Washington State
Toxics Monitoring Program

Freshwater Fish Tissue Component, 2010

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Cover photo: Mountain whitefish anglers on the Wenatchee River near Peshastin.

Washington State
Toxics Monitoring Program:
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by

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Waterbody Numbers: See Table D-1.

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Abstract

Since 2001, the Washington State Toxics Monitoring Program's (WSTMP) Exploratory Monitoring component characterized persistent, bioaccumulative, and toxic chemicals in freshwater fish throughout Washington. A Long-Term Monitoring component was added in 2009 to see whether changes in contaminant levels occur over time. Goals for the 2010 long-term monitoring effort were to (1) mimic historical sampling efforts at several sites to obtain comparable results; (2) compare results from two sample preparation methods: skin-on fillets versus skin-off fillets; and (3) better characterize levels of other contaminants in fish from selected sites.

Results from the 2010 Long-Term Monitoring effort are reported for three sites and chemicals of concern: Lake Chelan (DDTs), Wenatchee River (PCBs), and Banks Lake (dioxins/furans). Fish from Lake Wenatchee, Potholes Reservoir, and Lake Ozette (sockeye salmon) were also analyzed for mercury, PCBs, dioxins and furans, chlorinated pesticides, and PBDE flame retardants.

Key findings from this study are as follows:

- Levels of DDTs in lake trout from Lake Chelan remain high and are higher than levels measured in 2003.
- Levels of PCBs in mountain whitefish in the Wenatchee River are high and remain similar to levels measured in 2003.
- No significant differences were found in results from skin-off and skin-on fillets using fish from Lake Chelan and the Wenatchee River.
- Levels of dioxins/furans, PCBs, and DDTs in lake whitefish from Banks Lake appear to be lower than levels measured in 2003.
- Contaminant levels in returning sockeye salmon to Lake Ozette were generally low and comparable to levels found in salmon returning to other coastal streams.
- The previously issued Fish Consumption Advisories for Lake Chelan and the Wenatchee River are unlikely to be changed by the Washington State Department of Health.

Recommendations include increasing sample sizes and collaborating with other groups in future efforts at long-term monitoring sites.

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Introduction

Background

During the 1980s and 1990s, the Washington State Department of Ecology (Ecology) and other agencies found persistent, bioaccumulative, and toxic contaminants (PBTs) 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 long-term monitoring of chemicals in fish to determine trends over time.
- Improve access to information about monitoring toxic chemicals 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 2008, 270 fish tissue samples from 130 sites were analyzed for various contaminants as part of the WSTMP Exploratory Monitoring component. Six annual reports have been published (www.ecy.wa.gov/programs/eap/toxics/wstmp.htm). Results from all studies are available in Ecology's Environmental Information Management database (EIM) at www.ecy.wa.gov/eim/.

The Long-Term Monitoring component for organic PBTs began in 2009. This effort targets specific sites, species, and analytes with the goals to (1) determine near order-of-magnitude changes over time in levels of organic PBTs in fish tissue and (2) provide data to the Washington State Department of Health (Health) and local agencies for evaluating the risks of eating contaminated fish. The Long-Term component will:

- Focus on sites with known high levels of contaminants such as where Water Cleanup Plans or Fish Consumption Advisories for PBTs exist. Such sites are likely to garner attention from Ecology, Health, Tribes, local governments, and the public for many years.
- Conduct sampling at selected sites on an approximate five-year cycle and maintain the same sampling season as historical data in order to reduce seasonal variability.
- Target analytes most often found at higher levels such as: polychlorinated biphenyls (PCBs), chlorinated pesticides such as dichloro-diphenyl-trichloroethane (DDT) and its metabolites, and polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs or dioxins/furans).
- Allow flexibility in site selection over time and help maximize opportunities for complementary efforts, particularly with other groups concerned with the quality of these waters and in determining progress in reducing contaminant levels.

Ecology and Health are developing strategies to reduce PBTs in our environment. These strategies involve learning more about the sources, uses, risks, and fate of these compounds. Mercury and the PBDE flame retardants were the first PBTs for which chemical action plans were developed (www.ecy.wa.gov/programs/swfa/pbt/). Appendix A highlights some of the contaminants of concern for fish tissue.

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 (Appendix B) are being met. Contaminant concentrations in fish tissue that do not meet water quality standards are not necessarily high enough to warrant fish consumption advisories to eat less fish. Health evaluates the need for consumption advice based on multiple factors, including amounts consumed and the benefits of eating fish as part of a healthy diet.

Appendix C describes how fish tissue data are used by Ecology and Health. Health provides information to the public about the benefits and risks of eating fish, and addresses areas where fish consumption advisories currently exist (www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm).

Study Design

Both monitoring components of the WSTMP, Exploratory and Long-Term, were pursued in 2010. Table 1 summarizes the monitoring goals for each site sampled. Figure 1 shows locations of sample sites.

Lake Chelan had the largest historical data set available for comparisons for the Long-Term component because of the Total Maximum Daily Load (TMDL) study done in 2003 for DDT and PCBs (Coots and Era-Miller, 2005). The Wenatchee River, Banks Lake, and Potholes Reservoir had some historical data that could be compared to the 2010 Long-Term effort. The 2010 effort also aimed to provide larger data sets to which future monitoring efforts could make comparisons to. Wenatchee Lake, sampled as part of the Exploratory Monitoring component, would also serve as part of a spatial characterization of PCBs in fish from the Wenatchee River basin.

The Lake Chelan and Wenatchee River sites provided opportunity to complement other efforts in these basins. We worked with Ecology's Central Regional Office (CRO) to involve local groups in the sampling efforts and announced the effort prior to sampling (Seiders, 2010). Local stakeholders comprise the Watershed Planning Units and Water Quality Subcommittees in place for each of these watersheds. These groups and their efforts are part of the cumulative response to water quantity and water quality concerns which arose from other work in Lake Chelan (www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/tmdl-wria47.html) and the Wenatchee River basin (www.ecy.wa.gov/programs/wq/tmdl/WenatcheeMulti/index.html). Chelan County's Natural Resources Department (NRD) is the lead entity for these planning and implementation efforts (www.co.chelan.wa.us/nr/water_resources/).

Table 1. Summary of Monitoring Goals for Each Site Sampled in 2010.

Site	Goals			Long-Term Characteristics			Comment
	Exploratory Monitoring	Long-Term Monitoring	Prep Methods: Skin-on vs Skin-off	Target Analyte	Target Species	Year of Historical Data and Reference	
Lake Chelan	X	X	X	DDTs	LKT	2003: A	Exploratory - fuller characterization of other PBTs
Wenatchee River	X	X	X	PCBs	MWF	2003: B,C	Exploratory - fuller characterization of other PBTs
Wenatchee Lake	X						Little historical data
Banks Lake		X		PCDD/Fs	LWF	2003: D	Supports WDFW interest in LWF management options
Potholes Reservoir		X		PCDD/Fs	LWF	2005: C	Limited data yet gives perspective on Banks Lake LWF
Lake Ozette	X						Supports Makah Nation interest in PBTs in returning sockeye salmon

Fish species codes: LKT = lake trout, MWF = mountain whitefish, LWF = lake whitefish.
Historical data references: A - Coots and Era-Miller, 2005; B - Era-Miller, 2004; C - Seiders et al., 2007; D - Seiders et al., 2006.
WDFW = Washington Department of Fish and Wildlife.

For Lake Chelan and the Wenatchee River, there was local interest in how different sample preparation methods, specifically the use of skin-on or skin-off fillets, might affect the concentration of target contaminants in fillet tissue and the fish consumption advisories in place. We responded to this interest by preparing some samples both ways to see if any difference existed.

Efforts in the Wenatchee River focused on the high levels of PCBs found in fish during previous studies. Little work has been done to determine the sources of PCBs in this basin beyond sampling conducted in and near the Leavenworth National Fish hatchery which is operated by the U.S. Fish and Wildlife Service (USFWS, 2005). The USFWS sampling concluded that the hatchery was not a significant source of PCBs or pesticides to Icicle Creek.

The Yakama Nation's continuing concern about the high levels of PCBs in Wenatchee River fish led to a collaborative effort to screen river sediment for PCBs at sites and times concurrent with the 2010 fish collection efforts. The Yakama Nation collected the sediment samples, Ecology conducted the analyses, and Ridolfi, Inc. reported results of the survey (Ridolfi, 2011a). PCBs were found only in soils at the site of an old hydropower plant in Tumwater Canyon. Additional soil sampling by the Yakama Nation at the site found PCBs (Ridolfi, 2011b). The work to date shows that additional efforts are needed to identify sources of PCBs in the basin.

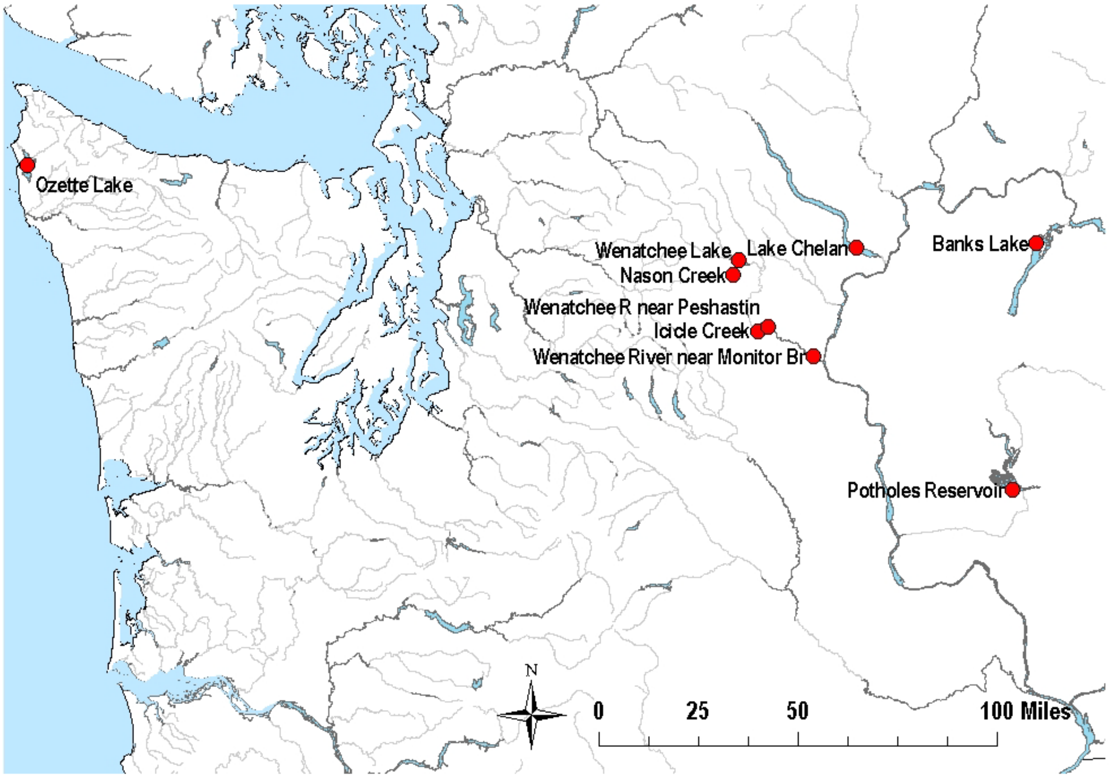

Figure 1. Fish Collection Sites for WSTMP 2010.

The Banks Lake work was a cooperative effort between the Washington Department of Fish and Wildlife (WDFW) and the WSTMP. Lake whitefish were collected by WDFW and analyzed by Ecology in order to provide information about contaminant levels in the fish and help determine fishery management strategies. Lake whitefish from Potholes Reservoir were also collected by WDFW and provide a comparison to fish from Banks Lake.

Sockeye salmon from Ozette Lake were sampled as part of a collaborative effort with the Makah Nation to address concerns about mercury (Furl, 2011). The WSTMP analyzed some of these fish for a broader range of organic contaminants which also supported the Makah Nation's concerns about PBTs in returning Lake Ozette sockeye salmon. These salmon are listed as Threatened under the Endangered Species Act.
(www.nwr.noaa.gov/ESA-Salmon-Listings/Index.cfm).

Methods

Field Procedures

The collection, handling, and processing of fish tissue samples for analyses were guided by methods described by EPA (2000) and Ecology's standard operating procedures (SOPs) (Sandvik, 2006 a, b, c). The collection and processing varied slightly among sites in order to maximize the comparability of the 2010 results to historical data.

Fish Collection

The sampling goals for each site guided the target fish species and the time and method of collection. Most fish were collected in the fall near the time of historical collections. Fish from Lake Chelan were collected during late spring to match the timeframe in which the 2003 fish were collected. The 2010 effort also aimed to increase the number of samples available for analyses compared to the number of samples collected during historical work.

Fish were captured by angling, gillnetting, or electrofishing. Captured fish were identified to species, and target species were retained while non-target species were released. Retained fish were inspected to ensure that they were acceptable for further processing (e.g., proper size – smallest fish at least 75% the length of largest fish in the sample, no obvious damage to tissues, skin intact). Field preparation of individual fish involved assigning an identification code, measuring length and weight, wrapping in foil and plastic zip-lock bags, and placing on ice for transport to a freezer for storage at -20 C.

Fish were collected using various methods:

- Lake Chelan - Trolling from boats hired or volunteered through local fishing guides: Darrel and Dad's Charter service, Don Talbot of Hooked on Toys, and Lake Chelan Adventures. Boat crews were provided by Ecology headquarters (HQ) in Lacey, CRO in Yakima, Chelan County NRD, Chelan-Douglas Health District (HD), and Chelan Public Utility District (PUD).
- Wenatchee River - Angling from riverbank. Angling participants included Don Talbot, Ecology HQ and CRO, Chelan NRD, Chelan-Douglas HD, and the Yakama Nation. Fish collection goals were only partially met because of challenging conditions such as high flows and snow.
- Banks Lake and Potholes Reservoir – Fish were collected by WDFW using gillnets.
- Lake Wenatchee – Angling from boat by Ecology.
- Lake Ozette – the Makah Nation provided sockeye salmon that returned to the Umbrella Creek hatchery.

Fish retained for later analyses were given a unique identifying code, measured for length and weight, individually wrapped in aluminum foil, put in plastic bags, placed in an iced cooler, and transported to freezer storage at Ecology headquarters in Olympia, WA. Fish were processed at a later date to form samples that would be sent to the laboratory for analysis.

Sample Preparation

Frozen fish were processed at Ecology's headquarters. Individual fish were assigned to composite samples based on the sampling goals for individual sites. Composite samples were used because they reduce the variability in contaminant levels that are often seen in individual fish, and they provide adequate tissue material for varied laboratory analyses. Generally, the 2010 effort tried to replicate the historical methods used to assign fish to composite samples, grouping by either total length or weight to match sizes of fish used in historical samples. In some cases where many fish were available to form multiple composite samples of similar size class, fish were randomly assigned to composite samples (e.g., Banks Lake).

For most samples, the edible portions (fillets) of individual fish were used to create composite samples. Composite samples were made up of five or more individual fish of similar size (e.g., the smallest fish being at least 75% the length of the largest fish in the composite sample). Two of the four samples of sockeye salmon from Lake Ozette were also processed as whole fish, rather than fillets, to better characterize the contaminant burden present in whole fish returning to the Lake Ozette watershed.

Individual fish selected for a specific composite sample were processed at the same time. Fish were partially thawed, and fillets were removed and cut into smaller pieces. One or both fillets were removed from the fish, depending on the fish size and sample mass required for laboratory analysis. Pieces of fillet tissue were then passed through a Kitchen-Aid food processer into a stainless steel bowl three times in order to grind and homogenize the tissue sample. Equal amounts of the ground and homogenized tissue from each fillet were then combined and homogenized to form a single composite sample. This composite was then passed once again through the grinder. An aliquot (30-90 grams) of the homogenized composite tissue was put in pre-cleaned jars (I-Chem 200 or 300) labeled for specific analyses and stored frozen until transport to the Ecology/EPA Manchester Environmental Laboratory (MEL).

To address questions about how results from skin-on and skin-off preparation techniques might differ, both methods were used on selected fish from Lake Chelan and the Wenatchee River. For each fish used in selected samples, skin-on and skin-off fillets were prepared as described above. The five skin-on fillets formed one composite sample, and the skin-off fillets formed the other composite sample. It was assumed that any substantial difference between the two samples would be due to the presence or absence of skin in the sample.

After fillets were removed from the fish, the abdominal cavity of the fish was opened to determine gender. Fish scales, otoliths, or other structures were removed for age determination by Washington Department of Fish and Wildlife (WDFW) biologists in Olympia, WA. All utensils used for tissue processing were cleaned to prevent contamination of the sample. The cleaning procedure involved soap and water washes followed by acid and solvent rinses. Sample collection and processing details are described in SOPs. (Sandvik, 2006 a, b, c).

Laboratory Methods

Table 2 describes analytical methods used in this study. MEL performed most analyses. AXYS Analytical Lab, of British Columbia, conducted analyses for PCDD/Fs. Results for all analytes (except lipids and mercury) 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. All results for fish tissue are reported on a wet-weight basis. Other conventions for reporting results are described below.

Table 2. Analytical Methods for Fish Tissue Samples, WSTMP 2010.

Parameter	Note	Description	Method	Reporting Limit (wet-weight basis)
Mercury	-	CVAA	EPA 245.6	17 ug/kg
Chlorinated Pesticides	Full list: 33 analytes	GC/ECD	EPA 8081	0.5 - 2.0 ug/kg
	4,4'-DDT, -DDE, -DDD only	GC/ECD	EPA 8081	0.5 - 2.0 ug/kg
PCB Aroclors	Full list of aroclors	GC/ECD	EPA 8082	1.0 ug/kg
	3 aroclors only: 1248, 1254, 1260	GC/ECD	EPA 8082	1.0 ug/kg
PBDEs (13 congeners)	-	GC/MS SIM	EPA 8270	0.5 - 1.0 ug/kg (except PBDE 209 which is 6-25 ug/kg)
PCDD/PCDFs (17 congeners)	-	HiRes GC/MS	EPA 1613B	0.00005 - 0.0030 ug/kg (each congener)
Lipids - percent	-	gravimetric	MEL SOP 730009	0.1%

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

Results from some groups of target analytes are summed to account for their additive effects and simplicity of comparison to other efforts. For historical comparisons in this report, total DDT is defined as the sum of the 4,4' isomers of DDD, DDE, and DDT. Total PCB is expressed as the sum of PCB Aroclors 1248, 1254, and 1260.

The target PCDD/Fs of concern were the 17 most toxic congeners. These congeners have different levels of toxicity compared to 2,3,7,8-TCDD, the most toxic congener. To account for the additive effects of all congeners, we use the EPA (2002) and international (Van den Berg et al., 2006) convention of expressing the cumulative toxicity of mixtures of congeners as a toxic equivalent (TEQ) to 2,3,7,8-TCDD. This TEQ is calculated by multiplying the result for each congener by its congener-specific toxicity equivalent factor (TEF) and then summing the products (which are congener-specific TEQs) to obtain the 2,3,7,8-TCDD TEQ. For the remainder of this report, TCDD is used in place of 2,3,7,8-TCDD.

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.

Results

Overview

Results are presented and discussed for each site in separate sections in the Discussion section below. Each section describes sample location, fish collected, composite sample formation, comparison to historical data, skin-on versus skin-off preparation, results for other PBTs, comparisons to water quality standards and screening levels, and conclusions for the site. Statistical approaches are described where used.

Summaries of results are presented in this report. Table E-1 gives physical characteristics and composite sample assignment for each fish used. Table G-1 summarizes key analytical results for each composite sample. Full results for all samples are in Ecology's Environmental Information Management (EIM) database (www.ecy.wa.gov/eim/). For this project, search User Study ID "WSTMP10". Historical data used for comparison to the 2010 results can also be found in EIM.

Table 3 identifies composite samples and shows the suite of analyses performed on each. Sample information includes field and lab identifiers. The "Sample Field ID" is coded with sample information such as location, species, size, and skin-on or skin-off. In many cases where multiple samples from the same site were available, analyses were done only for three DDT analogs (4,4'-DDT, 4,4'-DDE, and 4,4'-DDD) and three PCB Aroclors (1248, 1254, and 1260) to reduce costs.

The names and abbreviations of fish collected from different sites in 2010 are:

- Cutthroat trout (*Oncorhynchus clarki*), CTT.
- Lake trout (*Salvelinus namaycush*), LKT.
- Lake whitefish (*Coregonus clupeaformis*), LWF.
- Mountain whitefish (*Prosopium williamsoni*), MWF.
- Northern pikeminnow (*Ptychocheilus oregonensis*), NPM.
- Sockeye salmon (*Oncorhynchus nerka*), SOK.

Data Quality

Data quality for the 2010 sampling effort was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. MEL prepared case narratives for each set of analyses. The entire data package for dioxin and furans from Test America West Sacramento was reviewed by MEL who developed a case narrative for these data. 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, laboratory duplicates, and field replicates.

Table 3. Sample Analysis Plan, WSTMP 2010.

Site	Sample Information					Lab Analyses			
	Sample Field ID*	MEL Sample ID	# Fish in Sample	Skin status	Collect Date	3 PCBs, 3 DDTs, lipids	Pesticide, PCB, PBDE, lipids	Dioxin/ Furans, lipid	Mercury
Chelan L	C-L1-OFF	1101016-41	5	off	6/3/10		1		1
Chelan L	C-L1-ON	1101016-42	5	on	6/3/10		1	1	1
Chelan L	C-M1-OFF	1101016-35	5	off	6/3/10	1			1
Chelan L	C-M1-ON	1101016-36	5	on	6/3/10	1			1
Chelan L	C-M3-OFF	1101016-32	5	off	6/3/10	1			1
Chelan L	C-M3-ON	1101016-31	5	on	6/3/10	1		1	1
Chelan L	C-M4-OFF	1101016-40	5	off	6/3/10	1			1
Chelan L	C-M4-ON	1101016-39	5	on	6/3/10	1			1
Chelan L	C-S1-OFF	1101016-27	5	off	6/3/10		1		1
Chelan L	C-S1-ON	1101016-28	5	on	6/3/10		1	1	1
Chelan L	C-S2-OFF	1101016-33	5	off	6/3/10	1			1
Chelan L	C-S2-ON	1101016-34	5	on	6/3/10	1			1
Chelan L	C-S3-OFF	1101016-37	5	off	6/3/10	1			1
Chelan L	C-S3-ON	1101016-38	5	on	6/3/10	1		1	1
Chelan L	C-S4-OFF	1101016-29	5	off	6/3/10	1			1
Chelan L	C-S4-ON	1101016-30	5	on	6/3/10	1			1
Chelan L	C-S5-OFF	1101016-43	5	off	6/3/10		1		1
Chelan L	C-S5-ON	1101016-44	5	on	6/3/10		1	1	1
Wenatchee R nr Monitor	WM-L-OFF	1101016-17	5	off	12/7/10		1		1
Wenatchee R nr Monitor	WM-L-ON	1101016-16	5	on	12/7/10		1	1	1
Wenatchee R nr Monitor	WM-S-OFF	1101016-19	5	off	12/7/10		1		1
Wenatchee R nr Monitor	WM-S-ON	1101016-18	5	on	12/7/10		1	1	1
Wenatchee R nr Peshastin	WP-L-OFF	1101016-22	5	off	11/15/10		1		1
Wenatchee R nr Peshastin	WP-L-ON	1101016-23	5	on	11/15/10		1	1	1
Wenatchee R nr Peshastin	WP-S-OFF	1101016-20	5	off	11/15/10		1		1
Wenatchee R nr Peshastin	WP-S-ON	1101016-21	5	on	11/15/10		1	1	1
Icicle Crk	IC-L-OFF	1101016-10	5	off	12/7/10		1		1
Icicle Crk	IC-L-ON	1101016-09	5	on	12/7/10		1	1	1
Icicle Crk	IC-M-ON	1101016-11	5	on	12/7/10	1			1
Icicle Crk	IC-S-ON	1101016-12	5	on	12/7/10	1			1
Nason Crk	NS-L-ON	1101016-15	5	on	11/3/10		1	1	1
Nason Crk	NS-M-ON	1101016-14	5	on	11/3/10	1			1
Nason Crk	NS-S-ON	1101016-13	5	on	11/3/10	1			1
Wenatchee L	WENLKCTT	1101016-07	4	on	10/13/10		1		1
Wenatchee L	WENLKNPM	1101016-08	5	on	10/13/10		1	1	1
Banks L	BnkLWF-L1	1101016-01	5	on	10/14/10		1	1	1

Site	Sample Information					Lab Analyses			
	Sample Field ID*	MEL Sample ID	# Fish in Sample	Skin status	Collect Date	3 PCBs, 3 DDTs, lipids	Pesticide, PCB, PBDE, lipids	Dioxin/ Furans, lipid	Mercury
Banks L	BnkLWF-L2	1101016-04	5	on	10/14/10	1		1	1
Banks L	BnkLWF-L3	1101016-06	5	on	10/14/10	1		1	1
Banks L	BnkLWF-S1	1101016-02	5	on	10/14/10		1	1	1
Banks L	BnkLWF-S2	1101016-03	5	on	10/14/10	1		1	1
Banks L	BnkLWF-S3	1101016-05	5	on	10/14/10	1		1	1
Potholes Reservoir	PotLWF-1	1101016-24	4	on	10/20/10		1	1	
Potholes Reservoir	PotLWF-2	1101016-25	4	on	10/20/10	1		1	
Potholes Reservoir	PotLWF-3	1101016-26	3	on	10/20/10	1		1	
Ozette L	OZSOK-FF	1101016-47	5	on	10/29/09		1	1	
Ozette L	OZSOK-FM	1101016-48	4	on	10/29/09		1	1	
Ozette L	OZSOK-WF	1101016-45	4	on	10/29/09		1	1	
Ozette L	OZSOK-WM	1101016-46	8	on	10/29/09		1	1	

*Field ID coding: For Lake Chelan and Wenatchee R samples: site-size-skin.
For other sites: site-species-size.
For Lake Ozette: site-species-Whole or Fillet, Female or Male.

The quality of historical data was assessed by reviewing data quality sections in the published reports. All data were deemed acceptable as originally qualified except for cases where the historical analytical methods differed from those used in 2010. These cases for lipids, dioxins/furans, and mercury are addressed in the pertinent report sections.

Appendix F contains an overview of data quality, a summary of laboratory case narratives, and concerns with some lipids results and holding time exceedances. Other quality assurance information is available by contacting the authors of this report.

Overall, the 2010 data met most quality control criteria defined by MEL and the Quality Assurance Project Plan (Seiders and Yake, 2002). The measurement quality objectives in the project plan were met in most cases, and all results were deemed usable as qualified. Some data were qualified due to challenges encountered in analyses.

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Discussion

Lake Chelan

Sample Characteristics and Comparability to Historical Data

Fifty-five lake trout were collected on June 3 and 4, 2010, from the Wapato Basin of Lake Chelan in areas commonly frequented by fishing guides and anglers (Figure 2). The assignment of the 2010 fish to composite samples was based on weight in order to mimic the 2003 sampling effort for the Lake Chelan TMDL study (Coots and Era-Miller, 2005). The 2010 fish were ranked by weight and then graphically matched to the weight-ranked fish collected in 2003. Individual fish from 2010 were then assigned to composite groups that matched, as best possible, the weights of individual fish used in specific composite samples in 2003.

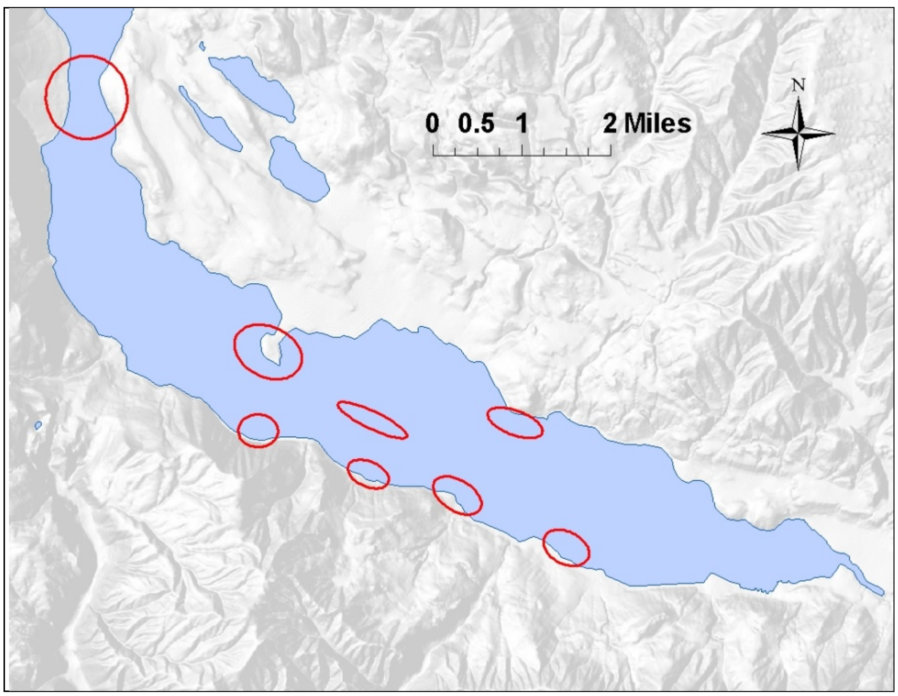

Figure 2. Areas in the Wapato Basin of Lake Chelan Where Fish Were Collected in 2010.

The 2010 fish yielded 18 composite samples (nine using skin-on and nine using skin-off fillets) from fish that were similar in weight to the fish used in nine of ten composite samples of skin-on fillets analyzed in 2003. These samples from 2003 (n=9) and 2010 (n=9) are likely the most comparable based on size and preparation method.

Other comparisons between the 2010 and other 2003 data sets were also possible. A tenth composite sample from 2003 was much larger in size than others from 2003 and 2010 (mean total length of 714 mm and mean weight of 3875 g) and was excluded from initial comparisons because of its much larger size; this sample was later included in some comparisons. The 2003 sampling effort also analyzed 30 individual fish for DDT and PCB compounds. The weights of these 30 fish spanned the range of the fish used in the 2010 composite samples and were also used for comparisons.

Figure 3 shows the weights and total lengths of samples from 2003 and 2010. The similar range of fish sizes shown by samples between years supports their use in comparisons for various chemicals in fish tissue.

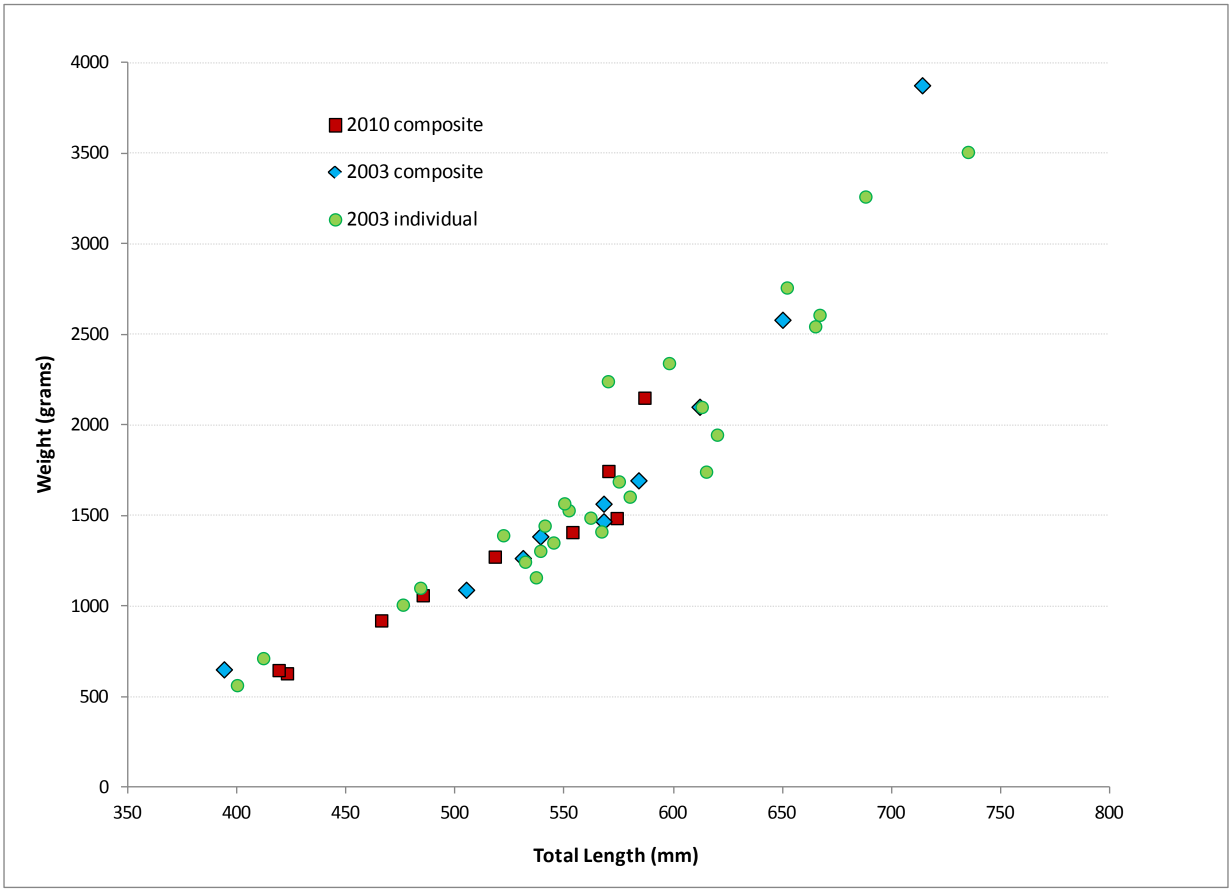

Figure 3. Lengths and Weights of Fish Used in Composite and Individual Samples from Lake Chelan in 2003 and 2010.

All 18 samples from Lake Chelan fish were analyzed for three DDT compounds (4,4'-DDT, -DDD, and -DDE), three PCBs (Aroclors 1248, 1254, and 1260), lipids, and mercury. Six samples were also analyzed for a larger suite of chlorinated pesticides, PCBs, and PBDE flame retardants, including the three DDTs and PCBs in the previous sentence. Five samples were analyzed for PCDD/Fs. Table 3 includes the analytical plan for the 2010 Lake Chelan samples.

Contaminant concentrations in fish are sometimes related to the size, age, or lipid content. Where relationships exist, they may help improve the sensitivity of tests to compare results among sites or over time. Results from 2010 were plotted to see whether the concentration of

DDTs were related to length, weight, age, or lipids. Linear regressions showed very weak relationships among DDTs and the physical factors of length, weight, lipids, or age. The technique of normalizing results for DDTs to these physical factors is therefore inappropriate.

Comparison to Historical Data

To compare the 2010 results to the 2003 results, sampling and analytical methods were reviewed to ensure that the methods used between years did not impart a bias to one or both data sets. The sampling methods used in 2010 were similar to those used in 2003: species, season, method and place of collection, formation of composite samples, and sample processing were the same. The analytical methods used were the same except for lipids and PCDD/Fs.

Lipids

For lipids, the gravimetric method was used in both years, yet the samples were treated with different solvents during the process. The 2010 lipids extraction solvent was methylene chloride. In 2003, the extraction solvent was a 1:1 acetone/hexane mix. The use of different solvents can lead to results that can vary by a factor of 2 or 3 (EPA, 2000) and thus prevent appropriate comparisons of the results. For consistency among fish contaminant monitoring efforts, EPA recommends that methylene chloride be used as the extraction solvent.

Figure 4 shows that the 2003 lipid levels are uncharacteristically lower than those from 2010. It seems likely that the 2003 lipid results are biased low relative to the 2010 results, so were deemed not comparable.

Dioxins and Furans

For PCDD/Fs, the 2003 samples were analyzed using EPA 8290 whereas the 2010 method used EPA 1613. Both methods are similar, using isotopic dilution with high resolution gas chromatography – high resolution mass-spectrometry (HRGC-HRMS) to determine the concentrations of the 17 toxic PCDD/Fs in various environmental media. Differences between these methods were judged less significant than other sources of variability in the monitoring efforts, so the results from the 2003 and 2010 analyses were deemed comparable.

Comparisons for DDT: 2010 versus 2003

The 2010 results were compared to several data sets from 2003 using boxplots: all composite samples (n=10), all composite samples except the one containing the heaviest fish (n=9); and all samples of individual fish (n=30). Figure 5 shows that the 2010 sample set had higher levels of t-DDT than all sample sets from 2003.

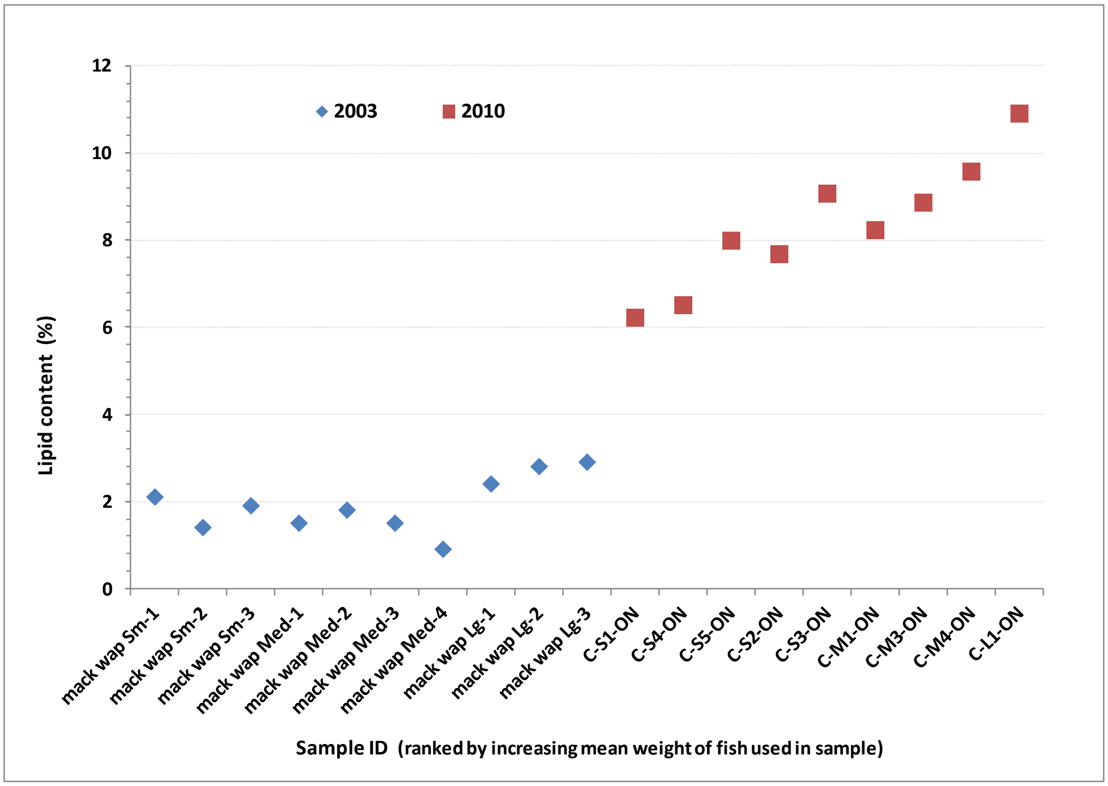

Figure 4. Results of Lipids Analyses on the 2003 and 2010 Fish Tissue Samples from Lake Chelan.

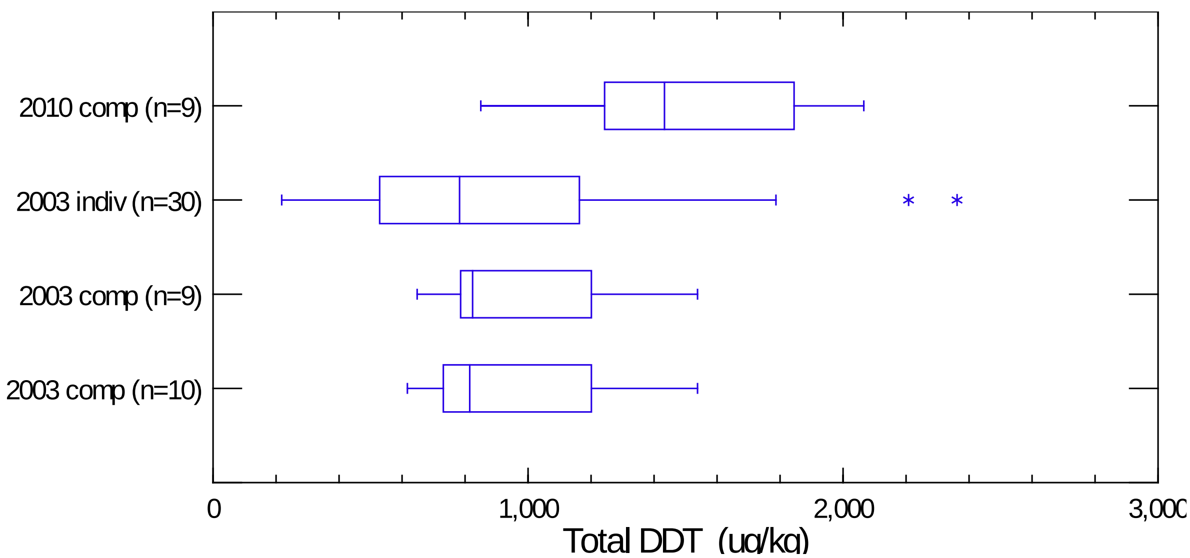

Figure 5. Boxplots of the 2003 and 2010 Results for Total DDT.

Boxplots show the range of results in a data set: the median is the vertical line within the box; the left and right ends of the box show the 25th and 75th percentiles, respectively; the horizontal lines extending from each end of the box show the range of results beyond the 25th and 75th percentiles; and the few dots beyond the ends of horizontal lines show outliers.

Two tests were then performed to determine if there were differences between the data sets from the two years: a two-sample t-test and a Mann-Whitney two-sample rank test (Zar, 1984; SYSTAT, 2007). The distribution-free Mann-Whitney test was added in case the assumptions for the two-sample t-test were not met.

These two tests indicate that the 2003 and 2010 data sets were different and that the differences were statistically significant. The 2010 mean t-DDT was 1505 ug/kg which was higher than each of the mean values from the 2003 data sets by 503-569 ug/kg, depending on which 2003 data set was used. Tables H-1 and H-2 show results from these tests.

To meet the assumptions of the two-sample t-test, the normality of distribution and equality of variances were confirmed. The Shapiro-Wilk test was used to test normality of distribution of sample results from 2003 and 2010. Results indicated that the samples came from a normal distribution. The data sets were tested for equality of variance to determine whether to use single variances (variances not equal) or pooled variance (variances equal) in applying the two-sample t-test. Two-tailed ratio tests for equal variances suggested that variances were equal. Table H-3 summarizes the tests for equal variance.

Comparison for DDT in Fish from Other Lakes

The lake trout from Lake Chelan are the only samples of that species collected so far in Washington. Comparing results from lake trout to results from other species introduces some bias in the comparison because bioaccumulation of contaminants can vary across species. When comparing all species sampled statewide, DDT levels in lake trout are among the highest 3% of 321 samples collected by the WSTMP since 2001. To compare Lake Chelan's lake trout to other lake trout, we looked at data collected during the National Study of Chemical Residues in Lake Fish Tissue (EPA, 2009). Figure 6 shows that DDT levels in lake trout from Lake Chelan are 10 to 100 times higher than from other lakes. These high levels have continued from 2000 (the EPA study) to this 2010 study.

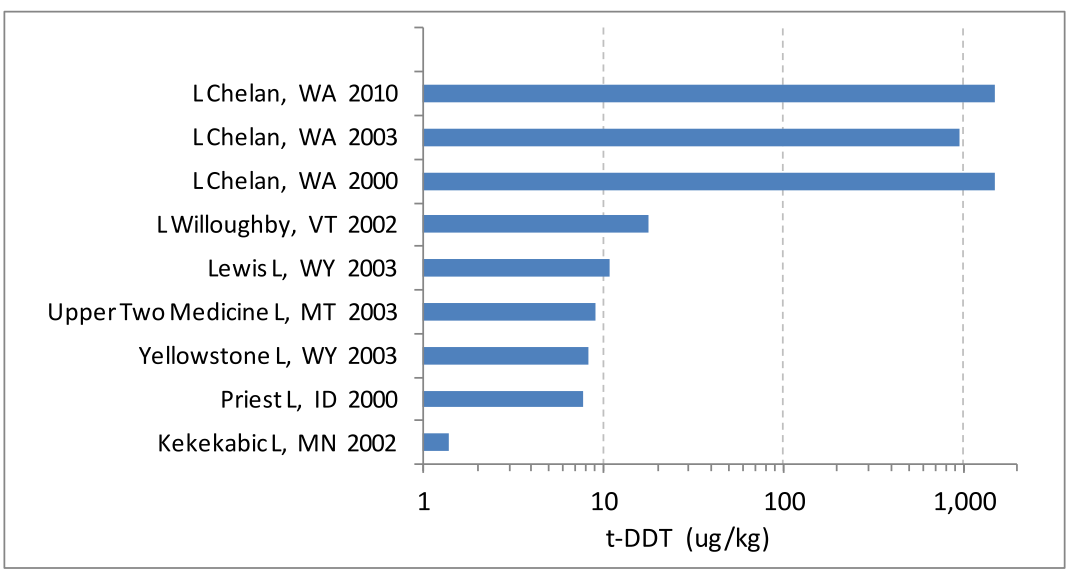

Figure 6. Comparison of DDT Levels in Lake Trout from Other Lakes.

Other PBTs and Comparisons to Standards and Screening Levels

Table 4 summarizes results for other contaminants that were measured in skin-on fillet samples taken from Lake Chelan in 2010. Some contaminants did not meet one or more water quality standards criteria or screening values shown in Table B-1. Dioxins and furans (expressed as TCDD TEQ) were found at levels up to three orders of magnitude greater than EPA's National Recommended Water Quality Criteria and EPA's Screening Values for Subsistence Fishers. Concentrations of the single congener TCDD were found up to nearly eight times (0.510 ng/kg) the value for Washington's Water Quality Standard (0.065 ng/kg). Total PCBs were mildly elevated compared to other fish in Washington and did not meet several criteria or screening values.

Table 4. Summary of Results for Lake Chelan Lake Trout, WSTMP 2010.

Field ID	C-S1-ON		C-S4-ON		C-S5-ON		C-S2-ON		C-S3-ON		C-M1-ON		C-M3-ON		C-M4-ON		C-L1-ON	
Sample ID (1101016-**)	28		30		44		34		38		36		31		39		42	
T-PCB (ug/kg)	**24.1**	J	**51**	J	**34.8**	J	**18**	J	**22**	J	**26.1**	J	**51.1**	J	**56.2**	J	**36**	J
T-PBDE (ug/kg)	18.3				31.1												44.7	J
T-DDT (ug/kg)	**1002**		**1243**		**1973**	J	**1831**		**850**		**1433**		**2066**		**1358**		**1880**	
T-Chlordane (ug/kg)	4.3				7.9	J											4.4	
TCDD TEQ (ng/kg)	**2.274**				**2.809**	J			**1.826**	J			**3.537**	J			**3.684**	
TCDD (ng/kg)	**0.350**				**0.410**				**0.220**	NJ			**0.410**	NJ			**0.510**	
Mercury (ug/kg)	**84.8**		**59.2**		**61.5**		**74.1**		**59.7**		**64.1**		**84.9**		**81.0**		**92.6**	
Lipid MEL (%)	6.22		6.51		7.99		7.67		9.07		8.23		8.86		9.57		10.9	
Mean Total Length (mm)	422.9		419.1		466.1		485.1		518.2		553.7		574.0		570.2		586.7	
Mean Weight (g)	630.4		648.0		922.2		1061.0		1274.0		1409.4		1486.8		1746.6		2151.0	

**The sample numbers in this row all begin with 1101016.
Values in **bold** do not meet water quality criteria or screening values in Table B-1.
J = The analyte was positively identified. The associated numerical result is an estimate.
NJ = The analyte was tentatively identified and the associated numerical value is an estimate.
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.

Many other contaminants were not detected or were detected at relatively low levels. Hexachlorobenzene was detected in only one of three samples (Field ID C-S5-on) at a level (1.08 ug/kg) that did not exceed Washington's water quality standard or EPA's Recommended Criterion (6.5 and 2.4 ug/kg, respectively). Toxaphene was not detected in samples, yet the reporting limit for toxaphene (10-60 ug/kg) was higher than some criteria or screening values. Dieldrin was not detected at reporting limits that were lower than criteria or screening values.

Conclusions

- Total DDT levels in lake trout from 2010 remain high. Levels are higher than they were in 2003.
- Lake trout also have high levels of dioxins/furans and PBDE flame retardants; levels of PCBs are mildly elevated. Other detected contaminants were at levels of lower concern.

Wenatchee River and Wenatchee Lake

Sample Characteristics and Comparability to Historical Data

Fifty-seven mountain whitefish were collected from four sites in November and December 2010: Wenatchee River near Monitor and Peshastin, Icicle Creek, and Nason Creeks. Figure 7 shows sites where fish were collected in 2003 and 2010. Four other sites were fished in 2010, yet no fish were caught: the Wenatchee River in Leavenworth and in Tumwater Canyon, the Chiwawa River by the WDFW hatchery, and Chumstick Creek near its mouth.

To compare the 2010 results to historical results, sampling and analytical methods were reviewed to ensure that the methods used among years did not impart a bias to one or more of the data sets. The sampling methods used in 2010 were similar to those used in 2003: species, season, and sample processing were the same. The places of collection were the same for some sites and different for others. The methods of collection also differed: the 2003 effort used boat electrofishing and boat-angling, while the 2010 effort used bank-angling only. The 2010 fishing effort did not obtain the desired numbers and sizes of fish resulting in smaller sample sizes and limited ability to perform the desired temporal and spatial comparisons.

Yet some composite samples were formed that would be comparable to samples from the 2003 effort, based on length. For each site, the fish collected in 2010 were ranked by total length and then graphically compared to the length-ranked fish collected in 2003. The individual fish from 2010 were then assigned to composite samples that matched, as best possible, the lengths of individual fish used in specific composite samples in 2003. Each composite sample for 2010 used five fish that were usually within a similar size range. Figure 8 shows how the total lengths of fish were distributed among the 2010 and historical samples for various sites.

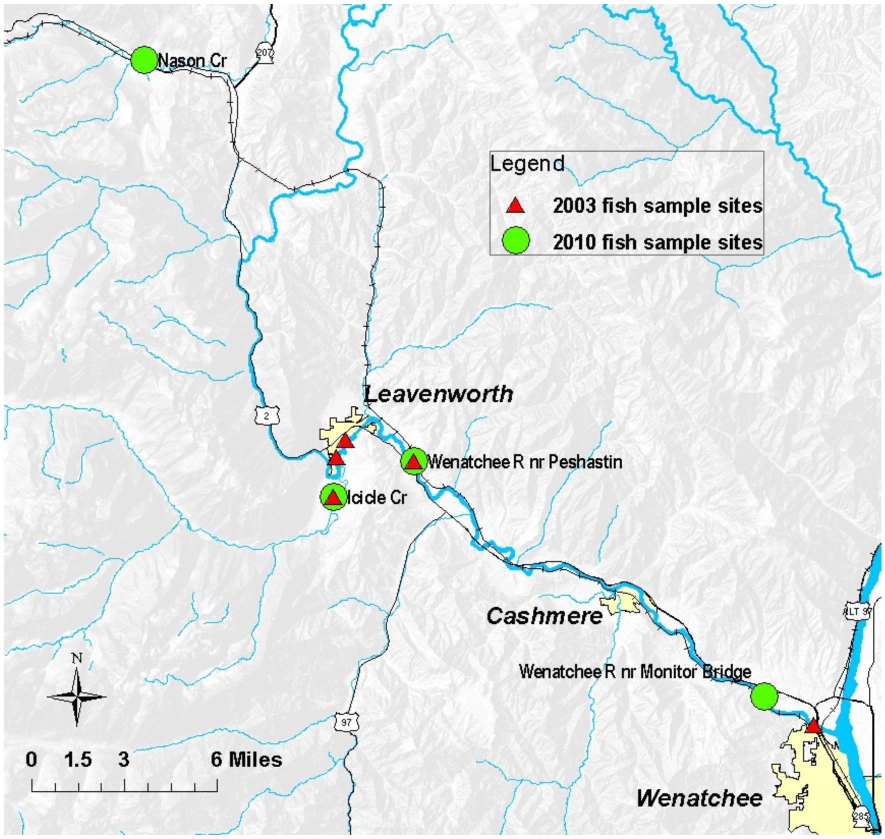

Figure 7. Sites in the Wenatchee River Basin Where Mountain Whitefish Fish Were Collected in 2003 and 2010.

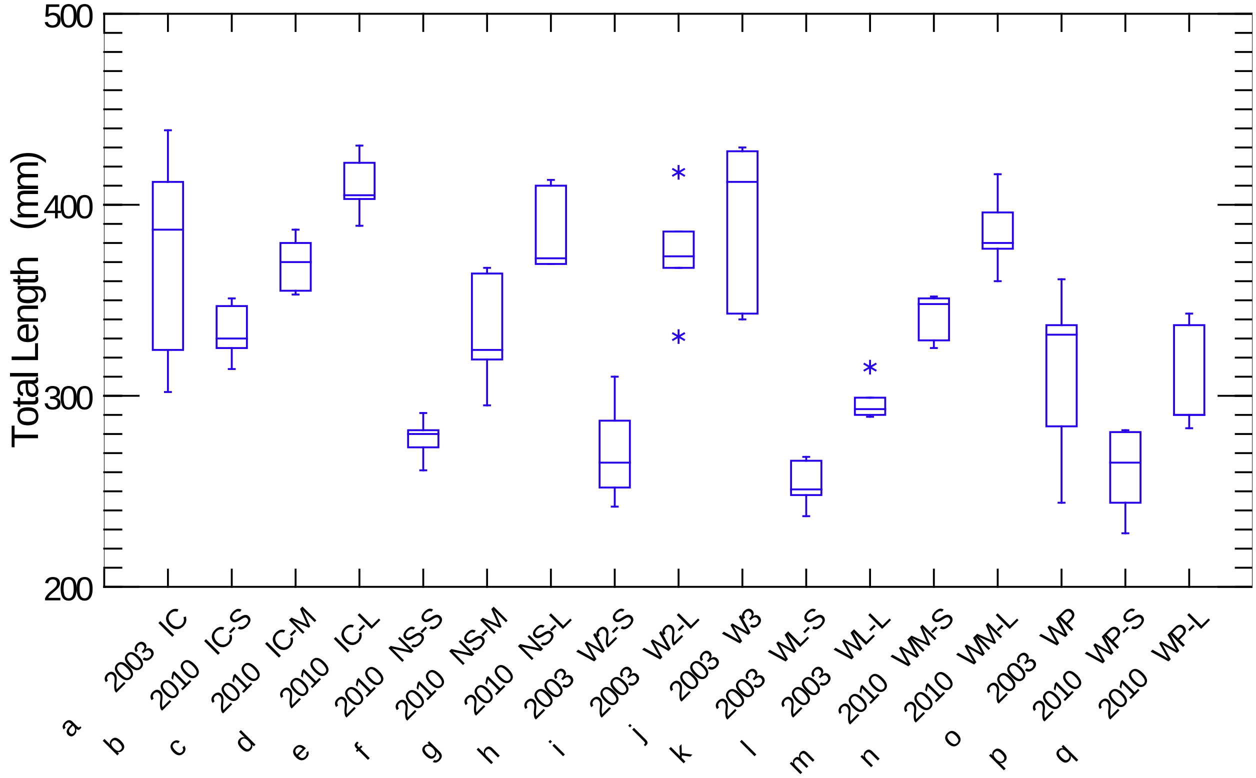

Figure 8. Boxplots Showing Total Lengths (in millimeters) of Fish Used in Composite Samples from the Wenatchee River in 2003 and 2010.

Key to Sample ID Coding:
IC – Icicle Cr, a-d.
NS – Nason Cr, e-g.
W2 – Blackbird Is, h-i.
W3 – Golf Course, j.
WL – lower river, k-l.
WM – Monitor Br, m-n.
WP – above Peshastin, o-q.
S – small size, M – medium size, L – large size
(sizes are relevant to fish collected at site at time of sampling).

Multiple samples were collected in 2010 at the two tributaries. For Icicle Creek (Figure 8, a-d), the 2003 effort had a single composite sample, while the 2010 effort yielded three composite samples having fish of different size ranges that spanned the lengths of the five fish used in the 2003 composite. Nason Creek was sampled in 2010 only and yielded three composite samples of different size classes (Figure 8, e-g).

Two sites where the 2003 effort collected fish yielded no fish in 2010: Wenatchee River in Leavenworth by Blackbird Island and Wenatchee River in Leavenworth by the downstream end of the golf course (Figure 8, h-j). The lower Wenatchee River site was not sampled in 2010 because of its proximity to the Columbia River; this site yielded small and large size classes of fish in 2003.

The Wenatchee River near Monitor (Figure 8, m-n) yielded small and large sizes of fish in 2010, which were assigned to two different composite samples. These fish were of larger size than those collected at the lower Wenatchee site in 2003 (Figure 8, k-l).

The Wenatchee River upstream of Peshastin yielded small and large sizes of fish in 2010, which were assigned to two different composite samples. This site was represented by a single composite sample in 2003 (Figure 8, o-q).

The analysis plan for the Wenatchee River samples is shown in Table 3. Laboratory analyses include DDTs, PCBs, and mercury on all samples, with selected samples analyzed for dioxins/furans, PBDE flame retardants, and other chlorinated pesticides. Skin-on and skin-off samples were taken from some groups for a total of 15 samples (10 skin-on and 5 skin-off).

As discussed in the Lake Chelan section, contaminant concentrations in fish are sometimes related to the size, age, or lipid content. Where relationships exist, they may help improve the sensitivity of tests to compare results among sites or over time. Results from 2010 were plotted to see whether the concentration of PCBs related to fish length, weight, age, or lipids. Linear regressions showed very weak relationships among PCBs and the physical factors of length, weight, lipids, or age. The technique of normalizing PCB data to these physical factors is therefore inappropriate.

Comparison to Historical Data

Temporal comparisons are confounded by several factors, especially small sample size and uncertainty about what area of the river is represented by the whitefish that were collected. Adult mountain whitefish in other river basins have been known to move throughout the basin in relation to seasonal feeding and spawning behaviors (Wydoski and Whitney, 2003). Such behavior could influence the high variability seen in PCB levels. Keeping in mind the small sample size and representativeness concerns, some qualitative comparisons can be made

Figure 9 shows results from 2010 plotted with historical data from the same or nearby sites for total-PCBs. For reference, PCBs in whitefish from areas in the Columbia River upstream and downstream of Wenatchee range were all below 80 ug/kg (Seiders et al., 2007).

Results from the Monitor Bridge site in 2010 (267 - 1700 ug/kg) ranged higher than results from the 2003 effort (Era-Miller, 2004) at the Wenatchee River near Wenatchee site (267 - 542 ug/kg). Upriver near Peshastin, the 2010 results (19 - 79 ug/kg) were lower than the single 2003 sample of 331 ug/kg. Results from the two sites in Leavenworth, by Blackbird Island and by the golf course, showed a very wide range of results (43 - 1300 ug/kg). Icicle Creek results from 2010 and 2003 were somewhat similar, ranging from 35 to 109 ug/kg. Fish from Nason Creek had the lowest levels of PCBs (2.4 – 13 ug/kg), suggesting that these fish are above any significant sources of PCBs. Nason Creek fish have low levels and appear to represent an environment with minimal PCB contamination.

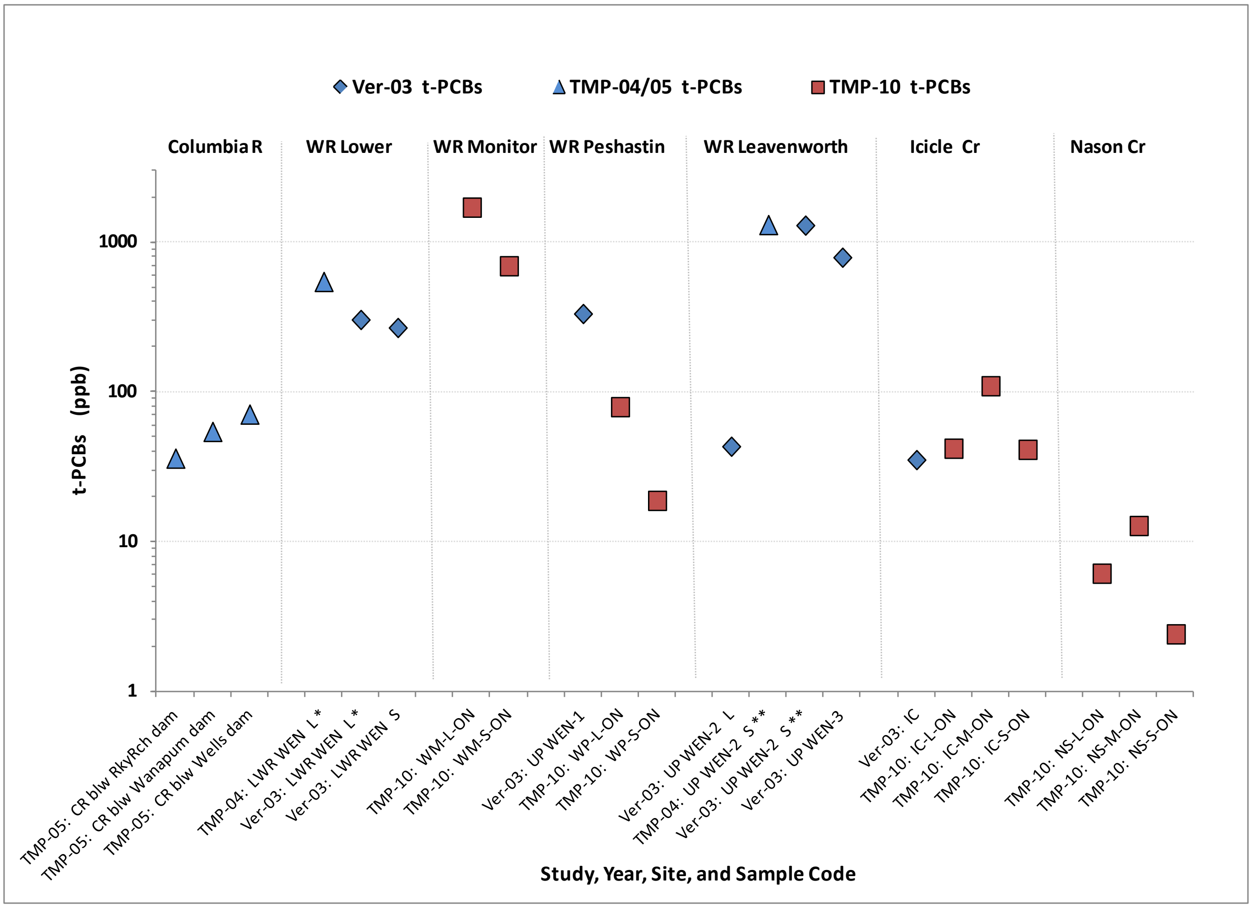

Figure 9. Total PCBs in Mountain Whitefish from the Wenatchee River, Icicle and Nason Creeks, and the Columbia River between 2003 and 2010.

Key to Study Year Site Sample Coding:
TMP-05 is WSTMP 2005 (Seiders et al., 2007).
TMP-04 is WSTMP 2004 (Seiders et al., 2007).
TMP-10 is WSTMP 2010 (this study).
VER-03 is a Verification Study (Era-Miller, 2004).
CR – Columbia R., WR – Wenatchee R.
LWR WEN – Lower Wenatchee R near Wenatchee.
WM – Wenatchee R near the Monitor Bridge.
Up WEN-1 – Wenatchee R near Peshastin.
Up WEN-2 – Wenatchee R near Leavenworth at Blackbird Is.
Up WEN-3 – Wenatchee R near Leavenworth at Golf Course.
WP – Wenatchee R near Peshastin (same site as Up WEN-1).
IC – Icicle Cr below fish hatchery.
NS – Nason Cr near Washington Department of Transportation rest area.
S – small size fish, M – medium size fish, L – large size fish
(sizes are relevant to fish collected at site at time of sampling).
Samples from 2003 that were analyzed a second time are designated "*" and **".

Levels of PCBs in Wenatchee River mountain whitefish are among the highest in Washington. Fish from the lower river near Wenatchee and Monitor Bridge have PCB levels that are in the highest 2% of the 322 samples analyzed by the WSTMP. PCB levels in fish from the Peshastin site range in the upper 28% of statewide values, while those from Icicle Creek are in the highest 15% of statewide values.

One picture from the 2010 and historical results that emerges is that PCB levels in Wenatchee River whitefish appear to increase in an upstream direction to the Leavenworth area. Yet the levels of PCBs in fish from the mainstem Wenatchee River sites within and between sample years are highly variable, suggesting high variance in the population being sampled. The high variability in PCBs could be due to several factors, such as:

- Seasonal movement/migration of fish within the river.
- Mixtures of older fish with younger fish within similar size class.
- Variation in feeding habits of whitefish and uptake of PCBs from sources.
- Multiple sources of PCBs.

Fish tissue data for the mainstem Wenatchee River above the Leavenworth area remain a data gap. Unfortunately, efforts to collect fish from Tumwater Canyon in 2010 were not successful.

Other PBTs and Comparisons to Standards and Screening Levels

Table 5 summarizes results for contaminants detected in skin-on fillet samples in mountain whitefish from the Wenatchee River taken in 2010. Contaminants that did not meet water quality standards criteria or screening values shown in Table B-1 were PCBs, DDTs, and dioxins/furans. Chlorinated pesticides that were detected below levels of concern for human health were chlorpyrifos, endosulfans, and chlordanes.

Table 5. Summary of Results for Wenatchee River, WSTMP 2010.

Field ID	WM-L-ON		WM-S-ON		WP-L-ON		WP-S-ON		IC-L-ON		IC-M-ON		IC-S-ON		NS-L-ON		NS-M-ON		NS-S-ON	
Sample ID (1101016-**)	16		18		23		21		09		11		12		15		14		13	
T-PCB (ug/kg)	**1700**	J	**690**	J	**79.0**	J	**18.7**	J	**41.7**	J	**109**	J	**41.0**	J	**6.1**	J	**12.7**	J	2.4	J
T-PBDE (ug/kg)	23.0		16.1		16.0	J	7.31	J	16.9						1.69	J				
T-DDT (ug/kg)	**174**	J	**59.1**	J	**73.6**	J	**34.3**		**50.6**		**64.4**		**42.3**		5.02		7.30		6.08	
2,3,7,8-TCDD TEQ (ng/kg)	**0.253**	J	**0.234**		**0.214**	J	**0.071**	J	**0.265**	J					**0.332**	J				
2,3,7,8-TCDD (ng/kg)	**0.097**	NJ	**0.053**	NJ	**0.040**	NJ	**0.043**	NJ	**0.071**	NJ					**0.074**	NJ				
Mercury (ug/kg)	**63.1**		37.8		40.8		30.5		**69.0**		46.4		33.4		**101**		**89.8**		**55.0**	
Lipid (%)	4.45		3.84		3.26		2.47		3.90		4.22		2.93		3.47		3.52		3.63	
Mean Total Length (mm)	385.8		341.0		308.6		260.0		410.0		369.0		333.4		386.6		333.8		277.4	
Mean Weight (g)	574.8		335.6		282.2		155.4		612.4		429.2		320.8		620.8		406.6		186.6	
Mean Age (years)	7.8		3.4		3.6		2.4		8.8		4.8		3.4		9.8		6.0		3.0	

Values in **bold** do not meet water quality criteria or screening values in Table B-1.
J = The analyte was positively identified. The associated numerical result is an estimate.
NJ = The analyte was tentatively identified and the associated numerical value is an estimate.
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.

Wenatchee Lake

Cutthroat trout and northern pikeminnow collected from Wenatchee Lake formed two composite samples, one for each species. Contaminant levels in both species were low, meeting all water quality standards or screening values with one exception: total-PCBs of 8.1 ug/kg in the northern pikeminnow sample exceeded one or more water quality standards criteria or screening values shown in Table B-1.

Wenatchee Lake served as a background site during a 1990 study that looked at dioxins/furans in Columbia River sportfish (Serdar et al., 1991). Levels of dioxins/furans in rainbow trout and mountain whitefish were also reported as low or not detected during the 1990 study.

Conclusions

- The 2010 sampling goals were only partly met due to poor angling conditions and catch success. Consequently, small sample sizes and fewer sampled locations led to weaker spatial and temporal comparability than was planned.
- Levels of PCBs in mountain whitefish remain high in the Wenatchee River. Fish from the Monitor Bridge area had the highest levels (690-1700 ug/kg). Samples from the mainstem near Peshastin and Icicle Creek had elevated levels (19-109 ug/kg). The Nason Creek samples showed low levels of PCBs (2.4-12.7 ug/kg) and likely represent background levels.
- The movement of mountain whitefish within a river system is a likely confounding factor in seeking differences among sites, especially sites that are relatively close to one another.
- Cutthroat trout and northern pikeminnow from Wenatchee Lake had low levels of contaminants relative to other areas of the state.

Comparison of Preparation Methods: Skin-on and Skin-off

Lake Chelan

Skin-on and skin-off fillets were taken from each fish used in the 2010 samples for a total of nine pairs of samples. Figure 10 shows results for five analytes that were measured using each preparation method. These results were tested for differences using paired-sample t-tests. Outcomes of these tests (Table H-4) suggest that there is no difference between results from the skin-on and skin-off preparation methods for t-DDT, t-PCB, t-PBDE, and lipids. A contributing factor to these outcomes is likely the variability associated with organic chemicals in fish tissue.

Results for mercury suggest that the different preparation methods do affect the level of mercury in samples, with the skin-on samples having slightly lower levels. Mercury is found in the muscle tissue of fish, so the addition of skin to the sample would act to dilute the concentration of mercury in the sample.

To meet the assumptions of the paired-sample t-test, the normality of distribution and equality of variances were confirmed. The Shapiro-Wilk test was used to test normality of distribution of sample results from 2003 and 2010. Results indicated that the samples came from a normal distribution. The data sets were tested for equality of variance to determine whether to use single variances (variances not equal) or pooled variance (variances equal) in applying the two-sample t-test. Two-tailed ratio tests for equal variances suggested that variances were equal. Table H-5 summarizes the tests for equal variance.

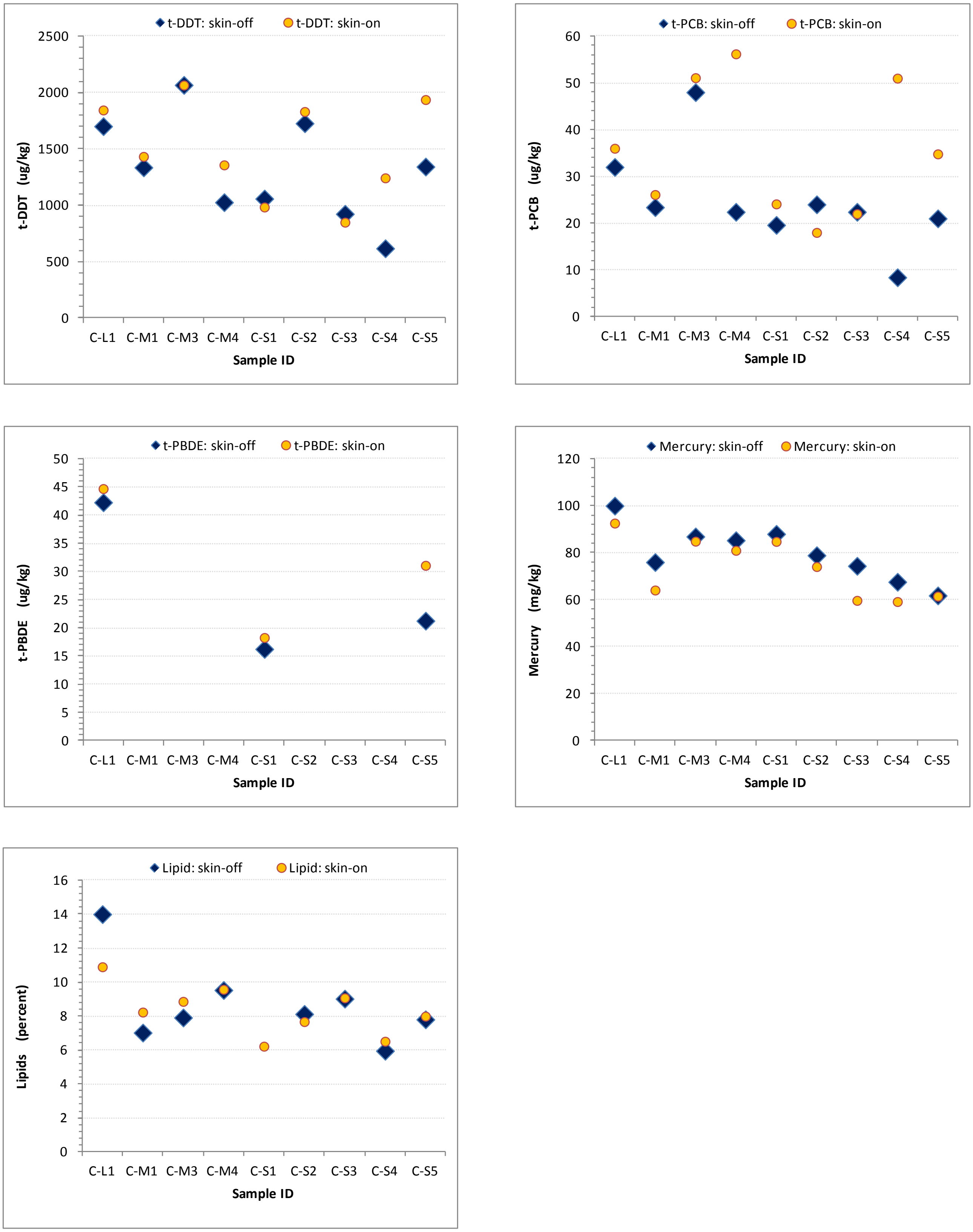

Figure 10. Results from Skin-on and Skin-off Sample Preparation Methods for Lake Trout from Lake Chelan.

Wenatchee River

Skin-on and skin-off fillets were taken from selected individual fish used in the 2010 samples for a total of five pairs of samples. Figure 11 shows results for five analytes that were measured using each preparation method. Paired t-tests were conducted in the same manner as for Lake Chelan samples described above. The tests suggest that there is no difference between results from the skin-on and skin-off preparation methods for t-DDT, t-PCB, t-PBDE, and lipids.

Results for mercury suggest that the different preparation methods do affect the level of mercury in samples. Again, a contributing factor to these outcomes is likely the variability associated with organic chemicals in fish tissue and a smaller variability associated with mercury.

Prior to the paired t-tests, the assumptions for normality and equal variance for the data sets were found to be valid. Tables H-6 and H-7 summarize results from these tests.

Conclusions

- No difference was found between results from the skin-on and skin-off preparation methods for t-DDT, t-PCB, t-PBDE, and lipids using fish from Lake Chelan and the Wenatchee River.
- Results for mercury indicate that the different preparation methods do affect the level of mercury measured in samples, with the skin-on sample having slightly lower levels.

Banks Lake

Sample Characteristics and Comparability to Historical Data

Thirty lake whitefish collected from Banks Lake were used to form six samples of five fish each. Three samples used fish from a small size class, and three samples used fish of a larger size class. Physical characteristics such as length, weight, age, and lipids were used to evaluate comparability of the 2010 samples to the 2003 samples (Table 6).

Table 6. Physical Characteristics of Lake Whitefish from Banks Lake, 2003 and 2010.

Sample ID: Site and Year	Date Collect	n	Mean Total Length (mm)	Mean Weight (g)	Mean Age (yrs)	Lipids (%)
Banks 2003 [A]	10/16/03	1	491.0	1107.3	10.0	6.6
Banks 2010-L	10/14/10	3	513.1 (5.0)	1490.3 (31.9)	8.9 (2.1)	7.0 (0.4)
Banks 2010-S	10/14/10	3	366.2 (8.6)	547.2 (17.1)	1.0 (0.0)	5.1 (0.2)

2010 values are the means of composite samples with standard error in parentheses.
A - Banks Lake sample Lab ID: 04064283.

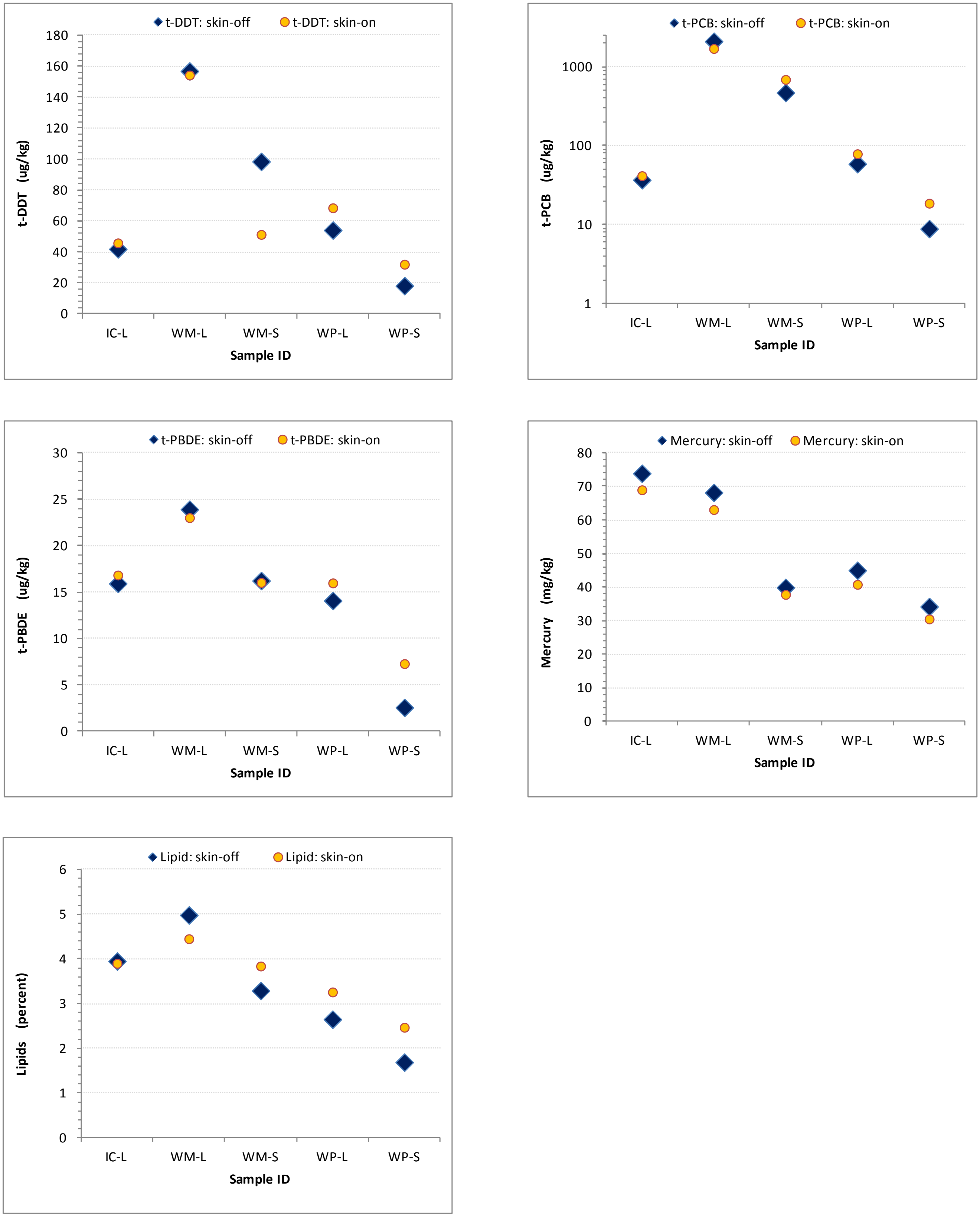

Figure 11. Results from Skin-on and Skin-off Sample Preparation Methods for Mountain Whitefish from the Wenatchee River and Icicle Creek.

The samples from the 2010 larger size class were deemed comparable to the single 10-fish composite sample from 2003 because of the similarities among the samples. Samples from the 2010 small size class contained fish that were much smaller and younger than those from 2003 and are not suitable for comparison to the 2003 samples.

Lake whitefish and other species were also collected as part of a study focused on mercury (Meredith et al., 2010).

Comparison to Historical Data

Table 7 shows that contaminant concentrations for most analytes were slightly lower in 2010 compared to levels seen in 2003. Relative percent differences (RPD) were 35%, 30%, and 43% for TCDD TEQ, T-PCB, and T-DDT, respectively. The difference for TCDD between years cannot be established because the 2003 value was qualified as a non-detect. Mercury is an exception because the 2010 mean value is about 10% higher than the 2003 value. A confounding factor in the comparison for mercury is the change in analytical methods used between the years. The data were not examined for statistically significant differences between the two years because of small sample size: only one sample was analyzed in 2003.

Table 7. Comparison of Results for Lake Whitefish from Banks Lake, 2003 and 2010.

Sample ID: Site and Year	Date collect	n	TCDD TEQ (ng/kg)	TCDD (ng/kg)	T-PCB (ug/kg)	T-DDT (ug/kg)	Mercury (ug/kg)
Banks 2003 [A]	10/16/03	1	**0.450**	0.130 U	**33.0**	35.1	80.4
Banks 2010-L	10/14/10	3	**0.315** (0.082)	**0.057** (0.006)	**24.4** (7.7)	**22.7** (2.0)	**90.5** (15.5)
Banks 2010-S	10/14/10	3	**0.071** (0.008)	**0.041** (0.002)	**5.3** (0.7)	3.5 (0.7)	31.5 (1.6)

Values in **bold** do not meet water quality criteria or screening values in Table B-1.
The 2010 values are the means of composite samples with standard error in parentheses.
A - Banks Lake sample Lab ID is 04064283.
U = The analyte was not detected at or above the reported value.

The consistent pattern of smaller concentrations in much of the 2010 data could suggest a true decrease between the years, especially for TCDD whose value approaches that found in the samples from the younger and smaller size class fish. The historically elevated levels of PCDD/Fs in fish from Banks Lake were likely due to elevated levels of PCDD/Fs in Lake Roosevelt, which is the source of water for Banks Lake. EPA and others are studying the contamination of Lake Roosevelt from a smelter and a pulp mill located in Canada (EPA, 2011).

Results from sampling at Potholes Reservoir in 2010 (next section) provide some perspective on contaminant levels in lake whitefish from Banks Lake. These are the only sites where lake whitefish have been collected by Ecology in recent years. The 2010 samples from Potholes Reservoir have size and lipid characteristics that are closer to samples from the larger size class collected at Banks Lake (Tables 7 and 9) so are somewhat comparable.

Samples from Banks Lake had higher levels of TCDD TEQ, t-PCBs, and mercury than samples from Potholes Reservoir. As the levels of PCDD/Fs and mercury in Lake Roosevelt decline due to clean-up actions, contaminant levels in lake whitefish from Banks Lake may eventually approach the levels seen in this species from Potholes Reservoir. Another perspective is that levels of TCDD TEQ in Banks Lake fish are at about the 65th percentile of statewide values.

Other PBTs and Comparisons to Standards and Screening Levels

Most of the 2010 samples met water quality standards shown in Table B-1. Exceptions were total PCBs and TCDD TEQ whose criteria are 5.3 ug/kg and 0.065 ng/kg, respectively. These exceptions are shown in bold in Table 7. While the criterion for TCDD is for the single congener, the criterion is also used to evaluate the TEQ value during Ecology's Water Quality Assessment process. For waters where any sample TEQ values are greater than (do not meet) the criterion, the waterbody is placed in Category 2 (Waters of Concern) during the assessment.

Conclusions

- Levels of TCDD TEQ, T-PCBs, and T-DDTs in lake whitefish from Banks Lake appear to be lower in 2010 than levels seen in 2003. The consistent pattern of lower concentrations in these analytes (30%-43% difference) could suggest a true decrease between the years.
- Sample sizes from the two years were too small for statistical evaluation of the data. Larger sample sizes in future monitoring will allow for a more definitive comparison to the 2010 results.

Potholes Reservoir

Sample Characteristics and Comparability to Historical Data

Eleven lake whitefish were used to form three composites of two different size classes. A four- fish composite made up a smaller size class, while a four- and a three-fish composite made up two larger size classes. Physical characteristics such as length, weight, age, and lipids were used to evaluate comparability of the 2010 samples to the 2005 samples (Table 8).

Table 8. Physical Characteristics of Lake Whitefish from Potholes Reservoir, 2005 and 2010.

Sample ID: Site and Year	Date collect	n	Mean Total Length (mm)	Mean Weight (g)	Mean Age (yrs)	Lipids (%)
Potholes 2005 [A]	10/25/05	1	576.2	2524.0	6.2	16.7
Potholes 2010	10/20/10	3	456.0 (52.2)	1209.4 (412.3)		10.7 (1.1)

The 2010 values are the means of composite samples with standard error in parentheses.
A - Potholes Reservoir sample Lab ID: 06024741.

The fish from 2010 were much smaller and had lower lipid content than the 10 fish used in the composite from 2005. This lack of similarity among samples from the two years reduces the usefulness of comparisons. However, the 2010 results will be useful in future efforts to compare contaminant levels over time at Potholes Reservoir.

Comparison to Historical Data

Table 9 shows contaminant concentrations for lake whitefish collected in 2005 and 2010. Most results for 2010 are much lower than those from 2005. Whether these differences are due to the smaller size of fish collected in 2005, or represent a true decrease over time, cannot be discerned due to the lack of similarity among samples.

Table 9. Comparison of Results for Lake Whitefish from Potholes Reservoir, 2005 and 2010.

Sample ID: Site and Year	Date collect	n	TCDD TEQ (ng/kg)	TCDD (ng/kg)	T-PCB (ug/kg)	T-DDT (ug/kg)	Mercury (ug/kg)
Potholes 2005 [A]	10/25/05	1	**0.326**	**0.153**	**17.2**	**59.5** [B]	46.0
Potholes 2010	10/20/10	3	**0.083** (0.018)	**0.042** (0.006)	**5.3** (2.4)	**21.0** (6.5)	**49.4** (3.0)

Values in **bold** do not meet water quality criteria or screening values in Table B-1.
The 2010 values are the means of composite samples with standard error in parentheses.
A - Potholes Reservoir sample Lab ID: 06024741
B - Sample exceeded the water quality standard for 4,4'-DDE which is 31.6 ug/kg.

Other PBTs and Comparisons to Standards and Screening Levels

One of the three samples collected in 2010 was analyzed for a broader suite of analytes including other chlorinated pesticides and PBDEs. Most other analytes were detected at low levels or not detected at all. An exception was dieldrin which was elevated at 1.42 ug/kg. Dieldrin was also the main focus of a recent Ecology study (Era-Miller, 2010) which reported that dieldrin levels in lake whitefish were the highest in freshwater fish fillet tissue in Washington.

Lake whitefish and other species were also collected as part of a study focused on determining trends in fish tissue mercury levels (Meredith and Friese, 2011). Bass were the focus of trend monitoring efforts, while mercury levels in other species were only characterized.

Two contaminants did not meet water quality standards in 2010: dieldrin and TCDD TEQ which exceeded the criteria of 0.65 ug/kg and 0.065 ng/kg, respectively. Potholes Reservoir will likely remain in Category 5 (the 303(d)) list for dieldrin and be placed in Category 2 (Waters of Concern) for TCDD TEQ during Ecology’s next Water Quality Assessment process.

Conclusion

- Contaminant levels in fish collected in 2005 and 2010 from Potholes Reservoir could not be compared because of differences in the size of fish used in samples.

Lake Ozette Sockeye

The Makah Nation provided Ecology with 30 sockeye salmon to test for mercury in a separate study (Furl, 2011). Four composite samples using 21 of these fish were analyzed by the WSTMP for other contaminants. These 4-year-old fish had returned to the Umbrella Creek hatchery and been used as brood stock. The fish were collected on 10/29/09, and all abdominal organs, including testes and eggs, had been removed prior to processing by Ecology. One group each of male and female whole fish formed two samples. Another group each of male and female fillets formed the other two samples.

Results

Table 10 shows contaminants detected in returning Lake Ozette sockeye salmon during 2010. Most results were near the reporting limit, yet PCBs, TCDD TEQ, and toxaphene were detected at levels that did not meet one or more of the National Toxics Rule (NTR) criteria, EPA's Recommended Water Quality Criteria, and EPA's Screening Values for Subsistence Fishers (Table B-1).

Table 10. Summary of Results for Ozette Lake Sockeye Salmon, WSTMP 2010.

Field ID	OZSOK-WF		OZSOK-WM		OZSOK-FF		OZSOK-FM	
MEL Sample ID	1101016-45		1101016-46		1101016-47		1101016-48	
Sample Type and Sex	Whole Fish: Female		Whole Fish: Male		Fillet Only: Female		Fillet Only: Male	
2,3,7,8-TCDD (ng/kg)	0.021	UJ	**0.046**	J	0.021	UJ	**0.030**	NJ
2,3,7,8-TCDD TEQ (ng/kg)	**0.103**	J	**0.223**	J	**0.088**	J	**0.158**	J
Dieldrin (ug/kg)	0.47	U	0.49	U	0.48	U	0.48	U
Hexachlorobenzene (ug/kg)	1.07		1.35		0.99		1.14	
Total Chlordane (ug/kg)	0.95	U	1.14	J	0.96	U	1.09	J
Total PBDE (ug/kg)	0.38	J	0.39	J	2.28	J	0.39	J
Total PCB aroclors (ug/kg)	**7.2**	J	**10.0**	J	**7.2**	J	**8.4**	J
Total-DDT (ug/kg)	3.27		5.83		2.84		5.03	
Toxaphene (ug/kg)	**9.66**	J	**11.1**	J	**7.31**	J	**14.5**	J
Lipid (%)	2.76		2.99		2.06		2.95	
Mean Total Length (mm)	552.5		598.8		568.0		587.5	
Mean Weight (g)	1373.3		2052.5		1610.2		1945.5	
Mean Age (years)	4.0		4.0		4.0		4.0	
# Fish in Composite	4		8		5		4	
Date Collected	10/29/09		10/29/09		10/29/09		10/29/09	

Values in **bold** do not meet water quality criteria or screening values in Table B-1.
A = Reporting Limit is greater than the EPA Screening Value for Subsistence Fishers: 0.307 ug/kg for carcinogenic effects (Table B-1).
J = The analyte was positively identified. The associated numerical result is an estimate.
NJ = The analyte was tentatively identified and the associated numerical value is an estimate.
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.

Comparisons to Other Data, Standards, and Screening Levels

The levels of contaminants in Table 10 appear to be typical, or lower than, contaminant levels found in other west coast salmon from various studies.

Concentrations of PCBs in the Lake Ozette sockeye were about three to four times lower than levels in Columbia River fall and spring Chinook salmon (37-38 ug/kg) sampled in 1996-98 (EPA, 2002b). 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. PCB levels in Chinook salmon returning to these coastal streams were about twice as high as levels found in the Lake Ozette sockeye salmon.

Levels of TCDD TEQ in the Lake Ozette sockeye were around three to four 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). Debruyn et al. (2009) reported dioxin levels in sockeye returning to Great Central Lake, British Columbia, that had mean levels of 0.13 and 0.11 ng/Kg (with standard deviations of 0.10 and 0.11 ng/kg, respectively). These levels are similar to the levels found in Lake Ozette sockeye. Debruyn et al. also suggest a possibility that the levels of dioxins and PCBs in sockeye returning to the Great Central Lake may affect reproduction and recruitment at population levels.

Levels of total PCBs and total DDTs in the sockeye samples 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).

Ecology's 2004 WSTMP sampled Chinook salmon returning to the Queets, Quinault, and Chehalis rivers (Seiders et al., 2007). The profile of contaminant levels in these Chinook salmon were similar to those found in Lake Ozette sockeye in 2010, with levels of dioxins, PCBs, and toxaphene not meeting water quality standards or screening values.

Conclusion

- Levels of contaminants found in Ozette Lake sockeye salmon appear to be typical, or lower than, contaminant levels found in other west coast salmon from various studies.

Conclusions and Recommendations

Conclusions

Results of this 2010 study support the following conclusions:

Lake Chelan

- Total DDT levels in lake trout from Lake Chelan remain high. Levels found in 2010 are higher than they were in 2003.

- Lake trout from Lake Chelan also have high levels of dioxins/furans and PBDE flame retardants; levels of PCBs are mildly elevated. Other detected contaminants were at levels of lower concern.

- Lake trout in Lake Chelan appear to be effective biomagnifiers of environmental pollutants because they are top predators, long-lived, and high in lipid content.

Wenatchee River and Wenatchee Lake

- Ecology's 2010 sampling goals for the Wenatchee River were only partly met due to poor angling conditions and catch success. Consequently, small sample sizes and fewer sampled locations led to weaker spatial and temporal comparability than was planned.

- Levels of PCBs in mountain whitefish from the Wenatchee River remain high and are comparable to levels measured in 2003. Fish from the Monitor Bridge area had the highest PCB levels (690-1700 ug/kg). Samples from the mainstem Wenatchee River near Peshastin and Icicle Creek had elevated PCB levels (19-109 ug/kg). The Nason Creek samples showed low levels of PCBs (2.4-12.7 ug/kg) and likely represent background levels.

- The movement of mountain whitefish within a river system is likely a confounding factor in seeking differences among sites, especially sites that are relatively close to one another.

- Cutthroat trout and northern pikeminnow from Wenatchee Lake had low levels of contaminants relative to other areas of Washington State.

Comparison of Preparation Methods: Skin-on and Skin-off

- No difference was found between results from the skin-on and skin-off preparation methods for Total DDT, Total PCB, Total PBDE, and lipids using fish from Lake Chelan and the Wenatchee River.

- Results for mercury indicate that the different preparation methods do affect the level of mercury measured in samples, with the skin-on sample having slightly lower levels.

Banks Lake

- Levels of TCDD TEQ, Total PCBs, and Total DDTs in lake whitefish from Banks Lake appear to be lower in 2010 than in 2003. The consistent pattern of lower concentrations in these analytes (30%-43% difference) could suggest a true decrease in these contaminants between the years.

Potholes Reservoir

- Contaminant levels in fish collected in 2003 and 2010 from Potholes Reservoir could not be compared because of size differences in the fish used in samples. The 2010 fish were much smaller than those collected in 2003.

Ozette Lake

- Levels of contaminants found in Ozette Lake sockeye salmon appear to be typical of, or lower than, contaminant levels found in other west coast salmon from various studies.

Recommendations

Results of this 2010 study support the following recommendations:

- The state Department of Health should review results from this study and take appropriate actions regarding risks to human health from eating contaminated fish.
- Ecology should make the PCB issue in the Wenatchee River a high priority and begin work to identify potential PCB sources and pursue corrective actions.
- Future long-term monitoring efforts should increase sample sizes. This would provide more definitive information about changes over time, particularly for organic compounds, because of the high variability of fish tissue data.
- Ecology's future efforts at WSTMP Long-Term Monitoring sites should collaborate with other governments (e.g., tribes, counties) in order to use resources most efficiently towards meeting water quality goals.

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Appendices

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Appendix A. Contaminants of Concern

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

Chlorinated Pesticides

Pesticides include insecticides, herbicides, fungicides, and related chemicals used to control pests. Chlorinated pesticides were analyzed 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 U.S. during the 1970s and 1980s as their hazards became evident. Some of the more frequently detected pesticides are described below.

- DDT (dichloro-diphenyl-trichloroethane) is a pesticide used to control insects in agriculture and insects that carry diseases such as malaria. Its use in the U.S. was banned in 1972 because of damage to wildlife. DDE (dichloro-diphenyl-dichloroethylene) and DDD (dichloro-diphenyl-dichloroethane) are contaminants or breakdown product of DDT. These chemicals stick strongly to soil and build up in fatty tissues of fish, birds, and other animals. (ATSDR, 2002a).
- Hexachlorobenzene was widely used as a pesticide to protect seeds and grains against fungus until 1965. It was also used to make fireworks, ammunition, and synthetic rubber. There are no current commercial uses of hexachlorobenzene in the U.S. Like many other chlorinated pesticides, hexachlorobenzene can build up in tissues of fish, birds, and mammals. Hexachlorobenzene can also build up in wheat, grasses, and other plants. (ATSDR, 2002b).
- Dieldrin is an insecticide that is very similar to aldrin. Aldrin quickly breaks down to dieldrin in the body and in the environment. These pesticides were widely used to protect corn and cotton. EPA banned most uses of aldrin and dieldrin in 1974 because of concerns about damage to the environment and human health. Their use continued for control of termites until 1987 when EPA banned all uses. (ATSDR, 2002c).
- Toxaphene was one of the most heavily used insecticides in the U.S. until 1982, when it was canceled for most uses. It was used widely in the southern U.S. to control pests on cotton and other crops. It was also used to kill unwanted fish in lakes and to control pests on livestock. Toxaphene is a mixture of over 670 chemicals and has varied formulations. (ATSDR, 1997).

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).

Thirty-three of the 36 samples from 2008 were analyzed for the 17 most toxic congeners. These congeners have different levels of toxicity compared to TCDD, the most toxic congener. The cumulative toxicity of mixtures of congeners in a sample can be expressed as a toxic equivalent (TEQ) to TCDD. This TEQ is calculated by multiplying the result for each congener by its congener-specific Toxicity Equivalent Factor (TEF) and then summing the products (which are congener-specific TEQs) to obtain the TCDD TEQ. This cumulative TEQ value is termed "dioxin/furan TEQ" in this report. The 2005 World Health Organization TEFs (Van den Berg et al., 2006) were used in this report.

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).

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 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.

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 U.S. used the trade name Aroclor. PCB Aroclors were analyzed for all 36 WSTMP samples from 2008; individual PCB congeners were analyzed in 30 (about 83%) of these samples.

PCBs in fish tissue were determined using two different methods: EPA 8082 for PCB Aroclors and EPA 1668A for PCB congeners. The Aroclor method relies on matching patterns in results to patterns for the commercial mixtures making up Aroclors. The congener method measures concentrations of all individual PCB congeners in a sample. These methods are further discussed later in this report.

Appendix B. Water Quality Criteria and Screening Values

Various criteria for the protection of human health 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. The criteria summarized below are the National Toxics Rule (NTR) criteria (used as Washington's Water Quality Standards), EPA's recommended criteria, and EPA's screening values

Fish tissue results from this 2010 study were compared to Washington's water quality standards to determine how sites should be evaluated during 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 NTR criteria as the water quality standards for toxic compounds associated with human-health concerns. While the water quality criteria are expressed as water concentrations, tissue criteria "equivalents" were calculated by multiplying the Bioconcentration Factor (BCF) for each analyte by the respective water quality standard criterion. The BCFs used were those from EPA's water quality criteria development documents.

The NTR 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 under *EPA Recommended Water Quality Criteria* and *EPA Screening Values.* These 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 Department of Health evaluate fish tissue data. Table B-1 shows the NTR and other EPA criteria and screening values for contaminants detected in this 2010 study.

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.

EPA issued the NTR criteria in 1992 to all states which had not adopted their own criteria. 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.

Table B-1. Water Quality Standards Criteria and Guidelines Used for the Protection of Human Health for Contaminants Detected in Fish Tissue, WSTMP 2010.

Analyte (ppb ww)[1]	National Toxics Rule Criteria: Fish Tissue Equivalents		National Recommended Water Quality Criteria [2]	EPA Screening Values			
				Subsistence Fishers		Recreational Fishers	
	Fresh-water	Marine		Non-carcino-gens	Carcino-gens	Non-carcino-gens	Carcino-gens
2,3,7,8-TCDD [4]	0.065	0.070	0.025	-	-	-	-
2,3,7,8-TCDD TEQ [4]	-	-	0.025 [5]	-	0.0315	-	0.256
4,4'-DDD	44	45	17	-	-	-	-
4,4'-DDE	32	32	12	-	-	-	-
4,4'-DDT	32	32	12	-	-	-	-
Total DDT [6]	-	-	-	245	14.4	2000	117
Aldrin	0.61	0.65	-	-	-	-	-
Alpha-BHC	0.5	1.7	0.64	-	-	-	-
Beta-BHC	1.8	6.0	2.2	-	-	-	-
Chlordane [7]	8.0	8.3	11	245	14.0	2000	114
Chlorpyriphos	-	-	-	147	-	1200	-
Dieldrin	0.65	0.65	0.24	24	0.307	200	2.5
Endosulfan Sulfate	251	540	24000	-	-	-	-
Endrin	3017	3216	230	147		1200	
gamma-BHC (Lindane)	2.5	8.2	127	147	3.78	1200	30.7
Heptachlor Epoxide	1.1	1.2	0.44	6.39	0.54	52	4.39
Hexachlorobenzene	6.5	6.7	2.4	393	3.07	3200	25.0
Mercury	770	1350	300	49	-	400	-
Mirex	-	-		98	-	800	-
PBDEs	-	-	-	-	-	-	-
Total PCBs [3]	5.3	5.3	2.0	9.83	2.45	80	20
Toxaphene	9.6	9.8	3.7	122	4.46	1000	36.3

1 - Values in parts per billion wet-weight (ug/kg ww) unless otherwise noted.

2 – EPA, 2009. www.epa.gov/waterscience/criteria/wqctable/index.html

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 TEQ to 2,3,7,8-TCDD. EPA (2002) states that the criterion for dioxin is expressed in terms of 2,3,7,8-TCDD and should be used in conjunction with the international convention of TEFs and TEQs to account for the additive effects of other dioxin-like compounds. When the TEQ is used, the toxicity of the single congener 2,3,7,8-TCDD is incorporated.

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. Where data for the 2,4’ isomers are lacking, the sum of the 4,4’- isomers is used.

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.

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 criteria for human health 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).

The NTR gives two sets of criteria for the protection of human health. One set is for *consumption of water and organisms* and the other is for *consumption of organisms only*. The criteria for *consumption of water and organisms* are used when evaluating contaminant levels in freshwater fish while the *consumption of organisms only* criteria are used for evaluating salt water fish.

In the past, Ecology usually evaluated freshwater fish tissue using the criteria intended for salt water fish. Recognizing this inconsistency, Ecology is developing guidance on how these criteria should be applied to ensure correct interpretation of water quality standards. For many chemicals, the difference between the two interpretations of criteria is small. The criteria based on the *consumption of water and organisms* are used in this report for determining whether fish tissue results exceed (do not meet) Washington's water quality standards.

EPA Recommended Water Quality Criteria

EPA publishes *National Recommended Water Quality Criteria* for many pollutants such as mercury and pesticides (EPA, 2001, 2002a, 2003, and 2009). These criteria are periodically updated to incorporate the latest scientific knowledge. EPA recommends these criteria be used by states and Indian tribes to establish water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants. Yet 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

EPA developed screening values (SVs) for carcinogenic and non-carcinogenic effects of substances 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 EPA SVs was similar to the approach used for developing the NTR, yet the SVs 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.

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

Washington State Department of Health (DOH) Screening Levels

Screening levels (SLs) for the carcinogenic effect of toxic substances were developed by the DOH to help determine whether a full risk assessment is needed. Such risk assessments may or may not lead to a fish consumption advisory for a specific site and species. More information about the health benefits of eating fish and fish consumption advisories in Washington are at DOH's website: www.doh.wa.gov/ehp/oehas/fish/.

Appendix C. Fish Tissue 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 (Ecology), Health (DOH), and Fish and Wildlife; the U.S. Environmental Protection Agency (EPA); 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 I 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 described above, incorporate the varied risk management decisions essential to developing fish consumption advisories.

Risk management concepts include:

- **Risk Assessment** involves calculating allowable meal limits based on known fish contaminant concentrations. These calculations are conducted for both non-cancer and cancer criteria 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 criteria 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. Site Descriptions, WSTMP 2010

Table D-1. Sample Site Locations for WSTMP 2010.

Site	County	WBID	Latitude	Longitude	EIM Location ID
Banks Lake	Grant	WA-42-9020	47.8770	-119.1652	Banks-F2
Lake Chelan	Chelan	WA-47-9020	47.8683	-120.1410	Wapato-F
Icicle Creek	Chelan	WA-45-1015	47.5654	-120.6696	451C02.6
Nason Creek	Chelan	WA-45-3000	47.7694	-120.8016	45NC09.5
Ozette Lake	Clallam	WA-20-9040	48.0967	-124.6338	OZ07
Potholes Reservoir	Grant	WA-41-9280	46.9813	-119.3144	Potholes-F
Wenatchee Lake	Chelan	WA-45-9100	47.8236	-120.7761	WENCH11
Wenatchee River near Monitor Bridge	Chelan	WA-45-1010	47.4725	-120.3725	WENTMDL-W03
Wenatchee River near Peshastin	Chelan	WA-45-1010	47.5822	-120.6146	45WR20.9

Datum for latitude and longitude coordinates is NAD 83 HARN.
WBID: Waterbody Identification Number System.
EIM: Environmental Information Management.

Appendix E. Fish Field Data, WSTMP 2010

Table E-1. Fish Field Data for WSTMP 2010.

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Banks L	LWF	BnkLWF-L1	01	ON	LWF 4	470	1248	M	2	10/14/10
Banks L	LWF	BnkLWF-L1	01	ON	LWF 30	501	1463	F	4	10/14/10
Banks L	LWF	BnkLWF-L1	01	ON	LWF 22	501	1361	F	3	10/14/10
Banks L	LWF	BnkLWF-L1	01	ON	LWF 28	523	1510	F	11	10/14/10
Banks L	LWF	BnkLWF-L1	01	ON	LWF 3	527	1731	F	4	10/14/10
Banks L	LWF	BnkLWF-L2	04	ON	LWF 31	492	1223	M	14	10/14/10
Banks L	LWF	BnkLWF-L2	04	ON	LWF 5	500	1494	M	5	10/14/10
Banks L	LWF	BnkLWF-L2	04	ON	LWF 23	512	1346	M	11	10/14/10
Banks L	LWF	BnkLWF-L2	04	ON	LWF 2	528	1588	F	15	10/14/10
Banks L	LWF	BnkLWF-L2	04	ON	LWF 32	534	1621	F	13	10/14/10
Banks L	LWF	BnkLWF-L3	06	ON	LWF 1	499	1455	F	5	10/14/10
Banks L	LWF	BnkLWF-L3	06	ON	LWF 33	515	1565	F	14	10/14/10
Banks L	LWF	BnkLWF-L3	06	ON	LWF 25	523	1418	F	11	10/14/10
Banks L	LWF	BnkLWF-L3	06	ON	LWF 24	535	1741	F	11	10/14/10
Banks L	LWF	BnkLWF-L3	06	ON	LWF 27	537	1591	F	11	10/14/10
Banks L	LWF	BnkLWF-S1	02	ON	LWF 17	368	447	M	1	10/13/10
Banks L	LWF	BnkLWF-S1	02	ON	LWF 6	381	620	M	1	10/13/10
Banks L	LWF	BnkLWF-S1	02	ON	LWF 12	384	575	F	1	10/13/10
Banks L	LWF	BnkLWF-S1	02	ON	LWF 16	385	644	M	1	10/13/10
Banks L	LWF	BnkLWF-S1	02	ON	LWF 15	386	615	M	1	10/13/10
Banks L	LWF	BnkLWF-S2	03	ON	LWF 35	288	586	M	1	10/13/10
Banks L	LWF	BnkLWF-S2	03	ON	LWF 13	360	578	M	1	10/13/10
Banks L	LWF	BnkLWF-S2	03	ON	LWF 8	362	484	M	1	10/13/10
Banks L	LWF	BnkLWF-S2	03	ON	LWF 18	362	465	U	1	10/13/10
Banks L	LWF	BnkLWF-S2	03	ON	LWF 7	383	503	U	1	10/13/10
Banks L	LWF	BnkLWF-S3	05	ON	LWF 34	359	508	M	1	10/13/10
Banks L	LWF	BnkLWF-S3	05	ON	LWF 19	361	551	M	1	10/13/10
Banks L	LWF	BnkLWF-S3	05	ON	LWF 14	362	524	M	1	10/13/10
Banks L	LWF	BnkLWF-S3	05	ON	LWF 10	372	534	M	1	10/13/10
Banks L	LWF	BnkLWF-S3	05	ON	LWF 9	380	574	M	1	10/13/10
Chelan L	LKT	C-L1-OFF	41	OFF	NR DD-11	578	2109	F	-	6/3/10
Chelan L	LKT	C-L1-OFF	41	OFF	BR DD-23	578	2164	F	-	6/2/10
Chelan L	LKT	C-L1-OFF	41	OFF	MB LCA-15	584	2199	F	-	6/2/10
Chelan L	LKT	C-L1-OFF	41	OFF	BR DD-22	591	2071	F	-	6/3/10

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Chelan L	LKT	C-L1-OFF	41	OFF	MB LCA-13	603	2212	F	-	6/3/10
Chelan L	LKT	C-L1-ON	42	ON	NR DD-11	578	2109	F	-	6/3/10
Chelan L	LKT	C-L1-ON	42	ON	BR DD-23	578	2164	F	-	6/2/10
Chelan L	LKT	C-L1-ON	42	ON	MB LCA-15	584	2199	F	-	6/2/10
Chelan L	LKT	C-L1-ON	42	ON	BR DD-22	591	2071	F	-	6/3/10
Chelan L	LKT	C-L1-ON	42	ON	MB LCA-13	603	2212	F	-	6/3/10
Chelan L	LKT	C-M1-OFF	35	OFF	MB LCA-14	533	1403	M	-	6/2/10
Chelan L	LKT	C-M1-OFF	35	OFF	WP LCA-16	552	1427	M	-	6/2/10
Chelan L	LKT	C-M1-OFF	35	OFF	WP DD-01	559	1392	M	-	6/2/10
Chelan L	LKT	C-M1-OFF	35	OFF	MB LCA-19	559	1417	M	-	6/2/10
Chelan L	LKT	C-M1-OFF	35	OFF	BR DD-07	565	1408	M	-	6/2/10
Chelan L	LKT	C-M1-ON	36	ON	MB LCA-14	533	1403	M	-	6/2/10
Chelan L	LKT	C-M1-ON	36	ON	WP LCA-16	552	1427	M	-	6/2/10
Chelan L	LKT	C-M1-ON	36	ON	WP DD-01	559	1392	M	-	6/2/10
Chelan L	LKT	C-M1-ON	36	ON	MB LCA-19	559	1417	M	-	6/2/10
Chelan L	LKT	C-M1-ON	36	ON	BR DD-07	565	1408	M	-	6/2/10
Chelan L	LKT	C-M3-OFF	32	OFF	MB LCA-17	533	1430	F	-	6/3/10
Chelan L	LKT	C-M3-OFF	32	OFF	BR DD-09	546	1453	M	-	6/2/10
Chelan L	LKT	C-M3-OFF	32	OFF	BR DD-05	591	1554	M	-	6/3/10
Chelan L	LKT	C-M3-OFF	32	OFF	BR LCA-25	597	1493	F	-	6/3/10
Chelan L	LKT	C-M3-OFF	32	OFF	BR LCA-24	603	1504	M	-	6/2/10
Chelan L	LKT	C-M3-ON	31	ON	MB LCA-17	533	1430	F	-	6/3/10
Chelan L	LKT	C-M3-ON	31	ON	BR DD-09	546	1453	M	-	6/2/10
Chelan L	LKT	C-M3-ON	31	ON	BR DD-05	591	1554	M	-	6/3/10
Chelan L	LKT	C-M3-ON	31	ON	BR LCA-25	597	1493	F	-	6/3/10
Chelan L	LKT	C-M3-ON	31	ON	BR LCA-24	603	1504	M	-	6/2/10
Chelan L	LKT	C-M4-OFF	40	OFF	MO DT-14	546	1700	F	-	6/2/10
Chelan L	LKT	C-M4-OFF	40	OFF	BR DD-06	565	1700	F	-	6/2/10
Chelan L	LKT	C-M4-OFF	40	OFF	MB LCA-18	572	1738	M	-	6/3/10
Chelan L	LKT	C-M4-OFF	40	OFF	SB DD-15	584	1792	M	-	6/2/10
Chelan L	LKT	C-M4-OFF	40	OFF	BR DD-24	584	1803	F	-	6/3/10
Chelan L	LKT	C-M4-ON	39	ON	MO DT-14	546	1700	F	-	6/2/10
Chelan L	LKT	C-M4-ON	39	ON	BR DD-06	565	1700	F	-	6/2/10
Chelan L	LKT	C-M4-ON	39	ON	MB LCA-18	572	1738	M	-	6/3/10
Chelan L	LKT	C-M4-ON	39	ON	SB DD-15	584	1792	M	-	6/2/10
Chelan L	LKT	C-M4-ON	39	ON	BR DD-24	584	1803	F	-	6/3/10
Chelan L	LKT	C-S1-OFF	27	OFF	MO DT-12	381	445	M	-	6/2/10
Chelan L	LKT	C-S1-OFF	27	OFF	MO DT-09	406	542	F	-	6/2/10

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Chelan L	LKT	C-S1-OFF	27	OFF	WP DD-12	419	583	F	-	6/2/10
Chelan L	LKT	C-S1-OFF	27	OFF	WP DD-03	445	770	F	-	6/2/10
Chelan L	LKT	C-S1-OFF	27	OFF	WP DD-02	464	812	F	-	6/2/10
Chelan L	LKT	C-S1-ON	28	ON	MO DT-12	381	445	M	-	6/2/10
Chelan L	LKT	C-S1-ON	28	ON	MO DT-09	406	542	F	-	6/2/10
Chelan L	LKT	C-S1-ON	28	ON	WP DD-12	419	583	F	-	6/2/10
Chelan L	LKT	C-S1-ON	28	ON	WP DD-03	445	770	F	-	6/2/10
Chelan L	LKT	C-S1-ON	28	ON	WP DD-02	464	812	F	-	6/2/10
Chelan L	LKT	C-S2-OFF	33	OFF	MO DT-02	457	1022	U	-	6/2/10
Chelan L	LKT	C-S2-OFF	33	OFF	MO DT-07	470	993	M	-	6/3/10
Chelan L	LKT	C-S2-OFF	33	OFF	MO DT-08	495	1090	F	-	6/2/10
Chelan L	LKT	C-S2-OFF	33	OFF	MO DT-10	495	1107	M	-	6/2/10
Chelan L	LKT	C-S2-OFF	33	OFF	MO DT-06	508	1093	F	-	6/3/10
Chelan L	LKT	C-S2-ON	34	ON	MO DT-02	457	1022	U	-	6/2/10
Chelan L	LKT	C-S2-ON	34	ON	MO DT-07	470	993	M	-	6/3/10
Chelan L	LKT	C-S2-ON	34	ON	MO DT-08	495	1090	F	-	6/2/10
Chelan L	LKT	C-S2-ON	34	ON	MO DT-10	495	1107	M	-	6/2/10
Chelan L	LKT	C-S2-ON	34	ON	MO DT-06	508	1093	F	-	6/3/10
Chelan L	LKT	C-S3-OFF	37	OFF	PM LCA-27	489	1200	M	-	6/2/10
Chelan L	LKT	C-S3-OFF	37	OFF	MB-RP LCA-22	495	1228	F	-	6/3/10
Chelan L	LKT	C-S3-OFF	37	OFF	WP DD-14	527	1261	U	-	6/2/10
Chelan L	LKT	C-S3-OFF	37	OFF	MO DT-11	533	1291	M	-	6/2/10
Chelan L	LKT	C-S3-OFF	37	OFF	MB LCA-26	546	1390	U	-	6/2/10
Chelan L	LKT	C-S3-ON	38	ON	PM LCA-27	489	1200	M	-	6/2/10
Chelan L	LKT	C-S3-ON	38	ON	MB-RP LCA-22	495	1228	F	-	6/3/10
Chelan L	LKT	C-S3-ON	38	ON	WP DD-14	527	1261	U	-	6/2/10
Chelan L	LKT	C-S3-ON	38	ON	MO DT-11	533	1291	M	-	6/2/10
Chelan L	LKT	C-S3-ON	38	ON	MB LCA-26	546	1390	U	-	6/2/10
Chelan L	LKT	C-S4-OFF	29	OFF	MO DT-16	400	515	M	-	6/3/10
Chelan L	LKT	C-S4-OFF	29	OFF	MO DT-13	406	657	F	-	6/2/10
Chelan L	LKT	C-S4-OFF	29	OFF	MO DT-18	413	624	U	-	6/3/10
Chelan L	LKT	C-S4-OFF	29	OFF	MO DT-04	419	594	M	-	6/3/10
Chelan L	LKT	C-S4-OFF	29	OFF	WP DD-04	457	850	F	-	6/2/10
Chelan L	LKT	C-S4-ON	30	ON	MO DT-16	400	515	M	-	6/3/10
Chelan L	LKT	C-S4-ON	30	ON	MO DT-13	406	657	F	-	6/2/10
Chelan L	LKT	C-S4-ON	30	ON	MO DT-18	413	624	U	-	6/3/10
Chelan L	LKT	C-S4-ON	30	ON	MO DT-04	419	594	M	-	6/3/10
Chelan L	LKT	C-S4-ON	30	ON	WP DD-04	457	850	F	-	6/2/10

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Chelan L	LKT	C-S5-OFF	43	OFF	MO DT-03	432	942	M	-	6/2/10
Chelan L	LKT	C-S5-OFF	43	OFF	MO DT-17	464	902	M	-	6/2/10
Chelan L	LKT	C-S5-OFF	43	OFF	MO DT-01	470	968	M	-	6/2/10
Chelan L	LKT	C-S5-OFF	43	OFF	MB-RP LCA-23	470	926	F	-	6/2/10
Chelan L	LKT	C-S5-OFF	43	OFF	MB-RP LCA-21	495	873	U	-	6/2/10
Chelan L	LKT	C-S5-ON	44	ON	MO DT-03	432	942	M	-	6/2/10
Chelan L	LKT	C-S5-ON	44	ON	MO DT-17	464	902	M	-	6/2/10
Chelan L	LKT	C-S5-ON	44	ON	MO DT-01	470	968	M	-	6/2/10
Chelan L	LKT	C-S5-ON	44	ON	MB-RP LCA-23	470	926	F	-	6/2/10
Chelan L	LKT	C-S5-ON	44	ON	MB-RP LCA-21	495	873	U	-	6/2/10
Icicle Cr	MWF	IC-L-OFF	10	OFF	MWF IC-11	389	528	F	6	12/7/10
Icicle Cr	MWF	IC-L-OFF	10	OFF	MWF IC-13	403	622	F	6	12/7/10
Icicle Cr	MWF	IC-L-OFF	10	OFF	MWF IC-8	405	559	M	10	12/7/10
Icicle Cr	MWF	IC-L-OFF	10	OFF	MWF IC-14	422	590	F	6	12/7/10
Icicle Cr	MWF	IC-L-OFF	10	OFF	MWF IC-15	431	763	F	16	12/7/10
Icicle Cr	MWF	IC-L-ON	9	ON	MWF IC-11	389	528	F	6	12/7/10
Icicle Cr	MWF	IC-L-ON	9	ON	MWF IC-13	403	622	F	6	12/7/10
Icicle Cr	MWF	IC-L-ON	9	ON	MWF IC-8	405	559	M	10	12/7/10
Icicle Cr	MWF	IC-L-ON	9	ON	MWF IC-14	422	590	F	6	12/7/10
Icicle Cr	MWF	IC-L-ON	9	ON	MWF IC-15	431	763	F	16	12/7/10
Icicle Cr	MWF	IC-M-ON	11	ON	MWF IC-4	353	389	F	4	12/6/10
Icicle Cr	MWF	IC-M-ON	11	ON	MWF IC-6	355	382	F	4	12/6/10
Icicle Cr	MWF	IC-M-ON	11	ON	MWF IC-12	370	427	F	4	12/7/10
Icicle Cr	MWF	IC-M-ON	11	ON	MWF IC-9	380	437	F	6	12/7/10
Icicle Cr	MWF	IC-M-ON	11	ON	MWF IC-1	387	511	F	6	12/6/10
Icicle Cr	MWF	IC-S-ON	12	ON	MWF IC-7	314	256	F	3	12/7/10
Icicle Cr	MWF	IC-S-ON	12	ON	MWF IC-5	325	293	M	3	12/6/10
Icicle Cr	MWF	IC-S-ON	12	ON	MWF IC-3	330	329	F	3	12/6/10
Icicle Cr	MWF	IC-S-ON	12	ON	MWF IC-10	347	368	F	4	12/7/10
Icicle Cr	MWF	IC-S-ON	12	ON	MWF IC-2	351	358	M	4	12/6/10
Nason Cr	MWF	NS-L-ON	15	ON	MWF NS-14	369	568	F	8	11/3/10
Nason Cr	MWF	NS-L-ON	15	ON	MWF NS-13	369	416	F	8	11/3/10
Nason Cr	MWF	NS-L-ON	15	ON	MWF NS-15	372	542	M	12	11/3/10
Nason Cr	MWF	NS-L-ON	15	ON	MWF NS-1	410	820	F	12	11/3/10
Nason Cr	MWF	NS-L-ON	15	ON	MWF NS-4	413	758	F	9	11/3/10
Nason Cr	MWF	NS-M-ON	14	ON	MWF NS-12	295	257	M	4	11/3/10
Nason Cr	MWF	NS-M-ON	14	ON	MWF NS-6	319	328	M	5	11/3/10
Nason Cr	MWF	NS-M-ON	14	ON	MWF NS-10	324	310	M	5	11/3/10

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Nason Cr	MWF	NS-M-ON	14	ON	MWF NS-8	364	546	F	8	11/3/10
Nason Cr	MWF	NS-M-ON	14	ON	MWF NS-2	367	592	F	8	11/3/10
Nason Cr	MWF	NS-S-ON	13	ON	MWF NS-5	261	151	M	3	11/3/10
Nason Cr	MWF	NS-S-ON	13	ON	MWF NS-9	273	188	F	3	11/3/10
Nason Cr	MWF	NS-S-ON	13	ON	MWF NS-11	280	184	M	3	11/3/10
Nason Cr	MWF	NS-S-ON	13	ON	MWF NS-3	282	204	F	3	11/3/10
Nason Cr	MWF	NS-S-ON	13	ON	MWF NS-7	291	206	M	3	11/3/10
Potholes Reservoir	LWF	POTLWF-1	24	ON	LWF 12	349	433	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-1	24	ON	LWF 4	356	525	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-1	24	ON	LWF 13	358	543	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-1	24	ON	LWF 2	367	498	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-2	25	ON	LWF 7	471	1146	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-2	25	ON	LWF 1	475	1298	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-2	25	ON	LWF 3	475	1122	F	-	10/20/10
Potholes Reservoir	LWF	POTLWF-2	25	ON	LWF 8	480	1236	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-3	26	ON	LWF 5	522	1989	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-3	26	ON	LWF 10	534	1784	M	-	10/20/10
Potholes Reservoir	LWF	POTLWF-3	26	ON	LWF 11	550	2011	M	-	10/20/10
Wenatchee L	CTT	WENLKCTT	07	ON	CTT 1	249	143	M	2	10/13/10
Wenatchee L	CTT	WENLKCTT	07	ON	CTT 4	268	162	M	R	10/14/10
Wenatchee L	CTT	WENLKCTT	07	ON	CTT 3	279	234	M	2	10/13/10
Wenatchee L	CTT	WENLKCTT	07	ON	CTT 2	288	219	F	3	10/13/10
Wenatchee L	NPM	WENLKNPM	08	ON	NPM 4	359	456	F	10	10/13/10
Wenatchee L	NPM	WENLKNPM	08	ON	NPM 6	360	422	F	9	10/13/10
Wenatchee L	NPM	WENLKNPM	08	ON	NPM 5	380	603	F	12	10/13/10
Wenatchee L	NPM	WENLKNPM	08	ON	NPM 8	415	692	F	14	10/13/10
Wenatchee L	NPM	WENLKNPM	08	ON	NPM 7	419	712	F	14	10/13/10
Wenatchee R (nr Monitor)	MWF	WM-L-OFF	17	OFF	MWF WM-7	360	425	F	4	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-L-OFF	17	OFF	MWF WM-5	377	502	F	6	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-L-OFF	17	OFF	MWF WM-2	380	675	F	9	11/15/10
Wenatchee R (nr Monitor)	MWF	WM-L-OFF	17	OFF	MWF WM-9	396	501	F	8	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-L-OFF	17	OFF	MWF WM-1	416	771	F	12	11/2/10
Wenatchee R (nr Monitor)	MWF	WM-L-ON	16	ON	MWF WM-7	360	425	F	4	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-L-ON	16	ON	MWF WM-5	377	502	F	6	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-L-ON	16	ON	MWF WM-2	380	675	F	9	11/15/10
Wenatchee R (nr Monitor)	MWF	WM-L-ON	16	ON	MWF WM-9	396	501	F	8	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-L-ON	16	ON	MWF WM-1	416	771	F	12	11/2/10
Wenatchee R (nr Monitor)	MWF	WM-S-OFF	19	OFF	MWF WM-10	325	269	F	4	12/8/10

Site	Species Code	Sample Field ID	Lab ID 1101016-	Skin Status	Individual Fish ID	Total Length (mm)	Weight (gm)	Sex	Age (yrs)	Collect Date
Wenatchee R (nr Monitor)	MWF	WM-S-OFF	19	OFF	MWF WM-3	329	316	F	3	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-S-OFF	19	OFF	MWF WM-6	348	384	F	3	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-S-OFF	19	OFF	MWF WM-8	351	310	F	3	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-S-OFF	19	OFF	MWF WM-4	352	399	F	4	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-S-ON	18	ON	MWF WM-10	325	269	F	4	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-S-ON	18	ON	MWF WM-3	329	316	F	3	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-S-ON	18	ON	MWF WM-6	348	384	F	3	12/7/10
Wenatchee R (nr Monitor)	MWF	WM-S-ON	18	ON	MWF WM-8	351	310	F	3	12/8/10
Wenatchee R (nr Monitor)	MWF	WM-S-ON	18	ON	MWF WM-4	352	399	F	4	12/7/10
Wenatchee R (nr Peshastin)	MWF	WP-L-OFF	22	OFF	MWF W1-6	283	207	F	3	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-L-OFF	22	OFF	MWF W1-12	290	205	F	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-L-OFF	22	OFF	MWF W1-13	290	181	F	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-L-OFF	22	OFF	MWF W1-8	337	349	F	5	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-L-OFF	22	OFF	MWF W1-11	343	469	F	4	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-L-ON	23	ON	MWF W1-6	283	207	F	3	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-L-ON	23	ON	MWF W1-12	290	205	F	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-L-ON	23	ON	MWF W1-13	290	181	F	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-L-ON	23	ON	MWF W1-8	337	349	F	5	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-L-ON	23	ON	MWF W1-11	343	469	F	4	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-S-OFF	20	OFF	MWF W1-5	228	102	M	1	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-OFF	20	OFF	MWF W1-4	244	122	F	2	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-OFF	20	OFF	MWF W1-10	265	160	M	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-S-OFF	20	OFF	MWF W1-7	281	211	F	3	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-OFF	20	OFF	MWF W1-2	282	182	F	3	11/5/10
Wenatchee R (nr Peshastin)	MWF	WP-S-ON	21	ON	MWF W1-5	228	102	M	1	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-ON	21	ON	MWF W1-4	244	122	F	2	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-ON	21	ON	MWF W1-10	265	160	M	3	11/16/10
Wenatchee R (nr Peshastin)	MWF	WP-S-ON	21	ON	MWF W1-7	281	211	F	3	11/15/10
Wenatchee R (nr Peshastin)	MWF	WP-S-ON	21	ON	MWF W1-2	282	182	F	3	11/5/10

Species Codes:
CTT = Cutthroat trout
LKT = Lake trout
LWF = Lake whitefish
MWF = Mountain whitefish
NPM = Northern pikeminnow
SOK = Sockeye salmon

Appendix F. Data Quality Assessment

Data quality for the 2010 study was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Ecology's Manchester Environmental Laboratory (MEL) prepared case narratives for each set of analyses. The entire data package for dioxin and furans from Test America West Sacramento was reviewed by MEL who developed a case narrative for these data. The narratives described the condition of samples upon receipt, analytical quality control procedures, and data qualifications. Laboratory quality control procedures included various analyses such as method blanks, calibration and control standards, matrix spikes, matrix spike duplicates, surrogate recoveries, and laboratory duplicates. Estimates of precision for sampling and analysis were made from analyses of field replicate samples.

The quality of historical data was assessed by reviewing data quality sections in the published reports. All data were deemed acceptable as originally qualified except for cases where the historical analytical methods differed from those used in 2010. These cases for lipids, dioxins/furans, and mercury are addressed in the pertinent report sections.

Overall, the 2010 data met most quality control criteria defined by MEL and the Quality Assurance Project Plan. The measurement quality objectives in the project plan were met in most cases, and all results were deemed usable as qualified. Some data were qualified due to challenges encountered in analyses.

Summary of Laboratory Case Narratives

Case narratives described many characteristics of the analytical procedure for each group of analytes. Lab analyses met most internal quality control limits with some exceptions. Exceptions often led to results being qualified in some manner. In other cases, exceptions led to re-analysis of samples.

Laboratory analyses encountered different challenges, depending on the group of analytes being measured. Analyses for mercury, lipids, PBDEs, and PCDD/Fs encountered few challenges. Chlorinated pesticides and PCBs presented more challenges, largely because of matrix interferences from high lipid content and/or high levels of target analyte already present in the sample. For example, levels of 4,4'-DDE in some Lake Chelan samples was four times the amount of the matrix spike, which negated the usefulness of this spike. Similarly, the levels of PBDE-47, -99, and -100 in two samples used for matrix spikes, one each from Lake Chelan and the Wenatchee River, were high enough to prevent calculating spike recoveries.

To help address matrix interference issues with chlorinated pesticide analyses, sample re-extractions, dilutions, and re-analyses were conducted to produce a more complete and improved data set. Many results were qualified, with some being rejected. Reporting limits for some analytes were also raised, which was of little consequence for most analytes except for those with water quality standards criteria close to the typical reporting limits, such as toxaphene and dieldrin.

The effects of interferences on PCB results were similar to those for pesticides. Reporting limits for PCBs were raised because of interference from lipids, mainly for samples from Banks Lake and Lake Chelan. Some PCB results qualified as estimates (J) because of poor pattern matching, resulting from weathering and degradation of the PCB Aroclors in samples. High surrogate recoveries in some samples suggest that these results be considered biased high. While this bias might be a factor in comparing skin-on and skin-off results for samples from the Wenatchee River, its effect is likely minimal because four results from two of the paired samples had bias in the same direction.

The four samples from Ozette Lake exceeded the recommended holding time for organic analytes of one year. The samples of sockeye salmon were collected on 10/29/09 and analyzed on 2/24/11, exceeding the recommended one-year holding time by nearly four months. Method 1613B states that there is no demonstrated maximum holding time for PCDD/Fs, and that samples may be stored for up to one year. It seems unlikely that this exceedance compromised the results because of the persistent nature of the target analytes for the screening level effort for Ozette Lake fish, yet this concern should be considered for other uses of the data.

Lipids

There were two minor concerns with lipids results: comparability of results from two labs, and two outlying values.

The 2010 samples were analyzed for PCDD/Fs and lipids at Test America West Sacramento. Test America used toluene during sample preparation. Comparing results from Test America and MEL, we observed that Test America lipids results were biased high by about 20% relative to results from split samples analyzed by MEL. MEL used methylene chloride during sample preparation. Contract labs often use solvents other than methylene chloride when analyzing lipids in conjunction with the main analytes of concern such as PCDD/Fs or PCB congeners. Because we routinely use lipids results from MEL, this difference in methods is rarely of concern.

The 2010 results for lipids contained two values that can be considered outliers because they are unrealistically low. Laboratory procedures and calculations were double-checked and found to be correct. The reason for these two low values is suspected to be high variability within the sample and aliquots. Poor homogenization of the sample can also contribute to variability.

The following lipids values were considered outliers and rejected from the data set:

- Lake Chelan lake trout, sample field ID of C-S1-OFF; MEL lab ID of 1101016-27; reported lipid value of 0.34%.
- Potholes Reservoir lake whitefish, sample field ID PotLWF-1; MEL lab ID of 1101016-24; reported lipid value of 0.17%.

Comparability to Historical Results

To compare 2010 results to historical results, sampling and analytical methods were reviewed to ensure that the methods used between years were comparable. The sampling approaches used in 2010 were similar to those used in historical studies. The target species, sampling season, method and place of collection, formation of composite samples, and sample processing were the same. The analytical methods used were the same except for lipids and dioxins/furans (Lake Chelan only) and mercury. Differences in sampling and analytical methods are discussed in sections for each site earlier in this report. Differences in mercury analytical methods apply to all samples and are discussed below.

MEL made a change in sample preparation methods for mercury in 2005. Tissue samples analyzed by MEL prior to 2005 used a sample digestion procedure for sediment (EPA Method 245.5) whereas samples analyzed in 2005 and later used the correct digestion procedure for tissues (EPA Method 245.6). A study comparing results from the two methods was conducted in 2006 (Furl, 2007). A regression analysis of results from the two methods found Method 245.5 to report mercury concentrations 25-38% lower than Method 245.6, depending on the magnitude of concentration. A correctional equation was developed to estimate mercury concentrations between methods. This equation was applied to historical mercury results in order to allow for better comparison to the 2010 results.

Field Replicates

Multiple samples were collected in 2010 that could be considered field replicates. These replicates were used to estimate sampling precision as expressed by the relative standard deviation (RSD) of the samples used (standard deviation divided by the mean).

Table F-1 shows the various groupings of field samples that can be considered field replicates based on criteria used often to designate field replicates. We typically use the “75% rule” based on total fish length from EPA guidance (EPA, 2000). This rule is: the total length of the smallest fish in a composite sample should be no less than 75% of the length of the largest fish in the samples.

In cases where the fish used in specific composite samples met this rule, these composite samples could be considered field replicates. For example, the fish used in six samples from Lake Chelan met the rule for length: the smallest of the 30 fish used in the six samples was no less than 75% of the length of the largest fish used in the six samples. For fish from Lake Chelan, we also applied the 75% rule to the weights of fish because the compositing scheme was based on weight. As Table F-1 shows, multiple combinations of samples from most sites could be considered field replicates using the 75% rule. These combinations provide multiple estimates of sampling precision.

The measurement quality objective for the precision of measuring organic chemicals in fish tissue samples was an RSD of 28%, as defined in the project plan (Seiders and Yake, 2002). The measurement quality objective for mercury and lipids was an RSD of 14%. Table F-2 shows the RSDs for various measurements.

The precision for DDTs, PCB, PBDEs, and PCDD/Fs ranged from 2% - 64% RSD while precision estimates for mercury and lipids were more often closer to the measurement quality objectives for these analytes. Replicate measurements of PCBs had the poorest precision. Poor precision is common for organic analytes in fish tissue due to several factors, such as interference from lipids and high levels of other analytes. Good precision for PCB Aroclors can be difficult to achieve because the pattern of Aroclor compounds in tissue are often degraded. Such degradation is due to metabolic breakdown of some Aroclor components, and general weathering and recycling over time since the compounds were banned. The value of the RSD can also be high when sample result values are low or close to reporting limits.

Overall, the precision estimates seem reasonable and within the ranges often found with analyses of fish tissue.

Table F-1. Field Replicate Group Identification, WSTMP 2010.

Site	Sample Field ID*	Lab ID (1101016-)	Field Replicate Group ID							
Lake Chelan	C-L1-ON	42	C-L1	C-L2			Cw1			
	C-M4-ON	39	C-L1	C-L2			Cw1	Cw2		
	C-M3-ON	31	C-L1	C-L2				Cw2	Cw3	
	C-M1-ON	36	C-L1	C-L2				Cw2	Cw3	
	C-S3-ON	38	C-L1		C-L3				Cw3	
	C-S2-ON	34	C-L1		C-L3					Cw4
	C-S5-ON	44			C-L3					Cw4
	C-S4-ON	30				C-L4				
	C-S1-ON	28				C-L4				
Banks Lake	BnkLWF-L1	01	BL1							
	BnkLWF-L2	04	BL1							
	BnkLWF-L3	06	BL1							
	BnkLWF-S1	02	Bs1							
	BnkLWF-S2	03	Bs1							
	BnkLWF-S3	05	Bs1							
Potholes Reservoir	POTLWF-1	24	P-L1							
	POTLWF-2	25	P-L1	P-L2						
	POTLWF-3	26		P-L2						
Icicle Creek	IC-L-ON	09	IC-L1							
	IC-M-ON	11	IC-L1	IC-L2						
	IC-S-ON	12		IC-L2						
Wenatchee R near Peshastin	WM-L-ON	16	WM-L1							
	WM-S-ON	18	WM-L1							

Table F-2. Estimates of Precision Expressed as Relative Standard Deviation (RSD) for Various Groupings of Field Replicate Samples, WSTMP, 2010.

Site	Repli-cate Group	t-PCBs	n	TCDD TEQ	n	TCDD	n	n	t-DDT	n	Mer-cury	n	Lipids	n	Mean Total Length	n	Mean Weight	n
Lake Chelan	C-L1	45%	6	34%	3	39%	3		28%	6	17%	6	12%	6	7%	6	25%	6
	C-L2	33%	4	3%	2	15%	2		20%	4	15%	4	12%	4	2%	4	20%	4
	C-L3	35%	3	30%	2	43%	2		39%	3	12%	3	9%	3	5%	3	16%	3
	C-L4	51%	2				1		15%	2	25%	2	3%	2	1%	2	2%	2
	C-w1	31%	2				1		23%	2	9%	2	9%	2	2%	2	15%	2
	C-w2	36%	3				1		24%	3	14%	3	8%	3	2%	3	11%	3
	C-w3	48%	3	45%	2	43%	2		42%	3	19%	3	5%	3	5%	3	8%	3
	C-w4	45%	2				1		5%	2	13%	2	3%	2	3%	2	10%	2
Banks Lake	B-L1	54%	3	45%	3	19%	3		15%	3	30%	3	9%	3	2%	3	4%	3
	B-s1	22%	3	20%	3	7%	3		36%	3	9%	3	8%	3	4%	3	5%	3
Potholes Reservoir	P-L1	50%	2	40%	2	28%	2		45%	2					20%	2	58%	2
	P-L2	60%	2	15%	2	2%	2		34%	2			14%	2	8%	2	33%	2
Icicle Creek	IC-L1	63%	2				1		17%	2	28%	2	6%	2	7%	2	25%	2
	IC-L2	64%	2				0		29%	2	23%	2	26%	2	7%	2	20%	2
Wenatchee R near Peshastin[1]	WM-L1	60%	2	6%	2	41%	2	2	70%	2	35%	2	10%	2	9%	2	37%	2

1. Field replicate (n=2) for t-PBDE was RSD of 25%.

Appendix G. Summary of Results for Fish Tissue Samples, WSTMP 2010.

Table G-1. Results for Fish Tissue Samples for WSTMP, 2010.

Site	Species Code	Field ID	LAB ID: 1101016-	Date Collect	Total PCBs (ug/kg)		2378 TCDD TEQ (ng/kg)		2378 TCDD (ng/kg)		Total PBDE (ug/kg)		T-DDT (ug/kg)		Hexachlorobenzene (ug/kg)		Total Chlordane (ug/kg)		Dieldrin (ug/kg)		Mercury (ug/kg)	Lipids (%)	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)	# Fish/Composite	Skin Status
Banks L	LWF	BnkLWF-L1	01	10/14/10	9.1	J	0.196	J	0.057	J	6.62		18.7		1.10		0.98	U	1.32	UJ	59.6	7.17	504.4	1462.6	4.8	5	on
Banks L	LWF	BnkLWF-L2	04	10/14/10	32.6	J	0.473	J	0.068	J			24.2								104	6.26	513.2	1454.4	11.6	5	on
Banks L	LWF	BnkLWF-L3	06	10/14/10	31.5	J	0.276		0.046	UJ			25.1								108	7.55	521.8	1554.0	10.4	5	on
Banks L	LWF	BnkLWF-S1	02	10/14/10	6.5	J	0.058		0.042	UJ	2.30	J	4.99		0.992	U	0.99	U	0.99	UJ	29.3	4.70	380.8	580.2	1.0	5	on
Banks L	LWF	BnkLWF-S2	03	10/14/10	4.2	J	0.086		0.044	UJ			2.80								30.6	5.46	351.0	523.2	1.0	5	on
Banks L	LWF	BnkLWF-S3	05	10/14/10	5.1	J	0.069		0.038	UJ			2.80								34.6	5.21	366.8	538.2	1.0	5	on
Chelan L	LKT	C-L1-OFF	41	6/3/10	32.0	J					42.3		1734		2.96	U	4.14	-	4.97	U	100	14.00	586.7	2151.0		5	off
Chelan L	LKT	C-L1-ON	42	6/3/10	36.0	J	3.684		0.510		44.7	J	1880		3.00	U	4.37	-	4.93	U	92.6	10.90	586.7	2151.0		5	on
Chelan L	LKT	C-M1-OFF	35	6/3/10	23.4	J							1336								76.0	7.02	553.7	1409.4		5	off
Chelan L	LKT	C-M1-ON	36	6/3/10	26.1	J							1433								64.1	8.23	553.7	1409.4		5	on
Chelan L	LKT	C-M3-OFF	32	6/3/10	48.0	J							2067								86.9	7.91	574.0	1486.8		5	off
Chelan L	LKT	C-M3-ON	31	6/3/10	51.1	J	3.537	J	0.410	NJ			2066								84.9	8.86	574.0	1486.8		5	on
Chelan L	LKT	C-M4-OFF	40	6/3/10	22.4	J							1027								85.3	9.53	570.2	1746.6		5	off
Chelan L	LKT	C-M4-ON	39	6/3/10	56.2	J							1358								81.0	9.57	570.2	1746.6		5	on
Chelan L	LKT	C-S1-OFF	27	6/3/10	19.6	J					16.3		1077		0.994	U	4.80	J	0.50	UJ	88.0		422.9	630.4		5	off
Chelan L	LKT	C-S1-ON	28	6/3/10	24.1	J	2.274		0.350		18.3		1002		0.989	U	4.26	-	0.99	UJ	84.8	6.22	422.9	630.4		5	on
Chelan L	LKT	C-S2-OFF	33	6/3/10	24.0	J							1727								78.9	8.12	485.1	1061.0		5	off
Chelan L	LKT	C-S2-ON	34	6/3/10	18.0	J							1831								74.1	7.67	485.1	1061.0		5	on
Chelan L	LKT	C-S3-OFF	37	6/3/10	22.4	J							924								74.4	9.02	518.2	1274.0		5	off
Chelan L	LKT	C-S3-ON	38	6/3/10	22.0	J	1.826	J	0.220	NJ			850								59.7	9.07	518.2	1274.0		5	on
Chelan L	LKT	C-S4-OFF	29	6/3/10	8.4	J							618								67.6	5.95	419.1	648.0		5	off

Site	Species Code	Field ID	LAB ID: 1101016-	Date Collect	Total PCBs (ug/kg)		2378 TCDD TEQ (ng/kg)		2378 TCDD (ng/kg)		Total PBDE (ug/kg)		T-DDT (ug/kg)		Hexachlorobenzene (ug/kg)		Total Chlordane (ug/kg)		Dieldrin (ug/kg)		Mercury (ug/kg)	Lipids (%)	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)	# Fish/Composite	Skin Status
Chelan L	LKT	C-S4-ON	30	6/3/10	51.0	J							1243								59.2	6.51	419.1	648.0		5	on
Chelan L	LKT	C-S5-OFF	43	6/3/10	21.0	J					21.3		1368		0.979	U	5.77	-	1.47	UJ	61.8	7.80	466.1	922.2		5	off
Chelan L	LKT	C-S5-ON	44	6/3/10	34.8	J	2.809	J	0.410		31.1		1973	J	1.08	J	7.90	J	1.46	UJ	61.5	7.99	466.1	922.2		5	on
Icicle Cr	MWF	IC-L-OFF	10	12/7/10	37.0	J					15.9	J	43.6		1.96	U	1.96	U	0.98	UJ	73.9	3.95	410.0	612.4	8.8	5	off
Icicle Cr	MWF	IC-L-ON	09	12/7/10	41.7	J	0.265	J	0.071	NJ	16.9		50.6		0.974	U	0.97	U	0.49	U	69.0	3.90	410.0	612.4	8.8	5	on
Icicle Cr	MWF	IC-M-ON	11	12/7/10	109	J							64.4								46.4	4.22	369.0	429.2	4.8	5	on
Icicle Cr	MWF	IC-S-ON	12	12/7/10	41.0	J							42.3								33.4	2.93	333.4	320.8	3.4	5	on
Nason Cr	MWF	NS-L-ON	15	11/3/10	6.1	J	0.332	J	0.074	NJ	1.69	J	5.02		0.996	U	1.00	U	1.00	UJ	101	3.47	386.6	620.8	9.8	5	on
Nason Cr	MWF	NS-M-ON	14	11/3/10	12.7	J							7.30								89.8	3.52	333.8	406.6	6.0	5	on
Nason Cr	MWF	NS-S-ON	13	11/3/10	2.4	J							6.08								55.0	3.63	277.4	186.6	3.0	5	on
Ozette L	SOK	OZSOK-FF	47	10/29/09	7.2	J	0.088	J	0.021	UJ	2.28	J	2.84		0.987		0.96	U	0.48	U		2.06	568.0	1610.2	4.0	5	on
Ozette L	SOK	OZSOK-FM	48	10/29/09	8.4	J	0.158	J	0.030	NJ	0.39	J	5.03		1.14		1.09	J	0.48	U		2.95	587.5	1945.5	4.0	4	on
Ozette L	SOK	OZSOK-WF	45	10/29/09	7.2	J	0.103	J	0.021	UJ	0.38	J	3.27		1.07		0.95	U	0.47	U		2.76	552.5	1373.3	4.0	4	on
Ozette L	SOK	OZSOK-WM	46	10/29/09	10.0	J	0.223	J	0.046	J	0.39	J	5.83		1.35		1.14	J	0.49	U		2.99	598.8	2052.5	4.0	8	on
Potholes Reservoir	LWF	PotLWF-1	24	10/20/10	1.9	U	0.050	J	0.054	UJ	0.80	J	10.3	J	2.00	U	2.00	U	1.42	J			357.5	499.8		4	on
Potholes Reservoir	LWF	PotLWF-2	25	10/20/10	4.0	U	0.089	J	0.036	J			19.9									9.60	475.3	1200.5		4	on
Potholes Reservoir	LWF	PotLWF-3	26	10/20/10	9.9	J	0.110		0.035	UJ			32.7									11.70	535.3	1928.0		3	on
Wenatchee L	CTT	WENLKCTT	07	10/13/10	1.5	J					2.00	U	2.59		0.992	U	0.99	U	0.50	U	25.6	1.36	271.0	189.5	2.3	4	on
Wenatchee L	NPM	WENLKNPM	08	10/13/10	8.1	J	0.020	NJ	0.033	UJ	0.86	J	9.05		0.995	U	1.00	U	1.00	UJ	185	2.81	386.6	577.0	11.8	5	on
Wenatchee R nr Monitor Br	MWF	WM-L-OFF	17	12/7/10	2100	J					23.9		175	J	0.983	U	0.55	J	12.0	UJ	68.2	4.98	385.8	574.8	7.8	5	off
Wenatchee R nr Monitor Br	MWF	WM-L-ON	16	12/7/10	1700	J	0.253	J	0.097	NJ	23.0		174	J	0.983	U	40.3	U	0.98	UJ	63.1	4.45	385.8	574.8	7.8	5	on
Wenatchee R nr Monitor Br	MWF	WM-S-OFF	19	12/7/10	470	J					16.3	J	107	J	1.95	U	13.3	U	4.04	UJ	39.9	3.29	341.0	335.6	3.4	5	off
Wenatchee R nr Monitor Br	MWF	WM-S-ON	18	12/7/10	690	J	0.234		0.053	NJ	16.1		59.1	J	2.91	U	15.7	U	4.11	UJ	37.8	3.84	341.0	335.6	3.4	5	on
Wenatchee R nr Peshastin	MWF	WP-L-OFF	22	11/15/10	59.0	J					14.1	J	57.3	J	0.997	U	1.96	U	0.50	U	45.0	2.65	308.6	282.2	3.6	5	off

Site	Species Code	Field ID	LAB ID: 1101016-	Date Collect	Total PCBs (ug/kg)		2378 TCDD TEQ (ng/kg)		2378 TCDD (ng/kg)		Total PBDE (ug/kg)		T-DDT (ug/kg)		Hexachlorobenzene (ug/kg)		Total Chlordane (ug/kg)		Dieldrin (ug/kg)		Mercury (ug/kg)	Lipids (%)	Mean Total Length (mm)	Mean Weight (g)	Mean Age (years)	# Fish/Composite	Skin Status
Wenatchee R nr Peshastin	MWF	WP-L-ON	23	11/15/10	79.0	J	0.214	J	0.040	NJ	16.0	J	73.6	J	0.995	U	2.61	U	1.00	UJ	40.8	3.26	308.6	282.2	3.6	5	on
Wenatchee R nr Peshastin	MWF	WP-S-OFF	20	11/15/10	8.9	J					2.59	J	19.1		0.985	U	0.99	U	0.49	U	34.2	1.69	260.0	155.4	2.4	5	off
Wenatchee R nr Peshastin	MWF	WP-S-ON	21	11/15/10	18.7	J	0.071	J	0.043	NJ	7.31	J	34.3		0.996	U	1.00	U	0.50	U	30.5	2.47	260.0	155.4	2.4	5	on

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

Species Codes:
CTT = Cutthroat trout
LKT = Lake Trout
LWF = Lake whitefish
MWF = Mountain whitefish
NPM = Northern pikeminnow
SOK = Sockeye salmon

Appendix H. Results from Statistical Tests, WSTMP 2003 and 2010

Table H-1. Summary of Two-Sample t-Tests for t-DDT in Lake Chelan Fish Tissue Samples from 2003 and 2010.

Data sets	N	Mean	Standard Deviation	Test statistic t	Critical value of t	Reject H_0?	p-Value	Difference between means
2003 c_all	10	963	331	-3.073	2.11	Yes	0.007	542
2010 c_all	9	1505	436					
2003 c_select	9	1002	326	-2.774	2.12	Yes	0.014	503
2010 c_all	9	1505	436					
2003 i_all	30	937	556	-2.813	2.026	Yes	0.008	569
2010 c_all	9	1505	436					

H_0: The means of the data sets are the same.
H_A: The means of the data sets are not the same.
Reject H_0 if critical value of t > test statistic t. Alpha = 0.05.

Table H-2. Summary of Mann-Whitney Two-Sample Rank Tests for t-DDT in Lake Chelan Fish Tissue Samples from 2003 and 2010.

Data sets	N	Rank Sum	Test statistic U	Test statistic U^1	Critical value of U	Reject H_0?	p-Value
2003 c_all	10	69	14	76	70	Yes	0.011
2010 c_all	9	121					
2003 c_select	9	59	14	67	64	Yes	0.019
2010 c_all	9	112					
2003 i_all	30	517	52	218	194	Yes	0.006
2010 c_all	9	263					

H_0: The data sets are the same value.
H_A: The data sets are not the same value.
Reject H0 if critical value of U < test statistic U or U'. Alpha = 0.05

Table H-3. Summary of Two-Tailed Variance Ratio Test for t-DDT in Lake Chelan Fish Tissue Samples from 2003 and 2010.

Pairing Group	Data sets	N	Mean	Variance	F-Ratio	df	p-Value	F Critical	Reject H_0?
A	2003 c_all	10	963	109,536	0.577	9, 8	0.429	4.36	No
	2010 c_all	9	1505	189,834					
B	2003 c_select	9	1002	106,572	0.561	8, 8	0.432	4.43	No
	2010 c_all	9	1505	189,834					
C	2003 i_all	30	937	308,588	1.63	29, 8	0.484	3.90	No
	2010 c_all	9	1505	189,834					

df: Degrees of freedom.
H_0: The difference between the variances is zero.
H_A: The difference between the variances is not zero.
Reject H_0 if critical value of F < test statistic F. Alpha = 0.05.

Table H-4. Summary of Paired-Sample t-Test for Target Analytes in Skin-On and Skin-Off Samples from Lake Chelan Fish Tissue from 2010.

Analyte	Data Set	N	Mean	Difference Between Means	df	Test Statistic t	Critical Value of t	Reject H_0?	p-Value
DDT	Skin-off	9	1,311.4	193.9	8	-2.186	2.306	No	0.060
DDT	Skin-on	9	1,505.3						
PCB	Skin-off	9	24.6	10.9	8	-1.987	2.306	No	0.082
PCB	Skin-on	9	35.5						
PBDE	Skin-off	3	26.6	4.8	2	-1.879	4.303	No	0.201
PBDE	Skin-on	3	31.4						
Mercury	Skin-off	9	79.9	6.3	8	4.029	2.306	Yes	0.004
Mercury	Skin-on	9	73.5						
Lipids	Skin-off	8	8.7	0.07	7	0.146	2.365	No	0.888
Lipids	Skin-on	8	8.6						

df: Degrees of freedom.
H_0: The difference between the mean values of the data sets is zero.
H_A: The difference between the mean values of the data sets is not zero.
Reject H_0 if critical value of t < test statistic t. Alpha = 0.05.

Table H-5. Summary of Two-Tailed Variance Ratio Test for Target Analytes in Skin-On and Skin-Off Samples from Lake Chelan Fish Tissue from 2010.

Analyte	Skin status	N	Mean	Variance	F-Ratio	df	p-Value	F Critical	Reject H_0?
DDT	Off	9	1311.4	209,020.9	1.101	8, 8	0.895	4.43	No
	On	9	1505.3	189,834.5					
PCB	Off	9	24.6	114.3	0.564	8, 8	0.436	4.43	No
	On	9	35.5	202.5					
PBDE	Off	3	26.6	190.4	1.092	2, 2	0.956	39.0	No
	On	3	31.4	174.4					
HG	Off	9	79.9	134.1	0.821	8, 8	0.788	4.43	No
	On	9	73.5	163.3					
LIPID	Off	8	8.7	5.9	3.346	7,7	0.134	4.49	No
	On	8	8.6	1.8					

df: Degrees of freedom.
H_0: The difference between the variances is zero.
H_A: The difference between the variances is not zero.
Reject H_0 if critical value of F < test statistic F. Alpha = 0.05.

Table H-6. Summary of Paired-Sample t-Test for Selected Analytes in Skin-On and Skin-Off Samples from Wenatchee River Fish Tissue from 2010.

Analyte	Data Set	N	Mean	Difference Between Means	df	Test Statistic t	Critical Value of t	Reject H_0?	p-Value
PCB	Skin-off	5	535.0	29.1	4	0.288	2.776	No	0.788
PCB	Skin-on	5	505.9						
DDT	Skin-off	5	73.9	3.5	4	0.309	2.776	No	0.773
DDT	Skin-on	5	70.4						
PBDE	Skin-off	5	14.6	1.3	4	-1.309	2.776	No	0.261
PBDE	Skin-on	5	15.8						
Mercury	Skin-off	5	52.2	4.0	4	7.454	2.776	Yes	0.002
Mercury	Skin-on	5	48.2						
Lipids	Skin-off	5	3.3	0.3	4	-1.112	2.776	No	0.328
Lipids	Skin-on	5	3.6						

df: Degrees of freedom.
H_0: The difference between the mean values of the data sets is zero.
H_A: The difference between the mean values of the data sets is not zero.
Reject H_0 if critical value of t < test statistic t. Alpha = 0.05.

Table H-7. Summary of Two-Tailed Variance Ratio Test for Selected Analytes in Skin-On and Skin-Off Samples from Wenatchee River Fish Tissue from 2010.

Analyte	Skin status	N	Mean	Variance	F-Ratio	df	p-Value	F Critical	Reject H_0?
DDT	Off	5	73.9	3,001.0	1.266	4, 4	0.825	9.60	No
	On	5	70.4	2,369.9					
PCB	Off	5	535.0	801,202.8	1.53	4, 4	0.69	9.60	No
	On	5	505.9	523,714.2					
PBDE	Off	5	14.6	59.0	1.88	4, 4	0.556	9.60	No
	On	5	15.8	31.4					
HG	Off	5	52.2	313.5	1.109	4, 4	0.923	9.60	No
	On	5	48.2	282.7					
LIPID	Off	5	3.3	1.6	2.768	4, 4	0.348	9.60	No
	On	5	3.6	0.6					

df: Degrees of freedom.
H_0: The difference between the variances is zero.
H_A: The difference between the variances is not zero.
Reject H_0 if critical value of F < test statistic F. Alpha = 0.05.

Appendix I. 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

- 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 J. Glossary, Acronyms, and Abbreviations

Glossary

Analyte: Water quality constituent being measured (parameter).

Basin: Watershed. A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Congener: In chemistry, congeners are related chemicals. For example, polychlorinated biphenyls (PCBs) are a group of 209 related chemicals that are called congeners.

Exceeded criterion: Did not meet or violated the criterion.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (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.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

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 beneficial 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.

Acronyms and Abbreviations

CRO	Central Regional Office
CVAA	Cold Vapor Atomic Absorption

DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-trichloroethylene
DDT	Dichloro-diphenyl-trichloroethane
DOH	Department of Health
ECD	Electron Capture Detection
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	Environmental Protection Agency
GC	Gas Chromatography
Health	Washington State Department of Health
HR	High Resolution
MEL	Manchester Environmental Laboratory
MS	Mass Spectrometry
n	number
NRD	Natural Resources Department
NTR	National Toxics Rule
PBDE	Polybrominated diphenyl ethers
PBT	Persistent, bioaccumulative, and toxic substance
PCB	Polychlorinated biphenyls
PCDD/Fs	Polychlorinated dibenzo-p-dioxins and –furans
RPD	Relative percent difference
RSD	Relative standard deviation
SIM	Single Ion Monitoring.
SOP	Standard operating procedures
t-DDT	Total DDTs
t-PBDE	Total PBDEs
t-PCB	Total PCBs
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalent Factor
TEQ	Toxic Equivalent
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSTMP	Washington State Toxics Monitoring Program

Units of Measurement

g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams.
mg	milligrams
mm	millimeters
ng/kg	nanograms per kilogram (parts per trillion)
ug/kg	micrograms per kilogram (parts per billion)