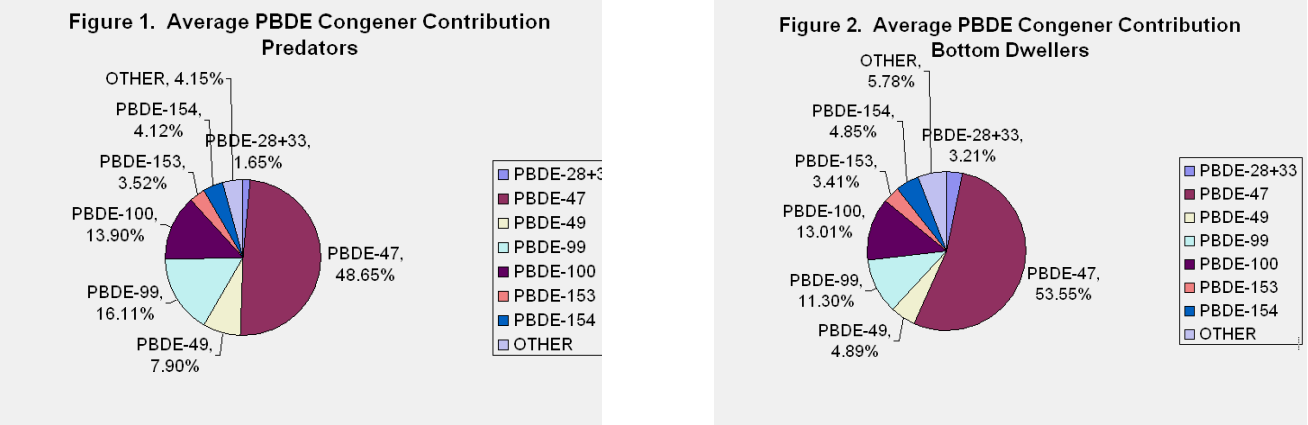

Figure 13. Average PBDE Congener Contribution in Fish Tissue Samples Analyzed for the EPA National Lakes Study (unpublished data summarized by EPA)

Table 16. Percent Contribution of Individual Congeners to Total PBDEs: Ecology Statewide Survey vs. EPA National Lakes Study

PBDE Congener	Ecology Statewide Survey (fillet)	EPA National Lakes Study	
		Predator Species (fillet)	Bottom-Dwelling Species (whole)
47	68%	49%	54%
99	16%	16%	11%
100	9%	14%	13%
49	3%	8%	5%
153	<1%	4%	3%
154	3%	4%	5%
28+33	NA	2%	3%

NA = not analyzed

5. PBDEs in Hatchery Trout and Feed

In a final 2005 study by Ecology, persistent organic pollutants were analyzed in rainbow trout fillets and fish feed from ten Washington Department of Fish and Wildlife hatcheries and one private hatchery (Serdar et al., 2006). Fish originating from the same hatchery populations were also sampled approximately 2½ months following planting into unpolluted lakes to assess contaminant depuration or uptake. All fillet and feed samples were analyzed for PBDEs.

Feed samples had <0.25 ug/Kg total PBDEs. Fillets from hatchery and planted trout had a mean total PBDE concentration of 0.66 ug/Kg. Results suggest that a portion of the PBDE concentrations in trout from unpolluted waters may originate from hatcheries (Serdar et al., 2006).

PBDEs in Fillet vs. Whole Fish

Both fillet and whole fish data were obtained on five fish species from Ecology's 2005 PBDE studies. The whole fish result was determined by analyzing PBDEs in the fillet and remaining carcass, then calculating a whole body concentration based on the relative weights. The results are in Table 17.

PBDE concentrations were three to five times higher in whole fish compared to the fillet. The whole fish total PBDE concentrations for mountain whitefish and rainbow trout collected from the Spokane River in the Ninemile reach were 4,110 and 1,773 ug/Kg, respectively. These are the highest levels so far recorded in Washington. Whole suckers analyzed from this site had total PBDE concentrations of 334 - 708 ug/Kg (see Table 11).

Table 17. Comparison of PBDE Concentrations Measured in Fillets vs. Whole Fish Samples during Ecology's 2005 Studies (ug/Kg, wet weight).

Location:	Lower Columbia River				Spokane R nr. Ninemile				Spokane R nr. Ninemile			
Species:	Northern pikeminnow				Bridgelip sucker				Mountain whitefish			
Tissue:	Fillet		Whole		Fillet		Whole		Fillet		Whole	
Sample No:	6024738		6024738/39		5494257		5494257/58		5494271		5494271/18	
Lipids (%)	2.0		4.6	J	1.5		3.8	J	**3.3**		**5.9**	J
PBDE-047	**13**		**44**	J	**59**		**298**	J	**494**		**1,619**	J
PBDE-049	**0.71**	J	**3**	J	**0.90**		**4.8**	J	**18**		**58**	J
PBDE-066	0.49	U	0.49	UJ	**0.29**		**1.3**	J	**19**		**53**	J
PBDE-071	0.49	U	0.49	UJ	0.21	U	0.4	UJ	0.21	U	0	UJ
PBDE-099	0.49	U	0.49	UJ	**0.46**		**2.1**	J	**525**		**1,807**	J
PBDE-100	**2.6**		**7.7**	J	**10**		**47**	J	**129**		**448**	J
PBDE-138	0.98	U	0.98	UJ	0.42	U	0.8	UJ	0.43	U	0	UJ
PBDE-153	0.19	J	0.67	J	**2.5**		**9.2**	J	**23**		**74**	J
PBDE-154	0.25	J	0.91	J	**2.8**		**11**	J	**14**		**42**	J
PBDE-183	0.98	U	0.98	UJ	0.42	U	0.8	UJ	**0.49**		**1.4**	J
PBDE-184	0.98	U	0.98	UJ	0.42	U	0.8	UJ	**0.12**	J	**0.7**	J
PBDE-191	0.98	U	0.98	UJ	0.42	U	0.8	UJ	0.43	U	0.95	UJ
PBDE-209	6.1	U	6.1	UJ	2.6	U	5	UJ	1.1	UJ	6	UJ
Total PBDEs	**17**	J	**56**	J	**76**		**374**		**1,225**		**4,110**	

Location:	Spokane R nr. Ninemile				Yakima R nr. Horn Rapids			
Species:	Rainbow trout				Smallmouth bass			
Tissue:	Fillet		Whole		Fillet		Whole	
Sample No:	5494272		5494272/19		5522025		5522025/24	
Lipids (%)	**2.1**		**4.3**	J	**1.1**		**4.0**	J
PBDE-047	**251**		**788**	J	**6.2**		**22**	J
PBDE-049	**7.9**		**26**	J	**0.32**		**0.84**	J
PBDE-066	6		22	J	REJ		REJ	
PBDE-071	0.22	U	0.5	UJ	0.22	U	1.1	UJ
PBDE-099	**236**		**744**	J			**6.5**	J
PBDE-100	**47**		**153**	J			**1.0**	J
PBDE-138	0.44	U	0.36	J	0.43	U	2.1	UJ
PBDE-153	**9.9**		**38**	J		J	**0.85**	J
PBDE-154	**5.4**		**19**	J		J	**0.46**	J
PBDE-183	**0.26**	J	**0.64**	J	0.43	U	2.1	UJ
PBDE-184	0.44	U	1	UJ	0.43	U	2.1	UJ
PBDE-191	0.44	U	1	UJ	0.43	U	2.1	UJ
PBDE-209	1.1	UJ	6.2	UJ	1.1	UJ	5.4	UJ
Total PBDEs	**560**		**1,773**		**8**		**36**	

U = Not detected at or above reported quantitation limit
J = Estimated value
UJ = Not detected at or above reported quantitation limit. Quantitation limit is approximate.
REJ = Data rejected

Species Differences

The preceding data provide evidence that fish species, lipid content, and age are important considerations for monitoring PBDEs.

The study that first reported PBDEs in Washington fish noted low accumulation of penta-BDEs by suckers and carp (Johnson and Olson, 2001). Since that time, research has shown that some fish have the capacity to debrominate penta-BDEs (LeBeuf et al., 2006). Stapleton et al. (2004b), for example, showed that carp fed food spiked with pentabrominated PBDE-99 accumulated only tetrabrominated PBDE-47 in their tissues.

The 2005 data show that members of the minnow and sucker families, Cyprinidae and Catostomidae (carp, suckers, and pikeminnow), have much lower percentages of pentabrominated PBDE-99 and -100 relative to total PBDEs than other species. PBDE-99 and -100 are two of the three major congeners detected in fish. Figure 14 plots data from the Statewide Survey and Spokane River Study. The mean percentage of PBDE-99 and -100 in carp, suckers, and pikeminnow ranged from 13-17% vs. 20-75% in other of species, chiefly salmonids and bass. Analysis of variance showed these differences were statistically significant (p <0.05).

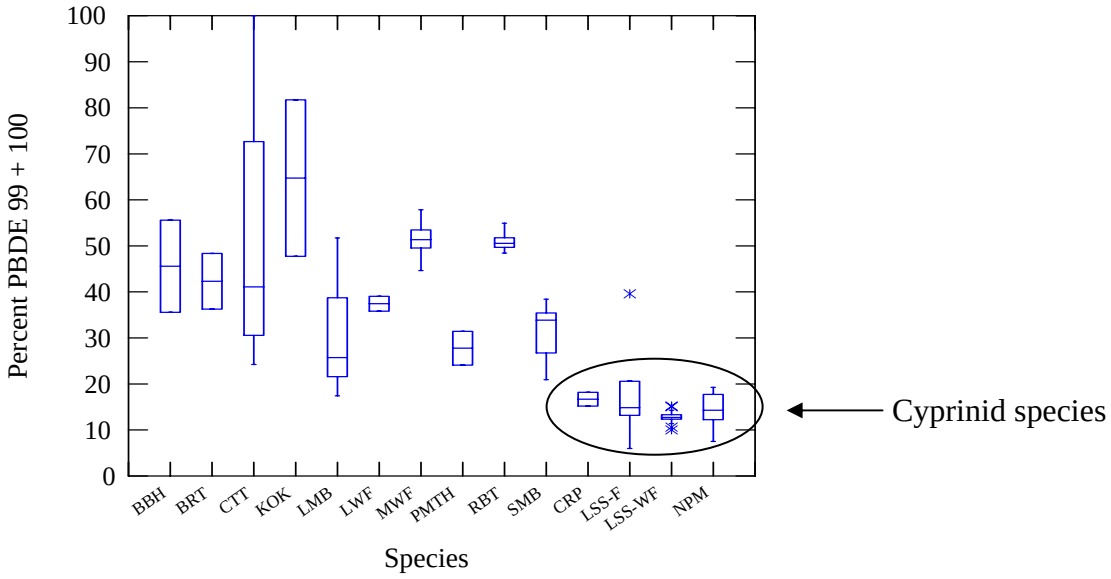

Figure 14. Relative Abundance of PBDE-99 and -100 in Fish Species Analyzed for the Statewide Survey and Spokane River Study (percent of total PBDEs; fillet data except whole largescale suckers (WF) as indicated.)

BBH = brown bullhead
BRT = brown trout
CTT = cutthroat trout
KOK = kokanee
LMB = largemouth bass
LWF = lake whitefish
MWF = mountain whitefish
PMTH = peamouth chub
RBT = rainbow trout
SMB = smallmouth bass
CRP = common carp
LSS = largescale sucker
NPM = northern pikeminnow

The statewide data (Table 9) illustrate that PBDE levels can vary directly and markedly with lipid content, as often observed for other halogenated organic compounds. The relationship tended to be stronger for rivers than lakes. For example, total PBDEs in Snake River fish increased from 0.6 ug/Kg in yellow perch (0.6% lipid), to 2.5 ug/Kg in peamouth (1.8% lipid), to 4.5 ug/Kg in suckers (4.0% lipid), to 30 ug/Kg in carp (5.4% lipid). Figure 15 shows the lipid correlation for the Snake and other rivers where at least four species were analyzed in the Statewide Survey.

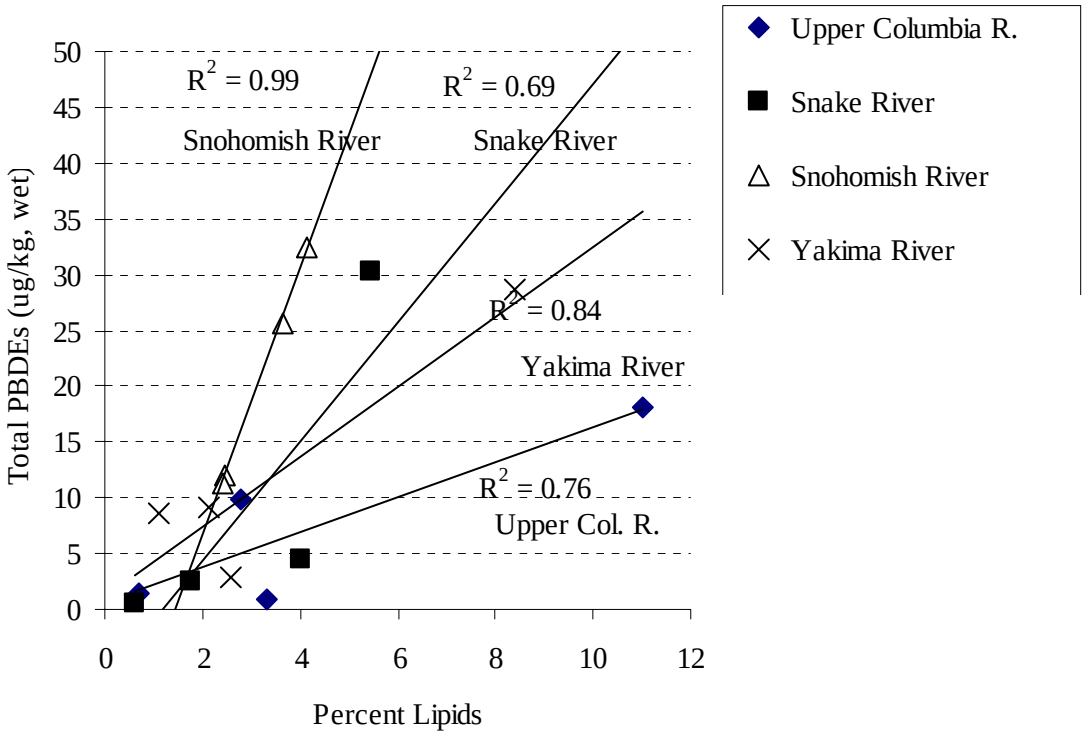

Figure 15. PBDE:Lipid Correlation for Fish Fillet Samples from Selected Rivers Analyzed for Ecology's Statewide Survey.

The relationship between PBDEs and lipids was also strong in some lakes (Mayfield Lake, R^2=0.81; Bead Lake, R^2=0.74), but weak or absent in others. A correspondence with lipid content was evident in the WDOH samples from Lake Washington (Figure 16).

The Lake Washington data also point to age as being an important factor in the amount of PBDEs accumulated in fish. As already noted, PBDE concentrations in cutthroat and pikeminnow were an order of magnitude higher in larger individuals. Figure 17 plots the wet weight and lipid normalized data for these two species. Other studies with fish have shown an age effect for PBDEs (Loganathan et al., 1995; Dodder et al., 2002).

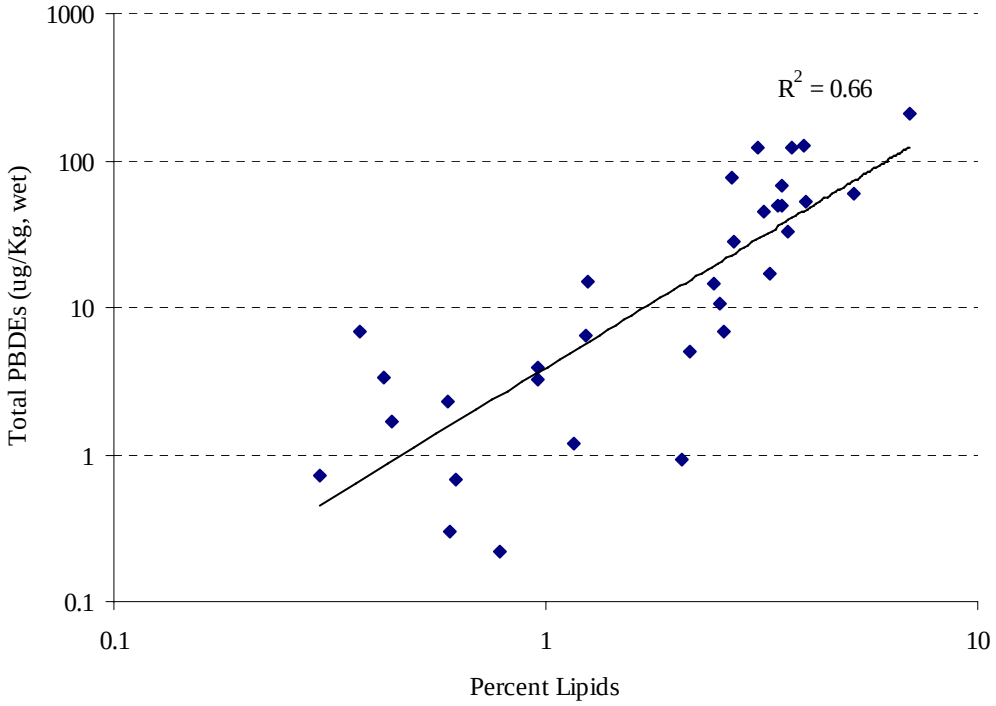

Figure 16. PBDE:Lipid Correlation for Fish Fillets Analyzed from Lake Washington during 2005 (WDOH unpublished data, non-detects not plotted).

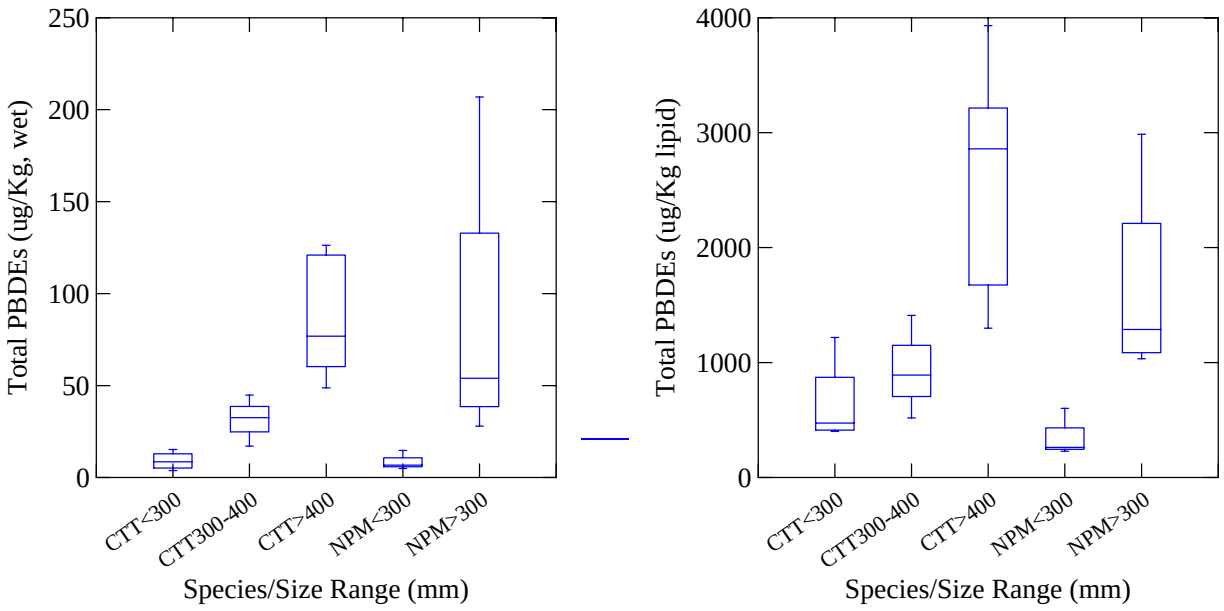

Figure 17. PBDE Concentrations vs. Size in Lake Washington Cutthroat Trout and Northern Pikeminnow (WDOH unpublished data)

Site Differences

The congener patterns in Ecology's 2005 fish samples were examined by comparing congener profiles and using factor analysis in an attempt to identify between-site differences that might relate to types of sources. Because of the large number of non-detects in the data and the dominance of a single congener, PBDE-47, no patterns could be discerned.

Non-detects were not an issue for the Spokane River, but here again no obvious patterns emerged. Figure 18, for example, compares results for whole suckers collected from the Stateline reach with those collected from the Ninemile reach where the spike in PBDE concentrations occurred. It appears that upstream and downstream sources have a similar PBDE signature.

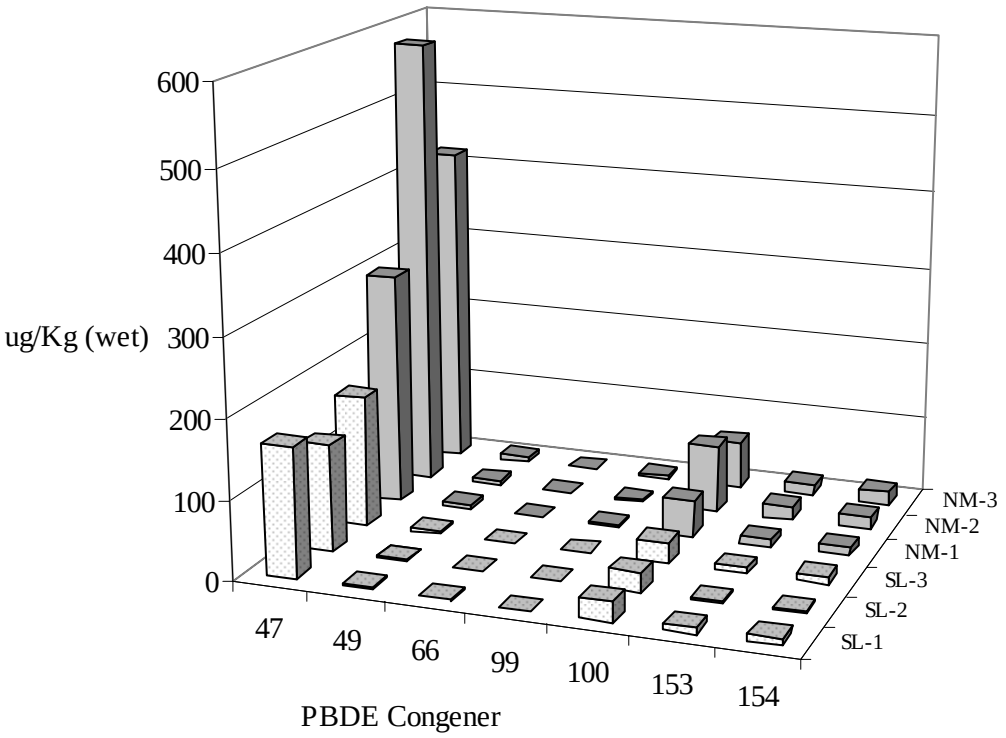

Figure 18. PBDE Congener Profiles in Spokane River Whole Suckers Collected from the Stateline (SL) and Ninemile Reaches (NM) in 2005. (Each sample a five-fish composite.)

Final Waterbody Ranking

The combined 2005 fish fillet data from the Statewide Survey, Spokane River Study, WDOH Lake Washington Study, WSTMP, and EPA National Lakes Study were used to develop a final waterbody ranking for PBDEs. These combined efforts obtained PBDE data on 44 sites representing 36 rivers/impoundments and lakes.

Figure 19 shows how the waterbodies rank on a wet-weight basis. Average values were used for each sampling site, pooling results for multiple samples from the same species before averaging. The Spokane River data were grouped into three reaches: Upper Spokane River (Stateline, Plante Ferry, and Mission Park samples); Ninemile; and Long Lake (upper and lower Long Lake samples).

The highest PBDE levels were almost exclusively found in rivers. Only three of the top 20 sites were lakes. Lake Washington was among the top five. The least contaminated sites were almost exclusively lakes. This finding presumably reflects the fact that rivers generally receive more urban/industrial discharges and runoff than lakes.

In light of the correlation between PBDEs and lipids, the same waterbodies were ranked after lipid normalizing the data (Figure 20). The results did not differ greatly. The primary effect of note was to move the upper and middle Columbia River sites lower in the ranking and to elevate the middle Palouse River.

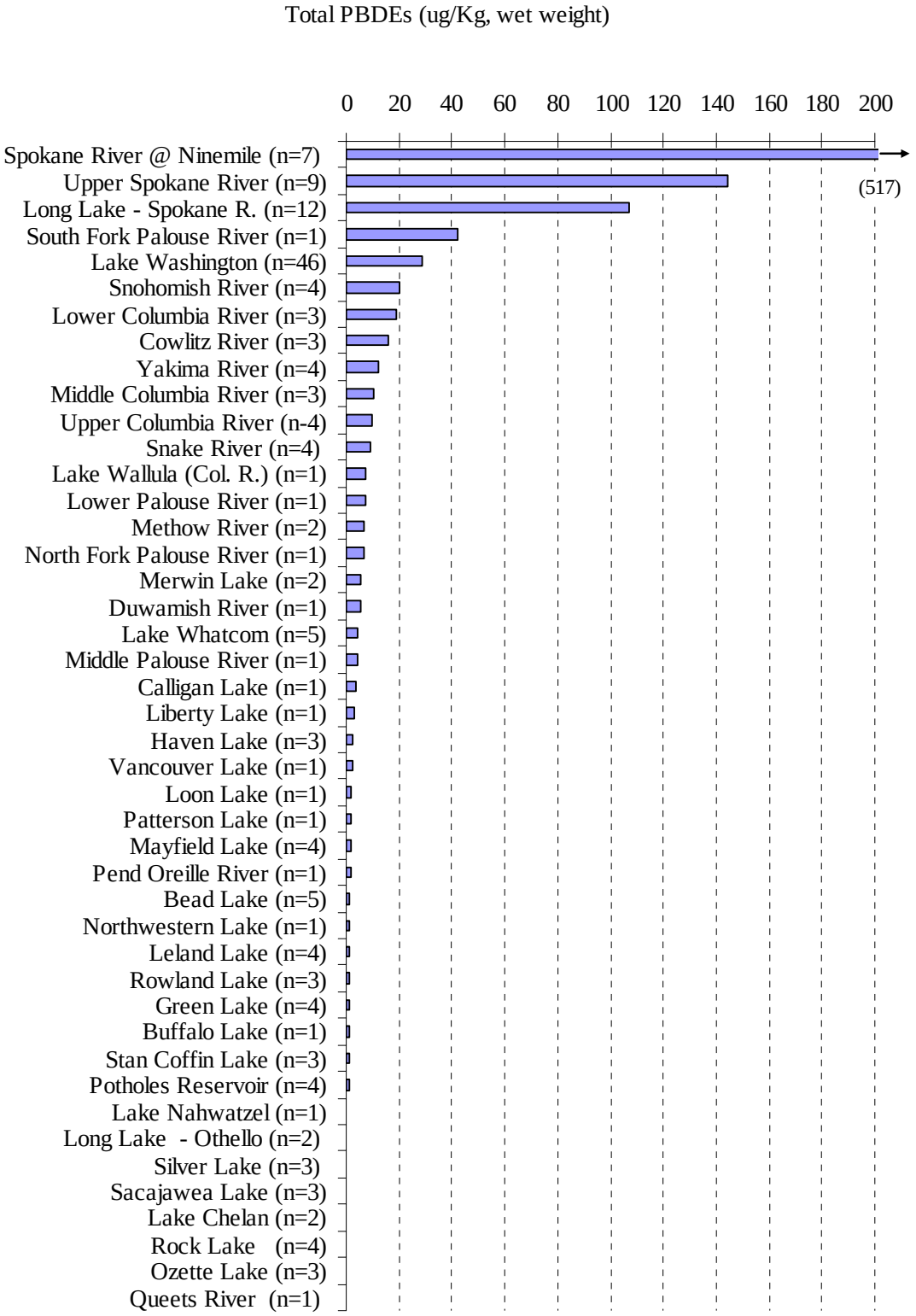

Figure 19. Final Waterbody PBDE Ranking Based on Fish Fillets Analyzed in 2005: Wet Weight Basis

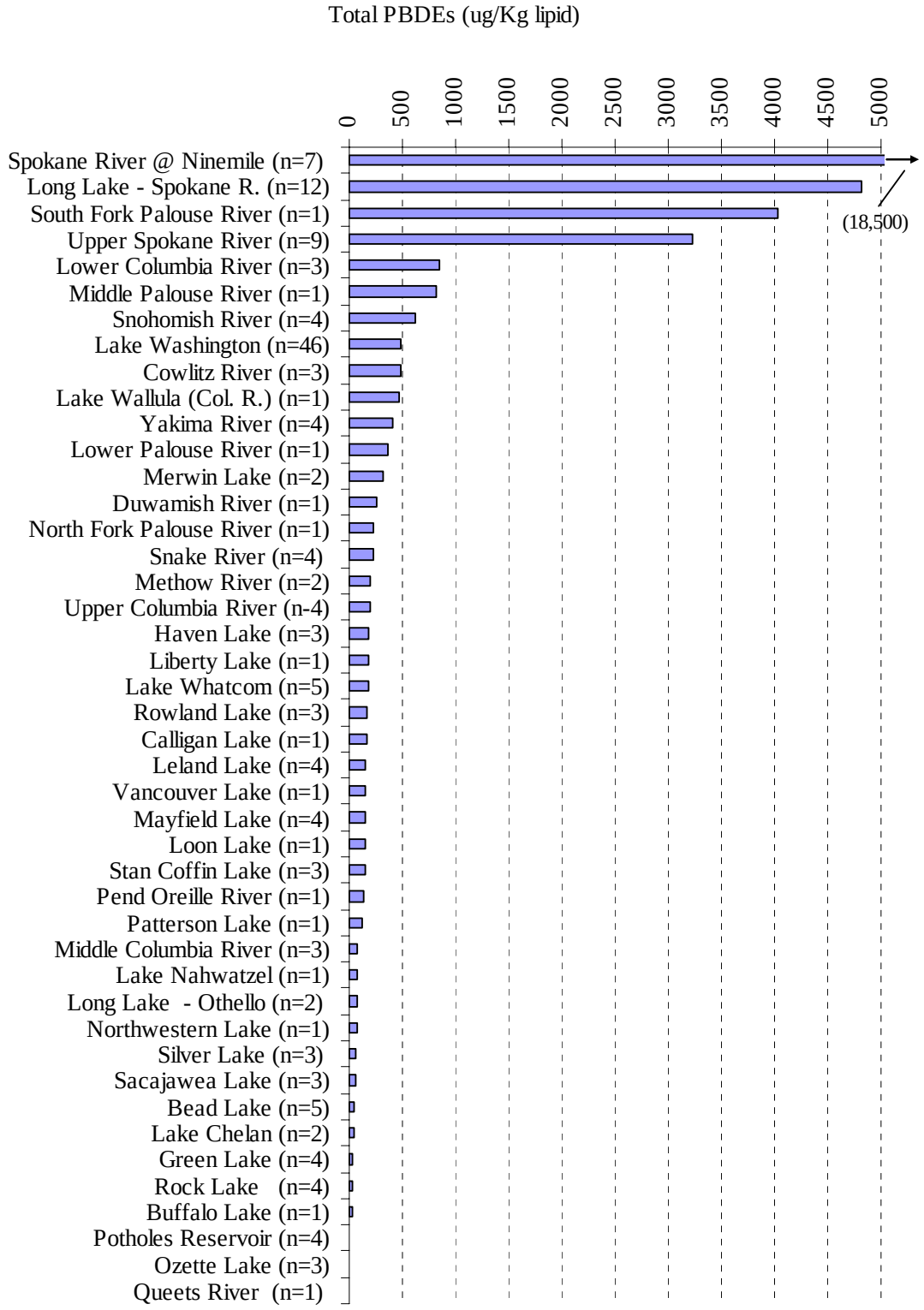

Figure 20. Final Waterbody PBDE Ranking Based on Fish Fillets Analyzed in 2005: Lipid Normalized

The wet weight and lipid based ranks were averaged to identify the 10 most contaminated and 10 least contaminated of the 36 waterbodies sampled in 2005 (Table 18). Except for Merwin Lake, the top 10 are all located in drainages with significant urban development. Merwin Lake, an impoundment of the Lewis River along the Clark/Lewis County boundary, is surrounded by forested land and has no obvious local source of PBDEs.

Table 18. Waterbodies with the Highest and Lowest PBDE Levels in Fish Fillet Samples Analyzed During 2005

Highest Total PBDEs (in descending order)	Lowest total PBDEs (in ascending order)
Spokane River	Queets River*
Palouse River	Ozette Lake
Columbia River	Rock Lake
Lake Washington	Lake Chelan
Snohomish River	Potholes Reservoir
Cowlitz River	Sacajawea Lake
Yakima River	Buffalo Lake*
Snake River	Silver Lake
Merwin Lake	Green Lake
Duwamish River*	Long Lake (Othello)

*based on one composite sample

National Fish Tissue Data

EPA provided preliminary statistics from their National Study of Chemical Residues in Lake Fish Tissue (Table 19). Except for the Spokane River, the PBDE levels recently measured in freshwater fish from Washington State fall within the range observed by EPA nation-wide in lakes.

Table 19. Statistical Summary of PBDE Data from the EPA National Lakes Study (unpublished data)

Species	Number of Samples	Total PBDEs (ug/Kg, wet)		
		Median	Minimum	Maximum
Predators	195	TBD	0.010	58
Bottom dwellers	157	TBD	0.080	125

TBD = to be determined

Hites (2004) reviewed the data on environmental concentrations of PBDEs and summarized fish tissue data for selected major North American rivers and lakes. The data available to Hites at the time of this review were biased toward areas with known or suspected contamination (e.g., Great Lakes, Upper Columbia River, Michigan/Illinois/Virginia waterbodies) and thus show a higher level of PBDE contamination relative to EPA's national lakes study.

Table 20 compares the statistics reported by Hites with results from Ecology's Statewide Survey (lipid-normalized). The two data sets may not be strictly comparable, because Hites drew on older studies from 1992-2000 and because the tissues analyzed were not specified. The Spokane River again, however, appears to stand out.

Table 20. Comparison of Total PBDE Concentrations Measured in Freshwater Fish During Ecology's Statewide Survey with those Reported in a Summary of North American Fish Tissue Data (ug/Kg lipid)

	Ecology Statewide Survey	Major North American Rivers and Lakes (Hites, 2004)
N =	63	281
Mean	1,090	1,050
Geometric mean	72	308
Minimum	0	12
Maximum	29,700	7,200

Fish Tissue Criteria

An effort was made to locate human health and aquatic life criteria for PBDEs to help put the Washington data in perspective. Contacts were made with the EPA Office of Water and Science Technology, Canadian Council of Ministers of the Environment, Fisheries and Oceans Canada, Ontario Ministry of the Environment, California Office of Environmental Health Hazard Assessment, San Francisco Estuary Institute, Maryland Department of the Environment, North Carolina Department Office of Health and Human Services, NOAA Fisheries Northwest Regional Office, and the Washington State Department of Health. With the exception of North Carolina, none of these agencies had developed or were aware of criteria or other guidelines pertaining to PBDEs in fish tissue or water. A cursory internet search of European sources gave similar results.

Dr. Luanne Williams, of the North Carolina Department of Health and Human Services, has made the following recommendations for issuing fish consumption advisories for PBDEs (March 29, 2005; Appendix F):

Average PBDE Level	Recommendations
<2,000 ug/Kg	No recommendations warranted – safe for unrestricted consumption
2,000 to 5,000 ug/Kg	(Species) in (waterbody) contains higher than normal levels of PBDEs. Women of childbearing age (15-44 years) and children under age 15 should not eat (species) in (waterbody). All others should limit consumption of (species) two meals per month.
6,000 ug/Kg or >	(Species) in (waterbody) contains higher than normal levels of PBDEs. No consumption of (species) is recommended.

Among the Washington waterbodies analyzed for PBDEs in 2005, only the Spokane River approached or exceeded the advisory levels recommended by North Carolina. Total PBDEs in mountain whitefish fillets from the Ninemile area (905 – 1,222 ug/Kg total PBDEs) were approximately half the 2,000 ug/Kg advisory level. The total PBDE concentrations in whole whitefish and whole rainbow trout from Ninemile were 4,110 and 1,773 ug/Kg, respectively, in the two samples analyzed.

The North Carolina recommendations were based on the reference doses in the EPA Integrated Risk Management System (IRIS) and advice from EPA (see Appendix F). EPA is currently in the process of revising the reference dose for PBDEs (Dave McBride, WDOH, personal communication). Therefore, the above recommendations may or may not be appropriate.

PBDE Concentrations in Water Samples

Residues Accumulated

A passive sampling technique using a semipermeable membrane device (SPMD) was employed to assess water column concentrations of PBDEs at 10 of the sites where fish were sampled for the Statewide Survey (Figure 4). The SPMDs were deployed for approximately 28 days during August – September 2005. There was a second deployment at six of the sites during March – April 2006. The PBDE residues accumulated in the SPMDs are shown in Table 21. Ancillary water quality data are in Appendix G.

The PBDE congeners most frequently detected in fish were also detected in the SPMDs. These included PBDE -47, -49, - 99, -100, -153, and -154. Except for PBDE-47 and -99, most congeners were detected near the reporting limit. PBDE-209 is too large a molecule to be taken up effectively by SPMDs and was not detected.

The amount absorbed by an SPMD is proportional to the local water concentration. As in the fish samples, SPMDs deployed in the Spokane River, Columbia River, Lake Washington, and Yakima River had the largest residues. The Duwamish River, Potholes Reservoir, Queets River, and Lake Ozette had very low residues. As noted earlier in this report, the fall 2005 SPMD data for Lake Washington are probably biased low (see Data Quality).

The Duwamish SPMD was deployed in the estuarine portion of the river where salinities reached 15 ppt. Results for this site reflect substantial dilution by seawater and are not representative of the free-flowing portion of the river. The Duwamish SPMD for spring 2006 was lost.

As part of a separate study, the U.S. Geological Survey (USGS) deployed SPMDs in the lower Columbia River during 2005. Their site at the Beaver Generating Station was the same site where Ecology's SPMDs were deployed, and the sampling periods were similar. Preliminary USGS data for this site were made available for this present report. The two data sets are compared in Table 22.

Table 21. PBDE Residues Accumulated in SPMDs (total ng in five SPMD membranes)

Waterbody:	Spokane River	Upper Columbia River	Middle Columbia River	Lower Columbia River	Lake Washington	Yakima River	Duwamish River	Potholes Reservoir	Queets River	Lake Ozette
Fall Deployment (August-September 2005)										
Sample No:	404113/14	404115	404110	394090	394092	404111	394091	404112	394093/94	394096
PBDE-47	**548**	**27**	**25**	**23**	**3.0**	**4.9**	2 U	**7.0**	**5.0**	2 U
PBDE-49	**33**	2 U	2 U	**2.7**	2 U	**2.4**	2 U	2 U	2 U	2 U
PBDE-66	**12**	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
PBDE-71	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
PBDE-99	**219**	**4.6**	**14**	**5.1**	2 U	2 U	2 U	**6.2**	**8.0**	**6.9**
PBDE-100	**54**	2 U	**3.6**	**2.5**	2 U	2 U	2 U	2 U	2 U	2 U
PBDE-138	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-153	**7.5**	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-154	**8.8**	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-183	4 U	4 U	4 U	**31***	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-184	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-191	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
PBDE-209	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Total PBDEs	**882**	**31**	**42**	**33**	**3**	**7.3**	ND	**13**	**13**	**6.9**
Spring Deployment (March - April 2006)										
Sample No:	164250	- -	- -	164248	164252	164249	- -	- -	164251	- -
PBDE-47	**96.2**	- -	- -	**45.8**	**19.2**	**29.4**	sampler	- -	**4.6**	- -
PBDE-49	**4.2**	- -	- -	**4.8**	2 U	**4.3**	lost	- -	2 U	- -
PBDE-66	**2.6** J	- -	- -	**1.6** J	5 U	**1.2** J		- -	5 U	- -
PBDE-71	2 U	- -	- -	2 U	2 U	2 U		- -	2 U	- -
PBDE-99	**44.1**	- -	- -	**18.3**	**6.5**	**12**		- -	**1.3**	- -
PBDE-100	**10.4**	- -	- -	**5.5**	**2.2** J	**4.1**		- -	**0.3** J	- -
PBDE-138	4 U	- -	- -	4 U	4 U	4 U		- -	4 U	- -
PBDE-153	**1.9**	- -	- -	**1.1**	2 U	2 U		- -	2 U	- -
PBDE-154	**2.0**	- -	- -	**1.5** J	**1.1** J	**1.3** J		- -	2 U	- -
PBDE-183	4 U	- -	- -	**2.1 J**	4 U	4 U		- -	**2** J	- -
PBDE-184	4 U	- -	- -	4 U	4 U	4 U		- -	4 U	- -
PBDE-191	4 U	- -	- -	4 U	4 U	4 U		- -	4 U	- -
PBDE-209	50 U	- -	- -	50 U	50 U	50 U		- -	50	- -
Total PBDEs	**161**	- -	- -	**81**	**29**	**52**		- -		- -

*High concentration also detected in blanks; not included in total PBDEs.
U = Not detected at or above reported quantitation limit
J = Estimated value

Table 22. Comparison of SPMD Results Obtained by Ecology and USGS for the Lower Columbia River (ng/SPMD) (preliminary USGS data provided by Jennifer Morace, USGS, 16 June 2006)

Agency:	Ecology	USGS	Ecology	USGS
Deployment Date:	29-Aug-05	9-Aug-05	21-Mar-06	12-Apr-05
Retrieval Date:	26-Sep-05	14-Sep-05	18-Apr-06	18-May-05
PBDE-28	NA	**2.2**	NA	**1.9**
PBDE-47	**23**	**56**	**46**	<44
PBDE-49	**2.7**	NA	**4.8**	NA
PBDE-66	<2	**1.2**	**1.6**	ND
PBDE-71	<2	NA	<2	NA
PBDE-85	NA	**0.94**	NA	<1
PBDE-99	**5.1**	**25**	**18**	<38
PBDE-100	**2.5**	**6.8**	**5.5**	<7
PBDE-138	<4	ND	<4	ND
PBDE-153	<4	**1.6**	**1.1**	<3
PBDE-154	<4	**1.5**	**1.5**	<2
PBDE-183	**31***	<1	**2.1**	<1
PBDE-184	<4	NA	<4	NA
PBDE-191	<4	NA	<4	NA
PBDE-209	<4	<16	<50	<17

NA = not analyzed
ND = not detected

Given the low levels being measured, the Ecology and USGS results for this site are in good agreement. The primary discrepancies are due to different reporting limits for PBDE-47 and -99.

Estimated Water Column Concentrations

The SPMD data were used to estimate dissolved concentrations of selected PBDEs, following the procedures outlined in Appendix H. Table 23 has the results. The calculations were limited to congeners where the octanol-water partition coefficient (K_{ow}) has been measured directly (Braekevelt et al., 2003). A chemical's uptake rate by an SPMD is a function of K_{ow}.

Total PBDE concentrations in the Spokane River were estimated at approximately 930 pg/L and 150 pg/L (parts per quadrillion) for the fall and spring deployments, respectively. The estimated PBDE-47 concentrations in the Spokane were, similarly, 510 and 76 pg/L. Other congeners in the Spokane samples were in the range of 3 – 67 pg/L. Much lower PBDE concentrations were estimated for the other rivers and lakes. The highest total PBDE concentrations observed here were 80 pg/L in Lake Washington, 50-57 pg/L in the Columbia River, and 40 pg/L in the Yakima River.

Table 23. SPMD-derived Estimates of Dissolved Concentrations of Selected PBDEs (pg/L, parts per quadrillion)

Waterbody:	Spokane River	Lake Washington	Upper Columbia River	Middle Columbia River	Lower Columbia River	Yakima River	Duwamish River	Potholes Reservoir	Queets River	Lake Ozette
Fall Deployment (August-September 2005)										
Sample No:	404113/14	394092	404115	404110	394090	404111	394091	404112	394093/94	394096
PBDE-47	**510**	**1**	**13**	**26**	**13**	**2**	<1	**4**	**4**	<1
PBDE-49	**31**	<1	<1	<2	**2**	**1**	<1	<1	<2	<1
PBDE-99	**287**	<1	**3**	**19**	**4**	<2	<1	**5**	**8**	**4**
PBDE-100	**67**	<1	<1	**5**	**2**	<2	<1	<2	<2	<1
PBDE-153	**15**	<3	<4	<9	<5	<4	<3	<5	<6	<3
PBDE-154	**17**	<3	<4	<9	<4	<4	<3	<5	<6	<3
PBDE-183	<11	<4	<6	<12	**53***	<5	<3	<7	<9	<4
Total PBDEs	**926**	**1**	**16**	**50**	**21**	**3**	ND	**9**	**12**	**4**
Spring Deployment (March - April 2006)										
Sample No:	164250	164252	- -	- -	164248	164249	- -	- -	164251	- -
PBDE-47	**76**	**46**	- -	- -	**27**	**20**	sampler	- -	**3**	- -
PBDE-49	**3**	<5	- -	- -	**3**	**3**	lost	- -	<1	- -
PBDE-99	**49**	**22**	- -	- -	**15**	**12**		- -	**1**	- -
PBDE-100	**11**	**7**	- -	- -	**4**	**4**		- -	**0.3**	- -
PBDE-153	**3**	<10	- -	- -	**1**	<3		- -	<3	- -
PBDE-154	**3**	**5**	- -	- -	**2**	**2**		- -	<3	- -
PBDE-183	<9	<28	- -	- -	**4**	<8		- -	**4**	- -
Total PBDEs	**146**	**80**	- -	- -	**57**	**40**		- -	**8**	- -

*Blank contamination suspected; not included in total PBDEs

There appeared to be substantial seasonal variation in PBDE levels. Much higher concentrations were found in the spring 2006 samples from Lake Washington, the Lower Columbia River, and the Yakima River. This may reflect the greater amount of urban runoff during this period, or, for the Yakima, an effect related to the beginning of the irrigation season. The opposite phenomenon was seen in the Spokane River where total PBDE concentrations were about five times lower in the spring. This could be interpreted as dilution of local sources by the high flows generated by snowmelt in the upper watershed.

Comparison with Fish Samples

Table 24 shows how PBDE levels in these waterbodies compare when ranked according to concentrations measured in fish vs. SPMDs. The average of the fall and spring concentrations derived from SPMDs was used for the comparison. Except for the Duwamish and the Middle Columbia River, both approaches give similar conclusions as to the relative level of contamination. The lack of agreement for the Duwamish River can be attributed to different sampling sites: the fish were freshwater species collected from the free-flowing portion of the river, while the SPMDs were deployed in the estuary.

Table 24. Relative Ranking of PBDE Levels in Waterbodies Where Both Fish and SPMDs were Analyzed by Ecology during 2005-06

Waterbody	Rank Based on:	
	Fish	SPMDs
Spokane River @ Ninemile	1	1
Lower Columbia River	2	2
Lake Washington	3	4
Yakima River	4	5
Upper Columbia River	5	6
Duwamish River	6	10
Middle Columbia River	7	3
Potholes Reservoir	8	8
Ozette Lake	9	7
Queets River	10	9

Bioaccumulation Factors for PBDEs

Bioaccumulation refers to uptake and retention of a chemical from food, water, and sediment as opposed to bioconcentration which considers uptake from water only. Bioaccumulation factors (BAFs) figure importantly in evaluating the fate and effects of persistent organic pollutants. BAF= C_t/C_w, where C_t is the contaminant concentration in tissue (wet weight) and C_w is the concentration in water. EPA recommends that BAFs be based on the freely dissolved form of a chemical since this is the most bioavailable fraction (EPA, 2000b).

BAFs (L/Kg) were calculated from the fish fillet and SPMD data collected in 2005-06. BAFs were determined only for those waterbodies where PBDEs were consistently quantified, these being the Spokane River (Ninemile data), Lower Columbia River, Lake Washington, and Yakima River. The average dissolved water column concentration was used, which brackets the timeframe when the fish were collected.

Results of the BAF calculations are shown in Table 25. For these waterbodies and species, BAFs for PBDEs appear to be on the order of 10^4 to 10^6, similar to other highly bioaccumulative organohalogens. It should be noted that a relatively small increase or decrease in the estimated water concentrations would have a large effect on the BAF.

Table 25. Bioaccumulation Factors (BAFs) for Selected PBDEs Calculated from Fish Fillet and SPMD Data

Species	N=	PBDEs						
		47	49	99	100	153	154	Total
Northern pikeminnow (<300 mm)	3	3.0E+05	NA	ND	1.1E+05	ND	6.5E+04	2.0E+05
Cutthroat (<400 mm)	4	2.3E+05	NA	1.1E+05	1.1E+05	ND	6.9E+04	2.2E+05
Smallmouth bass	1	5.6E+05	1.6E+05	9.5E+04	1.9E+05	ND	9.9E+04	4.0E+05
Peamouth	1	3.5E+05	3.5E+05	ND	ND	2.2E+05	1.3E+05	4.1E+05
Northern pikeminnow	2	6.2E+05	2.0E+05	ND	6.5E+05	1.3E+05	1.9E+05	6.3E+05
Common carp	2	9.5E+05	ND	ND	1.2E+06	ND	1.4E+05	7.5E+05
Rainbow trout	3	6.2E+05	3.9E+05	1.0E+06	1.0E+06	8.2E+05	5.1E+05	7.8E+05
Largescale sucker	3	1.3E+06	2.4E+05	ND	1.3E+06	3.7E+05	5.0E+05	1.2E+06
Mountain whitefish	3	1.5E+06	7.9E+05	2.7E+06	2.8E+06	1.8E+06	1.1E+06	2.0E+06
Cutthroat (>400 mm)	7	2.3E+06	NA	6.9E+05	1.2E+06	ND	6.4E+05	2.1E+06
Northern pikeminnow (>300 mm)	4	2.9E+06	NA	ND	1.5E+06	ND	7.9E+05	2.1E+06
Mean =		1.0E+06	3.3E+05	9.2E+05	9.7E+05	6.7E+05	3.7E+05	9.5E+05
Minimum =		2.3E+05	7.1E+04	9.5E+04	1.1E+05	1.3E+05	6.5E+04	2.0E+05
Maximum =		2.9E+06	7.9E+05	2.7E+06	2.8E+06	1.8E+06	1.1E+06	2.1E+06

ND = Not detected in fish and/or water samples
NA = Not analyzed in fish and/or water samples

Conclusions

The recent data collected on fillets from Washington freshwater fish indicate that total PBDE concentrations are less than 10 ug/Kg (parts per billion) in most rivers and lakes. Certain fish species from several large waterbodies – Palouse River, Columbia River, Lake Washington, Snohomish River, Cowlitz River, and Snake River – have total PBDE concentrations in the 10 – 200 ug/Kg range. Fish in watersheds with minimal human disturbance (e.g., the Queets River and Lake Ozette) have PBDE concentrations at or below the limit of detection (0.2-0.5 ug/Kg in the present study). Rivers clearly have higher PBDE levels than lakes.

High PBDE concentrations are found throughout the Spokane River. Peak concentrations occur in the Ninemile reach: 292 - 1,222 ug/Kg in fillets and up to 4,110 ug/Kg in whole fish samples. The data suggest major sources are located in the vicinity of the city of Spokane, and there may be significant sources in Idaho.

The most frequently detected PBDEs are the tetra, penta, and hexa congeners: PBDE-47, -49, -99, -100, -153, and -154. PBDE-47 is readily detectable in about 80% of fish samples and typically accounts for 60-70% of the total PBDE residue. PBDE-209, which continues to be produced (Deca-BDE), has a low detection frequency in Washington rivers and lakes, but could be a contributing source of some of the lower PBDEs through its breakdown. PBDE-209 was detected in 6% of the fillet samples (4 out of 63) analyzed for Ecology's Statewide Survey; concentrations were estimated at 0.26 – 2.5 ug/Kg.

PBDE levels vary substantially depending on which fish species and tissues are analyzed. Species with high lipid content and larger/older individuals tend to have the highest concentrations. Whole fish samples have about five times higher PBDE levels than fillets. Certain species in the minnow family (carp, suckers, and pikeminnow in this study) have the ability to debrominate penta-BDEs and are deficient in PBDE-99 and -100.

Except for the Spokane River, the PBDE concentrations measured in fish from Washington rivers and lakes are in the range reported from a recent EPA national study of 500 lakes: up to 58 ug/Kg in fillets and up to 125 ug/kg in whole fish samples. The Spokane River also appears high when compared to other sources of data on PBDEs in fish from North American rivers and lakes.

As far as could be determined, regulatory, human health, and natural resource agencies in the United States have not established what levels of PBDEs may adversely affect human health, aquatic life, or wildlife. North Carolina has recommended that fish consumption advisories be considered in cases where concentrations exceed 2,000 ug/Kg. The EPA reference dose, on which these recommendations are based, may be revised in the near future.

Estimates of dissolved PBDE concentrations were obtained for selected Washington rivers and lakes. Dissolved total PBDE concentrations in the Ninemile reach of the Spokane River ranged from approximately 150 – 950 pg/L (parts per quadrillion), with much lower concentrations in other waterbodies. The concentrations showed substantially seasonal variability. Bioaccumulation factors for PBDEs appear to be on the order of 10^4 – 10^6.

Recommendations

1. Conduct an investigation to identify PBDE sources to the Spokane River, focusing on inputs from the city of Spokane. A parallel effort should be made to confirm the existence of significant sources in Idaho.

2. Analyze additional fish and/or water samples from the Duwamish River and the South Fork Palouse to more accurately determine PBDE levels. Concentrations appear elevated, but this conclusion is based on one composite fish sample each. The Duwamish River is tentatively scheduled for sampling through Ecology's Washington State Toxics Monitoring Program in 2006. Archived fish tissue samples are available to conduct this analysis for the South Fork Palouse.

3. Additional sampling should be done to determine PBDE levels in waterbodies with significant potential for contamination, but where no data exist. The most prominent examples are creeks that drain urban/industrial areas and urban waterways in Puget Sound. This could be accomplished most efficiently with a passive sampling technique such as semipermeable membrane devices.

4. Selected sampling sites from Ecology's 2005-06 surveys should be re-sampled in three to five years to evaluate the effectiveness of the *Washington State PBDE Chemical Action Plan* and other efforts to reduce PBDE inputs to the environment.

5. An effort should be undertaken to develop human health, aquatic life, and wildlife criteria for PBDEs in Washington surface waters.

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Appendices

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Appendix A. Sampling Site Descriptions

Table A-1. Collection Sites of Ecology Fish Samples Analyzed for PBDEs in 2005

Waterbody	County	Sampling Dates	Area of Fish Collection	Agency/ Methods[1]	NAD83 Lat[2]	NAD83 Long[2]
Bead Lake	Pend Oreille	10/26	Entire lake	Ecy-E,G	48.2990	117.1126
Chelan Lake	Chelan	10/5	Lake River and lower 200 feet of First Creek	Ecy-A,DN	47.8396	120.0212
Columbia R., Lower	Wahkiakum	8/30	RM 38-42, near Cathlamet	Ecy-E	46.1784	123.3531
Columbia R., Middle	Benton	11/15	RM 298-301, upstream of McNary Dam	Ecy-E,G	45.9231	119.1482
Columbia R., Upper	Ferry/Stevens	9/13-14,10/20	RM 703-710, near Kettle Falls	Epa-E,G	48.6734	118.0891
Cowlitz River	Lewis	8/29	RM 24-27, near Olequa	Ecy-E	46.3836	122.9323
Duwamish/Green River	King	8/31	RM 10, between I-5 and 405 Hwy bridges	Ecy-E	47.4843	122.2607
Haven Lake	Mason	11/29	Entire lake	Ecy-E,G	47.4567	122.9835
Leland Lake	Jefferson	9/13-14	Entire lake	Dfw-?	47.8951	122.8840
Liberty Lake	Spokane	10/10-11	Entire lake	Dfw-G	47.6459	117.0776
Long Lake	Grant	8/24	Entire lake	Ecy-E	46.9319	119.2088
Loon Lake	Stevens	10/26	NW end	Ecy-E	48.0536	117.6319
Mayfield Lake	Lewis	9/15	Mouth of Tilton R. and mouth of Klickitat Creek	Ecy-E	46.5447	122.5393
Merwin Reservoir	Clark/Cowlitz	11/1	RM 29-31, Speelyai Boat launch to Cresep Bay	Ecy-G	45.9708	122.3893
Methow River	Okanogan	10/19-20	RM 47-49, two miles SE of Winthrop	Ecy-A	48.4430	120.1639
Northwestern Lake	Klickitat	11/2	White Salmon River, RM 3.3-4.9	Ecy-E	45.7750	121.5300
Ozette Lake	Clallam	10/6-7	North, east, and south end			
Palouse R., Lower	Whitman	9/2	RM 19.5 @ Hooper	Ecy-G	46.7586	118.1478
Palouse R., Middle	Whitman	9/8, 9/12	RM 78 @ Sheilds Rd bridge	Ecy-BP	46.9527	117.5041
Palouse R., N. Fork	Whitman	6/30	RM 6.4-22.3, various sites	Ecy-BP	46.9750	117.2108
Palouse R., S. Fork	Whitman	7/5	RM 4.3-20.3, various sites	Ecy-BP	46.8108	117.2583
Potholes Reservoir	Grant	10/25-26	Selected areas throughout entire lake	Dfw-G	46.9813	119.3144
Queets River	Jefferson	11/21	RM 11-12, two miles upstream of Hwy 101	Ecy-A	47.5524	124.2010
Rock Lake	Whitman	8/23-24	South end of lake	Ecy-E,G	47.1678	117.6915
Rowland Lake	Klickitat	9/7-8,11/2	Entire lake	Ecy-E, Dfw-?	45.7082	121.3812
Sacajawea Lake	Clark	9/14	Entire lake	Ecy-E	46.1365	122.9518
Silver Lake	Cowlitz	9/22	Entire lake	Ecy-E	46.2991	122.7702
Snake River	Franklin/Walla Walla	11/14	RM 11-12, near Charbonneau Park	Ecy-E	46.2627	118.8490
Snohomish River	Snohomish	9/1	RM 15-18, between French Ck and Beecher Lk	Ecy-E	47.8754	122.0870
Spokane River	Spokane	8/23	RM 85.0-86.0, near Plante Ferry	Ecy-E	47.6950	117.2399
Spokane River	Spokane	11/3	RM 39.44-40.8, lower Long Lake	Ecy-G	47.8347	117.7366
Spokane River	Spokane	8/22	RM 95.5-96.1, near Stateline	Ecy-E	47.6983	117.0444
Spokane River	Spokane	9/28-29	RM 74.5-78.5, near Mission Park	Ecy-E	47.6640	117.4041
Spokane River	Stevens	9/27-28,11/3	RM 50.6-56.3, upper Long Lake	Ecy-E,G	47.8009	117.5485
Spokane River	Spokane	9/29	RM 63.5-64.5, Nine Mile area	Ecy-E	47.7204	117.5006
Stan Coffin Lake	Grant	9/6	Entire lake	Ecy-E	47.1485	119.9179
Vancouver Lake	Clark	12/5	Entire lake	Ecy-E	45.6800	122.7196
Lake Washington	King	4/27,6/27-28	Entire lake	Dfw-E,G	47.6305	122.2594
Whatcom Lake	Whatcom	10/11-13	Entire lake	Ecy-E,G,A	48.7338	122.3293
Yakima River	Benton	11/16	RM 18-20, 2 mi. above Horn Rapids Dam	Ecy-E	46.3711	119.4364

[1]Ecy, Epa, and Dfw are codes for Wash. St. Dept. Ecology, U.S. Environmental Protection Agency, and Wash. Dept. Fish and Wildlife. E, G, A, DN, BP and ? are code for electroshocking, gillnetting, angling, dip netting, backpack shocking, and unknown.

[2]Latitude and longitude at approximate center of collection area.

RM - river mile

Table A-2. Description of Deployment Sites for Ecology SPMDs

Waterbody	County	Sampling Dates		Site Description	NAD83 Latitude	NAD83 Longitude
		Deployed	Retrieved			
Lower Columbia River	Wahkiakum	8/29/05 3/21/06	9/26/05 4/18/06	Upstream side of dock at Beaver Generation Station (OR)	46.8123	123.1809
Middle Columbia River	Benton	9/7/05	10/5/05	McNary Dam, upstream end of fish ladder, right bank	45.9405	119.2977
Upper Columbia River	Ferry/Stevens	9/8/05	10/6/05	Cliffs below power lines upstream of Kettle Falls bridge, left bank	48.6287	118.1121
Duwamish River*	King	9/14/05 3/29/06	9/30/05 lost	Harbor Island Marina, outer dock	47.5685	122.3470
Ozette Lake	Clallam	8/31/05	9/28/05	Anchored off boat ramp two miles before park campground	48.1417	124.6480
Potholes Reservoir	Grant	9/8/05	10/5/05	Hung from cabled buoys guarding Sullivan Dam outlet	46.9835	119.2585
Queets River	Jefferson	8/31/05 3/28/06	9/28/05 4/25/06	River mile 11-12, two miles upstream of Hwy 101, left bank	47.5526	124.1994
Spokane River	Spokane	9/8/05 3/23/06	10/6/05 4/20/06	Approximate center of upstream side of Nine Mile Dam	47.7751	117.5452
Lake Washington	King	9/2/05 3/29/06	9/30/05 4/26/06	Outer end of dock at Landefeld residence, south side Madison Park	47.6736	122.2514
Yakima River	Benton	9/7/05 3/22/06	10/5/05 4/19/06	Diversion structure at Horn Rapids Dam, right bank	46.3784	119.4181

* Sampler lost and replaced midway through fall deployment; spring deployment lost

Appendix B. Biological Data on Fish Samples

Table B-1. Biological Data on Ecology Fish Samples Analyzed for PBDEs in 2005

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Bead Lake	Largescale sucker	10/25/05	05512000	416	659	F	8
	Largescale sucker	10/25/05	05512000	427	718	M	14
	Largescale sucker	10/25/05	05512000	462	836	F	13
	Largescale sucker	10/25/05	05512000	415	667	F	8
	Largescale sucker	10/25/05	05512000	413	692	F	10
	Burbot	10/26/05	05514700	750	2173	F	6
	Burbot	10/26/05	05514700	688	2269	F	6
	Burbot	10/26/05	05514700	719	2219	F	10
	Burbot	10/26/05	05514700	570	1555	M	3
	Burbot	10/26/05	05514700	523	1014	M	3
	Kokanee	10/25/05	05514701	257	168	F	3
	Kokanee	10/25/05	05514701	270	204	M	3
	Kokanee	10/25/05	05514701	267	161	F	3
	Kokanee	10/25/05	05514701	260	172	F	3
	Kokanee	10/25/05	05514701	279	184	M	3
	Northern pikeminnow	10/26/05	05514702	483	1449	F	9
	Northern pikeminnow	10/26/05	05514702	481	1340	F	8
	Northern pikeminnow	10/26/05	05514702	483	1580	F	11
	Northern pikeminnow	10/26/05	05514702	520	1620	F	15
	Northern pikeminnow	10/26/05	05514702	546	2225	F	12
	Peamouth	10/25/05	05514703	239	93	M	8
	Peamouth	10/25/05	05514703	244	117	F	7
	Peamouth	10/25/05	05514703	246	109	F	7
	Peamouth	10/25/05	05514703	236	93	F	8
	Peamouth	10/25/05	05514703	258	125	F	7
Chelan Lake	Cutthroat trout	10/6/05	05512001	270	208	F	4
	Cutthroat trout	10/6/05	05512001	310	266	M	2
	Cutthroat trout	10/6/05	05512001	270	193	F	3
	Cutthroat trout	10/6/05	05512001	270	182	M	-
	Cutthroat trout	10/6/05	05512001	290	238	M	2
	Kokanee	10/5/05	05512002	305	329	M	3
	Kokanee	10/5/05	05512002	305	310	M	3
	Kokanee	10/5/05	05512002	315	312	M	3
	Kokanee	10/5/05	05512002	305	298	F	3
	Kokanee	10/5/05	05512002	300	264	M	3
Cowlitz River	Cutthroat trout	8/29/05	05514704	335	251	F	3
	Cutthroat trout	8/29/05	05514704	380	285	F	3
	Cutthroat trout	8/29/05	05514704	377	283	M	3

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Cowlitz River (cont.)	Cutthroat trout	8/29/05	05514704	370	278	M	-
	Cutthroat trout	8/29/05	05514704	337	253	M	-
	Cutthroat trout	8/29/05	05514705	376	282	F	3
	Cutthroat trout	8/29/05	05514705	347	260	M	3
	Cutthroat trout	8/29/05	05514705	332	249	F	3
	Cutthroat trout	8/29/05	05514705	369	277	M	3
	Cutthroat trout	8/29/05	05514705	373	280	M	3
	Mountain whitefish	8/29/05	05514706	431	323	F	-
	Mountain whitefish	8/29/05	05514706	427	320	F	-
	Mountain whitefish	8/29/05	05514706	420	315	F	-
	Mountain whitefish	8/29/05	05514706	436	327	F	-
	Mountain whitefish	8/29/05	05514706	492	369	F	-
	Northern pikeminnow	8/29/05	05514707	416	312	F	8
	Northern pikeminnow	8/29/05	05514707	446	335	F	15
	Northern pikeminnow	8/29/05	05514707	462	347	F	10
	Northern pikeminnow	8/29/05	05514707	409	307	F	12
	Northern pikeminnow	8/29/05	05514707	400	300	F	8
Duwamish / Green R	Largescale sucker	8/31/05	05512007	368	685	M?	2
	Largescale sucker	8/31/05	05512007	340	431	M?	2
	Largescale sucker	8/31/05	05512007	292	296	M?	2
	Largescale sucker	8/31/05	05512007	305	331	F?	2
	Largescale sucker	8/31/05	05512007	300	330	M?	2
	Northern pikeminnow	8/31/05	05522018	287	190	U	4
	Northern pikeminnow	8/31/05	05522018	237	111	F?	2
Haven Lake	Rainbow trout	11/29/05	06054769	377	414	U	2
	Rainbow trout	11/29/05	06054769	345	470	M	1
	Rainbow trout	11/29/05	06054769	345	345	F	1
	Rainbow trout	11/29/05	06054769	393	566	F	1
	Rainbow trout	11/29/05	06054769	365	519	F	1
	Largemouth bass	11/29/05	06054770	333	625	M	-
	Largemouth bass	11/29/05	06054770	344	704	M	-
	Largemouth bass	11/29/05	06054770	337	641	F	-
	Largemouth bass	11/29/05	06054770	280	329	F	-
	Largemouth bass	11/29/05	06054770	282	341	F	-
	Cutthroat trout	11/29/05	06054771	253	147	F	2
	Cutthroat trout	11/29/05	06054771	273	155	F	2
	Cutthroat trout	11/29/05	06054771	235	126	F	2
	Cutthroat trout	11/29/05	06054771	242	116	F	2
	Cutthroat trout	11/29/05	06054771	248	139	F	2
Ozette Lake*	Cutthroat trout	10/6/04	5084302	253	130	M	3
	Cutthroat trout	10/7/04	5084302	260	145	F	5
	Cutthroat trout	10/7/04	5084302	306	238	F	3
	Largemouth bass	10/6/04	5084303	445	1276	F	7

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Ozette Lake (cont.)	Largemouth bass	10/6/04	5084303	448	1546	F	6
	Largemouth bass	10/6/04	5084303	385	892	M	7
	Largemouth bass	10/6/04	5084303	414	1015	M	9
	Largemouth bass	10/6/04	5084303	345	690	F	2
	Largemouth bass	10/6/04	5084303	321	510	F	2
	Largemouth bass	10/6/04	5084303	310	437	F	2
	Largemouth bass	10/6/04	5084303	311	428	M	2
	Largemouth bass	10/7/04	5084303	410	1025	F	5
	Largemouth bass	10/7/04	5084303	325	578	M	2
	Northern pikeminnow	10/6/04	5084304	337	330	M	6
	Northern pikeminnow	10/6/04	5084304	334	335	M	4
	Northern pikeminnow	10/6/04	5084304	349	335	F	5
	Northern pikeminnow	10/6/04	5084304	407	596	F	12
	Northern pikeminnow	10/6/04	5084304	355	386	M	7
	Northern pikeminnow	10/6/04	5084304	343	318	U	5
	Northern pikeminnow	10/6/04	5084304	420	755	F	6
	Northern pikeminnow	10/7/04	5084304	390	515	F	7
	Northern pikeminnow	10/7/04	5084304	374	473	M	13
	Northern pikeminnow	10/7/04	5084304	404	592	F	7
	Yellow perch	10/6/04	5084305	230	144	F	2
	Yellow perch	10/6/04	5084305	228	146	F	2
	Yellow perch	10/6/04	5084305	224	127	F	2
	Yellow perch	10/6/04	5084305	213	108	F	2
	Yellow perch	10/6/04	5084305	216	113	F	2
	Yellow perch	10/6/04	5084305	193	79	F	2
	Yellow perch	10/6/04	5084305	212	103	F	2
	Yellow perch	10/6/04	5084305	195	79	F	2
	Yellow perch	10/6/04	5084305	195	80	F	2
	Yellow perch	10/7/04	5084305	207	101	F	2
Leland Lake	Largemouth bass	9/14/05	05514708	435	1376	M?	-
	Largemouth bass	9/13/05	05514708	505	2211	U	-
	Largemouth bass	9/13/05	05514708	455	1256	U	-
	Largemouth bass	9/14/05	05514708	501	2033	U	-
	Largemouth bass	9/14/05	05514708	507	2005	U	-
	Black crappie	9/14/05	06054752	218	158	F	-
	Black crappie	9/14/05	06054752	230	198	F	-
	Black crappie	9/14/05	06054752	224	170	M	-
	Black crappie	9/13/05	06054752	242	215	M	-
	Black crappie	9/14/05	06054752	223	183	F	-
	Bluegill	9/14/05	06054753	158	77	M	-
	Bluegill	9/13/05	06054753	174	113	F	-
	Bluegill	9/14/05	06054753	163	96	F	-
	Bluegill	9/14/05	06054753	172	104	F	-

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Leland Lake (cont.)	Bluegill	9/14/05	06054753	172	114	M	-
	Yellow perch	9/14/05	06054754	209	114	M	-
	Yellow perch	9/14/05	06054754	215	118	M	-
	Yellow perch	9/14/05	06054754	225	142	F	-
	Yellow perch	9/14/05	06054754	220	151	F	-
	Yellow perch	9/14/05	06054754	218	128	F	-
Liberty Lake	Smallmouth bass	10/10/05	06054755	364	648	F	4
	Smallmouth bass	10/11/05	06054755	369	709	M	3
	Smallmouth bass	10/11/05	06054755	396	832	M	4
	Smallmouth bass	10/11/05	06054755	382	778	F	4
	Smallmouth bass	10/11/05	06054755	360	712	M	4
	Smallmouth bass	10/10/05	06054756	349	636	F	3
	Smallmouth bass	10/10/05	06054756	390	879	F	4
	Smallmouth bass	10/10/05	06054756	354	635	F	4
	Smallmouth bass	10/11/05	06054756	375	733	F	4
	Smallmouth bass	10/11/05	06054756	410	1077	F	4
Long Lake	Smallmouth bass	8/24/05	05514709	320	494	M?	-
	Smallmouth bass	8/24/05	05514709	295	441	M?	-
	Smallmouth bass	8/24/05	05514709	322	420	F?	-
	Smallmouth bass	8/24/05	05514709	299	328	M	-
	Smallmouth bass	8/24/05	05514709	280	300	F	-
	Walleye	8/24/05	05514710	511	1275	F	-
	Walleye	8/24/05	05514710	436	766	M	-
	Walleye	8/24/05	05514710	410	581	M	-
	Walleye	8/24/05	05514710	409	597	F	-
	Walleye	8/24/05	05514710	420	606	M	-
Loon Lake	Largemouth bass	10/26/05	06054757	425	1289	M	7
	Largemouth bass	10/26/05	06054757	450	1725	F	11
	Largemouth bass	10/26/05	06054757	473	1917	F	11
	Largemouth bass	10/26/05	06054757	438	1525	M	10
	Largemouth bass	10/26/05	06054757	490	2381	F	12
Lower Columbia R	Largescale sucker	8/30/05	05512006	511	1445	F	6
	Largescale sucker	8/30/05	05512006	471	968	F	15
	Largescale sucker	8/30/05	05512006	446	997	F	5
	Largescale sucker	8/30/05	05512006	456	1023	F	9
	Largescale sucker	8/30/05	05512006	512	1566	F	12
	Peamouth	8/30/05	05524720	276	192	F	7
	Peamouth	8/30/05	05524720	280	197	F	7
	Peamouth	8/30/05	05524720	245	143	F	4
	Peamouth	8/30/05	05524720	283	196	F	6
	Peamouth	8/30/05	05524720	293	215	F	8
	Northern pikeminnow	8/30/05	06024738; 06024739	418	648	F	11
	Northern pikeminnow	8/30/05	06024738; 06024739	420	673	F	6

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Lower Columbia R (cont.)	Northern pikeminnow	8/30/05	06024738; 06024739	452	751	F	8
	Northern pikeminnow	8/30/05	06024738; 06024739	550	1519	F	12
	Northern pikeminnow	8/30/05	06024738; 06024739	489	1191	F	9
Mayfield Lake	Largescale sucker	9/15/05	05512008	484	1267	F	18
	Largescale sucker	9/15/05	05512008	462	918	F	16
	Largescale sucker	9/15/05	05512008	444	917	F	14
	Largescale sucker	9/15/05	05512008	413	723	F	8
	Largescale sucker	9/15/05	05512008	411	765	F	8
	Largemouth bass	9/15/05	05524721	310	452	F	3
	Largemouth bass	9/15/05	05524721	283	378	M	2
	Largemouth bass	9/15/05	05524721	297	323	M	5
	Largemouth bass	9/15/05	05524721	319	468	M	4
	Largemouth bass	9/15/05	05524721	430	1431	M	7
	Northern pikeminnow	9/15/05	05524722	311	248	M	6
	Northern pikeminnow	9/15/05	05524722	325	278	U	8
	Northern pikeminnow	9/15/05	05524722	300	201	U	5
	Northern pikeminnow	9/15/05	05524722	309	244	U	6
	Northern pikeminnow	9/15/05	05524722	315	251	U	7
	Yellow perch	9/15/05	05524723	230	156	F?	4
	Yellow perch	9/15/05	05524723	220	129	M?	4
	Yellow perch	9/15/05	05524723	222	130	F?	4
	Yellow perch	9/15/05	05524723	261	214	F?	4
	Yellow perch	9/15/05	05524723	251	192	F?	4
Merwin Lake	Kokanee salmon	11/1/05	06054758	381	533	F	3
	Kokanee salmon	11/1/05	06054758	359	467	M	1
	Kokanee salmon	11/1/05	06054758	384	478	M	2
	Kokanee salmon	11/1/05	06054758	357	477	M	2
	Kokanee salmon	11/1/05	06054758	368	478	M	2
	Northern pikeminnow	11/1/05	06054759	454	1055	F	6
	Northern pikeminnow	11/1/05	06054759	430	873	F	8
	Northern pikeminnow	11/1/05	06054759	418	776	F	7
	Northern pikeminnow	11/1/05	06054759	437	1060	F	7
	Northern pikeminnow	11/1/05	06054759	442	830	F	6
Methow River	Cutthroat trout	10/19/05	05524724	308	282	U	5
	Cutthroat trout	10/19/05	05524724	276	205	U	4
	Cutthroat trout	10/20/05	05524724	285	215	U	3
	Cutthroat trout	10/20/05	05524724	317	290	U	4
	Cutthroat trout	10/20/05	05524724	271	213	U	5
	Mountain whitefish	10/19/05	06024740	391	663	F	6
	Mountain whitefish	10/19/05	06024740	407	614	F	6
	Mountain whitefish	10/20/05	06024740	410	817	F	9
	Mountain whitefish	10/20/05	06024740	312	266	F	2
	Mountain whitefish	10/20/05	06024740	270	167	M	1

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Mid Columbia River	Yellow perch	11/15/05	05512014	272	273	F	4
	Yellow perch	11/15/05	05512014	280	306	F	5
	Yellow perch	11/15/05	05512014	262	287	F	5
	Yellow perch	11/15/05	05512014	295	316	F	4
	Yellow perch	11/15/05	05512014	273	281	F	4
	Channel catfish	11/15/05	05512015	555	1685	U	6
	Channel catfish	11/15/05	05512015	557	2228	F	7
	Channel catfish	11/15/05	05512015	581	2219	U	7
	Channel catfish	11/15/05	05512015	564	1788	U	6
	Channel catfish	11/15/05	05512015	606	2285	U	7
	Largescale sucker	11/15/05	05512016	465	1092	U	10
	Largescale sucker	11/15/05	05512016	490	1054	M	10
	Largescale sucker	11/15/05	05512016	503	1408	M	8
	Largescale sucker	11/15/05	05512016	447	1012	M	7
	Largescale sucker	11/15/05	05512016	556	1803	F	11
Northwestern Lake	Rainbow trout	11/2/05	06054760	392	608	M	3
	Rainbow trout	11/2/05	06054760	346	415	U	1
	Rainbow trout	11/2/05	06054760	326	328	F	2
	Rainbow trout	11/2/05	06054760	354	418	M	3
	Rainbow trout	11/2/05	06054760	325	363	F	3
Palouse River, Lower	Northern pikeminnow	8/3/05	05514711	420	792	F?	7
	Northern pikeminnow	6/22/05	05514711	443	844	F	8
	Northern pikeminnow	6/23/05	05514711	462	980	F	9
	Northern pikeminnow	6/23/05	05514711	481	1145	F?	10
	Northern pikeminnow	6/23/05	05514711	484	937	F	15
Palouse River, Mid	Smallmouth bass	6/6/05	05514712	181	79	F	2
	Smallmouth bass	6/6/05	05514712	184	73	M	2
	Smallmouth bass	6/6/05	05514712	184	76	M	2
	Smallmouth bass	6/6/05	05514712	164	60	F	2
	Smallmouth bass	6/6/05	05514712	176	74	U	2
	Smallmouth bass	6/6/05	05514712	184	83	U	2
	Smallmouth bass	6/6/05	05514712	171	62	M	2
Palouse River, N. Fork	Northern pikeminnow	6/8/05	05514713	307	264	M	6
	Northern pikeminnow	6/8/05	05514713	361	458	M	8
	Northern pikeminnow	6/8/05	05514713	310	301	M	6
	Northern pikeminnow	6/8/05	05514713	313	296	M	6
	Northern pikeminnow	6/9/05	05514713	399	621	F	9
	Northern pikeminnow	6/9/05	05514713	399	570	F	8
	Northern pikeminnow	6/9/05	05514713	368	420	F	7
	Northern pikeminnow	5/24/05	05514714	350	383	F	7
	Northern pikeminnow	5/24/05	05514714	397	644	F	8
	Northern pikeminnow	5/24/05	05514714	307	260	F	6
	Northern pikeminnow	5/24/05	05514714	363	481	F	7

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Potholes Reservoir	Largescale sucker	10/25/05	05512009	471	1222	F?	4
	Largescale sucker	10/25/05	05512009	509	1869	M	6
	Largescale sucker	10/25/05	05512009	503	1662	M	7
	Largescale sucker	10/25/05	05512009	527	1745	M	6
	Largescale sucker	10/25/05	05512009	499	1714	F	4
	Lake whitefish	10/25/05	06024741	580	2456	M	6
	Lake whitefish	10/25/05	06024741	572	2170	M	5
	Lake whitefish	10/25/05	06024741	572	2696	F	4
	Lake whitefish	10/25/05	06024741	532	2034	M	3
	Lake whitefish	10/25/05	06024741	625	3264	F	13
	Smallmouth bass	10/25/05	06024742	422	1016	F	5
	Smallmouth bass	10/25/05	06024742	499	1685	F	8
	Smallmouth bass	10/25/05	06024742	418	1182	F	5
	Smallmouth bass	10/26/05	06024742	408	982	M	3
	Smallmouth bass	10/26/05	06024742	508	2066	M	8
	Walleye	10/25/05	06024743	628	3042	F	5
	Walleye	10/25/05	06024743	576	1945	F	5
	Walleye	10/25/05	06024743	560	1573	M	5
	Walleye	10/25/05	06024743	562	1529	M	3
	Walleye	10/25/05	06024743	565	1908	F	3
Queets River	Mountain whitefish	11/21/05	05522028	278	182	F	2
	Mountain whitefish	11/21/05	05522028	305	231	F	2
Rock Lake	Largescale sucker	8/23/05	05512010	422	857	F	5
	Largescale sucker	8/23/05	05512010	443	970	F	7
	Largescale sucker	8/23/05	05512010	414	865	M?	6
	Largescale sucker	8/23/05	05512010	400	730	F	5
	Largescale sucker	8/23/05	05512010	451	883	F	8
	Brown trout	8/23/05	05524725	273	208	U	-
	Brown trout	8/23/05	05524725	243	149	U	1
	Brown trout	8/23/05	05524725	241	140	U	1
	Brown trout	8/23/05	05524725	272	231	M	1
	Brown trout	8/23/05	05524725	265	206	U	1
	Largemouth bass	8/23/05	05524726	270	322	F	3
	Largemouth bass	8/23/05	05524726	277	380	F	3
	Largemouth bass	8/23/05	05524726	282	377	M	3
	Largemouth bass	8/23/05	05524726	273	360	M	3
	Largemouth bass	8/23/05	05524726	256	292	F	2
	Yellow perch	8/24/05	05524727	333	647	M	7
	Yellow perch	8/24/05	05524727	349	652	M	7
	Yellow perch	8/24/05	05524727	290	348	M	5
	Yellow perch	8/24/05	05524727	292	349	M	5
Rowland Lake	Bluegill	9/7/05	06054761	168	96	M	-
	Bluegill	9/8/05	06054761	200	165	F	-

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Rowland Lake (cont.)	Bluegill	9/7/05	06054761	161	86	F	-
	Bluegill	9/7/05	06054761	173	96	M	-
	Bluegill	9/7/05	06054761	186	122	F	-
	Bluegill	9/7/05	06054761	177	105	M	-
	Bluegill	9/7/05	06054761	179	109	F	-
	Bluegill	9/7/05	06054761	153	69	M	-
	Largemouth bass	9/7/05	06054762	382	789	F	-
	Largemouth bass	11/2/05	06054762	326	478	M	-
	Largemouth bass	11/2/05	06054762	374	636	F	-
	Largemouth bass	11/2/05	06054762	382	893	F	-
	Largemouth bass	11/2/05	06054762	384	904	F	-
	Yellow perch	9/7/05	06054763	225	136	M	-
	Yellow perch	9/7/05	06054763	201	94	M	-
	Yellow perch	9/7/05	06054763	219	122	F	-
	Yellow perch	9/7/05	06054763	221	122	M	-
	Yellow perch	9/7/05	06054763	217	109	F	-
	Yellow perch	9/7/05	06054763	225	135	F	-
	Yellow perch	9/7/05	06054763	210	100	M	-
	Yellow perch	9/7/05	06054763	220	116	F	-
	Yellow perch	9/7/05	06054763	219	117	F	-
	Yellow perch	9/7/05	06054763	227	139	M	-
Sacajawea Lake	Grass carp	9/14/05	05514715	402	750	U	1
	Grass carp	9/14/05	05514715	457	1325	U	1
	Grass carp	9/14/05	05514715	450	1586	U	1
	Grass carp	9/14/05	05514715	477	1455	U	1
	Grass carp	9/14/05	05514715	450	1131	U	1
	Brown bullhead	9/14/05	05522019	182	77	U	1
	Brown bullhead	9/14/05	05522019	203	105	F	1
	Brown bullhead	9/14/05	05522019	194	103	U	1
	Brown bullhead	9/14/05	05522019	200	114	U	1
	Brown bullhead	9/14/05	05522019	254	241	U	4
	Largemouth bass	9/14/05	06024744	331	585	F	2
	Largemouth bass	9/14/05	06024744	335	663	M	2
	Largemouth bass	9/14/05	06024744	359	827	M	2
	Largemouth bass	9/14/05	06024744	333	630	M	2
	Largemouth bass	9/14/05	06024744	350	755	F	2
Silver Lake	Common carp	9/22/05	05514716	508	2178	F	5
	Common carp	9/22/05	05514716	575	3116	F	5
	Common carp	9/22/05	05514716	511	2117	F	4
	Common carp	9/22/05	05514716	471	1585	F	6
	Common carp	9/22/05	05514716	542	2568	F	4
	Bluegill	9/22/05	06054764	176	115	F	-
	Bluegill	9/22/05	06054764	158	82	M	-

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Silver Lake (cont.)	Bluegill	9/22/05	06054764	177	111	M	-
	Bluegill	9/22/05	06054764	158	80	F	-
	Bluegill	9/22/05	06054764	161	95	M	-
	Bluegill	9/22/05	06054764	167	100	F	-
	Bluegill	9/22/05	06054764	162	89	M	-
	Bluegill	9/22/05	06054764	160	90	M	-
	Bluegill	9/22/05	06054764	166	104	M	-
	Bluegill	9/22/05	06054764	155	86	M	-
	Largemouth bass	9/22/05	06054765	380	1011	F	5
	Largemouth bass	9/22/05	06054765	396	914	M	5
	Largemouth bass	9/22/05	06054765	359	676	F	3
	Largemouth bass	9/22/05	06054765	316	462	M	2
	Largemouth bass	9/22/05	06054765	307	411	F	3
Snake River	Largescale sucker	11/14/05	05522021	465	1025	F	6
	Largescale sucker	11/14/05	05522021	455	1045	M	9
	Largescale sucker	11/14/05	05522021	457	933	F	7
	Largescale sucker	11/14/05	05522021	488	1069	F	7
	Largescale sucker	11/14/05	05522021	490	1084	F	9
	Yellow perch	11/14/05	05524730	247	159	F	2
	Yellow perch	11/14/05	05524730	180	69	F	1
	Yellow perch	11/14/05	05524730	206	87	F	1
	Yellow perch	11/14/05	05524730	198	85	F	1
	Yellow perch	11/14/05	05524730	187	72	F	1
	Peamouth	11/14/05	05524731	260	137	M?	4
	Peamouth	11/14/05	05524731	282	163	M	5
	Peamouth	11/14/05	05524731	299	194	U	7
	Peamouth	11/14/05	05524731	294	197	F	5
	Peamouth	11/14/05	05524731	295	191	F	6
	Common carp	11/14/05	06024751	685	4175	F	13
	Common carp	11/14/05	06024751	655	3745	F	14
	Common carp	11/14/05	06024751	672	4274	F	17
	Common carp	11/14/05	06024751	698	4978	F	12
	Common carp	11/14/05	06024751	667	3865	M	12
Snohomish River	Largescale sucker	9/1/05	05512011	478	1073	F	16
	Largescale sucker	9/1/05	05512011	453	1047	F	9
	Largescale sucker	9/1/05	05512011	453	914	F	8
	Largescale sucker	9/1/05	05512011	423	832	F	5
	Largescale sucker	9/1/05	05512011	423	837	F	5
	Cutthroat trout	9/1/05	05524728	405	659	F	4
	Cutthroat trout	9/1/05	05524728	400	606	F	-
	Cutthroat trout	9/1/05	05524728	376	532	F	3
	Cutthroat trout	9/1/05	05524728	355	451	M	4
	Cutthroat trout	9/1/05	05524728	337	384	M	2

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Snohomish R (cont.)	Mountain whitefish	9/1/05	06024745	298	205	F	5
	Mountain whitefish	9/1/05	06024745	265	161	M	4
	Mountain whitefish	9/1/05	06024745	280	172	F	5
	Mountain whitefish	9/1/05	06024745	271	149	M	4
	Mountain whitefish	9/1/05	06024745	261	127	M	2
	Northern pikeminnow	9/1/05	06024746	357	474	F	4
	Northern pikeminnow	9/1/05	06024746	365	526	F	5
	Northern pikeminnow	9/1/05	06024746	335	350	M	5
	Northern pikeminnow	9/1/05	06024746	311	282	M	4
	Northern pikeminnow	9/1/05	06024746	293	229	M	4
	Mountain whitefish	9/1/05	06024749	262	153	F	3
	Mountain whitefish	9/1/05	06024749	253	146	F	3
	Mountain whitefish	9/1/05	06024749	268	152	M	4
	Mountain whitefish	9/1/05	06024749	275	168	M	4
	Mountain whitefish	9/1/05	06024749	266	151	M	4
Spokane River, Lower Long Lake	Mountain whitefish	11/3/05	05494233	368	544	F	5
	Mountain whitefish	11/3/05	05494234	356	536	F	4
	Mountain whitefish	11/3/05	05494235	365	524	F	7
	Mountain whitefish	11/3/05	05494236	365	573	F	11
	Mountain whitefish	11/3/05	05494237	341	413	M	3
	Mountain whitefish	11/3/05	05494238	349	468	M	5
	Largescale sucker	11/3/05	05494242	486	1382	-	15
	Largescale sucker	11/3/05	05494242	491	1378	-	6
	Largescale sucker	11/3/05	05494242	502	1501	F	13
	Largescale sucker	11/3/05	05494242	492	1410	F	13
	Largescale sucker	11/3/05	05494242	486	1483	F	7
	Largescale sucker	11/3/05	05494243	385	640	-	3
	Largescale sucker	11/3/05	05494243	409	757	-	3
	Largescale sucker	11/3/05	05494243	416	900	-	3
	Largescale sucker	11/3/05	05494243	401	724	-	3
	Largescale sucker	11/3/05	05494243	425	931	-	8
	Largescale sucker	11/3/05	05494244	468	1276	-	10
	Largescale sucker	11/3/05	05494244	475	1362	-	13
	Largescale sucker	11/3/05	05494244	451	1218	-	11
	Largescale sucker	11/3/05	05494244	459	1118	F	9
	Largescale sucker	11/3/05	05494244	447	1030	-	4
	Smallmouth bass	11/3/05	05494273	335	663	M	3
	Smallmouth bass	11/3/05	05494273	364	810	M	3
	Smallmouth bass	11/3/05	05494273	333	459	F	4
	Smallmouth bass	11/3/05	05494273	332	541	?	3
	Smallmouth bass	11/3/05	05494273	335	432	?	4
	Smallmouth bass	11/3/05	05494274	378	966	M	4
	Smallmouth bass	11/3/05	05494274	370	887	F	4

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Spokane River, Lower Long Lk (cont.)	Smallmouth bass	11/3/05	05494274	380	936	M	4
	Smallmouth bass	11/3/05	05494274	383	869	F	4
	Smallmouth bass	11/3/05	05494274	379	887	M	4
	Smallmouth bass	11/3/05	05494275	468	1625	F	7
	Smallmouth bass	11/3/05	05494275	386	905	F	5
	Smallmouth bass	11/3/05	05494275	400	995	F	4
	Smallmouth bass	11/3/05	05494275	411	1170	F	6
	Smallmouth bass	11/3/05	05494275	450	1333	F	7
Spokane River, Mission Park	Largescale sucker	9/28/05	05494251	483	1199	F	7
	Largescale sucker	9/28/05	05494251	525	1413	F	12
	Largescale sucker	9/28/05	05494251	486	994	F	11
	Largescale sucker	9/28/05	05494251	520	1467	F	11
	Largescale sucker	9/28/05	05494251	489	1225	F	14
	Largescale sucker	9/28/05	05494252	482	1002	F	8
	Largescale sucker	9/28/05	05494252	440	810	F	11
	Largescale sucker	9/28/05	05494252	458	874	F	8
	Largescale sucker	9/28/05	05494252	460	1004	F	8
	Largescale sucker	9/28/05	05494252	437	911	F	5
	Largescale sucker	9/28/05	05494253	411	667	F	8
	Largescale sucker	9/28/05	05494253	405	650	F	9
	Largescale sucker	9/28/05	05494253	420	703	-	8
	Largescale sucker	9/28/05	05494253	428	720	-	6
	Largescale sucker	9/28/05	05494253	405	692	-	7
	Rainbow trout	9/28/05	05494261	318	286	M	4
	Rainbow trout	9/28/05	05494261	310	277	F	2
	Rainbow trout	9/28/05	05494261	242	112	-	1
	Rainbow trout	9/28/05	05494261	252	145	imm. M?	1
	Rainbow trout	9/28/05	05494261	246	140	imm. M?	1
	Rainbow trout	9/28/05	05494262	345	410	?	3
	Rainbow trout	9/28/05	05494262	345	348	F	2
	Rainbow trout	9/28/05	05494262	335	342	F	3
	Rainbow trout	9/28/05	05494262	321	315	M	2
	Rainbow trout	9/28/05	05494262	330	328	?	2
	Rainbow trout	9/28/05	05494263	389	608	F	4
	Rainbow trout	9/28/05	05494263	372	448	F	4
	Rainbow trout	9/28/05	05494263	355	406	M	1
	Rainbow trout	9/28/05	05494263	423	726	F	5
	Rainbow trout	9/28/05	05494263	364	397	?	4
	Mountain whitefish	9/28/05	05494264	350	396	M	5
	Mountain whitefish	9/28/05	05494264	334	359	M	5
	Mountain whitefish	9/28/05	05494264	341	421	F	4

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Spokane River, Mission Park (cont.)	Mountain whitefish	9/29/05	05494264	355	428	M	6
	Mountain whitefish	9/29/05	05494264	353	464	F	4
	Mountain whitefish	9/28/05	05494265	365	443	F	5
	Mountain whitefish	9/28/05	05494265	362	393	M	6
	Mountain whitefish	9/29/05	05494265	364	506	F	6
	Mountain whitefish	9/29/05	05494265	356	400	F	6
	Mountain whitefish	9/29/05	05494265	355	434	M	5
	Mountain whitefish	9/28/05	05494266	374	531	M	6
	Mountain whitefish	9/28/05	05494266	374	457	F	7
	Mountain whitefish	9/29/05	05494266	382	585	F	7
	Mountain whitefish	9/29/05	05494266	370	466	M	5
	Mountain whitefish	9/29/05	05494266	372	471	F	4
Spokane R, Ninemile	Bridgelip sucker	9/29/05	05494259	430	777	-	7
	Bridgelip sucker	9/29/05	05494259	429	935	F	7
	Bridgelip sucker	9/29/05	05494259	417	842	F	7
	Bridgelip sucker	9/29/05	05494259	422	800	-	8
	Bridgelip sucker	9/29/05	05494260	391	649	-	5
	Bridgelip sucker	9/29/05	05494260	400	884	F	6
	Bridgelip sucker	9/29/05	05494260	414	756	F	8
	Bridgelip sucker	9/29/05	05494260	408	705	-	7
	Bridgelip sucker	9/29/05	05494260	410	884	F	6
	Mountain whitefish	9/29/05	05494267	309	254	M	4
	Mountain whitefish	9/29/05	05494267	277	187	F	2
	Mountain whitefish	9/29/05	05494267	304	289	F	3
	Mountain whitefish	9/29/05	05494267	282	199	M	3
	Mountain whitefish	9/29/05	05494267	287	184	F	2
	Rainbow trout	9/29/05	05494269	328	351	M	2
	Rainbow trout	9/29/05	05494269	295	270	M	1
	Rainbow trout	9/29/05	05494269	305	283	F	1
	Rainbow trout	9/29/05	05494269	265	179	?	1
	Rainbow trout	9/29/05	05494269	332	371	F	1
	Rainbow trout	9/29/05	05494270	341	394	F	4
	Rainbow trout	9/29/05	05494270	354	417	?	1
	Rainbow trout	9/29/05	05494270	341	388	F	2
	Rainbow trout	9/29/05	05494270	370	461	M	3
	Rainbow trout	9/29/05	05494270	348	415	M	3
	Bridgelip sucker	9/29/05	05494257; 05494258	446	956	F	7
	Bridgelip sucker	9/29/05	05494257; 05494258	438	980	F	10
	Bridgelip sucker	9/29/05	05494257; 05494258	435	839	U	7
	Bridgelip sucker	9/29/05	05494257; 05494258	435	782	F	6
	Bridgelip sucker	9/29/05	05494257; 05494258	449	969	F	11
	Rainbow trout	9/29/05	05494272; 05524719	372	472	F	2
	Rainbow trout	9/29/05	05494272; 05524719	430	646	U	4

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Spokane R, Ninemile (cont.)	Rainbow trout	9/29/05	05494272; 05524719	427	649	F	3
	Rainbow trout	9/29/05	05494272; 05524719	390	578	U	2
	Rainbow trout	9/29/05	05494272; 05524719	410	617	F	3
	Mountain whitefish	9/29/05	05524736; 05494268	316	308	F	2
	Mountain whitefish	9/29/05	05524736; 05494268	326	390	F	3
	Mountain whitefish	9/29/05	05524736; 05494268	318	271	F	4
	Mountain whitefish	9/29/05	05524736; 05494268	322	308	U	5
	Mountain whitefish	9/29/05	05524736; 05494268	321	268	F	3
	Mountain whitefish	9/29/05	05524736; 05524718; 05494268	343	369	F	3
	Mountain whitefish	9/29/05	05524736; 05524718; 05494271	346	356	F	5
	Mountain whitefish	9/29/05	05524736; 05524718; 05494271	368	390	F	12
	Mountain whitefish	9/29/05	05524736; 05524718; 05494271	344	396	M	5
	Mountain whitefish	9/29/05	05524736; 05524718; 05494271	344	316	F	5
Spokane River, Plante Ferry	Rainbow trout	8/23/05	05494230	510	1277	M	4
	Rainbow trout	8/23/05	05494230	442	860	F	4
	Rainbow trout	8/23/05	05494230	440	770	F	3
	Rainbow trout	8/23/05	05494230	452	780	F	3
	Rainbow trout	8/23/05	05494230	409	670	M	2
	Rainbow trout	8/23/05	05494231	406	609	M?	2
	Rainbow trout	8/23/05	05494231	365	530	F	2
	Rainbow trout	8/23/05	05494231	407	610	M?	2
	Rainbow trout	8/23/05	05494231	390	570	F	4
	Rainbow trout	8/23/05	05494231	348	445	M	3
	Rainbow trout	8/23/05	05494232	342	410	F?	2
	Rainbow trout	8/23/05	05494232	320	343	M?	2
	Rainbow trout	8/23/05	05494232	329	363	F	2
	Rainbow trout	8/23/05	05494232	311	296	M?	1
	Rainbow trout	8/23/05	05494232	338	310	F	2
	Largescale sucker	8/23/05	05494248	564	1802	-	9
	Largescale sucker	8/23/05	05494248	515	1337	-	7
	Largescale sucker	8/23/05	05494248	520	1188	-	9
	Largescale sucker	8/23/05	05494248	540	1410	-	10
	Largescale sucker	8/23/05	05494248	522	1370	-	8
	Largescale sucker	8/23/05	05494249	490	1115	-	8
	Largescale sucker	8/23/05	05494249	480	1070	-	7
	Largescale sucker	8/23/05	05494249	478	982	-	5
	Largescale sucker	8/23/05	05494249	509	1240	-	9
	Largescale sucker	8/23/05	05494249	464	1060	-	7
	Largescale sucker	8/23/05	05494250	440	846	-	7
	Largescale sucker	8/23/05	05494250	443	970	-	5

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
	Largescale sucker	8/23/05	05494250	454	1035	-	6
	Largescale sucker	8/23/05	05494250	456	995	-	6
	Largescale sucker	8/23/05	05494250	463	946	-	4
Spokane R, Stateline	Largescale sucker	8/22/05	05494245	498	1222	-	6
	Largescale sucker	8/22/05	05494245	511	1120	-	10
	Largescale sucker	8/22/05	05494245	520	1356	-	13
	Largescale sucker	8/22/05	05494245	532	1543	-	11
	Largescale sucker	8/22/05	05494245	517	1316	-	9
	Largescale sucker	8/22/05	05494246	485	1293	-	9
	Largescale sucker	8/22/05	05494246	455	986	-	4
	Largescale sucker	8/22/05	05494246	488	1168	-	8
	Largescale sucker	8/22/05	05494246	463	1035	-	6
	Largescale sucker	8/22/05	05494246	459	999	-	5
	Largescale sucker	8/22/05	05494247	438	986	-	6
	Largescale sucker	8/22/05	05494247	435	960	-	8
	Largescale sucker	8/22/05	05494247	453	942	-	9
	Largescale sucker	8/22/05	05494247	445	982	-	5
	Largescale sucker	8/22/05	05494247	448	932	-	7
Spokane River, Upper Long Lake	Mountain whitefish	9/27/05	05494239	347	409	F	13
	Mountain whitefish	9/27/05	05494239	317	344	F	5
	Mountain whitefish	9/27/05	05494239	295	276	F	3
	Mountain whitefish	9/27/05	05494239	313	294	M	3
	Mountain whitefish	9/28/05	05494239	316	316	F	5
	Mountain whitefish	9/27/05	05494240	287	218	F	3
	Mountain whitefish	9/27/05	05494240	284	209	F	2
	Mountain whitefish	9/27/05	05494240	283	233	F	2
	Mountain whitefish	9/27/05	05494240	272	211	F	2
	Mountain whitefish	9/28/05	05494240	283	225	M	3
	Mountain whitefish	9/27/05	05494241	270	183	M	2
	Mountain whitefish	9/27/05	05494241	251	122	imm. M?	1
	Mountain whitefish	9/27/05	05494241	245	148	imm. M?	1
	Mountain whitefish	9/28/05	05494241	258	125	F	1
	Mountain whitefish	9/28/05	05494241	256	134	M	1
	Largescale sucker	9/27/05	05494254	420	732	M	10
	Largescale sucker	9/27/05	05494254	450	954	F	7
	Largescale sucker	9/27/05	05494254	434	845	M	13
	Largescale sucker	9/27/05	05494254	440	793	M	8
	Largescale sucker	9/27/05	05494254	447	943	-	13
	Largescale sucker	9/27/05	05494255	465	917	-	13
	Largescale sucker	9/27/05	05494255	456	1024	F	8
	Largescale sucker	9/27/05	05494255	468	1254	-	14
	Largescale sucker	9/27/05	05494255	459	1151	-	15

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Spokane River, Upper Long Lk (cont)	Largescale sucker	9/27/05	05494255	459	912	-	9
	Largescale sucker	9/27/05	05494256	493	1267	-	11
	Largescale sucker	9/27/05	05494256	486	1045	F	10
	Largescale sucker	9/27/05	05494256	470	1047	F	15
	Largescale sucker	9/27/05	05494256	495	1359	F	12
	Largescale sucker	9/27/05	05494256	491	1294	F	11
	Brown Trout	11/3/05	05494276	471	1126	F	3
	Brown Trout	11/3/05	05494276	430	802	F	2
	Smallmouth bass	9/27/05	05494277	388	975	F	4
	Smallmouth bass	9/27/05	05494277	430	1186	F	6
	Smallmouth bass	9/27/05	05494277	341	557	F	3
	Smallmouth bass	11/3/05	05494277	317	523	M	3
Stan Coffin Lake	Channel catfish	9/6/05	06054766	610	2238	U	6
	Channel catfish	9/6/05	06054766	589	1539	U	5
	Channel catfish	9/6/05	06054766	490	1277	U	8
	Channel catfish	9/6/05	06054766	520	1459	F	6
	Channel catfish	9/6/05	06054766	531	1433	F	8
	Largemouth bass	9/6/05	06054767	351	729	M?	-
	Largemouth bass	9/6/05	06054767	339	630	M	-
	Largemouth bass	9/6/05	06054767	364	891	F?	-
	Largemouth bass	9/6/05	06054767	347	709	F?	-
	Largemouth bass	9/6/05	06054767	342	700	F	-
	Yellow perch	9/6/05	06054768	210	112	F	-
	Yellow perch	9/6/05	06054768	222	109	F	-
	Yellow perch	9/6/05	06054768	206	102	F	-
	Yellow perch	9/6/05	06054768	179	73	F	-
	Yellow perch	9/6/05	06054768	163	52	F	-
	Yellow perch	9/6/05	06054768	189	71	M	-
	Yellow perch	9/6/05	06054768	184	70	F	-
	Yellow perch	9/6/05	06054768	159	43	F	-
	Yellow perch	9/6/05	06054768	167	53	F	-
Upper Columbia River	Largescale sucker	10/20/05	05512003	405	750	M	3
	Largescale sucker	10/20/05	05512003	595	2607	F	31
	Largescale sucker	10/20/05	05512003	550	1767	F	30
	Largescale sucker	10/20/05	05512003	500	1665	U	25
	Largescale sucker	10/20/05	05512003	535	1690	F	-
	Rainbow trout	10/20/05	05512004	370	629	M	3
	Rainbow trout	10/20/05	05512004	320	395	M	2
	Rainbow trout	10/20/05	05512004	355	480	F	3
	Rainbow trout	10/20/05	05512004	354	467	F	2
	Walleye	10/20/05	05512005	420	636	M	4
	Walleye	10/20/05	05512005	429	746	F	3

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Upper Columbia River (cont.)	Walleye	10/20/05	05512005	359	436	M	2
	Walleye	10/20/05	05512005	335	289	M	2
	Walleye	10/20/05	05512005	366	432	M	4
	Lake whitefish	10/20/05	05522027	560	2102	F	5
	Lake whitefish	10/20/05	05522027	494	1412	M	3
	Lake whitefish	10/20/05	05522027	511	1773	F	3
	Lake whitefish	9/13/05	05522027	403	941	M	2
	Lake whitefish	9/14/05	05522027	420	909	M	2
Vancouver Lake	Largescale sucker	12/5/05	05522026	487	1101	F	12
	Largescale sucker	12/5/05	05522026	476	1001	F	11
	Largescale sucker	12/5/05	05522026	467	1016	F	8
	Largescale sucker	12/5/05	05522026	497	1057	F	13
	Largescale sucker	12/5/05	05522026	485	1063	F	10
Lake Washington	Largescale sucker	6/28/05	05512012	501	1332	U	7
	Largescale sucker	6/28/05	05512012	533	1707	U	17
	Largescale sucker	6/28/05	05512012	436	969	U	6
	Largescale sucker	6/28/05	05512012	449	856	U	6
	Largescale sucker	6/27/05	05512012	410	875	U	5
	Largescale sucker	6/27/05	05512013	410	744	U	4
	Largescale sucker	6/27/05	05512013	451	1042	F	7
	Largescale sucker	6/27/05	05512013	428	782	U	7
	Largescale sucker	6/27/05	05512013	443	990	U	8
	Largescale sucker	6/27/05	05512013	540	1555	F	23
	Common carp	6/28/05	05524717	670	4555	U	10
	Common carp	6/28/05	05524717	670	5280	M?	20
	Common carp	6/28/05	05524717	710	5994	U	14
	Common carp	6/28/05	05524717	680	5644	U	18
	Common carp	4/27/05	05524717	760	6322	U	23
Lake Whatcom	Brown bullhead	10/12/05	05522020	284	283	F	2
	Brown bullhead	10/12/05	05522020	270	242	F?	1
	Brown bullhead	10/12/05	05522020	279	272	M?	1
	Brown bullhead	10/12/05	05522020	287	280	M	1
	Brown bullhead	10/12/05	05522020	275	260	F	1
	Peamouth	10/11/05	05524729	278	200	M	17
	Peamouth	10/11/05	05524729	271	215	M	10
	Peamouth	10/11/05	05524729	270	173	M	8
	Peamouth	10/11/05	05524729	261	168	F	12
	Peamouth	10/11/05	05524729	252	157	M	7
	Cutthroat trout	10/12/05	06024747	435	770	F	4
	Cutthroat trout	10/12/05	06024747	445	752	F	6
	Cutthroat trout	10/12/05	06024747	412	722	M	4
	Cutthroat trout	10/12/05	06024747	384	550	F	4

Waterbody	Species	Collect Date	Sample Number	Total Length (mm)	Weight (gm)	Sex	Age
Lake Whatcom (cont.)	Cutthroat trout	10/13/05	06024747	330	283	F	3
	Yellow perch	10/12/05	06024748	337	475	F	6
	Yellow perch	10/12/05	06024748	319	493	F	6
	Yellow perch	10/12/05	06024748	345	549	F	8
	Yellow perch	10/12/05	06024748	316	421	F	4
	Yellow perch	10/12/05	06024748	336	543	F	7
	Smallmouth bass	10/11/05	06024750	427	1169	F	7
	Smallmouth bass	10/11/05	06024750	432	1357	M	7
	Smallmouth bass	10/12/05	06024750	362	665	F	3
	Smallmouth bass	10/12/05	06024750	446	1522	M	7
Yakima River	Common carp	11/16/05	05512017	412	1065	M	-
	Common carp	11/16/05	05512017	368	803	M	-
	Common carp	11/16/05	05512017	425	1334	M	-
	Common carp	11/16/05	05512017	390	999	M	-
	Common carp	11/16/05	05512017	396	1002	M	-
	Northern pikeminnow	11/16/05	05522022	288	203	M	1
	Northern pikeminnow	11/16/05	05522022	344	346	M	2
	Northern pikeminnow	11/16/05	05522022	340	347	M	2
	Northern pikeminnow	11/16/05	05522022	281	208	U	2
	Northern pikeminnow	11/16/05	05522022	309	245	F	2
	Largescale sucker	11/16/05	05522023	507	1434	F	5
	Largescale sucker	11/16/05	05522023	531	1695	M?	17
	Largescale sucker	11/16/05	05522023	485	1491	M	6
	Largescale sucker	11/16/05	05522023	487	1464	M	11
	Largescale sucker	11/16/05	05522023	571	2045	F	14
	Smallmouth bass	11/16/05	05522025	339	508	M	3
	Smallmouth bass	11/16/05	05522025	401	988	M	3
	Smallmouth bass	11/16/05	05522025	341	599	F	5
	Smallmouth bass	11/16/05	05522025	385	839	F	4
	Smallmouth bass	11/16/05	05522025	427	1088	F	4

* Present study uses Ecology data from Ozette Lake samples collected in 2004.

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Appendix C. Names of Fish Species Analyzed

Table C-1. Common and Scientific Names of Fish Species Analyzed for PBDEs in 2005

Common name	Scientific name	Family name
Black crappie	*Pomoxis nigromaculatus*	Centrarchidae
Blue gill	*Lepomis machrochirus*	Centrarchidae
Brown bullhead	*Ameiurus nebulosus*	Ictaluridae
Brook trout	*Salvelinus fontinalis*	Salmonidae
Bridgelip sucker	*Catostomus columbianus*	Catostomidae
Brown trout	*Salmo trutta*	Salmonidae
Burbot	*Lota lota*	Gadidae
Channel catfish	*Ictalurus punctatus*	Ictaluridae
Common carp	*Cyprinus carpio*	Cyprinidae
Cutthroat trout	*Oncorhynchus clarki*	Salmonidae
Grass carp	*Ctenopharyngodon idella*	Cyprinidae
Kokanee salmon	*Oncorhynchus nerka*	Salmonidae
Largemouth bass	*Micropterus salmoides*	Centrarchidae
Largescale sucker	*Catostomus macrocheilus*	Catostomidae
Lake whitefish	*Coregonus clupeaformis*	Salmonidae
Mountain whitefish	*Prosopium williamsoni*	Salmonidae
Northern pikeminnow	*Ptychocheilus oregonensis*	Cyprinidae
Peamouth	*Mylocheilus caurinus*	Cyprinidae
Pumpkinseed	*Lepomis gibbosus*	Centrarchidae
Rainbow trout	*Oncorhynchus mykiss*	Salmonidae
Smallmouth bass	*Micropterus dolomieu*	Centrarchidae
Walleye	*Stizostedion vitreum*	Percidae
Yellow perch	*Perca flavescens*	Percidae

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Appendix D. Department of Health PBDE Data on Lake Washington

Table D-1. WDOH Data on PBDEs in Lake Washington and Green Lake Fish Fillets Collected in 2005

Date	Sample No.	Species	Size Class (mm)	PBDEs (ug/Kg, wet weight)																						Lipids (%)
				47		66		71		99		100		138		153		154		183		190		209		
Lake Washington																										
5/2	5138741	Yellow perch		0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	2.5	U	0.6
5/3	5138742	Yellow perch		0.75	U	0.49	U	0.22	J	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	2.4	U	0.78
5/3	5138743	Yellow perch		0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	2.5	U	0.33
5/3	5138744	Yellow perch		2.0		0.48	U	0.26	J	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	0.59
5/5	5138751	Yellow perch		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.59
5/5	5138753	Yellow perch		0.15	J	0.5	U	0.15	J	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.6
6/1	5138761	Yellow perch		2.3		0.5	U	0.56		0.5	U	0.5	U	0.5	U	0.5	U	0.45	J	0.5	U	0.5	U	2.5	U	0.42
6/1	5138762	Yellow perch		1.0		0.49	U	0.24	J	0.49	U	0.49	U	0.49	U	0.49	U	0.42	J	0.49	U	0.49	U	2.4	U	0.44
6/3	5138764	Yellow perch		5.9		0.49	U	0.55		0.49	U	0.49	U	0.49	U	0.49	U	0.52		0.49	U	0.49	U	2.4	U	0.37
7/12	5138777	Yellow perch		0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	0.71
5/4	5138745	Cutthroat trout	>400	84	E	0.74		2.1		17		11		0.46	U	7		4.4		0.46	U	0.46	U	2.3	U	3.97
5/4	5138746	Cutthroat trout	>400	45	E	0.2	J	2.2		15		8		0.48	U	3.2		3.3		0.48	U	0.48	U	2.4	U	2.69
5/4	5138747	Cutthroat trout	>400	73	E	0.44	J	3.1		23		11		0.49	U	5.6		4.7		0.49	U	0.49	U	2.4	U	3.72
6/10	5138773	Cutthroat trout	>400	86	E	0.46	J	1.6		11		10		0.48	U	8		4		0.48	U	0.48	U	2.4	U	3.08
6/10	5138774	Cutthroat trout	>400	34	E	0.47	U	2.2		18		8.8		0.47	U	2.5		3.1		0.47	U	0.47	U	2.4	U	3.5
6/10	5138775	Cutthroat trout	>400	27	E	0.48	U	2.6		12		5.8		0.48	U	2.1		2.6		0.48	U	0.48	U	2.4	U	4.01
6/10	5138776	Cutthroat trout	>400	28	E	0.46	U	1.7		9.2		5.2		0.46	U	2.2		2		0.46	U	0.46	U	0.52	J	3.51
6/3	5138763	Cutthroat trout	300-400	18		0.5	U	0.96		7.6		3.4		0.5	U	1.2		1.4		0.5	U	0.5	U	2.5	U	3.65
6/8	5138769	Cutthroat trout	300-400	23	E	0.43	J	1.6		10.8		4.8		0.48	U	1.9		2.3		0.48	U	0.48	U	2.4	U	3.18
7/15	5138786	Cutthroat trout	300-400	9.9		0.48	U	0.6		4.2		1.4		0.48	U	0.47	J	0.49		0.48	U	0.48	U	2.4	U	3.29
5/5	5138748	Cutthroat trout	<300	8.7		0.49	U	0.36	J	3.3		1.4		0.49	U	0.61		0.87		0.49	U	0.49	U	2.5	U	1.25
5/5	5138749	Cutthroat trout	<300	6.5		0.49	U	0.27	J	2.8		0.55		0.49	U	0.27	J	0.31	J	0.49	U	0.49	U	2.4	U	2.52
5/5	5138750	Cutthroat trout	<300	3.5		0.48	U	0.48	U	2.4		0.31	J	0.48	U	0.15	J	0.15	J	0.48	U	0.48	U	2.4	U	1.24
5/5	5138752	Cutthroat trout	<300	2.8		0.47	U	0.47	U	0.75		0.47	U	0.47	U	0.15	J	0.15	J	0.47	U	0.47	U	2.4	U	0.96
5/8	5138754	Northern pikeminnow	>300	22.4	E	0.5	U	0.86		0.5	U	2.8		0.5	U	0.63		1.3		0.5	U	0.5	U	2.5	U	2.71
5/8	5138755	Northern pikeminnow	>300	48	E	0.47	U	1.4		0.47	U	5.9		0.47	U	1		2.5		0.47	U	0.47	U	2.3	U	5.16
5/8	5138756	Northern pikeminnow	>300	165	E	0.49	U	3.7		0.49	U	25.9	E	0.49	U	1.6		10.7		0.49	U	0.49	U	2.4	U	6.93
5/8	5138757	Northern pikeminnow	>300	38.5	E	0.49	U	1.6		0.49	U	6.2		0.49	U	0.44		2.5		0.49	U	0.49	U	2.5	U	3.43
5/9	5138758	Northern pikeminnow	<300	3.8		0.49	U	0.18	J	0.49	U	0.35	J	0.49	U	0.49	U	0.13	J	0.49	U	0.49	U	2.4	U	2.16
5/9	5138759	Northern pikeminnow	<300	5.7		0.48	U	0.27	J	0.48	U	0.46	J	0.48	U	0.11	J	0.23	J	0.48	U	0.48	U	2.4	U	2.58
5/9	5138760	Northern pikeminnow	<300	11.6		0.49	U	0.47	J	0.49	U	1.5		0.49	U	0.49	U	0.69		0.49	U	0.49	U	2.5	U	2.45
6/3	5138765	Black crappie		0.75		0.48	U	0.48	U	0.44	J	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	1.16
6/8	5138767	Black crappie		1.4		0.5	U	0.58		0.64		0.5	U	0.5	U	0.5	U	0.58		0.5	U	0.5	U	2.5	U	0.96
6/8	5138768	Black crappie		0.67		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.62
7/12	5138778	Pumpkin seed		0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	0.49	UJ	2.4	UJ	0.4
7/12	5138779	Pumpkin seed		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.4
7/12	5138780	Pumpkin seed		0.64		0.5	U	0.07	J	0.12	J	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.3
7/13	5138781	Pumpkin seed		0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	0.47	U	2.4	U	0.47
7/13	5138782	Pumpkin seed		0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	2.4	U	0.48
7/13	5138783	Pumpkin seed		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	0.32
7/13	5138784	Pumpkin seed		0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	0.34
7/14	5138785	Rainbow trout		0.75		0.49	U	0.49	U	0.18		0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	0.49	U	2.4	U	2.06

Table D-1 (cont.). WDOH Data on PBDEs in Lake Washington and Green Lake Fish Fillets Collected in 2005

Date	Sample No.	Species	Size Class (mm)	PBDEs (ug/Kg, wet weight)																						Lipids (%)
				47		66		71		99		100		138		153		154		183		190		209		
Green Lake																										
6/7	5138766	Common carp		0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	0.48	UJ	2.4	UJ	1.42
6/8	5138770	Common carp		1.4		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2.5	U	5.66
6/9	5138771	Common carp		2.0		0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	4.35
6/9	5138772	Common carp		1.2		0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	2.4	U	1.87

U = Not detected at or above reported quantitation limit
J = Estimated value
UJ = Not detected at or above reported quantitation limit. Quantitation limit is approximate.
E = Concentration exceeds known calibration range

Appendix E. EPA PBDE Data on Washington Lakes

Table E-1. Unpublished PBDE Data on Washington State from the EPA National Study of Chemical Residues in Lake Fish Tissue (**ng/Kg, parts per trillion**, wet weight)

Location	Date	Species	Tissue	PBDE													
				7		8/11		10		12/13		15		17/25		28/33	
Pend Oreille River	7/23/02	Largescale sucker	Whole	97.4	U	97.4	U	48.7	U	19.5	U	27.5	J	127	J	471	J
Pend Oreille River	7/23/02	Largescale sucker	Whole	95	U	95	U	47.5	U	19	U	16.2	J	124		489	
Pend Oreille River	7/23/02	Brown trout	Fillet	118	U	118	U	59.2	U	23.7	U	5.9	U	9.1	J	20.7	
Pend Oreille River	7/23/02	Brown trout	Fillet	98.6	U	98.6	U	49.3	U	19.7	U	4.9	U	9.4	J	20	
Lake Wallula	8/27/03	Smallmouth bass	Fillet	99.6	U	99.6	U	49.8	U	19.9	U	9.4	J	22.1		106	
Lake Wallula	11/6/02	Largescale sucker	Whole	93.1	U	93.1	U	46.6	U	18.6	U	42.7	J	170		1180	
Buffalo Lake	7/24/02	Largemouth bass	Fillet	99.2	U	99.2	U	49.6	U	19.8	U	5	U	10.4		21.7	
Calligan Lake	7/17/02	Rainbow trout	Fillet	97.9	U	97.9	U	49	U	19.6	U	4.9	U	6.5	J	13.6	
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	99.4	U	99.4	U	49.7	U	19.9	U	5	U	5	J	11.2	
Patterson Lake	8/26/03	Largemouth bass	Fillet	5.8	J	19		19.9	U	10	U	19.9	U	10	U	817	

Location	Date	Species	Tissue	PBDE													
				30		32		35		37		47		49		51	
Pend Oreille River	7/23/02	Largescale sucker	Whole	19.5	U	9.7	U	19.5	U	9.7	U	18700		352		57.5	J
Pend Oreille River	7/23/02	Largescale sucker	Whole	19	U	9.5	U	19	U	9.5	U	18100		286	J	44.4	J
Pend Oreille River	7/23/02	Brown trout	Fillet	23.7	U	11.8	U	23.7	U	11.8	U	1000		114		23.7	U
Pend Oreille River	7/23/02	Brown trout	Fillet	19.7	U	9.9	U	19.7	U	9.9	U	484	J	43.9	J	19.7	U
Lake Wallula	8/27/03	Smallmouth bass	Fillet	19.9	U	10	U	19.9	U	10	U	4720		130		19.9	U
Lake Wallula	11/6/02	Largescale sucker	Whole	18.6	U	9.3	U	18.6	U	9.3	U	16200		469		85.4	
Buffalo Lake	7/24/02	Largemouth bass	Fillet	19.8	U	9.9	U	19.8	U	9.9	U	518		49.3		19.8	U
Calligan Lake	7/17/02	Rainbow trout	Fillet	19.6	U	9.8	U	19.6	U	9.8	U	1050		73.2		5.7	J
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	19.9	U	9.9	U	19.9	U	9.9	U	565		16.3		19.9	U
Patterson Lake	8/26/03	Largemouth bass	Fillet	61.7		19.9	U	47.3		19.9	U	10	U	5	U	5	U

Table E-1 (cont.). Unpublished PBDE Data on Washington State from the EPA National Study of Chemical Residues in Lake Fish Tissue (**ng/Kg, parts per trillion**, wet weight)

Location	Date	Species	Tissue	PBDE													
				66		71		75		77		79		85		99	
Pend Oreille River	7/23/02	Largescale sucker	Whole	44.6	J	97.4	U	19.2	J	24.3	U	65.6		4.9	U	4.9	UJ
Pend Oreille River	7/23/02	Largescale sucker	Whole	14.6	J	7.6	J	20.5		4.7	U	15.8		4.7	U	4.8	UJ
Pend Oreille River	7/23/02	Brown trout	Fillet	39.8		8.5	J	11.8	U	5.9	U	8.5		5.9	U	625	
Pend Oreille River	7/23/02	Brown trout	Fillet	16	J	19.7	U	9.9	U	4.9	U	3.2	J	4.9	U	271	J
Lake Wallula	8/27/03	Smallmouth bass	Fillet	85.2		19.9	U	5.7	J	4.2	J	5	U	5	U	1190	
Lake Wallula	11/6/02	Largescale sucker	Whole	11.3	J	9.7	J	35.3		4.7	U	4.7	U	4.7	U	4.7	UJ
Buffalo Lake	7/24/02	Largemouth bass	Fillet	18.4	J	19.8	U	9.9	U	5	U	2.3	J	5	U	288	J
Calligan Lake	7/17/02	Rainbow trout	Fillet	65.2		19.6	U	2.8	J	1.5	J	14.3		4.9	U	1700	J
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	23.4		19.9	U	9.9	U	5	U	5	U	5	U	132	
Patterson Lake	8/26/03	Largemouth bass	Fillet	5	U	658		225		10	U	19.9	U	9.9	J	10	U

Location	Date	Species	Tissue	PBDE											
				100		105		116		119/120		126		128		138/166	
Pend Oreille River	7/23/02	Largescale sucker	Whole	3020	J	9.7	U	19.5	U	56.3		10.2		19.5	U	19.5	U
Pend Oreille River	7/23/02	Largescale sucker	Whole	2770	J	9.5	U	19	U	72.6	J	10.4	J	19	U	19	U
Pend Oreille River	7/23/02	Brown trout	Fillet	243		11.8	U	23.7	U	8.7	J	11.8	U	23.7	U	23.7	U
Pend Oreille River	7/23/02	Brown trout	Fillet	85.2	J	9.9	U	19.7	U	4.7	J	9.9	U	19.7	U	19.7	U
Lake Wallula	8/27/03	Smallmouth bass	Fillet	864		10	U	19.9	U	19.9		10	U	19.9	U	19.9	U
Lake Wallula	11/6/02	Largescale sucker	Whole	4540	J	9.3	U	18.6	U	81.4	J	16.7	J	18.6	U	18.6	U
Buffalo Lake	7/24/02	Largemouth bass	Fillet	87.7	J	9.9	U	19.8	U	4.6	J	9.9	U	19.8	U	19.8	U
Calligan Lake	7/17/02	Rainbow trout	Fillet	457	J	9.8	U	19.6	U	27.5	J	9.8	U	19.6	U	19.6	U
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	79.7		9.9	U	19.9	U	5.6	J	9.9	U	19.9	U	19.9	U
Patterson Lake	8/26/03	Largemouth bass	Fillet	19.9	U	19.9	U	19.9	U	76		67.3		19.9	U	19.9	U

Table E-1 (cont.). Unpublished PBDE Data on Washington State from the EPA National Study of Chemical Residues in Lake Fish Tissue (**ng/Kg, parts per trillion**, wet weight)

Location	Date	Species	Tissue	PBDE													
				140		153		154		155		181		183		190	
Pend Oreille River	7/23/02	Largescale sucker	Whole	19.5	U	197		909		95.4		19.5	U	4.9	U	19.5	U
Pend Oreille River	7/23/02	Largescale sucker	Whole	19	U	148		871		85.2		19	U	4.7	U	19	U
Pend Oreille River	7/23/02	Brown trout	Fillet	23.7	U	60.8		69.4		23.7	U	23.7	U	5.9	U	23.7	U
Pend Oreille River	7/23/02	Brown trout	Fillet	19.7	U	29		27		19.7	U	19.7	U	4.9	U	19.7	U
Lake Wallula	8/27/03	Smallmouth bass	Fillet	19.9	U	228		143		19.9	U	19.9	U	2	J	19.9	U
Lake Wallula	11/6/02	Largescale sucker	Whole	18.6	U	264		1030		133		18.6	U	4.7	U	18.6	U
Buffalo Lake	7/24/02	Largemouth bass	Fillet	19.8	U	29.4		26.6		19.8	U	19.8	U	5	U	19.8	U
Calligan Lake	7/17/02	Rainbow trout	Fillet	9.1	J	219		241		16.4	J	19.6	U	4.9	UJ	19.6	U
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	19.9	U	37.3		29.2		19.9	U	19.9	U	5	U	19.9	U
Patterson Lake	8/26/03	Largemouth bass	Fillet	1.4	J	19.9	U	49.8	U	49.8	U	49.8	U	49.8	U	996	U

Location	Date	Species	Tissue	PBDE										Lipids
				203		206		207		208		209		
Pend Oreille River	7/23/02	Largescale sucker	Whole	48.7	U	48.7	U	48.7	U	48.7	U	974	U	5.78
Pend Oreille River	7/23/02	Largescale sucker	Whole	47.5	U	47.5	U	47.6	UJ	47.5	U	950	U	6.38
Pend Oreille River	7/23/02	Brown trout	Fillet	59.2	U	59.2	U	59.2	U	59.2	U	1180	U	0.76
Pend Oreille River	7/23/02	Brown trout	Fillet	49.3	U	49.3	U	49.3	U	49.3	U	986	U	1.47
Lake Wallula	8/27/03	Smallmouth bass	Fillet	49.8	U	49.8	U	49.8	U	49.8	U	996	U	1.62
Lake Wallula	11/6/02	Largescale sucker	Whole	46.6	U	46.6	U	46.6	U	46.6	U	931	U	5.96
Buffalo Lake	7/24/02	Largemouth bass	Fillet	49.6	U	49.6	U	49.5	UJ	49.6	U	992	U	3.74
Calligan Lake	7/17/02	Rainbow trout	Fillet	49	U	49	U	49	UJ	49	U	979	U	2.41
Lake Nahwatzel	9/4/03	Largemouth bass	Fillet	49.7	U	49.7	U	49.7	U	49.7	U	994	U	1.1
Patterson Lake	8/26/03	Largemouth bass	Fillet	49.7	U	49.7	U	49.7	U	49.7	U	994	U	1.59

U = Not detected at or above reported quantitation limit
J = Estimated value
UJ = Not detected at or above reported quantitation limit. Quantitation limit is approximate.

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Appendix F. North Carolina PBDE Risk Assessment

(Provided by Dr. Luanne Williams, 6/14/06 email)

Polybrominated Diphenyl Ethers Fish Risk Assessment
Medical Evaluation and Risk Assessment Unit
Occupational and Environmental Epidemiology Branch
North Carolina Department of Health and Human Services
March 29, 2005

Prevalence of PBDEs in Environment

Most toxicological studies concerning PBDEs have been conducted with commercial products containing deca-BDEs, nona-BDEs, and octa-BDEs (Pijnenburg AMCM, Everts JW, De Boer J, and Boon JP 1995 Polybrominated Biphenyl and Diphenylether Flame Retardants: Analysis, Toxicity, and Environmental Occurrence, *Reviews of Environmental Contamination and Toxicology*, Vol. 141). Some studies have reported a greater bioaccumulation of the PBDEs with a low bromine content (such as the tetra-BDE and penta-BDE) as compared to the higher brominated compounds (Pijnenburg AMCM, Everts JW, De Boer J, and Boon JP 1995 Polybrominated Biphenyl and Diphenylether Flame Retardants: Analysis, Toxicity, and Environmental Occurrence, *Reviews of Environmental Contamination and Toxicology*, Vol. 141; Sellstrom U, Jansson B, Nylund K, Odsjo T, Olsson M 1990 Anthropogenic brominated aromatics in the Swedish environment. Dioxin 1990 EPRI-Seminar. Bayreuth, Germany. Short papers, pp. 357-360).

Toxicity of PBDEs

The toxicity values for PBDEs were researched within the US EPA Integrated Risk Information System (on-line at www.epa.gov/iris). Based on the review of the literature and the potential for the accumulation of the lower PBDEs, the toxicity of PBDEs increases as the bromine content decreases. According to the scientific literature, a greater bioaccumulation is likely to occur with PBDEs with a lower bromine content like tetra-BDE and penta-BDE. Using the 0.002 mg/kg-day reference dose for pentabromodiphenyl ether, a reference dose can be calculated for tetrabromodiphenyl ether by applying a safety factor of 2 to account for uncertainty in the differences in toxicity. A reference dose of 0.001 mg/kg-day is the recommended reference dose for the general public for tetrabromodiphenyl ether. According to Dr. Linda Birnbaum with the US EPA, reproductive and developmental effects have been observed in animals following exposure to PBDEs and the reference dose of 1 ug/kg-day for the general public may possibly need to be reduced by 1/3 which is equal to 0.0003 ug/kg-day. Additional research is needed (October 20-22, 2002 National Forum on Contaminants in Fish sponsored by American Fisheries Society and U.S. Environmental Protection Agency).

PBDEs	Reference Dose	Carcinogenicity Data
Tetrabromodiphenyl ether	Not available – recommend use of Rfd for pentabromodiphenyl ether of 0.002 mg/kg-day and safety factor of 2 to account for uncertainty in toxicity difference = 0.001 mg/kg-day for general public and a safety factor of 3 to account for uncertainty in reproductive/developmental toxicity = 0.0003 mg/kg-day for women of childbearing age and children	Class D (not classifiable because of no human or animal data)
Pentabromodiphenyl ether	0.002 mg/kg-day (induction of liver enzymes in rats)	Class D (not classifiable no data)
Octabromodiphenyl ether	0.003 mg/kg-day (induction of liver enzymes in rats)	Class D (not classifiable no data)
Decabromodiphenyl ether	0.010 mg/kg-day (no adverse effects observed)	Class C (possible human carcinogen, increased incidences of neoplastic liver nodules in rats, hepatocellular adenomas or carcinomas in mice)

Calculations

1. Calculated Fish Meals Per Month and Week for total PBDEs in fish (Tetra-BDE and Penta-BDE) for Women of Childbearing Age (15 to 44 years) and Children (less than 15 years)

$$CR_{mm} = \frac{CR_{lim} \times T_{ap}}{MS}$$

(Equation obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

CR_{mm} = maximum allowable fish consumption rate (meals/month)

CR_{lim} = maximum allowable fish consumption rate (kg/day)

$$CR_{lim} = \frac{RFD \times BW}{C_m}$$

RFD = 0.0003 mg/kg-day reference dose for developing fetus and adult women of childbearing age

BW = consumer body weight of 67 kg for women 15 to 44 years

(Body weight obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

C_m = average measured Total PBDE concentration of chemical contaminant *m* in a given species of fish (mg/kg)

T_{ap} = time average period (365.25 days/12 months = 30.44 days/month)

(Obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

MS = meal size (0.170 kilograms fish/meal or 6 ounces)

(Obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

Table F-1. Fish Meals Per Month and Week for Women of Childbearing Age (15 to 44 years) and Children (less than 15 years)

Fish PBDE Levels (mg/kg)	Equations	Fish meals per month (meals per week)
1.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{1.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	3.6 (or 0.9 per week)
2.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{2.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	1.8 (or 0.5 per week)
3.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{3.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	1.2 (or 0.3 per week)
4.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{4.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	0.9 (or 0.2 per week)
5.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{5.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	0.7 (or 0.2 per week)
6.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{6.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	0.6 (or 0.1 per week)
7.0	$\frac{0.0003 \text{mg/kg-day} \times 67 \text{ kg}}{7.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	0.5 (or 0.1 per week)

2. Calculated Fish Meals per Month and Week for General Public (males 15 years and older and women greater than 44 years)

$$CR_{mm} = \frac{CR_{lim} \times T_{ap}}{MS}$$

(Equation obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

CR_{mm} = maximum allowable fish consumption rate (meals/month)

CR_{lim} = maximum allowable fish consumption rate (kg/day)

$$CR_{lim} = \frac{RFD \times BW}{C_m}$$

RFD = 0.001 mg/kg-day reference dose for general public

BW = consumer body weight of 70 kg
(Body weight obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

C_m = average total PBDE concentration of chemical contaminant *m* in a given species of fish (mg/kg)

T_{ap} = time average period (365.25 days/12 months = 30.44 days/month)
(USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

MS = meal size (0.170 kilograms fish/meal or 6 ounces)
(USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

Table F-2. Fish Meals per Month and Week for General Public (males 15 years and older and women greater than 44 years)

Fish PBDE Levels (mg/kg)	Equations	Fish meals per month (meals per week)
1.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{1.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	12.5 (or 3.1 per week)
2.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{2.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	6.3 (or 1.6 per week)
3.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{3.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	4.2 (or 1.1 per week)
4.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{4.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	3.1 (or 0.8 per week)
5.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{5.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	2.5 (or 0.6 per week)
6.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{6.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	2.1 (or 0.5 per week)
7.0	$\frac{0.001\text{mg/kg-day} \times 70\text{ kg}}{7.0\text{ mg/kg}} \times 30.44\text{ d/mos} \times \frac{1\text{ meal}}{0.170\text{ kg fish}}$	1.8 (or 0.5 per week)

Recommendations

Average PBDE Level	Recommendations
<2 mg/kg	No recommendations warranted – safe for unrestricted consumption
2 to 5 mg/kg	(Species) in (waterbody) contains higher than normal levels of PBDEs. Women of childbearing age (15-44 years) and children under age 15 should not eat (species) in (waterbody). All others should limit consumption of (species) two meals per month.
6 mg/kg or >	(Species) in (waterbody) contains higher than normal levels of PBDEs. No consumption of (species) is recommended.

Appendix G. Ancillary Water Quality Data

Table G-1. Ancillary Water Quality Data for SPMD Deployments

Sample No.	Field ID	Parameter	Collection Date	Result	Qualifier	Units
Fall 2005 Deployment						
5364131	DUWAMISH R	SAL	9/2/05	17.5		g/Kg ww
5364131	DUWAMISH R	TOC	9/2/05	1.5		mg/L
5364131	DUWAMISH R	TSS	9/2/05	4	J	mg/L
5374020	DUWAMISH R	SAL	9/14/05	14.5		g/Kg ww
5374020	DUWAMISH R	TOC	9/14/05	1.6		mg/L
5374020	DUWAMISH R	TSS	9/14/05	4		mg/L
5394081	DUWAMISH R	SAL	9/30/05	15.5		g/Kg ww
5394081	DUWAMISH R	TOC	9/30/05	1.7		mg/L
5394081	DUWAMISH R	TSS	9/30/05	4		mg/L
5384035	LAKE ROOSEV	TOC	9/21/05	1.1		mg/L
5384035	LAKE ROOSEV	TSS	9/21/05	1		mg/L
5364139	LAKE ROOSEV	TOC	9/8/05	1.7		mg/L
5364139	LAKE ROOSEV	TSS	9/8/05	2		mg/L
5404109	LAKE ROOSEV	TOC	10/6/05	1.3		mg/L
5404109	LAKE ROOSEV	TSS	10/6/05	2		mg/L
5364132	LAKE WASH	TOC	9/2/05	2.6		mg/L
5364132	LAKE WASH	TSS	9/2/05	1	UJ	mg/L
5374021	LAKE WASH	TOC	9/14/05	3		mg/L
5374021	LAKE WASH	TSS	9/14/05	1		mg/L
5394082	LAKE WASH	TOC	9/30/05	2.5		mg/L
5394082	LAKE WASH	TSS	9/30/05	1	U	mg/L
5354134	LK OZETTE	TOC	8/31/05	4.2		mg/L
5354134	LK OZETTE	TSS	8/31/05	3		mg/L
5394084	LK OZETTE	TOC	9/28/05	4.5		mg/L
5394084	LK OZETTE	TSS	9/28/05	3		mg/L
5354130	LOWER COL R	TOC	8/29/05	1.5		mg/L
5354130	LOWER COL R	TSS	8/29/05	7		mg/L
5384030	LOWER COL R	TOC	9/19/05	1.9		mg/L
5384030	LOWER COL R	TSS	9/19/05	6		mg/L
5394080	LOWER COL R	TOC	9/26/05	1.8		mg/L
5394080	LOWER COL R	TSS	9/26/05	4		mg/L
5364135	MCNARY DAM	TOC	9/7/05	2.8		mg/L
5364135	MCNARY DAM	TSS	9/7/05	3		mg/L
5384031	MCNARY DAM	TOC	9/21/05	1.7		mg/L
5384031	MCNARY DAM	TSS	9/21/05	2		mg/L

Sample No.	Field ID	Parameter	Collection Date	Result	Qualifier	Units
5404105	MCNARY DAM	TOC	10/5/05	1.5		mg/L
5404105	MCNARY DAM	TSS	10/5/05	2		mg/L
5364138	SPOKANE R	TOC	9/8/05	1.3		mg/L
5364138	SPOKANE R	TSS	9/8/05	1	U	mg/L
5384034	SPOKANE R	TOC	9/21/05	1.3		mg/L
5384034	SPOKANE R	TSS	9/21/05	2		mg/L
5404108	SPOKANE R	TOC	10/6/05	1.4		mg/L
5404108	SPOKANE R	TSS	10/6/05	2		mg/L
5364137	POTHOLES	TOC	9/7/05	4.3		mg/L
5364137	POTHOLES	TSS	9/7/05	7		mg/L
5374022	POTHOLES	TOC	9/14/05	4.6		mg/L
5374022	POTHOLES	TSS	9/14/05	1		mg/L
5384033	POTHOLES	TOC	9/21/05	3.4		mg/L
5384033	POTHOLES	TSS	9/21/05	7		mg/L
5404107	POTHOLES	TOC	10/5/05	4.6		mg/L
5404107	POTHOLES	TSS	10/5/05	9		mg/L
5354133	QUEETS R	TOC	8/31/05	1	U	mg/L
5354133	QUEETS R	TSS	8/31/05	1		mg/L
5374023	QUEETS R	TOC	9/15/05	1	U	mg/L
5374023	QUEETS R	TSS	9/15/05	2		mg/L
5394083	QUEETS R	TOC	9/28/05	1	U	mg/L
5394083	QUEETS R	TSS	9/28/05	2		mg/L
5364136	YAKIMA R	TOC	9/7/05	2.1		mg/L
5364136	YAKIMA R	TSS	9/7/05	12		mg/L
5384032	YAKIMA R	TOC	9/21/05	2		mg/L
5384032	YAKIMA R	TSS	9/21/05	10		mg/L
5404106	YAKIMA R	TOC	10/5/05	2.2		mg/L
5404106	YAKIMA R	TSS	10/5/05	24		mg/L
Spring 2006 Deployment						
6124231	DUWAMISH R	SAL	3/29/06	12		g/Kg ww
6124231	DUWAMISH R	TOC	3/29/06	1.5		mg/L
6124231	DUWAMISH R	TSS	3/29/06	3		mg/L
6154237	DUWAMISH R	SAL	4/13/06	6.5		g/Kg ww
6154237	DUWAMISH R	TOC	4/13/06	2.1		mg/L
6154237	DUWAMISH R	TSS	4/13/06	3		mg/L
6124232	LAKE WASH	TOC	3/29/06	2.6		mg/L
6124232	LAKE WASH	TSS	3/29/06	3		mg/L
6154238	LAKE WASH	TOC	4/13/06	2.8		mg/L
6154238	LAKE WASH	TSS	4/13/06	5		mg/L
6174246	LAKE WASH	TOC	4/26/06	2.5		mg/L

Sample No.	Field ID	Parameter	Collection Date	Result	Qualifier	Units
6174246	LAKE WASH	TSS	4/26/06	4		mg/L
6124230	LOWER COL R	TOC	3/21/06	2		mg/L
6124230	LOWER COL R	TSS	3/21/06	6		mg/L
6164242	LOWER COL R	TOC	4/18/06	2.6		mg/L
6164242	LOWER COL R	TSS	4/18/06	18		mg/L
6144236	LOWER COL R	TOC	4/4/06	2.5		mg/L
6144236	LOWER COL R	TSS	4/4/06	6		mg/L
6124233	QUEETS R	TOC	3/28/06	1	U	mg/L
6124233	QUEETS R	TSS	3/28/06	6		mg/L
6154239	QUEETS R	TOC	4/10/06	1.3		mg/L
6154239	QUEETS R	TSS	4/10/06	5		mg/L
6174245	QUEETS R	TOC	4/26/06	1.5		mg/L
6174245	QUEETS R	TSS	4/26/06	5		mg/L
6124235	SPOKANE R	TOC	3/23/06	1.8		mg/L
6124235	SPOKANE R	TSS	3/23/06	3		mg/L
6146180	SPOKANE R	TOC	4/4/06	2.4		mg/L
6146180	SPOKANE R	TSS	4/4/06	4		mg/L
6164244	SPOKANE R	TOC	4/20/06	2		mg/L
6164244	SPOKANE R	TSS	4/20/06	6		mg/L
6124234	YAKIMA R	TOC	3/22/06	2.7		mg/L
6124234	YAKIMA R	TSS	3/22/06	12		mg/L
6144240	YAKIMA R	TOC	4/5/06	3.1		mg/L
6144240	YAKIMA R	TSS	4/5/06	58		mg/L
6164243	YAKIMA R	TOC	4/19/06	3		mg/L
6164243	YAKIMA R	TSS	4/19/06	43		mg/L

SAL – salinity
TOC – total organic carbon
TSS – total suspended solids

Table G-2. Mean Temperature for Deployment Period (C^o)

Field ID	Fall 05	Spring 06
DUWAMISH R	14.2	8.2
LAKE ROOSEV	15.8	- -
LAKE WASH	19.5	8.8
LK OZETTE	19.1	- -
LOWER COL R	19.7	7.3
MCNARY DAM	18.8	- -
SPOKANE R	14.0	4.4
POTHOLES	17.6	- -
QUEETS R	15.6	6.9
YAKIMA R	17.5	9.8

Appendix H. SPMD Excel Spreadsheet Calculator

Table H-1. Spreadsheet for Estimating Dissolved PBDE Concentrations from SPMD Data, Showing an Example Using the Fall 2005 Results for the Spokane River [empirical model in Huckins et al. (2006)]

			Comments
V_s (cm^3)	23.5		five membranes
Exp. Time (d)	28.9		
PRC start (pg)	1000		PCB-29
PRC end (pg)	721		
Log K_{ow}:			
-47	6.81		from Braekevelt et al. (2003)
-49	6.81		
-99	7.32		
-100	7.24		
-153	7.90		
-154	7.82		
-183	8.27		
PCB-29	5.70		
Residues (ng/SPMD)			
-47	548		
-49	33		
-99	219		
-100	54		
-153	7.5		
-154	8.8		
-183	4	U	
Rs of PRC:			$k_e = -\frac{\ln(N/N_0)}{t}$
k_e PRC (d^{-1})	0.011		
LogK_{sw} PRC	5.36		$\log K_{sw} = a_0 + 2.321 \log K_{ow} - 0.1618 (\log K_{ow})^2$
R_s PRC	61		PCBs, PAHs, 4,4'-DDE : $a_0 = -2.61$ $R_s = V_s K_{sw} k_e$
Relative Rs of PRC and Analytes			
log alpha PRC	4.8892		
log alpha -47	4.6722		
log alpha -49	4.6722		
log alpha -99	4.5233		$\log \alpha_i = 0.0130 \log K_{ow}^3 - 0.3173 \log K_{ow}^2 + 2.244 \log K_{ow}$
log alpha -100	4.5480		

		Comments
log alpha -153	4.3344	
log alpha -154	4.3612	
log alpha -183	4.2097	
alpha PRC	77488	
alpha -47	47009	
alpha -49	47009	
alpha -99	33365	
alpha -100	35318	
alpha -153	21598	
alpha -154	22971	
alpha -183	16208	
Rs of Analytes (L/d)		
-47	37.2	
-49	37.2	
-99	26.4	$R_{i,j} = R_{PRC,j} \frac{\alpha_i}{\alpha_{PRC}}$
-100	28.0	
-153	17.1	
-154	18.2	
-183	12.8	
Aqueous Concentration (ng/L)		
$LogK_{sw}$ -47	5.692357	
$LogK_{sw}$ -49	5.692357	
$LogK_{sw}$ -99	5.710088	
$LogK^{sw}$ -100	5.710088	
$LogK_{sw}$ -153	5.712872	
$LogK_{sw}$ -154	5.627962	
$LogK_{sw}$ -183	5.645762	
C_w-47	0.510	
C_w-49	0.031	$C_w = \frac{N}{V_s K_{sw} \left(1 - \exp\left(-\frac{R_s t}{V_s K_{sw}}\right)\right)}$
C_w-99	0.287	
C_w-100	0.067	
C_w-153	0.015	
C_w-154	0.017	
C_w-183	0.011	

Rs = sampling rate
PRC = performance reference compound
K_{ow} = octanol-water partition coefficient
R_s = sampling rate
k_e = rate constant
C_w = dissolved chemical concentration
N = starting concentration
N_o = ending concentration