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An Assessment of the Chlorinated Pesticide Background in Washington State Freshwater Fish and Implications for 303(d) Listings

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An Assessment of the Chlorinated Pesticide Background in Washington State Freshwater Fish and Implications for 303(d) Listings

by

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Water Resource Inventory Areas: Statewide

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Abstract

Twenty-nine chlorinated pesticides or breakdown products were analyzed in 48 fish fillet samples collected from 28 background lakes across Washington State, in 2010 and 2011. These legacy chemicals have become ubiquitous in the environment due to global use, persistence, long-range atmospheric transport, and bioaccumulation. In this study, the term *background* refers to waterbodies that appear to exhibit relatively low direct impact from local human activities.

The data were needed to prioritize 303(d)-listed waterbodies for water cleanup plans and support revisions to the water quality standards for chlorinated pesticides. The information can also be used to evaluate progress toward meeting cleanup targets for waterbodies where pollution control programs are already in place.

The most frequently detected compounds (80% or more of samples) included 4,4' isomers of DDT and its breakdown products DDE and DDD, dieldrin, chlordane components, hexachlorobenzene, and mirex. 4,4'-DDE occurred in much higher concentrations than any other pesticide analyzed, with a statewide median of 1.1 ug/Kg (parts per billion) and 90^{th} percentile of 6.5 ug/Kg. Other detected compounds had statewide medians in the range of approximately 0.01 – 0.2 ug/Kg. 4,4'-DDE showed evidence of increasing concentrations moving from western to eastern Washington, a pattern not seen for any of the other pesticides.

The Department of Ecology has begun formal rule-making activities to adopt new human health-based water quality standards for toxics that will include updated assumptions about how much fish Washington residents eat. About half of the lakes sampled in the background study would qualify for 303(d) listing (water quality limited) based on criteria tissue equivalent concentrations calculated using a fish consumption rate of 130 grams per day and Ecology's current 303(d) listing policy. About 1 in 5 (20%) would qualify for listing for consumption rates of 54 grams per day. Washington's current human health criteria are based on 6.5 grams per day.

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Introduction

In 2008, the Washington State Department of Ecology (Ecology) conducted a statewide study to assess PCB and dioxin levels in fish from background lakes and rivers thought to exhibit relatively low impact from human activities (Johnson et al., 2010a). The data were needed to help prioritize other waterbodies and set targets for cleanups to remedy PCB and dioxin contamination.

This report describes results of a similar study for chlorinated pesticides, conducted by Ecology in 2012. The pesticides of primary interest were the legacy insecticides DDT, dieldrin, chlordane, heptachlor, hexachlorobenzene, aldrin, alpha-BHC, and toxaphene. Like PCBs, these pesticides have become ubiquitous in the environment due to global use, persistence, long-range atmospheric transport, and bioaccumulation.

Chlorinated pesticides are routinely detected in Washington's freshwater fish (e.g., Seiders et al., 2012). There are currently over 100 listings in Category 5 of Washington's 2008 section 303(d) list for pesticide-impaired waterbodies that exceed National Toxics Rule human health criteria and/or the criteria fish tissue equivalent concentrations (FTECs) for fish consumption (Table 1). Many of the listings are for lakes and rivers with no obvious local sources of these compounds. The Clean Water Act requires that waterbodies in Category 5 have water cleanup plans or Total Maximum Daily Loads (TMDLs) developed to bring them into compliance with water quality standards (www.ecy.wa.gov/programs/wq/links/wq_assessments.html). A TMDL determines the loading capacity of a waterbody for a pollutant and allocates the load among point and nonpoint sources in the watershed.

Table 1. Washington State Freshwater Category 5 303(d) Listings for Chlorinated Pesticides or Breakdown Products based on Human Health Criteria (2008 list): www.ecy.wa.gov/programs/wq/links/wq_assessments.html

Pesticide or Breakdown Product	Number of Waterbody Listings	Percent of Total
4,4'-DDE	42	38%
Dieldrin	25	22%
Chlordane	8	11%
4,4'-DDD	10	9%
4,4'-DDT	9	8%
HCH, alpha	6	5%
Toxaphene	3	3%
Aldrin	2	2%
Hexachlorobenzene	2	2%
Heptachlor	1	1%
Total =	108	

Without better information on what constitutes present-day background for these ubiquitous contaminants in fish, it is difficult to prioritize which waterbodies should have cleanup plans developed and determine the feasibility and best approach for bringing listed waterbodies into compliance with standards. The information collected through this project will help prioritize the state's resources and accelerate pollution control actions related to chlorinated pesticides in freshwaters statewide. The data will also be useful in evaluating progress toward meeting cleanup targets for waterbodies where pollution control programs or TMDLs are already in place.

Ecology plans to adopt new human health criteria in the water quality standards. Part of this effort involves developing new, more accurate fish consumption rates. The current rates were developed in the 1980s and 1990s. More recent studies indicate these rates do not accurately reflect how much fish Washington residents eat (www.ecy.wa.gov/toxics/fish.html). If new criteria based on higher fish consumption rates are adopted, this could translate into lower, more conservative human health criteria. Data on chemical residues in fish from background areas provide a perspective on implications for new 303(d) listings based on more protective criteria and Ecology's current 303(d) listing policy.

Human Health Criteria

Ecology's 303(d) listing concentrations for chlorinated pesticides in edible fish tissue are shown in Table 2.

Table 2. 303(d) Human Health Criteria Equivalent Concentrations for Chlorinated Pesticides in Edible Fish Tissue (ug/Kg, wet weight; parts per billion).

Pesticide or Breakdown Product	Fish Tissue Criterion Equivalent
HCH, alpha	0.51
Aldrin	0.61
Dieldrin	0.65
Heptachlor Epoxide	1.1
HCH, beta	1.8
Heptachlor	2.4
HCH, gamma	2.5
Hexachlorobenzene	6.5
Chlordane	8.0
Toxaphene	9.6
4,4'-DDT	32
4,4'-DDE	32
4,4'-DDD	44
alpha-Endosulphan	251
beta-Endosulphan	251
Endosulphan Sulfate	251
Endrin	3,017
Endrin Aldehyde	3,017

The fish tissue equivalents are derived from EPA bioconcentration factors and human health water quality criteria established under the EPA National Toxics Rule (NTR) issued to Washington in 1992 (40 CFR Part 131; Federal Register Vol. 57, No. 246, and as updated). The criteria provide a cancer risk protection at the 10^{-6} (one in one million) excess lifetime cancer risk level. The criteria calculations incorporate values for average fish consumption among the general public (6.5 g/day), average adult weight (70 kg), a drinking water ingestion rate of 2 liters of water per day (for freshwater), and an exposure duration of 70 years.

The NTR does not include human health criteria for the following pesticides and breakdown products analyzed in the present study: 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, delta-HCH, endrin ketone, methoxychlor, and mirex.

The human health criteria are calculated using Equation1. Note that the criteria are inversely proportional to the fish consumption rate (FC). For highly bioaccumulative chemicals like the organochlorines the water consumption term (WC) has little effect on the criteria because most of the chemical intake comes from fish.

Equation1. $$\boldsymbol{HHC} = \frac{\boldsymbol{RF} \times \boldsymbol{BW} \times (\mathbf{10^9}\ \boldsymbol{pg/mg})}{\boldsymbol{q1}^* \times [\boldsymbol{WC} + (\boldsymbol{FC\ x\ BCF})]}$$

Where:

- HHC = human health water quality criteria.
- RF (risk factor) = the acceptable level of cancer risk. Washington's acceptable upper-bound excess cancer risk is one in a million (10^{-6}) for a lifetime exposure.
- BW (body weight) = the average body weight of the consumer. The NTR uses an average consumer body weight of 70 kg.
- q1* (cancer slope factor) = the cancer potency of each chemical. The NTR uses a q1* of 2 per mg/kg-day for PCBs.
- WC (water consumption) = the average daily consumption of water by a consumer. The NTR uses a water consumption rate of 2 L/day.
- FC (fish consumption) = the average fish tissue consumption by a consumer. The NTR uses a fish tissue consumption rate of 0.0065 kg/day (6.5 g/day).
- BCF (bioconcentration factor) = the concentration of a chemical in tissue accumulated through gill and skin divided by the concentration in the water column. For example, the NTR uses a BCF of 53,600 L/kg for DDT.

The water quality criterion can be converted to an equivalent fish tissue concentration using the BCF in Equation 2, where Cw is the concentration in water and Ct is the concentration in tissue:

Equation2. $$\boldsymbol{BCF} = \frac{\boldsymbol{C_t}}{\boldsymbol{C_W}}$$

NTR-equivalent fish tissue concentrations may then be calculated by $C_t = BCF \times C_w$.

Project Description

The objective of this project was to characterize chlorinated pesticide residues in edible tissues (fillets) of fish from background lakes in Washington. Sensitive analytical methods were employed to achieve detection in the sub-parts per billion range.

Statistical and graphical summaries of the data are provided. The results are further evaluated by comparing with fish tissue data on other waterbodies in Washington and by identifying exceedances of human health criteria for a range of fish consumption rates.

This report focuses on the median and 90th percentile to characterize the results of the pesticide analyses. The median is the value for which half the observations lie above and half the observations lie below. Median is a better measure of central tendency than the mean (average) which can be biased by a few high or low values (outliers).

Percentiles describe a location in the distribution of a data set. At the 90th percentile, 10% of the data lie above that value and 90% lie below. The 90th percentile is often used to define background concentrations for regulatory or investigative purposes (MTCA Cleanup Regulation WAC 173-340: Blakley et al., 1992; San Juan, 1994; Johnson et al., 2011).

The report uses the term *background* when referring to waterbodies that appear to exhibit relatively low direct impact from local human activities. These waterbodies are further affected to varying degrees by watershed and global-scale atmospheric influences. Given the extent of agricultural, urban, and industrial development in the Pacific Northwest and world-wide, all Washington waterbodies have been affected to at least some degree by humans.

Factors considered in waterbody selection for this study included land-use development, proximity to agriculture and industry, general local watershed conditions, and known lake management history. The study focused on lakes since larger rivers and streams often have a variety of known or potential anthropogenic influences. The sampling was also weighted toward lakes because of (1) the low diversity of fish species in most rivers that might qualify as background and (2) the greater ability of fish to move into and out of rivers as opposed to lakes. Lakes and impoundments also dominate the 303(d) list.

Forty-eight fish samples were collected from 28 background lakes in four regions of Washington, primarily during the summer and fall of 2011. One to three species were sampled in each waterbody, depending on availability. Composite fillets from each species were analyzed for 29 chlorinated pesticides or breakdown products and for lipid (fat) content.

Ecology's Environmental Assessment Program (EA Program) conducted this study, following a Quality Assurance Project Plan (Johnson, 2011) developed in accordance with the Ecology guidance in Lombard and Kirchmer (2004). Pesticides and lipids were analyzed by AXYS Analytical Services in Sidney B.C. through a contract with the Ecology Manchester Environmental Laboratory (MEL).

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Study Design

Target Chemicals

The fish fillet samples were analyzed for the chlorinated pesticides and breakdown products listed in Table 3. Detailed profiles on these compounds have been prepared by the Agency for Toxic Substances & Disease Registry (www.atsdr.cdc.gov/toxprofiles/index.asp). The profiles include descriptions of health effects, physical/chemical properties, production and use, environmental occurrence, and regulations.

Table 3. Chlorinated Pesticides and Breakdown Products Analyzed.

Chemical Name	CAS* Number	Year Banned or Restricted in U.S.
HCH, alpha	319-84-6	1977 (banned)
HCH, beta	319-85-7	"
HCH, delta	319-86-8	"
HCH, gamma	58-89-9	currently used
Heptachlor	76-44-8	1978 / 1987
Heptachlor Epoxide	1024-57-3	(heptachlor breakdown product)
Hexachlorobenzene	118-74-1	1984 (banned)
Chlordane, oxy-	27304-13-8	1978 / 1987 (chlordane)
Chlordane, gamma (trans)	5103-74-2	(chlordane component)
Chlordane, alpha (cis)	5103-71-9	"
Nonachlor, trans-	39765-80-5	"
Nonachlor, cis-	5103-73-1	"
4,4'-DDT	50-29-3	1972 (banned)
2,4'-DDT	789-02-6	(DDT component)
4,4'-DDE	72-55-9	(DDT breakdown product)
2,4'-DDE	3424-82-6	"
4,4'-DDD	72-54-8	"
2,4'-DDD	53-19-0	"
alpha-Endosulphan	959-98-8	2002 (restricted)
beta-Endosulphan	33213-65-9	"
Endosulphan Sulphate	1031-07-8	(endosulphan breakdown product)
Aldrin	309-00-2	1974 / 1987
Dieldrin	60-57-1	1974 / 1987
Endrin	72-20-8	1979 / 1984
Endrin Aldehyde	7421-93-4	(endrin breakdown product)
Endrin Ketone	53494-70-5	"
Methoxychlor	72-43-5	currently used
Mirex	2385-85-5	1977 (banned)
Toxaphene	8001-35-2	1982 (restricted)

*Chemical Abstracts Service: www.cas.org

All of the compounds analyzed in this study are lipid soluble. Lipid content of the fish tissue samples was therefore determined for possible use in normalizing the data to examine species differences and spatial patterns.

Lake Selection

Background lakes were selected by examining Washington State maps and GIS coverages showing population density, agricultural land use, public lands, annual precipitation, and wind direction. This exercise identified areas that have a low probability of being influenced by local sources of contamination.

Fisheries biologists and resource managers for the Washington Department of Fish and Wildlife (WDFW), Colville Confederated Tribes, National Park Service, U.S. Forest Service, and Ecology were asked to identify potential background lakes within these areas, using the following criteria:

- Elevation under approximately 3,000 ft.
- Watershed relatively undisturbed or logging only.
- At least two non-planted fish species of catchable size.
- Good accessibility.

Based on the mapping exercise and waterbody recommendations, six to eight lakes were selected for sampling in each of four regions: Western Washington, West Slope of the Cascades, East Slope of the Cascades, and Eastern Washington (Table 4). The location of these regions relative to the Pacific Ocean air mass, urban Puget Sound, and eastern Washington agricultural basins was viewed as having potential to result in lakes with substantially different levels of legacy pesticides.

Table 4. Lakes where Fish Samples were Collected for Chlorinated Pesticide Analysis.

Region and Lake Name	Surrounding Area	County	Lake Elevation (ft)	Lake Area (acres)	Max. Depth (ft)	Lat.	Long.
Western Washington							
Ozette	Olympic NP	Clallam	29	7,787	331	48.100	124.640
Tarboo	Olympic Peninsula	Jefferson	642	24	58	47.924	122.852
Cushman	Olympic NF	Mason	731	4,003	115	47.470	123.250
Wynoochee	Olympic NF	Grays Harbor	800	1,120	175	47.405	123.587
Devereaux	Kitsap Peninsula	Mason	215	100	50	47.405	122.848
Failor	Humptulips River basin	Grays Harbor	117	65	20	47.108	123.964
Silver	Seaquest SP	Cowlitz	485	2,996	10	46.290	122.792
West Slope Cascades							
Baker	N. Cascade NP	Whatcom	724	3,616	283	48.720	121.660
Diobsud	Noisy Diobsud Wilderness	Skagit	4,283	3	?	48.646	121.542
Gorge	Ross Lake NRA	Whatcom	883	210	125	48.698	121.208
Cavanaugh	Baker-Snoqualmie NF	Skagit	1,008	844	80	48.322	122.013
Cassidy	Marysville-Granite Falls	Snohomish	319	125	20	48.053	122.094
Chester Morse	Baker-Snoqualmie NF	King	1,555	1,682	116	47.390	121.700
Coldwater	St. Helens National Monument	Cowlitz	2,490	750	?	46.303	122.239
Merrill	Lewis River basin	Clark	1,541	344	60	46.090	122.330
East Slope Cascades							
Patterson	Okanogan NF	Okanogan	2,740	130	85	48.460	120.240
Wenatchee	Wenatchee NF	Chelan	2,257	513	300	47.830	120.700
Cle Elum	Wenatchee NF	Kittitas	2,224	4,810	140+	47.290	121.110
Bumping	Wenatchee NF	Yakima	3,426	1,310	89	46.850	121.320
Rimrock	Wenatchee NF	Yakima	3,615	265	54	46.630	121.280
Walupt	Goat Rocks Wilderness	Lewis	4,000	384	295	46.417	121.464
Eastern Washington							
Cedar	Colville NF	Stevens	2,135	52	28	48.943	117.594
Sullivan	Colville NF	Pend Oreille	1,380	1,290	330	48.816	117.292
Leo	Colville NF	Pend Oreille	2,588	39	37	48.910	118.130
Bayley	Colville NF	Stevens	2,400	17	12	48.420	117.644
South Twin	Colville NF	Ferry	2,572	973	57	48.264	118.387
Buffalo	Colville Reservation	Okanogan	954	3,244	121	48.280	119.400
Evergreen	Quincy Wildlife Area	Grant	~1,000	235	54	47.140	119.920

NP: National Park
NF: National Forest
SP: State Park
NWR: National Wildlife Refuge
NRA: National Recreation Area

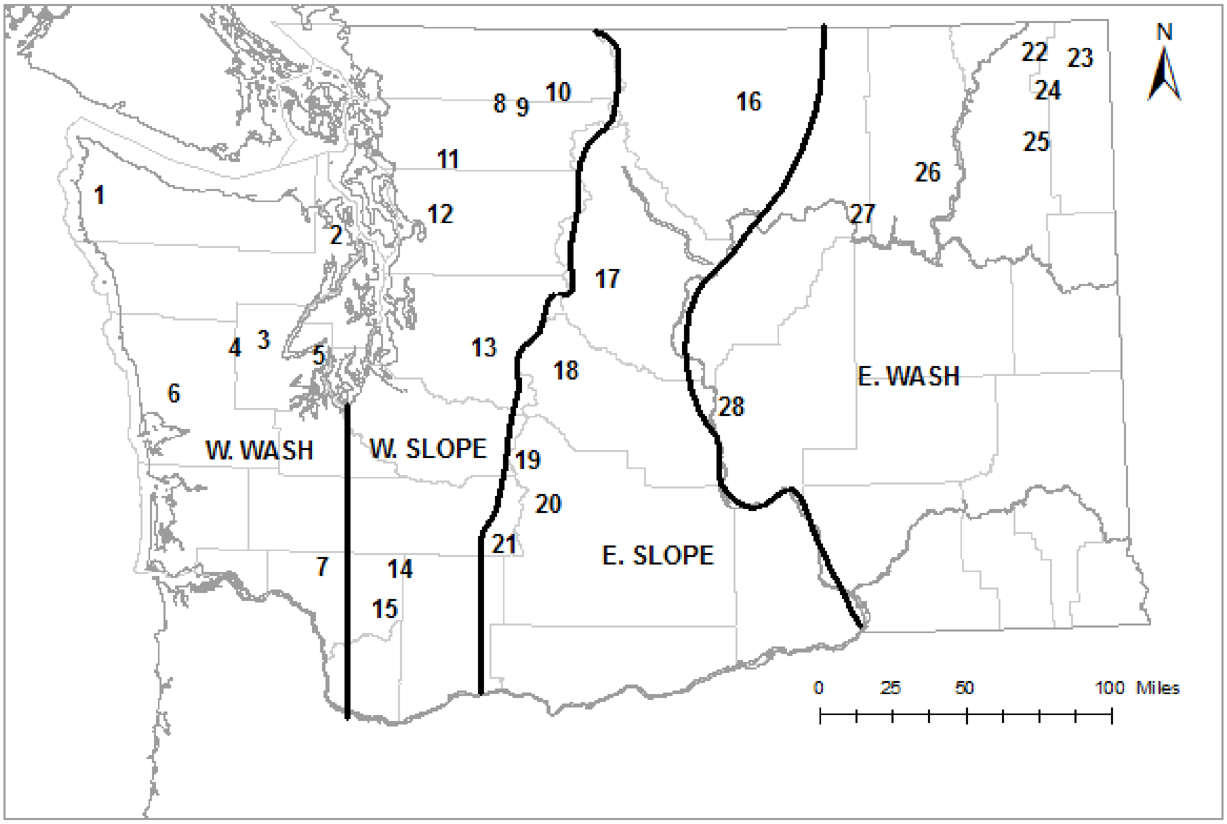


Figure 1. Lake Locations.

Key to Figure 1

Western Washington	West Slope Cascades	East Slope Cascades	Eastern Washington
1 = Ozette Lake	8 = Baker Lake	16 = Patterson Lake	22 = Cedar Lake
2 = Tarboo Lake	9 = Diobsud Lake	17 = Wenatchee Lake	23 = Sullivan Lake
3 = Cushman Lake	10 = Gorge Lake	18 = Cle Elum Lake	24 = Leo Lake
4 = Wynoochee Lake	11 = Cavanaugh Lake	19 = Bumping Lake	25 = Bayley Lake
5 = Devereaux Lake	12 = Cassidy Lake	20 = Rimrock Lake	26 = South Twin Lake
6 = Failor Lake	13 = Chester Morse Lake	21 = Walupt Lake	27 = Buffalo Lake
7 = Silver Lake	14 = Coldwater lake		28 = Evergreen Res.
	15 = Merrill Lake		

An effort was made to distribute the sampling along a north-south gradient within each of the four regions. The selected lakes include a mix of natural waterbodies and impoundments of various sizes, as is the case with the 303(d) list. It was not possible to locate potential background lakes within major eastern Washington agricultural basins such as the Yakima, Palouse, and Walla Walla.

The appropriateness of the lakes selected as representing background was checked against Ecology's Facility Site Identification System (http://ecyapps3/facilitysite/). Facility Site identifies sites known to Ecology as having an active or potential impact on the environment.

While pristine, high mountain lakes obviously qualify as background, they were not included in this study because of enhanced atmospheric deposition of synthetic organic compounds due to colder temperatures and greater amounts of precipitation (Wania and Mackay, 1993; Blais et al., 1998; Gillian and Wania, 2005; Moran et al., 2007). High lakes have the additional drawbacks of difficult access and low fish diversity.

The study sampled a range of lake and reservoir sizes and elevations to obtain a statewide assessment of the chlorinated pesticide background. The lakes selected for study ranged in size from less than 10 to approximately 8,000 acres, with maximum depths of 10 to over 300 feet. Elevations were between about 29 and 4,283 feet; most lakes were below 3,000 feet.

Fish Samples

This study targeted the larger fish species more likely to be consumed and on which most of the 303(d) listings for Washington are based. The species of primary interest were:

- rainbow trout (*Oncorhynchus mykiss*)
- largemouth bass (*Micropterus salmoides*)
- cutthroat trout (*Oncorhynchus clarki*)
- kokanee (*Oncorhynchus nerka*)
- yellow perch (*Perca flavescens*)
- mountain whitefish (*Prosopium williamsoni*)
- carp (*Cyprinus carpio)*
- largescale suckers (*Catostomus macrocheilus*)

Based on past experience, it was anticipated that one to three species could be collected from each lake. An effort was made to collect at least one predator and one bottom feeder from each site, as recommended by EPA (2000). Use of fish samples from two distinct ecological groups as target species reflects a range of habits, feeding strategies, and physiological factors that can result in differences in bioaccumulation of contaminants. No planted fish were analyzed, unless planted as fingerlings.

Large fish often have higher levels of chemical contaminants than small fish. Larger and older fish tend to consume larger, more contaminated prey, to eat at higher trophic levels, and have higher lipid content. It was beyond the scope and budget of this study to assess the effect of fish size on chemical residues. The fish obtained for samples were either legal size or, for species with no size limits, large enough to reasonably be retained for consumption. Very large and very small fish were avoided.

Fish were collected primarily during the late summer and fall of 2011. EPA (2000) recommends late summer to fall as the most desirable sampling period for surveying chemical contaminants in fish tissue. Due to more favorable water levels and endangered species concerns related to high summer water temperatures, most of Washington's 303(d) listings are based on fish surveys conducted around this timeframe. Lipid content of fall spawners is increasing at this time and spring spawners are rebuilding their lipid reserves. Being lipid-soluble, chlorinated pesticides are primarily associated with the lipids in fish tissues.

Fillets were analyzed for all fish samples. The field variability inherent in chemical residues accumulated by fish was reduced by using composite samples. Each sample consisted of a composite of pooled tissues from several individual fish, four or five in most cases. Composite samples provide a more cost-efficient estimate of mean contaminant concentrations than single fish samples. There was one composite per species from each lake. Length and weight were recorded for each fish used in the composites (Appendix A).

In order to obtain the desired sample size, several of the fish tissue samples analyzed for this project were from an Ecology 2010 study of the chemical background in northeast Washington fish (Johnson et al., 2011b). These samples were collected and prepared using the same procedures as in the present study and had been stored frozen. Chlorinated pesticides are considered stable for up to a year when samples are frozen (MEL, 2008).

Chemical Analysis

Chlorinated pesticides were analyzed using high-resolution gas chromatography/mass spectrometry (HR-GC/MS). Twenty-nine pesticides or breakdown products were analyzed down to 0.002 ug/Kg (parts per billion), depending on the compound in question.

Methods

Fish Collection

Fish sampling followed the EA Program SOP (Sandvik, 2006a). Collection methods included electroshocking, gill net, and hook and line.

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

Tissue Preparation

Tissue samples were prepared follow the EA Program SOP (Sandvik, 2006b). Techniques to minimize potential for contamination were used. People preparing the samples wore non-talc nitrile gloves and worked on heavy duty aluminum foil or a polyethylene cutting board. The gloves and foil were changed between samples, and the cutting board was cleaned between samples as described below.

The fish were thawed to remove the foil wrapper and rinsed with tap water, then deionized water, to remove any adhering debris. The entire fillet from one or both sides of each fish was removed with stainless steel knives and homogenized in a Kitchen-Aid blender. Following EPA (2000) recommendations, the fillets were scaled and analyzed skin-on, except for brown bullheads analyzed skin-off.

On average, five individual fish were used for each composite sample (range of two to ten). To the extent possible, the length of the smallest fish in a composite was no less than 75% of the length of the largest fish (EPA, 2000). The composites were prepared using equal weights from each fish. The pooled tissues were homogenized to uniform color and consistency, using three passes through the blender. The homogenates were placed in glass jars with Teflon lid liners, cleaned to EPA (1990) quality assurance/quality control specifications.

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

The fish tissue samples were refrozen for shipment, with chain-of-custody record, to AXYS laboratory. Excess tissue was retained for all samples where sufficient material was available and stored frozen at Ecology headquarters.

Analytical Methods and Detection Limits

Chlorinated pesticides analysis by HR-GC/MS is a relatively new application of this technique. Because Ecology had not accredited any laboratories to analyze pesticides by HR-GC/MS, a waiver was obtained from Ecology's Quality Assurance Officer to use AXYS in-house method MLA-028 for this project. Percent lipids were determined gravimetrically on a portion of the pesticide extract.

AXYS reported down to the detection limit and flagged concentrations between the detection and quantitation limit as estimates. The detection and quantitation limits achieved for this project (90% of samples) are shown for 303(d) listed pesticide compounds in Table 5. Quantitation limits were typically in the range of approximately 0.2 – 0.5 ug/Kg, with detection limits about a factor of 10 to 100 lower, 0.002 – 0.01 ug/Kg, except 0.2 ug/Kg for toxaphene.

Table 5. Detection and Quantitation Limits for Selected Compounds (ug/Kg, parts per billion).

Compound	Estimated Detection Limit	Estimated Quantitation Limit
4,4'-DDT	0.0119	0.237
4,4'-DDE	0.0040	0.235
4,4'-DDD	0.0053	0.237
Dieldrin	0.0100	0.207
Chlordane compounds	0.0052	0.473
HCH, alpha	0.0040	0.473
Aldrin	0.0040	0.470
Hexachlorobenzene	0.0020	0.233
Heptachlor	0.0040	0.235
Toxaphene	0.192	- -

Data Quality

Data Review and Verification

Ecology's MEL reviewed and verified all of AXYS' pesticide data for this project. The review followed National Functional Guidelines for Superfund Organic Methods Data Review (EPA, 2005).

MEL prepared written case narratives assessing the qualitative and quantitative precision and bias of the data. The reviews include a description of analytical methods and an assessment of holding times, calibration, internal standard recoveries, ion abundance ratios, method blanks, on-going precision and recovery, and labeled compound recoveries.

Flags were added by AXYS to draw attention to quality control conditions that may affect the data. MEL interpreted the effect on data quality and added qualifiers, where appropriate, that are consistent with MEL and Ecology Information Management (EIM) guidelines. No particular analytical difficulties were encountered on these samples and the data are usable as qualified. AXYS' data package and MEL's data review are available from the author on request.

The data from this project can be accessed through EIM (www.ecy.wa.gov/eim).

Method Blanks

Laboratory method blanks were included with each sample batch. Low levels of several target compounds were detected in the blanks. In cases where the concentration measured in a sample was at least five times greater than the blank, MEL considered the blank result to be insignificant relative to the native concentration in the sample and the data were used without further qualification. Where the sample concentration was less than five times the blank, the result was flagged as not detected (U flag). Results between the estimated quantitation limit (EQL) and estimated detection limit (EDL) were flagged as estimates (J flag).

Precision

Estimates of analytical precision were obtained by analyzing laboratory duplicates (one homogenized sample split into two subsamples). The results for target compounds of particular interest in this study are summarized in terms of relative percent difference (RPD) in Table 6. RPD is the difference between duplicates expressed as a percent of the mean value. RPDs for all analyzed compounds are in Appendix B.

In most cases the duplicates agreed within 20% or better. Overall, the average RPD was 7%. One result each for cis-nonachlor and mirex had RPDs of 27% and 29%, respectively (Appendix B).

Table 6. Precision of Duplicate Analyses for Selected Pesticide Compounds (ug/Kg, wet weight; parts per billion).

Pesticide	Lake Cushman Cutthroat			Silver Lake Black Bullhead			Evergreen Lake Smallmouth Bass		
	#1	#2	RPD	#1	#2	RPD	#1	#2	RPD
4,4'-DDE	0.74	0.76	**2%**	0.43	0.46	**7%**	8.12	8.03	**1%**
Nonachlor, trans-	0.58	0.56	**3%**	0.031 J	0.026 J	**18%**	0.12 J	0.10 J	**13%**
Dieldrin	0.034 J	0.035 J	**3%**	0.010 J	0.010 J	**2%**	1.87	1.74	**7%**
Toxaphene	0.11 U	0.17 U	**ND**	0.06 U	0.12 U	**ND**	4.53	4.04	**11%**

RPD: relative percent difference
ND: not detected
U: Not detected at or above reported result.
J: Result is an estimated value.

The average of duplicate results is used in the remainder of this report. In the few cases where one sample in a duplicate pair was non-detect, the detected result was used.

Results

Samples Analyzed

A total of 48 fish fillet samples were analyzed for the statewide chlorinated pesticide background study (Table 7). Samples were obtained from 28 lakes, six to eight in each of four regions of the state (Figure 1). Twelve fish samples were collected from each region. Two species were analyzed per lake, on average. Appendix A has a detailed listing of the samples analyzed.

Table 7. Number of Samples Analyzed.

Samples Analyzed	48
Lakes Sampled	28
Lakes per Region	6 - 8
Samples per Region	12
Species Sampled	15
Species per Lake	1 - 3
Average Species per Lake	2

Salmonids and spiny-rayed fishes such as bass and perch were analyzed in comparable numbers of samples, 26 vs. 22, respectively (Table 8). Of the 15 species collected for the study, rainbow trout, largemouth bass, cutthroat trout, kokanee (a land-locked sockeye salmon), and yellow perch were most frequently obtained, 10 - 17% of samples each. Mountain whitefish and largescale suckers comprised 6 - 8% of samples.

Table 8. Fish Species Analyzed.

Species	Number of Samples	Percent of Samples
Rainbow Trout*	8	17%
Largemouth Bass†	7	15%
Cutthroat Trout*	7	15%
Kokanee*	6	13%
Yellow Perch†	5	10%
Mountain Whitefish*	4	8%
Largescale Sucker†	3	6%
Peamouth †	1	2%
Brown Bullhead†	1	2%
Black Crappie†	1	2%
Eastern Brook Trout*	1	2%
Northern Pike Minnow†	1	2%
Burbot†	1	2%
Smallmouth Bass†	1	2%
Carp†	1	2%

*salmonid †spiny-ray

Lipid content of the samples ranged from 0.3 – 9.5%, with a median of 1.5% (Table 9). Salmonids had higher lipid levels than spiny-rayed species, typically by a factor of 2 to 3. Excluding the high lipid result for the one carp sample analyzed, the maximum percent lipids for a spiny-ray was 3.2 vs. 7.0 for salmonids. Individual results for percent lipids are in Appendix C.

Table 9. Summary of Lipids Data on Fish Fillets from Washington Background Lakes (percent)

N =	Median	90th Percentile	Minimum	Maximum	Mean
Salmonids					
26	2.5	3.8	0.6	7.0	2.5
Spiny Rays					
22	0.8	1.5	0.3	9.5	1.3
All Species					
48	1.5	3.5	0.3	9.5	2.0

Spatial patterns in the data could potentially be influenced by the amount of lipids in the samples because of its effect on chemical uptake across the gills and other membranes. An examination of Pearson correlation coefficients (R) showed no significant relationships between pesticide residues and percent lipids, either on a regional basis or when salmonids and spiny-rayed species were evaluated separately. Factors that can obscure relationships between lipids and bioaccumulative organic compounds in fish tissue studies include chemical uptake from food, the reproductive cycle, fish age, and differences in lake chemistry (Herbert and Keenleyside, 1995; Stow et al., 1997).

Detection Frequency and Concentration Levels

Results of the chlorinated pesticide analysis are summarized in Table 10. The quantitation limit was used to calculate the median, 90th percentile, and mean in instances where a compound was not detected. Maximum concentrations are for detected chemicals only. Where a high quantitation limit in one or more samples caused the mean, median, or 90th percentile to exceed the maximum detected value, a “U” flag was assigned indicating non-detect.

Twenty-eight of the 29 pesticides or breakdown products analyzed were detected in the fish fillets. The exception was methoxychlor which has relatively low persistence in biological systems (Smith, 1991). Compounds detected in 80% or more of the samples included 4,4’ isomers of DDT and its breakdown products DDE and DDD, dieldrin, chlordane components[1], hexachlorobenzene, and mirex (Figure 2). Except for mirex, these compounds are currently 303(d)-listed for exceeding human health criteria in Washington freshwater fish. Detection frequencies for the four other similarly listed pesticides were 71% for alpha-HCH, 33% for toxaphene, 15% for aldrin, and 6% for heptachlor.

[1] alpha-and gamma-chlordane, cis- and trans-nonachlor, and oxychlordane

Table 10. Summary of Chlorinated Pesticide Data on Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Pesticide or Breakdown Product	Detection Frequency (N=48)	Median	90th Percentile	Minimum	Maximum	Mean
4,4'-DDT	83%	0.08	0.51	0.011 J	1.0	0.21
4,4'-DDE	100%	1.1	6.5	0.018 J	57	4.2
4,4'-DDD	96%	0.10	1.0	0.007 J	5.1	0.49
2,4'-DDT	60%	0.21	0.25	0.009 J	0.39	0.15
2,4'-DDE	54%	0.18	0.23	0.002 J	0.31	0.13
2,4'-DDD	73%	0.03	0.23	0.004 NJ	0.44	0.11
Dieldrin	94%	0.04 J	0.26	0.007 J	8.7	0.32
Aldrin	15%	0.46 U	0.47 U	0.001 NJ	0.013 J	0.39 U
Endrin	23%	0.20 U	0.20 U	0.003 J	0.040	0.16 U
Endrin Aldehyde	4%	0.20 U	0.21 U	0.003 NJ	0.004 NJ	0.19 U
Endrin Ketone	2%	0.20 U	0.21 U	0.003 U	0.003 J	0.20 U
Chlordane, alpha (cis)	96%	0.04	0.28	0.003 NJ	0.49	0.10
Chlordane, gamma (trans)	69%	0.04	0.46 U	0.002 NJ	0.23 J	0.17
Chlordane, oxy-	90%	0.03	0.24 U	0.004 J	0.16 J	0.09
Nonachlor, cis-	92%	0.05	0.42	0.006 NJ	0.60	0.12
Nonachlor, trans-	98%	0.11	0.57	0.006 NJ	1.3	0.23
Toxaphene	33%	0.17	1.4	0.06 U	27	1.1
Hexachlorobenzene	100%	0.24	1.1	0.042 J	7.4	0.75
HCH, alpha	71%	0.02	0.46 U	0.003 J	0.051 J	0.15 U
HCH, beta	17%	0.46 U	0.47 U	0.002 NJ	0.44	0.39
HCH, delta	6%	0.18 U	0.19 U	0.001 NJ	0.001 NJ	0.17 U
HCH, gamma	35%	0.45 U	0.47 U	0.002 NJ	0.022 NJ	0.30 U
Heptachlor	6%	0.23 U	0.24 U	0.002 J	0.22	0.22 U
Heptachlor Epoxide	77%	0.02	0.20	0.003 NJ	0.34	0.07
alpha-Endosulphan	8%	0.20	0.21	0.15	0.63	0.21
beta-Endosulphan	31%	0.20	0.21	0.012 J	0.44	0.16
Endosulphan Sulphate	77%	0.09	0.26	0.013 NJ	3.0	0.18
Mirex	98%	0.01	0.05	0.001 NJ	0.17	0.03
Methoxychlor	0%	0.20 U	0.20 U	0.16 U	0.24 U	0.20 U

U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

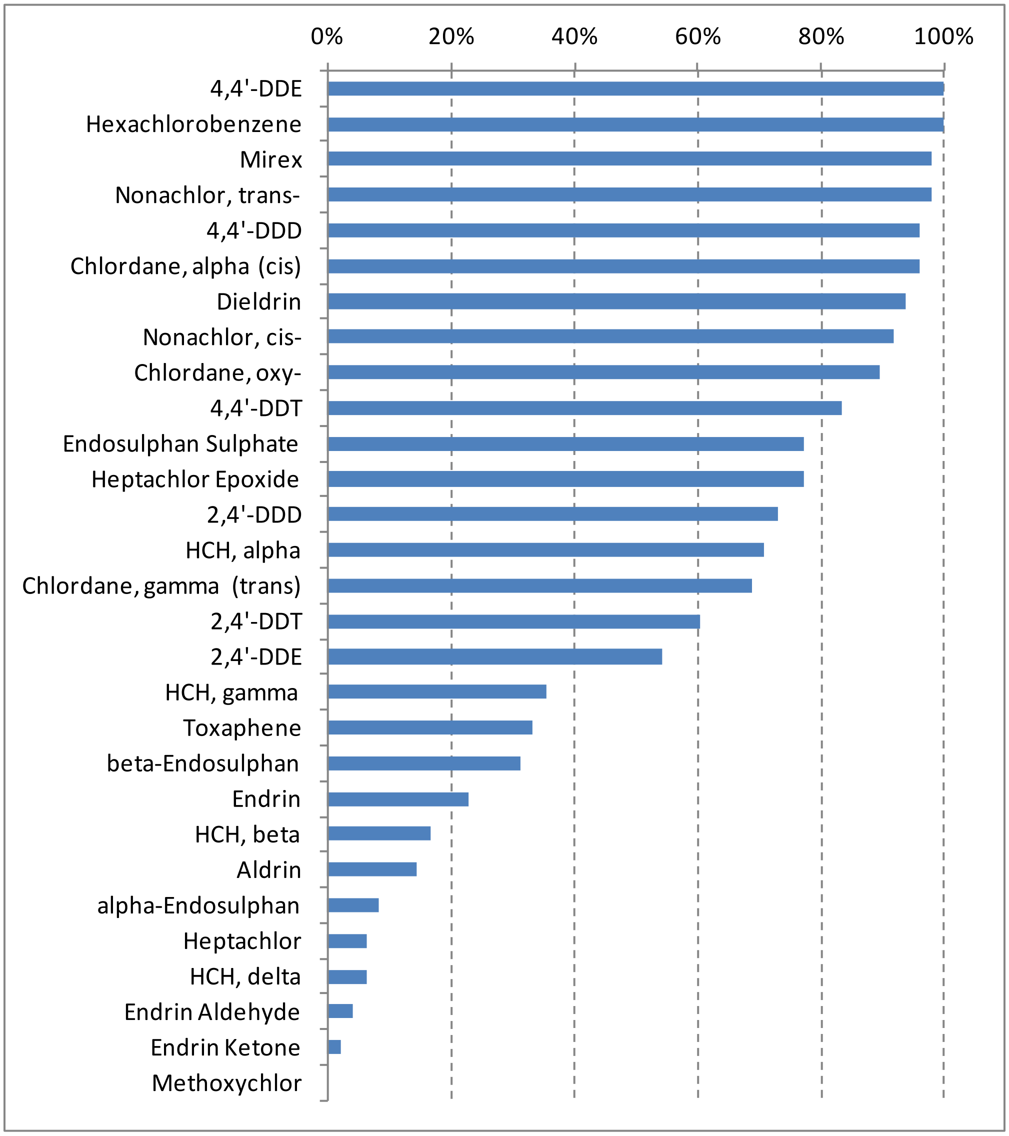


Figure 2. Detection Frequency of Chlorinated Pesticides and Breakdown Products in Fish Fillets from Washington Background Lakes (N = 48).

Figure 3 plots the median and 90th percentile for the most frequently detected compounds. The medians for aldrin, HCH compounds, heptachlor, endrin compounds, and methoxychlor were non-detect. These data are not shown.

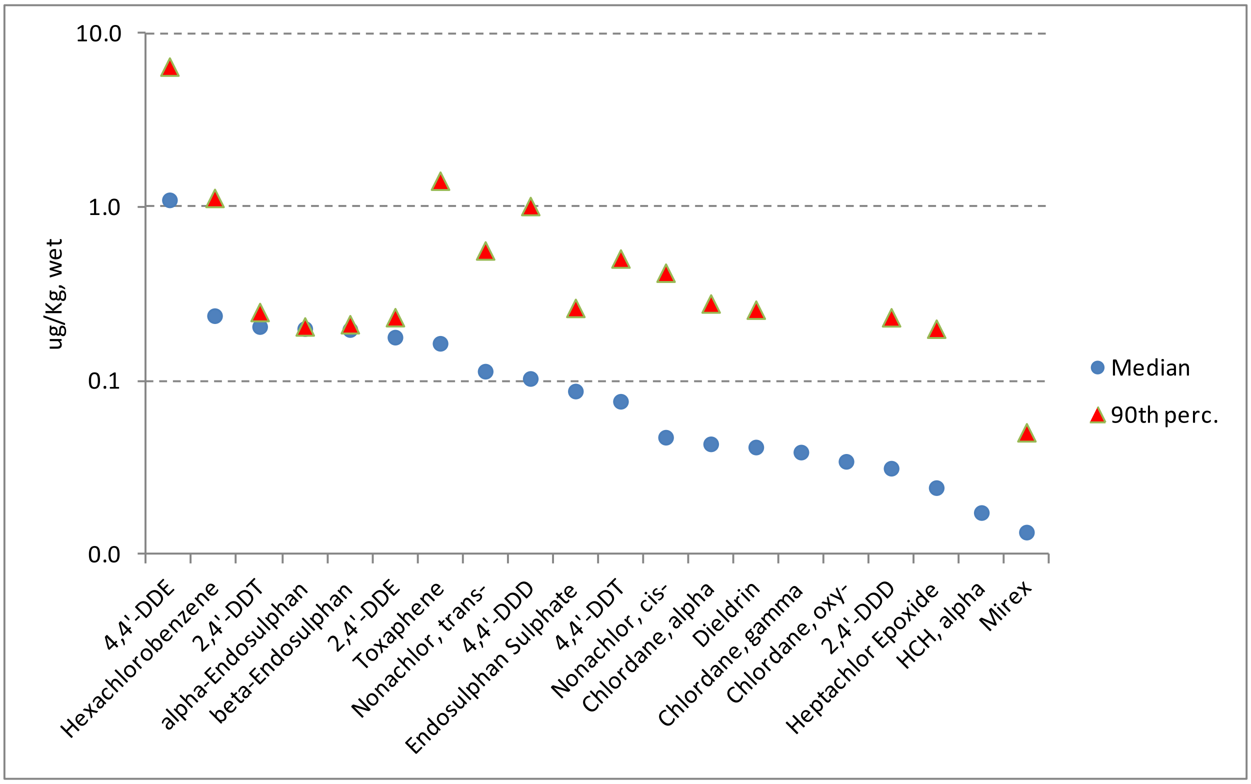


Figure 3. Median and 90th Percentile Concentrations for Frequently Detected Compounds (log scale).

4,4'-DDE occurred in much higher concentrations than any of the other pesticides analyzed, with a statewide median of 1.1 ug/Kg and 90th percentile of 6.5 ug/Kg. Other compounds with medians in the 0.2 – 0.1 ug/Kg range included hexachlorobenzene, other DDT compounds, endosulphan compounds, toxaphene, and trans-nonachlor (chlordane constituent). Eleven additional compounds were present at lower levels of 0.09 – 0.01 ug/Kg. Most of these are derived from or related to compounds present at higher concentrations.

A more detailed presentation of the data follows for individual pesticides or breakdown products, focusing on those responsible for Washington's 303(d) fish tissue listings.

DDT Compounds

The DDT breakdown product 4,4'-DDE is responsible for 38% of the freshwater 303(d) fish tissue listings for pesticide and, along with PCBs, is the legacy chemical most frequently identified in Washington as a water quality concern. 4,4'-DDE was detected in all fish samples analyzed for the background study. Concentrations ranged from 0.02 – 57 ug/Kg (Table 11). The overall median was 1.1 ug/K (Table 12).

Table 11. 4,4'-DDE Concentrations in Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Region / Lake	Species	4,4'-DDE		Region / Lake	Species	4,4'-DDE	
Western				**East Slope**			
Ozette	Peamouth	0.29		Patterson	Rainbow Trout	4.9	
Ozette	Yellow Perch	0.02	J	Patterson	Largemouth Bass	2.0	
Ozette	Largemouth Bass	0.08	J	Patterson	Yellow Perch	0.40	
Tarboo	Largemouth Bass	0.16	J	Wenatchee	Northern Pikeminnow	47	
Cushman	Cutthroat Trout	0.75		Wenatchee	Cutthroat Trout	3.7	
Cushman	Largescale Sucker	0.13	J	Cle Elum	Mountain Whitefish	0.46	
Wynoochee	Mountain Whitefish	0.57		Cle Elum	Rainbow Trout	0.85	
Devereaux	Largemouth Bass	0.84		Bumping	Kokanee	4.8	
Devereaux	Kokanee	3.8		Rimrock	Kokanee	2.3	
Failor	Cutthroat Trout	0.37		Rimrock	Mountain Whitefish	1.7	
Silver	Brown Bullhead	0.44		Rimrock	Largescale Sucker	0.62	
Silver	Black Crappie	0.15	J	Walupt	Cutthroat Trout	2.8	
	Median =	0.33			Median =	2.1	
West Slope				**Eastern**			
Baker	Mountain Whitefish	1.8		Cedar	Rainbow Trout	0.42	
Diobsud	Cutthroat Trout	1.1		Sullivan	Kokanee	4.6	
Gorge	Eastern Brook Trout	0.47		Sullivan	Burbot	2.6	
Gorge	Rainbow Trout	0.69		Leo	Yellow Perch	0.36	
Cavanaugh	Kokanee	5.3		Bayley	Rainbow Trout	1.1	
Cavanaugh	Cutthroat Trout	5.6		South Twin	Largemouth Bass	0.69	
Cavanaugh	Largemouth Bass	1.6		Buffalo	Rainbow Trout	6.3	
Cassidy	Largemouth Bass	0.30		Buffalo	Kokanee	13	
Cassidy	Yellow Perch	0.29		Buffalo	Largescale Sucker	6.8	
Chester Morse	Rainbow Trout	1.1		Evergreen	Yellow Perch	4.2	
Coldwater	Rainbow Trout	0.50		Evergreen	Smallmouth Bass	8.1	
Merrill	Cutthroat Trout	1.5		Evergreen	Common Carp	57	
	Median =	1.1			Median =	4.4	

J: Result is an estimated value.

Table 12. Summary of the 4,4'-DDE Data (ug/Kg, wet weight; parts per billion).

N =	Detection Frequency	Median	90th Percentile	Minimum	Maximum	Mean
Western Washington						
24	100%	0.54	3.2	0.02 J	5.6	1.2
Eastern Washington						
24	100%	2.7	11	0.36	57	7.3
Statewide						
48	100%	1.1	6.5	0.02 J	57	4.2

J: Result is an estimated value.

Relatively high 4,4'-DDE levels were found in Evergreen Lake carp (57 ug/Kg) and Wenatchee Lake pike minnow (47 ug/Kg). Both species are known to be strong accumulators of synthetic organic compounds. Other species from these lakes were not notably elevated in DDE. Wenatchee Lake is north of Leavenworth on the Stevens Pass highway. Evergreen Lake is in the Quincy Wildlife Area on the east side of the Columbia River.

There was evidence of a consistent trend toward increasing 4,4'-DDE concentrations moving from western to eastern Washington. Median concentrations increased from 0.33 to 1.1 to 2.1 to 4.4 ug/Kg in the four regions sampled. The 4,4'-DDE data are plotted by region in Figure 4. Differences between regions were statistically significant (Kruskal-Wallis test, $p < 0.05$). None of the other pesticide compounds analyzed showed this pattern.

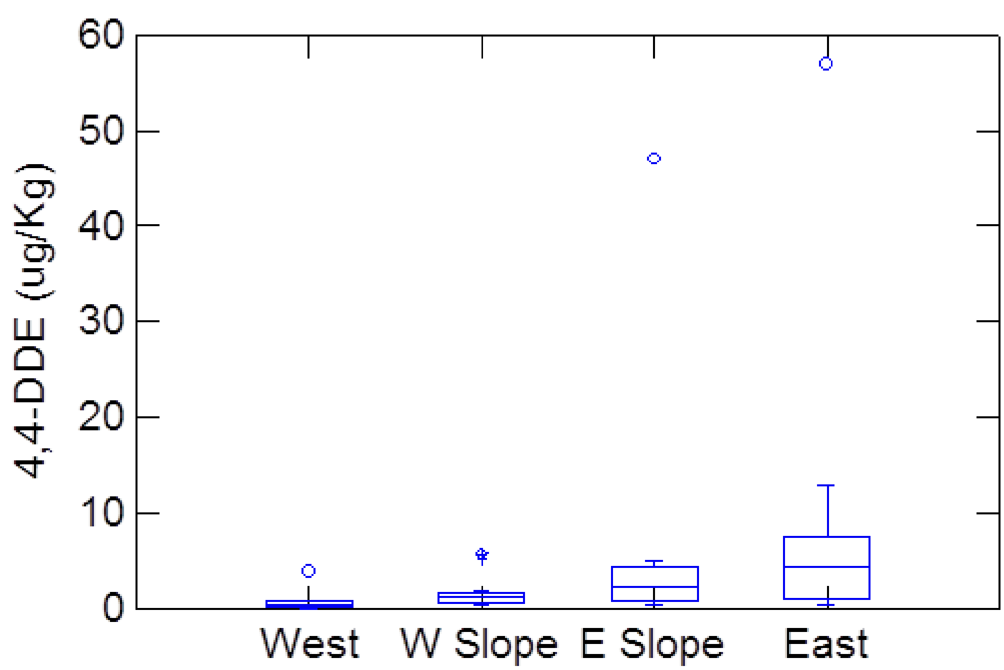


Figure 4. Regional Differences in 4,4'-DDE Concentrations in Fish Fillets from Washington Background Lakes.

The much higher DDE levels in eastern Washington fish may reflect the greater area devoted to agriculture and associated historical DDT use compared to western Washington. Lipid content of the samples was not correlated with DDE on a regional or statewide basis ($p > 0.05$) and thus does not appear to be a factor.

4,4'-DDT and its other major breakdown product 4,4'- DDD were also frequently detected in these samples (83% and 96%, respectively) although at much lower concentrations. 4,4'-DDT and 4,4'-DDD are responsible for 8% and 9%, respectively, of the 303(d) fish tissue listings. Figure 5 compares the statewide medians for 4,4'-DDT, -DDE, and -DDD. The relative contribution of these compounds to the total DDT concentration (sum of 4,4,' isomers) in the fish samples is shown in Figure 6. The 4,4'-DDT and 4,4'-DDD data are in Appendix D.

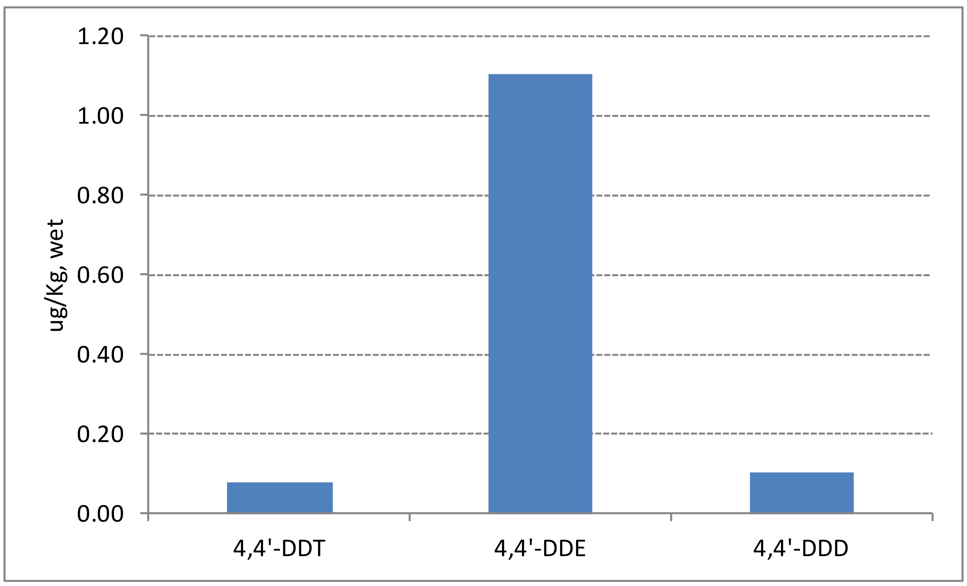


Figure 5. Median Concentrations of 4,4'-DDT and Breakdown Products in Fish Fillets from Washington Background Lakes.

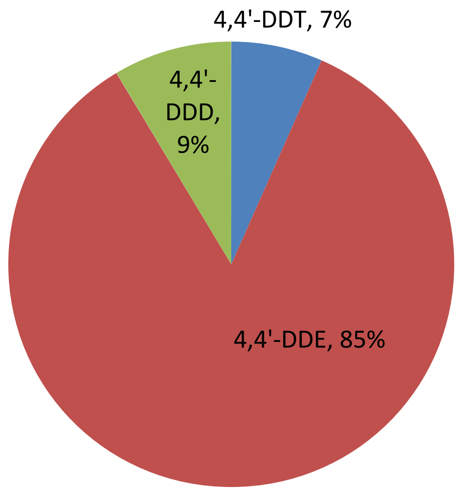


Figure 6. 4,4'- DDT, -DDE, and -DDD as Percent of Total DDT in Fish Fillets in Fish Fillets from Washington Background Lakes (based on median concentrations).

The percentages of 4,4'-DDT and -DDE in these samples are comparable to findings from a large interstate study of fish from the Columbia River basin where they accounted for 3% and 87%, respectively, of the total DDT compounds detected (Hinck et al., 2004). Most of the DDT in Pacific Northwest lakes and rivers has degraded to DDE and, to a much lesser extent, DDD.

The 2,4' homologs of DDT, DDD, and DDE were also detected at low levels in many of the background samples (Appendix E). EPA has not established human health criteria for these compounds which, historically, have been considered relatively benign.

Dieldrin

The dieldrin data are in Tables 13 and 14. Dieldrin is the cause of 22% of the 303(d) listings for pesticides in freshwater fish, second only to 4,4'-DDE. Dieldrin was detected in all but two of the fish fillet samples for this study (94% detection frequency).

Most (90%) of the dieldrin concentrations fell within a relatively narrow range of 0.01 to 0.26 ug/Kg. Once again, the highest concentration was detected in Evergreen Lake carp (8.7 ug/Kg).

The medians for each region were almost identical at 0.03 – 0.05 ug/Kg. The similarity between regions suggests a common predominant source, most likely atmospheric deposition, rather than localized historic use. Most of the dieldrin in the environment comes from the breakdown of aldrin, which was used in far greater quantities (ATSDR, 2002).

Table 13. Dieldrin Concentrations in Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Region / Lake	Species	Dieldrin		Region / Lake	Species	Dieldrin	
Western				**East Slope**			
Ozette	Peamouth	0.03	J	Patterson	Rainbow Trout	0.02	J
Ozette	Yellow Perch	0.20	U	Patterson	Largemouth Bass	0.01	NJ
Ozette	Largemouth Bass	0.21	U	Patterson	Yellow Perch	0.01	J
Tarboo	Largemouth Bass	0.02	J	Wenatchee	Northern Pikeminnow	0.15	J
Cushman	Cutthroat Trout	0.03	J	Wenatchee	Cutthroat Trout	0.06	J
Cushman	Largescale Sucker	0.25	U	Cle Elum	Mountain Whitefish	0.07	J
Wynoochee	Mountain Whitefish	0.01	J	Cle Elum	Rainbow Trout	0.14	J
Devereaux	Largemouth Bass	0.05	J	Bumping	Kokanee	0.12	J
Devereaux	Kokanee	0.05	J	Rimrock	Kokanee	0.16	J
Failor	Cutthroat Trout	0.02	NJ	Rimrock	Mountain Whitefish	0.01	J
Silver	Brown Bullhead	0.01	J	Rimrock	Largescale Sucker	0.01	NJ
Silver	Black Crappie	0.01	J	Walupt	Cutthroat Trout	0.04	J
	Median =	0.03			Median =	0.05	
West Slope				**Eastern**			
Baker	Mountain Whitefish	0.17	J	Cedar	Rainbow Trout	0.03	J
Diobsud	Cutthroat Trout	0.04	J	Sullivan	Kokanee	0.18	J
Gorge	Eastern Brook Trout	0.04	J	Sullivan	Burbot	0.04	J
Gorge	Rainbow Trout	0.03	NJ	Leo	Yellow Perch	0.01	J
Cavanaugh	Kokanee	0.42		Bayley	Rainbow Trout	0.06	J
Cavanaugh	Cutthroat Trout	0.06	J	South Twin	Largemouth Bass	0.01	J
Cavanaugh	Largemouth Bass	0.12	J	Buffalo	Rainbow Trout	0.03	J
Cassidy	Largemouth Bass	0.04	J	Buffalo	Kokanee	0.28	
Cassidy	Yellow Perch	0.06	J	Buffalo	Largescale Sucker	0.04	J
Chester Morse	Rainbow Trout	0.04	J	Evergreen	Yellow Perch	1.2	
Coldwater	Rainbow Trout	0.02	J	Evergreen	Smallmouth Bass	1.8	
Merrill	Cutthroat Trout	0.06	J	Evergreen	Common Carp	8.7	
	Median =	0.05			Median =	0.05	

U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

Table 14. Summary of the Dieldrin Data (ug/Kg, wet weight; parts per billion).

N =	Detection Frequency	Median	90th perc.	Minimum	Maximum	Mean
48	94%	0.04 J	0.26	0.01 J	8.7	0.32

J: Result is an estimated value.

Chlordane

The main components of chlordane are alpha- and gamma-chlordane, cis- and trans-chlordane, and trans-nonachlor[2]. Oxychlordane is a metabolite of cis-chlordane. One or more of these chlordane compounds are responsible for 11% of the 303(d) fish tissue listings. The summed concentrations detected are shown in Table 15. Table 16 has the summary statistics for chlordane.

Chlordane compounds were detected in 98% of the fish fillet samples. The median and 90th percentile for total chlordane were 0.24 and 1.2 ug/Kg, respectively. Regional medians for chlordane were confined to a narrow range of 0.18 - 0.32 ug/Kg and did not differ significantly. Concentrations at the upper end of the range – approximately 1 to 2 ug/Kg – were found in all four regions. As with dieldrin, the similar levels found across the state suggest that the atmosphere is now the primary source of contamination.

[2] The insecticide heptachlor is also a present in chlordane but is treated separately in this report.

Table 15. Chlordane Concentrations in Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Region / Lake	Species	Chlordane			Region / Lake	Species	Chlordane	
Western					**East Slope**			
Ozette	Peamouth	0.12	J		Patterson	Rainbow Trout	0.31	J
Ozette	Yellow Perch	0.45	U		Patterson	Largemouth Bass	0.05	J
Ozette	Largemouth Bass	0.02	J		Patterson	Yellow Perch	0.01	J
Tarboo	Largemouth Bass	0.04	J		Wenatchee	Northern Pikeminnow	2.23	J
Cushman	Cutthroat Trout	0.86	J		Wenatchee	Cutthroat Trout	0.24	J
Cushman	Largescale Sucker	0.60	J		Cle Elum	Mountain Whitefish	0.24	J
Wynoochee	Mountain Whitefish	0.24	J		Cle Elum	Rainbow Trout	0.26	J
Devereaux	Largemouth Bass	0.35	J		Bumping	Kokanee	0.87	J
Devereaux	Kokanee	1.15	J		Rimrock	Kokanee	0.73	J
Failor	Cutthroat Trout	0.12	J		Rimrock	Mountain Whitefish	0.15	J
Silver	Brown Bullhead	0.10	J		Rimrock	Largescale Sucker	0.07	J
Silver	Black Crappie	0.04	J		Walupt	Cutthroat Trout	0.30	J
	Median =	0.18	J			Median =	0.25	J
West Slope					**Eastern**			
Baker	Mountain Whitefish	1.17	J		Cedar	Rainbow Trout	0.05	J
Diobsud	Cutthroat Trout	0.17	J		Sullivan	Kokanee	1.23	J
Gorge	Eastern Brook Trout	0.19	J		Sullivan	Burbot	0.33	J
Gorge	Rainbow Trout	0.23	J		Leo	Yellow Perch	0.03	J
Cavanaugh	Kokanee	2.51	J		Bayley	Rainbow Trout	0.13	J
Cavanaugh	Cutthroat Trout	0.81	J		South Twin	Largemouth Bass	0.03	J
Cavanaugh	Largemouth Bass	0.89	J		Buffalo	Rainbow Trout	0.23	J
Cassidy	Largemouth Bass	0.16	J		Buffalo	Kokanee	1.10	J
Cassidy	Yellow Perch	0.16	J		Buffalo	Largescale Sucker	0.22	J
Chester Morse	Rainbow Trout	0.41	J		Evergreen	Yellow Perch	0.13	J
Coldwater	Rainbow Trout	0.06	J		Evergreen	Smallmouth Bass	0.24	J
Merrill	Cutthroat Trout	0.43	J		Evergreen	Common Carp	1.21	J
	Median =	0.32	J			Median =	0.22	J

U: Not detected at or above reported result.
J: Result is an estimated value.

Table 16. Summary of the Chlordane Data (ug/Kg, wet weight; parts per billion).

N =	Detection Frequency	Median	90th perc.	Minimum	Maximum	Mean
48	98%	0.24 J	1.2 J	0.01 J	2.5 J	0.45 J

J: Result is an estimated value.

The relative amounts of the five chlordane compounds analyzed are shown in Figures 7 and 8, based on median values. Trans-nonachlor accounted for almost half of the total, with lesser and similar contributions from the other four compounds. Nationally, trans-nonachlor is the most important chlordane contaminant in fish (Schmitt et al., 1999; EPA, 1992).

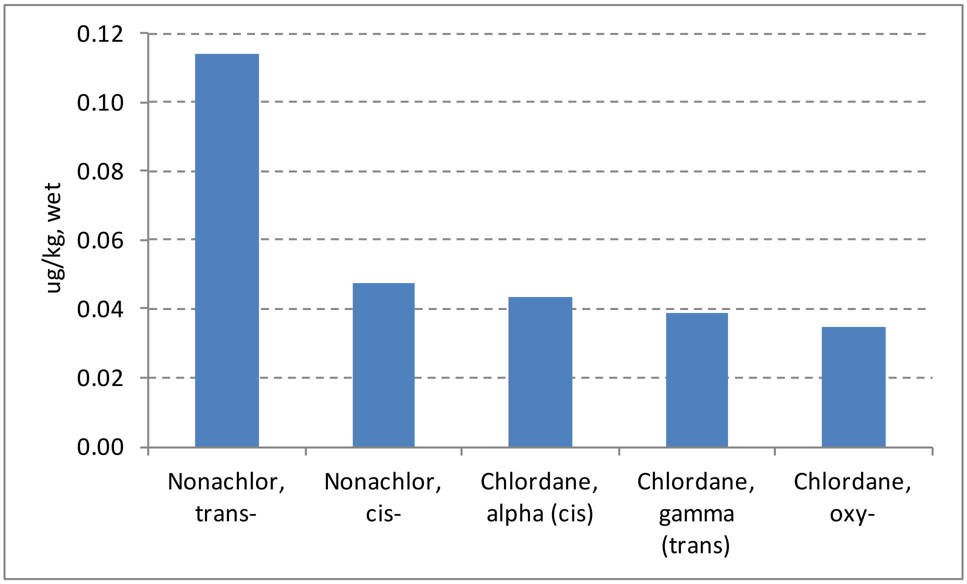


Figure 7. Median Concentrations of Chlordane Compounds in Fish Fillets from Washington Background Lakes.

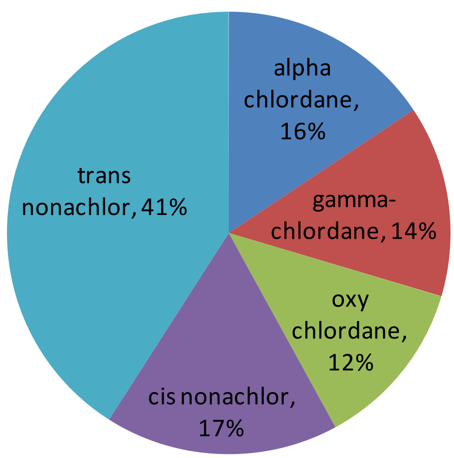


Figure 8. Relative Amounts of Five Chlordane Components in Fish Fillets from Washington Background Lakes (based on median concentrations).

Toxaphene

Toxaphene is a complex mixture of hundreds of individual compounds and difficult to analyze down to water quality criteria levels. It is currently responsible for only three of Washington's edible fish tissue listings (3% of the total). Recent improvements at the Ecology Manchester Laboratory have lowered the detection limit for toxaphene residues in environmental samples. As a result, fish in a number of Washington lakes and rivers have now been shown to exceed the toxaphene human health criterion of 9.6 ug/Kg (Johnson et al., 2012; Seiders et al., 2012). It is anticipated that the number of 303(d) listings for toxaphene will increase substantially in the next listing cycle (2012).

Tables 17 and 18 summarize the toxaphene data from the background study. Due to the low levels encountered, detection frequency was only 33%. The median was non-detect at 0.17 ug/Kg and the 90th percentile was 1.4 ug/Kg. As with DDE and dieldrin, Evergreen Lake carp were an outlier with relatively high toxaphene residues (27 ug/Kg).

The medians for toxaphene are difficult to compare across regions because of the many non-detects. On a qualitative basis, the level of contamination in fish appears lower in the western-most parts of Washington where toxaphene was detected in only one sample.

Table 17. Toxaphene Concentrations in Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Region / Lake	Species	Toxaphene		Region / Lake	Species	Toxaphene	
Western				**East Slope**			
Ozette	Peamouth	0.18	U	Patterson	Rainbow Trout	0.09	U
Ozette	Yellow Perch	0.13	U	Patterson	Largemouth Bass	0.10	U
Ozette	Largemouth Bass	0.12	U	Patterson	Yellow Perch	0.27	U
Tarboo	Largemouth Bass	0.12	U	Wenatchee	Northern Pikeminnow	1.2	
Cushman	Cutthroat Trout	0.11	U	Wenatchee	Cutthroat Trout	0.09	U
Cushman	Largescale Sucker	0.17	U	Cle Elum	Mountain Whitefish	0.16	
Wynoochee	Mountain Whitefish	0.80		Cle Elum	Rainbow Trout	0.14	U
Devereaux	Largemouth Bass	0.16	U	Bumping	Kokanee	0.89	
Devereaux	Kokanee	0.12	U	Rimrock	Kokanee	0.22	
Failor	Cutthroat Trout	0.19	U	Rimrock	Mountain Whitefish	0.16	U
Silver	Brown Bullhead	0.06	U	Rimrock	Largescale Sucker	0.27	U
Silver	Black Crappie	0.13	U	Walupt	Cutthroat Trout	0.11	U
	Median =	0.13	U		Median =	0.16	U
West Slope				**Eastern**			
Baker	Mountain Whitefish	5.1		Cedar	Rainbow Trout	0.11	U
Diobsud	Cutthroat Trout	0.31		Sullivan	Kokanee	1.9	
Gorge	Eastern Brook Trout	0.20	U	Sullivan	Burbot	0.23	
Gorge	Rainbow Trout	0.14	U	Leo	Yellow Perch	0.08	U
Cavanaugh	Kokanee	0.32		Bayley	Rainbow Trout	0.09	U
Cavanaugh	Cutthroat Trout	0.12	U	South Twin	Largemouth Bass	0.11	U
Cavanaugh	Largemouth Bass	0.17		Buffalo	Rainbow Trout	0.08	U
Cassidy	Largemouth Bass	0.46		Buffalo	Kokanee	0.53	
Cassidy	Yellow Perch	0.11	U	Buffalo	Largescale Sucker	0.18	U
Chester Morse	Rainbow Trout	0.06	U	Evergreen	Yellow Perch	3.4	
Coldwater	Rainbow Trout	0.25	U	Evergreen	Smallmouth Bass	4.3	
Merrill	Cutthroat Trout	0.18	U	Evergreen	Common Carp	27	
	Median =	0.19	U		Median =	0.20	

U: Not detected at or above reported result.

Table 18. Summary of the Toxaphene Data (ug/Kg, wet weight; parts per billion)

N =	Detection Frequency	Median	90th perc.	Minimum	Maximum	Mean
48	33%	0.17 U	1.4	0.06 U	27	1.1

U: Not detected at or above reported result.

Hexachlorobenzene, Alpha-HCH, Aldrin, and Heptachlor

Detection frequencies for the remaining 303(d) listed pesticides were either very high – 100% for hexachlorobenzene, 71% for alpha-HCH – or very low – 15% for aldrin, 6% for heptachlor. Once released to the environment, aldrin and heptachlor degrade to dieldrin and to heptachlor epoxide (a minor degradation product) which are more persistent than either parent compound. In the present study, dieldrin and heptachlor epoxide had detection frequencies of 94% and 77%, respectively.

The concentrations of hexachlorobenzene, alpha-HCH, aldrin, and heptachlor tended to be uniformly low across the state. Most fish samples had much less than 1 ug/Kg. The complete results are tabulated in Appendix D.

The primary finding of interest was an elevated level of hexachlorobenzene in Cavanaugh Lake, Skagit County. Concentrations were 7.4 ug/Kg in kokanee, 7.2 ug/Kg in largemouth bass, and 4.7 ug/Kg in cutthroat trout. The statewide median and 90th percentile for hexachlorobenzene were 0.24 ug/Kg and 1.1 ug/Kg, respectively. These findings raise the possibility of a historical source of hexachlorobenzene to Cavanaugh Lake.

Other Pesticides and Breakdown Products

Detection frequency for the sixteen additional pesticide compounds analyzed in this study tended to be low, except for 2,4' isomers of DDT compounds, heptachlor epoxide, endosulphan sulfate, and mirex (54 – 98%). 90th percentiles were less than 0.30 ug/Kg or non-detect in all cases. The complete results for these compounds are in Appendix E.

Only four of the detected compounds are addressed in Washington's human health criteria - heptachlor epoxide, alpha-endosulphan, beta-endosulphan, and endosulphan sulfate – and none are 303(d) listed.

Discussion

Statewide Non-Background Data

Table 19 illustrates the extent to which chlorinated pesticide levels in fish analyzed for the background study differ from those obtained from more highly developed urban, agricultural, and industrial waterbodies across Washington. These non-background data come from Ecology's Washington State Toxics Monitoring Program (WSTMP), a screening-level effort that targets lakes, rivers, and streams statewide (e.g., Seiders et al., 2012). Results are primarily used to identify areas of concern for follow-up actions. The bulk of the state's 303(d) listings for edible fish tissue come from this program.

Table 19 compares the medians and 90th percentiles for pesticides and breakdown products that account for most of the current 303(d) listings. WSTMP data on lakes sampled in the present study and other lakes or rivers used in previous Ecology background assessments were not included. Alpha-HCH, aldrin, and heptachlor were not detected frequently enough to form a basis for comparison.

WSTMP employs a less sensitive method to analyze pesticides in their fish samples. Except for total DDT, the non-background medians are non-detect at about 1 – 5 ug/Kg. The background median for total DDT is lower than the non-background median by a factor of 6. Background 90th percentiles are lower than non-background by an order of magnitude for total DDT and by factors of 3 to 10 for dieldrin, chlordane, toxaphene, and hexachlorobenzene.

Table 19. Comparison of Selected Chlorinated Pesticides in Fish Fillets from Background and Non-Background Waterbodies in Washington (ug/Kg, wet weight; parts per billion).

Non-background toxaphene data for 2005 and 10 samples from 2007-2010 not included due to reporting limits >20 ug/Kg.

Type of Waterbody	Total DDT		Dieldrin		Chlordane		Toxaphene		Hexachloro-benzene	
Medians										
Background*	1.2		0.04	J	0.24	J	0.17		0.24	
Non-background†	7.7		0.5	U	0.97	U	5.0	U	0.98	U
90th Percentiles										
Background*	7.5		0.26		1.2	J	1.4		1.1	
Non-background†	392		2.3		4.4		14	J	4.0	

*Present study (N = 48)
†WSTMP statewide data 2001-2010 (N = 130)
U: Not detected at or above reported result.
J: Result is an estimated value.

Chlorinated Pesticide TMDLs

Many of the most chemically contaminated waterbodies in Washington had already been identified and TMDLs initiated or planned prior to start up of the WSTMP. As a result, the WSTMP data set tends to be populated with waterbodies having moderate levels of contamination. The Yakima River and Lake Chelan in eastern Washington furnish examples of the magnitude of water quality improvements needed to return a highly contaminated fisheries resource to present-day background for chlorinated pesticide residues.

Yakima River

The Yakima River basin is the first and largest area in Washington where significant chlorinated pesticide contamination has been identified (Schmitt et al., 1990; Rinella et al., 1993; Johnson et al., 1988). TMDLs are currently in place and have resulted in improved water quality conditions (Joy and Patterson, 1997; Creech and Joy, 2002; Johnson et al., 2010b). Yakima River fish, however, continue to record some of the highest DDE, dieldrin, and toxaphene levels in the state.

4,4'-DDE, dieldrin, and toxaphene results from Ecology's most recent fish tissue survey in 2005 (Johnson et al., 2007) are compared to the medians and 90th percentiles from the background study in Figure 9. The data are arranged in downstream order, left to right. Non-detects are plotted as unfilled markers.

Keechelus and Kachess Lakes are two of the three large Yakima River storage reservoirs near Snoqualmie Pass in the Cascade Range. The third reservoir, Cle Elum Lake, was one of the lakes sampled for the background study. As shown in Figure 9, Keechelus and Kachess fish are at the eastern Washington background median for 4,4'-DDE and appear to be near or below the statewide background 90th percentile for dieldrin and toxaphene, both of which were below detection limits in 2005. Background study results for Cle Elum Lake fish show dieldrin concentrations of 0.06 – 0.14 ug/Kg and toxaphene concentrations of 0.16 ug/Kg or less.

The Yakima flows over 200 miles from the storage reservoirs to the Columbia River. Between the town of Cle Elum and the Yakima Canyon, the river receives agricultural runoff from the Kittitas Valley. The Lower Yakima River Valley lies below Yakima Canyon and is one of the most intensively irrigated and agriculturally diverse areas in the United States. The quality of the irrigation returns largely determines the quality of water in the lower river.

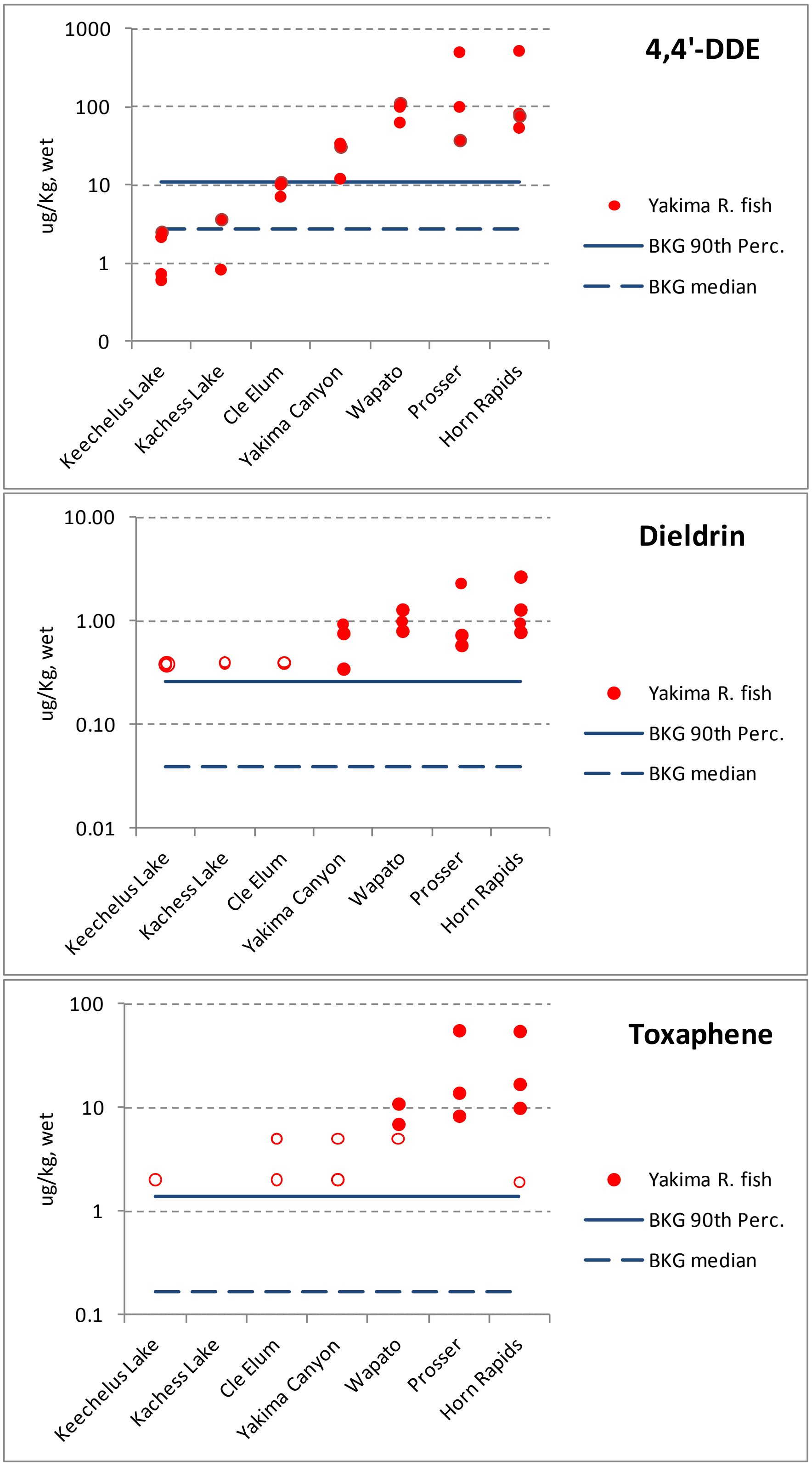


Figure 9. DDE, Dieldrin, and Toxaphene Levels in Yakima River Fish in 2005 Compared to Background Values from the Present Study (edible tissue data; log scale; unfilled markers are non-detects plotted at the reporting limit)

Agricultural impacts become evident for 4,4'-DDE and dieldrin in fish samples collected within the Yakima Canyon. The major toxaphene sources to the Yakima are further downstream. By the time the river reaches Prosser and Horn Rapids, 4,4'-DDE, dieldrin, and toxaphene levels in the fish are one to two orders of magnitude above background.

Lake Chelan

An EPA study of 140 lakes, nation-wide, during 2000-2003 found the highest levels of total DDT in lake trout from Lake Chelan (EPA, 2009). An Ecology field study for a pesticide/PCB TMDL, conducted in 2003, recommended a water quality target of 32 ug/Kg total DDT in Lake Chelan fish (Coots and Era-Miller, 2005). Follow-up sampling of lake trout by Ecology in 2010 showed that high levels of total DDT continued to persist (Seiders et al., 2012).

Figure 10 compares Ecology's Lake Chelan total DDT data from 2010 (lake trout) and 2003 (other species) to the statewide background median and 90th percentile (1.2 and 7.5 ug/Kg, respectively). Elevations above the background 90th percentile range from about a factor of 5 for rainbow trout to about a factor of 200 for lake trout, on average. The TMDL target is approximately 5 times higher than the background 90th percentile.

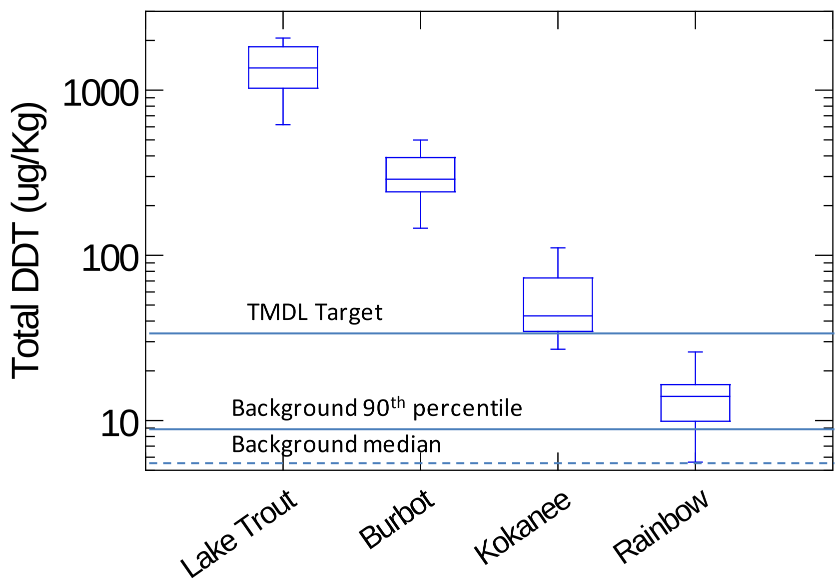


Figure 10. Total DDT in Lake Chelan Fish 2003-2010 Compared to Background Values from Present Study (edible tissue data, log scale).

Marine Data

As far as could be determined, the only other source of low-level pesticide data on Pacific Northwest fish comes from Puget Sound. West et al. (2011) report results of a HR-GC/MS analysis for chlorinated pesticides in hake and pollock from three basins – Strait of Juan de Fuca, Georgia Strait, and Hood Canal – which they class as "Less Developed" compared to Elliot Bay and other basins in Puget Sound. Hake and pollock are cod-like fish that "occupy an intermediate trophic level in the Puget Sound pelagic food web and … are suspected as a primary source of PBTs to apex predators." The samples were analyzed whole-body.

Table 20 compares the range of medians for total DDT, dieldrin, and chlordane in the hake and pollock samples from Puget Sound and vicinity to the medians for fish fillets from the background lakes. In view of the differences between the environments and species in these two studies, the similarity between marine and freshwater background is striking and suggests a common predominant source such as the atmosphere.

Table 20. Median Concentrations of Selected Chlorinated Pesticides in Puget Sound Whole Fish Samples Compared to Fish Fillets from Washington Background Lakes. (ug/Kg, wet weight; parts per billion).

Pesticide	Developed Puget Sound Basins * (N = 43)	Less Developed Puget Sound Basins * (N = 19)	Washington Background Lakes† (N = 48)
Total DDT	2.4 - 5.8	1.7 - 3.0	1.2
Dieldrin	0.11 - 0.40	0.08 - 0.12	0.04
Chlordane	0.63 - 1.9	0.46 - 0.78	0.24

*West et al. (2011).
†present study.

Background Compared to Human Health Criteria

Current Criteria

The 90th percentile and maximum concentrations of chlorinated pesticides and breakdown products measured in fish fillet samples from the background study are compared to the current human health criteria fish tissue equivalent concentrations (FTECs) used in Washington in Table 21.

Almost all background lake fish samples were well within the human health criteria FTECs. There were a few exceedances of criteria FTECs at the highest concentrations observed for dieldrin, hexachlorobenzene, toxaphene, and 4,4'-DDE.

Table 21. 303(d) Human Health Criteria FTECs Compared to 90th Percentile and Maximum Concentration Measured in Fish Fillets from Washington Background Lakes (ug/Kg, wet weight; parts per billion).

Pesticide or Breakdown Product	Wash. State FTECs	Background Lake Fish Fillet Samples (N = 48)			
		90th Percentile		Maximum	
HCH, alpha	0.51	0.46	U	0.051	J
Aldrin	0.61	0.47	U	0.013	J
Dieldrin	0.65	0.26		**8.7**	
Heptachlor Epoxide	1.1	0.20		0.34	
HCH, beta	1.8	0.47	U	0.44	
Heptachlor	2.4	0.24	U	0.22	
HCH, gamma	2.5	0.47	U	0.022	NJ
Hexachlorobenzene	6.5	1.1		**7.4**	
Chlordane	8.0	1.2	J	2.5	J
Toxaphene	9.6	1.4		**27**	
4,4'-DDT	32	0.51		1.0	
4,4'-DDE	32	6.5		**57**	
4,4'-DDD	44	1.0		5.1	
alpha-Endosulphan	251	0.21		0.63	
beta-Endosulphan	251	0.21		0.44	
Endosulphan Sulfate	251	0.26		3.0	
Endrin	3,017	0.20	U	0.040	
Endrin Aldehyde	3,017	0.21	U	0.004	NJ

Note: **Bold** values exceed FTEC
U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

A detailed comparison of the individual samples is provided in Figure 11 which plots the ratio of the chemical concentration in the fish fillets to the criterion FTEC. Ratios greater than 1 exceed the FTEC. Ratios for non-detects used the quantitation limit and are plotted as unfilled circles.

Overall, these lakes are characterized by low pesticide levels that support their being considered representative of background conditions. Criteria FTEC exceedances were restricted to dieldrin, toxaphene, and 4,4'-DDE in Evergreen Lake (one to three species), hexachlorobenzene in Cavanaugh Lake (two species), and 4,4'-DDE in Wenatchee Lake (one species). Except for dieldrin in Evergreen Lake carp, the exceedances were marginal, by a factor of about 2 or less.

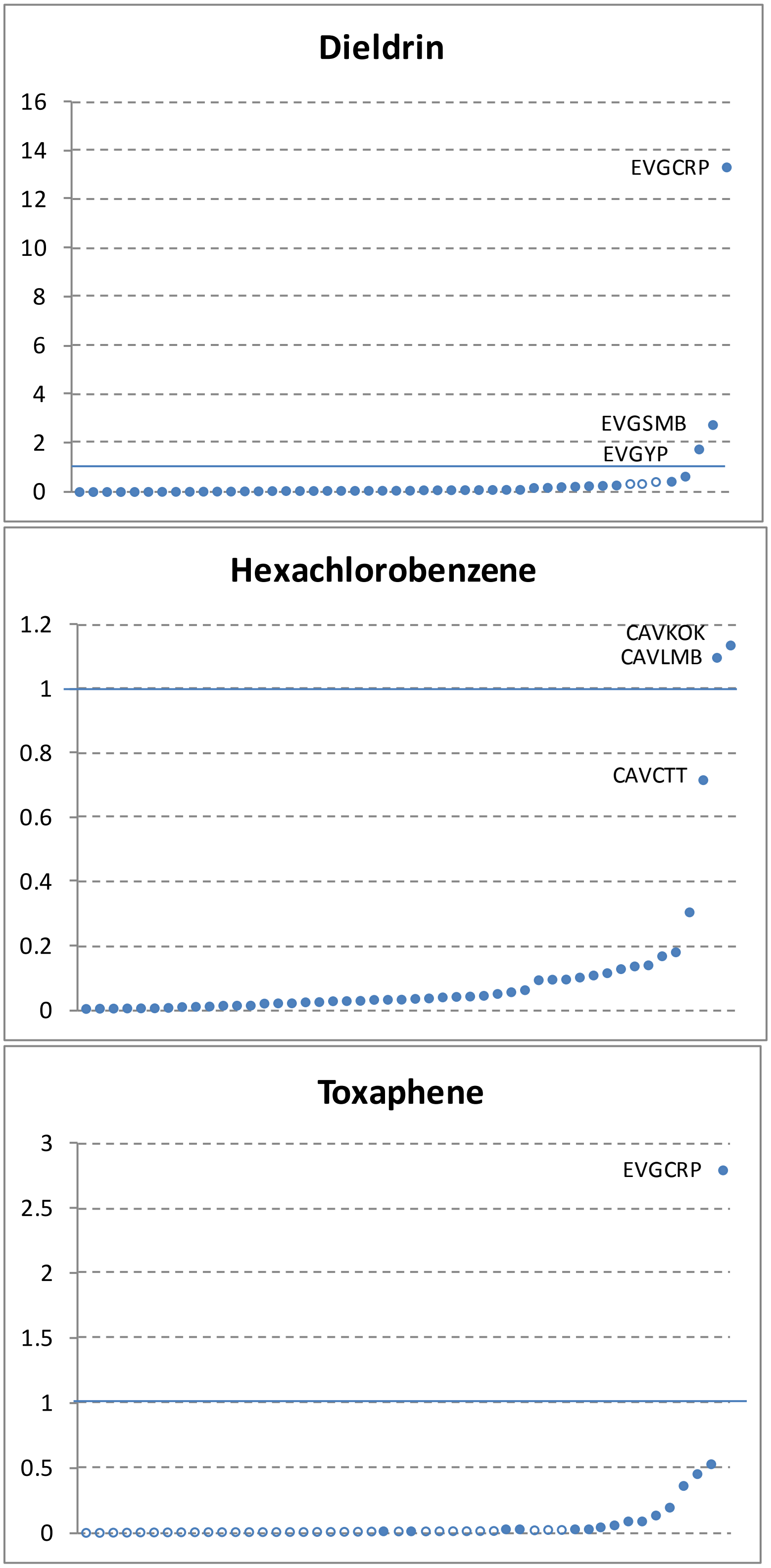


Figure 11. Chlorinated Pesticides in Background Lake Fish Fillets Compared to 303(d) Human Health Criteria FTECs (sample concentration divided by criterion; ratios > 1 exceed criterion FTEC; unfilled markers are non-detects plotted at the quantitation limit).

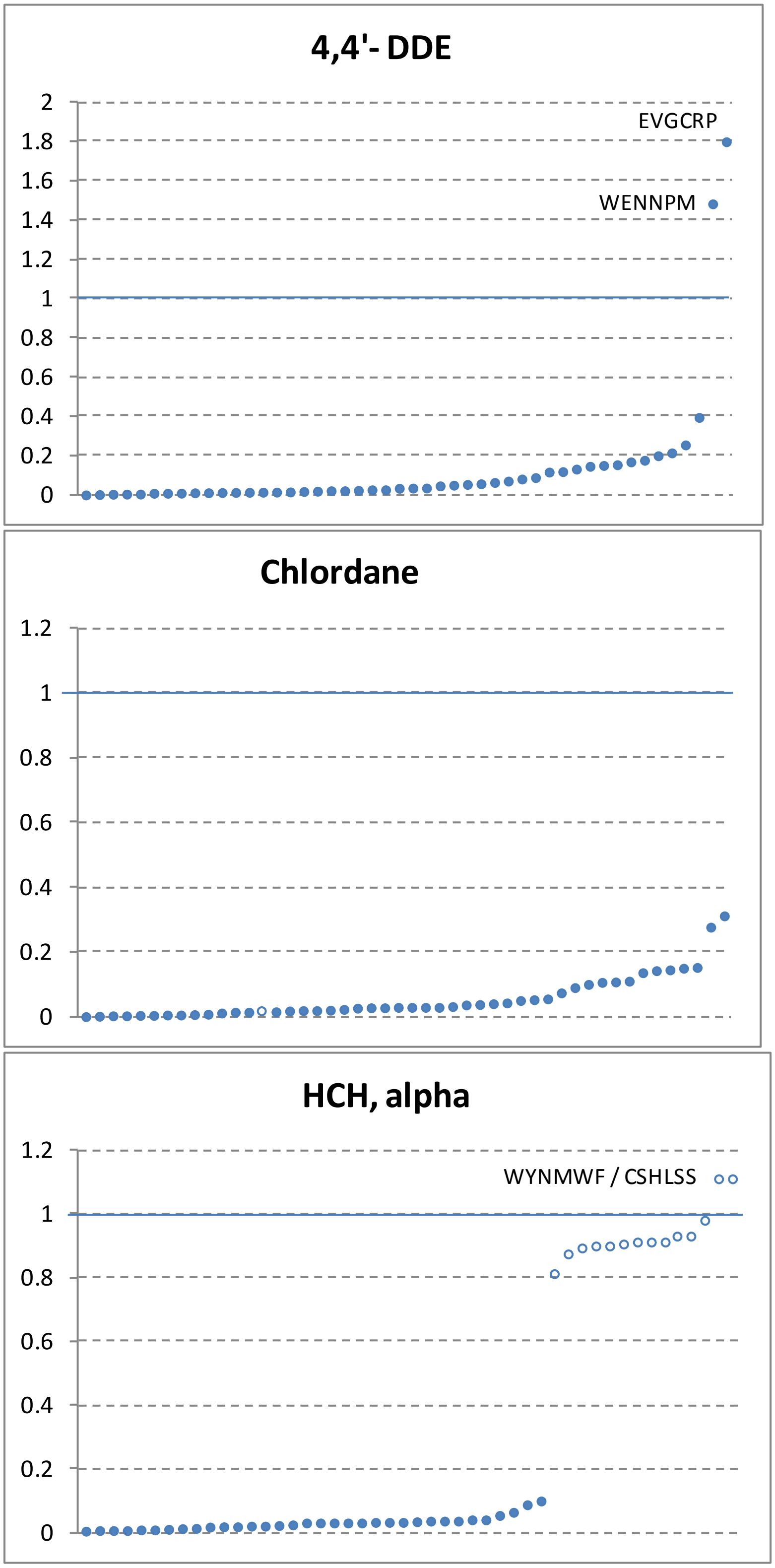


Figure 11. (continued)

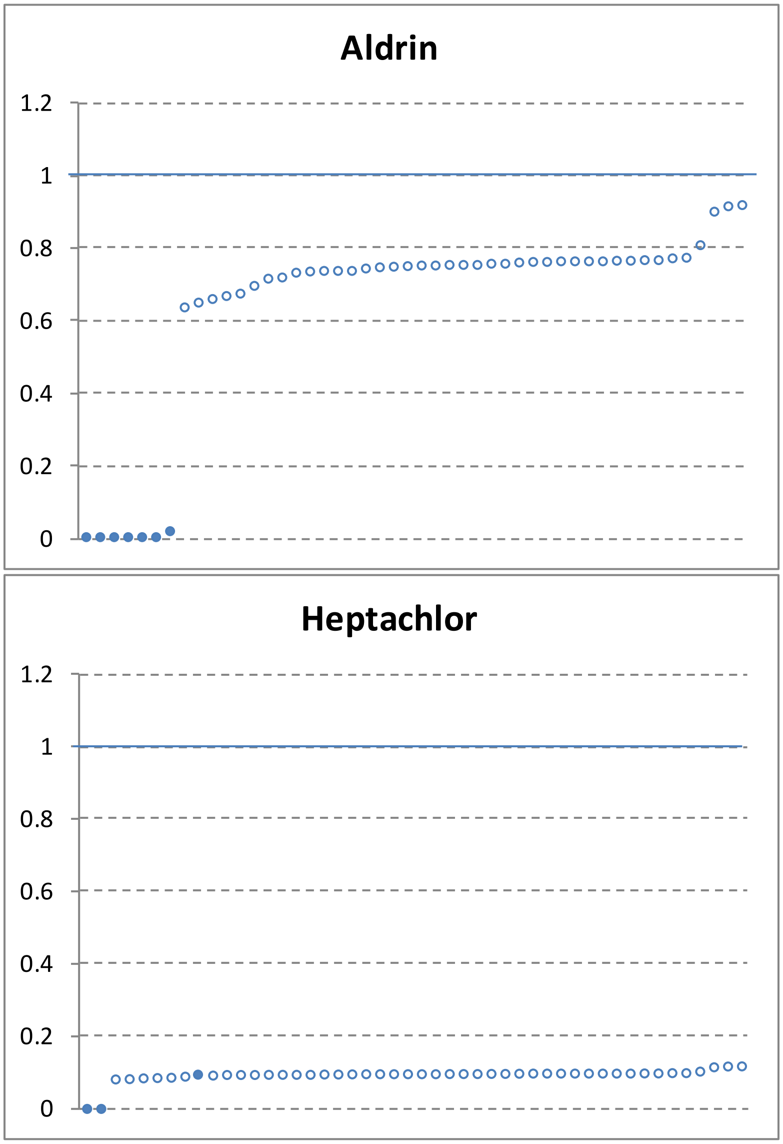


Figure 11. (continued)

Criteria at Higher Fish Consumption Rates

As previously described, Ecology has begun formal rule-making activities to adopt new human health-based water quality standards for toxics. The new standards will include updated estimates of how much fish Washington residents eat. Ecology has compiled current fish consumption research in a draft technical document that evaluates the available data on fish consumption in Washington (Ecology, 2012). Washington's current human health criteria in the water quality standards for toxics were issued under the National Toxics Rule (NTR) by EPA in 1992.

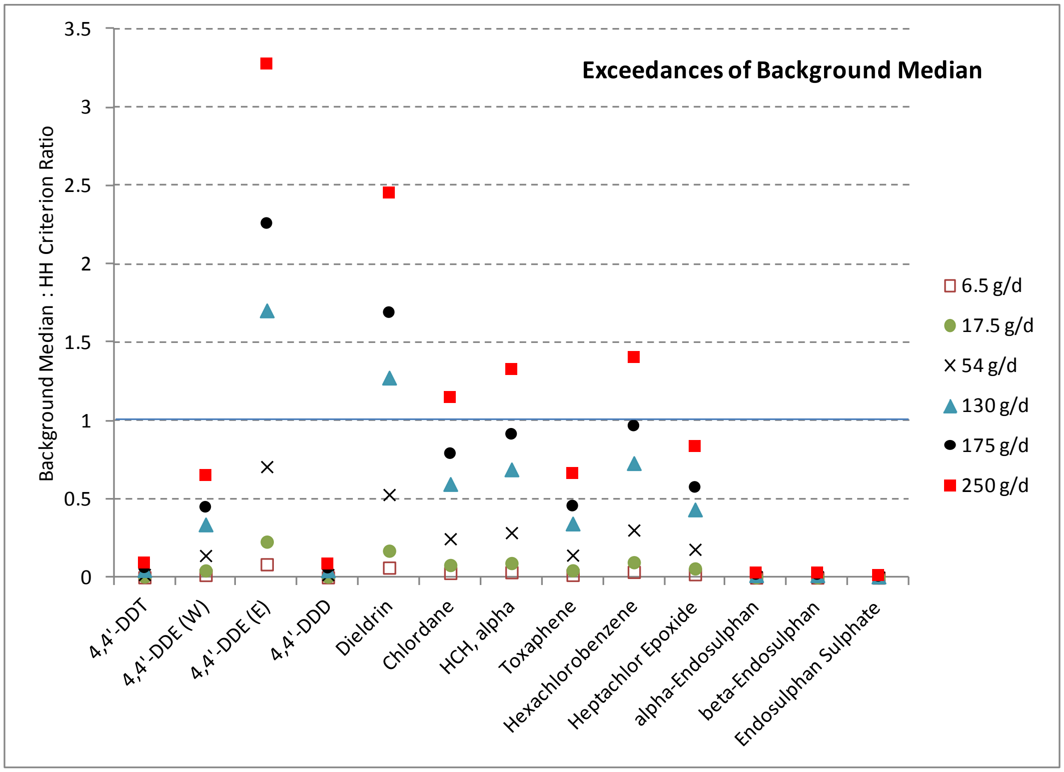
If other variables in the criteria calculation are held constant, calculating criteria using higher fish consumption rates would translate into lower, more conservative human health criteria for toxics (see Equation 1). This has the potential to increase the number of waterbodies 303(d) listed for fish consumption concerns. Conversely, a higher consumption rate at a less protective risk level could result in higher criteria values.

The background data obtained through the present study provide one perspective on implications of revising the chlorinated pesticides criteria. The criteria were re-calculated for a range of fish consumption rates[3]:

- 6.5 grams/day – Washington State Water Quality Standards for Surface Waters, current rate for human health protection.
- 17.5 grams/day – Environmental agencies in some other states, 90th percentile.
- 54 grams/day – Washington State Model Toxics Control Act (MTCA) Cleanup Regulation, default fish consumption rate.
- 130 grams/day – Columbia River Tribes, all fish sources.
- 175 grams/day – Recently adopted in the State of Oregon
- 250 grams/day – EPA-estimated per capita U.S. fish consumption, 90th percentile.

The current and re-calculated human health criteria are compared to background study medians and 90th percentiles in Figure 12. As in preceding figures, concentration:criterion FTEC ratios > 1 exceed the criterion FTEC. Comparisons could not be made for other pesticide chemicals addressed in the criteria (aldrin, beta- and gamma-HCH, heptachlor, endrin, and endrin aldehyde) due to infrequent detection.

[3] The rates listed above encompass the mean and 90th percentile values from multiple studies of Washington State freshwater recreational fishers (6 – 246 grams/day), as summarized in Ecology (2012).



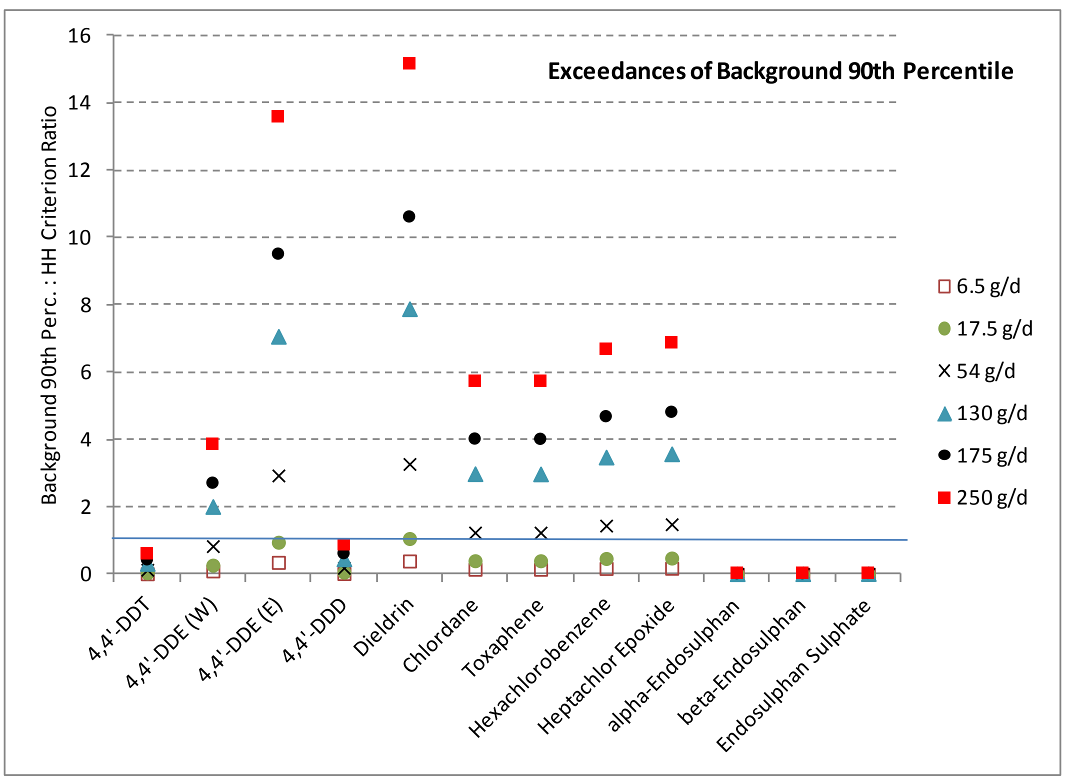


Figure 12. Pesticide Concentrations in Background Lake Fish Samples Compared to Human Health Criteria FTECs for Different Fish Consumption Rates (tissue concentration divided by FTEC value; ratios > 1 exceed criterion).

For the background median, exceedances of human health criteria FTECs begin to emerge as the consumption rate goes from 54 to 130 grams per day. At 130 grams per day the median is exceeded by 4,4'-DDE (eastern Washington only) and dieldrin, although by a factor of less than 2. At 250 grams per day, three additional pesticides exceed: chlordane, alpha-HCH, and hexachlorobenzene. 4,4'-DDE (eastern Washington) and dieldrin exceed by about a factor of 3 at this consumption rate.

When the background 90th percentiles are compared, 4,4-DDE (eastern Washington) and dieldrin are at the human health criterion FTEC for 17.5 grams per day. At 54 grams per day, exceedances in addition to 4,4-DDE include chlordane, toxaphene, hexachlorobenzene, and heptachlor epoxide, although marginally. The 90th percentile for 4,4'-DDE in western Washington background lakes exceeds the FTEC at the consumption rate of 130 grams per day. At 130 grams per day, FTEC exceedance factors are 2 – 8 and at 250 grams per day, 4 – 15. Alpha-HCH could not be evaluated at the 90th percentile due to the large number of non-detects in the results.

Thus, about half of the 28 lakes sampled in the background study would qualify for 303(d) listing based on an FTEC derived using criteria calculated using a fish consumption rate of 130 grams per day. A similar conclusion applies to Oregon's consumption rate of 175 grams per day. About 1 in 5 (20%) would qualify for listing for consumption rates as low as 54 grams per day.

Table 22 highlights the pesticides or breakdown products with greatest potential to exceed human health criteria FTECs in Washington lakes removed from significant local sources of contamination, depending on assumptions about fish consumption rates. The compounds most likely to become a concern are 4,4'-DDE, dieldrin, and, to a lesser extent, alpha-HCH, chlordane, toxaphene, hexachlorobenzene, and heptachlor epoxide.

Table 22. Chlorinated Pesticides and Breakdown Products with Greatest Potential to Exceed Human Health Criteria FTECs at Various Fish Consumption Rates (at 10^{-6} cancer risk level).

Fish Consumption Rate (grams/day)	Pesticides or Breakdown Products Potentially Exceeding Human Health Criteria FTECs in Background Waterbodies												
	4,4'-DDT	4,4'-DDE (W. Wash.)	4,4'-DDE (E. Wash.)	4,4'-DDD	Dieldrin	HCH, alpha	Chlordane	Toxaphene	Hexachlorobenzene	Heptachlor Epoxide	alpha-Endosulphan	beta-Endosulphan	Endosulphan Sulphate
	@ Background Median Fish Fillet Concentration												
6.5													
17.5													
54													
130			●		●								
175			●		●								
250			●		●	●	●		●				
	@ Background 90th Percentile Fish Fillet Concentration												
6.5						*							
17.5					●	*							
54			●		●	*	●	●	●	●			
130		●	●		●	*	●	●	●	●			
175		●	●		●	*	●	●	●	●			
250		●	●		●	*	●	●	●	●			

*Could not be evaluated at 90th percentile due to numerous non-detects.

Summary and Conclusions

Potential background values for chlorinated pesticides in edible freshwater fish tissue in Washington, as determined in this study, are summarized in terms of the median and 90th percentile in Table 23. Rejecting the few apparent high outliers encountered in this data set would have little or no effect on the median or 90th percentile.

These values are appropriately characterized as background, evidenced by the uniformly low concentrations generally found among 28 lakes sampled across the state (except for 4,4'-DDE) and by comparison to similar data from other Washington freshwater and marine areas.

Background could not be accurately assessed for the following infrequently detected compounds addressed in the human health criteria: HCH (except alpha-HCH), endrin compounds, aldrin, and heptachlor. For these chemicals, background lies somewhere below 0.5 to 0.2 ug/Kg.

In the background lakes, exceedances of the current human health criteria FTECs were restricted to dieldrin, toxaphene, and 4,4'-DDE in Evergreen Lake (one to three species each), hexachlorobenzene in Cavanaugh Lake (two species), and 4,4'-DDE in Wenatchee Lake (one species). Except for dieldrin in Evergreen Lake carp, the exceedances were marginal – by a factor of about 2 or less.

Ecology is in the process of adopting new human health criteria in the water quality standards. The implications of varying the fish consumption rate used in the criteria calculation were evaluated against background. About half of the sampled 28 background lakes would qualify for 303(d) listing based on a fish consumption rate of 130 grams per day and Ecology's current 303(d) listing policy. About 1 in 5 (20%) would qualify for listing for consumption rates as low as 54 grams per day. Oregon recently adopted a fish consumption rate of 175 grams per day in their water quality standards. The compounds most likely to become a concern in Washington are 4,4'-DDE, dieldrin, and, to a lesser extent, alpha-HCH, chlordane, toxaphene, hexachlorobenzene, and heptachlor epoxide.

Table 23. Potential Background Values for Chlorinated Pesticides, Breakdown Products, and Lipids in Edible Tissues of Washington Freshwater Fish (ug/Kg, wet weight; parts per billion).

Pesticide or Breakdown Product	Background Values for Edible Tissues of Washington Freshwater Fish			
	Median		90th Percentile	
303(d) Listed Compounds				
4,4'-DDT	0.08		0.51	
4,4'-DDE (Western Wash.)	0.54		3.2	
4,4'-DDE (Eastern Wash.)	2.7		11	
4,4'-DDD	0.10		1.0	
Dieldrin	0.04		0.26	
Chlordane	0.24	J	1.2	J
HCH, alpha	0.02		0.46	U
Toxaphene	0.17		1.4	
Hexachlorobenzene	0.24		1.1	
Aldrin	0.46	U	0.47	U
Heptachlor	0.23	U	0.24	U
Other Human Health Criteria Compounds				
Heptachlor Epoxide	0.02		0.20	
alpha-Endosulphan	0.20		0.21	
beta-Endosulphan	0.20		0.21	
Endosulphan Sulphate	0.09		0.26	
HCH, beta	0.46	U	0.47	U
Endrin	0.20	U	0.20	U
Endrin Aldehyde	0.20	U	0.21	U

Pesticide or Breakdown Product	Background Values for Edible Tissues of Washington Freshwater Fish			
	Median		90th Percentile	
Miscellaneous Compounds				
2,4'-DDT	0.21		0.25	
2,4'-DDE	0.18		0.23	
2,4'-DDD	0.03		0.23	
Mirex	0.01		0.05	
Endrin Ketone	0.20	U	0.21	U
HCH, delta	0.18	U	0.19	U
HCH, gamma	0.45	U	0.47	U
Methoxychlor	0.20	U	0.20	U
Lipids (percent)				
Salmonids	2.5		3.8	
Spiny rays	0.8		1.5	
Mixed species	1.5		3.5	

U: Not detected at or above reported result.
J: Result is an estimated value.

Recommendations

1. The background values developed here for legacy chlorinated pesticides and breakdown products in Washington State freshwater fish should be taken into account when prioritizing the state's resources to address 303(d) listings, setting cleanup targets for pesticide-contaminated waterbodies or assessing progress toward targets already set. These values could also be used when screening fish contaminant data and designing investigative studies.

2. Waterbodies that have fish with chlorinated pesticide levels below the background 90th percentiles from the present study are poor candidates for water cleanup plans or TMDLs.

References

ATSDR, 2002. Toxicological Profile for Aldrin/Dieldrin. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. www.atsdr.cdc.gov/ToxProfiles/tp1.pdf

Blakley, N., G. Glass, and C. Travers, 1992. Statistical Guidance for Ecology Site Managers. Washington State Department of Ecology, Toxics Cleanup Program, Olympia, WA. Publication No. 92-54. https://fortress.wa.gov/ecy/publications/SummaryPages/9254.html

Coots, R. and B. Era-Miller, 2005. Lake Chelan DDT and PCBs in Fish Total Maximum Daily Load Study. Washington State Department of Ecology. Publication No. 05-03-014. https://fortress.wa.gov/ecy/publications/summarypages/0503014.html

Creech, J. and J. Joy, 2002. Upper Yakima River Basin Suspended Sediment, Turbidity, and Organochlorine Pesticide Total Maximum Daily Load: Submittal Report. Washington State Department of Ecology, Olympia, WA. Publication No. 02-10-047-WQ. https://fortress.wa.gov/ecy/publications/summarypages/0210047.html

Ecology, 2012. Fish Consumption Rates Technical Support Document: A Review of Data and Information about Fish Consumption in Washington. Public Review Draft, August 27, 2012, Version 2.0. Washington State Department of Ecology, Toxics Cleanup Program, Olympia, WA. Publication No. 12-09-058.
https://fortress.wa.gov/ecy/publications/SummaryPages/1209058.html

EPA, 1990. Specifications and Guidance for Obtaining Contaminant-Free Sample Containers. OSWER Directive #93240.0-05. U.S. Environmental Protection Agency.

EPA, 1992. National Study of Chemical Residues in Fish. U.S. Environmental Protection Agency. EPA 823-R-92-008.

EPA, 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 1-4. U.S. Environmental Protection Agency, Office of Water. EPA-823-B-00-007.

EPA, 2005. National Functional Guideline for Superfund Organic Methods Data Review. OSWER 9240.1-46. U.S. Environmental Protection Agency. EPA-540-R-04-009.

EPA, 2009. A National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency. EPA-823-R-09-006. http://epa.gov/waterscience/fish/study/results.htm

Gillian, L.D. and F. Wania, 2005. Organic contaminants in mountains. Environ. Sci. Technol. 39(2):385-3398.

Herbert, C.E. and K.A. Keenleyside, 1995. To normalize or not to normalize: fat is the question. Environmental Toxicology and Chemistry 14(5):801-807.

Hinck, J.E. et al., 2004. Biomonitoring of Environmental Status and Trends (BEST) Program: Environmental Contaminants and their Effects on Fish in the Columbia River Basin. U.S. Geological Survey, Scientific Investigations Report 2004-5154.

Johnson, A., 2011. Quality Assurance Project Plan: Analyzing Chlorinated Pesticide Residues in Fish from Washington Background Lakes. Washington State Department of Ecology, Olympia, WA. Publication No. 11-03-108.
https://fortress.wa.gov/ecy/publications/summarypages/1103108.html

Johnson, A., D. Norton, and B. Yake, 1988. Persistence of DDT in the Yakima River Drainage. Archives Environmental Contamination and Toxicology, 17(289-297).

Johnson, A, B. Era-Miller, and R. Coots, 2007. Chlorinated Pesticides, PCBs, and Dioxins in Yakima River Fish in 2006: Data Summary and Comparison to Human Health Criteria. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-036.
https://fortress.wa.gov/ecy/publications/summarypages/0703036.html

Johnson, A., K. Seiders, and D. Norton, 2010a. An Assessment of the PCB and Dioxin Background in Washington Freshwater Fish, with Recommendations for Prioritizing 303(d) Listings. Washington State Department of Ecology, Olympia, WA. Publication No. 10-03-007.
https://fortress.wa.gov/ecy/publications/SummaryPages/1003007.html

Johnson, A., K. Carmack, B. Era-Miller, B. Lubliner, S. Golding, and R. Coots, 2010b. Yakima River Pesticides and PCBs Total Maximum Daily Load: Volume 1. Water Quality Study Findings. Washington State Department of Ecology, Olympia, WA. Publication No. 10-03-011.
https://fortress.wa.gov/ecy/publications/publications/1003018.pdf

Johnson, A., M. Friese, J. Roland, C. Gruenenfelder, B. Dowling, A. Fernandez, and T. Hamlin, 2011. Background Characterization for Metals and Organic Compounds in Northeast Washington Lakes, Part 2: Fish Tissue. Washington State Department of Ecology, Olympia, WA. Publication No. 11-03-054.
https://fortress.wa.gov/ecy/publications/SummaryPages/1103054.html

Johnson, A., K. Carmack, and B. Era-Miller, 2012. Toxaphene: Improved Recognition in Washington Streams, Rivers, and Lakes. Washington State Department of Ecology, Olympia, WA. Publication No. 12-03-004.
https://fortress.wa.gov/ecy/publications/SummaryPages/1203004.html

Joy, J. and B. Patterson, 1997. A Suspended Sediment and DDT Total Maximum Daily Load Evaluation Report for the Yakima River. Washington State Department of Ecology, Olympia, WA. Publication No. 97-321.
https://fortress.wa.gov/ecy/publications/summarypages/97321.html

Lombard, S. and C. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030.
https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

MEL. 2008. Manchester Environmental Laboratory, Lab Users Manual, Ninth Edition. Washington State Department of Ecology, Olympia, WA.

Moran, P.W., N. Aluru, R.W. Black, and M.M. Vijayan, 2007. Tissue Contaminants and Associated Transcriptional Response in Trout Liver from High Elevation Lakes of Washington. Environmental Science and Technology. 41(18):6591-6597.

Rinella, Joseph F., P.A. Hamilton, and S.W. McKenzie, 1993. Persistence of the DDT Pesticide in the Yakima River Basin. U.S. Geological Survey Circular 1090.

Sandvik, P., 2006a. Standard Operating Procedure for Field Collection, Processing, and Preservation of Finfish Samples at the Time of Collection in the Field. Version 1.0. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. www.ecy.wa.gov/programs/eap/quality.html

Sandvik, P., 2006b. Standard Operating Procedure for Resecting Finfish Wholebody, Body Parts, and Tissues. Version 1.0. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. www.ecy.wa.gov/programs/eap/quality.html

San Juan, C., 1994. Natural Background Soil Metals Concentrations. Washington State Department of Ecology, Toxics Cleanup Program, Olympia, WA. Publication No. 94-115. https://fortress.wa.gov/ecy/publications/SummaryPages/94115.html

Schmitt, C.J., J.L. Zajicek, and P.H. Peterman, 1990. National Contaminant Monitoring Program: Residues of Organochlorine Chemicals in U.S. Freshwater Fish, 1976-84. Arch. Environmental Contamination and Toxicology 19:748-781.

Schmitt, C.J., J.L. Zajicek, T.W. May, and D.F. Cowman, 1999. Organochlorine residues and elemental contaminants in U.S. freshwater fish, 1976-1986; National Contaminant Biomonitoring Program. Reviews of Environmental Contamination and Toxicology 162:43-104.

Seiders, K., C. Deligeannis, and M. Friese, 2012. Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2010. Publication No. 12-03-023. https://fortress.wa.gov/ecy/publications/summarypages/1203023.html

Smith, A.G., 1991. Chlorinated Hydrocarbon Insecticides. in Handbook of Pesticide Toxicology, Volume 3, Classes of Pesticides. Wayland J. Hayes Jr. and Edward R. Laws, Jr. editors. Academic Press, Inc., NY

Stow, C.A., L.J. Jackson, and J.F. Amrhein, 1997. An examination of the PCB: lipid relationship among individual fish. Canadian Journal of Fish and Aquatic Science 54:1031-1038.

Wania, F. and D. Mackay, 1993. Global fractionation and cold deposition of low volatility organochlorine compounds in polar regions. Ambio (22):10-18.

West, J., J. Lanksbury, S. O'Neill, and A. Marshall, 2011. Control of Toxic Chemicals in Puget Sound Phase 3: Persistent Bioaccumulative and Toxic Contaminants in Pelagic Marine Fish Species from Puget Sound. Washington Department of Fish and Wildlife, Olympia, WA. Washington State Department of Ecology Publication No. 11-10-003. https://fortress.wa.gov/ecy/publications/summarypages/1110003.html

Appendices

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Appendix A. Fish Samples Analyzed

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Ozette	PEA	9/13/11	OZPEA	1	131	254	ECY
Ozette	PEA	9/13/11		1	128	246	ECY
Ozette	PEA	9/13/11		1	112	250	ECY
Ozette	PEA	9/13/11		1	169	270	ECY
Ozette	YP	9/13/11	OZYP	2	195	259	ECY
Ozette	YP	9/13/11		2	90	200	ECY
Ozette	YP	9/13/11		2	98	203	ECY
Ozette	YP	9/13/11		2	57	168	ECY
Ozette	YP	9/13/11		2	71	180	ECY
Ozette	LMB	9/13/11	OZLMB	4	231	259	ECY
Ozette	LMB	9/13/11		4	574	338	ECY
Ozette	LMB	9/13/11		4	474	308	ECY
Ozette	LMB	9/13/11		4	223	242	ECY
Tarboo	LMB	8/17/11	TRBLMB	5	126	207	ECY
Tarboo	LMB	8/17/11		5	101	194	ECY
Tarboo	LMB	8/17/11		5	110	197	ECY
Tarboo	LMB	8/17/11		5	282	262	ECY
Tarboo	LMB	8/17/11		5	105	190	ECY
Cushman	CTT	9/19/11	CSHCTT	9	376	350	ECY
Cushman	CTT	9/19/11		9	277	325	ECY
Cushman	LSS	9/19/11	CSHLSS	10	247	290	ECY
Cushman	LSS	9/19/11		10	307	312	ECY
Cushman	LSS	9/19/11		10	206	274	ECY
Cushman	LSS	9/19/11		10	380	327	ECY
Wynoochee	MWF	11/1/11	WYNMWF	11	320	330	ECY
Wynoochee	MWF	11/1/11		11	249	305	ECY
Wynoochee	MWF	11/1/11		11	359	337	ECY
Wynoochee	MWF	11/1/11		11	322	317	ECY
Wynoochee	MWF	11/1/11		11	259	312	ECY
Devereaux	LMB	8/17/11	DEVLMB	6	406	275	ECY
Devereaux	LMB	8/17/11		6	74	170	ECY
Devereaux	LMB	8/17/11		6	89	175	ECY
Devereaux	LMB	8/17/11		6	89	170	ECY
Devereaux	LMB	8/17/11		6	55	155	ECY
Devereaux	KOK	11/11/11	DEVKOK	7	-	240	WDFW
Devereaux	KOK	11/11/11		7	148	268	WDFW
Devereaux	KOK	11/11/11		7	143	265	WDFW

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Devereaux	KOK	11/11/11		7	126	255	WDFW
Devereaux	KOK	11/11/11		7	120	242	WDFW
Failor	CTT	9/22/09	FLRCTT	53	130	238	ECY
Failor	CTT	9/22/09		53	148	250	ECY
Failor	CTT	9/22/09		53	149	251	ECY
Failor	CTT	9/22/09		53	136	235	ECY
Failor	CTT	9/22/09		53	118	245	ECY
Silver	BBH	11/29/11	SLVBBH	26	212	250	WDFW
Silver	BBH	11/29/11		26	169	240	WDFW
Silver	BBH	11/29/11		26	168	238	WDFW
Silver	BBH	11/29/11		26	106	205	WDFW
Silver	BBH	11/29/11		26	142	214	WDFW
Silver	BCR	11/29/11	SLVBCR	27	120	194	WDFW
Silver	BCR	11/29/11		27	99	185	WDFW
Silver	BCR	11/29/11		27	123	196	WDFW
Silver	BCR	11/29/11		27	115	193	WDFW
Silver	BCR	11/29/11		27	115	197	WDFW
Baker	MWF	10/12/11	BAKMWF	13	113	234	ECY
Baker	MWF	10/12/11		13	148	251	ECY
Baker	MWF	10/12/11		13	195	260	ECY
Baker	MWF	10/12/11		13	174	249	ECY
Baker	MWF	10/12/11		13	189	267	ECY
Diobsud	CTT	9/8/11	DIOCTT	44	239	271*	NPS
Diobsud	CTT	9/8/11		44	124	230*	NPS
Diobsud	CTT	9/8/11		44	174	245*	NPS
Diobsud	CTT	9/8/11		44	212	250*	NPS
Diobsud	CTT	9/8/11		44	144	236*	NPS
Gorge	EBT	7/11-14/11	GOREBT	28	74	202*	NPS
Gorge	EBT	7/11-14/11		28	72	205*	NPS
Gorge	EBT	7/11-14/11		28	80	206*	NPS
Gorge	EBT	7/11-14/11		28	162	267*	NPS
Gorge	EBT	7/11-14/11		28	194	272*	NPS
Gorge	RBT	7/11-14/11	GORRBT	29	159	264*	NPS
Gorge	RBT	7/11-14/11		29	179	274*	NPS
Gorge	RBT	7/11-14/11		29	234	300*	NPS
Gorge	RBT	7/11-14/11		29	220	298*	NPS
Gorge	RBT	7/11-14/11		29	250	305*	NPS
Cavanaugh	KOK	10/11/11	CAVKOK	14	316	305	ECY
Cavanaugh	KOK	10/11/11		14	332	320	ECY
Cavanaugh	KOK	10/11/11		14	324	340	ECY

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Cavanaugh	KOK	10/11/11		14	315	330	ECY
Cavanaugh	CTT	10/11/11	CAVCTT	15	160	281	ECY
Cavanaugh	CTT	10/11/11		15	205	295	ECY
Cavanaugh	CTT	10/11/11		15	208	295	ECY
Cavanaugh	CTT	10/11/11		15	163	260	ECY
Cavanaugh	CTT	10/11/11		15	136	273	ECY
Cavanaugh	LMB	10/11/11	CAVLMB	16	1167	458	ECY
Cavanaugh	LMB	10/11/11		16	1198	398	ECY
Cassidy	LMB	9/23/11	CASSLMB	45	162	240	ECY
Cassidy	LMB	9/23/11		45	216	251	ECY
Cassidy	LMB	9/23/11		45	220	246	ECY
Cassidy	LMB	9/23/11		45	597	333	ECY
Cassidy	LMB	9/23/11		45	307	295	ECY
Cassidy	YP	9/23/11	CASSYP	46	117	205	ECY
Cassidy	YP	9/23/11		46	114	212	ECY
Cassidy	YP	9/23/11		46	99	201	ECY
Cassidy	YP	9/23/11		46	91	197	ECY
Cassidy	YP	9/23/11		46	84	190	ECY
Chester Morse	RBT	2/14/12	CMRBT	17	493	375	SPU
Chester Morse	RBT	2/14/12		17	700	438	SPU
Chester Morse	RBT	2/14/12		17	587	409	SPU
Chester Morse	RBT	2/14/12		17	581	409	SPU
Chester Morse	RBT	2/14/12		17	563	403	SPU
Coldwater	RBT	9/2/11	CLDRBT	30	349	310*	WDFW
Coldwater	RBT	9/2/11		30	379	335*	WDFW
Coldwater	RBT	9/2/11		30	519	390*	WDFW
Coldwater	RBT	9/2/11		30	4416	343*	WDFW
Coldwater	RBT	9/2/11		30	487	365*	WDFW
Merrill	CTT	10/25/11	MERCTT	25	148	259	WDFW
Merrill	CTT	10/25/11		25	332	326	WDFW
Merrill	CTT	10/25/11		25	294	317	WDFW
Merrill	CTT	10/25/11		25	350	249	WDFW
Merrill	CTT	10/25/11		25	230	294	WDFW
Patterson	RBT	7/21/11	PATRBT	31	233	292	WDFW
Patterson	RBT	7/21/11		31	316	324	WDFW
Patterson	RBT	7/21/11		31	309	322	WDFW
Patterson	LMB	7/21/11	PATLMB	32	467	333	WDFW
Patterson	LMB	7/21/11		32	73	175	WDFW
Patterson	LMB	7/21/11		32	82	183	WDFW
Patterson	YP	7/21/11	PATYP	33	35	147	WDFW

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Patterson	YP	7/21/11		33	34	145	WDFW
Patterson	YP	7/21/11		33	39	146	WDFW
Patterson	YP	7/21/11		33	87	193	WDFW
Patterson	YP	7/21/11		33	90	200	WDFW
Patterson	YP	7/21/11		33	98	197	WDFW
Patterson	YP	7/21/11		33	82	186	WDFW
Wenatchee	NPM	10/13/11	WENNPM	34	837	428	ECY
Wenatchee	NPM	10/13/11		34	615	443	ECY
Wenatchee	NPM	10/13/11		34	1042	462	ECY
Wenatchee	NPM	10/13/11		34	598	414	ECY
Wenatchee	NPM	10/13/11		34	442	362	ECY
Wenatchee	CTT	10/13/11	WENCTT	35	146	256	ECY
Wenatchee	CTT	10/13/11		35	161	265	ECY
Wenatchee	CTT	10/13/11		35	139	245	ECY
Wenatchee	CTT	10/13/11		35	311	309	ECY
Wenatchee	CTT	10/13/11		35	338	325	ECY
Cle Elum	MWF	10/26/11	CLMMWF	23	94	215	ECY
Cle Elum	MWF	10/26/11		23	64	195	ECY
Cle Elum	MWF	10/26/11		23	55	185	ECY
Cle Elum	RBT	10/26/11	CLMRBT	24	270	284	ECY
Cle Elum	RBT	10/26/11		24	157	251	ECY
Cle Elum	RBT	10/26/11		24	142	222	ECY
Cle Elum	RBT	10/26/11		24	130	234	ECY
Bumping	KOK	8/22/11	BMPKOK	18	91	227	ECY
Bumping	KOK	8/22/11		18	106	235	ECY
Bumping	KOK	8/22/11		18	53	181	ECY
Bumping	KOK	8/22/11		18	102	235	ECY
Rimrock	KOK	8/23/11	RIMKOK	21	113	239	ECY
Rimrock	KOK	8/23/11		21	105	241	ECY
Rimrock	KOK	8/23/11		21	117	246	ECY
Rimrock	KOK	8/23/11		21	93	230	ECY
Rimrock	KOK	8/23/11		21	28	145	ECY
Rimrock	MWF	8/23/11	RIMMWF	22	92	235	ECY
Rimrock	MWF	8/23/11		22	59	202	ECY
Rimrock	MWF	8/23/11		22	54	195	ECY
Rimrock	LSS	8/23/11	RIMLSS	19	337	340	ECY
Rimrock	LSS	8/23/11		19	438	376	ECY
Rimrock	LSS	8/23/11		19	370	344	ECY
Rimrock	LSS	8/23/11		19	327	350	ECY
Rimrock	LSS	8/23/11		19	480	378	ECY

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Walupt	CTT	8/24/11	WALCTT	20	234	300	ECY
Walupt	CTT	8/24/11		20	145	260	ECY
Walupt	CTT	8/24/11		20	113	239	ECY
Walupt	CTT	8/24/11		20	118	242	ECY
Walupt	CTT	8/24/11		20	210	306	ECY
Cedar	RBT	10/18/10	CEDRBT	48	88	204	ECY
Cedar	RBT	10/18/10		48	123	221	ECY
Cedar	RBT	10/18/10		48	98	195	ECY
Cedar	RBT	10/18/10		48	104	210	ECY
Cedar	RBT	10/18/10		48	98	196	ECY
Sullivan	KOK	10/20/10	SULKOK	47	202	270	ECY
Sullivan	KOK	10/20/10		47	193	275	ECY
Sullivan	KOK	10/20/10		47	203	290	ECY
Sullivan	KOK	10/20/10		47	194	275	ECY
Sullivan	KOK	10/20/10		47	186	276	ECY
Sullivan	BRB	10/20/10	SULBRB	49	1437	612	ECY
Sullivan	BRB	10/20/10		49	1408	605	ECY
Sullivan	BRB	10/20/10		49	1278	556	ECY
Leo	YP	10/19/10	LEOYP	50	131	233	ECY
Leo	YP	10/19/10		50	117	226	ECY
Leo	YP	10/19/10		50	100	210	ECY
Leo	YP	10/19/10		50	66	190	ECY
Leo	YP	10/19/10		50	61	191	ECY
Leo	YP	10/19/10		50	54	174	ECY
Leo	YP	10/19/10		50	54	169	ECY
Leo	YP	10/19/10		50	50	171	ECY
Leo	YP	10/19/10		50	46	162	ECY
Leo	YP	10/19/10		50	45	159	ECY
Bayley	RBT	10/5/10	BAYRBT	51	1364	492	ECY
Bayley	RBT	10/5/10		51	1179	496	ECY
Bayley	RBT	10/5/10		51	1077	478	ECY
Bayley	RBT	10/5/10		51	920	447	ECY
Bayley	RBT	10/5/10		51	876	432	ECY
Buffalo	RBT	10/6/11	BUFRBT	40	464	350	CCT
Buffalo	RBT	10/6/11		40	419	345	CCT
Buffalo	RBT	10/6/11		40	315	330	CCT
Buffalo	KOK	10/6/11	BUFKOK	41	454	330	CCT
Buffalo	KOK	10/6/11		41	393	330	CCT
Buffalo	KOK	10/6/11		41	459	350	CCT
Buffalo	KOK	10/6/11		41	317	290	CCT

Lake	Species	Sample Date	Sample ID	Sample No. (1201017-)	Weight (gm)	Total Length (mm)	Collector
Buffalo	LSS	10/6/11	BUFLSS	42	586	350	CCT
Buffalo	LSS	10/6/11		42	1076	445	CCT
South Twin	LMB	5/24/11	STWLMB	39	199	247	ECY
South Twin	LMB	5/24/11		39	233	245	ECY
South Twin	LMB	5/24/11		39	228	255	ECY
South Twin	LMB	5/24/11		39	105	203	ECY
South Twin	LMB	5/24/11		39	151	225	ECY
Evergreen	SMB	8/5/11	EVGSMB	36	416	306	WDFW
Evergreen	SMB	8/5/11		36	483	297	WDFW
Evergreen	SMB	8/5/11		36	301	262	WDFW
Evergreen	SMB	8/5/11		36	404	294	WDFW
Evergreen	SMB	8/5/11		36	267	260	WDFW
Evergreen	CRP	8/5/11	EVGCRP	38	1975	515	WDFW
Evergreen	CRP	8/5/11		38	2604	550	WDFW
Evergreen	CRP	8/5/11		38	3434	580	WDFW
Evergreen	CRP	8/5/11		38	2363	530	WDFW
Evergreen	YP	8/5/11	EVGYP	43	99	192	WDFW
Evergreen	YP	8/5/11		43	72	174	WDFW
Evergreen	YP	8/5/11		43	56	152	WDFW
Evergreen	YP	8/5/11		43	48	159	WDFW
Evergreen	YP	8/5/11		43	48	153	WDFW

*fork length

BBH: brown bullhead *(Ameiurus nebulosus)*
BCR: black crappie *(Pomoxis nigromaculatus)*
BRB: burbot *(Lota lota)*
CRP: common carp (*Cyprinus carpio)*
CTT: cutthroat trout (*Oncorhynchus clarki*)
EBT: eastern brook trout (*Salvelinus fontinalis*)
KOK: kokanee (*Oncorhynchus nerka*)
LMB: largemouth bass (*Micropterus salmoides*)
LSS: largescale suckers (*Catostomus macrocheilus*)
MWF: mountain whitefish (*Prosopium williamsoni*)
NPM: northern pikeminnow *(Ptychocheilus oregonensis)*
PEA: peamouth *(Mylocheilus caurinus)*
RBT: rainbow trout (*Oncorhynchus mykiss*)
SMB: smallmouth bass (*Micropterus dolomieu*)
YP: yellow perch (*Perca flavescens*)
CCT: Colville Confederated Tribes
ECY: Washington State Department of Ecology
NPS: National Park Service
SPU: Seattle Public Utilities
WDFW: Washington Department of Fish and Wildlife

Appendix B. Results of Duplicate Analyses

Sample No.	Field ID	Parameter	Duplicate #1		Duplicate #2		Relative Percent Difference
1201017-09	CSHCTT	% Lipid	2.81		2.73		3%
1201017-09	CSHCTT	Hexachlorobenzene	0.428		0.417		3%
1201017-09	CSHCTT	HCH, alpha	0.010	J	0.009	J	11%
1201017-09	CSHCTT	HCH, beta	0.458	U	0.459	U	ND
1201017-09	CSHCTT	HCH, gamma	0.466	U	0.467	U	ND
1201017-09	CSHCTT	Heptachlor	0.229	U	0.229	U	ND
1201017-09	CSHCTT	Aldrin	0.459	U	0.459	U	ND
1201017-09	CSHCTT	Chlordane, oxy-	0.039	J	0.040	J	3%
1201017-09	CSHCTT	Chlordane, gamma (trans)	0.014	J	0.012	J	15%
1201017-09	CSHCTT	Chlordane, alpha (cis)	0.076	J	0.076	J	0%
1201017-09	CSHCTT	Nonachlor, trans-	0.577		0.558		3%
1201017-09	CSHCTT	Nonachlor, cis-	0.161	J	0.165	J	2%
1201017-09	CSHCTT	2,4'-DDD	0.229	U	0.229	U	ND
1201017-09	CSHCTT	4,4'-DDD	0.020	J	0.018	J	11%
1201017-09	CSHCTT	2,4'-DDE	0.229	U	0.230	U	ND
1201017-09	CSHCTT	4,4'-DDE	0.744		0.762		2%
1201017-09	CSHCTT	2,4'-DDT	0.009	J	0.231	U	ND
1201017-09	CSHCTT	4,4'-DDT	0.035	J	0.037	J	6%
1201017-09	CSHCTT	Mirex	0.104	J	0.101	J	3%
1201017-09	CSHCTT	HCH, delta	0.183	U	0.184	U	ND
1201017-09	CSHCTT	Heptachlor Epoxide	0.198	U	0.198	U	ND
1201017-09	CSHCTT	alpha-Endosulphan	0.201	U	0.202	U	ND
1201017-09	CSHCTT	Dieldrin	0.0337	J	0.0349	J	3%
1201017-09	CSHCTT	Endrin	0.20	U	0.20	U	ND
1201017-09	CSHCTT	beta-Endosulphan	0.20	U	0.20	U	ND
1201017-09	CSHCTT	Endosulphan Sulphate	0.20	U	0.20	U	ND
1201017-09	CSHCTT	Endrin Aldehyde	0.20	U	0.20	U	ND
1201017-09	CSHCTT	Endrin Ketone	0.204	U	0.205	U	ND
1201017-09	CSHCTT	Methoxychlor	0.198	U	0.198	U	ND
1201017-26	SLVBBH	% Lipid	0.90		1.04		14%
1201017-26	SLVBBH	Hexachlorobenzene	0.205		0.207	J	1%
1201017-26	SLVBBH	HCH, alpha	0.410	U	0.444	U	ND
1201017-26	SLVBBH	HCH, beta	0.406	U	0.441	U	ND
1201017-26	SLVBBH	HCH, gamma	0.414	U	0.448	U	ND
1201017-26	SLVBBH	Heptachlor	0.203	U	0.220	U	ND
1201017-26	SLVBBH	Aldrin	0.407	U	0.441	U	ND
1201017-26	SLVBBH	Chlordane, oxy-	0.007	J	0.007	NJ	0%

Sample No.	Field ID	Parameter	Duplicate #1		Duplicate #2		Relative Percent Difference
1201017-26	SLVBBH	Chlordane, gamma (trans)	0.406	U	0.44	U	ND
1201017-26	SLVBBH	Chlordane, alpha (cis)	0.034	J	0.035	J	3%
1201017-26	SLVBBH	Nonachlor, trans-	0.031	J	0.026	J	18%
1201017-26	SLVBBH	Nonachlor, cis-	0.034	NJ	0.026	NJ	27%
1201017-26	SLVBBH	2,4'-DDD	0.004	NJ	0.220	U	ND
1201017-26	SLVBBH	4,4'-DDD	0.053	J	0.053	J	0%
1201017-26	SLVBBH	2,4'-DDE	0.005	NJ	0.005	J	0%
1201017-26	SLVBBH	4,4'-DDE	0.426		0.457		7%
1201017-26	SLVBBH	2,4'-DDT	0.205	U	0.222	U	ND
1201017-26	SLVBBH	4,4'-DDT	0.205	U	0.223	U	ND
1201017-26	SLVBBH	Mirex	0.002	NJ	0.002	NJ	0%
1201017-26	SLVBBH	HCH, delta	0.163	U	0.176	U	ND
1201017-26	SLVBBH	Heptachlor Epoxide	0.175	U	0.190	U	ND
1201017-26	SLVBBH	alpha-Endosulphan	0.179	U	0.194	U	ND
1201017-26	SLVBBH	Dieldrin	0.0103	J	0.0101	J	2%
1201017-26	SLVBBH	Endrin	0.178	U	0.193	U	ND
1201017-26	SLVBBH	beta-Endosulphan	0.0156	NJ	0.008	J	64%
1201017-26	SLVBBH	Endosulphan Sulphate	0.0163	J	0.0149	J	9%
1201017-26	SLVBBH	Endrin Aldehyde	0.177	U	0.192	U	ND
1201017-26	SLVBBH	Endrin Ketone	0.181	U	0.196	U	ND
1201017-26	SLVBBH	Methoxychlor	0.175	U	0.190	U	ND
1201017-36	EVGSMB	% Lipid	1.18		NA		ND
1201017-36	EVGSMB	Hexachlorobenzene	0.186	J	0.175	J	6%
1201017-36	EVGSMB	HCH, alpha	0.008	J	0.007	J	13%
1201017-36	EVGSMB	HCH, beta	0.399	U	0.395	U	ND
1201017-36	EVGSMB	HCH, gamma	0.005	J	0.005	NJ	0%
1201017-36	EVGSMB	Heptachlor	0.20	U	0.002	J	ND
1201017-36	EVGSMB	Aldrin	0.400	U	0.396	U	ND
1201017-36	EVGSMB	Chlordane, oxy-	0.046	NJ	0.049	J	6%
1201017-36	EVGSMB	Chlordane, gamma (trans)	0.01	NJ	0.008	NJ	22%
1201017-36	EVGSMB	Chlordane, alpha (cis)	0.028	J	0.03	NJ	7%
1201017-36	EVGSMB	Nonachlor, trans-	0.117	J	0.103	J	13%
1201017-36	EVGSMB	Nonachlor, cis-	0.049	J	0.045	NJ	9%
1201017-36	EVGSMB	2,4'-DDD	0.022	J	0.021	NJ	5%
1201017-36	EVGSMB	4,4'-DDD	0.599		0.558		7%
1201017-36	EVGSMB	2,4'-DDE	0.043	J	0.043	J	0%
1201017-36	EVGSMB	4,4'-DDE	8.12		8.03		1%
1201017-36	EVGSMB	2,4'-DDT	0.059	J	0.048	J	21%
1201017-36	EVGSMB	4,4'-DDT	0.964		0.930		4%
1201017-36	EVGSMB	Mirex	0.004	J	0.003	J	29%

Sample No.	Field ID	Parameter	Duplicate #1		Duplicate #2		Relative Percent Difference
1201017-36	EVGSMB	HCH, delta	0.001	NJ	0.158	U	ND
1201017-36	EVGSMB	Heptachlor Epoxide	0.056	J	0.056	J	0%
1201017-36	EVGSMB	alpha-Endosulphan	0.175	U	0.174	U	ND
1201017-36	EVGSMB	Dieldrin	1.87		1.74		7%
1201017-36	EVGSMB	Endrin	0.175	U	0.173	U	ND
1201017-36	EVGSMB	beta-Endosulphan	0.174	U	0.173	U	ND
1201017-36	EVGSMB	Endosulphan Sulphate	0.346		0.309		11%
1201017-36	EVGSMB	Endrin Aldehyde	0.174	U	0.172	U	ND
1201017-36	EVGSMB	Endrin Ketone	0.178	U	0.176	U	ND
1201017-36	EVGSMB	Methoxychlor	0.172	U	0.171	U	ND

ND: not detected.
U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

Appendix C. Lipids Data (percent)

Western				East Slope		
Ozette	Peamouth	1.45		Patterson	Rainbow Trout	0.84
Ozette	Yellow Perch	0.50		Patterson	Largemouth Bass	0.48
Ozette	Largemouth Bass	0.71		Patterson	Yellow Perch	0.58
Tarboo	Largemouth Bass	1.11		Wenatchee	Northern Pikeminnow	3.16
Cushman	Cutthroat Trout	2.77		Wenatchee	Cutthroat Trout	2.83
Cushman	Largescale Sucker	0.71		Cle Elum	Mountain Whitefish	2.56
Wynoochee	Mountain Whitefish	3.23		Cle Elum	Rainbow Trout	3.41
Devereaux	Largemouth Bass	1.54		Bumping	Kokanee	6.99
Devereaux	Kokanee	1.38		Rimrock	Kokanee	4.21
Failor	Cutthroat Trout	3.03		Rimrock	Mountain Whitefish	0.57
Silver	Brown Bullhead	0.97		Rimrock	Largescale Sucker	0.34
Silver	Black Crappie	0.86		Walupt	Cutthroat Trout	1.77
	Median =	1.25			Median =	2.17
West Slope				**Eastern**		
Baker	Mountain Whitefish	3.36		Cedar	Rainbow Trout	2.11
Diobsud	Cutthroat Trout	3.58		Sullivan	Kokanee	2.45
Gorge	Eastern Brook Trout	1.86		Sullivan	Burbot	0.37
Gorge	Rainbow Trout	1.15		Leo	Yellow Perch	0.56
Cavanaugh	Kokanee	2.33		Bayley	Rainbow Trout	3.08
Cavanaugh	Cutthroat Trout	1.18		South Twin	Largemouth Bass	0.72
Cavanaugh	Largemouth Bass	1.46		Buffalo	Rainbow Trout	1.74
Cassidy	Largemouth Bass	0.41		Buffalo	Kokanee	4.47
Cassidy	Yellow Perch	0.40		Buffalo	Largescale Sucker	1.48
Chester Morse	Rainbow Trout	2.55		Evergreen	Yellow Perch	0.79
Coldwater	Rainbow Trout	1.24		Evergreen	Smallmouth Bass	1.18
Merrill	Cutthroat Trout	2.54		Evergreen	Common Carp	9.52
	Median =	1.66			Median =	1.61

Appendix D. Pesticide Data for Other 303(d) Listed Compounds: 4,4'-DDT, 4,4'-DDD, Hexachlorobenzene, Alpha-HCH, Aldrin, and Heptachlor

(ug/Kg, wet weight; parts per billion)

Table D-1.

Region / Lake	Species	4,4'-DDT			Region / Lake	Species	4,4'-DDT	
Western					**East Slope**			
Ozette	Peamouth	0.23	U		Patterson	Rainbow Trout	0.08	J
Ozette	Yellow Perch	0.23	U		Patterson	Largemouth Bass	0.04	NJ
Ozette	Largemouth Bass	0.24	U		Patterson	Yellow Perch	0.01	NJ
Tarboo	Largemouth Bass	0.24	U		Wenatchee	Northern Pikeminnow	0.04	J
Cushman	Cutthroat Trout	0.04	J		Wenatchee	Cutthroat Trout	0.19	J
Cushman	Largescale Sucker	0.28	U		Cle Elum	Mountain Whitefish	0.09	J
Wynoochee	Mountain Whitefish	0.05	J		Cle Elum	Rainbow Trout	0.07	J
Devereaux	Largemouth Bass	0.08	J		Bumping	Kokanee	0.47	
Devereaux	Kokanee	0.23			Rimrock	Kokanee	0.66	
Failor	Cutthroat Trout	0.04	J		Rimrock	Mountain Whitefish	0.27	
Silver	Brown Bullhead	0.21	U		Rimrock	Largescale Sucker	0.06	J
Silver	Black Crappie	0.25	U		Walupt	Cutthroat Trout	0.05	J
	Median =	0.23	U			Median =	0.07	J
West Slope					**Eastern**			
Baker	Mountain Whitefish	0.46			Cedar	Rainbow Trout	0.01	J
Diobsud	Cutthroat Trout	0.04	J		Sullivan	Kokanee	0.75	
Gorge	Eastern Brook Trout	0.05	J		Sullivan	Burbot	0.23	
Gorge	Rainbow Trout	0.05	J		Leo	Yellow Perch	0.01	J
Cavanaugh	Kokanee	0.49			Bayley	Rainbow Trout	0.03	J
Cavanaugh	Cutthroat Trout	0.05	J		South Twin	Largemouth Bass	0.01	J
Cavanaugh	Largemouth Bass	0.10	J		Buffalo	Rainbow Trout	0.05	J
Cassidy	Largemouth Bass	0.02	J		Buffalo	Kokanee	0.54	
Cassidy	Yellow Perch	0.02	J		Buffalo	Largescale Sucker	0.05	J
Chester Morse	Rainbow Trout	0.05	J		Evergreen	Yellow Perch	0.50	
Coldwater	Rainbow Trout	0.24	U		Evergreen	Smallmouth Bass	0.95	
Merrill	Cutthroat Trout	0.04	J		Evergreen	Common Carp	1.0	
	Median =	0.05	J			Median =	0.14	

Table D-2.

Region / Lake	Species	4,4'-DDD		Region / Lake	Species	4,4'-DDD	
Western				**East Slope**			
Ozette	Peamouth	0.01	J	Patterson	Rainbow Trout	0.59	
Ozette	Yellow Perch	0.23	U	Patterson	Largemouth Bass	0.16	J
Ozette	Largemouth Bass	0.23	U	Patterson	Yellow Perch	0.04	J
Tarboo	Largemouth Bass	0.03	J	Wenatchee	Northern Pikeminnow	3.5	
Cushman	Cutthroat Trout	0.02	J	Wenatchee	Cutthroat Trout	0.17	J
Cushman	Largescale Sucker	0.01	J	Cle Elum	Mountain Whitefish	0.04	J
Wynoochee	Mountain Whitefish	0.03	J	Cle Elum	Rainbow Trout	0.02	J
Devereaux	Largemouth Bass	0.14	J	Bumping	Kokanee	2.4	
Devereaux	Kokanee	1.2		Rimrock	Kokanee	0.38	
Failor	Cutthroat Trout	0.03	J	Rimrock	Mountain Whitefish	0.07	J
Silver	Brown Bullhead	0.05	J	Rimrock	Largescale Sucker	0.04	J
Silver	Black Crappie	0.02	J	Walupt	Cutthroat Trout	0.17	J
	Median =	0.03	J		Median =	0.16	J
West Slope				**Eastern**			
Baker	Mountain Whitefish	0.28		Cedar	Rainbow Trout	0.07	J
Diobsud	Cutthroat Trout	0.05	J	Sullivan	Kokanee	0.48	
Gorge	Eastern Brook Trout	0.02	J	Sullivan	Burbot	0.18	J
Gorge	Rainbow Trout	0.02	J	Leo	Yellow Perch	0.04	J
Cavanaugh	Kokanee	0.93		Bayley	Rainbow Trout	0.24	
Cavanaugh	Cutthroat Trout	0.34		South Twin	Largemouth Bass	0.03	J
Cavanaugh	Largemouth Bass	0.15	J	Buffalo	Rainbow Trout	0.61	
Cassidy	Largemouth Bass	0.04	J	Buffalo	Kokanee	3.7	
Cassidy	Yellow Perch	0.04	J	Buffalo	Largescale Sucker	0.61	
Chester Morse	Rainbow Trout	0.04	J	Evergreen	Yellow Perch	0.44	
Coldwater	Rainbow Trout	0.01	J	Evergreen	Smallmouth Bass	0.58	
Merrill	Cutthroat Trout	0.05	J	Evergreen	Common Carp	5.05	
	Median =	0.04	J		Median =	0.46	

Table D-3.

Region / Lake	Species	Hexachloro-benzene		Region / Lake	Species	Hexachloro-benzene	
Western				**East Slope**			
Ozette	Peamouth	0.15	J	Patterson	Rainbow Trout	0.16	J
Ozette	Yellow Perch	0.04	J	Patterson	Largemouth Bass	0.06	J
Ozette	Largemouth Bass	0.05	J	Patterson	Yellow Perch	0.05	J
Tarboo	Largemouth Bass	0.11	J	Wenatchee	Northern Pikeminnow	0.68	
Cushman	Cutthroat Trout	0.42		Wenatchee	Cutthroat Trout	0.29	
Cushman	Largescale Sucker	0.93		Cle Elum	Mountain Whitefish	0.28	
Wynoochee	Mountain Whitefish	0.23	J	Cle Elum	Rainbow Trout	0.38	
Devereaux	Largemouth Bass	0.62		Bumping	Kokanee	0.85	
Devereaux	Kokanee	0.90		Rimrock	Kokanee	0.64	
Failor	Cutthroat Trout	0.20	J	Rimrock	Mountain Whitefish	0.08	J
Silver	Brown Bullhead	0.21	J	Rimrock	Largescale Sucker	0.25	
Silver	Black Crappie	0.16	J	Walupt	Cutthroat Trout	0.29	
	Median =	0.20	J		Median =	0.28	J
West Slope				**Eastern**			
Baker	Mountain Whitefish	0.64		Cedar	Rainbow Trout	0.09	J
Diobsud	Cutthroat Trout	0.23		Sullivan	Kokanee	0.72	
Gorge	Eastern Brook Trout	0.20	J	Sullivan	Burbot	0.26	
Gorge	Rainbow Trout	0.23		Leo	Yellow Perch	0.06	J
Cavanaugh	Kokanee	7.41		Bayley	Rainbow Trout	0.18	J
Cavanaugh	Cutthroat Trout	4.68		South Twin	Largemouth Bass	0.09	J
Cavanaugh	Largemouth Bass	7.16		Buffalo	Rainbow Trout	0.77	
Cassidy	Largemouth Bass	0.05	J	Buffalo	Kokanee	2.00	
Cassidy	Yellow Perch	0.05	J	Buffalo	Largescale Sucker	1.11	
Chester Morse	Rainbow Trout	0.31		Evergreen	Yellow Perch	0.11	J
Coldwater	Rainbow Trout	0.11	J	Evergreen	Smallmouth Bass	0.18	J
Merrill	Cutthroat Trout	0.35		Evergreen	Common Carp	1.19	
	Median =	0.27	J		Median =	0.22	J

Table D-4.

Region / Lake	Species	HCH, alpha		Region / Lake	Species	HCH, alpha	
Western				**East Slope**			
Ozette	Peamouth	0.02	J	Patterson	Rainbow Trout	0.46	U
Ozette	Yellow Perch	0.01	J	Patterson	Largemouth Bass	0.44	U
Ozette	Largemouth Bass	0.01	J	Patterson	Yellow Perch	0.46	U
Tarboo	Largemouth Bass	0.01	J	Wenatchee	Northern Pikeminnow	0.02	J
Cushman	Cutthroat Trout	0.01	J	Wenatchee	Cutthroat Trout	0.01	J
Cushman	Largescale Sucker	0.56	U	Cle Elum	Mountain Whitefish	0.02	J
Wynoochee	Mountain Whitefish	0.56	U	Cle Elum	Rainbow Trout	0.02	J
Devereaux	Largemouth Bass	0.02	J	Bumping	Kokanee	0.02	J
Devereaux	Kokanee	0.02	J	Rimrock	Kokanee	0.02	J
Failor	Cutthroat Trout	0.03	J	Rimrock	Mountain Whitefish	0.46	U
Silver	Brown Bullhead	0.41	U	Rimrock	Largescale Sucker	0.45	U
Silver	Black Crappie	0.50	U	Walupt	Cutthroat Trout	0.46	U
	Median =	0.02	J		Median =	0.23	U
West Slope				**Eastern**			
Baker	Mountain Whitefish	0.02	J	Cedar	Rainbow Trout	0.02	J
Diobsud	Cutthroat Trout	0.01	J	Sullivan	Kokanee	0.02	
Gorge	Eastern Brook Trout	0.46	U	Sullivan	Burbot	0.00	J
Gorge	Rainbow Trout	0.46	U	Leo	Yellow Perch	0.01	J
Cavanaugh	Kokanee	0.03		Bayley	Rainbow Trout	0.02	J
Cavanaugh	Cutthroat Trout	0.01	J	South Twin	Largemouth Bass	0.01	J
Cavanaugh	Largemouth Bass	0.02	NJ	Buffalo	Rainbow Trout	0.01	NJ
Cassidy	Largemouth Bass	0.00	J	Buffalo	Kokanee	0.05	J
Cassidy	Yellow Perch	0.00	NJ	Buffalo	Largescale Sucker	0.01	J
Chester Morse	Rainbow Trout	0.47	U	Evergreen	Yellow Perch	0.00	NJ
Coldwater	Rainbow Trout	0.47	U	Evergreen	Smallmouth Bass	0.01	J
Merrill	Cutthroat Trout	0.02	J	Evergreen	Common Carp	0.05	J
	Median =	0.02	J		Median =	0.01	J

Table D-5.

Region / Lake	Species	Aldrin			Region / Lake	Species	Aldrin	
Western					**East Slope**			
Ozette	Peamouth	0.46	U		Patterson	Rainbow Trout	0.45	U
Ozette	Yellow Perch	0.46	U		Patterson	Largemouth Bass	0.44	U
Ozette	Largemouth Bass	0.47	U		Patterson	Yellow Perch	0.46	U
Tarboo	Largemouth Bass	0.47	U		Wenatchee	Northern Pikeminnow	0.42	U
Cushman	Cutthroat Trout	0.46	U		Wenatchee	Cutthroat Trout	0.45	U
Cushman	Largescale Sucker	0.56	U		Cle Elum	Mountain Whitefish	0.002	J
Wynoochee	Mountain Whitefish	0.56	U		Cle Elum	Rainbow Trout	0.001	NJ
Devereaux	Largemouth Bass	0.46	U		Bumping	Kokanee	0.46	U
Devereaux	Kokanee	0.46	U		Rimrock	Kokanee	0.002	NJ
Failor	Cutthroat Trout	0.45	U		Rimrock	Mountain Whitefish	0.002	J
Silver	Brown Bullhead	0.41	U		Rimrock	Largescale Sucker	0.45	U
Silver	Black Crappie	0.49	U		Walupt	Cutthroat Trout	0.001	NJ
	Median =	0.46	J			Median =	0.43	U
West Slope					**Eastern**			
Baker	Mountain Whitefish	0.55	U		Cedar	Rainbow Trout	0.46	U
Diobsud	Cutthroat Trout	0.45	U		Sullivan	Kokanee	0.44	U
Gorge	Eastern Brook Trout	0.46	U		Sullivan	Burbot	0.40	U
Gorge	Rainbow Trout	0.002	NJ		Leo	Yellow Perch	0.47	U
Cavanaugh	Kokanee	0.47	U		Bayley	Rainbow Trout	0.46	U
Cavanaugh	Cutthroat Trout	0.47	U		South Twin	Largemouth Bass	0.39	U
Cavanaugh	Largemouth Bass	0.47	U		Buffalo	Rainbow Trout	0.46	U
Cassidy	Largemouth Bass	0.46	U		Buffalo	Kokanee	0.41	U
Cassidy	Yellow Perch	0.46	U		Buffalo	Largescale Sucker	0.47	U
Chester Morse	Rainbow Trout	0.47	U		Evergreen	Yellow Perch	0.45	U
Coldwater	Rainbow Trout	0.47	U		Evergreen	Smallmouth Bass	0.40	U
Merrill	Cutthroat Trout	0.47	U		Evergreen	Common Carp	0.013	J
	Median =	0.47	U			Median =	0.44	U

Table D-6.

Region / Lake	Species	Heptachlor			Region / Lake	Species	Heptachlor	
Western					**East Slope**			
Ozette	Peamouth	0.23	U		Patterson	Rainbow Trout	0.23	U
Ozette	Yellow Perch	0.23	U		Patterson	Largemouth Bass	0.22	U
Ozette	Largemouth Bass	0.23	U		Patterson	Yellow Perch	0.23	U
Tarboo	Largemouth Bass	0.23	U		Wenatchee	Northern Pikeminnow	0.21	U
Cushman	Cutthroat Trout	0.23	U		Wenatchee	Cutthroat Trout	0.22	U
Cushman	Largescale Sucker	0.28	U		Cle Elum	Mountain Whitefish	0.00	J
Wynoochee	Mountain Whitefish	0.28	U		Cle Elum	Rainbow Trout	0.22	U
Devereaux	Largemouth Bass	0.23	U		Bumping	Kokanee	0.23	U
Devereaux	Kokanee	0.23	U		Rimrock	Kokanee	0.22	U
Failor	Cutthroat Trout	0.22	U		Rimrock	Mountain Whitefish	0.23	U
Silver	Brown Bullhead	0.20	U		Rimrock	Largescale Sucker	0.22	U
Silver	Black Crappie	0.25	U		Walupt	Cutthroat Trout	0.23	U
	Median =	0.23	U			Median =	0.22	U
West Slope					**Eastern**			
Baker	Mountain Whitefish	0.27	U		Cedar	Rainbow Trout	0.23	U
Diobsud	Cutthroat Trout	0.22	U		Sullivan	Kokanee	0.22	
Gorge	Eastern Brook Trout	0.23	U		Sullivan	Burbot	0.20	U
Gorge	Rainbow Trout	0.23	U		Leo	Yellow Perch	0.24	U
Cavanaugh	Kokanee	0.23	U		Bayley	Rainbow Trout	0.23	U
Cavanaugh	Cutthroat Trout	0.23	U		South Twin	Largemouth Bass	0.19	U
Cavanaugh	Largemouth Bass	0.23	U		Buffalo	Rainbow Trout	0.23	U
Cassidy	Largemouth Bass	0.23	U		Buffalo	Kokanee	0.21	U
Cassidy	Yellow Perch	0.23	U		Buffalo	Largescale Sucker	0.24	U
Chester Morse	Rainbow Trout	0.23	U		Evergreen	Yellow Perch	0.22	U
Coldwater	Rainbow Trout	0.23	U		Evergreen	Smallmouth Bass	0.002	J
Merrill	Cutthroat Trout	0.23	U		Evergreen	Common Carp	0.20	U
	Median =	0.23	U			Median =	0.22	U

U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

Appendix E. Pesticide Data for Pesticides not 303(d) Listed

Table E-1.

Region / Lake	Species	2,4'-DDT		2,4'-DDE		2,4'-DDD	
Western							
Ozette	Peamouth	0.23	U	0.23	U	0.005	J
Ozette	Yellow Perch	0.23	U	0.23	U	0.2	U
Ozette	Largemouth Bass	0.23	U	0.23	U	0.2	U
Tarboo	Largemouth Bass	0.23	U	0.23	U	0.004	J
Cushman	Cutthroat Trout	0.01	J	0.23	U	0.2	U
Cushman	Largescale Sucker	0.28	U	0.28	U	0.3	U
Wynoochee	Mountain Whitefish	0.03	J	0.004	J	0.004	J
Devereaux	Largemouth Bass	0.01	J	0.008	J	0.02	J
Devereaux	Kokanee	0.12	J	0.02	J	0.2	J
Failor	Cutthroat Trout	0.23	U	0.22	U	0.2	U
Silver	Brown Bullhead	0.21	U	0.005	J	0.004	NJ
Silver	Black Crappie	0.25	U	0.003	NJ	0.006	NJ
West Slope							
Baker	Mountain Whitefish	0.25	J	0.05	J	0.07	J
Diobsud	Cutthroat Trout	0.23	U	0.002	J	0.2	U
Gorge	Eastern Brook Trout	0.02	J	0.23	U	0.2	U
Gorge	Rainbow Trout	0.02	J	0.23	U	0.2	U
Cavanaugh	Kokanee	0.18	J	0.04	J	0.1	J
Cavanaugh	Cutthroat Trout	0.02	J	0.23	U	0.01	J
Cavanaugh	Largemouth Bass	0.02	J	0.004	J	0.01	J
Cassidy	Largemouth Bass	0.23	U	0.2	U	0.007	J
Cassidy	Yellow Perch	0.23	U	0.2	U	0.004	NJ
Chester Morse	Rainbow Trout	0.01	J	0.2	U	0.2	U
Coldwater	Rainbow Trout	0.24	U	0.2	U	0.2	U
Merrill	Cutthroat Trout	0.02	J	0.2	U	0.005	NJ

Table E-2.

Region / Lake	Species	2,4'-DDT		2,4'-DDE		2,4'-DDD	
East Slope							
Patterson	Rainbow Trout	0.02	J	0.01	J	0.04	J
Patterson	Largemouth Bass	0.22	U	0.009	J	0.03	NJ
Patterson	Yellow Perch	0.23	U	0.23	U	0.23	U
Wenatchee	Northern Pikeminnow	0.39		0.30		0.30	
Wenatchee	Cutthroat Trout	0.02	J	0.22	U	0.008	J
Cle Elum	Mountain Whitefish	0.03	J	0.005	J	0.008	NJ
Cle Elum	Rainbow Trout	0.04	J	0.22	U	0.005	J
Bumping	Kokanee	0.21	J	0.04	J	0.19	J
Rimrock	Kokanee	0.21	J	0.04	J	0.09	J
Rimrock	Mountain Whitefish	0.07	J	0.01	J	0.01	J
Rimrock	Largescale Sucker	0.23	U	0.22	U	0.006	J
Walupt	Cutthroat Trout	0.01	J	0.23	U	0.007	J
Eastern							
Cedar	Rainbow Trout	0.23	U	0.23	U	0.23	U
Sullivan	Kokanee	0.27		0.05	J	0.09	J
Sullivan	Burbot	0.03	J	0.003	NJ	0.02	J
Leo	Yellow Perch	0.24	U	0.24	U	0.24	U
Bayley	Rainbow Trout	0.23	U	0.003	J	0.01	J
South Twin	Largemouth Bass	0.20	U	0.002	J	0.007	J
Buffalo	Rainbow Trout	0.02	J	0.004	J	0.02	J
Buffalo	Kokanee	0.22		0.14	J	0.44	
Buffalo	Largescale Sucker	0.02	J	0.04	J	0.06	J
Evergreen	Yellow Perch	0.05	J	0.02	J	0.02	J
Evergreen	Smallmouth Bass	0.05	J	0.04	J	0.02	J
Evergreen	Common Carp	0.33		0.31		0.41	

Table E-3.

Region / Lake	Species	Endrin		Endrin Aldehyde		Endrin Ketone	
Western							
Ozette	Peamouth	0.20	U	0.20	U	0.21	U
Ozette	Yellow Perch	0.20	U	0.20	U	0.20	U
Ozette	Largemouth Bass	0.20	U	0.20	U	0.21	U
Tarboo	Largemouth Bass	0.20	U	0.20	U	0.21	U
Cushman	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Cushman	Largescale Sucker	0.24	U	0.24	U	0.25	U
Wynoochee	Mountain Whitefish	0.24	U	0.24	U	0.25	U
Devereaux	Largemouth Bass	0.20	U	0.20	U	0.21	U
Devereaux	Kokanee	0.20	U	0.20	U	0.20	U
Failor	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Silver	Brown Bullhead	0.18	U	0.18	U	0.18	U
Silver	Black Crappie	0.22	U	0.21	U	0.22	U
West Slope							
Baker	Mountain Whitefish	0.24	U	0.24	U	0.24	U
Diobsud	Cutthroat Trout	0.00	J	0.20	U	0.20	U
Gorge	Eastern Brook Trout	0.20	U	0.20	U	0.20	U
Gorge	Rainbow Trout	0.00	NJ	0.20	U	0.20	U
Cavanaugh	Kokanee	0.20	U	0.20	U	0.21	U
Cavanaugh	Cutthroat Trout	0.20	U	0.20	U	0.21	U
Cavanaugh	Largemouth Bass	0.20	U	0.20	U	0.21	U
Cassidy	Largemouth Bass	0.20	U	0.20	U	0.21	U
Cassidy	Yellow Perch	0.20	U	0.20	U	0.21	U
Chester Morse	Rainbow Trout	0.20	U	0.20	U	0.21	U
Coldwater	Rainbow Trout	0.20	U	0.20	U	0.21	U
Merrill	Cutthroat Trout	0.20	U	0.20	U	0.21	U

Table E-4.

Region / Lake	Species	Endrin		Endrin Aldehyde		Endrin Ketone	
East Slope							
Patterson	Rainbow Trout	0.20	U	0.20	U	0.20	U
Patterson	Largemouth Bass	0.01	J	0.19	U	0.20	U
Patterson	Yellow Perch	0.20	U	0.20	U	0.20	U
Wenatchee	Northern Pikeminnow	0.01	NJ	0.19	U	0.19	U
Wenatchee	Cutthroat Trout	0.00	NJ	0.19	U	0.20	U
Cle Elum	Mountain Whitefish	0.01	NJ	0.20	U	0.20	U
Cle Elum	Rainbow Trout	0.20	U	0.19	U	0.20	U
Bumping	Kokanee	0.20	U	0.20	U	0.21	U
Rimrock	Kokanee	0.01	J	0.19	U	0.20	U
Rimrock	Mountain Whitefish	0.20	U	0.20	U	0.20	U
Rimrock	Largescale Sucker	0.20	U	0.20	U	0.20	U
Walupt	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Eastern							
Cedar	Rainbow Trout	0.20	U	0.20	U	0.20	U
Sullivan	Kokanee	0.19	U	0.19	U	0.19	U
Sullivan	Burbot	0.16	U	0.16	U	0.16	U
Leo	Yellow Perch	0.21	U	0.21	U	0.21	U
Bayley	Rainbow Trout	0.20	U	0.20	U	0.20	U
South Twin	Largemouth Bass	0.17	U	0.17	U	0.17	U
Buffalo	Rainbow Trout	0.00	NJ	0.20	U	0.21	U
Buffalo	Kokanee	0.02	J	0.00	NJ	0.18	U
Buffalo	Largescale Sucker	0.003	J	0.21	U	0.21	U
Evergreen	Yellow Perch	0.20	U	0.00	NJ	0.20	U
Evergreen	Smallmouth Bass	0.17	U	0.17	U	0.18	U
Evergreen	Common Carp	0.04	J	0.17	U	0.003	J

Table E-5.

Region / Lake	Species	HCH, beta		HCH, delta		HCH, gamma	
Western							
Ozette	Peamouth	0.46	U	0.19	U	0.008	J
Ozette	Yellow Perch	0.46	U	0.18	U	0.46	U
Ozette	Largemouth Bass	0.47	U	0.19	U	0.47	U
Tarboo	Largemouth Bass	0.47	U	0.19	U	0.47	U
Cushman	Cutthroat Trout	0.46	U	0.18	U	0.47	U
Cushman	Largescale Sucker	0.56	U	0.22	U	0.57	U
Wynoochee	Mountain Whitefish	0.56	U	0.22	U	0.57	U
Devereaux	Largemouth Bass	0.46	U	0.19	U	0.47	U
Devereaux	Kokanee	0.46	U	0.18	U	0.009	J
Failor	Cutthroat Trout	0.004	J	0.18	U	0.005	NJ
Silver	Brown Bullhead	0.41	U	0.16	U	0.41	U
Silver	Black Crappie	0.49	U	0.20	U	0.50	U
West Slope							
Baker	Mountain Whitefish	0.55	U	0.22	U	0.56	U
Diobsud	Cutthroat Trout	0.002	NJ	0.18	U	0.46	U
Gorge	Eastern Brook Trout	0.46	U	0.18	U	0.46	U
Gorge	Rainbow Trout	0.46	U	0.18	U	0.27	U
Cavanaugh	Kokanee	0.009		0.19	U	0.47	U
Cavanaugh	Cutthroat Trout	0.47	U	0.19	U	0.47	U
Cavanaugh	Largemouth Bass	0.47	U	0.19	U	0.47	U
Cassidy	Largemouth Bass	0.46	U	0.18	U	0.004	J
Cassidy	Yellow Perch	0.46	U	0.18	U	0.002	J
Chester Morse	Rainbow Trout	0.47	U	0.19	U	0.47	U
Coldwater	Rainbow Trout	0.47	U	0.19	U	0.47	U
Merrill	Cutthroat Trout	0.47	U	0.19	U	0.48	U

Table E-6.

Region / Lake	Species	HCH, beta		HCH, delta		HCH, gamma	
East Slope							
Patterson	Rainbow Trout	0.45	U	0.18	U	0.46	U
Patterson	Largemouth Bass	0.44	U	0.18	U	0.45	U
Patterson	Yellow Perch	0.45	U	0.18	U	0.46	U
Wenatchee	Northern Pikeminnow	0.42	U	0.17	U	0.43	U
Wenatchee	Cutthroat Trout	0.45	U	0.18	U	0.45	U
Cle Elum	Mountain Whitefish	0.45	U	0.18	U	0.46	U
Cle Elum	Rainbow Trout	0.45	U	0.18	U	0.45	U
Bumping	Kokanee	0.46	U	0.18	U	0.47	U
Rimrock	Kokanee	0.45	U	0.18	U	0.45	U
Rimrock	Mountain Whitefish	0.46	U	0.18	U	0.46	U
Rimrock	Largescale Sucker	0.45	U	0.18	U	0.46	U
Walupt	Cutthroat Trout	0.45	U	0.18	U	0.46	U
Eastern							
Cedar	Rainbow Trout	0.46	U	0.18	U	0.005	J
Sullivan	Kokanee	0.44		0.17	U	0.007	
Sullivan	Burbot	0.40	U	0.16	U	0.002	NJ
Leo	Yellow Perch	0.002	NJ	0.19	U	0.003	NJ
Bayley	Rainbow Trout	0.46	U	0.18	U	0.007	J
South Twin	Largemouth Bass	0.39	U	0.001	NJ	0.005	J
Buffalo	Rainbow Trout	0.004	NJ	0.19	U	0.007	NJ
Buffalo	Kokanee	0.01	J	0.16	U	0.02	J
Buffalo	Largescale Sucker	0.005	J	0.19	U	0.006	NJ
Evergreen	Yellow Perch	0.45	U	0.18	U	0.002	NJ
Evergreen	Smallmouth Bass	0.40	U	0.001	NJ	0.005	J
Evergreen	Common Carp	0.39	U	0.001	NJ	0.02	NJ

Table E-7.

Region / Lake	Species	alpha-Endosulphan		beta-Endosulphan		Endosulphan Sulphate	
Western							
Ozette	Peamouth	0.20	U	0.20	U	0.02	NJ
Ozette	Yellow Perch	0.20	U	0.20	U	0.02	NJ
Ozette	Largemouth Bass	0.20	U	0.20	U	0.20	U
Tarboo	Largemouth Bass	0.20	U	0.23	U	0.20	U
Cushman	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Cushman	Largescale Sucker	0.25	U	0.24	U	0.24	U
Wynoochee	Mountain Whitefish	0.25	U	0.24	U	0.24	U
Devereaux	Largemouth Bass	0.20	U	0.20	U	0.20	U
Devereaux	Kokanee	0.20	U	0.20	U	0.05	J
Failor	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Silver	Brown Bullhead	0.18	U	0.01	J	0.02	J
Silver	Black Crappie	0.22	U	0.03	NJ	0.01	NJ
West Slope							
Baker	Mountain Whitefish	0.18	J	0.24	U	0.11	NJ
Diobsud	Cutthroat Trout	0.20	U	0.20	U	0.06	NJ
Gorge	Eastern Brook Trout	0.20	U	0.02	NJ	0.07	NJ
Gorge	Rainbow Trout	0.20	U	0.03	NJ	0.04	NJ
Cavanaugh	Kokanee	0.21	U	0.20	U	0.06	J
Cavanaugh	Cutthroat Trout	0.20	U	0.20	U	0.20	U
Cavanaugh	Largemouth Bass	0.20	U	0.20	U	0.20	U
Cassidy	Largemouth Bass	0.20	U	0.20	U	0.20	U
Cassidy	Yellow Perch	0.20	U	0.20	U	0.10	J
Chester Morse	Rainbow Trout	0.20	U	0.20	U	0.03	NJ
Coldwater	Rainbow Trout	0.20	U	0.02	NJ	0.03	J
Merrill	Cutthroat Trout	0.21	U	0.20	U	0.04	J

Table E-8.

Region / Lake	Species	alpha-Endosulphan		beta-Endosulphan		Endosulphan Sulphate	
East Slope							
Patterson	Rainbow Trout	0.20	U	0.20	U	0.02	NJ
Patterson	Largemouth Bass	0.19	U	0.19	U	0.19	U
Patterson	Yellow Perch	0.20	U	0.03	NJ	0.05	NJ
Wenatchee	Northern Pikeminnow	0.19	U	0.04	NJ	0.22	J
Wenatchee	Cutthroat Trout	0.20	U	0.04	NJ	0.12	J
Cle Elum	Mountain Whitefish	0.20	U	0.02	J	0.05	J
Cle Elum	Rainbow Trout	0.20	U	0.03	NJ	0.05	NJ
Bumping	Kokanee	0.16	J	0.20	U	0.32	
Rimrock	Kokanee	0.20	U	0.05	NJ	0.09	J
Rimrock	Mountain Whitefish	0.20	U	0.04	J	0.02	NJ
Rimrock	Largescale Sucker	0.20	U	0.04	J	0.05	NJ
Walupt	Cutthroat Trout	0.20	U	0.03	NJ	0.02	NJ
Eastern							
Cedar	Rainbow Trout	0.20	U	0.20	U	0.03	J
Sullivan	Kokanee	0.19	U	0.19	U	0.20	J
Sullivan	Burbot	0.16	U	0.16	U	0.13	NJ
Leo	Yellow Perch	0.21	U	0.21	U	0.10	J
Bayley	Rainbow Trout	0.20	U	0.20	U	0.09	NJ
South Twin	Largemouth Bass	0.17	U	0.17	U	0.02	NJ
Buffalo	Rainbow Trout	0.20	U	0.20	U	0.06	NJ
Buffalo	Kokanee	0.15	J	0.18	U	0.31	J
Buffalo	Largescale Sucker	0.21	U	0.21	U	0.04	J
Evergreen	Yellow Perch	0.20	U	0.20	U	0.61	J
Evergreen	Smallmouth Bass	0.17	U	0.17	U	0.33	
Evergreen	Common Carp	0.63		0.44		2.96	

Table E-9.

Region / Lake	Species	Heptachlor Epoxide		Mirex		Methoxychlor	
Western							
Ozette	Peamouth	0.20	U	0.01	NJ	0.20	U
Ozette	Yellow Perch	0.20	U	0.23	U	0.20	U
Ozette	Largemouth Bass	0.20	U	0.005	J	0.20	U
Tarboo	Largemouth Bass	0.20	U	0.006	NJ	0.20	U
Cushman	Cutthroat Trout	0.20	U	0.10	J	0.20	U
Cushman	Largescale Sucker	0.24	U	0.02	J	0.24	U
Wynoochee	Mountain Whitefish	0.24	U	0.02	J	0.24	U
Devereaux	Largemouth Bass	0.02	J	0.005	J	0.20	U
Devereaux	Kokanee	0.02	NJ	0.01	J	0.20	U
Failor	Cutthroat Trout	0.00	NJ	0.005	J	0.19	U
Silver	Brown Bullhead	0.18	U	0.002	NJ	0.18	U
Silver	Black Crappie	0.21	U	0.001	J	0.21	U
West Slope							
Baker	Mountain Whitefish	0.04	J	0.03	NJ	0.24	U
Diobsud	Cutthroat Trout	0.01	NJ	0.02	J	0.19	U
Gorge	Eastern Brook Trout	0.01	NJ	0.01	NJ	0.20	U
Gorge	Rainbow Trout	0.01	J	0.01	J	0.20	U
Cavanaugh	Kokanee	0.06	J	0.03		0.20	U
Cavanaugh	Cutthroat Trout	0.01	J	0.03	J	0.20	U
Cavanaugh	Largemouth Bass	0.02	J	0.02	J	0.20	U
Cassidy	Largemouth Bass	0.006	J	0.003	J	0.20	U
Cassidy	Yellow Perch	0.006	J	0.003	NJ	0.20	U
Chester Morse	Rainbow Trout	0.014	J	0.02	J	0.20	U
Coldwater	Rainbow Trout	0.20	U	0.009	J	0.20	U
Merrill	Cutthroat Trout	0.006	NJ	0.02	NJ	0.20	U

Table E-10.

Region / Lake	Species	Heptachlor Epoxide		Mirex		Methoxychlor	
East Slope							
Patterson	Rainbow Trout	0.006	NJ	0.08	J	0.20	U
Patterson	Largemouth Bass	0.19	U	0.006	J	0.19	U
Patterson	Yellow Perch	0.003	NJ	0.001	NJ	0.20	U
Wenatchee	Northern Pikeminnow	0.030	NJ	0.17	J	0.18	U
Wenatchee	Cutthroat Trout	0.008	NJ	0.02	J	0.19	U
Cle Elum	Mountain Whitefish	0.02	J	0.06	J	0.20	U
Cle Elum	Rainbow Trout	0.05	J	0.05	NJ	0.19	U
Bumping	Kokanee	0.04	NJ	0.02	J	0.20	U
Rimrock	Kokanee	0.038	NJ	0.03	J	0.19	U
Rimrock	Mountain Whitefish	0.003	NJ	0.03	J	0.20	U
Rimrock	Largescale Sucker	0.004	NJ	0.01	J	0.20	U
Walupt	Cutthroat Trout	0.006	NJ	0.02	J	0.20	U
Eastern							
Cedar	Rainbow Trout	0.01	J	0.001	NJ	0.20	U
Sullivan	Kokanee	0.09	J	0.02	J	0.19	U
Sullivan	Burbot	0.02	J	0.02	J	0.16	U
Leo	Yellow Perch	0.004	J	0.003	J	0.20	U
Bayley	Rainbow Trout	0.03	J	0.002	NJ	0.20	U
South Twin	Largemouth Bass	0.005	J	0.004	NJ	0.17	U
Buffalo	Rainbow Trout	0.02	J	0.01	J	0.20	U
Buffalo	Kokanee	0.15	J	0.01	NJ	0.18	U
Buffalo	Largescale Sucker	0.02	J	0.01	J	0.20	U
Evergreen	Yellow Perch	0.03	J	0.001	NJ	0.19	U
Evergreen	Smallmouth Bass	0.06	J	0.004	J	0.17	U
Evergreen	Common Carp	0.34		0.01	J	0.17	U

U: Not detected at or above reported result.
J: Result is an estimated value.
NJ: There is evidence the analyte is present. The associated numerical result is an estimate.

Appendix F. Glossary, Acronyms, and Abbreviations

Glossary

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Median: A statistical number obtained from the distribution of a data set, for which half the observations lie above and half the observations lie below.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

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.

Salmonid: Fish that belong to the family *Salmonidae*. Basically, species of salmon, trout, or char

Spiny-Ray: Fish such as bass and perch that have sharp, often pointed and usually rigid fin spines.

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.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exist and below which 90% of the data exist.

Acronyms and Abbreviations

AXYS	AXYS Analytical Services (Laboratory)
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethylene
DDT	dichloro-diphenyl-trichloroethane
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
FTEC	Fish Tissue Equivalent Concentration
GIS	Geographic Information System
HR-GC/MS	High resolution gas chromatography/mass spectrometry
MEL	Manchester Environmental Laboratory
MTCA	Model Toxics Control Act
NPDES	(See Glossary above)
NTR	National Toxics Rule
PBTs	Persistent, bioaccumulative, toxic chemicals
PCBs	Polychlorinated biphenyls
RPD	Relative percent difference
SOP	Standard operating procedure
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code

Units of Measurement

ft	feet
g	gram, a unit of mass
mm	millimeters
ug/Kg	micrograms per kilogram (parts per billion)