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State of Washington

Quality Assurance Project Plan

Freshwater Fish Contaminant Monitoring Program

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The plan for this study is available on Ecology's website at www.ecy.wa.gov/biblio/1303111.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID: FFCMPyy (where "yy" = last two characters of sample year).

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Quality Assurance Project Plan

Freshwater Fish
Contaminant Monitoring Program

May 2013

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EAP: Environmental Assessment Program
EIM: Environmental Information Management database

Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

The Washington Department of Ecology (Ecology) has many efforts underway to address concerns about toxic chemicals in the environment. Many of these chemicals are persistent, bioaccumulative, and toxic (PBTs). While such monitoring is conducted by different groups to meet varied needs, most of the monitoring of freshwater fish tissue in Washington has been conducted by Ecology's Environmental Assessment (EA) Program.

Data from fish contaminant monitoring is used for a variety of purposes, such as: assessing the quality of waterbodies, conducting health risk assessments developing Total Maximum Daily Loads, and evaluating contaminant trends over time.

Since 2001, the continuously-funded Washington State Toxics Monitoring Program has characterized PBTs in freshwater fish and water throughout Washington. Over 400 fish tissue samples from 150 sites were analyzed. Target analytes included mercury, PCBs, dioxins and furans, chlorinated pesticides, and PBDE flame retardants.

Most monitoring efforts were part of an exploratory monitoring component, with the goal of characterizing contaminants in fish tissue and water from places where historical data were lacking. In 2009, a long-term monitoring component was started with the goal of tracking contaminant levels in fish over time at selected sites to see if changes could be discerned.

This document is a revision of the original Quality Assurance Project Plan written in 2002 and includes changes in project objectives. This project now focuses on PBTs in fish tissue and is renamed the Freshwater Fish Contaminant Monitoring Program. Addendums to this plan will be produced annually to address site-specific objectives for the coming sampling season.

Background

Since the 1980s, toxic contaminants have been found in Washington's air, soil, water, sediment, and fish. Many of these chemicals are persistent, bioaccumulative, and toxic substances (PBTs). They do not break down easily and remain in the environment for decades. Traditionally these chemicals include polychlorinated biphenyls (PCBs), chlorinated pesticides (CPs), polybrominated diphenyl ethers (PBDEs), polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-p-furans (PCDD/Fs), and mercury. More information about these and other chemicals is at www.ecy.wa.gov/programs/eap/toxics/chemicals_of_concern.html.

The accumulation of such chemicals can have a variety of health effects on humans and wildlife, such as reproductive abnormalities, neurological problems, and behavioral changes. A primary route of exposure for people is through the consumption of contaminated food, particularly fish. The Washington State Department of Health (DOH) currently has a statewide fish consumption advisory for mercury in bass and northern pikeminnow. It also has 14 site-specific advisories due to contamination of fish by mercury, PCBs, CPs, and other chemicals (www.doh.wa.gov/CommunityandEnvironment/Food/Fish.aspx).

The Washington State Department of Ecology (Ecology) has many efforts underway to address concerns about toxic contaminants (www.ecy.wa.gov/toxhaz.html). Monitoring the environment for toxic chemicals is a key activity which informs other efforts to address threats from toxic chemicals. While monitoring may be done by various groups (e.g., federal, tribal, state, other Ecology programs) to meet differing needs, monitoring of freshwater fish tissue in Washington has mostly been done by Ecology's Environmental Assessment (EA) Program.

Data from fish contaminant monitoring is used for a variety of purposes, such as: assessing the quality of waterbodies, conducting health risk assessments developing Total Maximum Daily Loads, and evaluating contaminant trends over time. (www.ecy.wa.gov/programs/eap/toxics/index.html).

The Washington State Toxics Monitoring Program (WSTMP) has been one of Ecology's continuously-funded series of projects for characterizing contaminants in fish and has helped address some of the needs described above. Since 2001 the WSTMP has analyzed over 400 fish tissue samples from 150 sites (Figure 1) for various contaminants (www.ecy.wa.gov/programs/eap/toxics/wstmp.htm). While the WSTMP's main focus has been on "exploratory" monitoring, "long-term" monitoring efforts began in 2009 with work in the Snake River basin.

This document is a revision of the original Quality Assurance Project Plan for the WSTMP (Seiders and Yake, 2002) and follows Ecology's guidance for developing such plans (Lombard and Kirchmer, 2004).

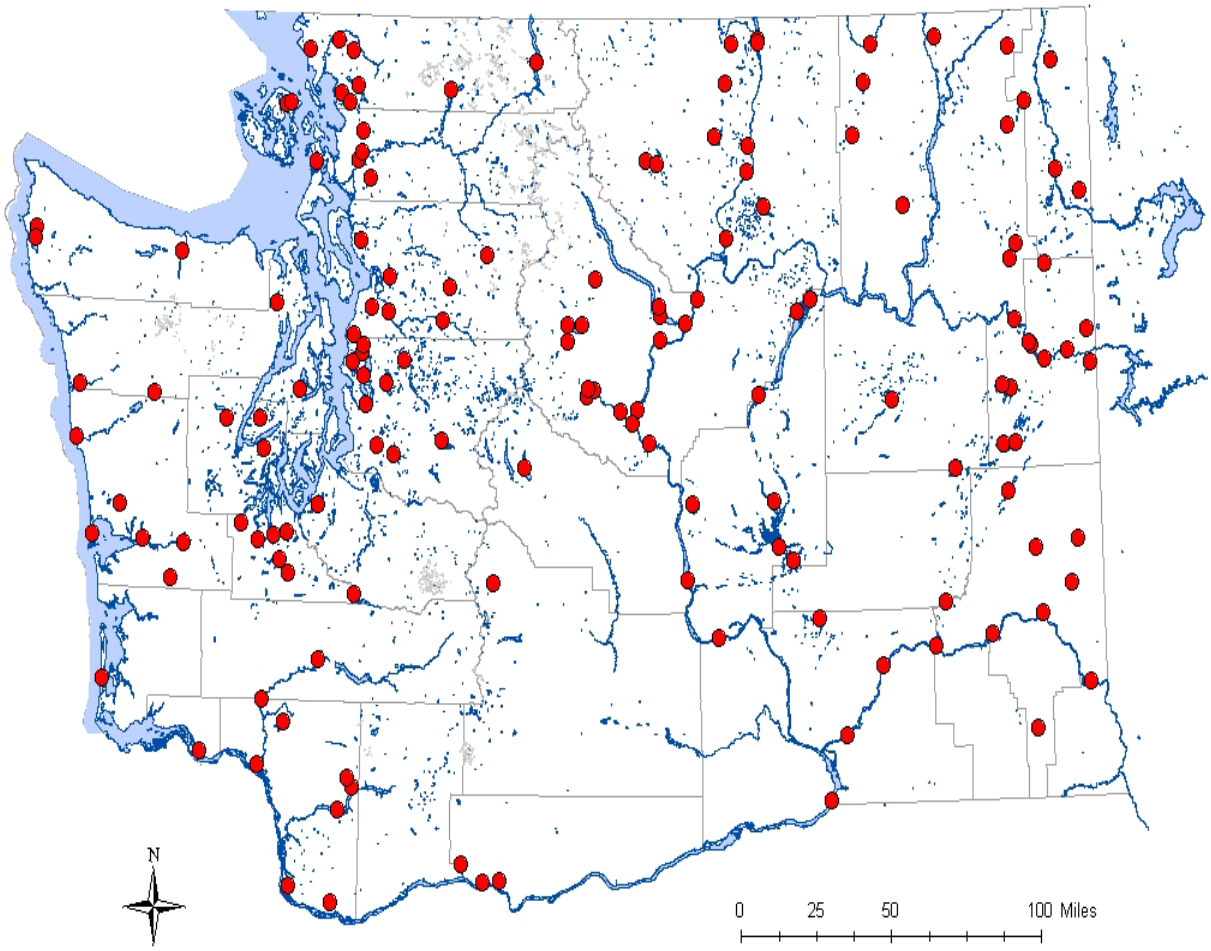

Figure 1. Location of freshwater fish monitoring efforts, 2001-2010.

Project Description

Overview

The primary goals of the Freshwater Fish Contaminant Monitoring Program are to:

- Conduct exploratory monitoring to identify instances and locations of toxics contamination in freshwater fish tissue from aquatic areas that have not yet been monitored or where relevant data are greater than ten years old.
- Conduct long-term monitoring of toxic contaminants in freshwater fish tissue in selected areas in order to track changes over time.
- Support other groups by providing data and information which complements their efforts, such as risk assessments of consuming contaminated fish (DOH) and monitoring related to water cleanup plans (Ecology).

Project goals will be realized by objectives that are refined each year to meet site-specific needs. In general, these objectives include:

- Review status of information about toxic contaminants in fish from locations across Washington for the purpose of selecting sites for exploratory monitoring.
- Compile information that can be used to determine changes in tissue contaminant levels over time for selected sites and design sampling plans to meet site-specific characteristics.
- Remain flexible and work with other groups concerned about toxic contaminants in fish. Help with monitoring where cooperation is beneficial to all, particularly with local, state, tribal, and federal groups.
- Periodically review the list of target analytes in order to remain responsive to current and emerging chemicals of concern.
- Document each year's monitoring plan in a formal addendum to this project plan, conduct sampling to collect fish, and arrange for chemical analyses of tissue samples by qualified laboratories.
- Use field and lab results to characterize contaminant levels, evaluate changes over time or space, and share results through various media such as reports, Ecology website, and presentations.

The information needed to meet project objectives includes defining the needs of the groups using fish tissue contaminant data, characteristics of the sites, target species, and historical data. Groups needing fish tissue data will be contacted before each sampling season to define how the data will be used, such as for health risk assessments or supporting TMDL and water cleanup plans' evaluations. For sites, permission and access for sampling activities need to be determined and appropriately permitted. For fish, species presence and abundance need to be estimated to help determine sampling methods. Historical information such as fish species and sizes, sample sizes, contaminant levels, and dates of sampling will help determine site-specific sampling strategies.

The target population will vary each year and will depend on the site and sampling objectives. In general, the target population will be resident freshwater fish throughout Washington. The target size of fish will usually meet any legal requirements of harvestable size or weight, as defined by the Washington Department of Fish and Wildlife (WDFW) in their sport fishing rules, or at least be of consumable size if no legal harvest requirements are in effect. For fish collected for long-term monitoring, historical data on species and size will help determine the target populations to sample. Anadromous fish species may also be sampled in order to help address concerns by cooperating groups such as tribes, federal agencies, and DOH.

This study includes all freshwater areas of Washington State. Site-specific study boundaries will be determined each year and be based on that year's objectives, site characteristics, and historical data.

The study design presents constraints that are common to many environmental monitoring efforts using fish. Variability among individual fish and sampling often yield data sets with variability that is high enough to confound spatial and temporal comparisons. While the use of multiple composite samples can reduce the effect of high variability, the cost of some analyses will likely limit the number of samples that can be analyzed. Another constraint can be inadequate numbers of target fish at sites. Additional sampling effort can help reduce this constraint. The detection and quantification of trends in contaminant levels in fish requires many years of monitoring. A possible constraint on this project is sustained funding over the decades needed to determine changes over time.

The tasks required to collect the needed data involve various efforts that are repeated each year. These efforts include compilation of historical information, sample design, coordination with other groups and permitting authorities, sample collection and processing, laboratory analyses, data management, and reporting.

Data from this project will be used to make decisions in three areas:

- Washington's water quality assessment: Section 303(d) of the Clean Water Act requires states to determine whether waterbodies meet water quality standards.
- Determinations of differences in tissue contaminant concentrations over time or space. This information may complement watershed cleanup and help support decisions made in those efforts.
- Assist DOH in determining the need for additional data collection to support development of fish consumption advisories.

It is worth noting that contaminant levels in fish tissue that do not meet water quality standards are not necessarily high enough to warrant fish consumption advisories to eat less fish. Conversely, DOH could issue a fish consumption advisory even when contaminant levels meet water quality standards (e.g., mercury). DOH evaluates the need for consumption advice based on multiple factors, such as: amount of fish consumed by different populations, the benefits of eating fish as part of a healthy diet, and use of more recent science and guidance on assessing risks to human health. Appendix A describes how Ecology and DOH evaluate fish contaminant data.

Various criteria for the protection of human health exist because of changing knowledge about the toxic effects of chemicals and subsequent risks to consumers of fish. The various criteria and screening values are often based on different assumptions used in determining risk, such as daily consumption rates, toxicological data used in calculations, and risk levels. Appendix B summarizes various criteria that are commonly used: the National Toxics Rule (NTR) criteria (used as Washington's Water Quality Standards), the U.S. Environmental Protection Agency (EPA) recommended criteria, and EPA's screening values. Ecology recognizes that its water quality standards are based on dated assumptions and is in the process of revising state standards for toxic chemicals (www.ecy.wa.gov/toxics/fish.html).

While the exploratory and long-term monitoring components of this project have different goals, the two efforts can overlap in order to use resources more efficiently. The overlap is typically related to sample planning, sample collection, and laboratory analyses. Information gathered to meet objectives for one component can often be used to help meet objectives for the other component. For example, when three replicate samples are collected to meet the needs for DOH's risk assessments, those three replicates may also help meet needs for larger sample sizes used for determining temporal or spatial differences.

The two monitoring components are characterized below.

Exploratory Monitoring

The exploratory component remains flexible to serve various needs:

- Continue screening-level monitoring at sites lacking historical data.
- Provide information to DOH and local agencies for evaluating the risks of eating contaminated fish.
- Contribute to cooperative efforts with other projects and agencies.
- Add emerging chemicals of concern as warranted (e.g., perfluorinated compounds).
- Target 5-10 sites per year for varied species and target analytes. Sites would be selected each spring, considering the points above as well as the location of long-term monitoring sites for that year.

Long-Term Monitoring

The long term component targets specific sites, species, and analytes with the goal to determine changes over time in levels of PBTs in fish tissue. The long term component will:

- Focus on sites with known high levels of contaminants such as where water cleanup plans or fish consumption advisories for PBTs exist. Such sites are likely to garner attention from Ecology, DOH, tribes, local governments, and the public for many years.
- Repeat sampling at selected sites on an approximate seven- to ten-year cycle and maintain the same sampling season and target species as historical efforts in order to reduce seasonal and inter-species variability.

- Target analytes that are most often found at higher levels such as: PCBs, chlorinated pesticides such as DDT and its metabolites, PCDD/Fs, PBDEs, mercury, and other metals.
- Allow flexibility in site selection over time and help maximize opportunities for complementary efforts, particularly with other groups concerned with the quality of these waters and in determining progress in reducing contaminant levels.

Organization and Schedule

Table 1 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 2 presents the proposed schedule for this project.

Table 1. Organization of project staff and responsibilities.

EAP Staff (except TMDL Leads)	Title	Responsibilities
Will Kendra SCS 360-407-6698	Client	Provides internal review of the QAPP, addendums, and reports. Approves the final QAPP and addendums.
Keith Seiders Toxics Studies Unit SCS 360-407-6689	Project Manager and Principal Investigator	Writes the QAPP, addendums, and reports. Reviews historical data and develops sample strategy for different sites on annual basis. Works with laboratories to obtain analytical services. Reviews, analyzes, and interprets data. Guides field assistants in various roles and tasks.
Casey Deligeannis Toxics Studies Unit SCS 360-407-7395	Field Lead, Project Assistant	Leads efforts for sample collection, processing, and transportation of samples to the laboratory. Ensures field and processing information is recorded. Enters field and laboratory data into EIM. Compiles and summarizes historical and current-year data. Assists report effort.
Patti Sandvik Toxics Studies Unit SCS 360-407-7198	Project Assistant	Assists with field and office tasks as needed.
Dale Norton Toxics Studies Unit SCS 360-407-6765	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, addendums, and reports. Approves the final QAPP and addendums. Manages budget and staffing needs.
Regional Office TMDL Points of Contact *	Watershed Leads in Regions where sampling occurs	Leads coordination and communication efforts with interested groups about Ecology's roles related to TMDLs, water cleanup plans, and STI efforts.
Joel Bird Manchester Environmental Lab. 360-871-8801	Laboratory Director	Approves the final QAPP. Oversees all operations at Manchester Lab regarding in-house analyses and processes for contracting analyses to commercial labs.
William R. Kammin EAP 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and addendums. Approves the final QAPP and addendums.

* TMDL Contacts listed at: www.ecy.wa.gov/programs/wq/tmdl/contacts.html

EAP: Environmental Assessment Program
SCS: Statewide Coordination Section
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan
STI: Straight to Implementation watershed cleanup efforts

Table 2. Proposed schedule for completing field, laboratory, and report tasks

Field and laboratory work	Due date	Lead staff
Field work (varies annually, depends on sites)	June to November	Casey Deligeannis, Patti Sandvik
Laboratory analyses completed	May-August, annually	
Environmental Information System (EIM) database		
EIM user study ID	FFCMPyy ("yy" = last two digits of sample year)	
Product	Due date	Lead staff
EIM data loaded	October, annually	Casey Deligeannis
EIM quality assurance	November, annually	Patti Sandvik
EIM complete	December, annually	Casey Deligeannis
Final report		
Author lead / Support staff	Keith Seiders / Casey Deligeannis, Patti Sandvik	
Schedule (may vary depending on annual sampling plan)		
Draft due to supervisor	August, annually	
Draft due to client/peer reviewer	September, annually	
Draft due to external reviewer(s)	October, annually	
Final (all reviews done) due to publications coordinator	November, annually	
Final report due on web	December, annually	
Addendum to QAPP	July, annually	

Each year's monitoring effort will be planned during the previous spring and will incorporate more detail about that year's sampling objectives. Tasks to be completed during the planning phase each year include:

- Compile and review historical data at each site: summarize contaminant levels, identify target species, size ranges, and sampling dates; estimate sample sizes and costs; and develop and distribute the Addendum to this project plan.
- Obtain necessary Scientific Collection Permits and permissions from federal, state, tribal, and local governments as needed.
- Schedule and conduct fish collection while coordinating with other entities where possible (e.g., as tribes, local governments, and watershed groups.
- Process fish collected and send samples to Ecology's Manchester Environmental Laboratory (MEL) and contract labs for analyses.
- Review laboratory and field data; resolve data quality issues.
- Report results using various formats (e.g., paper and electronic versions).
- Load data into agency data management tools (e.g., EIM, shared drives).

Any of the tasks and schedules may be modified in response to limitations posed by unexpected circumstances, such as: budget changes, staff availability, nature of collaboration, equipment problems, and hazardous sampling conditions. Other groups may also be contacted, such as tribes, local governments, watershed groups, and other agencies interested in this project's monitoring efforts.

Laboratory Budget

The current analytical budget for this effort is $88,000 per year and will be split between the exploratory and long-term monitoring components. The analytical budget allows flexibility each year to address site-specific goals and circumstances. Each year's analytical plan will be developed iteratively using information about site-specific goals, available budget, priorities, and the nature of collaborative efforts. Table 3 shows this project's costs for various analytes groups and include the 50% discount for analyses conducted by MEL. Additional analytes added in the future will be described in addendums to this project plan.

PCB congeners and PCDD/F analyses are performed by commercial laboratories hired by Ecology on a project-specific basis. Laboratories are hired using a request for proposal and bidding process with selection based on lowest bid. The use of different laboratories over time may increase laboratory variability and decrease the ability to detect changes in contaminant concentrations in fish tissue over time.

Table 3. Cost estimates for common laboratory analyses.

Parameter	Analytical Method	Approximate Cost per Analysis (dollars)	Laboratory Doing Analysis
Mercury	EPA 245.6 (CVAA)	50	MEL
Metals (one or more of: As, Cd, Cr, Cu, Pb, Ni, Se, Zn)	EPA 200.7, 200.8	50/1st element, 20/additional element	MEL
Chlorinated pesticides	EPA 8081 (GC/ECD); MEL SOP	210	MEL
PCB Aroclors	EPA 8082 (GC/ECD); MEL SOP	210	MEL
PCB congeners	EPA 1668C (HiRes GC/MS)	650	Contract Lab
PCDD/Fs	EPA 1613B (HiRes GC/MS)	650	Contract Lab
PBDEs	EPA 8270 (SIM); SOP 730104	210	MEL
Lipids	MEL SOP 730009	30	MEL

Quality Objectives

The data quality objective for this project is to obtain data of sufficient quality for use in comparisons to Washington's water quality standards criteria, other human health criteria or guidelines, and results from previous studies. This objective will be achieved through attention to sample design, sample collection and processing, laboratory measurement of target analytes, collection and review of historical data, data management, and quality control procedures described in this plan.

Measurement quality objectives (MQOs) are shown in Table 4. The MQOs for calibration verification, ongoing precision and recovery, and labeled compound recovery correspond to the quality control acceptance limits of the analytical methods.

These MQOs correspond to MEL's quality control limits (metals and ancillary parameters) or the acceptance limits specified in the analytical methods (organic compounds). The lowest concentrations of interest shown in the tables are the lowest currently attainable by MEL and its contract laboratories. MEL and contract labs are expected to meet the MQOs in Table 4. Results not meeting these MQOs will be evaluated for possible corrective action or use with qualification.

For most analytes, the designated method's achievable reporting limits (RL) will be adequate for this project. For organics, MEL will continue the current practice of reporting results down to their in-house DL (laboratory detection limit) and qualify results between the DL and PQL or EQL (practical quantitation limit or estimated quantitation limit) as estimates. For PCDD/Fs, contract labs will be required to report down to their in-house DL for all congeners and qualify results between the DL and PQL or EQL as estimates. These reporting practices improve the ability to compare results to water quality standards criteria and other values that serve as criteria or guidance for protection of human health and aquatic life.

Table 4. Measurement quality objectives.

Parameter	Analytical Method	Lab Duplicate (RPD)	Lab Control Sample (% recovery)	Surrogates (% recovery)	MS/MSD (% recovery)
Mercury	EPA 245.6 (CVAA)	0%-20% (for results > 5x RL)	85%-115%	NA	75%-125%; RPD limit 20%
Metals (one or more of: As, Cd, Cr, Cu, Pb, Ni, Se, Zn)	EPA 200.7 or 200.8	0%-20% (for results > 5x RL)	85%-115%	NA	75%-125%; RPD limit 20%
Chlorinated pesticides	EPA 8081 (GC/ECD); MEL SOP	0%-40%	50%-150%	20%-130% [a]	50%-150%; RPD limit 40%
PCB Aroclors	EPA 8082 (GC/ECD); MEL SOP	0%-40%	50%-150%	50%-150%	50%-150%; RPD limit 40%
PCB congeners	EPA 1668A (HiRes GC/MS)	0%-40%	per method for OPR, Internal Standards, and Labeled Compounds	NA	NA
PCDD/Fs	EPA 1613B (HiRes GC/MS)	0%-40%	per method for OPR, Internal Standards, and Labeled Compounds	NA	NA
PBDEs	EPA 8270 (SIM); SOP 730104	0%-40%	50%-150%	50%-150%	50%-150%; RPD limit 40%
Lipids	MEL SOP 730009	0%-20%	NS	NA	NA

[a] Surrogate recovery limits were recently revised by MEL and are specific to surrogate used. Some limits are 20%-120%; others are 30%-130%.

Method-specific quality control procedures will be used to evaluate analytical precision and bias. Laboratory Case Narratives will discuss the outcomes of quality control practices and address precision and bias for each batch of sample analyses.

Analytical precision will be estimated using the results from laboratory replicates expressed as the Relative Percent Difference (RPD) for duplicates or as the Relative Standard Deviation (RSD) where three or more replicates are analyzed.

Sampling precision will be estimated using results from true field replicates. Field replicate samples consist of another set of fish of the same species and size range as the sample. Field replicates are usually formed by random assignment of individual fish to a composite group. For example, 15 fish of the same species collected from the same site and all within a given size range could be assigned to 3 different composite samples of 5 fish each. Multiple field replicates

may also be part of the sampling strategy for some objectives, such as comparing results to historical data or for use in human health risk assessment performed by DOH.

Bias will be evaluated and kept within method-specific limits by use of various control standards and surrogate compounds that are analyzed along with study samples. Laboratory control samples contain known amounts of analyte and indicate bias due to sample preparation and/or calibration. Matrix spikes may indicate bias due to matrix effects and matrix spike duplicates provide an estimate of the precision of the results. Where isotopic dilution methods are used (e.g., PCB and PCDD/F congeners), each sample is spiked with labeled congeners. The concentration of target compounds is corrected for recovery of labeled congeners or other techniques allowed by the analytical method.

This project will use data collected through monitoring efforts conducted by others, such as historical data from Ecology or other organizations. These data and associated documentation (e.g., project plans, project reports, and laboratory data reports) will be reviewed to assess their usability in this project.

Sampling Process Design (Experimental Design)

Site Selection

Contaminants in fish tissue in Washington have been the subject of numerous studies by Ecology and other groups (e.g., EPA and USGS) since the 1980s. These efforts have advanced the knowledge of contaminants in fish tissue statewide and led to some water cleanup plans (also known as Total Maximum Daily Loads or TMDLs) and fish consumption advisories. Continued effort is needed to characterize the scope of contaminants in fish at sites not previously sampled and to determine change in contaminant levels over time due to investments in watershed cleanup efforts.

Factors considered in determining the suitability of a site for fish collection are:

- Nature of historical monitoring efforts.
- Location and proximity to potential contaminant sources.
- Nature of the fish resource and use by humans and wildlife.
- Need for, and type of, contaminant data from that site and species.
- Need for scientific collection permits from other entities.
- Ability to access the site and collect target species.
- Interest from other organizations (e.g., Ecology regions, DOH, tribes, EPA).

Figure 1 shows sites sampled between 2001 and 2010 for the WSTMP. Because Washington has over 8000 lakes and many miles of fish-bearing streams, all sites that may be selected for the exploratory component are not presented here.

Sites with fish consumption advisories issued by DOH and local jurisdictions are shown in Figure 2. There is great interest in these sites because of the public health risks, so long-term monitoring will help inform resource managers and the public about the status of contamination at these sites. More information about the benefits and risks of eating fish from these sites is at www.doh.wa.gov/CommunityandEnvironment/Food/Fish.aspx.

Sites suspected of having no contamination, or "reference" sites, may be chosen to gain perspective on the results from sites closer to sources of contamination. Such reference sites will be streams and lakes far from potential sources or contaminant transport mechanisms.

Sampling Design

The sampling design for each year's effort will relate to the objectives specific to the site, species, and use of the data for each of the two components.

For exploratory monitoring, at least one sample from different species will be collected to provide a general screening-level assessment of contaminants in fish. Results will be compared to water quality standards and to findings from other sites across Washington. Results may also

be used by those Ecology regions using the cyclical phases of the Watershed Approach to Water Quality Management (www.ecy.wa.gov/programs/wq/watershed/overview.html).

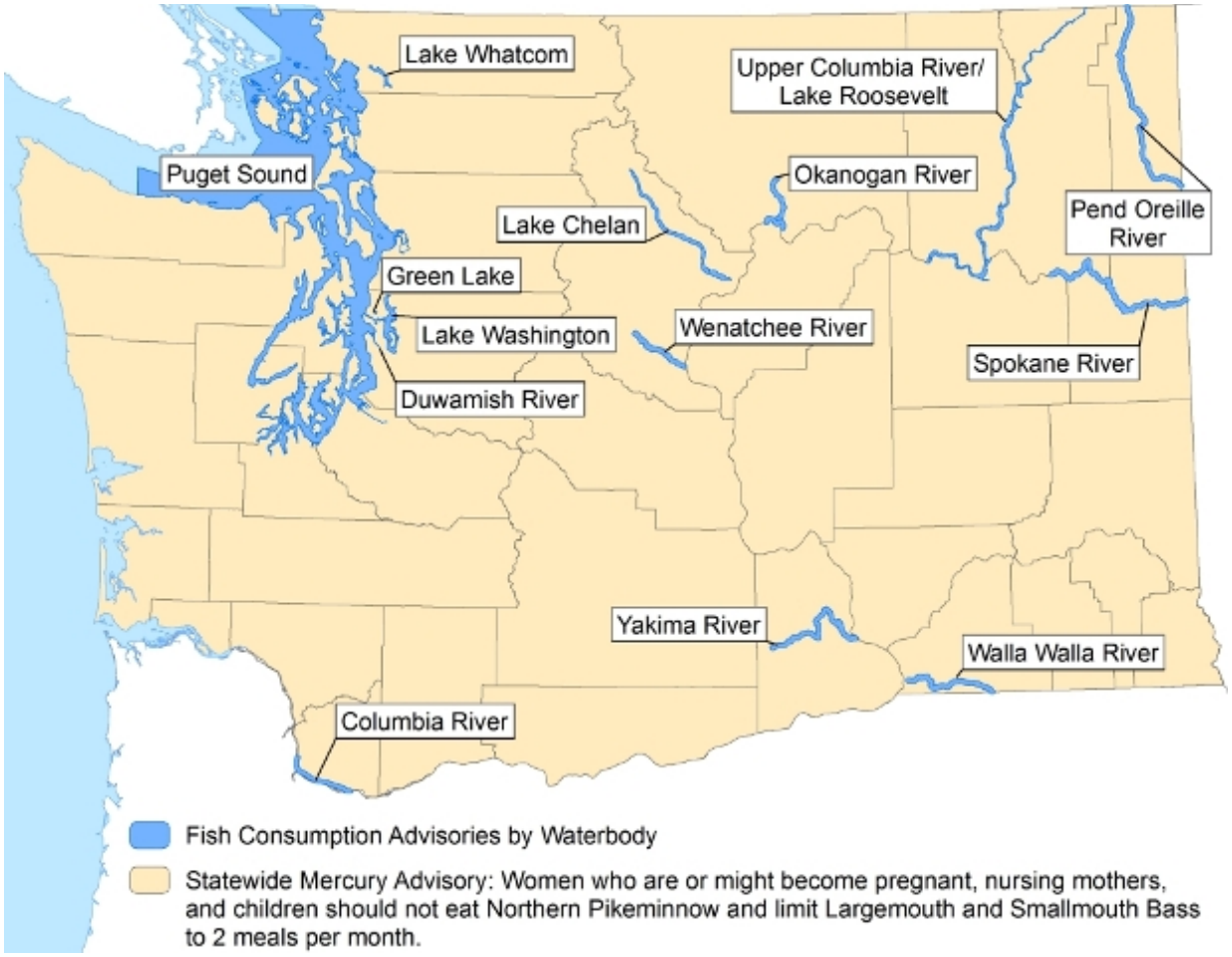

Figure 2. Location of fish consumption advisories in Washington.

For long-term monitoring, multiple replicates of composite samples for each species at each site are anticipated to provide an adequately robust data set that will meet objectives. Review of field replicate data from the WSTMP showed that variance is inconsistent and can be high for organic contaminants, ranging up to 100% RPD for PCBs, DDTs, and PCDD/Fs. A sample size of five to seven composite samples should reduce the variability associated with the mean and median tissue concentrations and improve the ability to determine change among sample results over time. A sample size of three replicates, as used in previous studies, has often been too small for determining differences between two data sets over time.

Table 5 lists potential sites that may be sampled under the long-term component of this effort. The proposed schedule in Table 5 is flexible to accommodate primary users of the data: Ecology and DOH. For example, Ecology's Eastern Regional Office in 2012 requested work on the Spokane River as part of watershed cleanup efforts. The data from the Spokane monitoring also

supports DOH's effort in re-evaluating the health consultation based on data collected in 2005 (Diaz, 2007). Ecology's Central Regional Office asked that Lake Chelan fish be sampled in 2010 to help inform watershed cleanup efforts related to the TMDL completed in 2005 (Schneider and Coots, 2006). Similar requests are expected from Ecology regions and DOH in coming years – which will likely influence the schedule in Table 5.

Physical attributes about individual fish will be collected to help select fish for analyses and interpret laboratory results. These attributes are fish length, weight, age, and sex. These attributes, along with lipid content, can affect contaminant levels in fish tissue. Relationships between contaminant concentrations in fish tissue and these attributes can be confounding and vary among species and sites and over time. Exponent (2003) reviewed these factors and their roles in fish contaminant monitoring programs.

Temporal trends will be assessed by various statistical procedures and be guided by the nature of data collected. The strength of trend assessment may vary depending on approaches used, ranging from simple qualitative reviews (e.g., plot of contaminant levels over time) to evaluations using hypothesis testing.

Major assumptions that underlie the design for the long-term monitoring component:

- Funding and resources will continue for the long-term monitoring component over the coming decades; such a timeframe is needed to detect changes.
- The species and size ranges of fish will be available at sites over time for the long term.
- Scientific collection permits required by federal, tribal, state, and other entities will be obtained in timely manner, which will allow sample collection at selected sites.
- Water quality management actions such as water cleanup plans will eventually reduce contaminant loading to waterbodies and result in decreasing contaminant concentrations in fish over time.
- Variability from laboratory analyses, sampling procedures, and natural sources are not easily controlled and will affect the ability to detect differences in contaminant concentrations over time and space. Larger differences (e.g., by a factor of 10) will be easier to detect than smaller ones (e.g., by a factor of 4).

Table 5. Candidate sites and analytes for long-term monitoring component.

Site	Chemical of Concern			Species of Concern	Target Sample Year, this Project	Previous Events				
	FCA	TMDL	Other Study			303(d) listing	TMDL	TMDL Eff. Mon.	FCA	WSTMP mon.
Snake R		PCDD/F	DDT, PCB, PCDD/F, Chlordane	CC, CCP, MWF	2009	2004	1991		2013	2004 2009
Chelan L	DDT	PCB, DDT	DDT, PCB, PCDD/F	LKT, RBT, KOK, BUR, NPM	2010	1998	2001		2006	2010
Wenatchee R	PCB		DDT, PCB, PCDD/F	MWF	2010	2004			2007	2010
Spokane R	PCB, Pb, PBDE		PCB, PBDE, PCDD/F, metals	MWF, RBT, BLS, LSS	2012	1996	2005 [1]		2001	2012
Columbia R [2]	PCB	PCDD/F	DDT, Hg, PCDD/F, PCB	MWF, NPM	2013	2004 2008	1991		2013	2005
Yakima R	PCB	PCB, DDT	CP, DDT, PCBs	CCP, NPM, other	2014	1994	1997	2006	1993	
Washington L	PCB		DDT, PCB, Hg, PBDE, PCDD/F, Chlordane	CCP, CTT, NPM, YP	2015	2004			2004	2005
Walla Walla R	PCB	PCB, CP		CCP, BLS, SMB, NPM, CC	2016	1996	2002		2006	
Roosevelt L [3]	Hg, PCB	PCDD/F [4]	Metals, PCB, PCDD/F	WAL, BUR, LSS	2017	2004			2002	
Okanogan R	DDT, PCB	PCB, DDT		CCP, MWF, SMB	2018	1998	2001	2008	2011	2008
Palouse R		PCB, CP		LSS, NPM, SMB, CHS	tbd	1984 1994	2005			2005
Green L (Seattle)	PCB		DDT, PCB, PCDD/F, Chlordane	CCP	tbd	2004			2003	2001
Meridian L			PCDD/F, PBDE, Chlordane, Dieldrin, Hg	KOK, LMB	tbd	2008				2006
Cowlitz R			PCB, Hg, PCDD/F, CP,	NPM, MWF, CTT	tbd	2004				2005

FCA: Fish consumption advisory; WSTMP: Washington State Toxics Monitoring Program; TMDL: TMDL study conducted; tbd: to be determined

1- While not a "formal" TMDL, this source assessment is used as a basis for watershed cleanup efforts.

2 - from mouth to Grand Coulee Dam

3 - EPA Superfund site for metals

4 - 303(d)-listed in 1984 also

Species codes:

BLS: Bridgelip sucker; BNT: Brown trout; BUR: Burbot; CC: Channel catfish; CCP: Common carp; CTT: Cutthroat trout; KOK: Kokanee salmon; LKT: Lake trout; LSS: Largescale sucker; LMB: Largemouth bass; MWF: Mountain whitefish; NPM: Northern pikeminnow; PEA: Peamouth; RBT: Rainbow trout; SMB: Smallmouth bass; YP: Yellow perch.

Representativeness

The fish collected for this project are expected to be representative of the collection site, with some exceptions that will be considered and addressed in annual sample designs and reports. Some species or populations of fish may be less representative of site conditions because of migratory activities such as seasonal feeding or reproduction. Many of Washington's lakes and streams also contain fish that originate from hatchery programs. Hatchery and naturally-produced fish may bioaccumulate different types and amounts of contaminants because of different places and time periods when they are exposed to contaminants. Before Ecology selects sites, we will contact WDFW biologists for information on the species present, the nature of the fishery, and level of fishery management.

Target species were selected based on EPA recommendations (2000) and previous experience with fish collection in Washington. The following criteria were used to select target species. They are:

- Commonly captured and likely to be consumed by humans.
- Likely to bioaccumulate chemicals of concern.
- Abundant, easy to identify, and easy to capture.
- Large enough to provide adequate tissue for analysis.
- Resident fish likely to stay relatively close to the sampling site.

Target species for this study are listed in Appendix C. Efforts will focus on collecting the desired species and number of fish, yet the outcome of field sampling will depend on the availability and abundance of fish at the study sites. In many cases, multiple species may be sought at any one site because of differences among species' abilities to bioaccumulate certain types of chemicals. While edible game fish are preferred over bottom-dwelling species, bottom-dwelling species may also be collected.

Comparability

The sample collection, processing, and analytical methods used should produce data comparable to regulatory criteria, guidelines for protection of human or aquatic life, and findings from historical work. Ancillary data on fish tissue samples such as fish size, fish age, lipid content, and tissue type will help determine cases where appropriate comparisons can be made.

Fish will most often be sampled in the fall of each year, which coincides with the timing of most other fish collecting by Ecology and other agencies. Yet there will be cases where fish need to be collected in a different season in order to be comparable to historic data (e.g., Lake Chelan trout collected in late spring).

The comparability of study results to other values will be maximized as best as possible through sample design, sample collection, laboratory analyses, and data evaluation on an annual basis. Sample design will be tailored annually for each target site and described in annual addendums to this project plan. Design factors such as species, target fish size, sample size, and sample compositing schemes will be based on site-specific objectives, historical data, and best

professional judgment. Fish for the trend monitoring component at specified sites will be collected from the same season and similar size ranges as fish collected during historical efforts.

Where analytical methods or laboratories conducting the analyses differ among data sets from different times, the comparability of the methods and results will be evaluated and documented. Examples include:

- *Mercury:* EPA method 245.5 was used for most Ecology fish tissue samples before 2004 while EPA 245.6 has been used since 2004. Furl (2007) examined paired results from use of both methods and found a relative bias of nearly 30% between the two methods. Linear regression was used to establish a relationship that could be used to compare results coming from the two analytical methods.

- *PCBs:* PCBs in fish tissue have been measured using two different analytical methods. EPA Method 8082 produces Aroclor data while EPA Method 1668A and 1668C yields data for individual or co-eluting congeners. The comparability of Aroclor to congener results were examined in previous tissue sampling efforts and found good correlation over three orders of magnitude (Seiders et al., 2009; Johnson, et al., 2010). The differences between the two methods were generally greater where total PCB concentrations were less than 10 ppb. This project will most often use EPA 8082 because of its lower cost. When mixtures of data from both methods are used in comparisons, the added variability from the different methodology will be addressed during sample design and data evaluations.

- *Dioxins/furans:* Data from at least two methods may be involved, specifically EPA Methods 8290 (historical data) and 1613b. As with PCB methodology above, when mixtures of data from both methods are used in comparisons, the added variability from the different methodology will be addressed during data analysis and reporting.

The wide range of recovery rates often seen in lab control samples, surrogates, matrix spikes, and matrix spike duplicates for target analytes in fish tissue suggest varying levels of uncertainty in laboratory result. This uncertainty is another component of the total variability associated with sampling fish tissue for determining changes over time and space. In this project we hope to investigate the analytical sensitivity and uncertainty associated with differing recoveries and the implications for comparability. Initial approaches could involve assigning quality codes to results in order to reflect the strength of recoveries. For example, recovery rates from +/- 20% = quality code 1, rates from +/-40% = quality code 2, rates from +/- 60% = quality code 3. Other approaches could involve determining confidence intervals associated with each result and seeing how those affect determinations of differences.

Differences in data reduction practices over time may also affect the comparability of results. One example includes methods of summing analytes having similar properties to yield "total" values, such as in total PCBs, total DDT, and toxic equivalents (TEQ) for dioxin/furan congeners expressed as TCDD TEQ. Where data reduction practices for historical results are not documented or comparability is otherwise uncertain, sums or TEQs may be recalculated using original laboratory data, following guidance developed by Ecology's EA Program.

Completeness

The goal of completeness for laboratory analytical data and for field measurements is 100%. The loss of any analytical or field data may decrease the ability of this project to achieve its objectives for either exploratory monitoring or trend monitoring. When needed, additional efforts will be taken to achieve 100% completeness of field and laboratory data. For example, sample collection at a site may be expanded until the numbers of target species are collected; aliquots of ground tissue will be archived in case re-analysis is needed; and iterative reviews or corrections of laboratory data may be requested until a data set is complete and accurate.

Sampling Procedures

Field Collection

Tissue samples will be collected, preserved, and transported following procedures designed to maintain the integrity, quality, and identification of the sample. Methods for the collection, handling, and processing of fish tissue samples for analysis will follow the EA Program's Standard Operating Procedure (SOP) for Field Collection, Processing, and Preservation of Finfish Samples at the Time of Collection in the Field (Sandvik, 2006a). These methods are summarized below.

Fish will be collected using a combination of methods such as electrofishing, netting, and angling. Fish may also be collected during cooperative efforts by other organizations, such as tribes, EPA, and WDFW.

Upon capture in the field, fish will be identified to species and target species retained; non-target species will be released. Fish that are retained will be inspected to ensure that they are acceptable for further processing (e.g., proper size, no obvious damage to tissues, skin intact).

Fish to be kept will be euthanized by a blow to the head with a dull object, rinsed in ambient water to remove foreign material from their exterior, weighed to the nearest gram, and their total lengths measured to the nearest millimeter. Individual fish will then be double-wrapped in foil and placed in a plastic Ziploc bag along with a sample identification tag. The sample tag will include the date, the site, and the field ID assigned to the individual fish. The bagged specimens will be placed on ice in the field. Fish may remain on ice for 24-72 hours and then frozen to -10° C. The fish will remain frozen until samples are prepared and transported to MEL.

Field notes will be kept during each sampling event. Notes will be entered in a field notebook and will include: date and time, sampling personnel, general sampling location for fish collection areas, general weather conditions, method of sampling, fish species collected, weights and lengths for individual specimens, and results from field measurements. Latitude and longitude coordinates will be obtained from maps or a GPS device.

Field crews will have a sampling guide for each site which details specific plans for sample locations, species, fish sizes, numbers of fish, collection methods, and alternative actions in case of unforeseen circumstances. Field crews will consult the Project Officer when circumstances are beyond those described in the year-specific sampling plan.

Invasive or unwanted aquatic species are likely to be encountered during fish collections for this project. Environmental ethics and Washington law prohibit the transportation of all aquatic plants, animals, and many noxious weeds. Sample collection efforts for this project will follow the EA Program's SOP to Minimize the Spread of Invasive Species (Parsons, et al., 2012) and WDFW's Invasive Species Management Protocols (Tweit, et al., 2011).

Sample Preparation

Further preparation of fish samples will occur after the compositing and lab analysis plans are finalized. Tissue samples will be prepared following the EA Program's SOP (Sandvik, 2009b). During processing, a hardcopy form (the "benchsheet") will be used to record various data, such as: processing date, processing crew, lab sample ID names, lab sample numbers, fillet weights, sex of individual fish, age structure container references, and relevant comments.

All utensils used for processing tissue samples will be cleaned in order to prevent contamination of the sample. Utensils include bowls and knives of stainless steel and tissue grinding appliances having plastic, wood, stainless steel, bronze, steel, and tin parts. The cleaning steps are: soap (Liquinox) and water wash, tap water rinse, 10% nitric acid rinse, deionized water rinse, and acetone and hexane rinses. Utensils will be air-dried and then packaged in aluminum foil until used. These procedures are described in Ecology's Chemical Hygiene Plan (Ecology, 2011).

Fish samples will be processed using methods that minimize the potential for sample contamination. Most fish will be processed on aluminum foil that covers a nylon cutting board laid on the workbench. The foil will be placed so that fish contact only the dull side of the foil. People preparing the samples will wear non-talc nitrile gloves. They will change gloves and foil between samples and cover the cutting board with new foil between samples.

Fish will be selected for processing in batches. Fish processed as fillets will be removed from the freezer, partially thawed, slime and scales removed, rinsed in tap water followed by a rinse in deionized water. Fish will then be filleted with the skin left on (except some species like catfish). Fillets will be cut into small cubes and passed three times through a Kitchen-Aid food grinder. The ground tissue will be homogenized by stirring to a consistent texture and color. Subsamples from the homogenate will be taken and placed into appropriate containers and refrozen (to 0° F) until shipped to MEL. The samples will be stored frozen at MEL until analyses by MEL or shipped to a contract laboratory for other analyses. Excess tissue will be retained for all samples and stored frozen at Ecology Headquarters.

Additional data are collected from individual fish during processing. Before fish are filleted, a section of the caudal or other fin may be removed and preserved in ethanol and sent to WDFW for DNA archiving following the EA Program's SOP (Sandvik, 2006c). Species-appropriate structures (e.g., otoliths, scales, opercula) will be removed and sent to WDFW biologists who will determine the age of individual fish. After fillets are removed, the sex of the fish will be determined and recorded.

Fish processed as "whole" fish will follow similar procedures described above except that a larger, commercial-grade grinder will be used. For whole fish samples, the only parts removed before grinding are structures for determining age (e.g., scales, opercula).

Sample Containers and Holding Time

Sampling containers, sample preservation, and holding times for fish tissue are shown in Table 6. Pre-cleaned sample containers will be obtained prior to sample processing. Containers should be suitable for the specific analyses to be performed on the sample within. Containers should also be free of contaminants according to EPA (1992) and meet quality assurance certification from the supplier.

Table 6. Containers, preservation, and holding times for fish tissue samples.

Parameter	Sample Container	Minimum Amount Required *	Preservation	Holding Time
Mercury	2 oz. precleaned glass jar w/teflon lid	5g	freeze, -10° C	6 months to extraction, then 28 days to analysis
Metals (one or more of: As, Cd, Cr, Cu, Pb, Ni, Se, Zn)	2 oz. precleaned glass jar w/teflon lid	10g total	freeze, -10° C	6 months to extraction, then 28 days to analysis
Chlorinated pesticides	4 oz. precleaned glass jar w/teflon lid	30g, 60g preferred	freeze, -10° C	1 year to extraction, then 40 days to analysis
PCB Aroclors	4 oz. precleaned glass jar w/teflon lid	30g, 60g preferred	freeze, -10° C	1 year to extraction, then 40 days to analysis
PCB congeners	4 oz. precleaned glass jar w/teflon lid	30g, 60g preferred	freeze, -10° C	1 year to extraction, then 40 days to analysis
PCDD/Fs	4 oz. precleaned glass jar w/teflon lid	30g, 60g preferred; 220g if base digestion used	freeze, -10° C	1 year to extraction, then 40 days to analysis
PBDEs	4 oz. precleaned glass jar w/teflon lid	30g, 60g preferred	freeze, -10° C	1 year to extraction, then 40 days to analysis
Lipids	4 oz. precleaned glass jar w/teflon lid	30 g	freeze, -10° C	1 year to extraction, then 40 days to analysis

* The minimum amount may be reduced if multiple parameters can be analyzed from a single container. For example, 30 g tissue is enough for PCB Aroclor and lipids analysis. Project staff will ask MEL staff about minimum amounts needed when multiple analyses are performed on the same sample.

Measurement Procedures

Laboratory analyses of samples will be conducted by MEL or an accredited laboratory through a contract managed by MEL. Both MEL and the contract laboratories are expected to meet the quality control requirements of the analytical methods being used and any other requirements specified by MEL or the Project Officer.

Table 7 shows the parameters to be analyzed, analytical methods, desired reporting limits, and ranges of expected results. While Table 7 includes a range of reporting limits for each group of analytes, Appendix D, Tables D1-D4, show reporting limits for all individual analytes.

Because sampling objectives and sites will change each year, the numbers of samples, target analytes, expected range of results, and required reporting limits will be refined to each year's effort. In August or September of each sampling year, initial and revised estimates of analytical needs (e.g., target analytes, sample numbers) will be communicated to MEL on a monthly basis until sampling is completed and a final lab analysis plan developed.

Table 7. Laboratory measurement methods for fish tissue samples.

Parameter	Methods, RLs, Sample n			
	Number of Samples & Arrival Date [a]	Expected Range of Results [b]	Reporting Limits [c]	Analytical Method
Mercury	40 - 80, January	10 - 1000 ug/kg	17 ug/kg	EPA 245.6 (CVAA)
Metals (one or more of: As, Cd, Cr, Cu, Pb, Ni, Se, Zn)	40 - 80, January	0.1 - 100 ug/kg	0.10 mg/kg	EPA 200.7 or 200.8
Chlorinated pesticides	40 - 80, January	0.1 - 1000 ug/kg	most 0.5-3.0 ug/kg	EPA 8081 (GC/ECD); MEL SOP
PCB Aroclors	40 - 80, January	0.5 - 1000 ug/kg, depending on Aroclor	1.1 - 44 ug/kg	EPA 8082 (GC/ECD); MEL SOP
PCB congeners	20 - 40, January	0.005 - 100 ug/kg, depending on congener	0.003-0.01 ug/kg	EPA 1668A (HiRes GC/MS)
PCDD/Fs	20 - 40, January	0.005 - 5.0 ng/kg, depending on congener and extraction method	EQL 0.017 - 0.5 ng/kg	EPA 1613B (HiRes GC/MS)
PBDEs	40 - 80, January	0.1 - 100 ug/kg	0.10 - 2.6 ug/kg; PBDE 209 1.9 - 4.3 ug/kg	EPA 8270 (SIM); MEL SOP 730104
Lipids	40 - 80, January	0.1 - 20%	0.10%	MEL SOP 730009

a - Approximate values that vary each year depending on sampling objectives. Samples are unlikely to be analyzed for all parameters. MEL will be informed of numbers and arrival dates as the sampling season progresses.
b - Value reflects statewide range. Ranges for some samples will vary each year by site and species. MEL will be informed of expected ranges when known from historical sampling.
c - Value reflects typical range. Required RLs for some samples may vary by site and species. Expectations will be communicated with MEL for each sample season.

Quality Control Procedures

Field

Quality control procedures for the field work of fish collection and fish processing will follow Ecology's EA Program SOP related to fish collection (Sandvik, 2010a, b, and c).

There are only two field measurements made when collecting and processing the fish: weight and total length. For weights, the accuracy of the bench scale for measuring the weights of whole or partial fish will be checked before and after each field season using primary weight standards maintained by Ecology's Marine Monitoring Unit. Secondary weight standards may be used on a daily basis. For determining total length, a ruler graduated to millimeters is used.

Annual fish collection will include gathering enough fish for true field replicates for selected sites and species as described in the Quality Objectives section above. The number of field replicates will vary each year and depend on site-specific sampling objectives. For trend analyses objectives, multiple field replicates (e.g., 5-7 replicates of same species at same site) may be collected to improve the sensitivity of statistical testing for differences in contaminant concentrations over time or space.

Laboratory

Laboratory quality control procedures (Table 8) will include various analyses such as calibration standards, lab control samples, matrix spikes, standard reference materials, blanks, and replicates to evaluate the quality of data that are generated. Precision will be estimated using laboratory duplicate analyses for tissue by calculating the Relative Percent Difference (RPD) of the results. Matrix spikes may be used to indicate the presence of bias due to the sample matrix. The project officer may indicate which samples should be used for laboratory duplicates and matrix spikes.

The Data Verification and Validation section below addresses corrective actions that can be taken by laboratory analysts or the Project Officer as needed to meet the needs for data quality.

Table 8. Laboratory quality control sample types and frequencies.

Parameter	Analytical Method	Lab Duplicates	Lab Control Standards	Surrogates	MS/MSD	Method Blanks
Mercury	EPA 245.6 (CVAA)	1/ batch [a]	1/batch	NA	NA	1/batch
Metals (one or more of: As, Cd, Cr, Cu, Pb, Ni, Se, Zn)	EPA 200.7 or 200.8	1/batch	1/batch	NA	NA	1/batch
Chlorinated pesticides	EPA 8081 (GC/ECD); MEL SOP	1/batch	1/batch	each sample	1/batch	1/batch
PCB Aroclors	EPA 8082 (GC/ECD); MEL SOP	1/batch	1/batch	each sample	1/batch	1/batch
PCB congeners	EPA 1668A (HiRes GC/MS)	1/batch	each sample & 1/batch [b]	NA	NA	1/batch
PCDD/Fs	EPA 1613B (HiRes GC/MS)	1/batch	each sample & 1/batch [b]	NA	NA	1/batch
PBDEs	EPA 8270 (SIM); SOP 730104	1/batch	1/batch	each sample	1/batch	1/batch
Lipids	MEL SOP 730009	1/batch	1/batch	NA	NA	1/batch

a - “Batch” is defined as up to 20 samples analyzed together
b - Labeled compounds in each sample and Ongoing Precision and Recovery standards in each batch

Data Management Procedures

Field

Data management for this project will include written and electronic media generated from field and laboratory activities. The EA Program SOPs for the collection and processing of fish samples describes formats to be used for all phases of recordkeeping (Sandvik 2010a, b, and c). Field notes and observations will be recorded by hand onto prepared field forms and/or notebooks. Pertinent data collected in field books will be transferred to electronic media using Microsoft Office products (Word, Excel, and Access) and ArcView GIS. After entry into electronic media, about 10% of the electronic data will be reviewed and compared to handwritten data to check and correct data entry errors. After these reviews, pertinent field data will be entered into Ecology's electronic Environmental Information Management (EIM) system. Hardcopy and electronic data not entered into EIM will be retained in a file system maintained by the project officer.

Laboratory

Laboratory analyses of samples generate data recorded in handwritten and electronic formats. These data will be examined by designated laboratory personnel for quality control, completeness, accuracy, errors, and usefulness. Laboratory data generated by MEL will be entered into the Laboratory Information System (LIMS) by MEL staff. When notified of the availability of data, project staff can then access LIMS data and load appropriate data into EIM.

Laboratory results from MEL will also be sent to the project officer in hardcopy format and will be accompanied by a case narrative for each batch of samples. The narrative should address condition of the samples on receipt, methods of analysis, sample preparation, instrument calibration, and results from quality control practices.

Results from contract laboratories will be delivered to MEL and contain information specified in two documents: one called a Request for Qualifications and Quotes (RFQQ) and the other known as the Request for Analysis (RFA). The RFQQ and RFA are developed by designated MEL staff and the project officer. Results from contract labs are reviewed by MEL staff who will then prepare a case narrative for delivery to the project officer. Results from contract labs will be provided in Excel spreadsheet format for ease of review, editing, and transfer into EIM.

Office

As field and lab data are completed, data will be organized using various tabular and graphical formats for additional review, calculations, characterization and reporting. Results from some groups of target analytes are summed in order to account for their additive effects and simplicity of comparison to various criteria and other data. Parameters that are commonly summed include: PCBs, PBDEs, PCDD/Fs, DDTs, and Chlordanes.

For dioxins and furans (PCDD/Fs), the cumulative toxicity of the 17 most toxic congeners will be calculated using the international convention (Van den Berg et al., 2006) as recommended by EPA (2010) of expressing the cumulative toxicity of mixtures of congeners as a toxic equivalent (TEQ) to 2,3,7,8-TCDD. This TEQ is calculated by multiplying the result for each congener by its congener-specific Toxicity Equivalent Factor (TEF) and then summing the products (which are congener-specific TEQs) to obtain the 2,3,7,8-TCDD TEQ.

Procedures for summing and handling qualified values such as non-detects will follow Ecology's EA Program guidance or be explained in reports.

Historical data from historical efforts will be obtained from various sources. The primary source will be Ecology's EIM databases and other Ecology repositories. Data from other agencies may also be used (e.g., EPA, USGS, tribes, WDFW). The quality of such data will be reviewed for its usability on a case-by-case basis and factors leading to its use documented in quality assurance reviews for each year's effort.

Audits and Reports

Audits

This project will be conducted according to established practices within Ecology which are designed to produce data of acceptable quality and ensure that corrective actions are implemented in a timely manner.

The laboratories conducting sample analyses are accredited through Ecology's Laboratory Accreditation Program. This program establishes whether a laboratory has the capability to provide accurate, defensible data. Accreditation involves an evaluation of the laboratory's quality system, staff, facilities and equipment, test methods, records, and reports. Audits of field procedures, sample processing, or other components outside of the laboratory environment may occur at the discretion of Ecology's Quality Assurance Manager, supervisors, or the project officer.

Reports

Annual reports will likely be a 2-6 page summary of each year's sampling effort. The report may contain:

- Sampling objectives.
- Map of locations.
- Summary of results using tables and graphs.
- Data analyses for temporal or spatial patterns with description of statistical procedures used.
- Comparisons to water quality standards or other guidance.
- Significant findings and recommend follow-up actions.

Other results from the annual effort will be made available to audiences upon request or through the Internet. This additional information may include topics that EA Program reports typically contain, such as:

- Acknowledgements.
- Background information and study design.
- Description of field and laboratory methods.
- Data quality assessments, copies of laboratory case narratives.
- Description of differences in laboratory methods over time and their implications.
- Results and discussion using text, tables and graphics.
- References and appendices.

Other formats may be used to report annual findings, such as Ecology's "Focus Sheet" or other summaries as needed.

Upon study completion, all project data will be entered into Ecology's EIM database. Public access to electronic data and the final report for the study will be available through Ecology's Internet homepage (www.ecy.wa.gov).

Data Verification and Validation

Hard copy and electronic forms of data will be verified by examining for legibility, errors, omissions, and compliance with MQOs and quality control acceptance criteria.

Qualified laboratory staff will examine laboratory data and document findings in a case narrative. Laboratory staff may be consulted in order to review quality control data that are normally retained by MEL. Field data will be examined by the field leader prior to leaving the sampling site or sample processing room.

Where errors or omissions in the data are found, the source of the data (e.g., field sampling personnel, laboratory technician) will be consulted to determine the correct value or form of the data in question. Corrections or qualifications will be made where possible. Where corrections cannot be made, samples may be re-analyzed, or the original results in question may be qualified or rejected.

Another data verification step is performed on about 10% of the data after they are entered into EIM. These data are verified for accuracy following business rules adopted by Ecology's EIM Steering Committee.

The Project Officer will be responsible for final verification of all data as there will be no "formal" third-party validation of project data. Final verification consists of examining the data record and determining whether the methods described in this Quality Assurance Project Plan were used and whether the data meet the MQOs and quality control criteria described earlier.

Data Quality (Usability) Assessment

The project officer will determine whether the data generated by the project can be used to meet the project objectives. The procedures described in previous sections will guide the project officer. Other staff may be consulted where their expertise can be of value (e.g., quality assurance staff, laboratory staff).

Once the data have been verified and validated, the project lead will determine if they can be used to make the calculations, determinations, and decisions for which the project was conducted. Tables and graphs may be prepared to aid these determinations.

If the results are satisfactory, analyses of data will proceed using various formats, such as:

- Table of summary statistics by parameter group.
- Identification of outliers.
- Graphical plots to identify exceedances of human health criteria.
- Plots to compare contaminant concentrations among sampling sites and species.
- Plots for temporal and spatial comparisons.
- Tabular summaries of two-sample hypotheses tests for determining differences between means or medians, such as the two sample t-test and the Mann-Whitney test.

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Appendices

Appendix A. Fish Tissue Data Evaluation by Ecology and DOH

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

Most fish tissue contaminant data from Washington fish, regardless of who conducted the study, make their way to DOH for evaluation regarding the safety of consuming fish. More information about fish consumption advisories in Washington and the health benefits of eating fish is at the DOH website: www.doh.wa.gov/ehp/oehas/fish/. The following is an overview of how Ecology and DOH evaluate fish tissue data to meet different needs.

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

Washington State Water Quality Standards

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

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

Risk Management Decisions

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

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

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

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

Appendix B. Water Quality Criteria and Screening Values

Various criteria for the protection of human health exist because of changing knowledge about the toxic effects of chemicals and subsequent risks to consumers of fish. The various criteria and screening values are often based on different assumptions used in determining risk, such as daily consumption rates, toxicological data used in calculations, and risk levels. The criteria summarized below are the National Toxics Rule (NTR) criteria (used as Washington's Water Quality Standards), EPA's recommended criteria, and EPA's screening values. Fish tissue results from this project may be compared to these and other values.

Fish tissue results from this study will be compared to Washington's water quality standards to determine how sites should be evaluated during Washington's Statewide Water Quality Assessment (the 303(d) assessment). The 303(d) Assessment procedure also describes sampling requirements and other details about how environmental results are reviewed (Ecology, 2012).

Washington adopted the NTR criteria as the water quality standards for toxic compounds associated with human-health concerns. While the water quality criteria are expressed as water concentrations, "Fish Tissue Equivalent Concentrations" (FTEC) were calculated by multiplying the Bioconcentration Factor (BCF) for each analyte by the respective water quality standard criterion. The BCFs used were those from EPA's water quality criteria development documents. Results from laboratory analyses of fish tissue which are greater than FTEC for a given contaminant are interpreted as not meeting the water quality standard for that contaminant.

The NTR criteria are one set of values that can be used in gauging the potential for human health risks from eating contaminated fish. EPA developed more recent criteria and guidance values which are described below. (See *EPA Recommended Water Quality Criteria* and *EPA Screening Values*.). These recommended criteria and screening values can be used by state, tribal, and local health jurisdictions in evaluating risks to human health from the consumption of contaminated fish.

Appendix A describes how Ecology and DOH evaluate fish tissue data. Table B1 shows the NTR (Washington's water quality standards criteria) and other EPA criteria and screening values for contaminants detected in this study.

National Toxics Rule (NTR)

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

The NTR criteria were issued by EPA to Washington State in 1992. These criteria are designed to minimize the risk of adverse effects occurring to humans from chronic (lifetime) exposure to toxic substances through the ingestion of drinking water and contaminated fish and shellfish obtained from surface waters. The NTR criteria are regulatory values used by Ecology for a

number of different purposes, including permitting wastewater discharges and assessing when waterbodies are adversely impacted by contaminants.

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

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

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

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

3 - EPA (2002) states that the criterion for dioxin is expressed in terms of 2,3,7,8-TCDD and should be used in conjunction with the international convention of TEFs and TEQs to account for the additive effects of other dioxin-like compounds (see note 5).

4 - Values in parts per trillion wet weight (ng/kg ww).

5 - The cumulative toxicity of a mixture of congeners in a sample can be expressed as a Toxic Equivalent (TEQ) to 2,3,7,8-TCDD. Toxicity Equivalent Factors (TEFs) used for individual congeners are those recommended in 2005 by the World Health Organization (see note 8).

6 - Total DDT is the sum of 2,4'- and 4,4'- isomers of DDD, DDE, and DDT; DDMU may also be included. DDD: 4,4'-dichlorodiphenyldichloroethane. DDE: 4,4'-dichlorodiphenyldichloroethylene. DDT: 4,4'-dichlorodiphenyltrichloroethane. DDMU: 1-chloro-2,2-bis(p-chlorophenyl)ethane); it is another breakdown product of DDT.

7 - The NTR criterion for chlordane is interpreted as the sum of five chlordane components: these can be individually quantified through laboratory analyses while chlordane cannot. The EPA screening values are for "Total Chlordanes"

which is the sum of five compounds: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane. Some analyses report a "chlordane, total" value which can be used instead of the sum of the five compounds.
8 - Total PCBs is the sum of either Aroclors or congeners

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

Ecology expresses the NTR water column criteria as tissue concentrations in order to compare the criteria to laboratory results from fish tissue samples (Ecology, 2012). These tissue concentrations are derived by multiplying the NTR water quality criteria for human health by the bioconcentration factor (BCF) for the specific contaminant. The BCFs for specific contaminants are found in EPA's 1980 Ambient Water Quality Criteria documents (EPA, 1980).

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

In the past, Ecology usually evaluated freshwater fish tissue using the criteria intended for salt water fish. Recognizing this inconsistency, Ecology is developing guidance on how these criteria should be applied to ensure correct interpretation of water quality standards. For many chemicals, the difference between the two interpretations of criteria is small. The criteria based on the "consumption of water and organisms" are used in this report for determining whether fish tissue results exceed Washington's water quality standards.

EPA Recommended Water Quality Criteria

EPA publishes *National Recommended Water Quality Criteria* for many pollutants such as mercury and pesticides (EPA, 2001, 2002, 2003, and 2009). These criteria are periodically updated to incorporate the latest scientific knowledge. EPA recommends these criteria be used by states and Indian tribes to establish water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants. Yet these EPA recommended criteria are not regulatory levels. Most of EPA's *Recommended Water Quality Criteria* are based on a daily fish consumption rate of 17.5 grams/day and a risk level of 10^{-6}.

EPA Screening Values

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

- A cancer risk level of 10^{-5}.

- Two consumption rates: 17.5 grams/day for recreational fishers, and 142.4 grams/day for subsistence fishers.

A difference between the EPA SVs and NTR relating to PCDD/Fs is that the SVs use the dioxin/furan TEQ value while Ecology uses the single congener (TCDD) for 303(d) assessments (Ecology, 2012).

Washington State Department of Health (DOH) Screening Levels

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

Appendix C. Target Fish Species

Table C-1. Target Fish Species.

Common name	Scientific name	Habitat	Ecology Species Code	Feeding	Water temp	Tolerance	Order of pref	Family name	Possible Hatchery or Transplant
Largemouth bass	*Micropterus salmoides*	water col.	LMB	piscivore	warm	T	1	Centrarchidae	Y
Smallmouth bass	*Micropterus dolomieui*	water col.	SMB	piscivore	cool	I	2	Centrarchidae	Y
Walleye	*Sander vitreus*	water col.	WAL	piscivore	cool	I	3	Percidae	Y
Rainbow trout [3]	*Oncorhynchus mykiss*	hider	RBT	invert/piscivore	cold	S	4	Salmonidae	Y
Brown trout	*Salmo trutta*	hider	BNT	invert/piscivore	cold	I	5	Salmonidae	Y
Cutthroat trout (Coastal) [1]	*Oncorhynchus clarki clarki*	water col.	CTTC	invert/piscivore	cold	S	6	Salmonidae	Y
Cutthroat Trout (Western) [1]	*Oncorhynchus clarki lewisi*	water col.	CTTW	invert/piscivore	cold	S	7	Salmonidae	Y
Cutthroat Trout (Lahontan) [1]	*Oncorhynchus clarki henshawi*	water col.	CTTL	invert/piscivore	cold	S	8	Salmonidae	Y
Kokanee salmon	*Oncorhynchus nerka*	water col.	KOK	invertivore	cold	S	9	Salmonidae	Y
Yellow perch	*Perca flavescens*	water col.	YP	invert/piscivore	cool	I	10	Percidae	
Channel catfish	*Ictalurus punctatus*	benthic	CC	invert/piscivore	warm	T	11	Ictaluridae	Y
Brook trout	*Salvelinus fontinalis*	hider	BKT	invert/piscivore	cold	I	12	Salmonidae	Y
Lake trout	*Salvelinus namaycush*	benthic	LT	piscivore	cold	S	13	Salmonidae	
Tiger Trout	*Salmo trutta X Salvelinus fontinalis*	hider?	TT	invert/piscivore	cold	I	14	Salmonidae	Y
White sturgeon	*Acipenser transmontanus*	benthic	WST	invert/piscivore	cold	I	15	Acipenseridae	
Green sturgeon	*Acipenser medirostris*	benthic	GST	piscivore	cold	S	16	Acipenseridae	
Burbot	*Lota lota*	benthic	BUR	piscivore	cold	I	17	Gadidae	
Mountain whitefish	*Prosopium williamsoni*	benthic	MWF	invertivore	cold	I	18	Salmonidae	
Lake whitefish	*Coregonus clupeaformis*	water col.	LWF	invertivore	cold	I	19	Salmonidae	
Northern Pike	*Esox lucius*	water col.	NOP	piscivore	cold			Esocidae	
Northern pikeminnow	*Ptychocheilus oregonensis*	water col.	NPM	invert/piscivore	cool	T	20	Cyprinidae	
Peamouth	*Mylocheilus caurinus*	water col.	PEA	invertivore	cool	I	21	Cyprinidae	

Common name	Scientific name	Habitat	Ecology Species Code	Feeding	Water temp	Tolerance	Order of pref	Family name	Possible Hatchery or Transplant
Pumpkinseed	*Lepomis gibbosus*	water col.	PMP	invert/piscivore	cool	T	22	Centrarchidae	
Black crappie	*Pomoxis nigromaculatus*	water col.	BC	invert/piscivore	warm	T	23	Centrarchidae	Y
White crappie	*Pomoxis annularis*	water col.	WC	invert/piscivore	warm	T	24	Centrarchidae	Y
Rock bass	*Ambloplites rupestris*	water col.	RKB	invert/piscivore	warm	I	25	Centrarchidae	
Warmouth	*Lepomis gulosus*	water col.	WM	invert/piscivore	warm	T	26	Centrarchidae	
Green sunfish	*Lepomis cyanellus*	water col.	GS	invert/piscivore	warm	T	27	Centrarchidae	
Bluegill	*Lepomis macrochirus*	water col.	BG	invert/piscivore	warm	T	28	Centrarchidae	Y
Common carp	*Cyprinus carpio*	benthic	CCP	omnivore	warm	T	29	Cyprinidae	
Brown bullhead	*Ameiurus nebulosus*	hider	BBH	invert/piscivore	warm	T	30	Ictaluridae	
Yellow bullhead	*Ameiurus natalis*	hider	YBH	invert/piscivore	warm	T	31	Ictaluridae	
Longnose sucker [2]	*Catostomus catostomus*	benthic	LNS	invertivore	cold	I	32	Catostomidae	
Salish Sucker [2]	*Catostomus catostomus*	benthic	SS	omnivore	cool	S	33	Catostomidae	
Largescale sucker	*Catostomus macrocheilus*	benthic	LSS	omnivore	cool	T	34	Catostomidae	
Bridgelip sucker	*Catostomus columbianus*	benthic	BLS	herbivore	cool	T	35	Catostomidae	
Mountain sucker	*Catostomus platyrhynchus*	benthic	MS	herbivore	cool	I	36	Catostomidae	
Chiselmouth	*Arocheilus alutaceus*	benthic	CLM	herbivore	cool	I	37	Cyprinidae	
Sculpins	*Cottus sp.*	benthic	COT	invertivore	cool	T	38	Cottidae	
Starry flounder	*Platicthys stellatus*	benthic	STF	invertivore	cold	S	39	Pleuronectidae	
Grass carp	*Ctenopharyngodon idella*	benthic	GCP	herbivore	warm	T	don't take	Ictaluridae	

1 - Cutthroat trout: if uncertain of subspecies, just call it CTT (*Oncorhynchus clarki*). Subspecies usually haven't been distinguished in past work. EIM doesn't distinguish fish subspecies yet. (2008).
2 - Same species, Salish Sucker appears to be dwarf form of Longnose. Salish is found west of Cascade crest. The Longnose is found east of the Cascade crest. EIM doesn't distinguish different forms.
3 - Some RBT hybridize with CTT so that fish have some characteristics of both species. Please note in field book if hybrids suspected.
Tolerance field describes overall pollution tolerance: S = sensitive, I = intolerant, T = tolerant

Use order of preference as a guide. Higher trophic level species preferred over lower level. Consider availability of fish, size, historical data available, mix of families/trophic levels per site, angler use.

Appendix D. Target Analytes and Reporting Limits

Table D-1. Reporting Limits for Chlorinated Pesticides in Fish Tissue.

Analyte	flag	Typical Desired Reporting Limit (ug/Kg)	NTR Water Quality Criterion (Tissue Equivalent - ug/Kg)	CAS
2,4'-DDD		0.5 - 1.0		53-19-0
2,4'-DDE		0.5 - 1.0		3424-82-6
2,4'-DDT		0.5 - 1.0		789-02-6
4,4'-DDD		0.5 - 1.0	45.0	72-54-8
4,4'-DDE		0.5 - 1.0	31.6	72-55-9
4,4'-DDT		0.5 - 1.0	31.6	50-29-3
Aldrin	x	0.5	0.65	309-00-2
alpha-BHC	x	0.5	1.7	319-84-6
beta-BHC		0.5 - 1.0	6.0	319-85-7
Chlorpyriphos		1.0 - 2.0		2921-88-2
cis-Chlordane (alpha-Chlordane)		0.5 - 1.0		5103-71-9
cis-Nonachlor		0.5 - 1.0		5103-73-1
Chlorthal-dimethyl (Dacthal)		1.0 - 2.0		1861-32-1
DDMU		0.5 - 1.0		1022-22-6
delta-BHC		0.5 - 1.0		319-86-8
Dieldrin	x	0.5	0.65	60-57-1
Endosulfan I		1.0 - 2.0	540	959-98-8
Endosulfan II		1.0 - 2.0	540	33213-65-9
Endosulfan Sulfate		1.0 - 2.0	540	1031-07-8
Endrin		1.0 - 2.0	3216	72-20-8
Endrin Aldehyde		1.0 - 2.0	3216	7421-93-4
Endrin Ketone		0.5 - 1.0		53494-70-5
Heptachlor	x	0.5	2.35	76-44-8
Heptachlor Epoxide	x	0.5	1.23	1024-57-3
Hexachlorobenzene		0.5 - 1.0	6.69	118-74-1
Lindane (gamma-BHC)		0.5 - 1.0	8.19	58-89-9
Methoxychlor		0.5 - 1.0		72-43-5
Mirex		0.5 - 1.0		2385-85-5
Oxychlordane		0.5 - 1.0		27304-13-8
Pentachloroanisole		0.5 - 1.0		1825-21-4
Toxaphene	x	2.0	9.80	8001-35-2
trans-Chlordane (gamma-Chlordane)		0.5 - 1.0		5103-74-2
trans-Nonachlor		0.5 - 1.0		39765-80-5

Flag: The RL for these analytes may need extra effort by MEL or other labs to achieve.

Table D-2. Reporting Limits for PCBs and PBDEs in Fish Tissue.

Analyte	flag	Typical Desired Reporting Limit (ug/Kg)	NTR Water Quality Criterion (Tissue Equivalent - ug/Kg)	CAS
PCB-aroclor 1260		1.0, 5.0, or 10.0 ppb (dependent on objectives and varies among samples)	5.3 *	11096-82-5
PCB-aroclor 1254			5.3 *	11097-69-1
PCB-aroclor 1248			5.3 *	12672-29-6
PCB-aroclor 1242			5.3 *	53469-21-9
PCB-aroclor 1232			5.3 *	11141-16-5
PCB-aroclor 1221			5.3 *	11104-28-2
PCB-aroclor 1016			5.3 *	12674-11-2
PCB congeners		0.5 - 5.0 ng/kg (depending on congener or co-eluting group)		
PBDE-047		0.5 - 1.0		5436-43-1
PBDE-049		0.5 - 1.0		
PBDE-066		0.5 - 1.0		189084-61-5
PBDE-071		0.5 - 1.0		
PBDE-099		0.5 - 1.0		60348-60-9
PBDE-100		0.5 - 1.0		189084-64-8
PBDE-138		0.5 - 1.0		182677-30-1
PBDE-153		0.5 - 1.0		68631-49-2
PBDE-154		0.5 - 1.0		207122-15-4
PBDE-183		0.5 - 1.0		
PBDE-184		0.5 - 1.0		
PBDE-191		0.5 - 1.0		
PBDE-209		1.0 - 6.0		1163-19-5

Flag: The RL for these analytes may need extra effort by MEL or other labs to achieve.
* value is for sum of PCBs.

Table D-3. Reporting Limits for PCDD/Fs in Fish Tissue.

Dioxin/Furan Congener		Required Detection Limit (ng/kg)	TEFs: WHO 2005	CAS
2,3,7,8-TCDD	x	0.03	1	1746-01-6
1,2,3,7,8-PeCDD	x	0.03	1	40321-76-4
2,3,4,7,8-PeCDF	x	0.1	0.3	57117-31-4
1,2,3,4,7,8-HxCDD	x	0.1	0.1	39227-28-6
1,2,3,4,7,8-HxCDF	x	0.1	0.1	70648-26-9
1,2,3,6,7,8-HxCDD	x	0.1	0.1	57653-85-7
1,2,3,6,7,8-HxCDF	x	0.1	0.1	57117-44-9
1,2,3,7,8,9-HxCDD	x	0.1	0.1	19408-74-3
1,2,3,7,8,9-HxCDF	x	0.1	0.1	72918-21-9
2,3,4,6,7,8-HxCDF	x	0.1	0.1	60851-34-5
2,3,7,8-TCDF	x	0.1	0.1	51207-31-9
1,2,3,7,8-PeCDF	x	0.1	0.03	57117-41-6
1,2,3,4,6,7,8-HpCDD	x	0.2	0.01	35822-46-9
1,2,3,4,6,7,8-HpCDF	x	0.2	0.01	67562-39-4
1,2,3,4,7,8,9-HpCDF	x	0.2	0.01	55673-89-7
1,2,3,4,6,7,8,9-OCDD	x	0.5	0.0003	3268-87-9
1,2,3,4,6,7,8,9-OCDF	x	0.5	0.0003	39001-02-0

Flag: The RL for these analytes may need extra effort by MEL or other labs to achieve.

Table D-4. Reporting Limits for Metals in Fish Tissue.

Metal	Symbol	Reporting Limit (mg/kg, wet wt)	Fish Tissue: EPA Method Number
Arsenic	As	0.1	200.8
Cadmium	Cd	0.1	200.8
Chromium	Cr	0.5	200.8
Copper	Cu	0.1	200.8
Lead	Pb	0.1	200.8
Mercury	Hg	0.017	245.6
Nickel	Ni	0.1	200.8
Selenium	Se	0.5	200.8
Zinc	Zn	5	200.8

Appendix E. Glossary, Acronyms, and Abbreviations

Glossary

Anadromous: Types of fish, such as salmon, that go from the sea to freshwater to spawn.

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.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is 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.

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

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

Salmonid: Fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): 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 standard and are not expected to improve within the next two years.

Acronyms and Abbreviations

CP	Chlorinated pesticides
DDT	dichloro-diphenyl-trichloroethane
DOH	Washington State Department of Health
e.g.	For example
EA	Environmental Assessment (Program)
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
FFCMP	Freshwater Fish Contaminant Monitoring Program
GIS	Geographic Information System software
GPS	Global Positioning System
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NTR	National Toxics Rule
PBDE	polybrominated diphenyl ethers
PBT	persistent, bioaccumulative, and toxic substance
PCB	polychlorinated biphenyls
PCDD/F	poly-chlorinated dibenzo-p-dioxins and -furans
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedure
SRM	Standard reference materials
TMDL	(See Glossary above)
USGS	U.S. Geological Survey

WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSTMP	Washington State Toxics Monitoring Program

Units of Measurement

°C	degrees centigrade
dw	dry weight
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
mg	milligram
mg/Kg	milligrams per kilogram (parts per million)
mm	millimeter
ng/g	nanograms per gram (parts per billion)
ng/Kg	nanograms per kilogram (parts per trillion)
pg/g	picograms per gram (parts per trillion)
ug/g	micrograms per gram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ww	wet weight