Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2007

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Cover photo: Skagit River near Burlington.

Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2007

by
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Waterbody Number(s): See Appendix A

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Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

Results of freshwater fish tissue sampling conducted in 2007 as part of the Washington State Toxics Monitoring Program (WSTMP) are reported. The "exploratory" monitoring component is a screening-level effort which targets areas across Washington where historical data are lacking. Results are used primarily to identify areas of concern for follow-up actions. Because the program is not designed to assess trends, caution should be used in comparing results from year to year.

Sixteen sites across Washington State representing 12 resident freshwater species of fish were sampled in 2007. Contaminants assessed include persistent, bioaccumulative, and toxic chemicals (PBTs) such as mercury, PCBs, dioxins and furans, chlorinated pesticides, and PBDE flame retardants.

Most sample results were within the lower range of values found in other studies of fish tissue in Washington. Mercury was detected in 100%, PBDEs in 97%, and PCBs in 91% of the 35 samples analyzed. Pesticides in the DDT and chlordane groups were detected in 63% and 6% of the 35 samples, respectively.

Twenty-eight percent of all samples did not meet Washington State water quality standards for contaminants in fish tissue. Total PCBs and 2,3,7,8-TCDD accounted for most of these exceedances. Other contaminants exceeding water quality standards were mercury and hexachlorobenzene.

This study recommends that five lakes and one river be added to the federal Clean Water Act Section 303(d) List for Washington State. These sites are: Ozette, Samish, Big, Campbell, and Sullivan Lakes, and the Samish River. Samples collected from the other ten sites met Washington State water quality standards.

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Background

During the 1980s and 1990s, the Washington State Department of Ecology (Ecology) and other agencies found toxic contaminants in fish, water, and sediment throughout Washington at varied levels of concern (www.ecy.wa.gov/toxics.html). In 2000, renewed concern about toxic contaminants in the environment led Ecology to revitalize a program to address toxic contaminants: the Washington State Toxics Monitoring Program (WSTMP).

The goals of the WSTMP are to:

- Conduct exploratory monitoring to characterize toxic contaminants in freshwater fish across Washington where historical data are lacking (the subject of this report).
- Conduct trend monitoring for persistent toxic chemicals.
- Improve access to information about monitoring contaminants in Washington: www.ecy.wa.gov/programs/eap/toxics/index.html.
- Establish cooperative efforts with other agencies and develop monitoring efforts to address topics of concern.

Between 2001 and 2007, 232 fish tissue samples from 104 sites were analyzed for various contaminants as part of the WSTMP Exploratory Monitoring component. Five annual reports have been published (www.ecy.wa.gov/programs/eap/toxics/wstmp.htm). Nearly 40,000 results are now available in Ecology's Environmental Information Management database (EIM) at www.ecy.wa.gov/eim/.

Ecology and the Washington State Department of Health (DOH) are developing strategies to address persistent, bioaccumulative, and toxic chemicals (PBTs) in our environment. These strategies involve learning more about the sources, uses, risks, and fate of these compounds. Mercury and flame retardants were the first PBTs for which chemical action plans were developed (www.ecy.wa.gov/programs/swfa/pbt/).

Fish are an important indicator of contaminant levels in the environment. Ecology evaluates fish tissue contaminant data to determine whether Washington State water quality standards are being met.

Contaminant concentrations in fish tissue that do not meet water quality standards are not necessarily high enough to warrant a fish consumption advisory to eat less fish. DOH evaluates the need for consumption advice based on multiple factors, including the benefits of eating fish as part of a healthy diet (www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm).

This report summarizes results of analyses of freshwater fish samples collected from 16 sites in 2007 (Figure 1 and Appendix A).

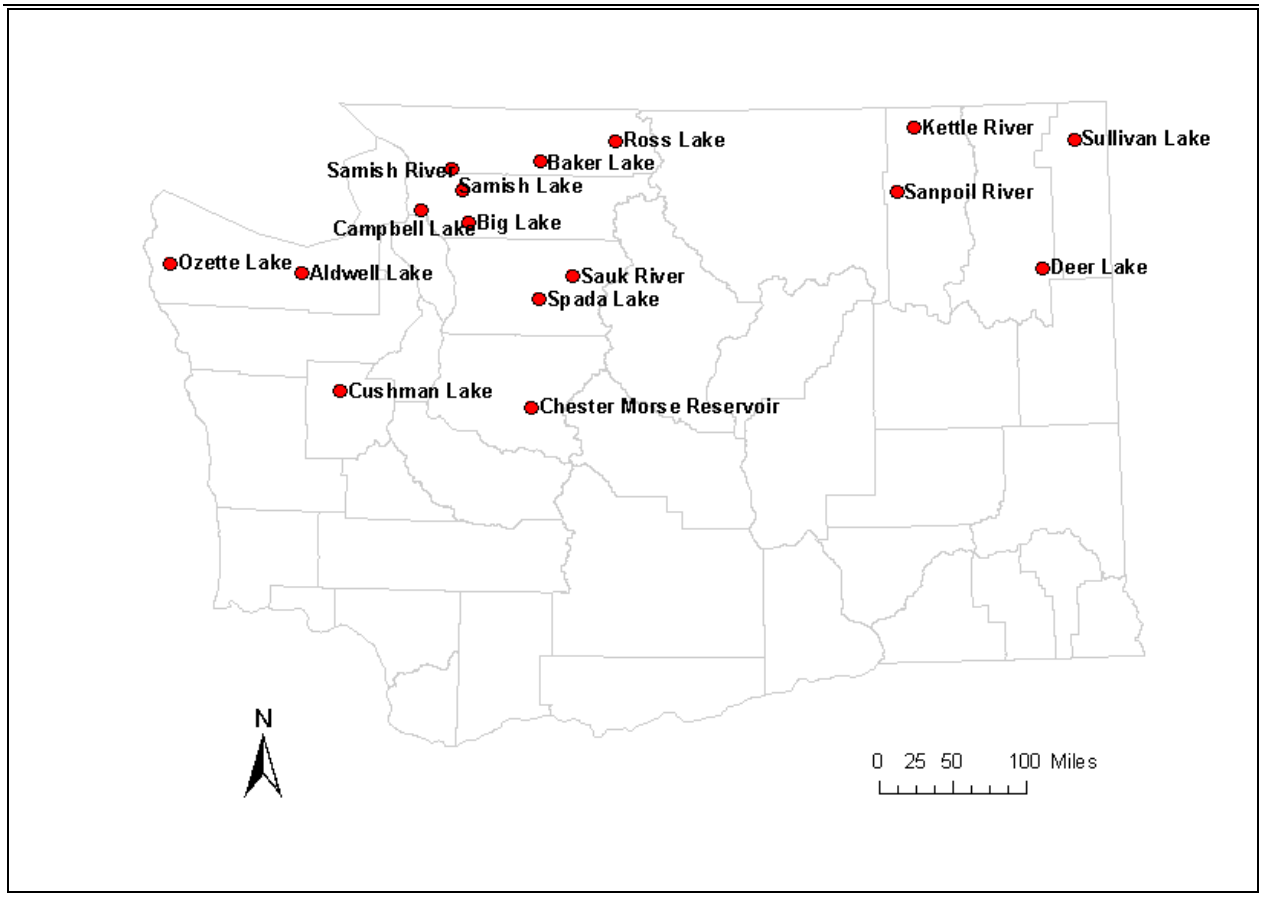

Figure 1. Sample Sites for the WSTMP, 2007.

Study Design

This exploratory monitoring component of the WSTMP targets resident freshwater fish from Washington. The primary purpose is to screen for PBT chemicals from areas with limited data available on toxic chemicals in fish. The project plan describes the program in more detail (Seiders and Yake, 2002).

Contaminants Assessed

An overview of target analytes for this component of the program is given below.

Mercury

Mercury occurs in the earth's crust and is released to the environment from natural events (e.g., volcanoes, weathering, and forest fires) and human activities (e.g., fossil fuel combustion, mining, and industrial processes).

Methylmercury is the toxic form of mercury which persists in the environment as it accumulates in the food web. Eating fish and shellfish contaminated with methylmercury is the primary route for exposure to mercury for most people (ATSDR, 1999; Ecology and DOH, 2003; EPA, 2007).

PCBs

Polychlorinated biphenyls (PCBs) are synthetic organic compounds historically used as cooling fluids in electrical equipment, and in inks, paints, and plastics. PCBs are stable, have low solubility in water, and have a high affinity for sediments and animal fats. The production of PCBs was banned in the U.S. in 1979 due to their persistence and toxicity (ATSDR, 2000).

There are 209 individual PCBs, or congeners. Commercial mixtures of PCB congeners were manufactured under various trade names. The most common in the United States used the trade name Aroclor. PCB Aroclors were analyzed in all 35 WSTMP samples from 2007; individual PCB congeners were analyzed in 27 (about 68%) of these samples.

Dioxins and Furans (PCDD/Fs)

Dioxins and furans, or polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs), are unintentional byproducts of combustion processes (e.g., burning household trash, forest fires, waste incineration), chlorine bleaching in paper production, and chemical and pesticide manufacturing. Agent Orange, which was used as a defoliant in the Vietnam War, contained dioxins (ATSDR, 2006).

Twenty seven of the 35 samples from 2007 were analyzed for the 17 most toxic congeners. These congeners have different levels of toxicity compared to 2,3,7,8-TCDD, the most toxic congener. The cumulative toxicity of mixtures of congeners in a sample can be expressed as a

toxic equivalent (TEQ) to 2,3,7,8-TCDD. The TEQ is calculated by multiplying the result for each congener by its congener-specific Toxicity Equivalent Factor (TEF) and then summing these products to obtain the 2,3,7,8-TCDD TEQ. The 1998 World Health Organization TEFs (Van den Berg et al., 1998) were used in this report.

Chlorinated Pesticides

Pesticides include insecticides, herbicides, fungicides, and related chemicals used to control pests. Chlorinated pesticides were analyzed for in this study because of their widespread occurrence and persistence in the environment.

Many of these pesticides are neurotoxins and are suspected or known carcinogens (EPA, 2000). Some pesticides were banned from use in the United States during the 1970s and 1980s as their hazards became evident (e.g., DDT, chlordane, and dieldrin).

PBDE Flame Retardants

Flame retardants, specifically poly-brominated diphenyl ethers (PBDEs), are compounds added to plastic and foam products such as electronic enclosures, wire insulation, adhesives, textile coatings, foam cushions, and carpet padding. Increasing concentrations of PBDEs in humans and wildlife worldwide continue to raise concerns about their health effects. The highest levels of PBDEs in human tissue have been found in the U.S. and Canada (Ecology and DOH, 2006).

Similar to PCBs, there are theoretically 209 individual congeners of PBDEs. Thirteen of these congeners were analyzed for during this study: PBDE-47, 49, 66, 71, 99, 100, 138, 153,154, 183, 184, 191, 209.

Site Selection

Sites are selected for sampling by examining various factors, such as the type of species present, the presence or absence of historical data, the value of the site for fishing, and the ability to cooperate with other monitoring or watershed planning efforts.

One of these efforts was a study of fish in Ross Lake in eastern Whatcom County. Mark Downen of the Washington Department of Fish and Wildlife (WDFW) provided bull trout, rainbow trout, and redside shiner to Ecology for tissue analysis. This is the first time that bull trout, a threatened species, has been included in Ecology's fish tissue monitoring efforts.

Appendix A lists the sample site locations and species of fish sampled. Additional site and sample information, including analytical results, are available in Ecology's Environmental Information Management (EIM) database at www.ecy.wa.gov/eim/index.htm. Search User Study ID: WSTMP07.

Field Procedures

Target fish species were chosen based on recommendations from the U.S. Environmental Protection Agency (EPA, 2000) and previous experience with fish collection efforts. Most fish were collected in late summer or fall by electro-fishing, gill netting, angling, or trapping. Fish kept for analyses were given a unique identifying code, measured for length and weight, individually wrapped in aluminum foil and put in plastic bags, and transported to freezer storage.

Fish were later processed at Ecology facilities. Composite samples were made up of skin-on fillets from five to ten fish of the same species from the same site. The sex of each fish was determined. Samples were then sent to laboratories for chemical analyses. Redside shiner from Ross Lake were processed as whole fish at the request of WDFW. Sample collection and processing details are described in a standard operating procedure (SOP) (Sandvik, 2006).

Analytical Methods

Table 1 describes analytical methods. Most analyses were performed by Ecology's Manchester Environmental Laboratory (MEL). Pace Analytical Services of Minneapolis, MN, conducted analyses for PCB congeners and PCDD/Fs. At Ecology's request, PCDD/Fs results were reported down to the limit of detection, with values qualified as estimates if they were between the limit of detection and the quantitation limit.

Table 1. Analytical Methods for Fish Tissue Samples, WSTMP 2007.

Parameter	Description	Method	Reporting Limit
PCB Aroclors	GC/ECD	EPA 8082	0.9 ug/kg, wet wt
PCB Congeners	HiRes GC/MS	EPA 1668A	0.05 - 1.2 ug/kg, wet wt
Chlorinated pesticides	GC/ECD	EPA 8081 [1]	0.25 -15 ug/kg, wet wt
PBDEs	GC/MS SIM	EPA 8270 [2]	0.1 - 2.6 ug/kg, wet wt
PCDD/PCDFs	HiRes GC/MS	EPA 1613B	0.1 - 1.0 ng/kg, wet wt
Mercury (total mercury)	CVAA	EPA 245.6	0.017 mg/kg, wet wt
Lipids - percent	gravimetric	MEL SOP 730009	0.1 percent

1. MEL 730073, a modification of EPA 8081 and others, was used in sample analyses.
2. MEL SOP 730096, a modification of EPA 8270, was used in sample analyses.

SOP = Standard Operating Procedure.
GC = Gas Chromatography.
MS = Mass Spectrometry.
ECD = Electron Capture Detection.
SIM = Single Ion Monitoring.
HiRes = High Resolution.
CVAA = Cold Vapor Atomic Absorbance.

Fish tissue was analyzed for total mercury because the analytical costs for methylmercury are prohibitively high. Methylmercury is also the predominant form of mercury found in free-swimming fish accounting for 95-100% of total mercury (Bloom, 1995). Both mercury and methylmercury are used as the basis for various water quality criteria or threshold values for the protection of human health and aquatic life.

Data Quality

Data quality was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Case narratives were written by MEL analytical staff. The narratives described the condition of samples upon receipt, analytical quality control procedures, and data qualifications. Quality control procedures included a mixture of analyses such as: method blanks, calibration and control standards, matrix spikes, matrix spike duplicates, surrogate recoveries, and laboratory and field duplicates.

Overall, the 2007 data met most quality control criteria defined by MEL and the Quality Assurance Project Plan. All results are usable as qualified. Initial analyses for PCB aroclors did not meet reporting limits, so samples were re-analyzed and met the desired reporting limits. No other data were rejected or re-analyzed. Some data were qualified due to challenges encountered in analyses. Estimates of precision were mixed, ranging from poor to good, and appear typical for samples of fish tissue.

Appendix B summarizes results from quality control and quality assurance procedures. Other quality assurance information is available by contacting the authors of this report.

Water Quality Criteria

Fish tissue results were compared to Washington's water quality standards to determine how sites should be assessed in Washington's Statewide Water Quality Assessment (the 303(d) assessment). This assessment also describes sampling requirements and other details about how environmental results are reviewed (Ecology, 2006).

Washington adopted the National Toxics Rule criteria (NTR) as the water quality standards for toxic compounds associated with human-health concerns. These criteria are one set of values that can be used in gauging the potential for human health risks from eating contaminated fish. EPA developed more recent criteria and guidance values which are described below. (See *EPA Recommended Water Quality Criteria* and *EPA Screening Values*).

The NTR criteria, EPA's recommended criteria, and EPA's screening values exist because of changing knowledge about the toxic effects of chemicals and subsequent risks to consumers of fish. The various criteria and screening values are often based on different assumptions used in determining risk, such as daily consumption rates, toxicological data used in calculations, and risk levels.

Results of this 2007 study are not compared to these other two EPA values because Ecology lacks authority to begin corrective actions where these criteria are exceeded. Yet the EPA recommended criteria and screening values can be used by state, tribal, and local health jurisdictions in evaluating risks to human health from the consumption of contaminated fish.

Appendix C describes how Ecology and DOH evaluate fish tissue data. Table 2 shows the NTR (Washington's water quality standards criteria) and other EPA criteria and screening values for contaminants detected in this study.

Table 2. Criteria and Guidelines Used for the Protection of Human Health for Contaminants Detected in Fish Tissue, WSTMP 2007.

Analyte[1]	National Toxics Rule	National Recommended Water Quality Criteria [2]	EPA Screening Values			
			Subsistence Fishers		Recreational Fishers	
			Non-carcino-gens	Carcino-gens	Non-carcino-gens	Carcino-gens
Mercury	825	300	49	-	400	-
Total PCBs [3]	5.3	2.0	9.83	2.45	80	20
2,3,7,8-TCDD [4]	0.07	-	-	-	-	-
2,3,7,8-TCDD TEQ [4, 5]	-	0.026	-	0.0315	-	0.256
4,4'-DDD	45	17	-	-	-	-
4,4'-DDE	32	12	-	-	-	-
4,4'-DDT	32	12	-	-	-	-
Total DDT [6]	-	-	245	14.4	2000	117
Chlordane [7]	8.3	11	245	14.0	2000	114
Chlordane (technical)	-	-	-	-	-	-
Dieldrin	0.65	0.25	24	0.307	200	2.5
DDMU [8]	-	-	-	-	-	-
Hexachlorobenzene	6.7	2.5	393	3.07	3200	25.0
Pentachloroanisole	-	-	-	-	-	-
PBDEs	-	-	-	-	-	-

1. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2. EPA (2001) for methylmercury, EPA (2002) for others.
3. Total PCBs is sum of Aroclors or congeners.
4. Values in parts per trillion wet weight (ng/kg ww).
5. The cumulative toxicity of a mixture of congeners in a sample can be expressed as a Toxic Equivalent (TEQ) to 2,3,7,8-TCDD.
6. Total DDT is the sum of 2,4'- and 4,4'- isomers of DDD, DDE, and DDT. DDD = 4,4'-dichlorodiphenyldichloroethane. DDE = 4,4'-dichlorodiphenyldichloroethylene. DDT = 4,4'-dichlorodiphenyltrichloroethane.
7. The NTR criterion for chlordane is interpreted as the sum of five chlordane components: these can be individually quantified through laboratory analyses while chlordane cannot. The EPA Screening Values are for "Total Chlordanes" which is the sum of five compounds: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane.
8. DDMU (1-chloro-2,2-bis(p-chlorophenyl)ethene) is another breakdown product of DDT.

National Toxics Rule (NTR)

Washington State's water quality standards for toxic substances (WAC 173-201A-040[5]) define human health-based water quality criteria by referencing 40 CFR 131.36, also known as the National Toxics Rule.

The NTR criteria were issued by EPA to Washington State in 1992. These criteria are designed to minimize the risk of adverse effects occurring to humans from chronic (lifetime) exposure to toxic substances through the ingestion of drinking water and contaminated fish and shellfish obtained from surface waters. The NTR criteria are regulatory values used by Ecology for a number of different purposes, including permitting wastewater discharges and assessing when waterbodies are adversely impacted by contaminants.

The NTR criteria values are based on a daily fish consumption rate of 6.5 grams/day and a risk level of 10^{-6}. A risk level is an estimate of the number of cases of adverse health effects (e.g. cancer) that could be caused by exposure to a specific contaminant. At a risk level of 10^{-6}, one person in a million would be expected to contract cancer due to long-term exposure to a specific contaminant.

Ecology expresses the NTR water column criteria as tissue concentrations in order to compare the criteria to laboratory results from fish tissue samples (Ecology, 2006). These tissue concentrations are derived by multiplying the NTR water quality criterion for "human health for consumption of organisms only" by the bioconcentration factor (BCF) for the specific contaminant. The BCFs for specific contaminants are found in EPA's 1980 Ambient Water Quality Criteria documents (EPA, 1980).

EPA Recommended Water Quality Criteria

EPA has published *National Recommended Water Quality Criteria* for some substances such as mercury and pesticides (EPA, 2001, 2002, and 2003). These recommended criteria are updates to previously developed criteria that occur on an ongoing basis. EPA recommends these criteria be used when states and tribes revise their regulatory criteria. These EPA recommended criteria are not regulatory levels. Most of EPA's *Recommended Water Quality Criteria* are based on a daily fish consumption rate of 17.5 grams/day and a risk level of 10^{-6}.

EPA Screening Values

Screening values (SVs) for carcinogenic and non-carcinogenic effects of substances were developed by EPA to help prioritize areas that may present risks to humans from fish consumption. The EPA SVs are considered guidance only; they are not regulatory thresholds (EPA, 2000). The approach in developing the EPA SVs was similar to the approach used for developing the NTR, yet differs in two key assumptions:

- A cancer risk level of 10^{-5}.
- Two consumption rates: 17.5 grams/day for recreational fishers, and 142.4 grams/day for subsistence fishers.

A difference between the EPA SVs and NTR relating to PCDD/Fs is that the SVs use the 2,3,7,8-TCDD TEQ value while Ecology uses the single congener (2,3,7,8-TCDD) for 303(d) assessments (Ecology, 2006).

Results and Discussion

In 2007 sixteen sites were sampled yielding 35 sample results representing 12 freshwater species of fish. Most results from the 2007 WSTMP were within the lower range of values found in other studies of fish tissue in Washington.

Bull trout were included in the 2007 samples and represent the first known case of this species being analyzed for contaminants in fillet tissue. Contaminant levels were generally low in this sample except for mercury which was moderately elevated. These fish were from Ross Lake and were provided by the Washington Department of Fish and Wildlife (WDFW).

The concentrations of contaminants in fish tissue are expressed in wet weight using these units of measure:

- mg/kg = ppm, or parts per million
- ug/kg = ppb, or parts per billion
- ng/kg = ppt, or parts per trillion

Table 3 shows summary statistics for key contaminants in freshwater fish. Mercury was detected in 100% of the 35 samples, PBDEs in 97%, and PCBs in 91%. Pesticides in the DDT and chlordane groups were detected in 63% and 6% of the samples, respectively. Twenty-seven samples were analyzed for PCB congeners and dioxins/furans with all samples having detectable levels.

Concentrations of PCBs in 26% of the samples exceeded the NTR criterion. Nineteen percent of the samples tested for 2,3,7,8-TCDD exceeded the NTR criterion. Total PCBs and 2,3,7,8-TCDD accounted for most of the NTR exceedances.

Appendix D shows results for key analytes in fish tissue samples.

Table 3. Summary Statistics for Fish Tissue Samples, WSTMP 2007.

Parameter [1]	n	Min	Max	Median	Mean	Standard Deviation	Detection Frequency	NTR Criteria Exceedance Frequency
Total PCB Aroclors [2]	35	0.97 U	28.4 J	3.7	4.53	4.94	77%	26%
Total PCB Congeners [2]	27	0.31 J	19.1 J	2.6	3.72	4.11	100%	19%
Total DDT [3]	35	0.85 U	24.2	1.8	2.68	3.96	63%	NC
Total Chlordane [4]	35	0.85 U	1.3 J	0.95	0.95	0.08	6%	0%
Total PBDE [5]	35	0.16 J	4.3	1.3	1.60	1.07	97%	NC
2,3,7,8-TCDD TEQ [6] (ng/kg)	27	0.010 J	0.911 J	0.149	0.2253	0.2191	100%	78% [7]
2,3,7,8-TCDD (ng/kg)	27	0.014 NJ	0.195 J	0.038	0.0522	0.0394	63%	19%
Mercury	35	41	1600	130	236.5	300.8	100%	3%

1. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2. Total PCBs is the sum of the individual Aroclors or congeners.
3. Total DDT is the sum of 4,4' and 2,4' isomers of DDT, DDD, and DDE.
4. Total PBDE is the sum of the 13 individual congeners that were analyzed for.
5. Total chlordane is the sum of: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane

6 . 2,3,7,8-TCDD TEQ, is the sum of the 17 PCDD/F congener results using TEFs by Van den Berg et al., 1998.

7. Washington discontinued using the TEQ value for comparison to the NTR in 2006. The exceedance values given here are so that comparisons to historical data can be made. The summing process used only values qualified as estimates: non-detect values were excluded.

U = The analyte was not detected at or above the reported value.

J = The analyte was positively identified. The associated numerical result is an estimate.

NJ = The analyte was tentatively identified and the associated numerical value represents an approximate concentration.

NC = No criteria for this parameter.

Contaminants in Freshwater Fish

Mercury

Mercury was detected in all samples. Only one sample exceeded the NTR criterion of 825 ug/kg while seven others were greater than EPA's *Recommended Water Quality Criterion* for methylmercury of 300 ug/kg (EPA, 2001). The range of values was similar to those seen in past WSTMP samples (Figure 2) as well as in other mercury monitoring efforts in Washington (Furl and Meredith, 2008).

Older and larger piscivorous (fish-eating) fish tended to have higher mercury levels. The highest levels were found in samples of northern pikeminnow and largemouth bass with mean ages ranging from 5.8 – 15.8 years old. The highest level of mercury, 1600 ug/kg, was in the northern pikeminnow sample from Lake Ozette. Largemouth bass from Big, Campbell, and Samish Lakes had mercury levels of 497-754 ug/kg. Mercury levels in other fish from Samish Lake were also elevated: 575 ug/kg in northern pikeminnow and 429 ug/kg in peamouth.

Rainbow trout from Chester Morse Reservoir had the highest level of mercury (407 ug/kg) found in 56 samples of five species of trout analyzed in the WSTMP since 2001. Brook trout from the Sanpoil River (234 ug/kg) and bull trout from Ross Lake (216 ug/kg) also had some of the highest mercury levels found in trout species collected thus far (89th and 88th percentile, respectively).

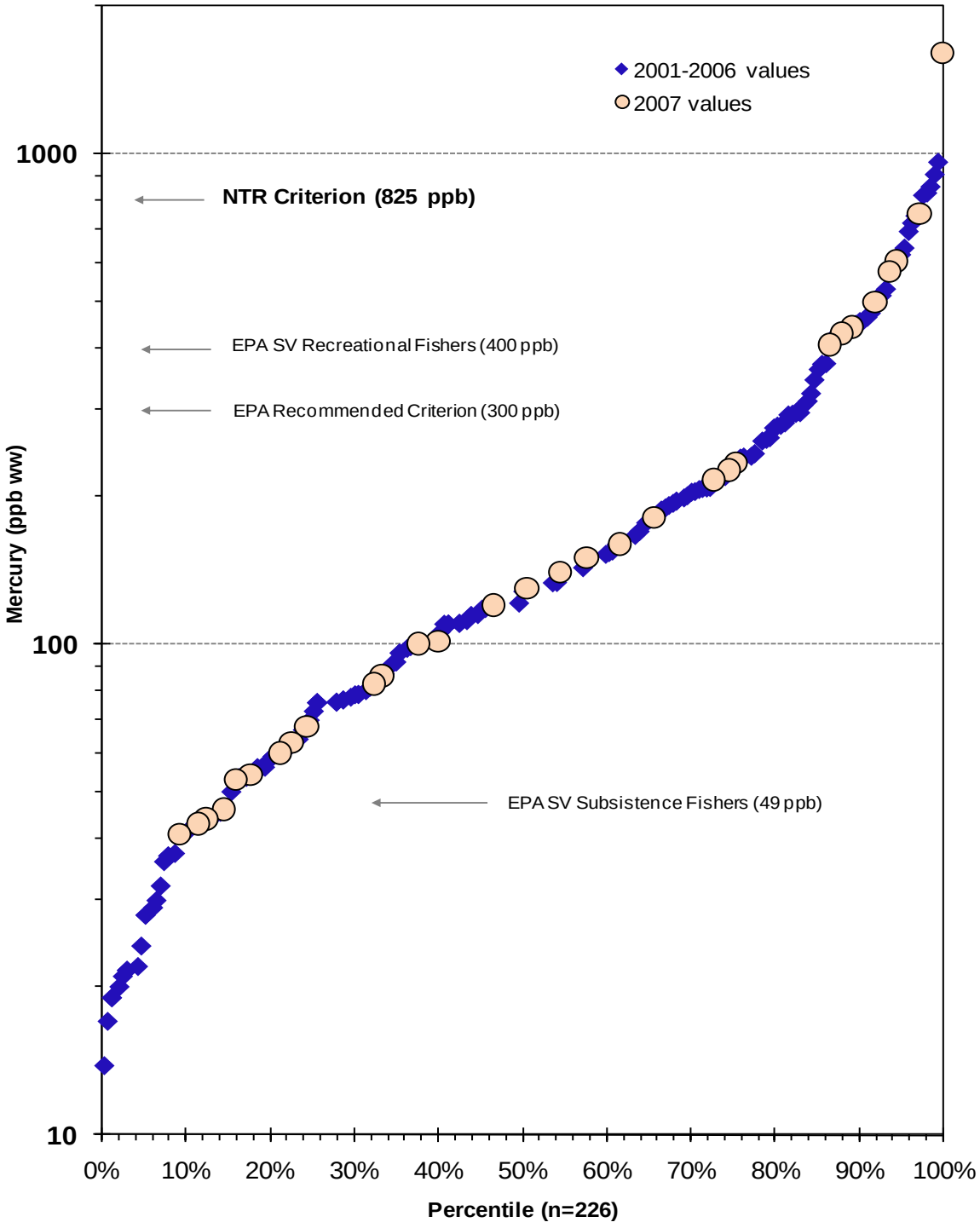

Figure 2. Distribution of Mercury in Edible Fish Tissue, WSTMP 2001-2007.

PCBs

PCBs were detected in 91% of the 35 samples with 26% of the samples exceeding the NTR criterion of 5.3 ug/kg total PCBs. The highest levels of total PCBs were found in brown trout from Sullivan Lake and northern pikeminnow from Samish Lake (28.4 ug/kg Aroclors and 12.6 ug/kg Aroclors, respectively). Fish from the remaining sites had total PCB levels below 10 ug/kg.

Figure 3 shows total PCB levels in edible fish tissue from 218 samples collected during the 2001-2007 WSTMP. Most results from the 2007 sampling effort fell below the median (50^{th} percentile) while two samples discussed above ranked at the 81^{st} and 68^{th} percentiles. For all fish analyzed for PCBs during the WSTMP from 2001-2007, about 55% of samples exceed the NTR criterion of 5.3 ppb wet weight (ww) for the protection of human health. About 85% of fish also exceed EPA's lower SV for Subsistence Fishers (2.45 ppb ww).

Dioxins and Furans (PCDD/Fs)

Dioxins and furans were detected in all samples with 19% of samples exceeding the NTR criterion for 2,3,7,8-TCDD of 0.07 ng/kg. The highest levels of 2,3,7,8-TCDD were found in Samish Lake northern pikeminnow (0.195 ng/kg), Samish Lake cutthroat trout (0.12 ng/kg), Sullivan Lake brown trout (0.1 ng/kg), and Big Lake cutthroat trout (0.099 ng/kg). Corresponding 2,3,7,8-TCDD TEQ values for these samples ranged from 0.665-0.911 ng/kg.

Figure 4 shows 2,3,7,8-TCDD TEQ values for all results from the WSTMP. The TEQ value, instead of the single 2,3,7,8-TCDD congener, is shown here because the TEQ is a more conservative expression of the risks posed by all 17 toxic dioxin and furan congeners. The 2007 results have a broad distribution compared to all results from the WSTMP. Overall, about 80% of fish sampled for PCDD/Fs during the WSTMP exceeded the NTR criterion of 0.07 ppt ww for the single congener 2,3,7,8-TCDD. TEQ values for about 90% of the WSTMP samples exceeded EPA's SV for Subsistence Fishers (0.032 ppt ww).

Chlorinated Pesticides

The most frequently detected chlorinated pesticide was 4,4'-DDE. Eight other pesticides or breakdown products were detected at frequencies less than 10%. These were: 4,4'-DDD, 4,4'-DDT, DDMU, technical grade chlordane, trans-nonachlor, hexachlorobenzene, dieldrin, and pentachloroanisole.

While DDT compounds were detected in 63% of the samples, none of the samples exceeded NTR criteria for individual DDT compounds. The highest levels of total DDT were found in Sullivan Lake brown trout (24.2 ug/kg) and Samish Lake northern pikeminnow (5.2 ug/kg). The remaining sites had fish containing less than 5 ug/kg total DDT. DDT compounds found in this 2007 study were generally at lower levels than found in other Ecology studies conducted in Washington.

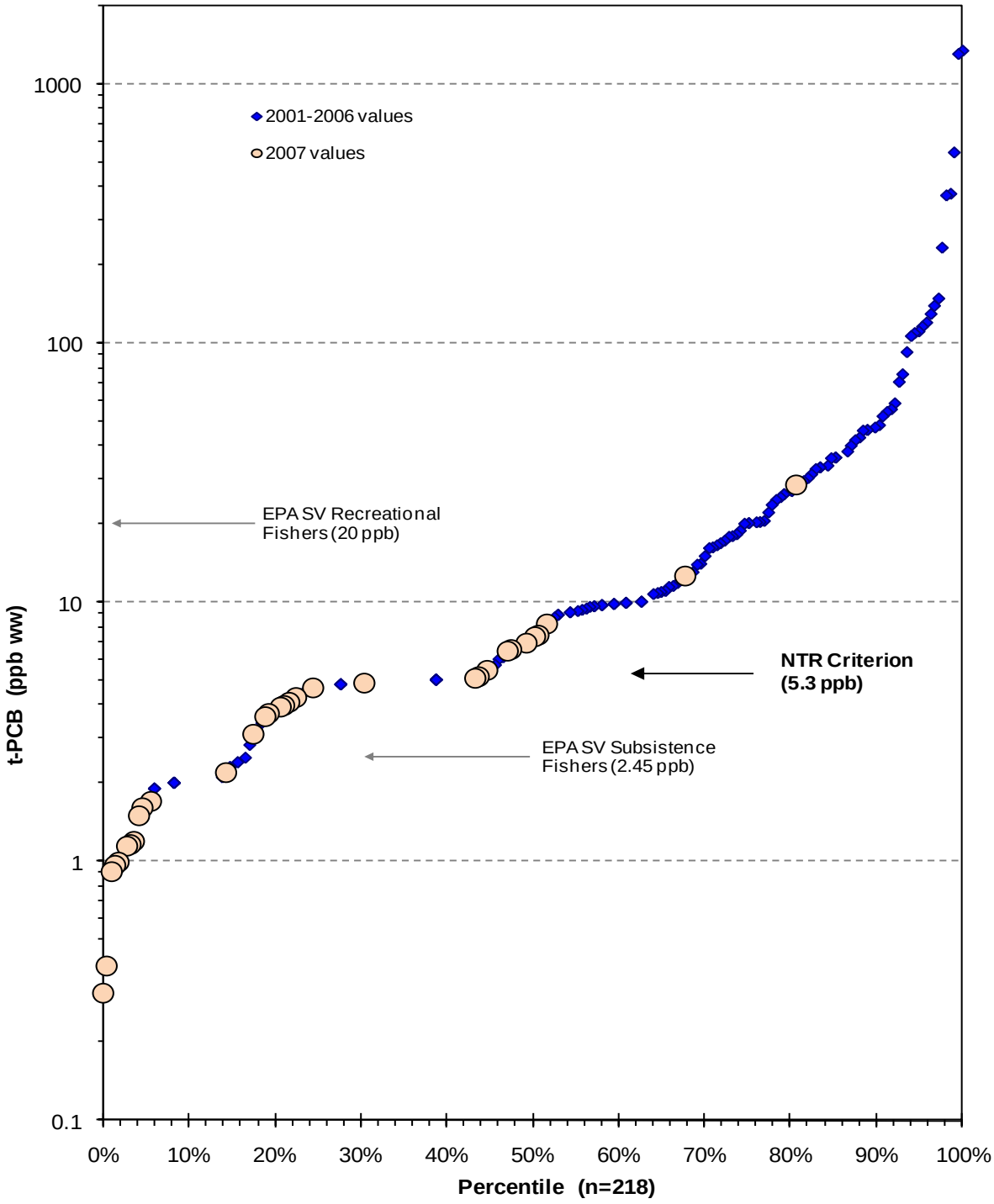

Figure 3. Distribution of Total PCBs in Edible Fish Tissue, WSTMP 2001-2007.

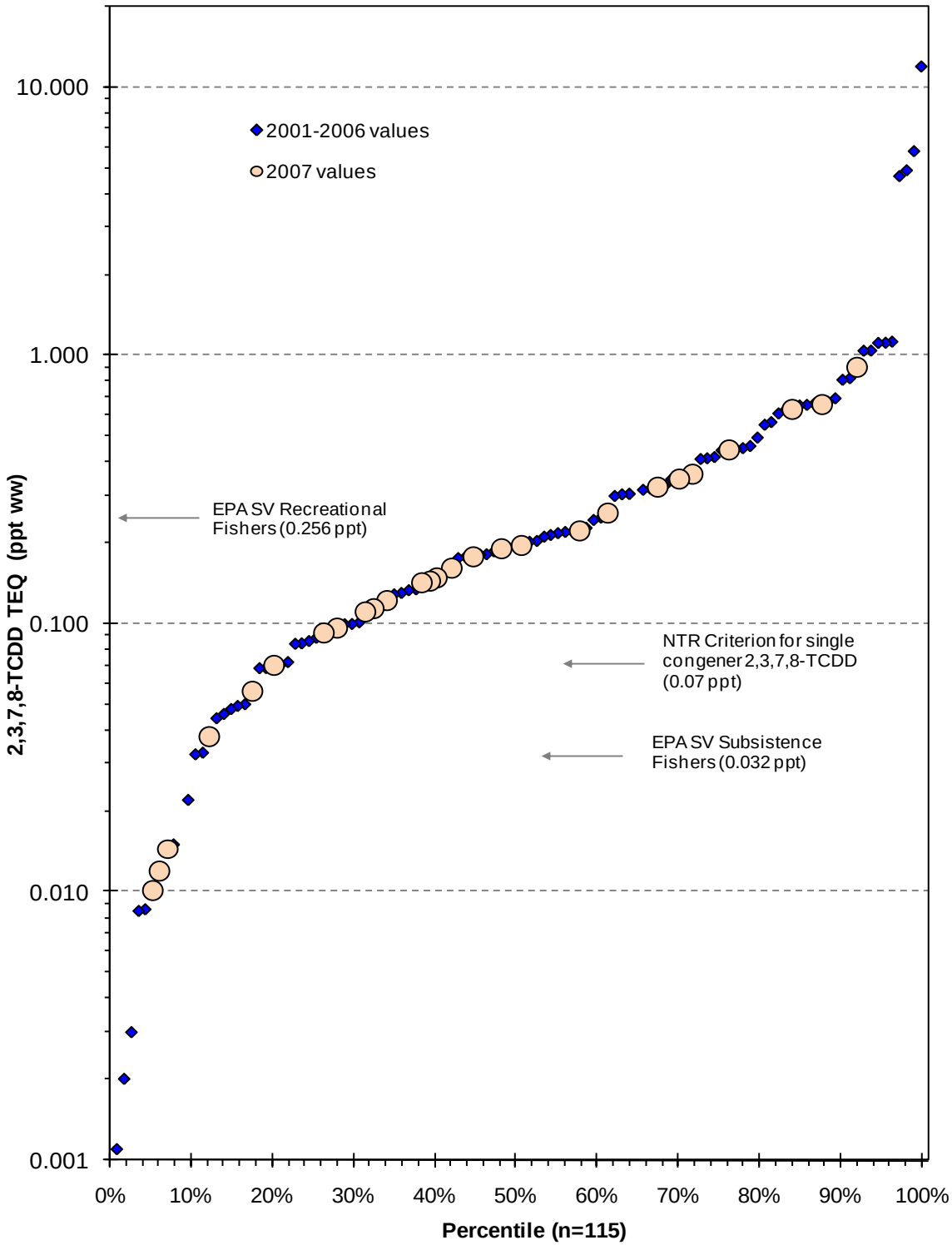

Figure 4. Distribution of 2,3,7,8-TCDD TEQ in Edible Fish Tissue, WSTMP 2001-2007.

Total chlordane was detected in only two samples: Sullivan Lake brown trout (1.3 ug/kg) and Samish Lake northern pikeminnow (1.1 ug/kg). Neither sample exceeded the NTR criterion of 8.3 ug/kg. However, technical grade chlordane was found at low levels (4.7-7.9 ug/kg) in three samples: Samish Lake northern pikeminnow and peamouth, and Sullivan Lake brown trout.

Regarding residues in fish tissue, total chlordane and technical grade chlordane can be considered synonymous based on descriptions by the Agency for Toxic Substances and Disease Registry (ASTDR, 1994) and EPA's Substance Registry System (EPA, 2008).

While technical chlordane is a complex mixture of over 100 individual chemicals, EPA (2000) recommends summing the concentrations of its major components and metabolites to yield a concentration called "total chlordane". The major components used in this summing are cis- and trans-chlordane, cis- and trans-nonachlor, and oxychlordane. These components have been target analytes and more consistently determined in fish tissue studies in Washington while technical grade chlordane has not. Ecology employs the total chlordane summing procedure to determine whether water quality standards are met (Ecology, 2006).

The only detection of hexachlorobenzene was in the cutthroat trout sample from Big Lake. The concentration of 8.3 ug/kg exceeded the NTR criterion of 6.7 ug/kg.

Dieldrin was found in two samples from the Samish River: cutthroat trout (0.46 ug/kg) and mountain whitefish (0.61 ug/kg). Both of these results were below the NTR criterion of 0.65 ug/kg.

Pentachloroanisole, a breakdown product of pentachlorophenol, was found in Samish Lake cutthroat trout (2.8 ug/kg) and peamouth (2.6 ug/kg). There are no regulatory criteria for Pentachloroanisole.

PBDE Flame Retardants

PBDEs were detected in 97% of fish tissue samples at low levels: all samples had less than 5 ug/kg total PBDEs. The highest levels of total PBDEs were in cutthroat trout from Samish Lake (4.3 ug/kg) and brown trout from Sullivan Lake (3.8 ug/kg). The remaining values were less than or equal to 3.5 ug/kg which is in the range of the median value of 2.8 ug/kg found during a survey of PBDEs in Washington (Johnson et al., 2006). The 2007 results were also in the lower 65% of all results for the WSTMP (Figure 5). About 80% of all WSTMP samples had PBDE levels below 10 ug/kg.

Comparisons to Historical Data

Only two sites sampled in 2007 had been studied in the past: Samish Lake and Lake Ozette. Two species from Samish Lake and one species from Lake Ozette can be compared.

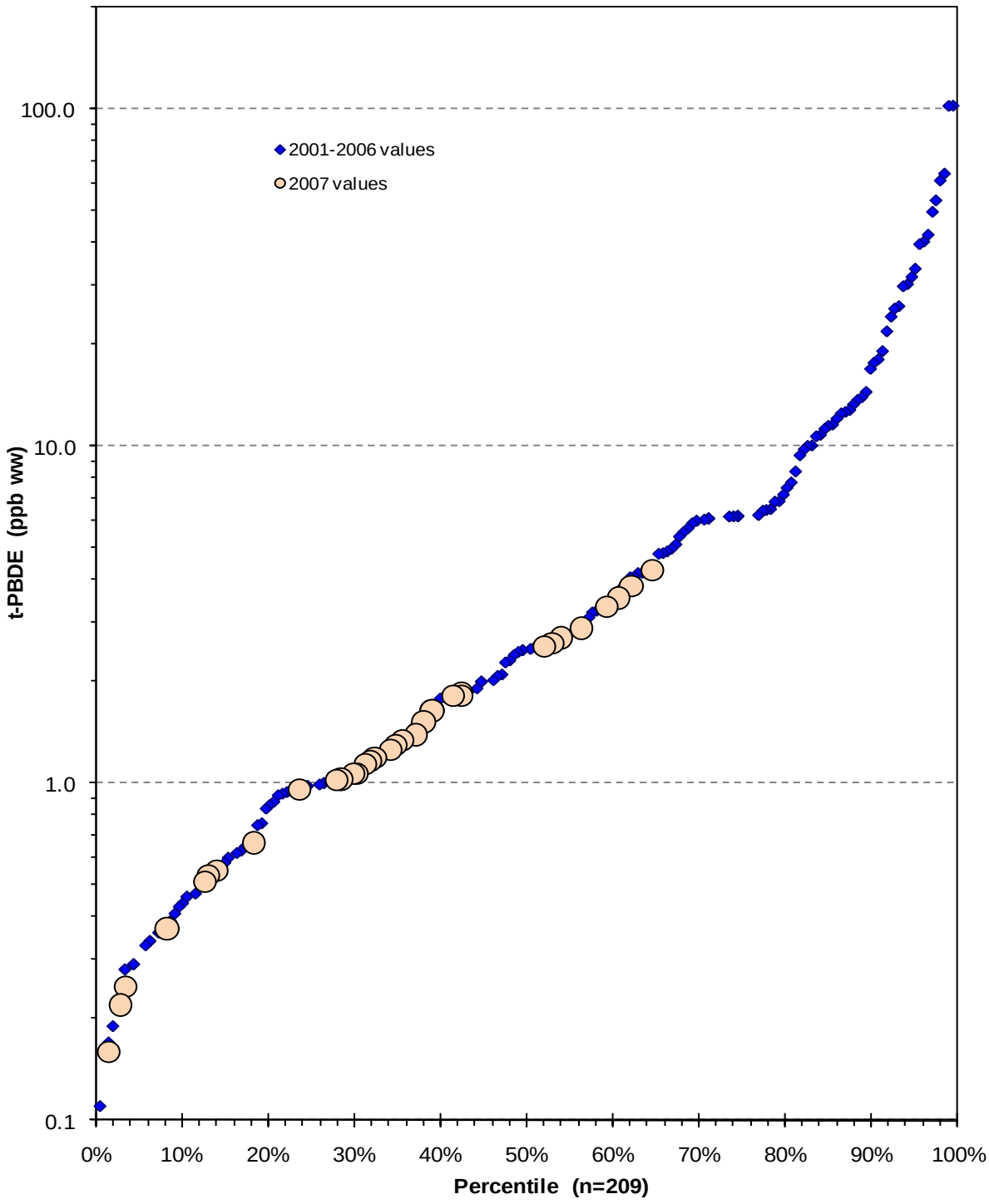

Figure 5. Distribution of Total PBDEs in Edible Fish Tissue, WSTMP 2001-2007.

Fish from Samish Lake were included in three studies: a statewide survey of 10 lakes in 1989 (Johnson and Norton, 1990); a statewide survey of mercury in fish (Fischnaller et al., 2003); and as part of the 2001 WSTMP (Seiders, 2003). Results from cutthroat trout samples from the 2001 and 2007 surveys are compared below. Changes in mercury levels in largemouth bass over time are discussed by Furl and Meredith (2008) as part of a statewide mercury trend monitoring effort. For Samish Lake, an insignificant difference (1%) was found in mercury levels between bass collected in 2003 and 2008.

Lake Ozette was initially sampled during the 2004 WSTMP (Seiders et al., 2007). While the 2007 sampling was part of a study to determine levels of PCBs and PCDD/Fs at "background" sites across the state (Johnson et al., 2007), the WSTMP analyzed one sample of northern pikeminnow for the same suite of contaminants that were analyzed in 2004. This additional analysis of a high trophic-level species should improve confidence in the data for this site within the Olympic National Park.

Differences in contaminant levels in samples can be influenced by many characteristics of the fish sampled, such as size, age, and lipid content. The greater the similarity among these factors, the stronger any comparison will be. Sample collection, preparation, and analytical methods were similar for all samples which also improves the comparability of results.

Tables 4 and 5 show that fish size, age, and lipids were similar between samples for each site. Samples were collected at nearly the same time during the season which helps negate any influence of seasonality that may affect contaminant levels. Levels of most contaminants were similar between years. Differences in levels are generally within the variability seen among field and laboratory duplicate samples. Yet fish from Lake Ozette showed larger differences in mercury and PCDD/Fs levels.

Mercury levels in both Lake Ozette samples were among the highest seen in Washington. The 2007 sample result (1600 ppb) is more than twice that of the 2004 result (724 ppb). This difference is likely due in part to the 2007 fish being about 20% older than those from 2004. Other reasons for the difference could be sampling variability and a real increase in mercury accumulation in Lake Ozette fish. In 2008, Lake Ozette was added to Ecology's effort to examine trends in mercury levels in fish, primarily largemouth bass (Furl and Meredith, 2008). Future sampling under the trends monitoring effort will provide more information about changes in mercury levels at Lake Ozette.

The 2,3,7,8-TCDD TEQ result for the 2004 sample is nearly 20 times higher than that for the 2007 sample. This difference is most likely due to changes in analytical detection limits and reporting practices between years rather than differences in the environment. For example, results for individual congeners that were near detection limits and reported as estimates may not be very accurate. Even so, such values were included in calculating the 2,3,7,8-TCDD TEQ.

Table 4. Comparison of Historical to Recent Fish Tissue Data from Samish Lake.

Parameter	2001 Sample	2007 Sample
Collection Date	9/11/01	9/4/07
Mean Total Length (mm)	291.0	271.6
Mean Weight (g)	213.0	179.6
Mean Age (years)	2.4	2.0
Lipids (%)	2.1	1.9
Total PCB aroclors (ug/kg)	13.1	8.2
Total PBDE (ug/kg)	2.9	3.7 A
T-DDT (ug/kg)	5.0	2.9
Total Chlordane (ug/kg)	2.0	0.98 U
Pentachloroanisole	0.58	2.8 J
MEL Sample ID	02088428	07494507
No. fish/composite	10	5

A Only the same congeners that were analyzed in 2001 were used to calculate this value.
J The analyte was positively identified. The associated numerical result is an estimate.
U The analyte was not detected at or above the reported result.

Table 5. Comparison of Historical to Recent Fish Tissue Data from Lake Ozette.

Parameter	2004 Sample	2007 Sample
Collection Date	10/6/04	9/12/07
Mean Total Length (mm)	371.3	377.2
Mean Weight (g)	463.5	433.2
Mean Age (years)	7.2	9.0
Lipids (%)	0.91	0.81
Total PCB aroclors (ug/kg)	5.0 U	1.7 J
Total PCB congeners (ug/kg)	0.91	1.4 J
T-DDT (ug/kg)	0.57	1.4
2378 TCDD TEQ (ng/kg)	0.195	0.010 J
2378 TCDD (ng/kg)	0.03 UJ	0.033 UJ
Mercury (ug/kg; EPA 245.6)	724	1600
MEL Sample ID	05084304	07494503
No. fish/composite	10	5

J = The analyte was positively identified. The associated numerical result is an estimate.
U = The analyte was not detected at or above the reported result.
UJ = The analyte was not detected at or above the reported estimated result.

Water Quality Standards Exceeded

Six of the 16 sites had fish tissue that did not meet one or more NTR criteria. Total PCBs and 2,3,7,8-TCDD accounted for 81% of these exceedances. The other exceedances were due to hexachlorobenzene and mercury. Table 6 shows the 11 cases from six sites recommended for Category 5 classification, *Does Not Meet Criteria*, in Ecology's 303(d) assessment method (Ecology, 2006).

A total of 12 sites had fish where 2,3,7,8-TCDD TEQ levels exceeded the NTR criterion for the single congener 2,3,7,8-TCDD (0.07 ppt). Ecology recently changed how dioxin/furan data are used for the 303(d) assessment method. Prior to Ecology documenting the assessment method (Ecology 2006), TEQ values were used in classifying waters as Category 5, which is the 303(d) list. Currently, when TEQ values exceed the NTR criterion for the single congener 2,3,7, 8-TCDD, the site is classified as Category 2. So, 12 cases are recommended for Category 2 classification, *Waters of Concern* (Table 6, last column on right).

Twenty-six sample analyses for aldrin, dieldrin, heptachlor epoxide, and toxaphene could not be compared to NTR criteria because the analyte was not detected at reporting limits that were greater than the respective criteria. These cases are recommended for a category 3 classification, *Lack of Sufficient Data*. The remaining results (n=822) that met NTR criteria are recommended for Category 1 classification, *Meets Tested Criteria*.

Table 6. Recommended 303(d) Listings for Fish Tissue Sample Results, WSTMP 2007.

Recommended Category for 303(d) Assessment -->			5				2
Site Name	Species Exceeding NTR Criteria	Sum of Recommended Category 5 Listings	Total PCBs	2,3,7,8-TCDD	Hexachloro-benzene	Mercury	2,3,7,8-TCDD TEQ
Baker Lake	RBT, CTT						x
Big Lake	CTT, LMB	3	x	x	x		x
Campbell Lake	LMB, CTT	2	x	x			x
Cushman Lake	KOK						x
Deer Lake	LMB, RBT						x
Kettle River	RBT						x
Ozette Lake	NPM	1				x	
Samish Lake	CTT, NPM, LMB, PEA	2	x	x			x
Samish River	CTT, MWF	1	x				x
Sanpoil River	RBT						x
Sauk River	MWF						x
Spada Lake	CTT						x
Sullivan Lake	BNT, CTT, MWF, RBT	2	x	x			x
Count of Recommended Category 5 Listings:		11	5	4	1	1	
Percent of Recommended Category 5 Listings:			45%	36%	9%	9%	
Count of Recommended Category 2 Listings:							12

Species Codes: CTT = Cutthroat trout, KOK = Kokanee salmon, LMB = Largemouth bass, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, BNT = Brown trout, MWF = Mountain whitefish.

Site Scoring and Ranking

In order to compare results across many species and sites, a scoring and ranking method was used. The scoring method used results for key contaminants that had high frequencies of detection and/or exceeded their respective benchmark values (described below). The sample and site scores give an overall picture of how far contaminant levels in fish are above benchmark values.

This scoring and ranking was applied only to sites sampled by the WSTMP from 2001 through 2007. Scoring and ranking results from other fish tissue studies conducted in Washington to gain a broader perspective is beyond the scope of this project's reporting effort.

Scoring

Contaminant scores were developed for each sample, then for each site. For samples, levels of contaminants in each sample were divided by a benchmark value which produced a ratio of the contaminant concentration in the sample to the benchmark value. These ratios show whether individual contaminants are higher or lower than the benchmark values and by how much. The ratios for each contaminant were then summed to give a sample contaminant score. Finally, site contaminant scores were derived by averaging the sample contaminant scores from each site.

Table 7 shows the benchmark values used and the contaminant scores generated for two samples from one site. The benchmark values used were the NTR criteria or other value as described in the table's footnotes. Where results were qualified as non-detects, the reporting limit was used.

Table 7. Example Calculation of Contaminant Scores for Samples and Sites Using the Campbell Lake Site near Anacortes, WSTMP 2007.

Contaminant [1]	Benchmark Value [2]	Sample Result Value				Benchmark Exceedance Factor	
		CTT		LMB		CTT	LMB
Total PCB Aroclors	5.3	3.6	J	7.4	J	0.7	1.4
Total DDT [3]	32	1.2		2.4		0.0	0.1
Total PBDE [4]	31.0	1.25		2.55	J	0.0	0.1
Total Chlordane	8.3	0.87	U	0.86	U	0.1	0.1
2,3,7,8-TCDD TEQ [5]	0.07	0.325	J	0.365	J	4.6	5.2
Mercury	825	44		603		0.1	0.7
Dieldrin	0.65	0.7	U	0.34	U	1.1	0.5
Sample Contaminant Score:						6.6	8.1
Site Contaminant Score: [6]						7.4	

1. Species Codes: CTT- Cutthroat trout, LMB - Largemouth bass.
2. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
3. Benchmark values are NTR criteria unless noted otherwise.
4. Benchmark value is the NTR criterion for both 4,4'-DDE and 4,4'-DDT, the compounds which usually contribute the most to the total DDT value
5. There are no NTR criteria for PBDEs. The benchmark value is the 90th percentile from a statewide study of PBDEs (Johnson et al., 2006).
6. Benchmark value is the NTR criterion for the single congener 2,3,7,8-TCDD. The TEQ value is used for contaminant scoring purposes because it represents all dioxins and furan congeners. Values in parts per trillion (ng/kg ww).
7. The site contaminant score is the mean of the sample contaminant scores from that site.

U = The analyte was not detected at or above the reported result.
J = The analyte was positively identified. The associated numerical result is an estimate.

For site contaminant scoring, sample results for some areas were consolidated to represent one site. For example, sample results from Lake Washington were associated with three areas (north, south, and entire lake) so samples from these areas were combined to represent Lake Washington as a single site. Similarly, samples from four areas along the Spokane River between river miles 64 and 85 were combined to represent the Spokane River as a single site. Other consolidations were for sites on the Wenatchee and Palouse Rivers.

Overall, the 2007 sample contaminant scores were in the lower range of all scores from the 2001 through 2007 samples. The lowest contaminant scores for 2007 were for Cushman Lake rainbow trout (1.0) and Big Lake yellow perch (1.0). These samples did not exceed any benchmark values. The highest contaminant scores were for Samish Lake northern pikeminnow (17.1) and Sullivan Lake brown trout (17.8) where benchmark values were exceeded for three of the seven key contaminants.

The median score for all 2007 samples was 3.5. As in previous years, PCBs and 2,3,7,8-TCDD TEQ contributed most to these scores. For example, the Samish Lake northern pikeminnow sample had a 2,3,7,8-TCDD TEQ level which exceeded the benchmark value of 0.07 ng/kg by a factor of 13, accounting for about 75% of that sample's contaminant score of 17.1. The PCB level in this same sample accounted for nearly 14% of the contaminant score.

Ranking

Site contaminant scores were ranked from high to low to show the relative amount of contamination in fish from sampled sites. Figure 6 shows site contaminant scores for the 2001-2007 results with the 2007 sites identified. Site contaminant scores ranged from 1.8 (Aldwell Lake) to 7.4 (Campbell Lake) with the median score being 3.7. Thirteen of the 16 sites had at least one sample that exceeded NTR criteria as described earlier and shown in Table 6.

Overall, the 2007 site contaminant scores were in the lower half of the ranking for all 2004-2006 sites except for Campbell, Sullivan, Samish, and Big Lakes. These four sites ranked in the 55^{th} to 63^{rd} percentile of all sites sampled from 2001-2007. The species from these four sites that had higher levels of contamination included cutthroat trout, largemouth bass, brown trout, and northern pikeminnow. These four sites were near urbanized areas or had older fish that were sampled.

The site ranking presented here was done using PCDD/F data in scoring, although only about half of the samples were analyzed for PCDD/Fs. Sites were also scored without using PCDD/F data to see how much scores would change. The scores for 90% of all sites changed by no more than 5 points when PCDD/F data were excluded which is a minor effect on overall scores. While the effect on ranking was more pronounced, the general pattern of ranking for the majority of sites changed little.

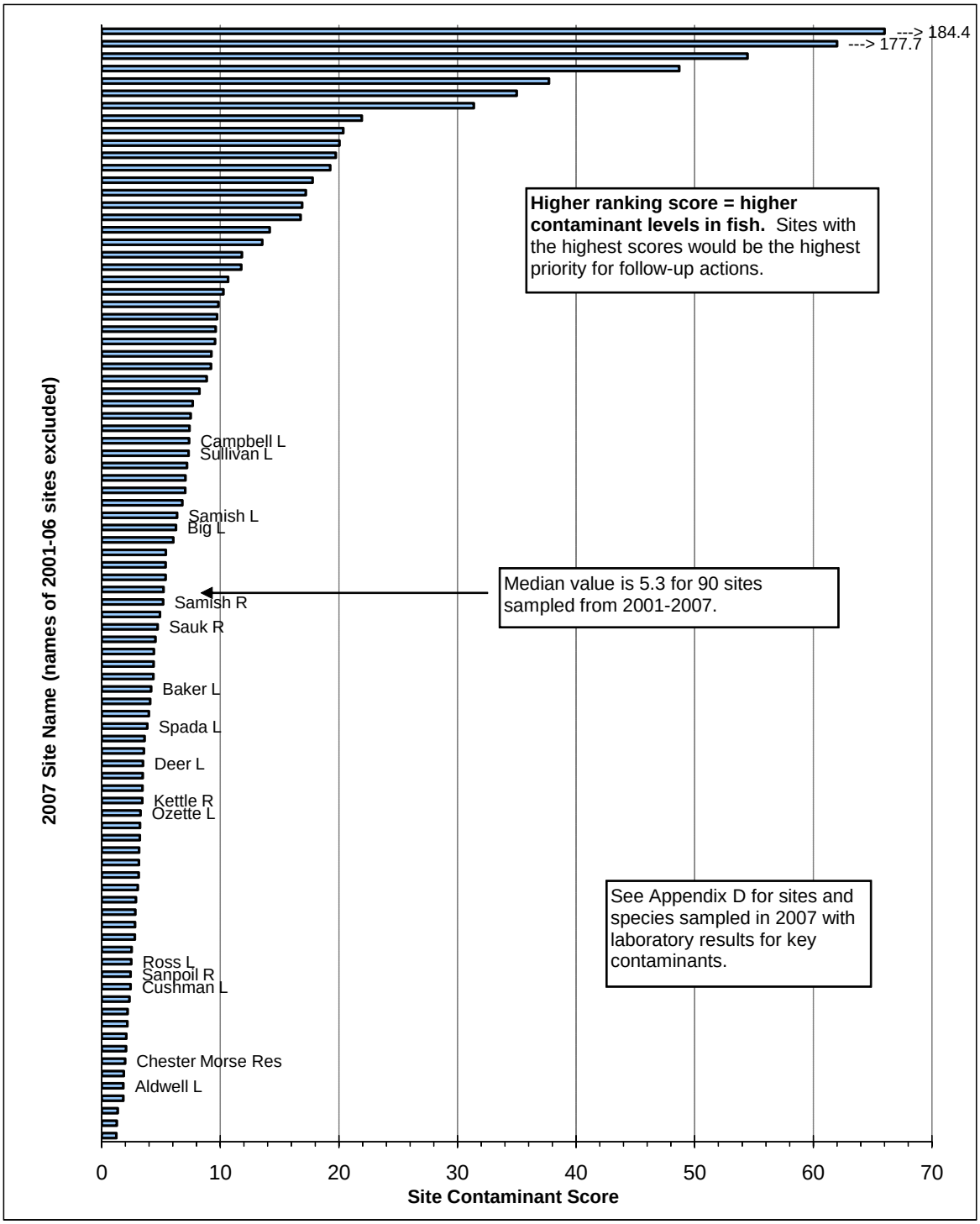

Figure 6. Site Ranking for Fish Tissue Results, WSTMP 2001-2007.

Conclusions and Recommendations

Conclusions

During 2007, PCBs, dioxin/furans, chlorinated pesticides, PBDE flame retardants, and mercury were frequently detected in 35 samples of fish from 16 lakes and rivers across Washington State.

A total of 10 of the 35 samples, from six of the 16 lakes, did not meet Washington State water quality standards for contaminants in fish tissue. Total PCBs and 2,3,7,8-TCDD accounted for most of these exceedances. Other contaminants exceeding water quality standards were mercury and hexachlorobenzene.

Overall, the 2007 site contaminant scores ranked in the lower half of all sites sampled between 2001 and 2007 for the WSTMP except for Campbell, Sullivan, Samish, and Big Lakes. These four sites ranked in the 55th to 63rd percentile of all sites sampled from 2001-2007. These four sites were near urbanized areas or had older and larger fish that were sampled.

Levels of mercury and 2,3,7,8-TCDD TEQ in the 2007 samples has a wide spread of values which was representative of all sample results from 2001-2007. Northern pikeminnow from Lake Ozette had the highest level of mercury found at WSTMP sites since 2001. Levels of PCBs and PBDEs in the 2007 samples were in the low to median range of all WSTMP samples since 2001.

Bull trout from Ross Lake were sampled in 2007, representing the first known case of this species being analyzed for contaminants in Washington. Contaminant levels in this bull trout sample were generally low except for mercury, which was among the highest level found in trout species collected thus far in Washington.

Recommendations

Because the WSTMP is a screening-level assessment only, the Washington State Department of Health, local health jurisdictions, and affected tribes should evaluate the need for more detailed assessment of risks to human health from the consumption of contaminated fish. The initial focus should be on the six sites where contaminant levels did not meet the NTR criteria (Category 5 sites in Table 6).

Ecology should determine what follow-up actions to take for the most contaminated sites identified in 2007: Campbell, Sullivan, Samish, and Big Lakes. Levels of PCBs and TCDD in fish from these sites were the main chemicals of concern.

Ecology should review the tissue data from the 13 lakes and rivers listed in Table 6 for placement of these sites in Categories 5 and 2 of Washington State's 303(d) assessment. Other results from this 2007 sampling effort should be reviewed and the remaining three lakes placed in Categories 1 and 3 of the 303(d) assessment.

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Appendices

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Appendix A. Site and Species Sampled: WSTMP 2007

Table A-1. Site and Species Sampled: WSTMP 2007.

Sample Site	County	WRIA	Species Sampled	Longitude	Latitude	WBID
Aldwell Lake	Clallam	18	BKT, RBT	-123.5730	48.0781	WA-18-9010
Baker Lake	Whatcom	4	CTT, RBT	-121.6555	48.7218	WA-04-9010
Big Lake	Skagit	3	CTT, LMB, YP	-122.2300	48.3792	WA-03-9020
Campbell Lake	Skagit	3	CTT, LMB	-122.6211	48.4390	WA-03-9040
Chester Morse Reservoir	King	8	RBT	-121.6979	47.3861	WA-08-9060
Cushman Lake	Mason	16	KOK, MWF, RBT, SS	-123.2240	47.4501	WA-16-9010
Deer Lake	Stevens	59	LMB, RBT	-117.5881	48.1116	WA-59-9040
Kettle River	Ferry	60	RBT	-118.5996	48.8884	WA-60-1020
Ozette Lake	Clallam	20	NPM	-124.6338	48.0967	WA-20-9040
Ross Lake	Whatcom	4	BLT, RBT, RSS	-121.0417	48.8333	WA-04-9180
Samish Lake	Whatcom	3	CTT, LMB, NPM, PEA, YP	-122.3861	48.6666	WA-03-9160
Samish River	Skagit	3	CTT, MWF	-122.2900	48.5571	WA-03-2010
Sanpoil River	Ferry	52	BKT, RBT	-118.7477	48.5442	WA-52-1010
Sauk River	Skagit	4	MWF	-121.3881	48.0987	WA-04-1080
Spada Lake	Snohomish	7	CTT	-121.6500	47.9700	WA-07-9710
Sullivan Lake	Pend Oreille	62	BNT, CTT, MWF, RBT	-117.2900	48.8000	WA-62-9190

WRIA = Water Resource Inventory Area.
WBID = Ecology's Water Body Identification Number (WBID).
Latitude and longitude coordinates datum is NAD 83 HARN.
Species Codes: BLT = Bull trout, BNT = Brown trout, BKT = Brook trout, CTT = Cutthroat trout, KOK = Kokanee salmon, LMB = Largemouth bass, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, RSS = Redside shiner (whole fish), SS = Salish sucker, YP = Yellow perch

Appendix B. Data Quality Assessment

Data quality was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Case narratives were written by Manchester Laboratory (MEL) analytical staff. The narratives described the condition of samples upon receipt, analytical quality control (QC) procedures, and data qualifications. Quality control (QC) procedures included analysis of method blanks, calibration and control standards, matrix spikes, matrix spike duplicates, surrogate recoveries, and laboratory and field duplicates.

Lab duplicate samples were created at the analytical lab by splitting the tissue sample that was sent to them and analyzing each split. Field duplicate samples consisted of two samples that were created from different, yet similar-sized, fish of the same species collected from the same site at the same time. Individual fish were assigned to the two composite samples randomly.

Overall, the 2007 data met most quality control (QC) criteria defined by MEL and the Quality Assurance Project Plan. Initial analyses for PCB aroclors did not meet reporting limits, so samples were re-analyzed and met the desired reporting limits. No other data were rejected or re-analyzed. Some data were qualified due to challenges encountered in analyses. Estimates of precision appear typical for samples of fish tissue. All results are usable for this project as qualified. Table B1 summarizes results from quality control (QC) and quality assurance procedures while data quality for selected parameters is discussed below.

Standard Reference Materials (SRM) were analyzed to help evaluate analytical accuracy. The SRM 1946 (Lake Superior Fish Tissue) from the National Institute of Standards and Technology was analyzed for mercury, chlorinated pesticides, and PCB Aroclors. The SRM "Carp-2" (carp from Saginaw Bay, Lake Huron) obtained from the National Research Council of Canada was analyzed for dioxin/furan analysis and PCB congeners. Discussion of SRM results are included below.

Mercury, Chlorinated Pesticides, PCB Aroclors, PBDEs, and Lipids

Results of two SRM analyses for mercury were 7% and 12%, which are outside the 95% confidence interval (CI) of 2.1%. Results of SRM analyses for 16 chlorinated pesticides had 22 results (71%) outside the SRM's approximate 95% CI. These 22 results ranged from 2% - 276% outside the CI. The remaining 9 results (29%) were within the desired CI. Overall, results suggest that analytical accuracy was moderate to poor for chlorinated pesticides while accuracy for mercury was moderate.

Several target analytes were detected in two sets of lab and field duplicate samples. Estimates of precision based on the small number of results met requirements of the lab and the QA Project Plan, so analytical and sampling precision was deemed adequate.

Estimates of precision for lipids analyses were mixed. Two sets of lab duplicates by MEL had very good precision with relative percent differences (RPDs) of 1% and 4%. Three sets of lab duplicates by the contract lab Pace Analytical, Inc. were poor with RPDs of 68% to 148%. Inter-

laboratory analyses of 28 samples yielded poor to moderate precision in most cases, with RPDs ranging from 5% to 130%. Differences in analytical methods and the extraction solvents used by the different labs likely contribute to poor inter-laboratory precision.

PCB Congeners

Fourteen results for seven PCB congeners were within the SRM's approximate 95% CI of the certified or reference values. These results suggest good analytical accuracy at concentrations in the SRM. Concentrations of the PCB congener in the SRM are one to two orders of magnitude greater than concentrations found in the 2007 fish tissue samples.

Precision as determined through two lab and one field duplicate analyses was moderate to good. Interestingly, where field and lab duplicate analyses were done on the same samples, the field duplicate had better precision than the lab duplicate.

Dioxins and Furans

Sample analysis experienced difficulties that resulted in heavily qualified data with reporting limits being higher than desired. Technical issues with the initial and second extractions led to the use of results from the two different extractions. Some results were also affected by interfering substances or target analytes being found in blanks. Detections that were above the Limit of Detection (LOD) yet below the Estimated Quantitation Limit (EQL) were qualified as estimates at request of the project manager: 56% of results fell within this range while 43% of results were qualified as not detected. Less than 2% of results had no qualifiers attached.

Precision as determined through lab and field duplicate analyses was generally poor due to so many result values reported between the EQL and LOD. Table B1 summarizes other QA/QC characteristics of this data set.

Fifteen results for nine dioxins/furans had seven results that were slightly outside the SRM's approximate 95% CI. The remaining eight results were within the desired CI. Three results were qualified as not-detected yet two of the reporting limits for these were outside the 95% CI of the SRM. Overall, results suggest moderate to good analytical accuracy for dioxin/furans at the concentrations in the SRM. This SRM has concentrations that are one or more orders of magnitude greater than concentrations typically found in the 2007 samples. An SRM with lower concentrations would be more useful in evaluating analytical accuracy at levels typically found in fish tissue samples from Washington.

Table B1. Summary of Quality Assurance/Quality Control Specifications and Data Review Findings, WSTMP 2007.

Parameter	Analytical Method	Holding Time	Calibrations	Blanks	Reporting Limits [a]	Lab Dup (RPD)	Field Dup (RSD)	LCS (% recovery)	Surrogates (% recovery)	MS/MSD (% recovery)	Overall Decision
Mercury											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	NA	Acceptable	Acceptable
QAPP or PSN specification	EPA 245.6 (CVAA) [b]	6 months [c]	NS	NS	17 ug/kg	NS	0%-14%	NS	NA	NS	-
LAB specification	EPA 245.6 (CVAA)	NS	See Method	g	17 ug/kg	0%-20%	NS	85%-115%	NA	75%-125%; RPD limits 0%-20%	-
Chlorinated pesticides											
Finding	Acceptable	Acceptable	Acceptable [n]	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [p]	Acceptable	Acceptable [r]	Acceptable
QAPP or PSN specification	EPA 8081 (GC/ECD); MEL SOP*	1 year	NS	NS	most 0.5-2.0 ug/kg	NS	0%-28%	NS	NS	NS	-
LAB specification	SW 8081 & 8082 (GC/ECD)	1 year	See Method	g	ae	0%-40% [o]	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40%	-
PBDEs											
Finding	Acceptable	Acceptable	Acceptable	Acceptable [h]	Acceptable [i]	Acceptable [k]	Acceptable [L]	Acceptable	Acceptable [v]	Acceptable	Acceptable
QAPP or PSN specification	EPA 8270 (SIM); MEL SOP*	1 year	NS	NS	0.5-1.0 ug/kg [f]	NS	0%-28%	NS	NS	NS	-
LAB specification	EPA 8270 (SIM); SOP 730104	1 year [d]	See Method	h	0.10-2.6 ug/kg; PBDE 209 2.6-28 ug/kg	0%-40%	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40% [e]	-
PCB Aroclors											
Finding	Acceptable	Acceptable	Acceptable [m]	Acceptable	Acceptable [t]	Acceptable	Acceptable	Acceptable	Acceptable [u]	Acceptable	Acceptable
QAPP or PSN	EPA 8082 (GC/ECD); MEL SOP*	1 year	NS	NS	1.0 ug/kg	NS	0%-28%	NS	NS	NS	-
LAB specification	SW 8082 (GC/ECD)	1 year	See Method	g	0.92-15 ug/kg	0%-40%	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40%	-

Parameter	Analytical Method	Holding Time	Calibrations	Blanks	Reporting Limits [a]	Lab Dup (RPD)	Field Dup (RSD)	LCS (% recovery)	Surrogates (% recovery)	MS/MSD (% recovery)	Overall Decision
PCB Congener											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [af]	Acceptable [ag]	Acceptable	NA	NA	Acceptable
QAPP or PSN specification	EPA 1668A (HiRes GC/MS)	NS	NS	NS	0.02-0.08 ug/kg	NS	NS	NS	NA	NA	-
LAB specification	EPA 1668A (HiRes GC/MS)	1 year	See Method	w	0.05-1.2 ug/kg	NS	NS	z, ab, ac	NA	NA	-
PCDD/Fs (17 congeners)											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Not Achieved	Acceptable [aa]	Acceptable [aa]	Acceptable [x,y,z]	NA	NA	Acceptable
QAPP or PSN	EPA 1613B (HiRes GC/MS)	1 year	NS	NS	0.05-0.30 ng/kg	NS	0%-28%	NS	NA	NA	-
LAB specification	EPA 1613B (HiRes GC/MS)	NS	See Method	w	EQL 1 -10 ng/kg	NS	NS	See Method	NA	NA	-
Lipids											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [s]	NS	NA	NA	Acceptable
QAPP or PSN specification	MEL SOP 730009	1 year	NS	NS	0.1%	NS	0%-14%	NS	NA	NA	-
LAB specification	MEL SOP 730009	NS	See Method	g	0.01%	0%-20%	NS	NS	NA	NA	-

Notes:

Abbreviations: NS - Not Specified, NA - Not Applicable, QAPP - Quality Assurance Project Plan, RPD - Relative Percent Difference, RSD - Relative Standard Deviation, MS/MSD - Matrix Spike and MS Duplicate.

Data Qualifiers: J - estimated value, NJ - target analyte tentatively identified at estimated value, E - estimate because value outside calibration range, U - not detected at reported result or estimated ("UJ") result.

PSN = Pre Sample Notification. This is an annual correspondence to MEL, prior to sample delivery, updating and describing analytical needs such as methods, reporting limits, and sample processing.

* - MEL modifications to analytical methods are documented in their Standard Operating Procedures.

a - The value given in the "Lab" row is the Reporting Limit achieved by the lab.

b - EPA method 245.5 was used for WSTMP samples from 2001-2003. EPA Method 245.6 has been used once 2004.
c - Holding time of six months was established for WSTMP fish tissue in 2002, after determining that 28-day holding time for tissue was unnecessary.
d - Case narrative: All samples remained frozen until thawed. All samples were analyzed within the required 40 days from extraction.
e - 1 of 26 matrix spike recoveries was above acceptance limits, PBDE 209.
f - Reporting limit for all congeners except PBDE 209 which is 1-6 ug/kg.
g - Case narrative: No analytically significant levels of analyte were detected in the method blanks associated with these samples.
h - No target compounds were detected in method blanks, with the exception of PBDE 209.
i - PBDE 209 in twelve of thirty nine samples had reporting limits of 8-28 ug/kg due to blank contamination.
k - All RPD limits within range except PBDE 49 in one sample which had RPD of 49%.
L - 5 of 6 within QAPP RSD limits. PBDE 49 in one sample had an RSD of 54%.
m - All PCB aroclors were recovered within acceptance limits of 85%-115%, with the exception of PCB aroclor 1016.
n - The following analytes did not meet acceptable independent calibration verifications (ICV) and/or continuing calibration verification (CCV) standards. These samples have been qualified as estimated reporting limits "UJ", or estimated detection limits "J" in some samples. Toxaphene, Hexachlorobenzene, Endosulfan Sulfate, Methoxychlor, Endrin Aldehyde, and Endosulfan II.
o - All RPDs were within acceptable limits except sample 07494518 technical chlordane with RPD of 51%, these results were qualified as "J".
p - Recoveries all within acceptable limits. Because of interference from other analytes, the recovery of DDMU was not calculated, "NC".
r - All matrix spike recoveries were within acceptable limits except chlorpyrifos and endrin aldehyde. Due to interference from analytes DDMU was not calculated "NC".
s - RSDs achieved were 30-33%. High RSDs likely due to differences in fish used for field duplicate samples. Lab dup RSDs were very good, less than or equal to 3%.
t - Reporting limits not met with initial analysis. Samples were reanalyzed and RLs were met.
u - All surrogate recoveries were within acceptable limits, except 8 of the 39 samples which were qualified "J" due to high recoveries (153%-166%) - Aroclor 1254 & 1260.
v - All surrogate recoveries were within acceptable limits except one sample which had a low recovery (30%). All results for this sample were qualified as estimates.
w - Few target analytes detected in blanks resulting in some qualifications of data
x - QC limits for Internal Standard recoveries not met in some cases leading to re-analyses of some samples and qualification of some data.
y - On-going Precision and Recovery (OPR) and LCS within limits with few exceptions resulting in qualification of some data and possible bias.
z - Ion Abundance Ratios and Retention Time Criteria were met with few exceptions resulting in qualification of some data.
aa - RPDs achieved for lab dups were 14%-171%. RSDs achieved for field dups were 25-130%. Results were heavily qualified due to being below range of calibration; poor precision is reasonable.
ab - OPR recoveries within QC limits of 50-100%. Labeled compound recoveries within QC limits of 30-140%.
ac - Internal Standard recoveries within QC limits of 25-150% except several above 150% which were qualified "J" as estimates.
ad - Values for "Lab" reflect the reporting limits that were actually achieved.
ae - Most analytes 0.34-3.4 ug/kg; Chlordane (technical) 3.4-7.8 ug/kg ; Hexachlorobenzene 3.4-4.6 ug/kg; Toxaphene 3.7-20 ug/kg.
af - RPDs achieved were 3%-117%.
ag - RSDs achieved were 0%-59%.

Appendix C. Data Evaluation by Ecology and DOH

Several state and federal agencies collect and evaluate fish tissue data in Washington State. These include the Washington State Departments of Ecology, Health (DOH), and Fish and Wildlife; the U.S. Environmental Protection Agency; and the U.S. Geological Survey. Tissue data are evaluated differently by these agencies because their mandates and roles are varied. These multiple evaluations often lead to confusion and misunderstanding among agencies and the public on how fish tissue data are used and interpreted. Adding to potential confusion are the numerous criteria or screening values derived to provide guidance for determining the risks of consuming contaminated fish and protecting public health.

Most fish tissue contaminant data from Washington fish, regardless of who conducted the study, make their way to DOH for evaluation regarding the safety of consuming fish. Appendix E has information about health benefits of eating fish and potential risks from consuming contaminated fish. The following is an overview of how Ecology and DOH evaluate fish tissue data to meet different needs.

For the WSTMP and many other Ecology studies, fish tissue data are evaluated primarily to determine if (1) Washington State water quality standards are being met, and (2) potential risks to human health from consuming contaminated fish warrant further study and/or development of a fish consumption advisory. Ecology's role is to determine whether water quality standards are met and to begin the process to correct problems where standards are not met. DOH and local health departments are responsible for developing fish consumption advisories in Washington. There is some overlap in these evaluations because the water quality standards that fish tissue data are compared to were developed for the protection of human health.

Washington State Water Quality Standards

Washington's water quality standards criteria for toxic contaminants were issued to the state in EPA's 1992 National Toxics Rule (NTR) (40CFR131.36). The human health-based NTR criteria are designed to minimize the risk of effects occurring to humans from chronic (lifetime) exposure to substances through the ingestion of drinking water and consumption of fish obtained from surface waters. *The NTR criteria, if met, will generally ensure that public health concerns do not arise, and that fish advisories are not needed.*

The NTR criteria are thresholds that, when exceeded, may lead to regulatory action. When water quality criteria are not met (exceeded), the federal Clean Water Act requires that the waterbody be put on a list and that a water cleanup plan be developed for the pollutant causing the problem. This list is known as the 303(d) list, and the water cleanup plan results from a Total Maximum Daily Load (TMDL) study and public involvement process. Ecology uses the TMDL program to control sources of the particular pollutant in order to bring the waterbody back into compliance with the water quality standards.

Risk Management Decisions

While DOH supports Ecology's use of the NTR criteria for identifying problems and controlling pollutant sources so that water quality will meet standards, DOH does not use the NTR criteria to establish fish consumption advisories (McBride, 2006). DOH uses an approach similar to that in EPA's *Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories Vol. 1-4* for assessing mercury, PCBs, and other contaminants (EPA, 2000). These guidance documents provide a framework from which states can evaluate fish tissue data to develop fish consumption advisories. The framework is based on sound science and established procedures in risk assessment, risk management, and risk communication. Neither the NTR criteria, nor the screening values found in the EPA guidance documents above, incorporate the varied risk management decisions essential to developing fish consumption advisories.

- **Risk Assessment** involves calculating allowable meal limits based on known fish contaminant concentrations. These calculations are conducted for both non-cancer and cancer endpoints using the appropriate Reference Dose (RfD) or Cancer Slope Factor (CSF), if available. These initial calculations are the starting point for evaluating contaminant data to determine whether a fish advisory is warranted. Additionally, known or estimated fish consumption rates help determine the potential magnitude of exposure and highlight the sensitive groups or populations that may exist due to elevated consumption rates.

- **Risk Management** includes (but is not limited to) consideration of contaminant background concentrations, reduction in contaminant concentrations through preparation and cooking techniques, known health benefits from fish consumption, contaminant concentrations or health risks associated with replacement foods, and cultural importance of fish. Other considerations are the possible health endpoints associated with a contaminant, the strength or weaknesses of the supporting toxicological or sampling data, and whether effects are transient or irreversible.

- **Risk Communication** is the outreach component of the fish advisory. The interpretation of the data from the risk assessment and risk management components drives how and when the fish advisory recommendations are issued to the public, dependent on whether the message is targeted toward a sensitive group or a population or the general public. DOH's dual objective is (1) how best to provide guidance to the public to increase fish consumption of fish low in contaminants to gain the benefits of eating fish, while (2) steering the public away from fish that have high levels of health-damaging contaminants.

Appendix D. Summary of Results, WSTMP 2007

Table D1. Summary of Fish Tissue Sample Results, WSTMP 2007.

Site	Species Code	MEL Sample ID	Date collect	Total PCB aroclors (ug/kg)		Total PCB congeners (ug/kg)		Total PBDE (ug/kg)		Total DDT (ug/kg)		Total Chlordane (ug/kg)		Dieldrin (ug/kg)		2378 TCDD TEQ (ng/kg)		2378 TCDD (ng/kg)		Mercury 245.6 (ug/kg)		Lipids (%)		Mean Total Length (mm)		Mean Weight (g)		Mean Age (years)	
Aldwell Lake	BKT	07494543	10/10/07	4.7	J	na		0.96		0.93	U	0.93	U	0.37	U	na		na		181		0.58		319.6		331.0		3.0	
	RBT	07494544/4532	10/10/07	3.95	J,m	1.98	J	0.67	m	0.97	U,m	0.97	U,m	0.39	U,m	0.012	J	0.02	UJ	101.5	m	1.14	m	306.2	m	272.8	m	2.6	m
Baker Lake	CTT	07494512	10/9/07	0.98	U	1.16	J	0.55	J	0.95	U	0.95	U	0.38	U	0.092	J	0.031	UJ	100		1.26		235.4		121.0		2.2	
	RBT	07494511	10/9/07	0.98	U	0.91	J	0.37	J	0.96	U	0.96	U	0.38	U	0.350	J	0.063	NJ	41		1.48		215.0		103.0		1.0	
Big Lake, near Mt. Vernon	CTT	07494527	9/6/07	7	J	6.04	J	1.39		3.5		0.91	U	0.37	U	0.665	J	0.099	J	130		1.64		317.0		292.0		3.0	
	LMB	07494528	9/6/07	3.1		3.27	J	1.07		0.93	U	0.93	U	0.37	U	0.261	J	0.06	J	754		0.44		449.2		1542.6		10.4	
	YP	07494529	9/6/07	0.99	U	na		0.22		0.97	U	0.97	U	0.39	U	na		na		83		0.26		190.4		103.2		1.2	
Campbell Lake, near Anacortes	CTT	07494530	9/5/07	3.6	J	3.14	J	1.25		1.2		0.87	U	0.7	U	0.325	J	0.065	NJ	44		4.41		342.4		469.6		2.0	
	LMB	07494531	9/5/07	7.4	J	7.69	J	2.55	J	2.4		0.86	U	0.34	U	0.365	J	0.08	J	603		1.7		515.6		2744.6		15.8	
Chester Morse Reservoir	RBT	07494545	11/5/07	1.2	J	1.36	J	0.53	J	0.97	U	0.97	U	0.39	U	0.070	J	0.024	UJ	407		1.12		411.6		602.8		3.6	
Cushman Lake	KOK	07494515	10/4/07	2	U	1.14	J	3.54		0.98	U	0.98	U	0.98	U	0.143	J	0.016	NJ	130		1.21		253.8		146.4		3.0	
	MWF	07494516	9/27/07	1.6	J	1.30	J	1.64		0.85	U	0.85	U	0.34	U	0.056	J	0.014	NJ	86		2.31		276.0		180.8		6.0	
	RBT	07494517	9/27/07	0.99	U	na		1.30		0.87	U	0.87	U	0.35	U	na		na		100		1.75		282.0		203.5		1.8	
Deer Lake, 20 miles SE of Chewelah	LMB	07494501	9/18/07	5.2		2.62	J	1.07		2.4		0.97	U	0.39	U	0.111	J	0.024	NJ	443		0.59		421.8		1159.6		7.6	
	RBT	07494502	9/18/07	4		3.79	J	1.14		3.1		0.95	U	0.38	U	0.097	J	0.037	NJ	60		0.8		363.0		472.4		na	
Kettle River, at Curlew	RBT	07494526	10/10/07	0.99	U	0.31	J	1.81		2.5		0.99	U	0.4	U	0.163	J	0.028	UJ	43		1.23		282.8		193.2		2.0	
Ozette Lake	NPM	07494503	9/12/07	1.7	J	1.38	J	0.51	J	1.4		0.96	U	0.38	U	0.010	J	0.033	UJ	1600		0.81		377.2		433.2		9.0	
Ross Lake	BLT	07494540	7/19/07	5.1	J	3.01	J	1.19	J	3.1		0.88	U	0.71	U	0.038	J	0.037	UJ	216		4.24		504.4		1184.4		5.0	
	RBT	07494541	7/19/07	1.4	U	0.40	J	0.16	J	0.96	U	0.96	U	0.77	U	0.014	J	0.041	UJ	63		3.6		328.0		339.4		2.8	
	RSS	07494542	7/19/07	3.1	J	na		2.70	U	1.8		0.94	U	0.75	U	na		na		160		4.6		108.6		10.8		na	
Samish Lake	CTT	07494507	9/4/07	8.2		5.80	J	4.27		2.9		0.98	U	0.39	U	0.446	J	0.12	NJ	68		1.88		271.6		179.6		2.0	
	LMB	07494500	9/4/07	4.3	J	2.79	J	1.03	J	1.5		0.98	U	0.39	U	0.115	J	0.036	NJ	497		0.41		414.8		1166.6		5.8	
	NPM	07494508/4518	9/4/07	12.6	J,m	13.48	J,m	2.60	m	5.20	m	1.10	m	0.39	U,m	0.911	J,m	0.195	J,m	575	m	1.17	m	395.4	m	543.5	m	7.5	m
	PEA	07494509	9/4/07	6.6		na		2.70		3.9		0.94	U	0.38	U	na		na		429		2.4		284.4		220.6		8.4	
	YP	07494510	9/4/07	0.97	U	na		0.25	J	0.88	U	0.88	U	0.35	U	na		na		226		0.18		225.4		131.0		3.4	
Samish River, near 5 miles north of Burlington	CTT	07494533	10/3/07	2.2	J	1.71	J	1.02		1.9		0.86	U	0.46		0.196	J	0.032	NJ	160		1.35		269.4		210.0		2.6	
	MWF	07494534	10/3/07	7.5	J	5.17	J	2.87		4.8		0.87	U	0.61		0.222	J	0.038	UJ	140		2.05		265.2		186.8		3.6	
Sanpoil River, near 10 miles south of Republic	BKT	07494535	10/11/07	1.5		na		1.16		2		0.95	U	0.38	U	na		na		234		0.95		246.6		193.6		2.4	
	RBT	07494536	10/11/07	1.6	J	1.71	J	3.34		2.5		0.99	U	0.39	U	0.149	J	0.053	UJ	140		2.13		270.4		242.6		2.4	
Sauk River, near confluence of N&S Forks	MWF	07494514	10/4/07	3.7	J	1.97	J	1.65	J	2.1		0.96	U	0.77	U	0.178	J	0.06	NJ	53		3.81		255.0		172.5		2.5	
Spada Lake	CTT	07494537	10/17/07	4.1	J	2.38	J	1.52	J	0.99	U	0.99	U	0.4	U	0.145	J	0.045	UJ	150		0.39		291.0		173.2		3.4	
Sullivan Lake	BNT	07494519	9/18/07	28.4	J	19.12	J	3.84	J	24.2		1.3	J	1.4	U	0.635	J	0.1	NJ	120		9.03		575.4		2521.0		4.8	
	CTT	07494521	9/17/07	6.5	J	3.53	J	1.34	J	0.92		0.92	U	0.74	U	0.123	J	0.017	NJ	41		3.57		299.6		267.4		2.4	
	MWF	07494522	9/17/07	4.9	J	3.37	J	1.81	J	3.2		0.93	U	0.37	U	0.191	J	0.041	NJ	54		2.91		264.8		163.6		2.6	
	RBT	07494524	9/17/07	5.5	J	na		1.85	J	4.9		0.99	U	0.79	U	na		na		46		3.3		319.5		307.8		2.2	

See next page for qualifier codes and species codes.

Qualifier Codes

J	The analyte was positively identified. The associated numerical result is an estimate.
NJ	The analyte was tentatively identified and the associated numerical value represents an approximate concentration.
U	The analyte was not detected at or above the reported value.
UJ	The analyte was not detected at or above the reported estimated result.
m	Mean value from analyses of field duplicates where two results are available. Where both values were non-detect, the highest value was usually used. Where one duplicate was qualified as a non-detect (U, UJ), the reported value was used in determining the mean value. For some duplicate pairs, analysis for PCDD/Fs and PCB congeners was done on only one of the samples; these results are not qualified with an "m".

Species Codes

BKT	Brook trout
BLT	Bull trout
BNT	Brown trout
CTT	Cutthroat trout,
KOK	Kokanee salmon
LMB	Largemouth bass
MWF	Mountain whitefish
NPM	Northern pikeminnow
PEA	Peamouth
RBT	Rainbow trout
RSS	Redside shiner (whole fish)
YP	Yellow perch.

Appendix E. Health Information about Fish

Fish is good food. Trying to balance the health benefits of fish with concerns about contaminant levels can be challenging, yet information is available to help consumers make healthy choices. Contaminants are found in most foods, and choosing fish wisely can be an excellent health choice. The key is to make smart decisions and choose fish that are low in mercury, PCBs, and other contaminants.

The American Heart Association recommends eating fish twice a week because fish are a great source of protein, vitamins, and nutrients. Fish are loaded with omega-3 fatty acids, which provide protection from heart disease and are great "brain food" for adults and children.

A valuable source of information about eating fish is the Washington State Department of Health (DOH) website:

www.doh.wa.gov/ehp/oehas/fish/default.htm

- Advice for women and children who eat fish.
- Waterbody-specific fish consumption advisories in Washington.
- How contaminants (mercury, PCBs, PBDEs, DDTs) get into fish.
- How you can help reduce contaminants.

www.doh.wa.gov/ehp/oehas/fish/fishchart.htm

- Healthy fish eating guide.
- Checklist to reduce contaminant exposure including the proper way to fillet and prepare fish meals.
- Health benefits of fish/recipes.

www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm

- Fish and shellfish consumption advisories.

The U.S. Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) also provide information on health benefits of fish:

www.epa.gov/waterscience/fish/

- What you need to know about mercury - 10 frequently asked questions.

www.cfsan.fda.gov/seafood1.html

- Seafood information and resources.

Appendix F. Glossary, Acronyms, and Abbreviations

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which designated uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

DDMU	1-chloro-2,2-bis(p-chlorophenyl)ethane
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-trichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	Environmental Protection Agency
MEL	Manchester Environmental Laboratory
ng/kg	nanograms per kilogram, or parts per trillion (ppt)
NTR	National Toxics Rule
mg/kg	milligrams per kilogram, or parts per million (ppm)
PBDE	polybrominated diphenyl ethers
PBT	persistent, bioaccumulative, and toxic substance
PCB	polychlorinated biphenyls
PCDD/Fs	polychlorinated dibenzo-p-dioxins and -furans
SOP	Standard operating procedures
SRM	Standard reference materials
SV	Screening values
TCDD	tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalent Factor
TEQ	Toxic Equivalent
ug/kg	micrograms per kilogram, or parts per billion (ppb)
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSTMP	Washington State Toxics Monitoring Program
ww	wet weight