Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005

Publication No. 07-03-024

June 2007

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Publication Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/0703024.html

Data for this project are available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study IDs: WSTMP04 and WSTMP05.

Ecology's Study Tracker Codes for this study are 02-500-01-03 and 02-500-01-04.

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Cover photo: Cutthroat trout (*Oncorhynchus clarkii*).

Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005

by

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June 2007

Waterbody Numbers: Statewide

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Abstract

The exploratory monitoring component of the Washington State Toxics Monitoring Program (WSTMP) has characterized toxic contaminants in freshwater fish since 2001, primarily from sites never before sampled. Contaminants assessed include persistent, bioaccumulative, and toxic chemicals such as mercury, PCBs, dioxins and furans, chlorinated pesticides, and PBDE flame retardants.

During the 2004-2005 study, a total of 52 sites across the state were sampled which yielded 104 fish tissue samples representing 19 species. Detection frequencies ranged from 59% to 100% for mercury, PCBs, dioxins and furans, DDT pesticides, and PBDEs. Older and larger fish showed higher concentrations of organic contaminants.

Contaminants were detected in Chinook salmon from three coastal rivers with most results being near reporting limits. Levels of PCBs and DDTs in coastal fish were lower than levels found in fish from Puget Sound and the Columbia River. Total PCBs, 2,3,7,8-TCDD TEQ, and toxaphene were detected at levels higher than (exceeding) EPA's Screening Values for Subsistence Fishers.

A total of 45 sites had 93 fish tissue results that exceeded the National Toxics Rule (NTR) criteria for contaminants in fish tissue. Four contaminants accounted for 85% of the exceedances: PCBs, 2,3,7,8-TCDD, 4,4'-DDE, and dieldrin. Other NTR exceedances were due to mercury and four pesticides: 4,4'-DDD, total chlordane, hexachlorobenzene, and toxaphene.

This study recommends that these 45 sites be added to the federal Clean Water Act Section 303(d) List for Washington State.

This study also recommends that the Washington State Department of Health, local health jurisdictions, and affected Tribes should (1) evaluate the results from this study, and (2) assess the risks to human health from the consumption of contaminated fish.

Acknowledgements

The authors thank the following people and organizations for their cooperation and help with this study:

- Washington State Department of Fish and Wildlife (WDFW) Warmwater Enhancement Program staff and others for helping with fish collection and site information: Bruce Bolding, Marc Divens, Marc Petersen, Steve Caromile, Art Viola, Mark Downen, Gary Osborne, Dan Collins, Eric Shoblom, and Matt Polacek. John Sneva and Lucinda Morrow for providing the ages of fish. Many other WDFW staff and citizen volunteers also helped.

- The National Park Service and Makah Indian Tribe for helping with the Lake Ozette fishing effort: Jerry Freilich, Mark McCool, Sam Brenkman, and Caroline Peterschmidt. Ed Bowen also helped with local knowledge of the lake.

- Dennis Flowers, Marta Branch, and others from Moran State Park and the Moran Outdoor School for helping with fishing Cascade and Mountain Lakes and for a warm meal after a long day.

- Robert Leach, Will Pink, and others of Taholah, Washington, for helping collect Chinook salmon from the Queets, Quinault, and Chehalis Rivers.

- Rene Hamilton (Northwest Land Management) and Rex Baxter (Army Corps of Engineers) for Snake River access and information.

- David Beauchamp, Nathanael Overman, and Christopher Sergeant from the University of Washington's School of Aquatic and Fisheries Sciences; and Liz Carr and Dave McBride at the Washington State Department of Health, for collecting Lake Washington fish and for sharing data.

- Jane Hills and others at PacifiCorp for access to Lake Merwin.

- Al George and others from the City of Longview for access and field support on Lake Sacajawea.

- Nan Berger, U.S. Forest Service, for access and information for Bead Lake.

- U.S. Fish and Wildlife Service staff at the Twisp office for help collecting fish from the Methow River.

- Bob and Deanna Gossett for help with Haven Lake.

- Manchester Environmental Laboratory staff for laboratory services: Myrna Mandjikov, Debi Case, Dean Momohara, Greg Perez, Kamilee Ginder, Bridget Mason, Jessica Daiker, Kelly Donegan, Karin Feddersen, Stuart Magoon, Cheryln Milne, Pam Covey, Will White, and Leon Weiks.

- Department of Ecology Olympia staff for help with many hours of sample collection, processing, and data management: Dave Serdar, Brandee Era-Miller, Paul Anderson, Kristin Kinney, Brenda Nipp, Art Johnson, Randy Coots, Darren Alkire, Craig Graber, Chris Burke, and Carolyn Lee.

- Department of Ecology Olympia staff for other support: Dale Norton for project guidance and for design and review of this summary report; Randy Coots, Cheryl Niemi, and Melissa Gildersleeve for reviewing the draft report; and Joan LeTourneau for formatting and editing the final document.

Introduction

Various monitoring efforts by the Washington State Department of Ecology (Ecology) and others have found toxic chemicals in water, sediment, and fish throughout Washington's freshwater and marine environments. Many of these chemicals are persistent, bioaccumulative, and toxic compounds (PBTs). For many areas of Washington, there is little information about the levels of toxic contaminants in the environment

Ecology and the Washington State Department of Health (DOH) are developing strategies to address 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/eap/toxics/PBT_strategy.html).

Fish are an important indicator of contaminant levels in the environment. Fish tissue contaminant data collected by various agencies are evaluated by DOH and local health jurisdictions to determine whether fish consumption advisories are needed. While many areas of Washington do not warrant consumption advisories, a number of site-specific and statewide fish consumption advisories have been issued. (www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm).

Ecology evaluates fish tissue contaminant data to determine whether 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 advice about eating 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.

Background

During the 1980s and 1990s, Ecology and other agencies found toxic contaminants in fish, water, sediment, and soil 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.
- 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 issues of concern.

Between 2001 and 2005, 150 fish tissue samples from over 70 sites were analyzed for various contaminants as part of the WSTMP's Exploratory Monitoring component. Three annual reports were published (Seiders et al, 2006; Seiders and Kinney, 2004; Seiders, 2003) and over 27,000 results are now available in Ecology's Environmental Information Management database (EIM) at www.ecy.wa.gov/eim/.

This report summarizes results from fish samples collected in 2004 and 2005.

Sampling occurred at 21 sites in 2004 and at 31 sites in 2005 (Figure 1 and Appendix A). These 52 sites yielded 104 samples representing 18 freshwater and one marine (Chinook salmon) species.

Study Design

The study targeted a broad range of contaminants in fish tissue from multiple sites. Site selection involved reviewing existing information on fish contaminants in Washington and choosing sites and species where historical data were lacking or were more than ten years old. The project plan for the WSTMP describes the selection of sites, species, and analytes in more detail (Seiders and Yake, 2002).

Contaminants Assessed

Target analytes included persistent, bioaccumulative, and toxic chemicals (PBTs) described below. Lipid content of samples was also determined. A brief description of contaminants is given here. More detailed information about individual analytes is available through internet links in EIM.

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 methyl-mercury is the primary route for exposure to mercury for most people (ATSDR, 1999; Ecology and DOH, 2003; EPA, 2007).

PCBs

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 (ASTDR, 2000).

There are 209 individual PCBs, or congeners. Commercial mixtures of PCB congeners were known in the United States by the trade name Aroclor. PCB Aroclors were analyzed in all WSTMP samples from 2004 and 2005; individual PCB congeners were analyzed in about half 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, used as a defoliant in the Vietnam War, contained dioxins (ATSDR 2006).

About half of the 2004-2005 samples 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.

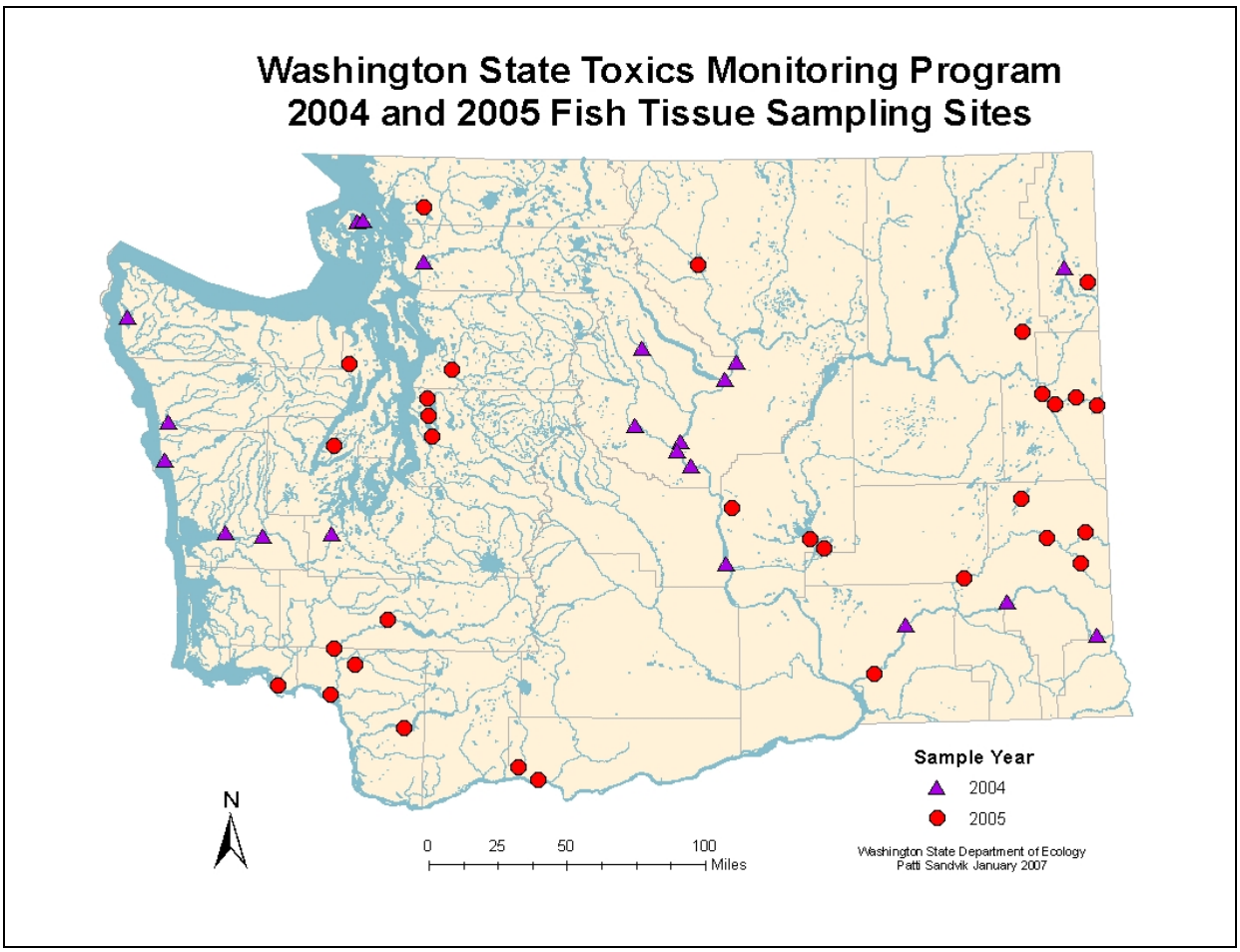

Figure 1. Sample Sites for the WSTMP, 2004-2005.

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 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 PBDE in human tissue have been found in the U.S. and Canada (Ecology and DOH, 2006).

Site Selection

Sites were selected 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 coordinate with other monitoring or watershed planning efforts. Site location information is further described in EIM.

Other monitoring efforts provided tissue samples to the WSTMP which helped enlarge the sampling area of the WSTMP. Using fish from other sites allowed analyses of these already-collected samples for analytes targeted by the WSTMP but not examined by the other studies. These additional tissue samples were from the Pend Oreille and Wenatchee Rivers (Era-Miller and Kinney, 2005; and Era-Miller, 2004); Palouse River (Johnson et al., 2007); Spokane River (Serdar and Johnson, 2006); and Lake Washington (DOH, 2007). These studies provide more detailed information about fish tissue contaminants in their respective geographic areas.

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. For catfish, skin was removed from the fillet before processing. The sex and age of each fish was determined. Samples were then sent to laboratories for chemical analyses. Sample collection and processing details are described in a standard operating procedure (SOP) (Ecology, 2006a).

Analytical Methods

Table 1 describes analytical methods. Most analyses were performed by Manchester Environmental Laboratory (MEL). Pacific Rim Laboratories, Inc. of Surry B.C. conducted analyses for PCB congeners and PCDD/Fs. At Ecology's request, PCDD/Fs results were reported down to the method detection limit (MDL). Values were qualified as estimates if they were between the MDL and the quantitation limit.

Fish tissue was analyzed for total mercury because analytical costs for methylmercury are prohibitive. Methylmercury is the predominant form of mercury in fish tissue (Bloom, 1995). EPA's National Recommended Water Quality Criteria and EPA's Screening Values are based on methylmercury.

Table 1. Analytical Methods for Fish Tissue Samples, WSTMP 2004-2005.

Parameter	Description	Method	Reporting Limit
PCB Aroclors	GC/ECD	EPA 8082	0.5 ug/kg, wet wt
PCB Congeners	HiRes GC/MS	EPA 1668A	0.02 - 0.08 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]	0.5 - 1.0 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 700009	0.1 percent

1 - MEL SOP 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.

Quality Assurance

Data quality was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Case narratives were written by the laboratory's analytical staff. The narratives described conditions of the samples upon receipt, analytical quality control procedures, and data qualifications.

Overall, the 2004 and 2005 data met most quality control criteria defined by MEL and the quality assurance project plan. Some data were rejected, and many results were qualified. Estimates of precision for six field replicates were typical for samples of fish tissue. Detailed quality assurance information is available by contacting the authors.

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).

Washington's water quality standards for toxic compounds (the National Toxics Rule criteria) are one set of values that can be used in helping to gauge the potential for human health risks from eating contaminated fish. EPA developed more recent criteria and guidance values which are summarized below (*EPA Recommended Water Quality Criteria* and *EPA Screening Values*).

Report results are not compared to these EPA criteria because Ecology lacks authority to begin corrective actions where these criteria are exceeded. Yet these EPA criteria can be used by state, tribal, and local health jurisdictions in evaluating risks to human health from the consumption of contaminated fish.

These EPA criteria and guidance values are compared with Washington's water quality standards criteria in Appendix B. Appendix C describes how Ecology and DOH evaluate fish tissue data.

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

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 (NTR).

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 cancer cases 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.

EPA Recommended Water Quality Criteria

EPA has published *National Recommended Water Quality Criteria* for some substances such as mercury and pesticides (EPA, 2001, 2002a, 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 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 that used for developing the NTR, yet differ 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.

Results and Discussion

In 2004 and 2005, 52 sites were sampled and yielded 104 samples representing 18 freshwater and one anadromous species (Chinook salmon). Results for the Chinook salmon are discussed later in this report, separately from results for freshwater fish.

The concentrations of contaminants in fish tissue are expressed in wet weight basis 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 2 shows summary statistics for key contaminants in freshwater fish. Detection frequencies ranged from 59% to 100% for PCBs, DDTs, PBDEs, PCDD/Fs, and mercury. Contaminant levels in samples

frequently exceeded the NTR criteria for PCBs (58-82% of samples) and 2,3,7,8-TCDD (73% of samples) in resident species. Appendix D shows results for key analytes in fish tissue samples.

The 2004-2005 WSTMP results were within the range of values detected in other studies of fish tissue in Washington. The 2004-2005 median values for PCBs, PBDEs, DDTs, and 2,3,7,8-TCDD TEQs were generally lower than median values derived from other fish tissue studies in Washington.

Contaminants in Freshwater Fish

Mercury

Mercury was detected in all but one of 97 samples, with 4% of samples exceeding the NTR criterion of 0.825 mg/kg. The range of values was similar to those seen in other mercury monitoring efforts in Washington (Serdar et al., 2001; Fischnaller et al., 2003; Furl et al., 2007). Larger and older piscivorous fish tended to have higher mercury levels. The highest levels of mercury (> 0.500 ug/kg) were found in (1) northern pikeminnow from the Chehalis, Cowlitz, Pend Oreille, Palouse, Snohomish, and Columbia Rivers, and Lake Washington, and (2) largemouth bass from Ozette, Leland, and Silver Lakes.

Other species having levels greater than EPA's Recommended Water Quality Criterion for methylmercury of 0.300 mg/kg (EPA, 2001) were smallmouth bass, yellow perch, cutthroat trout, and channel catfish.

PCBs

PCB levels in excess of 40 ug/kg were found in fish from the Columbia, Snake, Spokane, Palouse, and Cowlitz Rivers, and Lake Washington. Species having higher levels of PCBs include channel catfish, common carp, mountain whitefish, northern pikeminnow, and cutthroat trout.

Table 2. Summary Statistics for 2004-2005 WSTMP Fish Tissue Sample Results.

Parameter	n	Min	Max	Median	Mean	Standard Deviation	Detection Frequency	No. Exceeding NTR Criteria
Total PCB Aroclors [1] (ug/kg)	101	4.2 U	1339	10.9	65.2	196.0	59%	59
Total PCB congeners [1] (ug/kg)	49	0.91	1632	21.1	92.7	250.3	100%	40
Total DDT [2] (ug/kg)	98	0.21	509	5.8	56.0	118.7	88%	-
Total PBDE [3] (ug/kg)	100	0.17	1136	5.5	22.7	114.0	87%	-
Total Chlordane [4] (ug/kg)	98	0.22	68	1.0	3.4	10.7	33%	6
2,3,7,8-TCDD TEQ [5] (ng/kg)	48	0.01	12	0.30	0.88	2.02	98%	-
2,3,7,8-TCDD (ng/kg)	48	0.03 UJ	1.9	0.10	0.183	0.316	69%	35
Mercury (mg/kg)	97	0.017 U	0.964	0.160	0.238	0.232	99%	4

1 - Total PCBs is the sum of the individual Aroclors or congeners.
2 - Total DDT is the sum of 4,4' and 2,4' isomers of DDT, DDD, and DDE.
3 - Total chlordane is the sum of cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane.
4 - Total PBDE is the sum of the individual congeners.
5 - 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).
The summing process used values without qualifiers and values qualified as estimates. Non-detect values were excluded.
U = The analyte was not detected at or above the reported value.
UJ = The analyte was not detected at or above the estimated reported value.

The highest levels of PCBs were found in fish from Lake Washington and the Wenatchee River. PCB levels in Lake Washington fish were: common carp (1339 ug/kg Aroclors and 611 ug/kg congeners), northern pikeminnow (375 ug/kg Aroclors and 241 ug/kg congeners), and cutthroat trout from the south and north basins (370 and 232 ug/kg Aroclors, and 292 – 383 ug/kg congeners), respectively.

PCB levels in Wenatchee River fish were 1300 ug/kg Aroclors and 1632 ug/kg congeners for mountain whitefish from the Leavenworth area, and 542 ug/kg Aroclors for mountain whitefish near Wenatchee. Similarly high levels of PCBs were documented in previous studies (Era-Miller, 2004; Davis et al., 1995; and Hopkins et al., 1985).

Dioxins and Furans (PCDD/Fs)

Dioxins and furans were detected in 98% of 48 samples tested. 73% of samples exceeded the NTR criterion for 2,3,7,8-TCDD. The highest levels of 2,3,7,8-TCDD were found in the four samples from Lake Washington (0.68 – 1.9 ng/kg). Catfish from the Snake River at Central Ferry had the next highest levels at 0.37 ng/kg. Corresponding 2,3,7,8-TCDD TEQ values for Lake Washington samples were 4.6 – 12 ng/kg and 1.1 ng/kg for catfish from the Snake River at Central Ferry.

The Lake Washington carp result of 12 ng/kg for 2,3,7,8-TCDD TEQ is the highest value found in Washington since 1990, based on data from EIM. Fish from upper Lake Roosevelt had TEQ values up to 17 ng/kg in 1990 which have decreased since a pulp mill in Celgar, Canada improved wastewater treatment processes (Serdar et al., 1994; Munn, 2000).

Chlorinated Pesticides

The most frequently detected chlorinated pesticides were 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, hexachlorobenzene, trans-nonachlor, dieldrin, and cis-chlordane. Eleven other pesticides were detected at frequencies less than 4%.

The highest levels of total DDT were found in fish from the Columbia, Snake, and Wenatchee Rivers, and in fish from Lake Washington. Northern pikeminnow, mountain whitefish, walleye, and peamouth from the mid- to upper-Columbia River sites had total DDT levels from 112 to 509 ug/kg. Lake Washington carp contained 418 ug/kg total DDT which was the third highest level found during this study. Most of the remaining 2004-2005 samples had lower levels of total DDT, with 75% of samples having less than 29 ug/kg total DDT.

Haven Lake, Snake River, and Lake Washington fish had some of the highest levels of hexachlorobenzene found in Washington (5-12 ug/kg). Largemouth bass from Haven Lake exceeded the NTR criteria for hexachlorobenzene, with a level of 12 ug/kg. Rainbow and cutthroat trout had hexachlorobenzene levels of 5 and 6 ug/kg, respectively, which are slightly below the NTR criterion.

Chlordane was detected in 33% of the 98 samples, of which six samples exceeded the NTR criterion. These exceedances included four samples from Lake Washington, with chlordane levels from 36 – 68 ug/kg, and catfish from two sites on the Snake River (Central Ferry and downstream of Lower Monumental Dam) which had 9.1 and 9.9 ug/kg. Fish from Lake Washington appear to contain the highest chlordane levels found in Washington, based on review of data in Ecology's EIM database.

11% of samples exceeded the NTR criterion for dieldrin. The highest levels (2.0-3.9 ug/kg) were found in fish from four lakes (Bead, Potholes, Rock, and Whatcom) and four rivers (Snake, Methow, Snohomish, and Cowlitz).

PBDE Flame Retardants

Like PCBs, higher levels of PBDEs (> 7 ug/kg) were found in fish from the Columbia, Snake, Spokane, Palouse, and Cowlitz Rivers, and Lake Washington.

Fish from the Spokane River had the highest levels of PBDEs (102-1136 ug/kg), followed by fish from Lake Washington (54-102 ug/kg). PBDE levels in these areas are described in more detail by Serdar and Johnson (2006) and DOH (2007). Generally, PBDE levels from the 2004-2005 WSTMP were within the range of values seen in a recent survey of PBDEs in Washington (Johnson et al., 2006).

Contaminants in Chinook Salmon

Chinook salmon were sampled to supplement data collected for this species by EPA in the Columbia River basin, WDFW in Puget Sound, and the U.S. Fish and Wildlife Service in two coastal fish hatcheries and two hatcheries in Puget Sound.

Table 3 shows contaminants detected in returning fall Chinook salmon from the Queets, Quinault, and Chehalis Rivers in 2004. Most results were near the reporting limit, yet PCBs, 2,3,7,8-TCDD TEQ, and toxaphene were detected at levels exceeding one or more of the NTR criteria, EPA's Recommended Water Quality Criteria, and EPA's Screening Values for Subsistence Fishers.

Contaminant levels detected in Chinook salmon from coastal rivers during this study were lower than levels found in several other studies.

Levels of PCBs in Chinook salmon collected in 2004 for the WSTMP were about six times lower than levels in Columbia River fall and spring Chinook salmon (37-38 ug/kg) sampled in 1996-98 (EPA, 2002b). Similarly, 2004 levels of 2,3,7,8-TCDD TEQs in coastal Chinook salmon were two to three times lower than levels found in fall and spring Chinook salmon (mean of 0.4 – 0.6 ng/kg) from the Columbia River basin during 1996-98 (EPA, 2002b).

Levels of total PCBs and total DDTs in coastal Chinook salmon collected during this study in 2004 were nearly ten times lower than the mean value (54 ug/kg PCBs and 21 ug/kg DDTs) of over 200 muscle tissue samples from Puget Sound Chinook salmon collected by WDFW during the 1990s (O'Neill et al., 1998; West et al., 2001; and Hardy and Palcisko, 2006). Mercury levels in Puget Sound Chinook salmon were about two times higher than those found in Chinook salmon from coastal rivers in 2004.

Missildine et al (2005) reported PCBs levels of 16-19 ug/kg in Chinook salmon that returned to the Makah and Quinault National Fish Hatcheries in 2003. These hatcheries are located in the coastal Sooes and Quinault River basins. These PCB levels were about three times higher than levels found during the 2004 WSTMP.

Table 3. Contaminants in Chinook Salmon from Three Coastal Rivers.

Parameter	Chehalis		Queets		Quinault	
Total PCB Aroclors (ug/kg)	5.00		5.60		6.30	
Total PCB congeners (ug/kg)	5.12		4.71		4.44	
Total DDT (ug/kg)	2.63		2.56		3.53	
Total PBDE (ug/kg)	2.30		0.28		0.42	
Total Chlordane (ug/kg)	0.76		1.26		1.68	
2,3,7,8-TCDD TEQ (ng/kg)	0.09		0.23		0.22	
2,3,7,8-TCDD (ng/kg)	0.10	U	0.10	U	0.10	U
Mercury (mg/kg)	0.049		0.041		0.030	
Toxaphene (ug/kg)	5.7	J	9.7	NJ	9.7	U
Lipids (percent)	3.6		2.8		3.5	
Mean Age (years)	4.8		4.8		4.0	

U - not detected at given reporting limit.
J - The analyte was positively identified. The reported result is an estimate.
NJ - The analysis indicates the presence of an analyte that has been tentatively identified. The reported result is an estimate.

Comparisons to Historical Data

There were only two sites where the 2004-2005 results could be compared to historical data because the exploratory monitoring component of the WSTMP focuses on sites where no data exist. The two sites were the mid-Columbia River and the Cowlitz River. Comparison of recent and historical walleye results from Potholes Reservoir was not pursued because of dissimilar fish sizes.

Historical data were obtained from published EPA and Ecology reports or Ecology's EIM database. The same methods for deriving summed values were used among the recent and historical data to allow comparisons (e.g., total PCB Aroclors).

Columbia River: Hanford Reach to Wanapum Dam

Figure 2 shows that levels of DDTs and PCBs in one sample of mountain whitefish collected in 2004 just downstream of Wanapum Dam were lower than the mean value from three samples collected by EPA (2002b) in 1997 from the Hanford Reach by factors of about 2 and 9, respectively. The level of 2,3,7,8-TCDD TEQ in the 2004 sample was about five times lower than the mean 1997 value. The 2004 and 1997 samples contained fish having similar size, weight, and lipid content.

Dioxin/furan levels in a sample of walleye collected downstream of Wenatchee in 2004 were slightly lower than levels found in 1990 (Serdar et al., 1991). The TEQ for the 2004 sample of 0.13 ng/kg was about half of the 1990 mean TEQ of 0.25 ng/kg. The TEQ calculation for this comparison used only the TCDD and TCDF congeners. The fish used in the 2004 samples were also older and larger than those used in the 1990 sample; this strengthens the interpretation that contaminant levels have decreased over time.

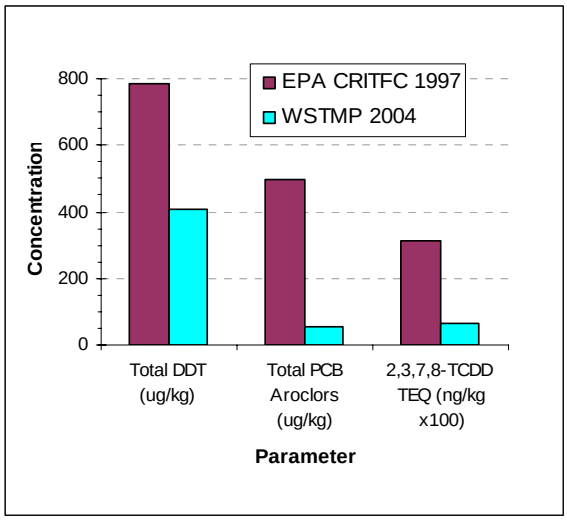

Figure 2. Comparison of Historical to Recent Data for Mountain Whitefish from the Mid-Columbia River: Hanford Reach to Wanapum Dam.

Cowlitz River near Vader

Levels of total PCB Aroclors in cutthroat trout and mountain whitefish from the Cowlitz River were slightly lower in the WSTMP 2005 samples (55 and 46 ug/kg) than in samples collected in 1995 (84 and 60 ug/kg) (Davis et al., 1998). Levels of total DDT in these two species were also lower in 2005 compared to those seen in 1995. The 2005 fish were also larger and had higher lipid content than those analyzed in 1995; this strengthens the interpretation that contaminant levels have decreased over time.

Water Quality Standards Exceeded

A total of 45 of the 49 sites where resident fish were collected had 93 fish tissue results exceeding the NTR criteria. Four contaminants accounted for 85% of these exceedances: total PCBs, 2,3,7,8-TCDD, 4,4'-DDE, and dieldrin. Other contaminants that exceeded criteria were 4,4'-DDD, mercury, total chlordane, hexachloro-benzene, and toxaphene. Table 4 shows the 93 cases recommended for Category 5 classification, *Does Not Meet Criteria*, in Ecology's 303(d) assessment (Ecology, 2006b).

Chinook salmon are excluded from the 303(d) assessment because they accumulate contaminants in the ocean environment which is outside of Ecology's ability to address contaminants in these fish.

A total of 36 sites had fish with 2,3,7,8-TCDD TEQs levels exceeding the NTR criterion for 2,3,7,8-TCDD. Ecology recently changed how dioxin/furan data are assessed (Ecology, 2006b), and TEQ values are no longer used for Category 5 classification. Therefore, these cases are recommended for Category 2 classification, *Waters of Concern* (Table 4).

A total of 159 analyses for toxaphene, aldrin, and dieldrin 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=1761) that met NTR criteria are recommended for Category 1 classification, *Meets Tested Criteria*.

Site Ranking

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

This scoring and ranking method has not been applied to results from other fish tissue

Table 4. Recommended 303(d) Listings for 2004-2005 WSTMP Fish Tissue Sample Results.

Recommended Category for 303(d) Assessment -->			5									2
Site Name	Species Exceeding NTR Criteria	Sum Cat. 5	Total PCBs	2,3,7,8-TCDD	4,4'-DDE	4,4'-DDD	Dieldrin	Total Chlordane	Hexachloro-benzene	Toxaphene	Mercury	2,3,7,8-TCDD TEQ
Bead Lake	PEA, KOK, NPM	2	x	x								x
Black Lake	RBT	1	x									
Chehalis R, near Satsop	CTT, NPM	2	x								x	x
Columbia R, above Rock Island Dam	NPM, WAL, PEA	3	x		x	x						x
Columbia R, below Rocky Reach Dam	MWF	2	x		x							x
Columbia R, below Wanapum Dam	MWF	3	x		x	x						x
Columbia R, below Wells Dam	MWF	3	x		x	x						x
Columbia R, near Beebe Bridge	NPM, PEA	3	x		x	x						
Columbia R, near Cathlamet	NPM, PEA	2	x	x								x
Cowlitz R, near Vader	CTT, MWF, NPM	3	x	x							x	x
Haven Lake	RBT, CTT, LMB	2	x						x			x
Lake Washington, Entire	CCP, NPM	5	x	x	x	x		x				x
Lake Washington, North	CTT	2	x	x								x
Lake Washington, South	CTT	2	x	x								x
Leland Lake	LMB	3	x	x							x	x
Liberty Lake	SMB	1	x									
Long Lake, near Othello	SMB, WAL	1					x					
Loon Lake	LMB	2	x				x					x
Mayfield Reservoir	LMB, NPM	1	x									
Merwin Lake	NPM	1	x									x
Methow R, SE of Winthrop	CTT, MWF	1		x								x
Mountain Lake, Orcas Island	KOK	1	x									x
Northwestern Lake	RBT	1	x									x
Ozette Lake	NPM, LMB	1									x	x
Palouse R, Lower	NPM	2	x		x							x
Palouse R, North Fork	NPM	2	x		x							x
Palouse R, South Fork	NPM	3	x		x		x					x
Pend Oreille R, South	NPM	1	x									
Potholes Reservoir	LWF, SMB, WAL	4	x	x	x		x					x
Rock Lake	LMB, YP	1					x					
Sacajawea Lake, at Longview	GCP, LMB	1	x									
Silver Lake, near Castle Rock	CCP, LMB	2	x	x								x
Skagit R, near Burlington	CTT, MWF	1	x									x
Snake R, at Central Ferry	CC, LMB, PEA	5	x	x	x		x	x				x
Snake R, below Lower Monumental Dam	CC	6	x	x	x		x	x		x		x
Snake R, below Clarkston	MWF, PEA	3	x		x		x					x
Snake R, above Ice Harbor Dam	CCP, PEA	3	x	x	x							x
Snohomish R, above Snohomish	CTT, MWF, NPM	2	x	x								x
Spokane R, at Monroe St.	RBT	0										x
Spokane R, above Ninemile Dam	MWF	1		x								x
Spokane R, at Plante Ferry	RBT	1		x								x
Stan Coffin Lake	CC	1		x								x
Wenatchee R, near Leavenworth	MWF	2	x		x							x
Wenatchee R, near Wenatchee	MWF	2	x		x							
Whatcom Lake	CTT	2	x	x								x
Count of Recommended Category 5 or Category 2 Listings:		93	37	18	16	5	8	3	1	1	4	36
Percent of Recommended Category 5 Listings:			40%	19%	17%	5%	9%	3%	1%	1%	4%	

Species Codes: CC = Channel catfish, CCP = Common carp, CTT = Cutthroat trout, GCP = Grass carp, KOK = Kokanee salmon, LMB = Largemouth bass, LWF = Lake whitefish, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, SMB = Smallmouth bass, WAL = Walleye, YP = Yellow perch.

Recommendations for listing are based on 2004/2005 data only. Some sites already listed are based on previous studies (example= Spokane River for PCBs)

studies conducted in Washington, so a statewide perspective is limited to sites sampled in 2004 and 2005 by the WSTMP.

Contaminant scores were first developed from results for each sample as described below. Sample contaminant scores from each site were then averaged to produce a site contaminant score. Site contaminant scores were then ranked from high to low to help show the relative amount of contamination in fish from sampled sites (Figure 3).

Table 5 shows the benchmark values that were used and the contaminant scores generated for three samples from one site. Levels of contaminants in each sample were divided by the benchmark value which produced a ratio of the contaminant concentration to the benchmark value. These ratios show whether individual contaminants are higher or lower than the benchmark values and by how much. These ratios were then summed to give a sample contaminant score, which is an overall indicator of the amount of toxic pollutants in each sample. Appendix D shows the fish species sampled at each site and the results for key contaminants. Results for Chinook salmon were excluded from this ranking process.

Contaminant scores for individual samples ranged from 1.1 for Silver Lake bluegill, where samples did not exceed any benchmark values, to 446 for Lake Washington carp, where benchmark values were exceeded for all contaminants except mercury. The median score for all samples was 4.6. PCBs, dioxin/furans, and total DDT contributed most to these scores. For example, the total PCB value of 1339 ug/kg in Lake Washington carp exceeded the benchmark value of 5.3 ug/kg by a factor of 253, accounting for about 57% of that sample's contaminant score of 446.

Table 5. Example Calculation of Contaminant Scores for Samples and Sites Using the Columbia River Site above Rock Island Dam.

		Sample Result Value			Ratio of Sample Result to Benchmark Value		
Contaminant	**Benchmark Value [1]**	**NPM**	**PEA**	**WAL**	**NPM**	**PEA**	**WAL**
Total PCB Aroclors (ppb)	5.3	52.0	15.0	46.0	9.81	2.83	8.68
Total DDT (ppb)	32	415	151	343	13.0	4.71	10.7
Total PBDE (ppb) [3]	31.0	10.8	6.18	21.9	0.35	0.20	0.71
Total Chlordane (ppb)	8.3	0.78	0.23	0.84	0.09	0.03	0.10
2,3,7,8-TCDD TEQ (ppt) [2]	0.07	0.442	na	0.318	6.31	na	4.54
Mercury (ppm)	0.825	0.515	0.110	0.644	0.62	0.13	0.78
Dieldrin (ppb)	0.65	nd	nd	nd	nd	nd	nd
Sample Contaminant Score:					**30.2**	**7.9**	**25.5**
Site Contaminant Score: [4]					**21.2**		

1 - Benchmark values are NTR criterion unless noted otherwise.
2 - Benchmark value is the NTR criterion for 2,3,7,8-TCDD.
3 - Benchmark value is the 90th percentile from statewide study of PBDEs (Johnson et al., 2006).
4 - The site contaminant score is the mean of the sample contaminant scores from that site.
na - Not analyzed, excluded from calculations. nd - Not detected, excluded from calculations.
Species Codes: NPM - northern pikeminnow, PEA - peamouth, WAL - walleye

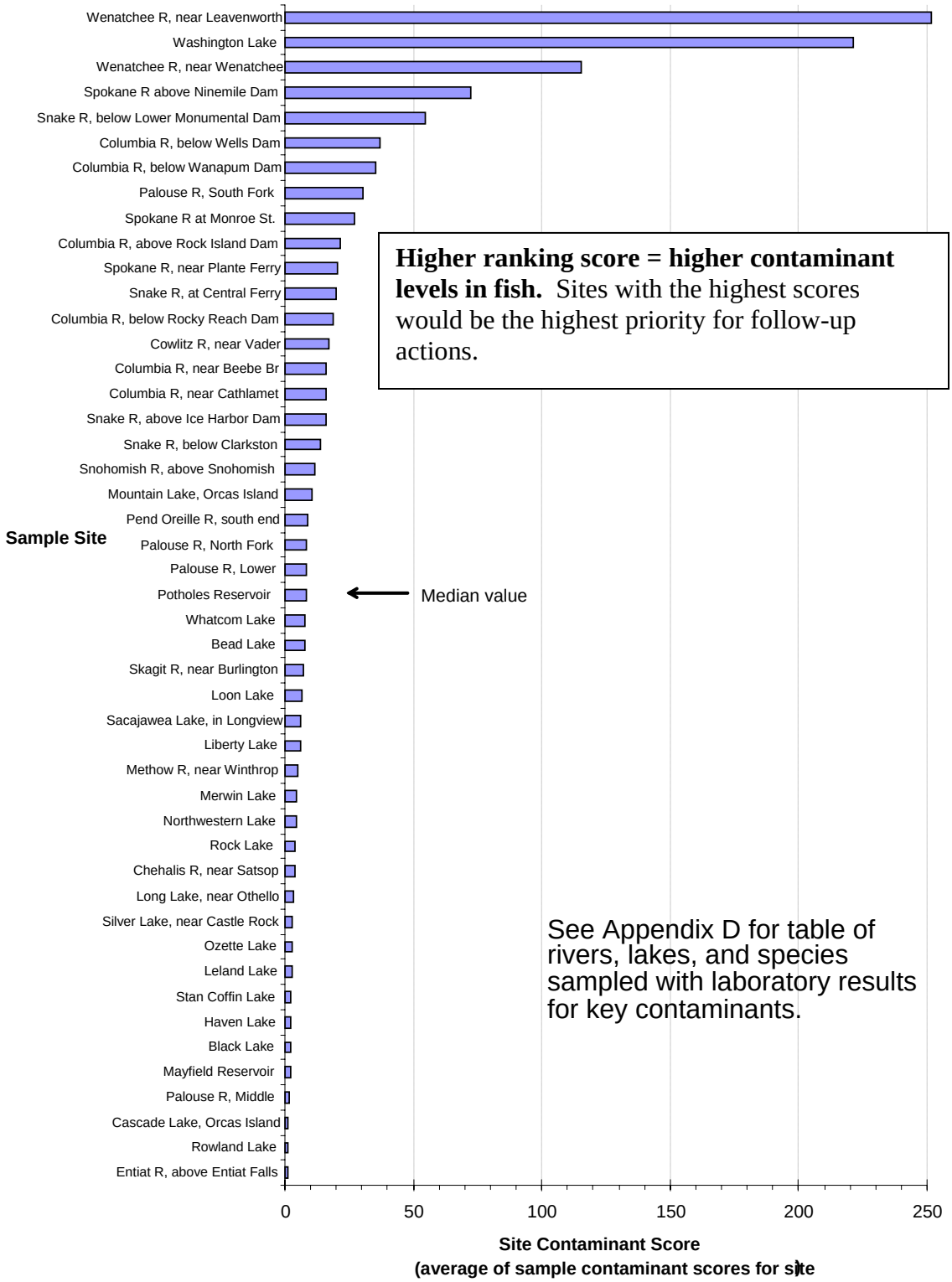

Figure 3. Site Ranking for the 2004-2005 WSTMP Fish Tissue Results.

Site contaminant scores ranged from 1.1 (Entiat River) to 252 (Wenatchee River near Leavenworth): the median score for sites was 8.1. Most sites had at least one sample that exceeded NTR criteria as described earlier and shown in Table 4.

The sites with the highest contaminant scores include Lake Washington and the Wenatchee, Spokane, Snake, Columbia, Palouse, and Cowlitz Rivers. The species having higher levels of contamination at these sites include mountain whitefish, common carp, northern pikeminnow, cutthroat trout, and channel catfish.

Chinook salmon from three coastal rivers had lower levels of contaminants than Chinook salmon from the Puget Sound basin and the Columbia River. Nevertheless, total PCBs and dioxin/furan levels in coastal river Chinook salmon exceeded NTR criteria and EPA's Screening Values for Subsistence Fishers.

Comparison of recent data to historical data was possible in two cases: (1) Levels of PCBs, dioxins/furans, and DDTs have likely decreased in fish from the mid-Columbia River area, and (2) Levels of PCBs and DDTs appear to have decreased in fish from the Cowlitz River near Vader.

Conclusions

PCBs, dioxin/furans, chlorinated pesticides, flame retardants, and mercury were frequently detected in 104 samples of fish from 52 lakes and rivers across Washington during 2004-2005.

A total of 45 sites had 93 fish tissue results that exceeded National Toxics Rule (NTR) criteria for contaminants in fish tissue. Four contaminants accounted for 85% of these exceedances: total PCBs, 2,3,7,8-TCDD, 4,4'-DDE, and dieldrin. Other contaminants exceeding NTR criteria were 4,4'-DDD, mercury, total chlordane, hexachloro-benzene, and toxaphene.

The highest levels of contamination were in fish from Lake Washington and the Wenatchee, Spokane, Snake, Columbia, Palouse, and Cowlitz Rivers. Larger rivers and highly urbanized lake basins (e.g., Lake Washington) generally had fish with higher levels of contaminants. Older, larger, and more piscivorous fish generally had greater occurrences and levels of contaminants.

Recommendations

The Washington State Department of DOH, local health jurisdictions, and affected Tribes should evaluate the results from this study and determine the need for additional sampling in order to assess the risks to human health from the consumption of contaminated fish.

Ecology should review the fish tissue data from the 45 sites listed in Table 4 for placement in Categories 5 and 2 of Washington State's 303(d) assessment. Other results from this 2004-2005 sampling effort should be reviewed and corresponding sites placed in Categories 1 and 3 of the 303(d) assessment.

Ecology should determine what action to take for the most contaminated sites identified in this study, particularly Lake Washington and the Wenatchee, Spokane, Snake, and Columbia Rivers.

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Appendices

Appendix A. Site and Species Sampled for the WSTMP, 2004-2005

Site	County	WRIA	Species
2004 WSTMP Sample Year			
Black L	Thurston	23	RBT
Cascade L, Orcas Is	San Juan	2	KOK, LMB, RBT
Chehalis R, nr Aberdeen	Grays Harbor	22	CHK
Chehalis R, nr Satsop	Grays Harbor	22	CTT, NPM
Columbia R, abv Rock Is Dam	Chelan-Douglas	44	NPM, PEA, WAL
Columbia R, blw Rocky Reach Dam	Chelan-Douglas	45	MWF
Columbia R, blw Wanapum Dam	Kittitas-Grant	41	MWF
Columbia R, blw Wells Dam	Chelan-Douglas	47	MWF
Columbia R, nr Beebe Bridge	Chelan-Douglas	47	NPM, PEA
Entiat R	Chelan	46	RBT
Mountain L, Orcas Is	San Juan	2	KOK
Ozette L	Clallam	20	CTT, LMB, NPM, YP
Pend Oreille R, South	Pend Oreille	62	NPM
Queets R	Jefferson	21	CHK
Quinault R	Grays Harbor	21	CHK
Skagit R, nr Burlington	Skagit	3	CTT, MWF, PEA
Snake R, at Central Ferry	Columbia-Garfield-Whitman	35	CC, LMB, PEA, YP
Snake R, blw Lower Monumental Dam	Franklin-Walla Walla	33	CC
Snake R, ds of Clarkston	Whitman-Asotin	35	LMB, MWF, PEA
Wenatchee R, nr Leavenworth	Chelan	45	MWF
Wenatchee R, nr Wenatchee	Chelan	45	MWF
2005 WSTMP Sample Year			
Bead L	Pend Oreille	62	BUR, KOK, NPM, PEA
Columbia R, nr Cathlamet	Wahkiakum	25	NPM, PEA
Cowlitz R, nr Vader	Cowlitz	26	CTT, MWF, NPM
Haven L	Mason	15	CTT, LMB, RBT
Lake Washington, Entire	King	8	CCP, NPM
Lake Washington, North	King	8	CTT
Lake Washington, South	King	8	CTT
Leland L	Jefferson	17	BC, BG, LMB, YP
Liberty L	Spokane	57	SMB
Long L, nr Othello	Grant	41	SMB, WAL
Loon L	Stevens	59	LMB
Mayfield Res.	Lewis	26	LMB, NPM, YP
Merwin L	Lewis	27	KOK, NPM
Methow R, SE of Winthrop	Okanogan	48	CTT, MWF
Northwestern L	Skamania-Klickitat	29	RBT
Palouse R, Lower	Whitman-Adams	34	NPM
Palouse R, Middle	Whitman	34	SMB
Palouse R, North Fork	Whitman	34	NPM
Palouse R, South Fork	Whitman	34	NPM
Potholes Res	Grant	41	LWF, SMB, WAL
Rock L	Whitman	34	BNT, LMB, YP
Rowland L	Klickitat	29	BG, LMB, YP
Sacajawea L, at Longview	Cowlitz	25	GCP, LMB
Silver L, nr Castle Rock	Cowlitz	26	BG, CCP, LMB
Snake R, ups of Ice Harbor Dam	Franklin-Walla Walla	33	CCP, PEA, YP
Snohomish R, ups of Snohomish	Snohomish	7	CTT, MWF
Spokane R, at Monroe St.	Spokane	57	RBT
Spokane R, at Ninemile	Spokane	54	MWF
Spokane R, at Plante Ferry	Spokane	57	RBT
Stan Coffin L	Grant	41	CC, LMB, YP
Whatcom L	Whatcom	1	CTT, PEA, SMB, YP

Species Codes: BC = Black crappie, BG = Bluegill, BNT = Brown trout, BUR = Burbot, CC = Channel catfish, CCP = Common carp, CHK = chinook salmon, CTT = Cutthroat trout, GCP = Grass carp, KOK = Kokanee salmon, LMB = Largemouth bass, LWF = Lake whitefish, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, SMB = Smallmouth bass, WAL = Walleye, YP = Yellow perch.

Appendix B. National Toxics Rule Criteria, National Recommended Water Quality Criteria, and EPA Screening Values for the Protection of Human Health for Contaminants Detected in Fish Tissue, WSTMP 2004-2005

Analyte (ppb ww)[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
Aldrin	0.65	0.23	-	-	-	-
Alpha-BHC	1.7	0.64	-	-	-	-
Beta-BHC	6.0	2.2	-	-	-	-
Chlorpyriphos	-	-	147	-	1200	-
Chlorthal-Dimethyl (Dacthal)	-	-	-	-	-	-
Dieldrin	0.65	0.25	24	0.307	200	2.5
Endosulfan Sulfate	540	24000	-	-	-	-
Endrin	3200	230	147		1200	
Heptachlor Epoxide	1.2	0.44	6.39	0.54	52	4.39
Hexachlorobenzene	6.7	2.5	393	3.07	3200	25.0
gamma-BHC (Lindane)	8.2	230	147	3.8	1200	30.7
Methoxychlor	-	-	-	-	-	-
Mirex	-	-	98	-	800	-
Pentachloroanisole	-	-	-	-	-	-
Toxaphene	9.8	3.7	122	4.46	1000	36.3
PBDEs	-	-	-	-	-	-

1. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2. EPA 2001 for methylmercury, EPA 2003 for endrin and gamma-BHC, 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 mix of congeners is expressed as 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 = p,p'-dichlorodiphenyldichloroethane. DDE = p,p'-dichlorodiphenyldichloroethylene.
   DDT = p,p'-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 chlordane" which is the sum of five compounds: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane.

Note: The NTR Criteria and National Recommended Water Quality Criteria for fish tissue are calculated using water column concentrations (the human health water quality criteria for consumption of organisms only: column D2 of the matrix in 40 CFR 131.36) and bioconcentration factors from EPA's 1980 Ambient Water Quality Criteria documents.

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 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 two things (1) if Washington State water quality standards are being met, and (2) if 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 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, 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 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 in messaging is 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 at the same time steering the public away from fish that have high levels of health-damaging contaminants.

Appendix D. Summary of Fish Tissue Sample Results

Site	Species Code	MEL Sample ID	WSTMP Study Year	Date collect	Total PCB aroclors (ug/kg)	q	Total PCB congeners (ug/kg)	q	T-DDT (ug/kg)	q	Total PBDE (ug/kg)	q	Total Chlordane (ug/kg)	q	2378 TCDD TEQ (ng/kg)	q	2378 TCDD (ng/kg)	q	Mercury (mg/kg)	q	Lipid MEL (%)	q	Lipid CL (%)	q	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)
Bead L	BUR	05514700	2005	10/26/05	5.0	U			1.4		6.2	UJ	1.0	U					0.130		0.4				650	1846	5.6
Bead L	KOK	05514701	2005	10/26/05	16				16		2.6		0.95	U					0.030		1.7				267	178	3.0
Bead L	NPM	05514702	2005	10/26/05	36		21		29		4.1		0.99	U	1.04		0.134		0.260		8.2		8.1		503	1643	11.0
Bead L	PEA	05514703	2005	10/26/05	5.7				2.5		0.29		0.88	U					0.170		1.4				245	107	7.4
Black L	RBT	05084284	2004	9/16/04	9.1				1.1		4.8		0.29						0.100		1.9				292	229	1.9
Cascade L, Orcas Is	KOK	05084286	2004	9/30/04	4.8	U			0.53		1.6		0.96	U					0.199		2.8				415	686	2.0
Cascade L, Orcas Is	KOK	05084285	2004	9/30/04	4.9	U			0.32		2.9		0.97	U					0.241		5.3				205	87	1.0
Cascade L, Orcas Is	LMB	05084287	2004	9/29/04	4.7	U			0.33		0.39		0.94	U					0.194		1.0				304	448	2.3
Cascade L, Orcas Is	RBT	05084288	2004	9/29/04	4.9	U	1.1		0.49		2.4	UJ	0.94	U					0.201		0.7		1.3		303	280	1.1
Chehalis R, nr Aberdeen	CHK	05084289	2004	10/18/04	5.0		5.1		2.6		2.3		0.76		0.089		0.100	U	0.049		3.6		3.3		910	7938	4.8
Chehalis R, nr Satsop	CTT	05084280/4290	2004	9/8/04	9.6	m	13	m	8.9	m	0.88	m	0.36	m	0.099	m	0.100	U	0.054	m	4.0	m	5.6	m	330	376	3.0
Chehalis R, nr Satsop	NPM	05084291	2004	9/8/04	13		17		4.5		2.7		0.49						0.964		0.6		1.4		415	650	8.9
Columbia R, abv Rock Is Dam	NPM	05084292	2004	11/2/04	52		88		415		11		0.78		0.442		0.100	U	0.515		1.8		2.0		400	614	8.4
Columbia R, abv Rock Is Dam	PEA	05084293	2004	11/2/04	15				151		6.2		0.23						0.110		2.3				257	159	4.0
Columbia R, abv Rock Is Dam	WAL	05084294	2004	11/3/04	46		108		343		22		0.84		0.318		0.100	U	0.644		2.6		6.4		652	3601	9.0
Columbia R, blw Rocky Reach Dam	MWF	05084295	2004	11/3/04	36		75		112		10		0.39		0.550		0.100	U	0.022		3.0		3.3		279	187	1.6
Columbia R, blw Wanapum Dam	MWF	05084296	2004	11/4/04	54		91		406		50		2.4		0.652		0.150		0.042		6.9		6.7		355	472	3.3
Columbia R, blw Wells Dam	MWF	05084281/4297	2004	10/28/04	71	m	92	m	430	m	40	m	1.5	m	0.606	m	0.115	U	0.073	m	4.3	m	5.4	m	353	454	3.6
Columbia R, near Cathlamet, RM 38-42	NPM	06024738	2005	8/30/05	76		46		32		17		2.5		0.345		0.110		0.596		2.0		2.5		466	956	9.2
Columbia R, near Cathlamet, RM 38-42	PEA	05524720	2005	8/30/05	47				27		13		1.0	U					0.140		1.6				275	189	6.4
Columbia R, nr Beebe Br	NPM	05084298	2004	10/26/04	31		65		509		18		0.51						0.456		2.4		4.6		431	766	7.4
Columbia R, nr Beebe Br	PEA	05084299	2004	10/26/04	14				197		4.4		0.23						0.130		1.4				259	155	4.3
Cowlitz R, 8 mi N Castle Rock, RM 24-27	CTT	05514704/4705	2005	8/29/05	55	m	24	m	29	m	5.0	m	0.97	U	0.303	m	0.131	m	0.087	m	4.7	m	5.3	m	360	493	3.0
Cowlitz R, 8 mi N Castle Rock, RM 24-27	MWF	05514706	2005	8/29/05	46				6.2		24		0.88	U					0.205		6.8				441	859	5.6
Cowlitz R, 8 mi N Castle Rock, RM 24-27	NPM	05514707	2005	8/29/05	92		56		21		18		0.93	U	0.410		0.124		0.859		1.8		1.7		427	656	10.6
Entiat R, abv Entiat Falls	RBT	05084300	2004	10/12/04	4.9	U	3.8		2.8		0.99		0.22						0.037		2.8		5.0		169	42	3.0
Haven L	CTT	06054771	2005	11/29/05	5.0	U			1.3		2.5		0.99	U					0.192		2.3				250	137	2.0
Haven L	LMB	06054770	2005	11/29/05	4.7	U			1.3		2.3		0.94	U					0.079		1.3				315	528	1.6
Haven L	RBT	06054769	2005	11/29/05	5.0	U	6.3		1.2		1.1		1.0	U	0.186		0.068		0.130		1.0		1.1		365	463	1.2
Leland L	BC	06054752	2005	9/14/05	4.7	U			0.95	U	0.43		0.95	U					0.120		0.8				227	185	2.0
Leland L	BG	06054753	2005	9/14/05	4.8	U			0.97	U	6.0	UJ	0.97	U					0.130		0.8				168	101	2.0
Leland L	LMB	05514708	2005	9/14/05	11		6.2		1.9		1.5		0.96	U	0.181		0.122		0.834		0.9		1.0		481	1776	11.0
Leland L	YP	06054754	2005	9/14/05	4.9	U			0.98	U	6.1	UJ	0.98	U					0.196		0.5				217	131	2.2
Liberty L	SMB	06054755/4756	2005	10/11/05	24	m	11		23	m	3.2	m	0.99	m	0.048		0.044	J	0.154	m	1.6	m	1.7		375	764	3.8
Long L, 8 mi N of Othello	SMB	05514709	2005	8/24/05	4.9	U			3.0		6.1	UJ	0.98	U					0.110		1.0				303	397	3.2
Long L, 8 mi N of Othello	WAL	05514710	2005	8/24/05	4.5	U			9.6		0.34		0.90	U					0.207		1.3				437	765	3.4
Loon L	LMB	06054757	2005	10/26/05	16		11		5.7		1.7		0.92	U	0.084		0.066		0.280	n	1.4		2.0		455	1767	10.2
Mayfield Res.	LMB	05524721	2005	9/15/05	5.5		3.4		0.97	U	2.0		0.97	U	0.050	UJ	0.030	UJ	0.242		0.9		1.0		328	610	4.2
Mayfield Res.	NPM	05524722	2005	9/15/05	8.9		5.0		2.5		2.3		0.98	U	0.009		0.030	UJ	0.474		1.5		1.7		312	244	6.4

Site	Species Code	MEL Sample ID	WSTMP Study Year	Date collect	Total PCB aroclors (ug/kg)	q	Total PCB congeners (ug/kg)	q	T-DDT (ug/kg)	q	Total PBDE (ug/kg)	q	Total Chlordane (ug/kg)	q	2378 TCDD TEQ (ng/kg)	q	2378 TCDD (ng/kg)	q	Mercury (mg/kg)	q	Lipid MEL (%)	q	Lipid CL (%)	q	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)
Mayfield Res.	YP	05524723	2005	9/15/05	5.0	U			1.0	U	0.38		1.0	U					0.084		0.5				237	164	4.0
Merwin Lake	KOK	06054758	2005	11/1/05	5.0	U			1.5		5.7		1.0	U					0.078		1.5				370	487	2.0
Merwin Lake	NPM	06054759	2005	11/1/05	20		10		4.9		5.6		0.95	U	0.219		0.059		0.373		2.1		1.4		436	919	6.8
Methow R, 2 mi SE of Winthrop, RM 47-49	CTT	05524724	2005	10/20/05	4.9	U	1.9		9.2		2.6		0.98	U	0.304		0.097		0.028		2.4		2.0		291	241	4.2
Methow R, 2 mi SE of Winthrop, RM 47-49	MWF	06024740	2005	10/20/05	4.9	U	1.3		1.4		11		0.99	U	0.214		0.083		0.037		3.9		2.5		358	505	4.8
Mountain L, Orcas Is (natural repro)	KOK	05084301	2004	9/29/04	4.8	U	10		3.4		0.75		0.47		0.627		0.100	U	0.076		3.7		3.8		271	179	3.1
Northwestern Lake	RBT	06054760	2005	11/2/05	8.7		5.7		3.7		0.76		0.98	U	0.133		0.046	J	0.295		1.7		0.9		349	426	2.4
Ozette L	CTT	05084302	2004	10/6/04	4.8	U			0.21		6.0	UJ	0.96	U					0.279		1.7				273	171	3.7
Ozette L	LMB	05084303	2004	10/6/04	4.9	U			0.98	U	6.1	UJ	0.98	U					0.910		0.7				371	840	4.4
Ozette L	NPM	05084304	2004	10/6/04	5.0	U	0.9		0.57			R	1.0	U	0.195		0.100	U	0.724		0.9		3.0		371	464	7.2
Ozette L	YP	05084305	2004	10/6/04	4.7	U			0.95	U	5.9	UJ	0.95	U					0.240		0.5				211	108	2.0
Palouse R, Lower	NPM	05514711	2005	6/23/05	20		11		44		7.5		0.97	U	0.128		0.033	J	0.749	p	2.0		1.9		458	940	7.0
Palouse R, Middle	SMB	05514712	2005	6/6/05	5.0	U			7.6		3.8		0.99	U					0.120	p	0.5				178	72	2.0
Palouse R, North Fork	NPM	05514713	2005	6/9/05	22				80		6.9		0.94	U	0.101		0.030	UJ			2.9		3.0		351	419	7.1
Palouse R, South Fork	NPM	05514714	2005	5/24/05	109		35		57		42		0.97	U	0.211		0.055		0.465	p	1.1		0.4		354	442	9.8
Pend Oreille R, south end	NPM	05084319	2004	8/18/04	38		34		8.1		11		0.53						0.825		2.5		4.8		391	758	12.1
Potholes Res	LWF	06024741	2005	10/25/05	17		6.0		60		1.9		6.7		0.326		0.153		0.046		17		18		576	2524	6.2
Potholes Res	SMB	06024742	2005	10/26/05	4.4	U			4.3		0.62		0.88	U					0.118	n	1.9				451	1386	5.8
Potholes Res	WAL	06024743	2005	10/25/05	5.2				18		0.46		1.0	U					0.170		1.7				578	1999	4.2
Queets R	CHK	05084306	2004	10/18/04	5.6		4.7		2.6		0.28		1.3		0.233		0.100	U	0.041		2.8		4.7		932	7983	4.8
Quinault R	CHK	05084307	2004	10/18/04	6.3		4.4		3.5		0.42		1.7		0.218		0.100	U	0.030		3.5		4.9		868	7892	4.0
Rock L	BNT	05524725	2005	8/23/05	4.9	U			8.5		0.60		0.97	U					0.021		4.2				259	187	1.0
Rock L	LMB	05524726	2005	8/23/05	4.9	U			2.7		0.58		0.98	U					0.044		1.0				272	346	2.8
Rock L	YP	05524727	2005	8/24/05	4.7	U			7.9		0.44		0.94	U					0.160		0.8				316	499	6.0
Rowland L	BG	06054761	2005	9/7/05	4.9	U			0.98	U	6.1	UJ	0.98	U					0.044		0.6				175	106	3.1
Rowland L	LMB	06054762	2005	9/7/05	4.9	U			3.6		1.1		0.98	U					0.120		0.8				370	740	3.6
Rowland L	YP	06054763	2005	9/7/05	4.9	U			0.98	U	6.1	UJ	0.98	U					0.036		0.7				218	119	2.5
Sacajawea L @ Longview	GC	05514715	2005	9/14/05	30				2.2		0.56		1.0	U					0.017	U	1.2				447	1249	1.0
Sacajawea L @ Longview	LMB	06024744	2005	9/14/05	29		17		2.3		0.86		0.95	U	0.068		0.049	J	0.059		1.0		0.5		342	692	2.0
Silver L, near Castle Rck	BG	06054764	2005	9/22/05	4.8	U			0.96	U	0.28		0.96	U					0.020		1.7				164	95	2.0
Silver L, near Castle Rck	CCP	05514716	2005	9/22/05	6.8		5.6		1.3		0.33		0.94	U	0.130		0.083		0.043		2.0		1.8		521	2313	4.8
Silver L, near Castle Rck	LMB	06054765	2005	9/22/05	4.8	U	2.7		1.4		0.34		0.95	U	0.094		0.030	UJ	0.799	n	0.7		0.8		352	695	3.6
Skagit R, nr Burlington	CTT	05084308	2004	10/4/04	36		22		7.3		14		0.69		0.220		0.100	U	0.140		3.1		6.3		370	501	4.0
Skagit R, nr Burlington	MWF	05084309	2004	10/5/04	19		12		6.1		7.8		0.62		0.299		0.100	U	0.076		1.4		6.5		245	103	2.5
Skagit R, nr Burlington	PEA	05084310	2004	10/5/04	4.9	U			3.0		2.6		0.99	U					0.241		1.6				250	151	6.2
Snake R, at Central Ferry (L Bryan)	CC	05084311	2004	12/1/04	148		65		389		14		9.9		1.12		0.370		0.283		13		11		565	1842	12.0
Snake R, at Central Ferry (L Bryan)	LMB	05084312	2004	12/1/04	11				9.3		0.47		1.0	U					0.092		0.7				295	399	2.1
Snake R, at Central Ferry (L Bryan)	PEA	05084313	2004	12/1/04	10				29		2.1		0.91	U					0.264		2.2				284	186	5.1
Snake R, at Central Ferry (L Bryan)	YP	05084314	2004	12/1/04	5.0	U			5.9		6.2	UJ	1.0	U					0.196		0.5				258	232	3.3

Site	Species Code	MEL Sample ID	WSTMP Study Year	Date collect	Total PCB aroclors (ug/kg)	q	Total PCB congeners (ug/kg)	q	T-DDT (ug/kg)	q	Total PBDE (ug/kg)	q	Total Chlordane (ug/kg)	q	2378 TCDD TEQ (ng/kg)	q	2378 TCDD (ng/kg)	q	Mercury (mg/kg)	q	Lipid MEL (%)	q	Lipid CL (%)	q	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)
Snake R, blw Lower Monumental Dam	CC	05084283/4315	2004	11/8/04	111	m	165		373	m	26	m	9.1		1.11		0.520	U	0.347	m	7.2	m	7.3		491	1162	11.5
Snake R, ds Clarkston at Chief Timothy park	LMB	05084316	2004	11/30/04	4.2	U			22		1.8		0.85	U					0.140		0.7				283	346	1.9
Snake R, ds Clarkston at Chief Timothy park	MWF	05084317	2004	11/29/04	106		70		38		9.4		0.98	U	0.413		0.100	U	0.120		2.0		1.4		299	231	2.5
Snake R, ds Clarkston at Chief Timothy park	PEA	05084318	2004	11/30/04	26				86		12		0.47						0.296		1.9				273	155	4.3
Snake R, ups Ice Harbor Dam, RM 11-12	CCP	06024751	2005	11/14/05	115		65		146		30		5.1		0.417		0.100		0.180		5.4		1.7		675	4207	13.6
Snake R, ups Ice Harbor Dam, RM 11-12	PEA	05524731	2005	11/14/05	43				22		2.5		0.98	U					0.190		1.8				286	4207	5.4
Snake R, ups Ice Harbor Dam, RM 11-12	YP	05524730	2005	11/14/05	4.9	U			6.7		0.60		0.99	U					0.045		0.6				204	94	1.2
Snohomish R, ups Snohomish, RM 15-18	CTT	05524728	2005	9/1/05	42		32		4.7		26		0.99	U	0.304		0.097		0.120		3.6		6.2		375	526	3.4
Snohomish R, ups Snohomish, RM 15-18	MWF	06024749/4745	2005	9/1/05	20	m	9.5	m	3.2	m	32	m	0.98	U	0.243	m	0.077	m	0.076	m	4.1	m	3.5	m	304	268	3.8
Snohomish R, ups Snohomish, RM 15-18	NPM	06024746	2005	9/1/05	48		30		3.7		12		1.5		0.100		0.077		0.696		2.5		1.8		332	372	4.4
Spokane R nr Monroe St., RM 75.2	RBT	05524735	2005	9/28/05	120	s					30	s			0.248		0.032	J			1.5		1.8		358	433	3.0
Spokane R nr Ninemile, RM 64.0	MWF	05524736	2005	9/29/05	129	s					1136	s			0.809		0.083				3.4		2.3		335	337	4.7
Spokane R nr Plante Ferry, RM 85.0	RBT	05524737	2005	8/23/05	58	s					102	s			0.448		0.096				3.4		2.2		400	625	2.7
Stan Coffin L	CC	06054766	2005	9/6/05	4.6	U	2.4		7.2		0.55		0.92	U	0.175		0.082		0.029		3.5		5.1		548	1589	6.6
Stan Coffin L	LMB	06054767	2005	9/6/05	5.0	U			1.8		6.2	UJ	2.0	U					0.150		0.7				349	732	5.0
Stan Coffin L	YP	06054768	2005	9/6/05	4.9	U			0.99	U	6.2	UJ	0.99	U					0.042		0.4				187	76	2.6
Washington L	CCP	05524717	2005	6/28/05	1339		611		418		54		68		11.9		1.93		0.160		9.0		11		698	5559	17.0
Washington L	NPM	05524734	2005	3/9/05	375	w	241		103	w	61	w	37	w	5.75		0.684		0.531	w	3.8		4.8		430	917	5.7
Washington L, North	CTT	05524732	2005	3/3/05	233	w	292		117	w	64	w	37	w	4.64		0.741		0.277	w	3.8		4.2		433	934	3.4
Washington L, South	CTT	05524733	2005	3/1/05	370	w	384		115	w	102	w	66	w	4.88		0.876		0.308	w	3.1		5.9		437	1027	4.0
Wenatchee R, nr Leavenworth	MWF	05084320	2004	11/18/03	1300		1632		43		7.2		3.4	UJ	0.315		0.100		0.028		3.0		3.3		271	182	2.4
Wenatchee R, nr Wenatchee	MWF	05084321	2004	11/18/03	542				378		40		0.32						0.050		3.9				297	226	3.4
Whatcom L	CTT	06024747	2005	10/12/05	40		23		7.2		13		6.2		0.563		0.156		0.364		2.8		2.7		401	615	4.2
Whatcom L	PEA	05524729	2005	10/12/05	18				3.7		1.9		1.6						0.245		2.1				266	183	10.8
Whatcom L	SMB	06024750	2005	10/12/05	29				2.3		5.4		4.2						0.425		2.4				417	1178	6.0
Whatcom L	YP	06024748	2005	10/12/05	4.9	U			0.97	U	0.17		0.97	U					0.423		0.5				331	496	6.2

Data Qualifiers and Notes

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.

R = Rejected (due to poor data quality and apparent spurious value of 31.62 ppb)

m = mean value from analyses of field duplicates where two results are available. Where analysis was not done on only one sample, that sample result is given. Where both values were non-detect, the highest value was used. Where one duplicate was qualified as a non-detect (U, UJ), the reported value was used in determining the mean value.

n = mean value of 10 individuals: individual fish results from Mercury Trends in Fish project, (C. Furl, in preparation).

s = values from Spokane R study by Serdar and Johnson, ECY pub # 06-03-025. Values are means from multiple samples from other study that were combined to make a WSTMP sample for contract lab analyses of PCB congeners and PCDD/Fs.

p = values from Palouse R study by Johnson et al (in preparation). Values are from corresponding sample or from means from multiple samples from other study that were combined to make a WSTMP sample for contract lab analyses of PCB congeners and PCDD/Fs. Value for sample 05514711 is based on result from analyses of 4 of 7 fish used. All fish were of same size and weight range.

w = values from Lake Washington study by DOH (in preparation). Values are means from multiple samples from other study that were combined to make a WSTMP sample for contract lab analyses of PCB congeners and PCDD/Fs.

For completeness, included values for some parameters that were analyzed by MEL for different studies: Spokane R, Palouse R, Lake Washington. These are qualified as "s","p", or "w", and are explained above.

Size and age data were obtained from studies that shared fish: 303d Ver. Studies (Wenatchee, Pend Oreille) and Lake WA DOH study, Spokane, and Palouse studies.

Species Codes: BC = Black crappie, BG = Bluegill, BNT = Brown trout, BUR = Burbot, CC = Channel catfish, CCP = Common carp, CHK = Chinook salmon, CTT = Cutthroat trout, GCP = Grass carp, KOK = Kokanee salmon, LMB = Largemouth bass, LWF = Lake whitefish, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, SMB = Smallmouth bass, WAL = Walleye, 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 choices 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 get into fish (mercury, PCBs, PBDEs, DDTs).
- 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.