APPENDIX B

TECHNICAL MEMORANDUM: EVALUATION OF EXISTING FISH TISSUE DATA

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UPPER COLUMBIA RIVER RI/FS

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ACRONYMS AND ABBREVIATIONS

AFDW	ash-free dry weight
ANOVA	analysis of variance
AWQC	ambient water quality criteria
B.C. MoE	British Columbia Ministry of Environment
BCF	bioconcentration factor
BERA	baseline ecological risk assessment
CBR	critical body residue
CCME	Canadian Council of Ministers of the Environment
COI	chemical of interest
CRIEMP	Columbia River Integrated Environmental Monitoring Program
CV	coefficient of variation
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DL	detection limit
DMA	dimethylarsenic acid
DOH	U.S. Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EVS	EVS Environmental Consultants, Inc.
FSCA	fish sample collection area
NCBP	National Contaminant Biomonitoring Program
NOAEC	no-observed-adverse-effects-concentration
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PCOI	potential chemical of interest
QA/QC	quality assurance and quality control
QAPP	Quality Assurance Project Plan
RESET	Regression Equation Specification Error test
RI/FS	remedial investigation and feasibility study
RM	River Mile
SLERA	Screening Level Ecological Risk Assessment
SSD	species sensitivity distribution
TAI	Teck American Incorporated
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TEF	toxic equivalency factor
TEQ	toxic equivalent

TRA	tissue residue approach
TRV	toxicity reference value
UCR	Upper Columbia River
USGS	U.S. Geological Survey
ww	wet weight

B1 INTRODUCTION

Teck American Incorporated (TAI) is conducting a remedial investigation and feasibility study (RI/FS) for the Upper Columbia River (UCR), inclusive of reaches from the U.S.-Canadian border to the Grand Coulee Dam (Figure B1). Among the data that will be considered for analysis of risks during this process are chemical concentrations in tissues of fish. Several studies have generated fish tissue chemistry data for the UCR since the early 1970s, and the U.S. Environmental Protection Agency (EPA) performed extensive sampling of fish tissue for chemical analysis in September and October of 2005 as part of Phase I of the RI/FS. USEPA (2007a) recently published their evaluation of the 2005 fish tissue data.

As part of the UCR RI/FS, TCAI will conduct a baseline ecological risk assessment (BERA) for the UCR Site. One or more species and size classes of fish will likely be considered ecological receptors in the BERA, and several species and size classes will be sampled for chemical analysis to assess risks to piscivorous fish and wildlife, and to people. This appendix is intended to address fish tissue chemistry data collected to date for the UCR, specifically to:

- Determine the usefulness of historical (i.e., pre-2005) fish tissue data and the 2005 USEPA (2007a) fish tissue data for the ecological risk assessment and for scoping and planning future fish tissue sampling programs and the BERA.
- Analyze the historical and 2005 data to identify potential spatial and temporal patterns in residues of chemicals in fish from the UCR.
- Evaluate fish tissue data interpretations by authors of historical reports, and by USEPA (2007a).
- Identify candidate reference areas and describe reference conditions by compiling available tissue data from reference area lakes in Eastern Washington. Compare the reference area data with EPA's 2005 site data.
- Identify candidate approaches for evaluating potential toxicity to fish, and identify candidate toxicity benchmarks for assessment of toxicity to fish. Compare UCR fish tissue concentrations to fish toxicity benchmarks as appropriate.
- Evaluate the comments on USEPA (2007a) provided by the participating parties.
- Gather and evaluate information on polybrominated diphenyl ethers (PBDEs) in fish tissue.

Based on these evaluations, recommendations for conducting assessment of risks to fish and piscivorous wildlife as part of the UCR BERA are identified in the final section of this appendix.

B2 USEFULNESS OF EXISTING UCR FISH TISSUE DATA FOR ECOLOGICAL RISK ASSESSMENT

Several studies involving the collection and chemical analyses of fish tissue have been conducted in the UCR since the early 1970s. Target chemical analytes have included metals[1], polychlorinated biphenyls (PCBs), dioxins and furans, and pesticides (Hopkins et al. 1985; Johnson 1991; Johnson et al. 1988, 1989, 1990, 1991a,b; Johnson and Yake 1989; Serdar et al. 1991, 1994; Johnson and Serdar 1991; Munn et al. 1995; EVS Environmental Consultants, Inc. [EVS] 1998; Hinck et al. 2004, 2006; U.S. Geological Survey [USGS] 2006). Details of each of these documents are provided by USEPA (2006). More recently, EPA collected and analyzed fish tissue from six locations across the UCR Site in 2005 (USEPA 2007a). Deviations from the original study design are documented by USEPA (2007a).

To determine the usefulness of available fish tissue data for the purposes of the BERA, criteria for determining the applicability of data for ecological risk assessment and for scoping purposes are briefly discussed; and the historical and 2005 data for UCR fish tissue are compared to these criteria.

B2.1 CRITERIA FOR APPLICATION OF DATA TO ECOLOGICAL RISK ASSESSMENT

To determine the value of the existing fish tissue chemistry data for ecological risk assessment, acceptability criteria were identified according to the specific potential uses of the data for the UCR BERA. Fish tissue chemistry data may have one or more of the following uses in the BERA:

Assessment of exposure to fish

Assessment of toxicity to fish

Assessment of exposure to piscivorous fish and wildlife.

Criteria for the acceptability of fish tissue data for each of these applications are listed below. The discussion assumes that any analytical chemistry data have undergone an independent quality assurance and quality control (QA/QC) review.

For the three uses of fish tissue chemistry data listed above, the following categories of information can be used to evaluate the historical fish tissue data sets:

[1] Metals include metalloids.

Analytical history

Transparent analytical history

Documentation of laboratory reports and QA review available

Quality assured according to EPA protocols

Use of standard analytical methods.

Spatial coverage

Representation of areas in the UCR relevant to the risk assessment

Averaging procedures (e.g., compositing, spatial interpolation to derive averages) are appropriate to the risk questions.

For the following specific uses of the data identified below, additional considerations include those listed:

For comparison to toxicological data

Relevant tissue

Relevant life stage

Relevant chemical form (e.g., congeners vs. total PCBs, total mercury vs. methyl mercury) chemicals of interest (COIs) are reported

Seasonal or life-stage consistency with fish used in relevant toxicity tests

Compatible and appropriate units of exposure

Toxicologically important ancillary data are reported (e.g., percent lipid, fish age).

For assessment of exposure to piscivores

Size classes are appropriate to predators prey size preference

Species can be accessed by predators (i.e., fish species does not occupy a habitat that is physically inaccessible to the piscivore)

Appropriate tissue (e.g., whole body) is represented or can be estimated.

- For analysis of spatial or temporal trends

Comparable age

Comparable size

Same species.

For a BERA, the data should also be reasonably recent, to effectively describe the current (i.e., baseline) conditions.

While it may not be possible or practical to evaluate historical data using all of the above mentioned acceptability criteria, they provide a framework for assessing the applicability of the available data to the risk assessment and the BERA.

B2.2 EVALUATION OF HISTORICAL UCR FISH TISSUE DATA FOR USE IN ECOLOGICAL RISK ASSESSMENT

As noted previously, several studies involving the collection and chemical analyses of fish tissue have been conducted in the UCR since the early 1970s (Table B1). Target chemical analytes have included metals, PCBs, dioxins and furans, and pesticides. This section evaluates the applicability of historical UCR fish tissue data (those data preceding EPA's 2005 investigation) to the ecological risk assessment, within the framework outlined in Section B.2.1.

The set of historical reports preceding EPA's 2005 study, ranges in subject matter and focus, sample numbers, extent of sampling, tissue types, analytes, and the degree to which data analysis was presented (Hopkins et al. 1985; Johnson et al. 1988, 1989, 1990, 1991a,b; Serdar et al. 1991, 1994; Johnson and Yake 1989; Munn et al. 1995; EVS 1998; Hinck et al. 2004; USGS 2006). EPA has conducted a systematic review of some of these historical fish tissue reports to ensure that the data were of acceptable quality for the remedial investigation process. EPA's data evaluation, which included QA/QC review by an EPA chemist, is documented by USEPA (USEPA 2004a,b); analytical data are included as Appendix F of the RI/FS work plan (USEPA 2008). EPA's analysis classified several of the reports providing historical fish tissue data for the UCR as either Category 2 (containing data of partially known quality) or Category 3 (containing data of unknown quality). None of those reports reviewed by EPA were in Category 1 (known quality). All of the historical documents containing fish tissue data have been individually summarized by USEPA (2005a).

To supplement EPA's technical review, the applicability of the historical data to analysis of ecological risk relative to the framework described in Section B.2.1 was evaluated. The historical data are considered to have limited applicability to ecological risk assessment for the following reasons:

- Much of the data are for fillet tissue. For assessment of risks to piscivorous fish and wildlife, and for assessing exposures and toxicity of some chemicals to fish, whole body tissue residues are more relevant than fillet residues.
- Whole body samples in the pre-2005 historical data are primarily for largescale sucker *(Catastomus macrocheilus)*, with the most recent data from 1997, and therefore do not describe current conditions in the UCR.
- Historical data for whole body sucker do not differentiate gut contents from other tissues. This may confound interpretation of exposure and risk to some wildlife consumers of largescale sucker (i.e., those that do not consume whole fish), and the inclusion of

sediment in a whole body sample does confound understanding exposures of the fish to the potentially biologically active fraction of chemicals.

Concentrations of chemicals in selected tissues such as fish eggs and liver samples were measured infrequently and sporadically by the historical studies, precluding analysis of patterns.

Species sampled tended to be those targeted by anglers, and the samples represented relatively large size classes within those species. Although some of the species represented prey of piscivorous fish and wildlife, other species (e.g. sculpins, dace) that are more likely to be prey are not represented in the historical data set.

Spatial representation in the UCR is uneven, and sample sizes of each species and tissue type vary. There is a mixture of individual fish and composite samples for both fillet and whole body samples. These differences between data sets make it difficult to generalize about exposures or risks using the pre-2005 historical data.

In spite of the limitations identified above, the pre-2005 historical data do provide insights into patterns of exposure among fish species (Table B2). Spatial and temporal trends described by the authors of the primary reports are summarized in Section B.3.2.1 below.

B2.3 EVALUATION OF 2005 UCR DATA FOR USE IN THE ECOLOGICAL RISK ASSESSMENT

EPA collected samples of the following fish species:

- Burbot (*Lota lota*)
- Largescale sucker *(Catastomus macrocheilus)*
- Rainbow trout (*Oncorhynchus mykiss*, including wild and hatchery-reared fish)
- Lake whitefish (*Coregonus clupeaformis*)
- Mountain whitefish (*Prosopium williamsoni*)
- Walleye (*Sander vitreum*).

Fish were collected from six fish sample collection areas (FSCAs) distributed throughout the UCR Site (Figure B1), with FSCAs selected to correspond to the general locations of focus areas for sediment samples that also were collected in 2005 (USEPA 2006). Individual fish were sexed, aged, and their lengths and weights measured. Walleye and rainbow trout from FSCAs 1, 3 and 6 were sectioned, and fillet and non-fillet (i.e., offal) tissues analyzed separately; mass-weighted concentrations of individual tissue classes were used to estimate whole body concentrations. Samples of fillet tissues and whole body fish for all species, other than largescale sucker, were submitted as composites for chemical analyses. Composites generally consisted of tissues from five fish, with a few exceptions noted by EPA (Section 2.2.4, USEPA 2007a).

Largescale suckers were analyzed whole, or as paired gut samples and gutless whole body samples. To estimate concentrations of chemicals in the sucker gut contents, the full stomach and tissues from the stomach, the esophagus, and the intestines were excised from the fish, and each was analyzed as an individual sample, separate from the remaining fish tissue. These samples are referred to as "gut/gut contents" samples to acknowledge the presence of the fish stomach tissue in the sample. Analytical results for these samples were used by USEPA (2007a) to evaluate the contribution of sediment in sucker stomachs to whole-body chemical concentrations.

While EPA's original sampling design could not be achieved because some target species were not available in some areas, the final sampling design was relatively systematic and balanced (Table B3), allowing for spatial and interspecific statistical comparisons of tissue chemistry. Note that mountain whitefish was only collected in FSCA 1 (where no lake whitefish were available), and that among rainbow trout, those considered wild rainbow dominated the sample upstream (FSCAs 1 and 2), while hatchery-reared rainbow were more abundant in samples in more downstream areas (FSCAs 3, 4, 5 and 6).

EPA's report on this sampling event (USEPA 2007a) provides a summary of the methods, analytical results, statistics and some statistical analyses, data gaps and recommended analyses. These evaluations were critically reviewed, and are summarized in Section B.3 herein. The text below examines whether the data reported by USEPA (2007a) can be used for the ecological risk assessment, using the criteria defined in Section B.2.1. Section B.3.2 describes spatial and interspecific patterns that can be derived using the EPA data (USEPA 2007a).

In describing their data quality objectives for fish tissue collection, USEPA (2007a) provided the following Problem Statements:

"Contaminants are likely present in edible fish at concentrations that pose unacceptable risk to some people who consume fish from the UCR."

"Determine whether measures are needed to prevent exposure of fish or bioaccumulation of site contaminants from the UCR to contaminant concentrations that pose unacceptable risk to fish."

"Contaminants may be present in fish and invertebrates at concentrations that pose unacceptable risk to wildlife (birds and mammals) in the UCR Site."

Although the 2005 data can be used for some aspects of the UCR BERA, they are considered insufficient to fully characterize risks to fish and wildlife. For assessment of risks to piscivorous fish and wildlife, EPA's data (USEPA 2007a) have the following limitations:

All fish represented in the 2005 data set were relatively large, ranging in size from 35 to 60 cm (14 to 24 inches). These sizes are greater than the preferred sizes of many piscivorous fish and wildlife found at the UCR Site.

- Species sampled do not necessarily represent those that are most likely to be the prey of piscivorous fish and wildlife, such as sculpins (*Cottus* spp.).
- For assessment of risks to fish resulting from metals exposures, both fillet and whole body concentrations of metals are considered to be unreliable indicators or predictors of toxic effects (Section B.5.1.2), unless a specific exposure-response relationship can be derived (Meador 2006). Therefore, while the 2005 data may be of use in characterizing the degree of exposure of fish to metals, they may not be as useful for assessment of risks to fish. However, whole body concentrations of organic compounds, such as PCBs, dioxins, and furans can be used to assess potential toxicity to fish.
- Assessment of exposures of fish to all chemicals included by USEPA (2007a) may be confounded for some species when a composite sample was created with individuals that have widely varying ages. This issue affects longer-lived species (i.e., for which individuals of similar size may differ greatly in age), particularly the largescale sucker, but may be a confounding factor for other species as well. It will affect both the comparability of samples in space and time, and the interpretation of the importance of the exposure relative to other species and to toxicity benchmarks.

Despite these limitations, the 2005 tissue chemistry data have value in both the exposure and risk assessments for piscivorous fish and wildlife, and in characterizing spatial and species-specific patterns of exposure. However, the overall 2005 data set is considered insufficient for a complete evaluation of risks to piscivorous fish and wildlife. Specific data needs and recommended future analyses for a fish and wildlife risk assessment are provided in Section B.8.

B3 ANALYSIS OF EXISTING UCR FISH TISSUE DATA

As described in Section B.2, the available data to describe fish tissue chemistry in the UCR consist of the pre-2005 historical data generated for a variety of purposes, as well as the 2005 data generated by USEPA (2007a). Although it was concluded in Section B.2 that both the pre-2005 and 2005 fish tissue data have limitations for use in assessing baseline risks to fish, both are helpful in understanding temporal trends and other patterns in fish exposures, which can be useful for the purpose of the BERA. Among the various datasets that are available to describe chemical concentrations in fish tissues within the UCR (Table B1), the 2005 fish tissue dataset (USEPA 2007a) represents the most comprehensively designed and systematically collected dataset. It also provides relatively uniform spatial coverage within the study area. The 2005 data therefore provide significant fish exposure information relevant to the BERA.

This section uses data provided by the pre-2005 historical studies and the 2005 data set to address Objectives 2 and 3 of this appendix. Independent analyses of the data are conducted, and temporal, spatial and interspecific patterns are evaluated using statistical comparisons among chemical concentrations in fish tissues. In these types of comparisons, uncertainties resulting from the influence of differing food habits, fish sizes, patterns of bioaccumulation, or lipid contents (for nonmetabolizable organic chemicals) (Bryan 1979; Gobas and Mackay 1987; Michaels and Flegal 1990) are unavoidable. Nevertheless, these analyses provide insights useful for developing a fish sampling plan, and for the BERA.

Since the pre-2005 reports and USEPA (2007a) provide similar analyses to some extent, relevant sections of these reports are critically reviewed. The data from key historical studies are also compared to results of recent EPA analyses of the 2005 dataset (USEPA 2007a). Tissue concentrations are expressed in wet weight (ww) unless otherwise noted.

B3.1 SUMMARY OF PRE-2005 HISTORICAL UCR FISH TISSUE DATA

A summary of the chemical concentrations reported for fish tissue samples in pre-2005 studies is provided in Table B2. While these data do not provide an adequate basis for ecological risk assessment, some spatial and temporal patterns have been observed, which can help to focus sampling programs and the BERA.

Historical fish tissue studies have focused primarily on seven metals (i.e., arsenic, cadmium, copper, lead, mercury, selenium, and zinc), but some data for pesticides, dioxins, furans, and PCBs are also included. Historical patterns for metals and organic compounds are reviewed briefly below.

B 3.1.1 Metals

On the basis of data collected in the 1980s and 1990s, copper, lead, and zinc concentrations in fish tissue generally decline with increasing distance downstream from Northport (Johnson et al. 1989; Serdar et al. 1994). For example, mean lead concentrations in whole body largescale suckers measured at River Mile (RM) 732 below Northport, RM 680 above Gifford, and RM 635 near Seven Bays were 6.09, 2.00, and 0.39 mg/kg ww, respectively (Johnson et al. 1988). However, it should be noted that these concentrations may have been influenced to an unknown degree by sediment in the sucker guts, as the guts were not removed from the fish prior to chemical analysis. Mercury concentrations did not follow the spatial pattern observed for copper, lead, and zinc. Cadmium, copper, lead, and zinc concentrations in fish were greater than national averages in the historical data set (Serdar et al. 1994). Historical concentrations of mercury were generally higher in walleye and largescale sucker relative to other species (Table B2). Mercury in walleye generally declined from 1994 through 1998 (Munn et al. 1995; Munn 2000).

Upstream of the U.S.-Canadian border, several metals in fish tissue were stable over time or declined from 1995 to 1999 (Aquatic Resources Ltd 2001; Teck Cominco 2001), including arsenic, cadmium, copper, lead, mercury, thallium, and zinc.

B 3.1.2 Organic Compounds

Washington State Department of Ecology (Ecology), USGS, and EPA studied dioxin/furan concentrations during the 1990s, and a summary of their data is presented in Table B2. Dioxins and furans were detected in several fish species, including kokanee *(Oncorhynchus nerka)*, lake whitefish, mountain whitefish, rainbow trout, walleye, and white sturgeon (*Acipenser transmontanus*). 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF) was the predominant form among dioxins/furans found in UCR fish (EVS 1998; Johnson et al. 1991a, b; Munn 2000). Historically, the ranges of 2,3,7,8-TCDF wet weight concentrations found in lake whitefish and white sturgeon were broader than the range in other fish species within the UCR (Table B2).

Tissue concentrations of dioxins and furans measured in the mid-1990s were found to substantially decrease following improvements in the Zellstoff Celgar Ltd. bleached kraft pulp mill (EVS 1998; Munn 2000; Serdar et al. 1994). For example, EVS (1998) found that mean concentrations of 2,3,7,8-TCDF in lake whitefish declined either 7-fold (on a wet-weight basis) or 34-fold (when normalized for lipid content) from 1990 to 1994. These differences were highly significant ($p \leq 0.01$; Spearman's rank correlation coefficient). Similarly, EVS (1998) reported substantial declines in tetrachlorodibenzo-*p*-dioxin (TCDD) and 2,3,7,8-TCDF concentrations in kokanee, rainbow trout, walleye, and white sturgeon. Hinck et al. (2004) found dioxin-like potency of extracts of whole fish collected in 1997 from the UCR to be similar to, or lower, than those measured in fish from the middle or lower Columbia River. Decreasing concentrations of dioxins and furans have also been observed above the U.S.-Canadian border since 1992

(Antcliffe et al. 1997a; 1997b; British Columbia Ministry of Environment [B.C. MoE] 2000; 2001). Overall, pre-2005 historical data suggest that dioxin/furan concentrations have declined in fish tissues.

PCBs Aroclors 1254 and 1260 were the primary PCBs measured in a variety of fish species from the UCR since the early 1970s. In 1984 and 1990, Ecology found PCB concentrations in fish from the UCR to be less than national averages, and lower than in the nearby Spokane River (Hopkins et al. 1985; Johnson 1991).

Tissue concentrations of PCBs in fish from the Spokane River (Ecology 1995; Jack and Roose 2002; Serdar et al. 1994; Johnson 2000) have typically been higher than those found in fish from the UCR. For example, Serdar et al. (1994) measured concentrations of PCBs in fillet tissues of walleye, smallmouth bass (*Micropterus dolomieu*), kokanee, rainbow trout, largemouth bass (*Micropterus salmoides*), mountain whitefish, and yellow perch (*Perca flavescens*); and whole body tissues of largescale suckers from the Spokane Arm of Lake Roosevelt and the Spokane River (i.e., Long Lake, above Nine Mile Dam, and above Upriver Dam). The authors found that total PCBs in fillets and whole body tissues from the Spokane Arm ranged from 15 to 92 µg/kg ww and 630 µg/kg ww, respectively, while concentrations from the Spokane River ranged from 9.4 to 1,124 µg/kg ww and 450 to 2,775 µg/kg ww, respectively. The majority of fish tissue samples collected from the UCR during that time had concentrations of Aroclors 1254 and 1260 lower than 500 µg/kg ww, although the maximum concentrations of these Aroclors in samples of sucker species, carp (*Cyprinus carpio*), and walleye from the UCR were 4,800, 1,900 and 3,600 µg/kg, respectively (Table B2).

EPA and USGS studied PCB concentrations in fish from Lake Roosevelt in the 1990s (EVS 1998; Munn 2000)[2]. These studies evaluated tissues from kokanee, lake whitefish, rainbow trout, smallmouth bass, walleye, and white sturgeon (Table B2). EVS (1998) found PCB concentrations in wild rainbow trout fillets to be higher in the upper reach of the UCR, near Northport (mean total PCB concentration = 88 µg/kg ww) than in parts of the lower reservoir that included a sampling reach just downstream of the Spokane Arm, waters within the Sanpoil Arm, and a region just above the Grand Coulee Dam (mean total PCB concentration = 22 µg/kg ww). PCB concentrations in wild rainbow trout fillets were higher than the concentrations in hatchery-raised rainbow trout. This trend was not found in other fish species. Concentrations of PCBs in the lower reach of Lake Roosevelt were shown to have substantially decreased in

[2] Definitions of “upper,” “middle,” and “lower” differ for EVS (1998) and Munn et al. (2000). EVS (1998) does not specify the river miles sampled, but data provided are from a reach near Northport, centered approximately at RM 730 (upper); a reach at the mouths of the Colville River and Sherman Creek and centered approximately at RM 700 (middle); and a three separate sampling areas consisting of waters just upstream of the Grand Coulee Dam, the mouth of the Sanpoil Arm, and the Seven Bays area (lower). Munn et al.’s (2000) data are from the “upper” UCR, consisting of the reach between Northport and Kettle Falls, and the “lower” reach, between the Spokane River and Grand Coulee Dam. For locations established for the UCR RI/FS, see Figure B1.

wild rainbow trout from 1994 to 1998 (Munn 2000) and in largescale suckers from 1976 to 1997 (Hinck et al. 2004).

Pesticide residues have been monitored infrequently in fish tissues collected from the UCR. USGS (2006) monitored pesticide residues at Grand Coulee Dam from 1969 to 1986 through the National Contaminant Biomonitoring Program (NCBP). Whole body composite samples for several species (including yellow perch, walleye, largescale sucker, northern pikeminnow [*Ptychocheilus oregonensis*], carp, channel catfish [*Ictalurus punctatus*], and others) were analyzed for select pesticides (varying by year). Pesticides detected at least once by the NCBP were chlordane (alpha and gamma), Dacthal™,[3] dieldrin, *p,p′*-DDD (dichloro-diphenyl-dichloroethane), *p,p′*-DDE (dichloro-diphenyl-dichloroethene), *p,p′*-DDT, endrin, hexachlorobenzene, heptachlor epoxide, lindane (alpha and gamma), nonachlor (*cis* and *trans*), pyrazon, and toxaphene. Since the completion of the NCBP, the only pesticides evaluated and detected in subsequent investigations of fish tissues in the UCR were *p,p′*-DDE, and other DDT metabolites (Johnson 1991; Hinck et al. 2004).

Concentrations of *p,p′*-DDE measured in a variety of fish species by the NCBP (1969 to 1986) ranged from ≤10 to 3,000 µg/kg ww. Hinck et al. (2004) found that 1997 concentrations of DDT and its metabolites were significantly lower ($p \leq 0.05$) than historical concentrations in the UCR (i.e., NCBP data) and significantly ($p \leq 0.05$) lower than concentrations from tissues collected from the Middle and Lower Columbia River (i.e., below Grand Coulee Dam).

Other pesticides analyzed in fish tissue from the UCR by the USGS in 1997 but never detected included chlordane (alpha, gamma, and oxy), dieldrin, DDT and metabolites, endrin, hexachlorobenzene, heptachlor epoxide, lindane (alpha, beta, delta, and gamma), mirex, nonachlor (*cis* and *trans*), and toxaphene. In summary, review of the historical data for pesticides in fish tissues indicates that concentrations of *p,p′*-DDE have been decreasing over time, DDT metabolite concentrations are lower than they are in other portions of the Columbia River, and other pesticides are infrequently detected in the UCR.

B3.2 ANALYSIS OF 2005 UCR FISH TISSUE DATA

Because of the more comprehensive nature and balanced design of the 2005 fish tissue data set, analysis of those data allows for greater insights into patterns of fish exposure than does analysis of the pre-2005 data sets. This section describes patterns in the distribution of chemicals among the species sampled, as well as the spatial distribution of chemicals in fish tissue. USEPA (2007a) conducted several similar statistical analyses and other inquiries using different methods. Because the 2005 data will be used to support the BERA, differences

[3] Dacthal™ is a pre-emergent herbicide also known as DCPA, DAC, and dimethyl ester 2,3,5,6-tetracholoroterephthalic acid.

between the two approaches that have the potential to affect the BERA are identified and discussed in Section B.3.2.2.

B 3.2.1 Spatial Patterns in 2005 UCR Fish Tissue Data

Analyses of spatial and interspecific patterns using the 2005 tissue data set were conducted;results are summarized and interpreted below.

To analyze the data for spatial and interspecific patterns the following methods were applied:

- Concentrations of non-detected (*U*-qualified data) chemicals were conservatively assumed to equal the detection limit (DL). *J*- (estimated) or *K*- (biased) qualified data were analyzed at the value reported.

- Age was found to correlate positively with length and weight, so length was used to evaluate the potential for size- or age-related differences within species.

- Whole body concentrations were calculated from concentrations in fillet and offal samples that had been analyzed separately.

- Tests for normality and homogeneity of variance for data sets pooled across the sampling area within species were conducted, and data were transformed appropriately before conducting statistical tests.

- One-way analysis of variance (ANOVA) was used for normal data sets, although the Kruskal-Wallis test was used for the non-parametric data sets. Comparisons among species within FSCAs were conducted using the Kruskal-Wallis test.

- Patterns in PCB concentrations were evaluated using only data for Aroclor 1254 or Aroclor 1260, because all other Aroclors (except Aroclor 1016, frequency of detection = 2 percent) were not detected in UCR fish tissue, and PCB congeners were not analyzed. Data analyses are conducted for the sum of these two Aroclors, referred to as "Aroclor 1254/1260" herein.

- Among the dioxins and furans, only 2,3,7,8-TCDF was consistently detected, so only concentrations of this chemical were considered in spatial and interspecific comparisons.

The RI/FS work plan also provides summary information on the chemistry of the 2005 fish tissue (Appendix F), and is presented herein (Attachment B1), for completeness.

B 3.2.1.1 Metals

Spatial variation of metal concentrations among FSCAs in the UCR was common, but the magnitude of variation differed among the fish species evaluated. To determine which of the metals in each species and in each tissue type were at concentrations that differed significantly in different areas of the UCR, concentrations of each metal in each tissue type (whole fish, fillets, gutless whole bodies or gut/gut contents for suckers) within each species were compared among FSCAs using ANOVA on non-transformed (normal) or log-transformed data; or using the Kruskal-Wallis test for non parametric datasets. For each species, all composite sample data available for any tissue analyzed were used. Whole body estimates based on fillet and offal concentrations were also used where available (FSCAs 1, 3, and 6). Mean concentrations of several metals differed significantly for various species, and for fillet and whole body tissues, but not for all metals in any one species or tissue type, nor for all species for any given metal. Results indicating existence of significant differences within a species and tissue type, and among FSCAs for selected metals are summarized in Table B4 for burbot, walleye, and largescale sucker. Largescale suckers, burbot, and walleye tended to have the highest whole body metals concentrations among the fish when averaged across the UCR (with the exception of selenium in mountain whitefish) (Figures B2 through B11), so spatial patterns evident in these species are highlighted.

Largescale Sucker

The greatest spatial variation occurred in whole body metals concentrations in largescale suckers (Table B4). Spatial differences among FSCAs for this species resulted primarily from relatively greater metals concentrations measured at FSCAs l, 2 and/or 3, with the exceptions of mercury and selenium (Figure B12). Arsenic was significantly different ($p \leq 0.5$) among FSCAs in whole bodies and in gut/gut contents samples, but not in gutless whole bodies. This could indicate that the non-gut fish tissues were not necessarily as impacted by elevated metal concentrations in the system as might appear to be the case on the basis of whole body (including gut contents) measurements. Rather, the gut/gut contents were the reason for the spatial variation observed for arsenic, as well as for mercury and selenium (Table B4). Mean concentrations of copper in whole body tissue differed by almost an order of magnitude between the most upstream collection area (FSCA 1) and the one at Marcus Flats (FSCA 3). Other metals, such as lead and zinc, differed by a factor 3 to 5 over the length of the river, with the greatest mean concentrations measured upstream. Mercury concentrations differed by a factor of 3 between FSCAs 1 and 3, but in this case, the greatest measured concentration was in whole body tissue from FSCA 3. In many cases, however, spatial variation in tissue concentrations resulted in significant differences among FSCAs even when the magnitude of differences was not large.

Burbot

The least spatial variation in metal concentrations was found in burbot; mean concentrations of most metals in whole burbot were not significantly different among FSCAs (Table B4). However, although mean arsenic concentrations only ranged from 0.64 and 0.87 mg/kg ww (FSCAs 3 and 6, respectively), the differences were statistically significant (ANOVA, $p=0.033$).

Selenium in burbot was also significantly different among stations (ANOVA, $p = 0.005$), and tended to decline with distance from the border (USEPA 2007a).

Walleye

Whole body concentrations of most metals in walleye differed by less than 50 percent across the entire study area, but concentrations of chromium, copper, lead and selenium (and several other metals) were greatest or nearly greatest at FSCA 4, near Inchelium (Figure B13). Mercury concentrations tended to increase in whole body, fillet, and offal of walleye moving downstream, and were greatest in FSCAs 5 and 6.

B3.2.1.2 Organic Compounds

Results of statistical comparisons of tissue concentrations among FSCAs for each tissue type and each species are provided by TCAI (2007). Both normal and lipid-normalized concentrations were evaluated for spatial differences. A summary of observed statistical differences among FSCAs is provided below.

2,3,7,8-TCDF

Lipid-normalized concentrations of 2,3,7,8-TCDF in whole bodies of largescale sucker, lake whitefish or rainbow trout did not differ significantly ($p>0.05$) among FSCAs. Lipid-normalized 2,3,7,8-TCDF concentrations in burbot, walleye fillet and whole walleye differed significantly ($p\leq0.05$) among stations (Figure B14). The maximum lipid-normalized 2,3,7,8-TCDF concentration for burbot was from near Inchelium (FSCA 4), and was higher than at any other location. Both wet-weight and lipid normalized 2,3,7,8-TCDF concentrations in whole body and fillet tissues of walleye were significantly different ($p\leq0.05$) among FSCAs. Lipid-normalized concentrations in whole bodies of walleye from FSCAs 1 and 6 were higher than other collection areas (Figure B14).

Aroclor 1254/1260

Concentrations of Aroclor 1254/1260 in whole bodies of largescale suckers and burbot did not show a significant pattern among FSCAs. Concentrations of Aroclor 1254/1260 in whole bodies and fillets of walleye (wet-weight and lipid normalized) from FSCAs 3 and 4 were lower than at all other FSCAs, and lipid-normalized Aroclor 1254/1260 concentrations were highest in whole walleye from FSCAs 1 and 2 (Figure B14). Walleye fillets from FSCAs 1, 3, and 6 showed a general decrease from north to south. Lipid-normalized Aroclor 1254/1260 concentrations in whole lake whitefish appear to decline with distance from Northport, while whole wild rainbow trout generally followed the same pattern as whole walleye, with lowest concentration at FSCAs 3 and 5. The differences between FSCAs in whole wild rainbow and lake whitefish were not significant.

B 3.2.1.3 Interspecific Differences

Metals

Because many data were neither normally nor lognormally distributed, and because variances differed among species, comparisons of metal concentrations among species at each FSCA were made using the Kruskal-Wallis non-parametric test. In nearly every case, differences among species were significant ($p \leq 0.05$). Because the concentrations of each metal in largescale sucker whole body tissues were often much greater than concentrations in all other species, the Kruskal-Wallis procedure was repeated with largescale suckers removed from the data set. From 84 tests (14 trace elements at six collection areas), only nine were non-significant, with $p > 0.05$ (data not shown). However, as with the spatial comparisons, in many cases, the differences were not large (Figures B2 through B11).

Mean tissue concentrations of lead in whole body samples of largescale suckers were more than 10 times greater than those of rainbow, walleye and whitefish in each FSCA (Figure B15). In addition to lead, whole body largescale suckers had the greatest mean concentrations of cadmium, chromium, cobalt, manganese, and nickel at each FSCA (Attachment B1).

Mean tissue concentrations of total arsenic in burbot were 2 to 3 times greater than for all other species in each FSCA (Figure B16). Mean total arsenic concentration was greatest at FSCA 6, near the Grand Coulee Dam (at 0.87 mg/kg ww). The arsenic speciation results indicated that accumulation of the organic arsenic species, dimethylarsenic acid (DMA), in burbot tissue explains the difference. DMA in burbot whole body tissue ranged from 0.50 mg/kg ww in FSCA 3 to 0.78 mg/kg in FSCA 6. All other fish species had whole body concentrations of DMA less than 0.02 mg/kg ww.

The spatial pattern of mercury accumulation in fish tissue appeared to be related primarily to the trophic position of each fish species (Figure B17). For example, the mean concentration in the two piscivorous species (i.e., walleye and burbot) followed a similar pattern among FSCAs, as did the mean concentration of the invertivorous/planktivorous species (i.e., rainbow trout and whitefish). By contrast, the benthivorous largescale sucker exhibited a pattern distinct from the piscivores and invertivores/planktivores.

Organic Compounds

Nearly all comparisons of organic compounds among species at FSCA's indicated significant differences among species ($p \leq 0.05$, Kruskal-Wallis). Major patterns, based on lipid-normalized concentrations of Aroclors 1254/1260 and 2,3,7,8-TCDF, were as follows:

- Lipid-normalized 2,3,7,8-TCDF concentrations were highest in burbot, compared to other species (Figure B18). Whole burbot had the lowest mean lipid content at 1.7 percent, while mean lipid contents for the other species' whole body samples ranged from 3 to 12 percent.

- Both Aroclor 1254/1260 and 2,3,7,8-TCDF concentrations were higher in rainbow trout fillets than walleye fillets, but this was reversed when fillet concentrations were lipid-normalized; the mean lipid content in walleye fillet was 0.4 percent, while in rainbow fillets it was 3.6 percent. Concentrations of 2,3,7,8-TCDF in hatchery and wild rainbow trout fillets were comparable, as were lipid contents.

- Whole burbot, walleye, and largescale suckers had the highest median lipid-normalized Aroclor 1254/1260 concentrations among fish species (Figure B18).

B3.2.1.4 Other Tissue Chemistry Patterns, and Occurrence of External Anomalies in Fish

Differences in Size and Age within Species

There were highly significant differences ($p \leq 0.001$) in the sizes of fish among FSCAs for all species except for wild rainbow trout. In particular, largescale suckers were much smaller in FSCA 1 than in other FSCAs. This was due to a shift by EPA in sampling strategy when they found that smaller suckers, which were targeted by the sampling design, were less abundant (more difficult to catch) than larger in FSCA 1, and they changed the design to target larger suckers. Largescale suckers also had the widest age range (≤10 to 40 years). Wild rainbow trout were larger than hatchery rainbow; and walleye were larger in downstream FSCAs than in upstream FSCAs. Since composites were created on the basis of consistency in fish size, these factors add uncertainty to the spatial patterns described above, because size (length) correlates with age and age may affect concentrations of chemicals in fillet or whole body tissue.

Temporal Patterns in Fish Tissue Chemistry

Temporal trends can be qualitatively evaluated in cases where the same species and tissues have been analyzed within a particular part of the river over time (in the pre-2005 and 2005 datasets). USEPA (2007a) provides a summary of data from key historical studies (USGS 1995; EVS 1998) compared to the 2005 data set for metals in fillets of walleye, wild rainbow trout, and hatchery rainbow trout; and for 2,3,7,8,-TCDF and total PCBs in walleye and rainbow trout fillets. These comparisons were made on the basis of general areas or reaches (i.e., upper, middle, and lower)[4], and are summarized in Figures B19 through B26. Although the sizes of the fish and the locations of capture are not perfectly matched among these datasets, the comparisons provide some insights into temporal trends in some tissues. The results of this comparison are as follows:

[4] USGS (1995) defines lower, middle, and upper reaches of the UCR system as follows: "the Sanpoil River embayment, the middle reach of Lake Roosevelt and Lower Spokane River, and Columbia River and Lake Roosevelt near Kettle Falls." Fish sampling areas established for the RI/FS by USEPA (2007a) are shown in Figure B1.

- Temporal patterns for arsenic and cadmium were difficult to discern as the result of elevated DLs for the 1995 data (Figures B19 and B20).

- Concentrations of copper, lead, and mercury have generally declined in walleye, wild rainbow trout and hatchery rainbow trout between 1995 and 2005 (Figures B21 to B23). However, because lead in walleye was undetected in 1995 in fish from the middle and lower reaches, the presence of a declining trend is less certain for that species (Figure B22).

- Concentrations of selenium in walleye, hatchery rainbow, and wild rainbow trout tended to vary, and increased in all parts of the river between 1995 and 2005.

- Wet-weight concentrations of 2,3,7,8-TCDF have generally declined in walleye and rainbow trout between 1994 and 2005, but this pattern is not observed when 2,3,7,8-TCDF is lipid-normalized.

- Lipid-normalized concentrations of total PCBs have declined somewhat in rainbow trout in the upper and lowest reaches, and in walleye in the middle and lowest reaches. PCB concentrations have increased in walleye in the upper reach of the study area.

Whole Body and Fillet Tissue Concentrations

Concentrations of metals in composite fillet and composite offal samples were measured in walleye and rainbow trout from FSCAs 1, 3, and 6. As described above, these two measurements were later combined mathematically to estimate composite whole body concentrations. In nearly all cases, metals concentrations in fillets were lower than in whole body samples from the same location. The exception was for mercury, for which concentrations in fillets were generally greater than concentrations in whole bodies.

To determine whether concentrations in fillet can be predicted from concentrations in whole fish, correlations between metal concentrations in whole body samples and fillets for walleye and rainbow trout were evaluated using Spearman's rho. When a significant relationship was found (experiment-wise $p \leq 0.05$), whether a linear or non-linear relationship provided a better fit to the data was tested using Ramsey Regression Equation Specification Error tests (RESET). The results were metal- and tissue-specific: some metals can be predicted in fillet from data on whole body concentrations, and some cannot (Tables B5 and B6). For both species, whole body concentrations can be used to predict fillet concentrations of arsenic, beryllium, and mercury. In addition to these metals, concentrations of antimony, chromium, selenium and silver in rainbow trout fillets can be predicted from concentrations in whole rainbow. Where significant correlations do occur, the relationship is not always linear, and none are proportional. Therefore fillet concentrations cannot always be predicted from whole body fish samples, and any predictions should be based on a regression equation that is both metal- and species-specific.

Largescale Sucker Gut Analysis

Because largescale suckers ingest sediment during feeding, sediment ingestion may be an important exposure pathway for this species. In addition, sediment and metals in the gut of fishes may contribute to the estimate of whole body concentration. Inclusion of gut that contains sediment in estimates of whole body concentrations has the potential to overestimate exposure to consumers that do not eat gut contents of fish, and may overestimate risk to consumers or to the fish themselves if the metals in the gut are not bioavailable, or are excreted by the fish. More refined understanding of these relationships can be used to reduce uncertainties in assessment of exposure to both suckers and their predators.

The strength of correlations and the types of statistical relationships between concentrations in paired gut/gut contents and gutless whole body samples provide insights into patterns of uptake and retention of metals from ingested sediment by largescale sucker (Table B7). Using a Spearman's rank correlation coefficient, the concentrations of aluminum, cadmium, copper, iron, lead manganese, and zinc in gutless whole bodies were found to correlate significantly (experimentwise $p<0.05$) and positively with those in gut/gut contents samples (Table B7). Two-sided, non-parametric regressions were fitted for each of the metals with significant correlations. Ramsey's RESET was used as a proxy for estimating the nature of significant correlations between gutless whole body and gut/gut contents samples, and both linear and non linear relationships were identified (Table B7). Scatter plots for arsenic, cadmium, lead and zinc illustrate the three patterns observed (Figure B27): concentrations of arsenic in gut/gut contents and gutless whole bodies do not correlate (as for antimony, barium, beryllium, calcium, chromium, magnesium, nickel, selenium and silver); concentrations of cadmium show a significant linear relationship (as for cobalt); and lead and zinc in the two media show significant non-linear relationships (as for copper, iron and manganese). For those metals with non-linear relationships between gutless whole bodies and gut/gut contents, the upper limit on the uptake of the metal by sucker may indicate a limit on the bioavailability of the metal from the gut contents, or an increased tendency to excrete the metal as concentrations of the gut contents increase. Those metals with linear relationships may also ultimately show non-linear relationships if the range of the concentrations in gut/gut contents were expanded.

The percent of the gut contents consisting of organic matter, or the ash-free dry weight (AFDW) of the gut/gut contents sample, was lowest in FSCA1, but the median AFDWs for FSCAs 1a[5], 3 and 6 were greater, ranging from 79 to 92 percent (Figure B28). Effects of the variation in percent AFDW on the relationships between metals concentrations in gut/gut contents and gutless whole bodies were not investigated with multivariate methods because the gut/gut

[5] For the purposes of sampling gut/gut contents in largescale sucker, EPA sampled suckers in a portion of the UCR that was somewhat downstream of FSCA 1, from RM 735.5 just upstream of the Northport public boat ramp (Figure B1). This station was termed FSCA 1a. Only largescale suckers were sampled there, and only for evaluation of stomach contents of individuals and individual gutless whole body samples.

contents samples contained variable amounts of stomach and other intestinal tissue, which could not be distinguished from ingested food with the available data.

Detailed results of the chemical analyses for all largescale sucker tissues analyzed are presented with the whole body results, see Attachment B1.

Sediment-Fish Tissue Relationships

Statistical correlations between concentrations of chemicals in fish tissue and in sediment collected from the same areas can provide insights into fish exposure pathways. In addition, comments on USEPA (2007a) requested that tissue-sediment relationships be evaluated (see Section B6). For these reasons, correlations between metals in whole body or fillet tissue samples and concentrations of metals in sediment were evaluated. Although there was not perfect spatial concordance between sediment collection areas and FSCAs, multiple sediment samples were collected for analysis of metals within each of the FSCAs, facilitating the comparison of fish tissue metal concentrations to those of the sediments. Only data for those sediment samples collected by EPA in 2005 (USEPA 2007a) from within the boundaries of the FSCAs were used.

Sediment data were aggregated in two ways. First, sediment samples from locations within the boundaries of the FSCAs were identified, and these were sorted into two groups: samples occurring within the UCR thalweg and those outside of the thalweg. Two sediment datasets were created: a set of all stations within the boundaries of the FSCA (including thalweg samples); and a set excluding thalweg samples. Evaluation of thalweg-only sediment COI concentrations relative to fish tissue COI concentrations was not performed, because the majority of fish species sampled by EPA (USEPA 2005a) are not likely to ever have direct contact with sediments in the UCR thalweg; those that could (largescale sucker and burbot), are not expected to dwell exclusively within the thalweg for significant periods, but instead to contact both thalweg and non-thalweg sediments randomly, in proportion to the relative abundance of sediment within each of these two sediment categories. The resulting number of sediment stations within each group varied among the FSCAs; mean concentrations of metals calculated using each of these two datasets are provided in Table B8 (with thalweg data) and Table B9 (without thalweg data). Neither the raw values, nor the transformed concentrations of metals in sediment accurately fit the assumption of normality (Shapiro-Wilk tests). Various logarithm bases, square root and Box-Cox transformations were attempted without positive result. Because of the non-normal distribution of the data, parametric statistics and linear models were not considered appropriate for data analysis. Concentrations of metals were compared between the two groups (with and without thalweg data) using pair-wise Mann-Whitney-Wilcoxon rank-sum tests. With the exception of nickel, metal concentrations in the group that included the thalweg were significantly greater than those of samples collected from outside of the thalweg. Therefore, correlations between sediment and tissue were conducted separately using each of the two sediment data sets.

The arithmetic mean concentration of each metal in sediment was calculated for each FSCA for the dataset inclusive of the thalweg data and the one not including thalweg sediment data, and correlations between this mean and the individual tissue concentrations were computed. Correlations between concentrations of metals in sediments and those in both whole body fish and fillet tissue were evaluated using Spearman's rank correlation coefficient (rho). Those metals with detection frequencies of less than 50 percent in the fish tissue samples (vanadium in whole body samples of some fish species; aluminum, barium, cadmium, lead, nickel and vanadium in fillets of walleye and rainbow) were excluded from the analysis. Statistical significance was recognized at an experimentwise $p \leq 0.05$.

Results of the correlation analyses using whole body fish samples are presented in Tables B10 and B11; results of correlation analyses using fillet tissue, including a result with all rainbow trout fillet tissue combined are presented in Tables B12 and B13. There are few general patterns, except that among the sediment-whole body correlations, cobalt and nickel are the only metals for which none are significant; for the sediment-fillet correlations, arsenic, cobalt, iron and vanadium are never significant. Otherwise, significant correlations occur for one to three metals per fish species, and for one to three fish species per metal, except for the combined dataset of rainbow trout fillets. Aggregating the rainbow trout fillets across the wild and hatchery groups resulted in a greater number of significant correlations (Tables B12 and B13) regardless of the sediment dataset. However, when thalweg data are excluded, uranium does not correlate significantly with the combined rainbow trout fillet data, and lead does, in contrast to the result when thalweg data are included.

The relationship of fish tissue metal concentrations to those in sediments may be complicated by a number of factors, such as the bioavailability of metals in sediments, fish migration, and the numerous exposure pathways and processes that can link metal concentrations in fish tissue to those in sediment.

Occurrence of Lesions and Other Anomalies in Fish

The occurrence and types of external lesions observed on fish collected by EPA in 2005 (USEPA 2007a) were recorded prior to processing fish for chemical analysis. The examination protocol and data collection form for external examination described by Smith et al. (2002) were used. Tissue anomalies recorded included lesions, deformities, abnormalities, fin erosion, and visible external parasites (Table B14). In recommending assessment of these lesions, Smith et al. (2002) does not provide any information on their etiology. Internal examinations and analysis of histopathology were not performed on the fish collected by EPA in 2005.

A summary of the frequency of lesions for each species collected by USEPA (2007a), by FSCA, is provided in Table B15. EPA recorded results of examinations of individual fish for all fish that were used in the composite samples plus a random selection of additional fish that were available; selection of fish was not dependent upon whether or not external anomalies were apparent. Lesions were counted individually, but in many cases more than one lesion occurred on a single fish (Table B15)[6]. The percent of all fish examined in each FSCA that had external anomalies was highest in FSCA 5 at 81 percent (Figure B29). When the percent of anomalies is considered by species, the maximum for each species is also in FSCA 5, with the exceptions of lake whitefish (Figure B30) and burbot, although the 100 percent incidence for burbot in FSCA 1 is based on only one fish. For all species combined, the average number of lesions per fish examined (within species) generally increased moving downstream (Figure B31).

Hinck et al. (2006) monitored fish throughout the Columbia River Basin for both internal and external lesions, abnormalities, and histopathology in 1997 and 1998. Two of their monitoring stations were in the UCR: Northport and Grand Coulee Dam. A total of 74 percent of all fish sampled throughout the Columbia River Basin had some type of external anomaly, and 50 percent or more of fish had external anomalies at any given station. EPA's 2005 results indicate that the percent of all fish with external anomalies in the UCR overall was 66 percent in 2005, and that the percentages of all fish with anomalies in FSCAs 2 and 3 were close to the lower end of the range observed by Hinck et al. (2006) across the Columbia River Basin (Table B15). Seventy-eight percent of all largescale sucker (N=160) throughout the Columbia River Basin had one or more lesions (Hinck et al. 2006); in the UCR (EPA's 2005 study), 88 percent of suckers had external anomalies, with the highest rates in FSCAs 3, 4, 5 and 6. Histopathological examinations by Hinck et al. (2006) indicated that the majority of external lesions observed (and several types of lesions on internal organs) were the result of inflammatory responses to parasitic or bacterial infections.

An investigation by Peters (2005) within the UCR linked parasites to a number of fish abnormalities (gross and histopathological) and lesions. Peters (1995) used gill nets to sample 598 fish from three areas within Lake Roosevelt: near Kettle Falls (~RM 700), Gifford (~RM 675) and Hunters (~RM 660). The nematode *Eustrongylides* spp. occurred in at least seven species of fish in Lake Roosevelt (Peters 2005). It infects oligochaetes, fish, and birds. More importantly, *Eustrongylides* can cause lesions in fish and illness and death in birds and mammals. The highest frequency of infestation (18 to 19 percent) occurred in lake whitefish and mountain whitefish, but also in walleye (8 percent), kokanee (5.5 percent), and rainbow trout (0.7 percent). A higher infestation (66 percent) was observed in burbot, but only three fish were sampled. Lake whitefish had the greatest number of nematodes (7.2 ± 16.2) per fish, but infestations could reach 100 per fish. Most infected fish came from the station sampled farthest upriver (Kettle Falls).

The Canadian government sponsored a major study in the early 1990s of fish health in relation to organic and metal concentrations in fish tissues and upgrades in wastewater treatment at the pulp mill in Celgar, B.C. and smelter at Trail, B.C (Boyle et al. 1992; Nener et al. 1995a,b;

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[6] Counts of anomalies reported in Table B15 do not include anomalies that were recorded in the "notes" sections of the field forms.

Antcliffe et al. 1997a,b). They also documented parasites of fish as being associated with many of the morphological, histological, and biochemical abnormalities found in at least seven fish species in the Columbia River upstream to Hugh Keenleyside Dam in British Columbia. The Canadian government comprehensively examined the causes of abnormalities by investigating chemicals in fish tissues, viruses, bacteria, and parasites. The most important biological stressor was identified as the blood fluke (*Sanguinicola* sp.), which was associated with multiple external and internal lesions and other pathologies in the whitefish (Antcliffe et al. 1997b). The evidence indicated that the blood fluke infestations were a natural occurrence.

Data collected by USEPA (2007a) do not include information that allows determination of the etiology of fish lesions. However, lesions are common in fish throughout the Columbia River Basin, and the majority appear to be the result of bacterial or parasitic infections.

B3.2.2 Critical Review of Selected Analyses by EPA

Often, multiple approaches are possible for using statistics or other quantitative methods to characterize patterns in environmental data. USEPA (2007a) analyzed relevant patterns of exposure to fish, but in several cases the choice of methods generated different results and conclusions. The discussion below evaluates EPA's screening approach, and outlines the methods applied by EPA for which alternatives could be used . Methods addressed include:

Selection and application of ecological comparison values

Treatment of non-detects

Statistical analyses of the fish tissue data.

These issues are highlighted because the methods applied or the uncertainties resulting from omissions in reporting could affect interpretation of information relevant to the BERA.

B3.2.2.1 Selection and Application of Ecological "Comparison Values"

To limit the list of chemicals for which detailed discussion is provided in the report, USEPA (2007a) used a set of screening values to estimate concentrations at or above which adverse effects on fish may occur. USEPA (2007a) termed these screening values ecological comparison values. The comparison values were concentrations in whole bodies of fish (critical body residues, or CBRs) that were presented as possible screening level concentrations by Dyer et al. (2000). For chemicals not addressed by Dyer et al. (2000), USEPA (2007a) used CBR values from a Quality Assurance Project Plan (QAPP) for fish tissue sampling developed by Windward (2004) for the Lower Duwamish Waterway RI/FS. USEPA (2007a) compared the concentrations of chemicals in tissue of fish from the UCR to the comparison values, and results were used to determine whether an individual chemical was a potential chemical of interest (PCOI) for analysis in the document. There are several concerns with this approach:

The application of values provided by Dyer et al (2000) may not be appropriate and the values could not be replicated. Dyer et al. (2000) provides three sets of screening values, expressed as CBRs for individual chemicals in fish tissue at or above which adverse effects are expected.. Problems with this approach are that for metals, CBRs are widely considered to be a poor predictor of toxicity to aquatic species, especially fish (Section B.5.1.2). Moreover, the paper presents data to indicate that the approach may be inappropriate, by demonstrating that for community-level endpoints, their CBRs are substantially greater than the CBRs developed using more commonly applied methods, and the more common values may therefore be overly conservative. In addition, the derivation of the values reported by Dyer at al. (2000) (i.e., multiplying a water quality criterion by a bioconcentration factor [BCF]) could not be repeated in the present analysis using the cited sources. BCFs for metals have also been shown to vary with concentration in water, a finding that further complicates the selection of a single BCF (McGeer et al. 2003). Finally, the wide range of BCFs available for most metals adds uncertainty to the validity of the CBRs developed by Dyer et al. (2000).

The process used by USEPA (2007a) to select PCOIs following application of comparison values (which included human health risk-based comparison values) was not consistent among chemicals, and was not fully transparent. For example, while many chemicals were retained as PCOIs because they exceeded the stated screening values, barium was retained because it showed "some unique intraspecies patterns," which were not described.

USEPA (2007a) acknowledged that the screening exercise was not intended to substitute for a more formal screening level analysis.

B 3.2.2.2 Treatment of Non-Detects

USEPA (2007a) develops summary statistics for the 2005 fish tissue concentrations, and performs both spatial and interspecific comparisons. The following rules were applied by USEPA (2007a) to chemicals reported as not detected:

For metals, non-detects were assumed to be equal to one-half the DL.

Total PCBs were calculated as the sum of Aroclors, with non-detected Aroclors estimated as ½ DL.

Several arsenic species were analyzed. When computing the percent of inorganic arsenic in tissue samples, any non-detected arsenic species were assumed to be present at the DL.

Other methods can be used, possibly generating different results for various analyses. For example, metals concentrations data can be evaluated with non-detects set equal to the DL, a more conservative approach for estimating the true concentrations. In the UCR dataset, rainbow trout and walleye are most often affected by data sets with both detects and non-detects.

PCBs can also be treated differently. Aroclors 1254 and 1260 were detected in 100 percent of samples, and Aroclor 1016 was detected in 2 percent of samples. No other Aroclors were detected in the 2005 study. USEPA (2007a) estimates total PCBs as the sum of all Aroclors, assuming non-detected Aroclors are present at ½ DL. For analysis of patterns in total PCBs, the sum of congeners could be used, and the concentration of each non-detected congener set to zero. It may also be more appropriate to analyze patterns in PCBs in tissue using data for Aroclors 1254 and 1260, without including an estimate for the non-detected Aroclors, since the absence of any detections in tissue suggests that exposures to fish are minimal.

For understanding patterns in dioxin and furan concentrations, USEPA (2007a) uses concentrations of 2,3,7,8-TCDF alone, because this congener was detected in 99 percent of tissue samples. Detection frequencies of the other dioxin and furan congeners were variable, and were generally less than 33 percent, making them less useful for understanding patterns of exposure.

B3.2.2.3 Statistical Analyses

USEPA (2007a) applied statistical methods to analyze the 2005 fish tissue data. Concerns with the statistical analyses used by USEPA (2007a) include the following:

- Use of composite data to calculate individual level variability in fish tissue
- Exclusive use of wet weight concentrations of organic chemicals in comparisons between reaches
- Presentation and interpretation of correlations between metals concentrations in whole bodies of largescale suckers and sediments
- Presentation and interpretation of spatial patterns.

Specific concerns with these items are described below.

Composite vs. Individual-Level Variance

Because most of the fish tissue samples collected in 2005 were used to create composites before chemical analyses were performed, there is little information on the variance of chemical concentrations among individual fish, only the data for individual largescale suckers from FSCAs 1, 1a, 3 and 6. USEPA (2007a) noted that the variance of fish tissue concentrations in composite samples may not accurately represent the variance among individual fish, and presented a method for deriving an estimate of the individual-level variance based on composite data. To estimate the individual-level variance on the mean from the dataset consisting of composite samples, USEPA (USEPA 2007a) assumes that the individual-level variance is equal to the variance of the composite multiplied by the number of fish in the composite. This approach, based on an assumed relationship to between-composite variance and sample size, is not supported by either a citation or empirical test, and the reason for the analysis is not stated. It is not clear whether or how the estimated individual-level variance in fish tissue concentrations was applied, or why this statistic was a preferred alternative to the estimate of variance provided by the variance among composite samples.

To evaluate the USEPA (2007a) assumption about the magnitude of the difference between individual and composite variance, the available data for individual largescale sucker samples and for sucker composites were analyzed.

Largescale sucker metal concentration data consists of two variables: mean whole body concentration at each FSCA representing composite samples consisting of five fish, and an estimated whole body concentration calculated from concentrations in individual samples of gut/gut contents and gutless whole body samples, as described in Phase I Tissue Sampling Data Evaluation Section of USEPA (2007a). To determine whether the composite and individual data had comparable variance, means and standard deviations of the concentrations of metals in each tissue type were calculated for each metal and FSCA separately. Only FSCAs 1, 3, and 6 contained data for both variables. The coefficient of variation (CV), expressed as a percentage, was calculated for each metal in each of the three FSCAs as:

$$CV = \frac{SD}{Mean} \times 100$$

The differences in CV between composite and individual measures of metal concentrations were tested using the method of Miller (1991; cited in Zar 1996). Only 5 of 63 tests (across all metals and FSCAs) had a p value less than 0.05, providing little evidence of a difference in CV (and variance) between the individual and composite samples. This result is not in agreement with EPA's assumption that the variance of individual samples is higher by a factor of 5 than that of composite samples (for composites of five individual fish), but it is consistent with other evaluations of the effects of compositing, which indicate that the variance of individual and composite samples will be equivalent when the distribution of values for individual samples is platykurtic or the variability among individual samples is large relative to the variability of analytical methods (Brumelle et al. 1984, Garner et al. 1988). Planning for the next round of sampling, however, incorporated the more conservative assumption that the variance between individuals is greater than the variance among composites (see Appendix D of the Fish Tissue QAPP).

Influence of Lipid Normalization on Organic-Chemical Concentrations

USEPA (2007a) evaluated the significance of differences in mean chemical concentrations between reaches for each fish species to describe spatial trends. These comparisons were conducted using wet weight concentrations for TCDFs and PCBs. Because a correlation between concentrations of these hydrophobic chemicals and lipid content is expected, the influence of lipid normalization on the observed spatial and interspecific comparisons should have been evaluated.

Correlations between Metals Concentrations in Largescale Sucker and Sediment

USEPA (2007a) evaluated correlations between chemical concentrations in whole bodies of largescale suckers and sediment. The methods suggest that the data for whole body suckers were used for this analysis. Whole body sucker concentrations, whether measured or estimated by USEPA (2007a), were derived from samples containing both biological tissue (the sucker's tissues and their ingested prey) and the sediment in the suckers' stomachs (gut/gut contents samples). USEPA's (2007a) data for chemical concentrations in gut/gut contents relative to the remainder of the sucker body suggest that concentrations of most metals in gut/gut contents were high relative to concentrations in the remainder of the fish tissue. Regardless of whether the gut/gut contents concentrations are high or low relative to remaining biological tissues, the presence of sediment in the stomachs of sucker at the time tissue samples were processed would confound the estimate of the actual tissue burden of any of the metals. Therefore, it would be appropriate for understanding fish exposures to conduct this sediment/tissue comparison on the basis of the concentration in sucker whole bodies without the gut contents. Section B.3.2.1.4 of this appendix presents an analysis of the correlations between gut/gut contents and gutless whole bodies. Correlations between concentrations in sediment and whole body samples or sediment and fillet are also discussed in that section.

Analysis of Spatial Patterns

USEPA (2007a) used ANOVA and the F-test to evaluate spatial patterns in concentrations of PCOIs in fish tissue. Several aspects of this analysis are unclear:

While it is stated that data not conforming to normality were treated using nonparametric statistics, the types of tests conducted for each chemical and fish combination are not specified. The choice of statistical test has ramifications for determination of the power of the test (further discussed below), and therefore should be included in the description of the statistical analysis.

It is unclear whether other assumptions of parametric tests were examined, such as homogeneity of variances, and how results affected the selection of statistical tests.

The choice of a p-value of 0.10 for determining the statistical significance of test results (which is also the p-value used for many of the other statistical tests in USEPA [2007a]) is unconventional, but is not justified.

The report does not sufficiently describe the methods used nor explain the rationale for the chosen approach to test for spatial trends.

USEPA (2007a) conducts power calculations based on the results of Phase I fish tissue sampling to examine the ability to detect a difference in chemical concentrations among reaches if that difference exists. The reader is provided with coefficients of variation in USEPA's (2007a) Table 3-19 and power charts provided in Figure 3-65 (assuming that most sample sizes were n = 10 per reach) to satisfy questions about statistical power of individual tests. Questions and concerns with respect to this analysis include:

It is not clear whether the coefficients of variation provided in USEPA's (2007a) Table 3-19 include estimated reconstructed whole-body concentrations. Sample sizes for each of the coefficients should be provided to clarify what data were used to generate these values.

A visual review of USEPA's (2007a) Figure 3-65 suggests that to obtain an 80 percent probability of detecting a difference among composites, the CV needs to be approximately ≤0.55 to detect an increase of 100 percent between samples (or a decrease of 50 percent), or ≤0.2 to detect a 25 percent increase (or 20 percent decrease). However, these power analyses are not brought forward into the interpretation of the results examining differences among reaches. For example, USEPA (2007a) states that no significant difference (p>0.1) was found in mean whole-body walleye concentrations among reaches for aluminum. However, the CV for aluminum in whole body walleye of 0.633, when examined in the context of the power analysis, indicates that power would be low (≤0.7) to detect ev en a 100 percent increase or 50 percent decrease, and would be≤0.3 for an increase of 50 percent or less. Similarly for whole -body wild rainbow trout, only lead and PCBs were determined to differ significantly (p≤0.05) among reaches; however, coefficients of variation for several chemicals including aluminum, barium, cadmium, and 2,3,7,8-TCDF were higher than 0.3, so the power to detect differences for these chemicals would be limited to those exhibiting large (approximately 50 percent or greater) increases or (33 percent or greater) decreases. In other words, it cannot be concluded with a high degree of confidence that there are not significant differences among reaches. These issues with low statistical power should be included with any discussion of significance, or lack of significance, in spatial analyses.

The discussion of the analysis of spatial trends in USEPA 2007a) contains discrepancies between results presented in the text and those presented in supporting tables, as well as the figures in Appendix E of USEPA (2007a). Examples include:

Differences in nickel concentrations in whole-body walleye are described as significant in the text, but are not indicated as significant in USEPA's (2007a) Table 3-21.

Among-reach differences in lead in whole whitefish are listed as not significant in USEPA's (2007) Table 3-26, but identified as significant in the text. Also, for whole whitefish, the text states that arsenic is highest in the middle reach, but both the mean and maximum arsenic values for whole whitefish in USEPA's (2007a) Table 3-25 are highest in the lower reach.

Selenium in whole body lake whitefish is described as having a "decreasing trend" downstream, but the highest average value as reported in USEPA's (2007a) Table 3-25 is in the middle reach, and USEPA's (2007a) Table 3-26 reports no significant linear trend (p = 0.12) for selenium in whole-body lake whitefish. .

Recommended Alternative Approaches

Choices about treatment of the data affect the conclusions that can be derived from data analyses. Alternative methods to those used by USEPA (2007a) are discussed in the text above, and can be summarized as follows:

Use of CBRs to interpret the risk associated with fish exposures to COIs should be done only if an exposure response relationship has been established, which is rare for metals. Further discussion of the application of this approach is provided in Section B5, below.

Non-detected chemical concentrations can be estimated in a variety of ways. The selected method or default assumption (e.g., ND = 1/2DL) depends largely on the degree of censorship in the data to be evaluated. Once a method has been selected, it can be informative to evaluate the data using an alternative method, especially for highly censored data sets like the tissue concentrations of most Aroclors reported by USEPA (2007a). Results of analyses using alternative methods to estimate non-detect values can be important to full characterization of uncertainties.

Available evidence for evaluating the variance of individual fish tissue concentrations relative to the variance of composites indicates that an assumption that the variance of individuals is equal to the variance of composites multiplied by the number of fish in the composite is inappropriate. Site specific data available to address broad assumptions about data distributions, variability, and other data characteristics should always be considered, to avoid inappropriate analyses or erroneous conclusions.

Spatial and temporal patterns in tissue data can be evaluated using either wet weight or lipid weight concentrations. For organic COIs, lipid weight concentrations should be considered.

Sediment/tissue comparisons with largescale sucker in the UCR should be performed on the basis of the concentration in sucker whole bodies without the gut contents, because the gut contents often include a large fraction of sediment.

B3.3 SUMMARY OF PATTERNS IN UCR FISH TISSUE DATA

Evaluation of the pre-2005 historical and the 2005 fish tissue data identified several spatial and interspecific patterns in fish tissue chemistry that may be useful for the BERA are summarized below:

Pre-2005 historical data were primarily for fillet tissue and for species and sizes considered edible by people. A few studies provided data for whole largescale sucker, but were published in 1997. As such, the data are not believed to be sufficiently systematic, current, or representative of fish and tissues eaten by piscivorous fish and wildlife to have substantial value for the BERA.

USEPA (2007a) provides the most systematic and robust data set for fish tissue for the UCR, and the data are useful for ecological risk assessment. However, the fish sampled were generally larger than those consumed by ecological receptors, and therefore COI concentrations in tissues of smaller fish remain a data gap.

Pre-2005 historical data are primarily of value in understanding temporal and interspecific contaminant trends:

Concentrations of copper, lead, and zinc in whole largescale sucker declined significantly ($p \leq 0.05$) with increasing distance downstream from Northport. However, arsenic, cadmium and mercury concentrations did not decrease significantly with distance from Northport.

Concentrations of mercury were generally higher in walleye and largescale sucker than in other species. Mercury in walleye tissues declined from 1994 to 1998.

Several metals, including arsenic, cadmium, copper, lead, mercury, and zinc declined in fish tissue upstream of the U.S.-Canadian border between 1995 and 1999.

Simple, qualitative comparisons between pre-2005 historical data sets and recent samples (USEPA 2007a) suggest that tissue concentrations of copper, mercury, lead, and 2,3,7,8 TCDF have been declining from the mid- to late-1990s to 2005; while data for arsenic and cadmium are equivocal due to high DLs. PCBs may have increased in some species in the middle and lower portions of the UCR between 1994 and 2005.

Even though USEPA's (2007a) data describe fish species and size classes primarily of interest for human consumption risk, the data are sufficient to illuminate patterns in the spatial distribution of fish exposures, and other species-specific fish exposure patterns relevant to the BERA. These include:

The highest concentrations of most metals occurred in largescale sucker, burbot and walleye. Consistent with historical trends, the highest mercury concentrations were in walleye and largescale sucker; relatively high concentrations were also detected in burbot, which were not sampled historically.

As in the historical data, concentrations of copper, lead, and zinc declined with distance downstream from the U.S.-Canadian border, but only for largescale sucker. This pattern was not observed for other species.

Differences among species in the locations and magnitude of peak concentrations of both metals and organic compounds suggest different pathways and mechanisms of exposure among the species. This is consistent with the different life histories, feeding habits, migration patterns, and other species-specific variables that control chemical uptake, retention and elimination processes in fish. Benthic fish (largescale suckers) and top predators (walleye, burbot and to some degree rainbow trout) consistently show the most pronounced spatial patterns (i.e., high spatial variability) and highest body burdens.

Understanding patterns of exposure may be confounded by the effect of length (as a surrogate for size and age) on tissue concentrations, but no consistent patter among species or metals was observed. Understanding historical patterns in whole largescale sucker may be confounded by the presence of sediment in the fish guts.

Statistically significant relationships between metals concentrations in sediments and whole fish tissue occurred in several species-sediment combinations. Strong associations between mean concentrations of metals in sediment and individual fillet samples of rainbow trout occurred for several metals when all rainbow trout fillet samples were considered as a group, and were rare in walleye.

B4 SELECTION AND DESCRIPTION OF REFERENCE CONDITIONS

Several studies and databases provide concentrations of chemicals in fish tissue from rivers and lakes in Washington and elsewhere in the Pacific Northwest. However, the definitions of "reference areas" or "reference conditions" are often subjective. The data and statistical methods used to define reference conditions generally depend on the specific questions to be addressed regarding comparisons with Site conditions. The discussion below provides one possible approach and set of results for describing reference conditions for comparisons with fish tissue chemical concentrations in the UCR.

B4.1 DEVELOPMENT OF THE REFERENCE AREA DATA SET

To begin the evaluation of reference conditions for fish tissue chemistry, general criteria for sites potentially representative of the UCR were defined. Fish tissue data were included if they were from water bodies (lakes and rivers) that:

- Are in the state of Washington
- Are monitored by Ecology or are among sites in EPA's National Study of Chemical Residues in Lake Fish Tissue
- Are not directly adjacent to or clearly influenced by large municipal and industrial areas
- Are east of the Cascade crest.

Fish tissue chemistry data meeting these criteria were compiled from various sources, including several reports by Ecology (Johnson et al. 2006; Seiders et al. 2006; Seiders et al. 2007; Seiders et al. 2008), and results of the EPA fish study(USEPA 2005b). Each data source included a list of locations where samples had been acquired. These locations were cross-referenced with maps to determine which of the sampling sites were in eastern Washington. All sites monitored by Ecology or in the EPA databases and within this geographic region were included, with the exceptions of any reach of the Spokane River and Moses Lake (Table B16). Fish from those two water bodies may be impacted by municipal or other sources and were excluded.

Data for all years, for any fish species represented in the pre-2005 or 2005 data sets for the UCR, and for any analyte in these data sets (Tables B1 and B2) were compiled for the selected water bodies (Table B16). Analytes of concern included metals, PCBs, PBDEs, selected pesticides, and conventional variables such as percent lipid and percent moisture.

B4.2 SUMMARY OF REFERENCE CONDITIONS

The available reference areas identified using this approach were found to be very limited and did not provide a consistent or coherent picture of conditions outside the UCR. All of the important parameters for providing a consistent data set to which site conditions can be compared varied considerably, such as species sampled, tissue types analyzed, analytes, and years sampled. It was therefore concluded that statistically and conceptually robust comparisons between fish from the UCR and the available reference area data sets were not appropriate at this time.

However, the data that were generally comparable to data reported by USEPA (2007a) are summarized in Table B17. For qualitative comparison with the 2005 UCR data, only data from 2000 and later were included, and summary statistics calculated. Only walleye and rainbow trout fillet, and whole largescale sucker sampled from both the candidate reference areas and the UCR in 2005 were included in this summary, because the most robust data sets for the Site are for these sample types, and only for mercury and PCBs. Concentrations of PBDEs in fish from reference (and other) areas are summarized in Section B.7.

A relatively large data set for both largemouth and smallmouth bass tissue samples from waterbodies other than the UCR in Washington by EPA and Ecology has been collected. If bass were collected from the UCR, these reference area data may be sufficiently numerous and recent for comparison to bass collected from the UCR. Among recent Ecology and EPA reports, there are approximately 20 recent smallmouth and largemouth bass samples (collected since 2000) each from sites that meet the criteria for reference locations defined above. Nearly all of these bass tissue samples were skin-on fillets analyzed for total mercury; more than half were analyzed for PCBs and chlorinated pesticides, with a subset analyzed for PBDEs, dioxins and furans. Ecology continues to generate new data on mercury and other chemicals in bass, prompted in part by the U.S. Department of Health (DOH)'s statewide advisory for mercury in smallmouth and largemouth bass. Both species are favorable for regional-scale monitoring because they're ubiquitous, and both are found in the UCR (e.g., Scofield et al. 2007).

B5 EVALUATION AND APPLICATION OF CANDIDATE TOXICITY BENCHMARKS

The following section addresses candidate approaches for assessment of toxicity to fish, toxicity benchmarks that can potentially be used to evaluate risks to UCR fish, and application of benchmarks to the 2005 fish tissue data set for the UCR.

B5.1 RISK ASSESSMENT COMBINING EMPIRICAL AND MODELED DATA

Risk assessment requires exposure and toxicity information. Exposure to fish can be expressed as concentrations in environmental media (including tissue) or as the cumulative dose through multiple media, and is estimated on the basis of empirical and/or modeled concentrations in sediments, water, prey or tissue of fish species of interest. When using fish tissue concentrations, fish can either be sectioned into specific tissue types before concentrations are measured, or concentrations in whole fish can be measured. Models of bioaccumulation in fish generally require some empirical data for water and/or sediment.

Exposure and toxicity estimates must be expressed in the same terms. Once exposure estimates are available, risk assessors select the type of toxicity benchmarks against which to compare them. The following general types of metrics can be applied to evaluate risks to fish at a given exposure to individual compounds:

Water quality benchmarks—The UCR Screening Level Ecological Risk Assessment (SLERA) (TCAI 2007) applied several sets of water quality benchmarks to interpret available water chemistry data for the UCR. All of the benchmarks (except the Canadian guidelines)[7] are based to some degree on the EPA's water quality criteria for the protection of aquatic life. To derive ambient water quality criteria (AWQC) for the protection of aquatic life, USEPA (2002) combined toxicity data for a minimum number and specified set of aquatic plant and animal taxa, generated a series of distribution functions, and selected percentile values from those distribution functions to generate aquatic criteria offering certain assumed levels of protection of the entire aquatic community over specified exposure periods. The method incorporates estimates of the tendency of the subject chemical to bioaccumulate, and in some cases AWQC are strongly influenced not by the sensitivity of aquatic species, but the sensitivity of their predators (i.e., via consumption of contaminated prey). Resulting AWQC are considered to be protective of 95 percent of aquatic species.

[7] As described in the SLERA, the Canadian Council of Ministers of the Environment (CCME) guidelines are for total metals concentrations. Since dissolved concentration is a better reflection of the bioavailable metal, EPA's AWQC, which provides criteria for dissolved metals, are considered more ecologically relevant.

Tissue residue approach (TRA)—Concentrations in the tissue of a specified organ such as the gills, liver or kidney or in the whole body of fish may be measured in laboratory tests of chemical toxicity and related to any observed toxic effects. CBRs can then be derived that relate fish tissue concentrations to toxics effects in the fish. However, the application of CBRs to ecological risk assessment has been controversial, as discussed in greater detail below.

Toxicity reference values (TRVs)—These values are expressed as chemical concentrations in prey or other ingested media that may result in adverse effects to fish or other predators. Studies in which fish are fed media spiked with known concentrations of a chemical followed by measurement of effects parameters (e.g., fecundity, percent mortality, reductions in growth) can generate TRVs that can be compared to site-specific concentrations in the prey or other ingested media. This approach is commonly employed for assessment of risk to wildlife (e.g., birds and mammals), because other metrics of exposure to wildlife (i.e., tissue residues) are impractical. However, when applied to fish, TRVs can be complicated by test conditions, as discussed below.

It is also theoretically possible to have sediment quality guidelines that are protective of fish (e.g., Meador 2006), but broadly applicable sediment guidelines of this nature are not yet available.

Each type of benchmark can have multiple meanings depending on how they are derived. Because AWQC are a complex representation of toxicity and bioaccumulation metrics, methods for derivation of individual AWQC should be checked to ensure that the appropriate conclusion is reached when a chemical exceeds AWQC. Individual studies selected for derivation of CBRs and TRVs should conform to certain minimum standards of quality to ensure that application to risk assessment is valid and will generate meaningful results (Durda and Preziosi 2000).

B5.1.1 Water Quality Benchmarks

The AWQC developed by USEPA (2002) were derived to be protective of 95 percent of the aquatic species in any given aquatic environment. Criteria for the protection of freshwater aquatic life are derived on the basis of a data set that includes, at a minimum, the following types of toxicity information:

Results of acute tests for at least eight different families that include salmonids and at least one other bony fish family, one other family in the phylum Chordata, a planktonic crustacean, a benthic crustacean, an insect, and two additional families not represented by these groups

Acute-chronic ratios for species representing at least three different families, of which there must be at least one fish, one invertebrate, and one acutely sensitive invertebrate

Results of tests with an alga or freshwater vascular plant (and another plant result if plants are the most sensitive to the material)

At least one BCF determined using a freshwater species.

The method allows for incorporation of additional information, when available. An array of statistical procedures is applied to data sets for each chemical according to guidance (USEPA 1985), which vary depending on the data available. Final criteria are expressed as the criterion maximum concentration (the acute water quality criteria), and the criterion continuous concentration (the chronic water quality criteria), and the duration and frequency of exceedance of these values is considered in interpreting water quality information. When the chemistry of a water body meets these criteria, "…*aquatic organisms and their uses should not be affected unacceptably*" (USEPA 1985).

B5.1.2 Tissue Residue Approach

Scientific debate about the appropriate applications of CBR values in risk assessment has been ongoing for 20 years, beginning with McCarty (1986) who advocated the critical body residue as a useful dose metric for non-polar, non-metabolized compounds. Proponents of this approach have emphasized that the method accounts for the bioavailability of a chemical from different media, and for exposure over protracted periods. Later authors (Barron et al. 2002) discouraged use of tissue residues, pointing to the substantial variability among species and toxicants when whole body residue values were used as the metric of exposure. Recognizing that further refinements were needed to address the apparent variability in CBRs, later publications (e.g., Landrum and Meador 2002; Meador 2006) provide more specific considerations for applications that require comparisons between CBRs, between CBRs and concentrations in aquatic organisms from a site under investigation, or aggregations of CBR data (e.g., calculation of summary statistics, derivation of species sensitivity distribution [SSD] functions). These considerations are relevant to the uses of CBRs as toxicity metrics in risk assessments:

Standardization of the response metric

Standardization of exposure duration

Lipid normalization for hydrophobic chemicals

Consistency in the mode of action

Understanding and accounting for the toxicity of metabolites

Accounting for the effects of non-toxicant stressors.

Finding CBRs that can be successfully applied in the context of these considerations can be difficult. In June 2007, a Pellston Workshop was convened for the purposes of discussing the scientific basis for using tissue residues as a dose metric for toxicity assessment. The results of the workshop were presented at the 2007 Annual Meeting of the Society of Toxicology and Chemistry. Among the nine abstracts presented, several themes emerged:

The TRA provides a robust framework from which better understanding of dose/effect relationships can be assessed.

The TRA is increasingly being used and sometimes offers a better model for a dose metric than other surrogates, such as exposure concentration in ambient media or oral dose.

The TRA does not work where the tissue measured does not represent the site of toxicological activity, the chemical is highly metabolizable, the mechanism is irreversible, or the chemical is non-bioaccumulative (e.g., nonorganic metals, mutagens, irritants, cyanide, and ammonia).

The TRA is most appropriate for organic chemicals acting via baseline toxicity or non-specific toxicity, and for a few acting via AhR receptor. It is not applicable to metals, except for some organometals (e.g., TBT and methyl mercury). However, the Biotic Ligand Model, based implicitly on a residue-response relationship, may be applicable for some metals. In addition, there are examples of exposure-response relationships with metals in aquatic species (e.g., cadmium).

More sophisticated toxicokinetic/toxicodynamic models need to be used for some chemicals, depending on the underlying mechanistic processes of toxic action. For metals, the rate of uptake has been found to be important, since it affects the ability of an organism to detoxify excess levels of accumulating metals.

The narcosis model (now called the target lipid model) is being used to fill in data gaps for critical body residues. It applies to chemicals acting by what is now called "baseline toxicity mechanism."

USEPA (2007b) cautions against the use of CBRs for assessment of risk to aquatic organisms from exposure to metals (with the exception of organometals such as tributyltin and methylmercury), unless a toxicologically valid residue-response relationship supports the use of the CBR threshold. Even within datasets that provide exposure-response relationships, the rate of chemical uptake must be considered. The rate of uptake of some metals has been linked to toxicity in aquatic organisms (e.g., Andres et al. 1999; Kraak et al. 1992), such that an organism may survive in an environment with a relatively low concentration significantly better than in an environment with a high concentration, while in both environments the ultimate concentration in tissues is the same (Andres et al. 1999).

B5.1.3 Toxicity Reference Values for Ingested Media

Many publications on the toxicity of chemicals to fish involve feeding spiked media (e.g., fish food, prey organisms grown in contaminated water or sediment) containing a known concentration of a single chemical to fish under controlled conditions, and monitoring responses. TRVs derived from such studies can be expressed as the concentration in the ingested medium (mg/kg), or as the cumulative ingested dose (mg/kg food/day). While this approach offers a viable alternative to the TRA, the literature on these metrics is imperfect. Issues that can result in uncertainties include:

Differences in the form of the metal contaminating ingested media between the test environment and the natural environment. Foods given to test animals in the laboratory are often spiked with highly bioavailable or highly toxic forms of the test chemical, while the concentrations reported in environmental samples reflect the sum of numerous forms, some of which are less bioavailable or toxic than others. While this can make TRVs expressed as prey concentrations a more conservative approach, it can also reduce the toxicological realism of the TRV.

Differences in metal toxicokinetics in different fish species. This variation will affect the relative sensitivity of any one fish species to toxicity, and create uncertainty when laboratory results for one species are extrapolated to other species in the field.

Differences in the response when exposed to a chemical via ingestion relative to exposure via respiration or other contact. Use of the concentration in an ingested medium to estimate exposure may not capture all relevant exposures experienced by a fish in a contaminated environment.

Difficulties with quantifying the dose ingested by the tested organism in the lab. Depending on the medium used to expose the fish in the laboratory, it can be very challenging to determine how much of the spiked food is ingested by an individual fish. Therefore, toxicity observed in a group of exposed fish cannot necessarily be interpreted to reflect equal exposures, because some fish may have eaten more than others in the same tank. This type of uncertainty is controlled by careful study design, systematic observations and thorough reporting. In addition, controls on dosing should be specifically confirmed in the reference publication.

As a result of the uncertainties resulting from the application of these types of TRVs, USEPA (2007b) recommends that TRVs expressed as the ingested dose or as the concentration in ingested media be used as a conservative screening tool in assessment of risks to aquatic organisms resulting from exposure to metals.

B5.1.4 Recommended Approach for Toxicity Assessment

All of the available methods for assessment of toxicity of individual chemicals to fish are associated with some uncertainties, and application of single chemical toxicity values to risk assessment for chemical mixtures will also result in some uncertainties. To minimize uncertainty in the analysis of risk to fish in the UCR, the following approach is recommended:

Water quality benchmarks for the protection of aquatic life for both metals and organic compounds should be used as a line of evidence. The benchmarks should be considered sufficiently protective of the fish in the UCR, such that concentrations consistently below them can be interpreted to indicate no unacceptable risk to fish. When a benchmark is exceeded, the conceptual basis of the value (i.e., the nature of the data most influential in deriving the value) should be considered in interpreting the exceedance.

The TRA should generally not be used for estimating toxicity of metals to fish, unless a relevant exposure-response relationship documented in the literature has been identified. The TRA can be used in assessment of the toxicity of organic compounds, when appropriate data are available in the literature. The criteria outlined for application of TRAs (Section B.5.1.2) should be considered when TRAs for any chemical are applied.

TRVs expressed as a concentration in prey or a cumulative ingested daily dose should be used for assessment of risks to fish due to metals exposure. This method may also be used for assessment of risks due to exposure to organics, if appropriate benchmarks are available.

Risk assessment methods that combine empirical exposure data with modeled toxicity information will result in risk estimates that are uncertain. Uncertainty can be reduced by using an effective sampling design to assess exposures, by critical analysis of the water quality benchmarks, CBRs, and TRVs that are selected, and by limiting their application and interpretation appropriately. Because the interactions of metal mixtures from dietary sources is complex due to differing modes of action (i.e., can result in synergistic, additive, or antagonistic responses), characterizing risk from simultaneous exposures through the use of simple hazard (or risk) quotients is not feasible. Therefore, metal mixtures are not discussed in this section, but will be addressed in the BERA either through higher tiered approaches or in the uncertainty discussions.

Given that the three approaches identified above results in some uncertainty, multiple lines of evidence should be applied where they are available. Any individual line of evidence can be weighted according to the merits of the studies that support it. Development of a weight-of-evidence approach for assessing risks to fish should be considered, and the approach should allow detailed consideration of the quality of data underlying the toxicity benchmarks applied. If unacceptable uncertainties remain after the analysis of risks to fish using the methods described above, empirical studies exposing fish to site-specific media that include a mixture of COIs should be considered.

B5.2 COMPARISON OF FISH EXPOSURES IN THE UCR TO SELECTED TOXICITY BENCHMARKS

Currently available water and tissue chemistry data for the UCR, including those reported by USEPA (2007a) and data from other sources, provide perspective on the degree of exposure of UCR fish relative to toxicity benchmarks. Understanding the magnitude of exposures relative to conservative toxicity benchmarks for fish will help refine the focus of the BERA with respect to assessment of risks to fish.

While a comprehensive search for toxicity benchmarks is not provided herein, readily available benchmarks either recently applied in risk evaluations in EPA Region 10 or from a high quality technical publication were compiled for comparison to available data for the UCR. The discussion below describes the sources of CBR and TRV benchmarks and process for their selection for this analysis; identifies the data used to describe exposure to fish, and provides simple comparisons of these toxicity benchmarks to measures of fish exposure. Results of the water quality analysis in the SLERA (TCAI 2008) are also summarized. This analysis is not intended to substitute for a SLERA, but to provide perspective that can help focus the BERA, and future sampling events.

B5.2.1 Sources and Selection of Benchmarks

Benchmarks used for this analysis include the following:

Screening ecotoxicity values for surface water

TRVs expressed as concentrations of chemicals in the tissue of foods of fish (no-observed-adverse-effects-concentrations [NOAECs] were used)

CBRs expressed as whole body concentrations in fish (NOAECs were used).

Water chemistry data were compared to the lowest values for each metal among a suite of water quality benchmarks in the SLERA (TCAI 2008). The benchmarks were generally based on EPA's AWQC for protection of aquatic life, with some regional considerations for protection of salmonids. Methods are described in the SLERA (TCAI 2008).

TRVs expressed as concentrations of metals in the foods of fish at or below which adverse effects are not expected to occur were taken from the ecological risk assessment conducted by Windward (2007) for the Lower Duwamish Waterway in Seattle, Washington. This resource was selected because the values were derived following literature review, the values are the lowest NOAECs among the available TRVs used by Windward (2007), and the values have been accepted by EPA Region 10 for risk assessment. Because not all metals were considered chemicals of potential concern by Windward (2007), these TRVs are available only for arsenic, cadmium, chromium, copper, lead, silver, vanadium, and zinc (Table B18).

CBRs expressed as concentrations in whole body samples of fish were identified for total PCBs, and for toxic equivalents (TEQs)[8] for fish (Table B19). For total PCBs, the lowest of all the whole

[8] Several PCB, dioxin and furan congeners are thought to act through a common mechanism in inducing toxicity in a variety of organisms. The potency of each individual congener in initiating toxicity, *via* the common mechanism of initial binding to the aryl-hydrocarbon (Ah) receptor, can be measured in standard bioassays, 2,3,7,8-TCDD is considered the most potent of the congeners, and the relative potency of each of the other individual dioxin, furan, and dioxin-like PCB congener is quantified using a toxic equivalency factor (TEF). Separate sets of TEFs have been published for assessment of toxicity to fish, birds and mammals (van den Berg et al. 1998).

body NOAECs used by Windward (2007) was selected for comparison to data from the UCR. This value is affected by uncertainties related to incomplete documentation of the study methods. It represents a NOAEC for spawning of females and survival of eggs and larvae of the European barbell (*Barbus barbus*), but was also considered a lowest-observed-adverse-effects-concentration for fecundity in females. The source paper (Hugla and Thome 1999) provides tissue concentrations in wet weight, and does not report the lipid content of tissue. All other whole body NOAECs for total PCBs in fish available in the literature are higher than this value.

Risks to fish resulting from exposures to chemicals with dioxin-like toxicity (the adjusted sum of dioxins, furans and dioxin-like PCBs, expressed as TEQ concentrations) were not addressed by Windward (2007). Steevens et al (2005) used 26 results of studies of the toxicity to early life stage effects of 2,3,7,8-TCDD in multiple fish species to derive an SSD for 2,3,7,8-TCDD. Using the SSD, Steevens et al. (2005) derived several values that can be used as benchmarks against which to compare fish exposures expressed as whole body TEQ concentrations. They provide whole body concentrations of 2,3,7,8-TCDD considered protective of 90 percent, 95 percent, 97.5 percent, and 99 percent of fish species, and the lower and upper confidence limits on each value using the SSD.

In the present study, the mean whole body concentrations of 2,3,7,8-TCDD derived to be protective of 95 percent of fish exposed was selected for this analysis (Table B19). This value was compared to the TEQ concentration for each UCR fish species calculated using dioxins, furans, and dioxin-like PCB congeners (TEQ_{DFP}), and using TEFs for fish provided by van den Berg et al. (1998).

B5.2.2 Data Useful for Estimating Exposures to Fish

The sets of available water chemistry data for comparison to benchmarks are described and analyzed in the SLERA (TCAI 2008).

Although no tissue chemistry data for benthic macroinvertebrates from UCR are available, a recent study by Besser et al. (2008) provides information useful for comparison to TRVs. Besser et al. (2008) collected sediments in 2004 from seven stations distributed along the length of the UCR, as well as one station located in the Sanpoil Arm, which was considered a reference area by the authors. Oligochaetes (*Lumbriculus variegatus*) were exposed in the laboratory to the sediments for 28 days according to accepted protocols, and depurated prior to chemical analysis. Tissue samples were analyzed for six metals (i.e., arsenic cadmium, copper, lead, mercury, and zinc [Table B20]). These data are compared to TRVs in the next section.

As discussed previously, USEPA (2007a) measured metals concentrations of samples of gut/gut contents for individual largescale suckers from FSCAs 1, 3, and 6 in 2005. These samples were analyzed to evaluate the contribution of sediment in sucker stomachs to whole body metal concentrations. Concentrations of selected metals in gut/gut contents samples from individual largescale suckers in FSCAs 1, 3 and 6 were compared with NOAEC-based TRVs to provide an initial evaluation of whether the gut contents may pose risks to the suckers. This comparison also informs whether a conservative assumption that metals are 100 percent bioavailable in sediment in the stomachs of suckers would result in a determination of risk to suckers based only on concentrations of gut/gut contents. Finally, to inform whether piscivorous fish could be at risk due to ingestion of fish prey, the maximum concentration of each of the metals for which there are TRVs (as prey concentrations) among all the whole fish tissue samples were identified and compared to TRVs.

Concentrations of total PCBs in whole fish were taken from the 2005 UCR fish tissue data set (USEPA 2007a). Total PCBs were calculated by EPA as the sum of Aroclors, with undetected Aroclors estimated at one-half the DL. This is a conservative representation of PCB concentrations because only Aroclors 1254 and 1260 were detected, with the exception of 2 percent of samples in which Aroclor 1016 was detected. All other Aroclors were never detected, but were conservatively assumed to be present in fish tissues at one-half the DL for calculation of total PCBs.

Concentrations of TEQs in whole fish were also based on the data from the 2005 UCR fish tissue data set (USEPA 2007a). They were calculated by multiplying each dioxin, furan, or dioxin-like PCB congener by its congener-specific TEF for fish (van den Berg et al. 1998), and computing a sum of these products. Calculations were performed using three different methods for treatment of non-detects, to ensure that the uncertainties associated with undetected congeners would not result in underestimating exposures. TEQs were calculated setting non-detects estimated as zero, one-half the DL, or the full DL.

B5.2.3 Comparison of Measures of Exposure to Toxicity Benchmarks

Water chemistry data were compared to benchmarks in the SLERA (TCAI 2008). Although the water data are limited to a single station near the U.S.-Canadian border (i.e., Northport, Washington), the screening level analysis found few exceedances of water quality benchmarks:

One measurement of cadmium near Northport exceeded the dissolved cadmium AWQC on one occasion. There was one exceedance each for cadmium, copper, lead and zinc of the CCME values for total concentrations of these metals in 2003, and exceedances were not great (several cadmium results were below DLs, but DLs exceeded the CCME criterion).

None of the pesticides that have been measured in water exceeded screening criteria for water. Two pesticides (dieldrin and malathion) had DLs that exceeded screening values.

Figures B32 and B33 illustrate the concentrations of metals in oligochaetes analyzed by Besser et al. (2008) relative to NOAEC-based TRVs for fish prey. Metals concentrations in oligochaetes exposed to UCR sediments were generally below the TRVs, with the following exceptions:

Copper exceeded its TRV by a factor of 3 at the location closest to the border with Canada (~RM 734).

Arsenic exceeded its TRV at RM 710 and 625 by factors of 1.4 and 1.5, respectively. Arsenic also exceeds its TRV at the reference station (i.e., Sanpoil Arm) by a factor of 1.4.

Table B21 provides the numbers of gut/gut contents samples with concentrations that exceed TRVs expressed as a concentration in fish prey. None of the 20 samples of gut/gut contents exceed the TRVs for arsenic, cadmium, lead or silver. Chromium was the chemical with the highest number of exceedances (17). Exceedances of TRVs were also found for copper (7), vanadium (14), and zinc (3). This analysis conservatively assumes that metals in sediment are as bioavailable as they were in the foods used in the toxicity studies on which the TRVs are based. The results indicate that concentrations of several metals (arsenic, cadmium, lead and silver) in sediment are not higher than no-effects levels for prey. Table B22 shows the maximum concentration of each of these metals in the whole body dataset for all fish combined relative to the TRVs. Only the maximum concentrations of chromium, copper and vanadium among all the whole fish samples exceed the NOAEC TRVs. All of the maximum concentrations that exceeded TRVs occurred in whole suckers.

For organic compounds, only one whole body fish sample had a total PCB concentration that exceeded the CBR for total PCBs (Figure B34). The arithmetic means of whole body fish TEQ_{DFP} concentrations were below concentrations protective of 97.5 percent of fish species (Figure B35), as were maximum values for all fish calculated using the most conservative assumption: that undetected congeners were present at concentrations equal to the DL.

Although this evaluation does not constitute a formal risk assessment, preliminary observations can be made. Where both metrics of exposure and benchmarks of toxicity are available, the overall pattern suggests that risks to fish from exposures to chemicals in water and prey, and due to bioaccumulation of chemicals are generally low. There have been very few exceedances of conservative water quality benchmarks that are considered protective of aquatic life. Among oligochaetes exposed to Site sediments for 28 days, only the mean concentrations of arsenic (three times, including in the reference area) and copper (once) exceeded no-effects levels for these metals in prey of fish. The maximum concentrations of chemicals in fish rarely exceeded TRVs expressed as NOAECs, and exceedances were low. All fish whole body concentrations (USEPA 2007a) of TEQ_{DFP} were below the concentration protective of 97.5 percent of fish species, and all but one concentration of total PCBs in whole body fish were below the lowest available TRV for fish.

B6 REVIEW OF COMMENTS BY PARTICIPATING PARTIES

Participating parties reviewed USEPA's (2007a) report in draft form, and made recommendations for additional evaluations of the 2005 fish tissue data set, as well as evaluations of future data collected as part of the UCR RI/FS. Several of the recommendations have been satisfied by the analyses performed by USEPA (2007a) or herein. However, most of the recommendations (particularly those related to future data collection) are most appropriate for consideration during the development of the BERA.

Table B23 lists the comments by the participating parties according to the summary of comments received from EPA, and identifies where each comment has been or will be addressed in the RI/FS.

B7 POLYBROMINATED DIPHENYL ETHERS IN FISH

PBDEs are a class of compounds structurally similar to PCBs, consisting of two carbon rings linked by an oxygen bond. The carbon rings have various degrees of bromination, giving rise to 209 individual BDE compounds, or congeners. Manufactured for use as flame retardants and textile coatings, PBDEs have recently gained widespread scientific and public attention because of apparent increases in concentrations in human tissue and environmental media in recent decades. PBDEs have been measured in fish tissue in the UCR and in nearby areas, and are among the chemical groups potentially of interest to the BERA.

This section describes the available information on PBDE concentrations in tissue of fish collected from the UCR basin, and considers additional collection of tissue and analysis for PBDEs.

B7.1 PBDE CONCENTRATIONS IN FISH

PBDEs bioaccumulate in fish, and tri- to hepta-BDEs biomagnify, with the maximum biomagnification in a community of pike, perch, and roach observed to be by the penta-brominated group by Burreau et al. (2004). These authors reported that biomagnification by the hexa- and hepta-brominated groups was inversely proportional to the degree of bromination; and that octa-, nona- and deca-brominated BDEs did not biomagnify, but did occur in fish tissue sampled during their study (i.e., they bioaccumulated). Fish size, but not fish sex, affected concentrations of PBDEs in this study when trophic position was accounted for. Differences in the apparent rates of bioaccumulation by different fish species have been attributed to the ability of some fish to debrominate some of the congeners, and interspecific differences in metabolism (Rayne et al. 2003).

Data describing concentrations of total PBDEs in fillet tissue of fish from the UCR are available from three studies (Rayne et al. 2003; Johnson et al. 2006; Hatfield Consultants 2008) (Table B24). Rayne et al. (2003) analyzed fillets of mountain whitefish collected from the confluence of Beaver Creek and the Columbia River, 9 kilometers (~6 miles) downstream from Trail, British Columbia in 1992 and 2000; and from a site near the town of Genelle, British Columbia 13 kilometers downstream of the City of Castlegar, British Columbia; and upstream from Trail in 1992, 1996, and 2000. Rayne et al. (2003) compared concentrations in individual mountain whitefish skinless fillet tissue from the 1990s with concentrations found in 2000, and reported that, while tissue concentrations at both sites generally increased from 1992 to 2000, the rate of increase in PBDEs in mountain whitefish fillets downstream of Trail (a factor of 6.5 increase) was less than the rate of increase at Genelle (a factor of 11.8 increase). In 2000, the mean PBDE concentration in whitefish fillets below Trail (29.2 μg/kg ww) was significantly less than at Genelle (71.8 μg/kg ww).

PBDEs analyzed in mountain whitefish from the Genelle and Beaver Creek reaches during 2002 and 2004 indicate that concentrations may have continued to increase in the UCR (Hatfield Consultants 2008). Skin-on fillets of mountain whitefish from Genelle analyzed for the Columbia River Integrated Environmental Monitoring Program (CRIEMP) during 2002 and 2004 had mean total PBDE concentrations of 107 µg/kg ww and 130 µg/kg ww, respectively. Lower mean total PBDE concentrations were reported in specimens from Beaver Creek in 2002 and 2004 (90.8 µg/kg ww and 85.5 µg/kg ww, respectively), but the differences between sites were not as pronounced as those reported earlier by Rayne et al. (2003). The larger sample sizes analyzed during 2004 demonstrate the wide range of concentrations from the same reach. However, the absence of lipid data in the Hatfield Consultants (2008) report precludes the examination of this variable as an influencing factor.

Skin-on rainbow trout fillets were also analyzed for PBDEs as part of the CRIEMP sampling during 2003 (Hatfield Consultants 2008). Mean total PBDEs from Genelle and Beaver Creek specimens were 18.4 µg/kg ww and 17.3 µg/kg ww, respectively, much lower than concentrations in mountain whitefish. Hatfield Consultants (2008) attributed the differences in PBDE concentrations to dissimilarity in feeding behavior between rainbow trout, a surface-feeder, and mountain whitefish, a near bottom-feeder. While variables accounting for differences between species have yet to be thoroughly examined, much lower PBDE concentrations in rainbow trout compared to mountain whitefish has also been reported elsewhere, most notably at two locations in the Spokane River (Table B24).

All mountain whitefish data analyzed in the Columbia River upstream of the international boundary since 2000 had greater mean concentrations than the 18 µg/kg ww total PBDEs found in one composite of lake whitefish fillets (with skin) from the UCR near Kettle Falls by Johnson et al. (2006). Other species tested at this location by Johnson et al. (2006) had lower total PBDE concentrations (Table B24).

Information on PBDE concentrations in fish is available for elsewhere in eastern Washington state (Johnson and Olson 2001, Serdar and Johnson 2006, Johnson et al. 2006; Seiders et al. 2006). A summary of the data for PBDEs in various fish species from among the reference area data set described in Section B.4.1 was compiled (Table B24). Concentrations of total PBDEs in reference area lakes are generally comparable to those downstream of Trail (Rayne et al. 2003) and from Kettle Falls (Johnson et al. 2006). Figure B36 shows lipid-normalized concentrations of total PBDEs in the mountain whitefish samples from the Methow, Wenatchee, Middle Columbia, and Spokane rivers, and the two sites in Rayne et al.'s (2003) study and the CRIEMP (Hatfield Consultants 2008) study, as well as for the lake whitefish fillet without skin from the UCR.[9]

[9] Rayne et al (2003) did not report lipid content. Lipids were estimated using the percent lipid for a skin-off fillet sample from the Methow River (3.9 percent), because it was the only available lipid measurement for a mountain whitefish skinless fillet. Lipid was estimated for samples for the Upper and Lower Long Lake samples as the mean of lipids in three skin-on fillets from reference areas. That estimated lipid value was 4.6 percent.

This limited comparison suggests that the near-urban areas of Upper and Lower Long lakes (downstream of Spokane, Washington) and Genelle tend to have higher concentrations of total PBDEs than fish from the reference areas. On the basis of lipid-normalized concentrations, the value for the lake whitefish sample from the UCR near Kettle Falls was more comparable to the values for mountain whitefish from the reference areas than to the values for mountain whitefish from rivers near urban areas (e.g., Upper Long Lake and Lower Long Lake). However, because mountain whitefish tended to have higher wet-weight concentrations of total PBDEs than lake whitefish, it is important to note that the UCR sample is a different species than that collected by Rayne et al. 2003) and Hatfield Consultants (2008), with a different life history, and likely different prey and habitats. Figure B36 also illustrates the difference between the mean PBDE concentrations in whitefish at Genelle, upstream of Trail, and at Beaver Creek downstream.

Rayne et al. (2003) evaluated the potential sources of PBDEs, and discussed spatial patterns of their data, which include largescale sucker samples from the more rural area downstream of Nelson, British Columbia and multiple sediment samples. They concluded that relatively elevated concentrations of PBDEs were likely attributable to releases of domestic wastewaters and septic systems from diffuse communities that reside along the waterways they examined. PBDE sampling by Serdar and Johnson (2006) from the Spokane River (Table B24; Figure B36) support this finding.

B7.2 ANALYSIS OF PBDE CONCENTRATIONS IN FISH TISSUE

Comments received by EPA and participating parties recommended that additional fish tissue samples be collected for analysis of PBDEs (Comment TF8, Table B23). However, the data presented in this section strongly suggest that PBDE concentrations in fish tissue in the UCR were generally comparable to concentrations in those from reference areas in eastern Washington. Moreover, samples taken directly downstream from Trail were not elevated relative to concentrations in fish from the reference areas and were lower than concentrations in fish from areas near other municipal sources like Castlegar and the greater Spokane area. These patterns suggest that there is not a major source of PBDEs to fish tissues in Trail, BC.

For assessment of potential risks to fish, additional data describing PBDEs in tissue is not considered useful because CBRs are not available in the literature for PBDEs, either as total concentrations or as concentrations of congeners. In addition, the toxicity of PBDEs to fish is not well described, although some data are available for evaluating responses due to ingestion exposure (Hornung et al. 1996; Boon et al. 2003). More data are available to assess the potential toxicity of ingested PBDEs on consumers of fish (e.g., Darnerud 2003), potentially enabling assessment of potential risks to piscivorous birds and mammals from the UCR.

B8 SUMMARY AND RECOMMENDATIONS

This appendix provides an overview of information on the concentrations of chemicals in fish tissue from the UCR; evaluates the value of historical (pre-2005) and recent (2005) fish tissue data for ecological risk assessment purposes; explores spatial, temporal and interspecific patterns in fish tissue chemistry; and interprets information on exposures of fish to chemical contaminants. The results can be used to guide development of the BERA and future sampling plans, both for risk assessment to fish and to piscivorous wildlife. This section provides a summary and synthesis of the information presented, and identifies potential data needs and recommendations for future evaluations to more effectively evaluate potential risks to fish in the UCR.

B8.1 SUMMARY OF FINDINGS

Several important findings resulted from the evaluation of existing information on fish tissue chemistry in the UCR:

- The data on chemical concentrations in fish tissue collected in the UCR prior to 2005 were primarily for fillet tissue and for species and sizes considered edible by people. A few studies provided data for whole bodies of largescale sucker, but the most recent data of this kind were published in 1997. The pre-2005 data are not considered to be highly useful for the RI/FS BERA, because they vary substantially with respect to target species, fish size, and sampling locations. In addition, the data generally are not representative of the tissue (i.e., whole body) and size ranges commonly consumed by piscivorous fish and wildlife, and are not considered representative of current conditions in the UCR, as required for a BERA. Although the historical data are not considered highly useful ecological risk assessment, the data may have some value for assessing potential risks to people, which is being conducted by EPA.
- Although the historical data have limitations for ecological risk assessment, they have some value in qualitatively evaluating general spatial and temporal trends in historical fish tissue concentrations in the UCR, and the following generalizations can be made:
  - Concentrations of copper, lead, and zinc in whole largescale sucker declined considerably with increasing distance downstream from Northport. However, arsenic, cadmium and mercury concentrations did not decrease with distance from Northport. Results for whole bodies of suckers were likely affected to an unknown degree by sediment in their guts.
  - Tissue concentrations of mercury were generally higher in walleye and largescale sucker than in other species.
  - Mercury concentrations in walleye tissues generally declined in the middle and lower reaches of the UCR between 1995 and 2005.

Several metals, including cadmium, copper, lead, and mercury declined in tissue of whitefish, rainbow trout and walleye collected upstream of the U.S.-Canadian border between 1995 and 1999.

The data set on fish tissue concentrations in the UCR collected by USEPA (2007a) in 2005 provides the most systematic and robust data set for fish tissue for the UCR. This data set is considered useful for ecological risk assessment, and representative of baseline conditions in the UCR. However, it is incomplete with respect to smaller fish species and life stages that are important for understanding risks to piscivorous fish and wildlife.

Qualitative comparisons between the pre-2005 and 2005 data for chemical concentrations in UCR fish suggest that tissue concentrations of copper, lead, and mercury have declined in fillet of walleye and rainbow trout from the mid- to late-1990s to 2005; whereas patterns for arsenic, cadmium and 2,3,7,8-TCDF are equivocal, partly due to the high metals DLs for the pre-2005 data. Concentrations of PCBs appear to have decreased in walleye and trout fillets from the middle and lower portions of the site over that time period.

Although the 2005 fish tissue data were primarily for fish species and size classes of interest to human consumption, the data are useful for evaluating patterns in the spatial distribution of fish exposures, and other species-specific fish exposure patterns that are relevant to the BERA. These include:

The highest concentrations of most metals occurred in largescale sucker, burbot and walleye. Consistent with trends identified for the pre-2005 data, the highest mercury concentrations were found in walleye and sucker. In 2005, mercury concentrations in burbot were also among the highest for the species evaluated. Mercury was not measured in this species in the pre-2005 data set. The elevated concentrations in walleye and burbot likely reflect their high trophic level as piscivores. The relatively long lifespan of the benthivorous largescale sucker may affect concentrations of mercury in that species.

As found for the pre-2005 data, tissue concentrations of copper, lead and zinc in largescale sucker declined with distance downstream from the U.S.-Canadian border. However, clear patterns of declining concentrations from north to south were not observed for other fish species.

Differences among species in the locations and magnitude of peak tissue concentrations of both metals and organic compounds suggest different pathways and mechanisms of exposure. Benthic fish (i.e., largescale suckers) and top predators (i.e., walleye, burbot and to some degree rainbow trout) consistently showed the most pronounced spatial patterns (i.e., high spatial variability). However, some of these spatial differences, while statistically significant ($p \leq 0.05$), were not large. Whether these differences reflect such factors as variations in age, life history, and diet of each species across the UCR is unknown.

Understanding the spatial patterns of exposure for each fish species may be confounded to some degree by the effect of length (i.e., as a surrogate for size and age) on tissue concentrations. In addition, understanding the spatial patterns for whole bodies of largescale sucker may be confounded by the presence of sediment in the fish stomachs.

Statistically significant correlations between whole body concentrations and fillet concentrations in rainbow trout and walleye occur in both species for arsenic, beryllium and mercury, and only in rainbow trout for antimony, chromium, selenium and silver. Therefore, if it is necessary to predict fillet concentrations from whole body concentrations, this should only be performed where a statistically significant relationship can be demonstrated and described.

Correlations between concentrations of metals in the gut/gut contents samples of largescale sucker and the gutless whole body samples were conducted. The analysis identifies three different patterns: no relationship between gut/gut contents and gutless whole body concentrations (antimony, arsenic, barium, beryllium, calcium, chromium, magnesium, nickel, potassium, selenium, silver), a significant linear relationship (aluminum, cadmium, cobalt) and a significant non-linear relationship (copper, iron, lead, manganese zinc). The differences suggest that the uptake, retention, and excretion rates of metals from the guts, which contained large amounts of sediment, are variable.

Statistically significant correlations ($p \leq 0.05$) between chemical concentrations in whole fish and sediments were apparent for several species, and several metals. When wild and hatchery rainbow trout data were combined, the largest number of significant correlations between sediment and tissue occurred. The absence of a consistent pattern of sediment-tissue correlations suggests that exposure pathways vary across the UCR or among species, or the confounding effect of fish movements within the Site. It may also be an indication of the limits of this analysis resulting from the use of mean sediment concentrations for each of only three locations.

A variety of external abnormalities including skin lesions, hemorrhagic abnormalities, fin erosion, external parasites and other anomalies were observed and recorded by EPA biologists during the 2005 sampling event (USEPA 2007a). Their data showed that the greatest percentage of fish examined with external anomalies was in FSCA 5, and that the overall percent of fish affected with anomalies in the UCR (66 percent) was less than the percent of fish affected across the Columbia River Basin (74 percent from Hinck et al. 2006). EPA did not conduct histopathological examinations to determine the cause of the anomalies. However, Hinck et al. (2006) concluded that the majority of anomalies (including lesions) observed throughout the Columbia River Basin (including the UCR) are inflammatory responses to parasitic or bacterial infections. Peters (2005) and studies sponsored by the Canadian government also equated most fish lesions with parasitic infections.

USEPA (2007a) assumed that the variance of chemical concentrations in individual fish is greater than the variance in composite fish tissue samples, and can be estimated by multiplying the composite variance by the number of fish in the composite. The data for individual largescale suckers was used to test this assumption, and it was determined that there is little difference in the variance of mean concentrations of chemical between whole body sucker composites and individual whole sucker samples. Therefore, it may not be appropriate to assume that the variance of individual fish in a composite as a function of the composite variance times the number of fish in the composite, as was done by USEPA (2007a).

The information on reference conditions for fish tissue concentrations in eastern Washington was found to be limited. Data are lacking for many chemicals, and have been intermittently collected for many others. In addition, most of the tissue data collected in candidate reference areas were for fillet tissue, rather than whole bodies. It was therefore concluded that quantitative comparisons of these small data sets with data for the UCR was limited at this time. However, both smallmouth and largemouth bass fillet samples have been analyzed in many potential reference areas in eastern Washington. Data for these species from the UCR could allow for direct comparison with available reference areas.

Three general approaches to evaluating risks to fish where evaluated: water chemistry relative to water quality benchmarks for the protection of aquatic life for all chemicals, CBRs for organic compounds, and TRVs for metals expressed as concentrations in prey of fish.

The three general approaches for assessing risk to fish were applied to all of the recent data collected for surface water and oligochaete and fish tissue in the UCR, with the following results:

Based on the results presented in the SLERA (TCAI 2008), concentrations of metals in surface water of the UCR were generally below water quality benchmarks, suggesting that they do not pose unacceptable risks to aquatic life in the UCR. However, the existing data are limited to a small number of analytes measured at a single station at Northport, Washington near the upstream boundary of the Site. The existing water quality data are considered insufficient for risk characterization throughout the Site (TCAI 2008). Additional water quality data that will be collected in the UCR as part of the RI/FS will allow a more definitive evaluation of potential risks to fish (and other aquatic organisms) posed by chemicals in surface water of the UCR.

Total PCB concentrations in all but one of the whole body fish samples collected in 2005 by USEPA (2007a) were below conservative NOAECs-based CBRs for fish.

TEQ_{DFP} concentrations in all of the whole body fish samples collected by EPA in 2005 were below concentrations protective of 97.5 percent of fish species.

- Concentrations of selected metals in a surrogate prey for benthivorous fish (i.e., oligochaetes exposed in the laboratory for 28 days to site sediments) were generally below NOAEC-based TRVs for fish prey. Exceptions included arsenic at two of the seven UCR Site stations evaluated, although arsenic also exceeded its TRV in the Sanpoil Arm reference area, and copper at the station closest to the U.S.-Canadian border.
- Concentrations of selected metals in gut/gut contents samples from individual largescale suckers in FSCAs 1, 3 and 6 were compared with NOAEC-based TRVs for fish to provide an initial evaluation of whether the gut contents (which included sediment) may pose a risk to the largescale suckers. This analysis was very conservative as metals bioavailability was assumed to be high. Results of this evaluation showed that concentrations of four other metals (i.e., arsenic, cadmium, lead, and silver) did not exceed their TRVs, whereas concentrations of four other metals (i.e., chromium, copper, vanadium and zinc) exceeded their TRVs. These results indicate that an evaluation of the bioavailability of metals in the gut contents of suckers should be addressed in the BERA, so that more realistic estimates of risk can be developed.
- The maximum concentration of arsenic, cadmium, chromium, copper, lead, silver, vanadium and zinc among all whole body fish tissue samples from 2005 were compared to TRVs for these metals expressed as prey concentrations. Among all the whole fish samples, only the maxima for chromium, copper and vanadium exceeded these TRVs, which represent NOAECs, and the degree of exceedance was low. All of these maxima occurred in adult largescale sucker.

Although PBDEs have been detected in fish from the UCR, as well as other water bodies in the UCR drainage basin, they appear to be associated primarily with domestic wastewaters, and are typically lower in fish tissue from stations downstream from Trail, British Columbia, than from locations upstream of that location. In addition, PBDE concentrations in fish tissue from the UCR were generally comparable to concentrations in fish from reference areas in eastern Washington.

The set of observations listed above should be used to facilitate development of the BERA, including identification of data gaps, and specification of analyses required to address key risk questions.

B8.2 RECOMMENDATIONS FOR FISH TISSUE SAMPLING

The following items are potential data needs that should be considered during the development of the fish tissue sampling program for the UCR:

Fish that are smaller than the ones represented in the pre-2005 and 2005 data sets should be sampled to provide a better estimate of chemical concentrations in the prey species typically consumed by piscivorous fish and wildlife.

Given that lack of information on bioaccumulation in the primary prey of planktivorous and benthivorous fish (i.e., zooplankton and benthic macroinvertebrates, respectively) in the UCR, chemical concentrations should be evaluated by focusing on key prey organisms, such as daphnids and chironomids (Scofield et al. 2007), or by employing the "market basket" approach used in the RI/FS for the Lower Duwamish River (Windward 2007). The market basket sample, as applied to invertebrate tissue by Windward (2007), retained tissue from a variety of species, depending on what was captured. This method assumes that species preying on the invertebrate market basket are non-selective.

Additional fish species should be collected and their tissue chemistry analyzed to provide a more complete assessment of the chemical concentrations in fish in the UCR. Additional sampling should include representation of benthic fish, because the 2005 data for the largescale sucker suggests that those species are the ones with the greatest potential for exposure to contaminated sediments in the UCR. A key family that should be considered is the cottids (i.e., sculpins), because they typically exhibit greater site fidelity than many other species, and therefore may have tissue concentrations more reflective of the sediments where they are captured, than species that exhibit greater movement and thereby tend to average sediment exposure over greater areas. In addition, cottids have been documented to be a key prey species for piscivorous fish in the UCR (e.g., Scofield et al. 2007) and therefore represent an important pathway by which chemicals can move from sediments to piscivorous fish.

Additional fish species should be collected in the UCR for chemical analysis to provide a basis for more definitive comparisons with reference conditions. A key species for consideration is smallmouth bass, a species for which a relatively large statewide database exists (e.g., Fishnaller et al. 2003, Seiders et al. 2008). Comparisons with reference conditions could be particularly valuable for addressing chemicals for which reliable toxicity benchmarks are not available. In addition, those comparisons would be valuable for placing any identified risks into a larger context. That is, if a chemical is identified as posing a risk in the UCR, it will be important to determine whether its UCR tissue concentrations are within the range of reference conditions, to guide risk management decisions. This concept particularly applies to chemicals that have known atmospheric sources, such as mercury.

Future evaluations based on statistical comparisons of fish tissue concentrations should use variance estimates based on the 2005 data to determine appropriate sample sizes (see Appendix D of the QAPP). In addition, the pros and cons of measuring tissue concentrations in individual fish and in composite samples should be further evaluated.

B9 REFERENCES

Andres, S., M. Baudrimont, Y. Lapaquellerie, F. Ribeyere, N. Maillet, C. Latouche, and A. Boudou. 1999. Field transplantation of the freshwater bivalve *Corbicula fluminea* along a polymetallic contamination gradient (Lot River, France): I. Geochemical characteristics of the sampling sites and cadmium and zinc bioaccumulation kinetics. *Environ. Toxicol. Chem.* 18(11) 2462–2471.

Antcliffe, B.L., D. Kieser, G. Lawrence, W.L. Lockhart, D.A. Metner, and J.A.J. Thompson. 1997a. Monitoring of mountain whitefish, *Prosopium williamsoni*, from the Columbia River system near Castlegar, British Columbia: Final assessment of fish health and contaminants, July 1996. Report no. 2184. *Can. Tech. Rep. Fish. Aquat. Sci*. xiii 79 pp.

Antcliffe, B.L., D. Kieser, W.L. Lockhart, D.A. Metner, J.A.J. Thompson, and J.R. Roome. 1997b. Monitoring of mountain whitefish, *Prosopium williamsoni*, from the Columbia River system near Castlegar, British Columbia: Fish health assessment and contaminants in 1994. Report no. 2142. *Can. Tech. Rep. Fish. Aquat. Sci.* xii+100 pp.

Aquatic Resources Ltd. 2001. Sediment and water quality in the Lower Columbia River from Birchbank to Waneta: A comparison of 1995 and 1999 monitoring data. September.

B.C. MoE. 2000. Dioxins and furans in rainbow trout, mountain whitefish, and walleye collected from the Columbia River in September 2000. Unpublished data provided by B.C. Environment.

B.C. MoE. 2001. September 2001 Columbia River fish quality objectives monitoring. Unpublished dioxin and furan data for mountain whitefish. Unpublished data provided by B.C. Environment.

Barron, M.G., J.A. Hansen, and J. Lipton. 2002. Association between contaminant tissue residues and effects in aquatic organisms. *Rev. Environ. Contam. Toxicol.* 173:1–37.

Besser, J.M., W.G. Brumbaugh, C.D. Ivey, C.G. Ingersoll, and P.W. Moran. 2008. Biological and chemical characterization of metal bioavailability in sediments from Lake Roosevelt, Columbia River, Washington, USA. *Arch. Environ. Contam. Toxicol.* DOI 10.1007/s00244-007-9074-5.

Boon, J.P., J.J. van Zancen, W.E. Lewis, B.N. Zegers, A. Goksoyr, and A. Arukwe. 2003. Abstract: The expression of CYP1A, vitellogenin and zona radiate proteins in Atlantic salmon (*Salmo salar*) after oral dosing with two commercial PBDE flame retardant mixtures: absence of short-term responses. *Environ. Internat.* 29(6):841-853.

Boyle, D.E., B.A. Bravender, T.J. Brown, D. Keiser, C.D. Levings, W.L. Lockhart, J.A. Servizi, and T.R. Whitehouse. 1992. Baseline monitoring of mountain whitefish, *Prosopium williamsoni*, from the Columbia River system near Castlegar, British Columbia: Health, contaminants and biology. *Can. Tech. Rep. Fish. Aquat. Sci.* 1883. 64 pp. + appendices.

Brumelle, S. P. Nemetz, and D. Casey. 1984. Estimating means and variences: The comparity efficiency of composite and grab samples. *Environmental Monitoring and Assessment*. 4(1):81-84.

Bryan, G.W. 1979. Bioaccumulation of marine pollutants. *Phil. Trans. R. Soc. Lond. B.* 286:483-505.

Burreau, S., Y. Zebühr, D. Broman, and R. Ishaq. 2004. Biomagnification of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) studied in pike (*Esox lucius*), perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) from the Baltic Sea. *Chemosphere*. 55(7):1043-1052.

Darnerud, P.O., G.S. Eriksen, T. Jóhannesson, P.B. Larsen, and M. Viluksela. 2003. Polybrominated diphenyl ethers: Occurrence, dietary exposure, and toxicology. *Environ. Health Perspect.* 2001 Mar; 109 Suppl. 1:49-68.

Durda, J. L. and D.V. Preziosi. 2000. Data quality evaluation of toxicological studies used to derive ecotoxicological benchmarks. *Hum. Ecol. Risk Assess*. 6(5): 747-765.

Dyer, S.C., C.E. White-Hull, and B.K. Shephard. 2000. Assessments of chemical mixtures via toxicity reference values overpredict hazard to Ohio fish communities. *Environ. Sci. Technol.* 34:2518-2524.

Ecology (Washington State Department of Ecology). 1995. Department of Ecology 1993-94 investigation of PCBs in the Spokane River. Publication #95-310. Washington State Department of Ecology, Olympia, WA.

EVS. 1998. Assessment of dioxins, furans, and PCBs in fish tissue from Lake Roosevelt, Washington, 1994. Final Report. December. EVS Environmental Consultants, Inc., Seattle, WA.

Fischnaller, S., P. Anderson, and D. Norton. 2003. Mercury in edible fish tissue and sediments from selected lakes and rivers of Washington State. EIM Project Number PAND0001. Washington State Department of Ecology, Olympia, WA.

Garner, F.C., M.A. Stapanian, and L.R. Williams. 1988. Composite sampling for environmental monitoring. pp. 363-374. In: *Principles of Environmental Sampling*. L.H. Keith (ed.). American Chemical Society, Washington, DC.

Gobas, F.A.P.C. and D. Mackay. 1987. Dynamics of hydrophobic organic chemical bioconcentration in fish. *Environ. Toxicol. Chem.* 6:495-504.

Hatfield Consultants. 2008. Lower Columbia River water quality objectives monitoring program – Birchbank to the International Boundary 1997–2005: Data summary and interpretive report. Prepared for CRIEMP (Columbia River Integrated Environmental Monitoring Program). Prepared by Hatfield Consultants, Vancouver, B.C.

Hinck, J.E., C.J. Schmitt, T.M. Bartish, N.D. Denslow, V.S. Blazer, and P.J. Anderson. 2004. Biomonitoring of Environmental Status and Trends (BEST) Program: Environmental contaminants and their effects on fish in the Columbia River Basin. Scientific Investigations Report 2004 – 5154. U.S. Geological Survey, Washington, D.C.

Hinck, J.E., C.J. Schmitt, V.S. Blazer, N.D. Denslow, T.M. Bartish, P.J. Anderson, J.J. Coyle, G.M. Dethloff, and D.E. Tillitt. 2006. Environmental contaminants and biomarker responses in fish from the Columbia River and its tributaries: Spatial and temporal trends. *Sci. Tot. Environ.* 366 (2006):549–578.

Hopkins, B.S., D.K. Clark, M. Schlender, and M. Stinson. 1985. Basic water monitoring program, fish tissue and sediment sampling for 1984. Publication No. 85-7. Washington State Department of Ecology, Olympia, WA.

Hornung, M.W., E.W. Zabel, and R.E. Peterson. 1996. Abstract: Toxic equivalency factors of polybrominated dibenzo-*p*-dioxin, dibenzofuran, biphenyl, and polyhalogenated diphenyl ether congeners based on rainbow trout early life stage mortality. *Toxicology and Applied Pharmacology*, Volume 140, Issue 2, pp. 227-234.

Hugla, J.L. and J.P. Thome. 1999. Effects of polychlorinated biphenyls on liver ultrastructure, hepatic mono-oxygenases, and reproductive success in the barbel. *Ecotoxicol. Environ. Saf.* 42: 265-273.

Jack, R. and M. Roose. 2002. Analysis of fish tissue from Long Lake (Spokane River) for PCBs and selected metals. Publication No. 02-03-049. Washington State Department of Ecology, Olympia, WA. 37 pp.

Johnson, A. 1991. Results of screen for EPA xenobiotics in sediment and bottom fish from Lake Roosevelt (Columbia River). Memorandum to Carl Nuechterlein July 22, 1991. Publication 91-e24. Washington State Department of Ecology, Olympia, WA

Johnson, A. 2000. Results from analyzing PCBs in 1999 Spokane River fish and crayfish samples. Memorandum to John Roland. Publication No. 00-03-040. Washington State Department of Ecology, Olympia, WA.

Johnson, A. and W. Yake. 1989. Survey of mercury and dioxin in Lake Roosevelt sportfish in 1989. Preliminary results for mercury. Publication No. 89-e29. Washington State Department of Ecology, Olympia, WA.

Johnson, A., and D. Serdar. 1991. Metals concentrations in Lake Roosevelt (Columbia River) largescale suckers. Memorandum to Carl Nuechterlein June, 21, 1991. Publication 91-e26. Washington State Department of Ecology, Olympia, WA.

Johnson, A., and N. Olson. 2001. Analysis and occurrence of polybrominated diphenyl ethers in Washington State freshwater fish. *Arch. Environ. Contam. Toxicol*. 41: 339-344.

Johnson, A., B. Yake, and D. Norton. 1988. An assessment of metals contamination in Lake Roosevelt. Publication No. 89-e26. Washington State Department of Ecology, Olympia, WA.

Johnson, A., B. Yake, and D. Norton. 1989. An assessment of metals contamination in Lake Roosevelt. Segment No. 26-00-04. Washington State Department of Ecology, Olympia, WA. 84 pp.

Johnson, A., D. Norton, W. Yake, and S. Twiss. 1990. Transboundary metal pollution of the Columbia River (Franklin D. Roosevelt Lake). *Bull. Environ. Contam. Toxicol*. 45:703-710.

Johnson, A., D. Serdar, and D. Norton. 1991a. Spatial trends in TCDD/TCDF concentrations in sediment and bottom fish collected in Lake Roosevelt (Columbia River). Publication No. 91-29. Washington State Department of Ecology, Olympia, WA.

Johnson, A., D. Serdar, and S. Magoon. 1991b. Polychlorinated dioxins and furans in Lake Roosevelt (Columbia River) sport fish, 1990. Publication No. 91-4. Washington State Department of Ecology, Olympia, WA.

Johnson, A., K. Seiders, C. Deligeannis, K. Kinney, P. Sandvik, B. Era-Miller, and D. Alkire. 2006. PBDE Flame retardants in Washington rivers and lakes: Concentrations in fish and water 2005-06. Publication No. 06-03-027. Washington State Department of Ecology, Olympia, WA.

Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert-de Jong, C.J. De Groot, and W. Admirall. 1992. Chronic ecotoxicity of Zn and Pb to the zebra mussel *Dreissena polymorpha*. *Aquat Toxicol.* 30(1994): 77-89.

Landrum, P.F., and J.P. Meador. 2002. Is the body residue a useful dose metric for assessing toxicity? *SETAC Globe*. 3(3): 32-34.

McCarty, L.S. 1986. The relationship between aquatic toxicity QSARS and bioconcentration for some organic chemicals. *Environ. Toxicol. Chem.* 5(1071):1080.

McGeer, J.C., K.V.Brix, J.M. Skeaff, D.K. DeForest, S. I. Brigham, W.J. Adams, and A. Green. 2003. Inverse relationship between bioconcentration factor and exposure concentration for metals: Implications for hazard assessment of metals in the aquatic environment. *Environ. Toxicol. Chem. 22*, 645 1017–1037.

Meador, J. 2006. Rationale and procedures for using the tissue-residue approach for toxicity assessment and determination of tissue, water, and sediment quality guidelines for aquatic organisms. *Hum. Ecol. Risk Assess.* 12(1018):1073.

Michaels, A.F. and A.R. Flegal. 1990. Lead in marine planktonic organisms and pelagic food chains. *Limnol. Oceanogr.* 35(2):287-295.

Miller, G.E. 1991. Asymptotic test statistics for coefficients of variation. *Communic. Statist.—Theor. Meth.* 20:2251-2262.

Munn, M.D. 2000. Contaminant trends in sport fish from Lake Roosevelt and the Upper Columbia River, Washington, 1994-1998. Report 00-4024. U.S. Geological Survey, Water Resources Division, Tacoma, WA.

Munn, M.D., S.E. Cox, and C.J. Dean. 1995. Concentrations of mercury and other trace elements in walleye, smallmouth bass, and rainbow trout in Franklin D. Roosevelt Lake and the Upper Columbia River, Washington, 1994. Open-File Report No. 95-195. U.S. Geological Survey, Water Resources Division, Tacoma, WA.

Nener, J., B.L. Antcliffe, D. Kieser, and J.R. Roome. 1995a. Columbia River mountain whitefish health study, March 28–29, 1993. Department of Fisheries and Oceans, Vancouver, BC. 53 pp.

Nener, J., D. Kieser, J.A.J. Thompson, W.L. Lockhart, D.A. Metner, and J.R. Roome. 1995b. Monitoring of mountain whitefish, *Prosopium williamsoni*, from the Columbia River system near Castlegar, British Columbia: Health parameters and contaminants in 1992. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2036. Department of Fisheries and Oceans, Vancouver, BC. 2036:89 pp.

Peters, R.L. 1995. Ecological investigations into the natural history of the nematode *Eustrongylides* sp. (Nematoda: Dioctophymatoidea) found in Franklin D. Roosevelt Lake, WA. Department of Biology, Eastern Washington University, Cheney, WA: 83 pp.

Rayne, S., M.G. Ikonomou, and B. Antcliffe. 2003. Rapidly increasing polybrominated diphenyl ether concentrations in the Columbia River system from 1992 to 2000. *Environ. Sci. Technol.* 37(13):2847-2854.

Scofield, B. C. Lee, D. Pavlik-Kunkel, and K. Fields. 2007. Lake Roosevelt Fisheries Evaluation Program, annual report, January 2005–December 2005. Prepared for U.S. Department of Energy, Bonneville Power Administration, and Division of Fish and Wildlife, Portland, OR. Washington State Department of Natural Resources, Spokane Tribe of Indians, Wellpinit, WA.

Seiders, K., C. Deligeannis, and K. Kinney. 2006. Washington State Toxics Monitoring Program: Toxic contaminants in fish tissue and surface water in freshwater environments, 2003. Publication No. 06-03-019. Washington State Department of Ecology, Olympia, WA.

Seiders, K., C. Deligeannis, and P. Sandvik. 2007. Washington State Toxics Monitoring Program: Toxic contaminants in fish tissue from freshwater environments in 2004 and 2005. Publication No. 07-03-024. Washington State Department of Ecology, Olympia, WA.

Seiders, K., C. Deligeannis, and P. Sandvik. 2008. Washington State Toxics Monitoring Program: Toxic contaminants in fish tissue from freshwater environments in 2006. Publication No. 08-03-002. Washington State Department of Ecology, Olympia, WA.

Serdar, D. and A. Johnson. 2006. PCBs, PBDEs, and selected metals in Spokane River fish, 2005. Publication No. 06-03-025. Washington State Department of Ecology, Olympia, WA.

Serdar, D., A. Johnson, and S. Magoon. 1991. Polychlorinated dioxins and -furans in Columbia River sportfish, Chief Joseph Dam to McNary Dam. Publication No. 91-49. Washington State Department of Ecology, Olympia, WA.

Serdar, D., B. Yake, and J. Cubbage. 1994. Contaminant trends in Lake Roosevelt. Publication No. 94-185. Washington State Department of Ecology, Olympia, WA.

Smith, S.B., A.P. Donahue, R.J. Lipkin, V.S. Blazer, C.J. Schmitt, and R.W. Goede. 2002. Illustrated field guide for assessing external and internal anomalies in fish. U.S. Geological Survey Information and Technology Report USGS/BRD/ITR—2002-0007. U.S. Geological Survey, Reston, VA. September.

Steevens, J.A., M.R. Reiss, and A.V. Pawlisz. 2005. A methodology for deriving tissue residue benchmarks for aquatic biota: A case study for fish exposed to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and equivalents. *IEAM.* 1(2):142–151.

TCAI. 2007. Upper Columbia River: Work Plan for the remedial investigation and feasibility study. Prepared by Integral Consulting Inc. and Parametrix, Inc. Teck Cominco American Incorporated, Spokane, WA.

TCAI. 2008. Upper Columbia River: Draft Screening-Level Ecological Risk Assessment (SLERA). Prepared by Parametrix, Inc. and Integral Consulting, Inc. Teck Cominco American Incorporated, Spokane, WA.

Teck Cominco. 2001. Assessment of Columbia River receiving waters - final report. G3 Consulting Ltd. December. Teck Cominco Ltd., Trail, B.C., Canada.

USEPA. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. NTIS No. PB85-227049. U.S. Environmental Protection Agency, Washington, DC.

USEPA. 2002. Columbia River Basin fish contaminant survey: 1996-1998. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 284 pp.

USEPA. 2004a. Document and data gathering task summary, Upper Columbia River Site RI/FS. December 2004. Prepared by CH2MHILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2004b. Historical electronic data management process, Upper Columbia River Site RI/FS. December 2004. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2005a. Draft Phase I fish tissue sampling approach and rationale, Upper Columbia River Site CERCLA RI/FS. January 14, 2005. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2005b. National study of chemical residues in lake fish tissue: Interim data for years 1-4. http://www.epa.gov/waterscience/fish/study/. U.S. Environmental Protection Agency, Office of Water.

USEPA. 2006. Draft final Phase I sediment sampling field sampling report, Upper Columbia River Site CERCLA RI/FS. July 13, 2006. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2007a. Phase I Fish Tissue Sampling Data Evaluation Report, Upper Columbia River Site CERCLA RI/FS. October 30, 2007. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2007b. Framework for metals risk assessment. EPA 120/R-07/001. March. U.S. Environmental Protection Agency, Office of the Science Advisor Risk Assessment Forum, Washington, DC.

USEPA. 2008. Upper Columbia River: work plan for the remedial investigation and feasibility study. Modified by the U.S. Environmental Protection Agency based on the draft work plan provided by Teck Cominco American Incorporated. December 2008.

USGS. 1995. Concentrations of Mercury and other trace elements in walleye, smallmouth bass, and rainbow trout in Franklin D. Roosevelt Lake and the Upper Columbia River, Washington 1994. 95-195. U.S. Geological Survey, Tacoma, WA. 35 pp.

USGS. 2006. National Contaminant Biomonitoring Program (NCBP) Database. http://www.cerc.usgs.gov/data/ncbp/ncbp.html. U.S. Geological Survey, Columbia Environmental Research Center.

van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Geisy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacherewski. 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environ. Health Perspect*. 106(12):775-792.

Windward. 2004. Lower Duwamish Waterway remedial investigation, Quality Assurance Project Plan: Fish and crab tissue collection and chemical analyses. Final. August 27, 2004. Prepared by Windward Environmental, LLC. Lower Duwamish Waterway Group, Seattle, WA.

Windward. 2007. Lower Duwamish Waterway remedial investigation. Phase 2 remedial investigation report, Appendix A: Baseline ecological risk assessment. Final. July 31, 2007. Prepared by Windward Environmental, LLC. Lower Duwamish Waterway Group, Seattle, WA.

Zar, J.H. 1996. *Biostatistical Analysis*. Third Edition. Prentice Hall, Upper Saddle River, NJ. 662 pp.

FIGURES

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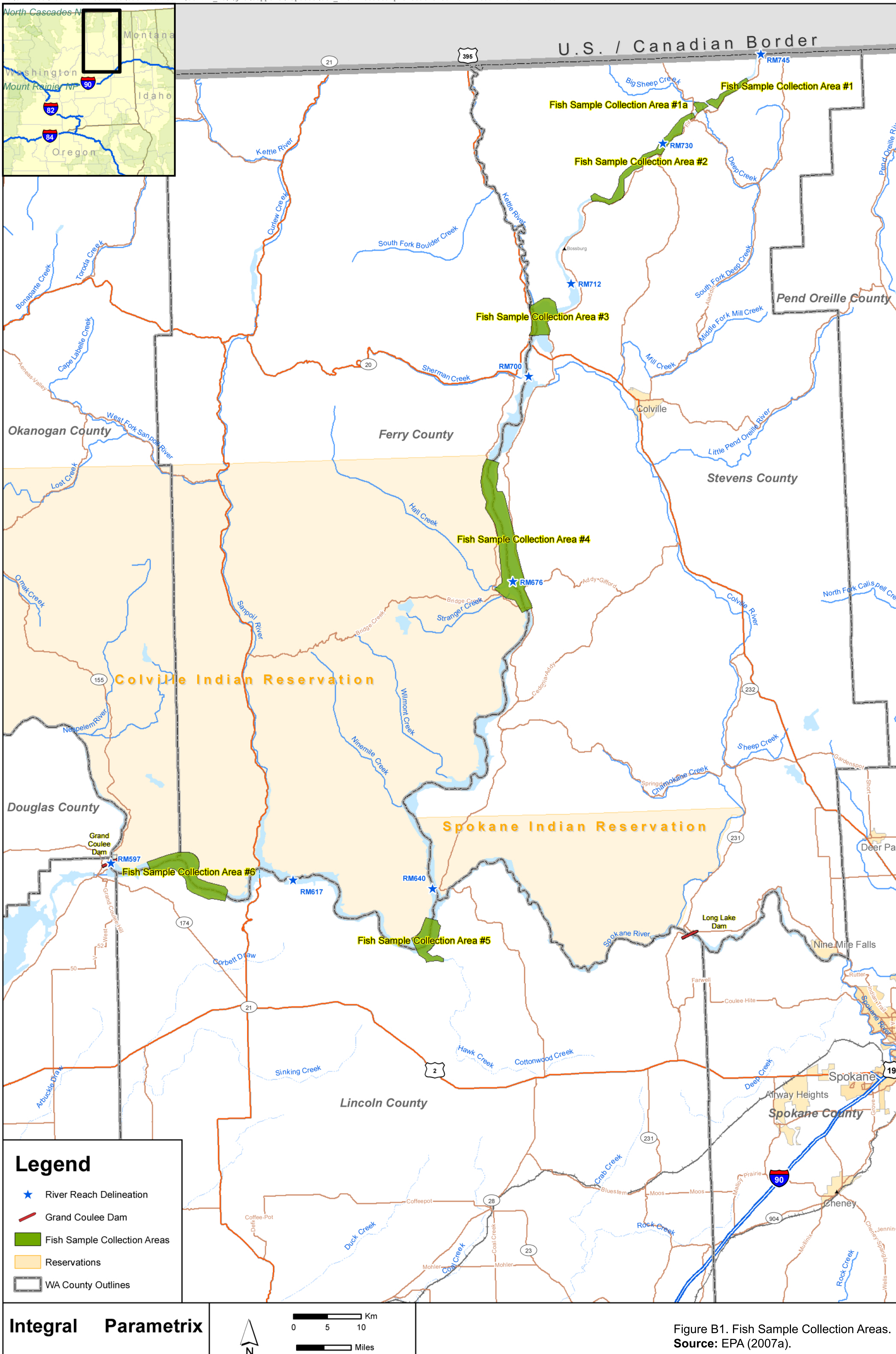


Integral Parametrix

Figure B1. Fish Sample Collection Areas.
Source: EPA (2007a).

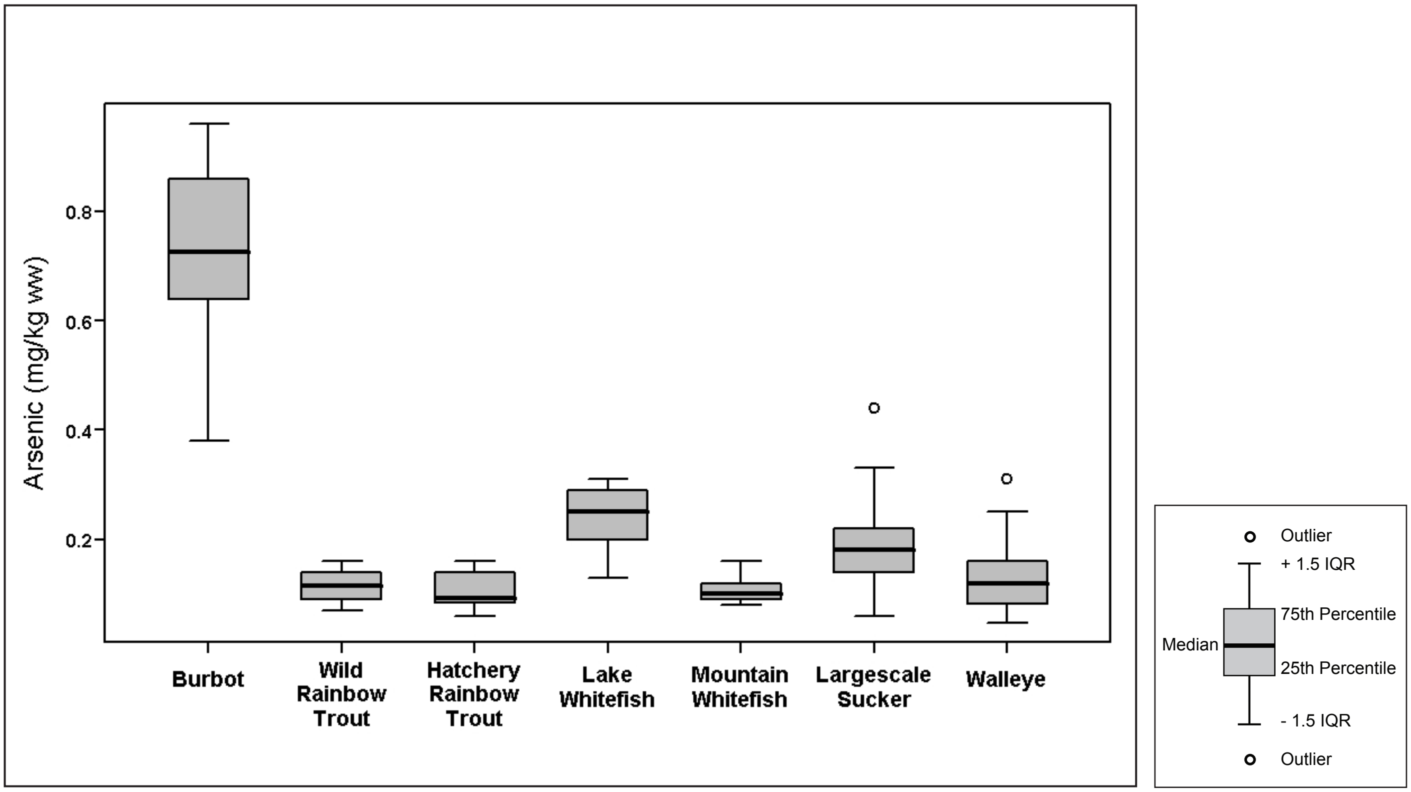


Figure B2. Comparison of Arsenic Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

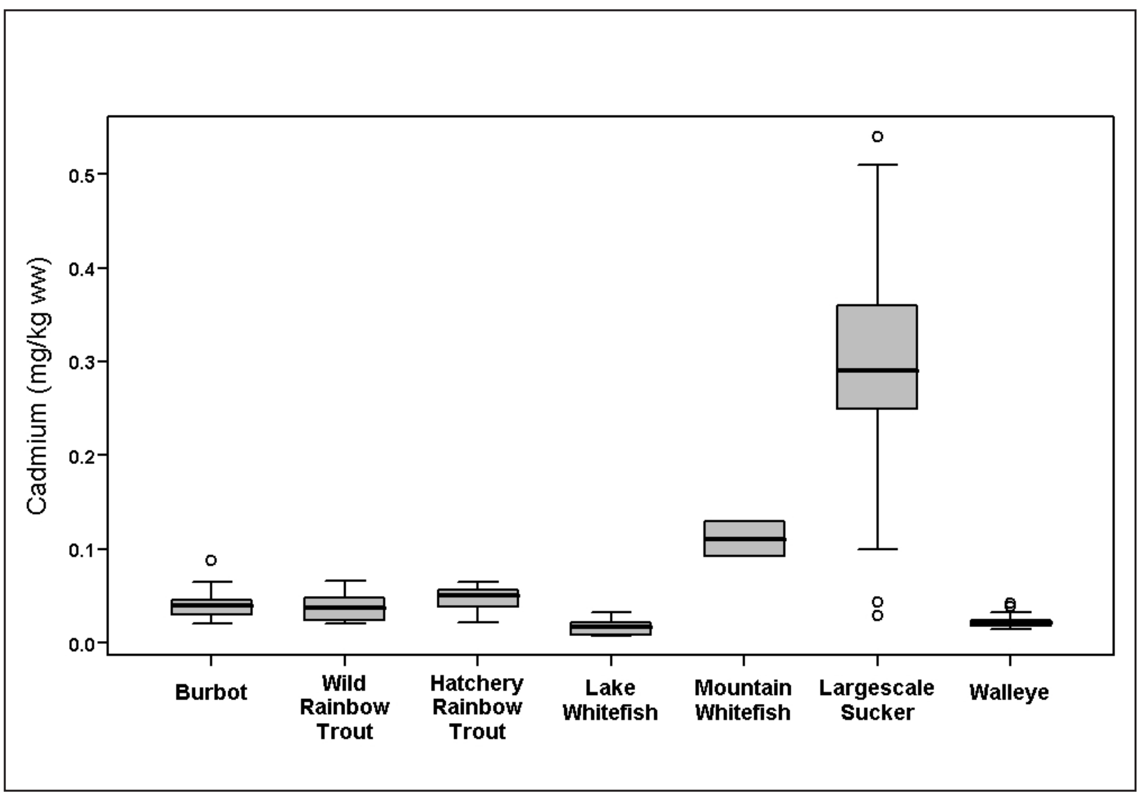


Figure B3. Comparison of Cadmium Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

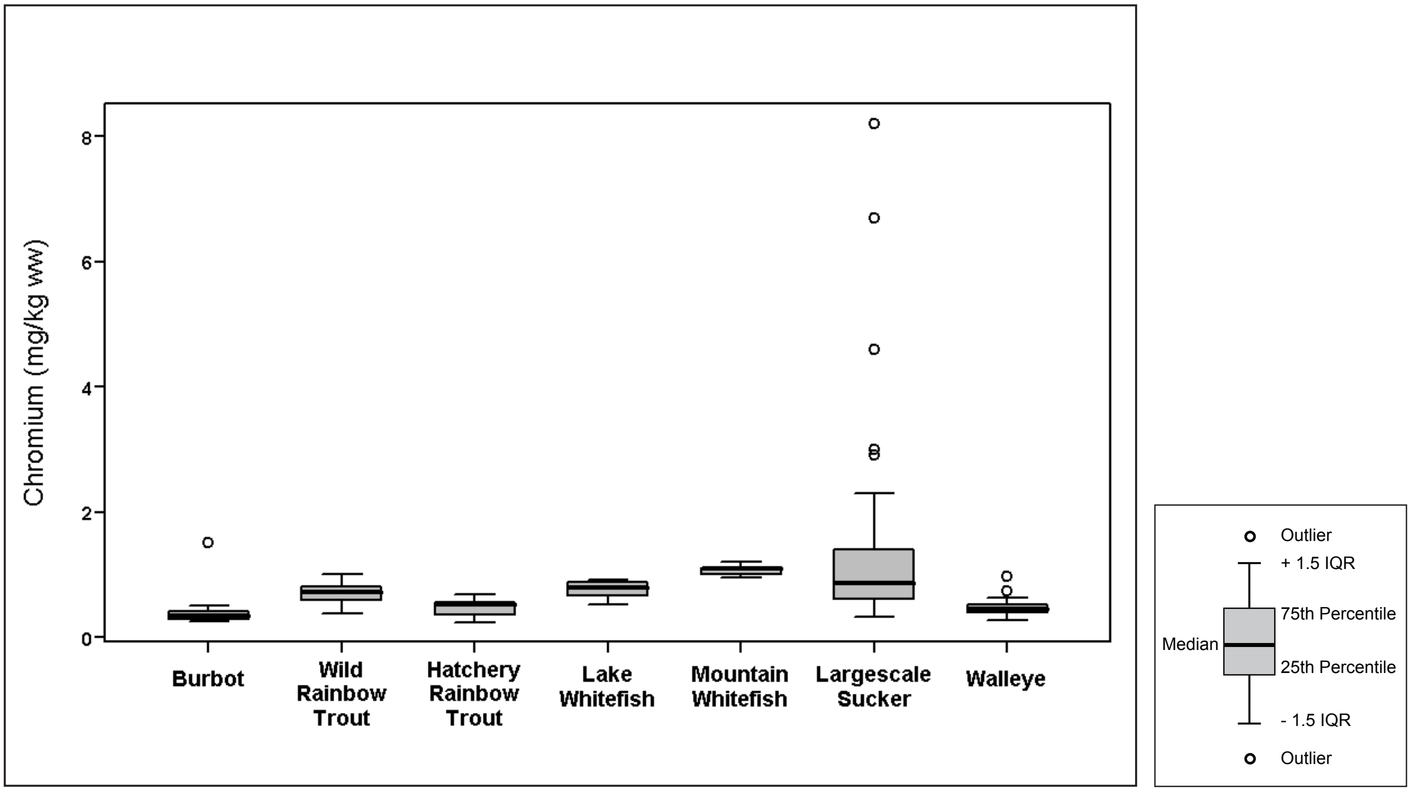


Figure B4. Comparison of Chromium Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

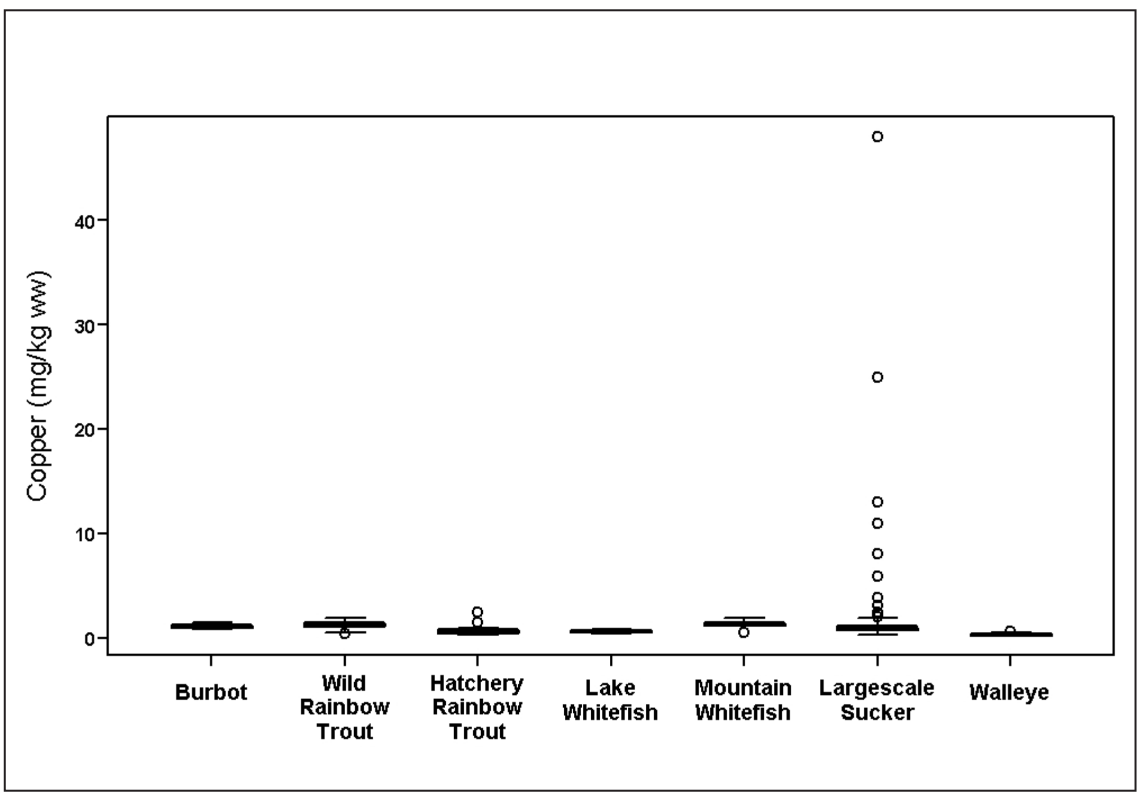


Figure B5. Comparison of Copper Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

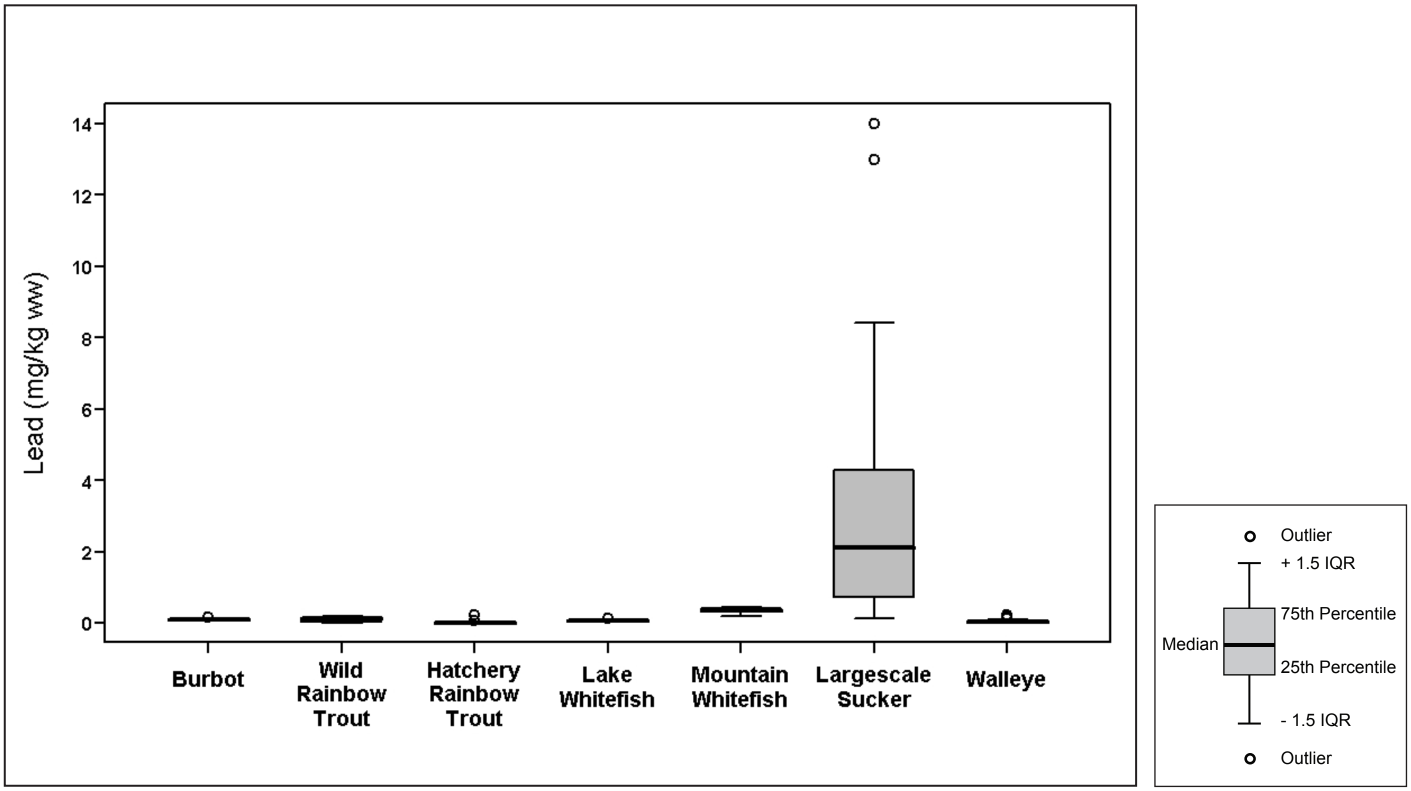


Figure B6. Comparison of Lead Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

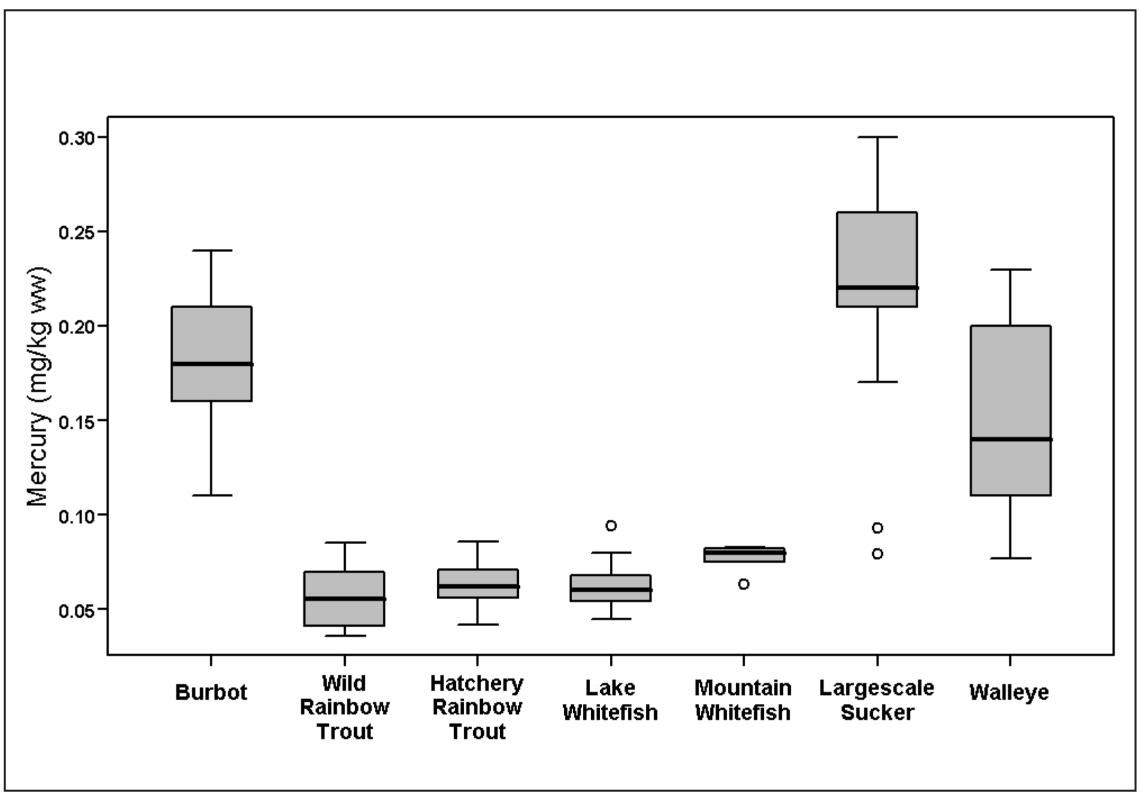


Figure B7. Comparison of Mercury Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

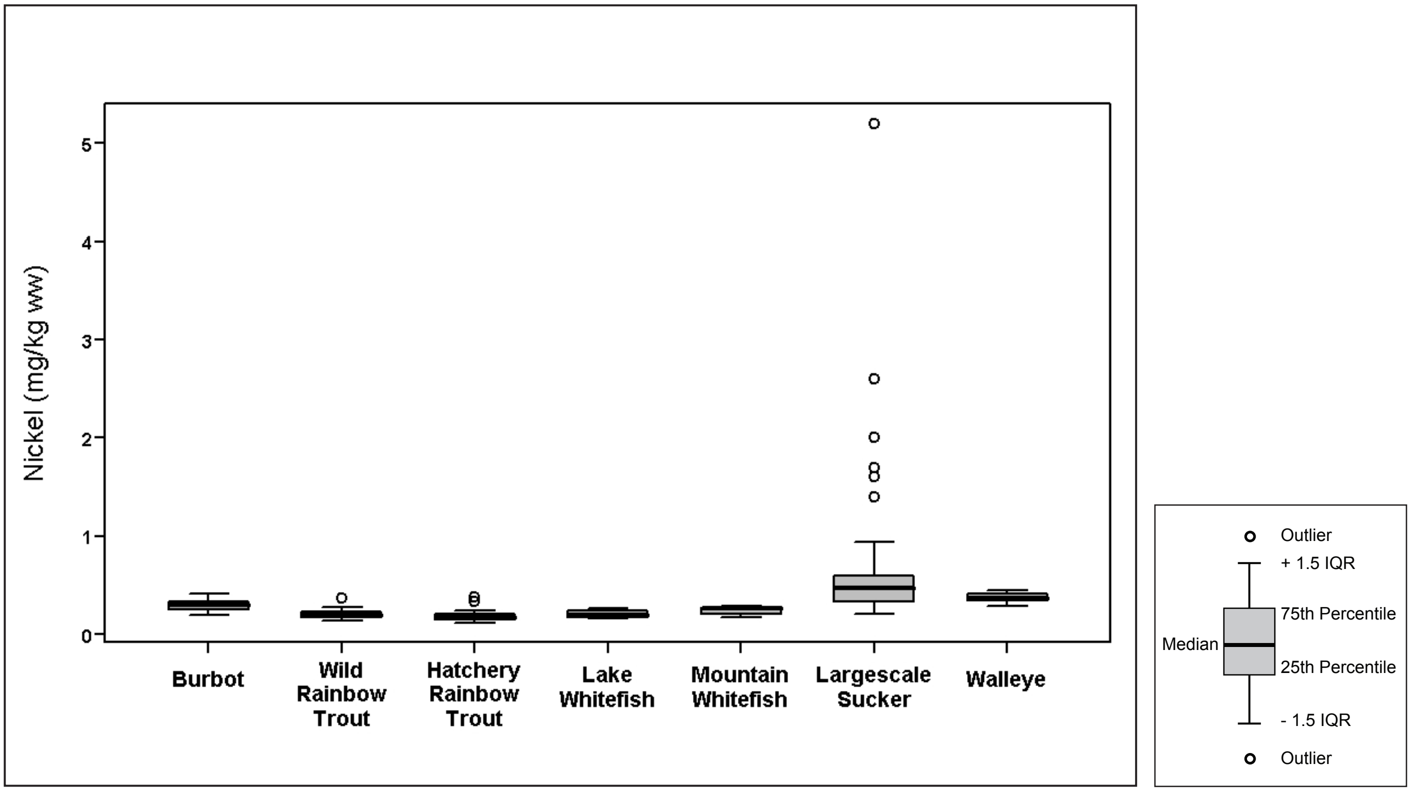


Figure B8. Comparison of Nickel Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a). **Note:** IQR - Interquartile Range.

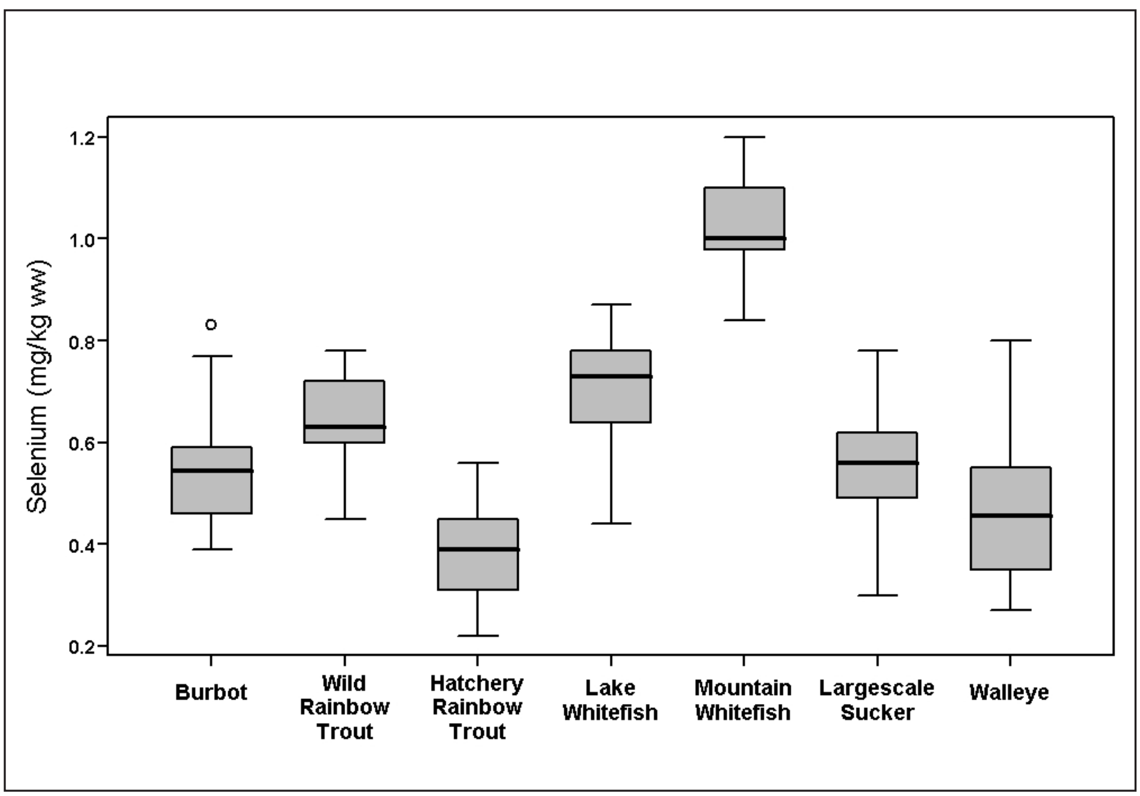
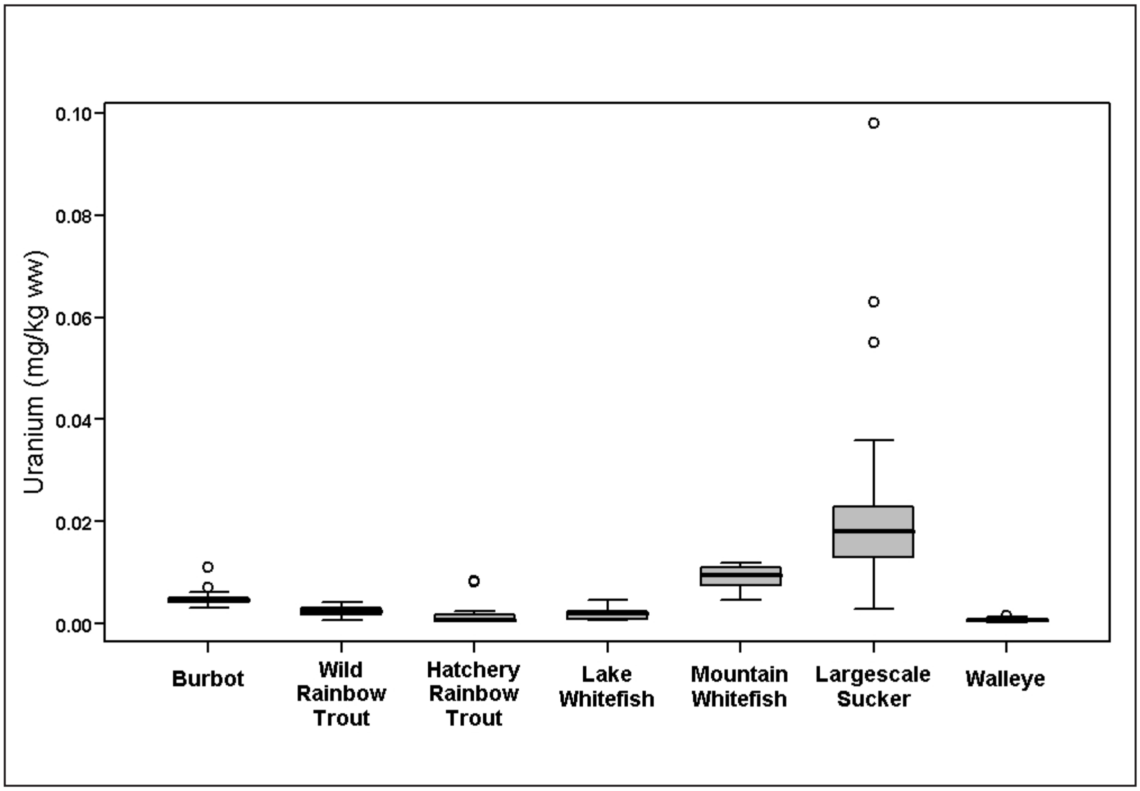


Figure B9. Comparison of Selenium Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a). **Note:** IQR - Interquartile Range.



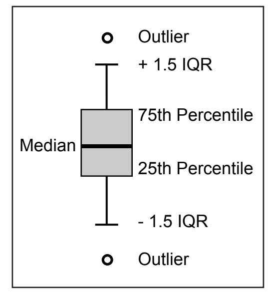


Figure B10. Comparison of Uranium Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.

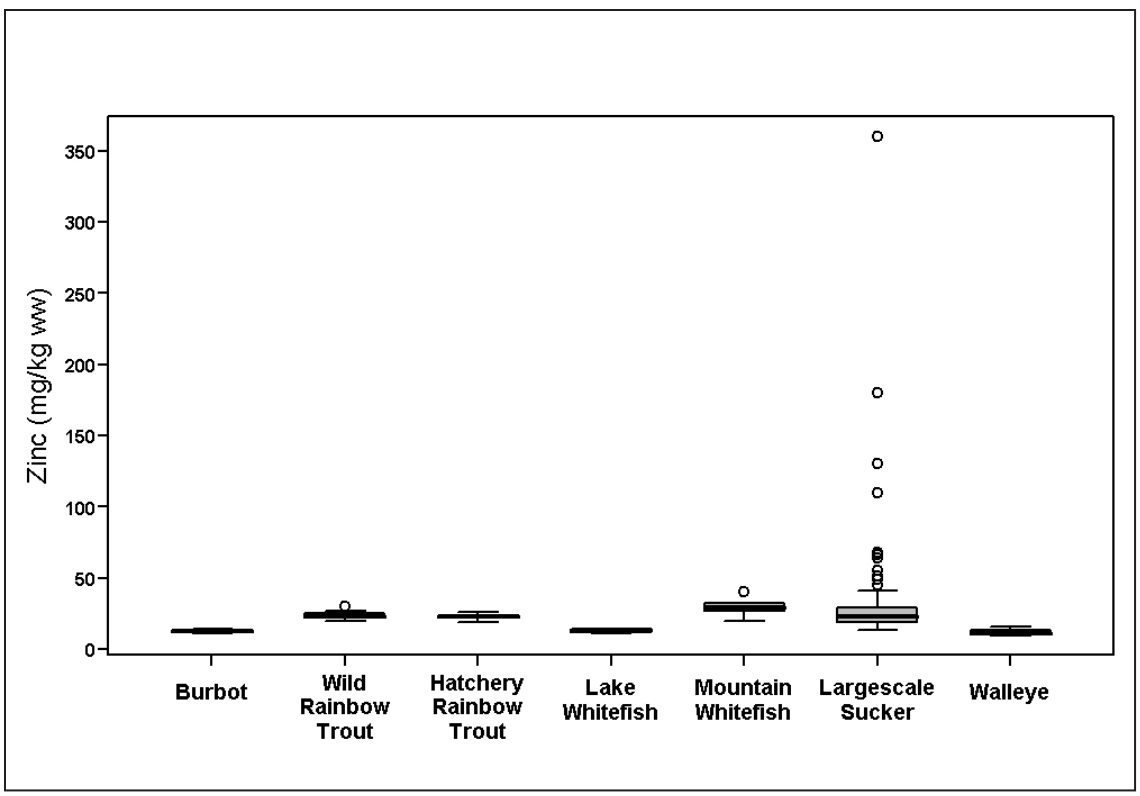
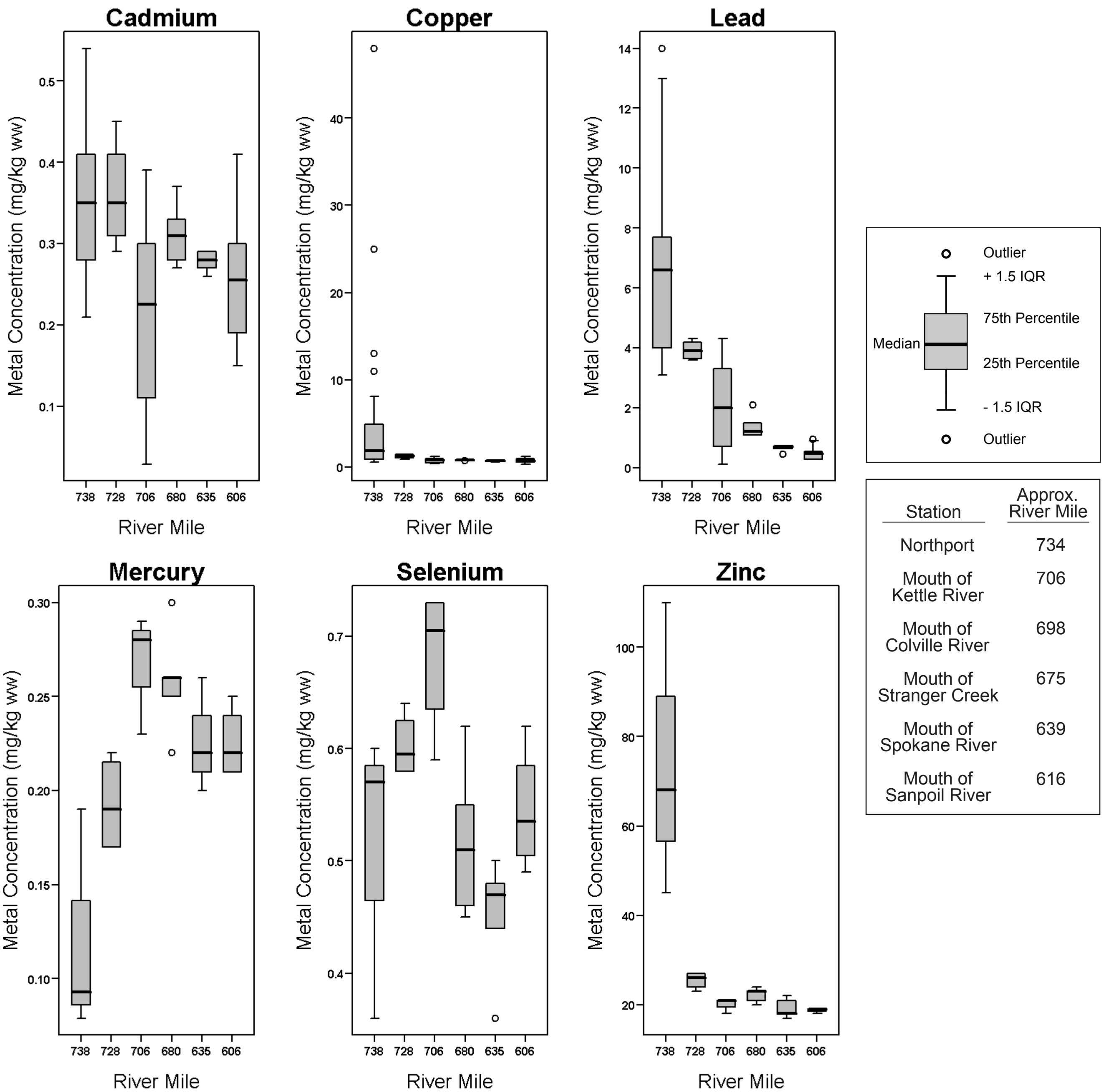
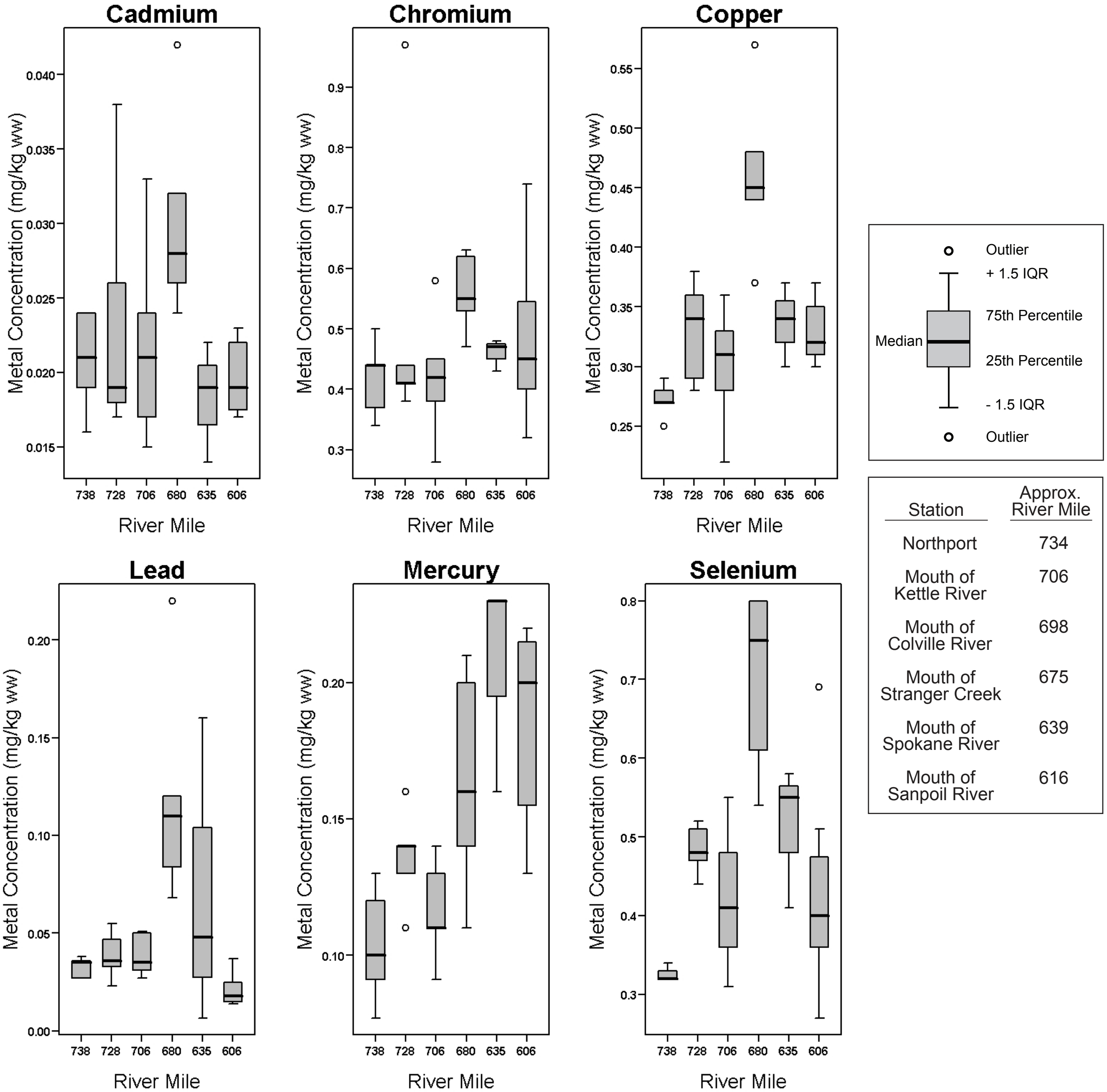


Figure B11. Comparison of Zinc Concentrations in Whole Body Samples of Target Species across all FSCAs (USEPA 2007a).
Note: IQR - Interquartile Range.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

Figure B12. Concentrations of Cadmium, Copper, Lead, Mercury, Selenium, and Zinc in Whole Largescale Sucker Composites (USEPA 2007a).
Note: IQR - Interquartile Range.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

Figure B13. Concentrations of Cadmium, Chromium, Copper, Lead, Mercury, and Selenium in Whole Walleye Composites (USEPA 2007a).
Note: IQR - Interquartile Range.

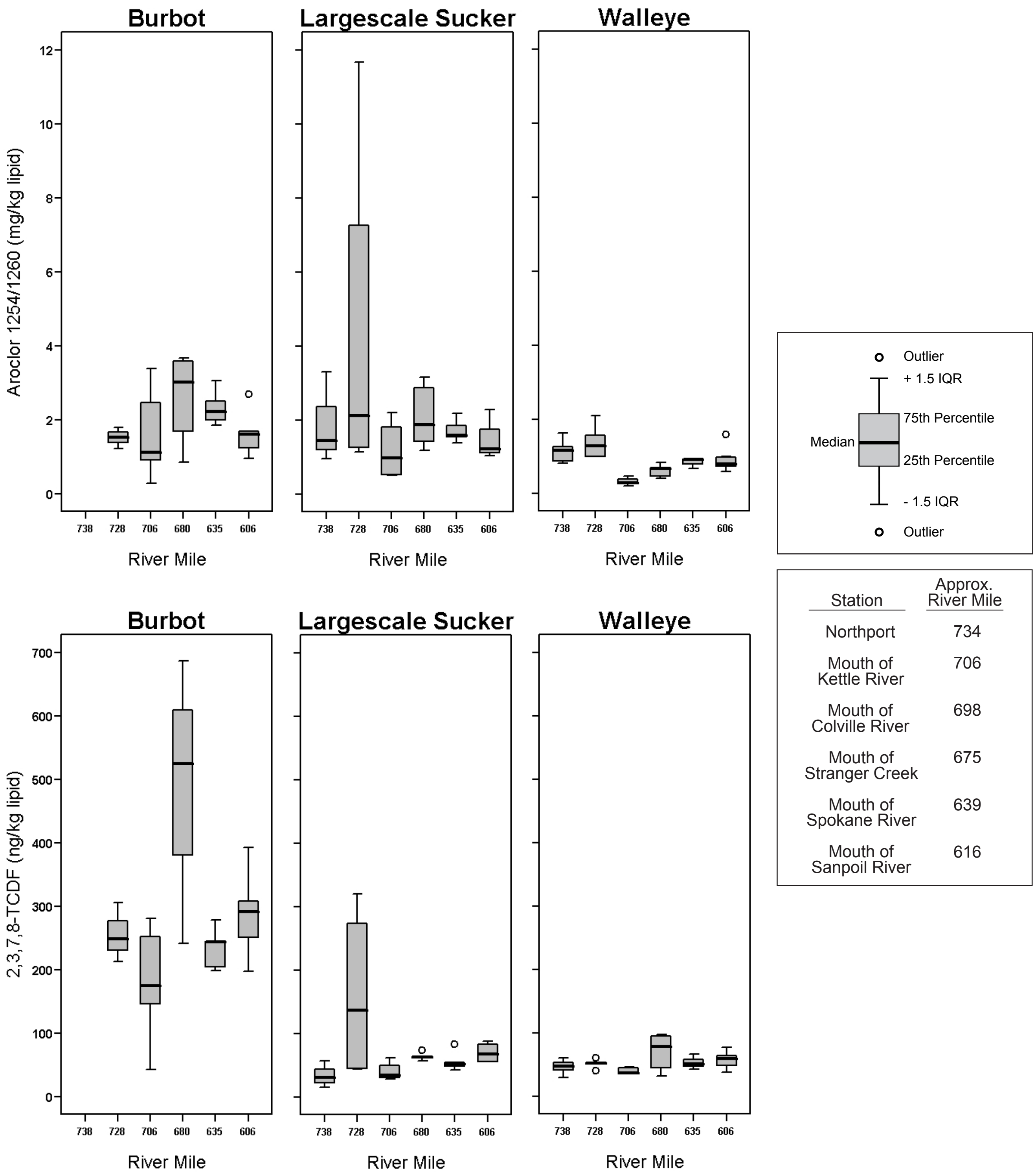


Figure B14. Lipid-Normalized Concentrations of Aroclor 1254/1260 and 2,3,7,8-TCDF in Whole Burbot, Largescale Sucker, and Walleye by River Mile (USEPA 2007a).
Note: IQR - Interquartile Range.

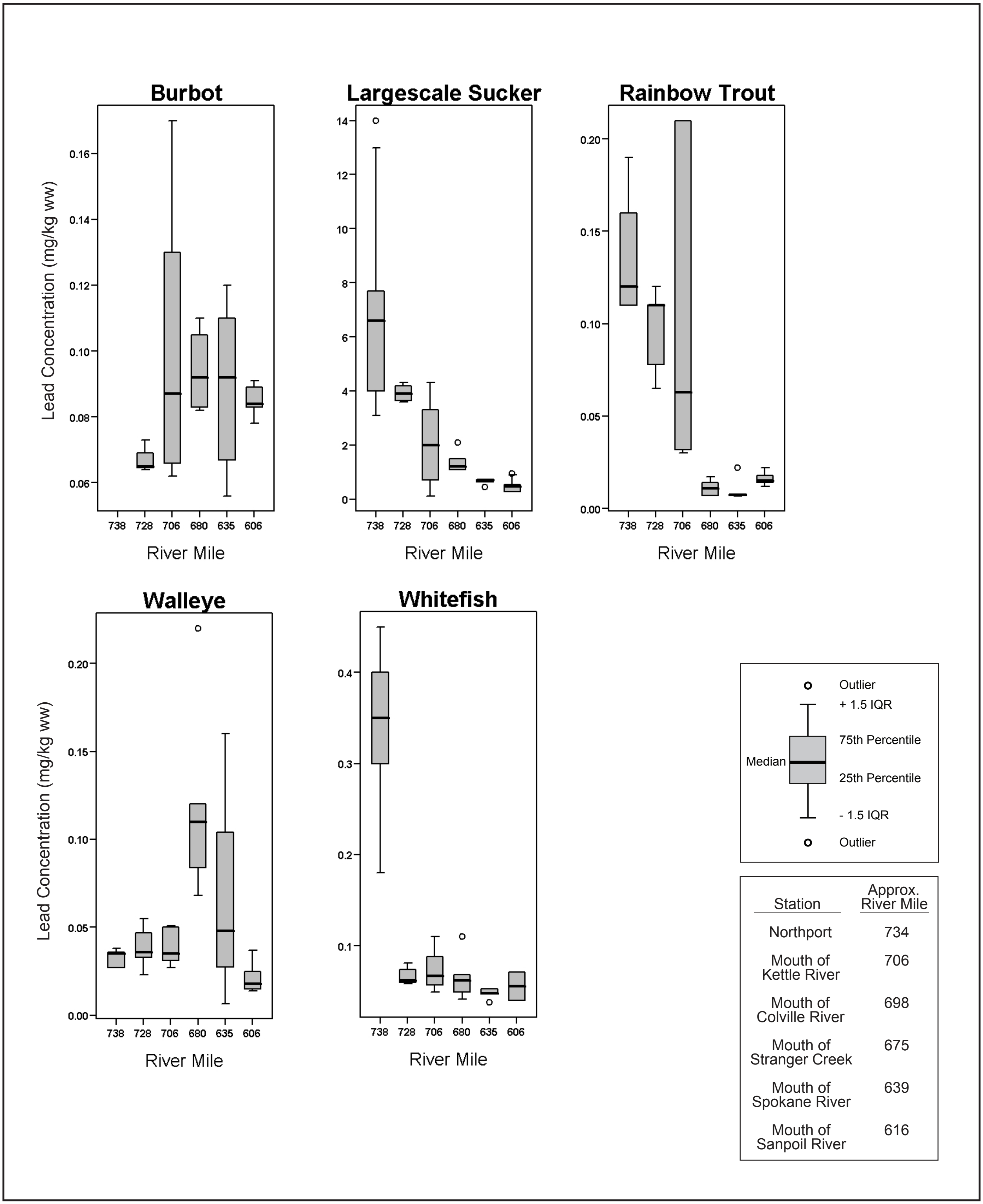


Figure B15. Lead Concentrations in Composite Samples of Whole Burbot, Largescale Sucker, Rainbow Trout, Walleye, and Whitefish by River Mile (USEPA 2007a).
Note: IQR - Interquartile Range.
Only Mountain Whitefish Were Collected from FSCA1, and Only Lake Whitefish Were Collected from Other FSCAs.

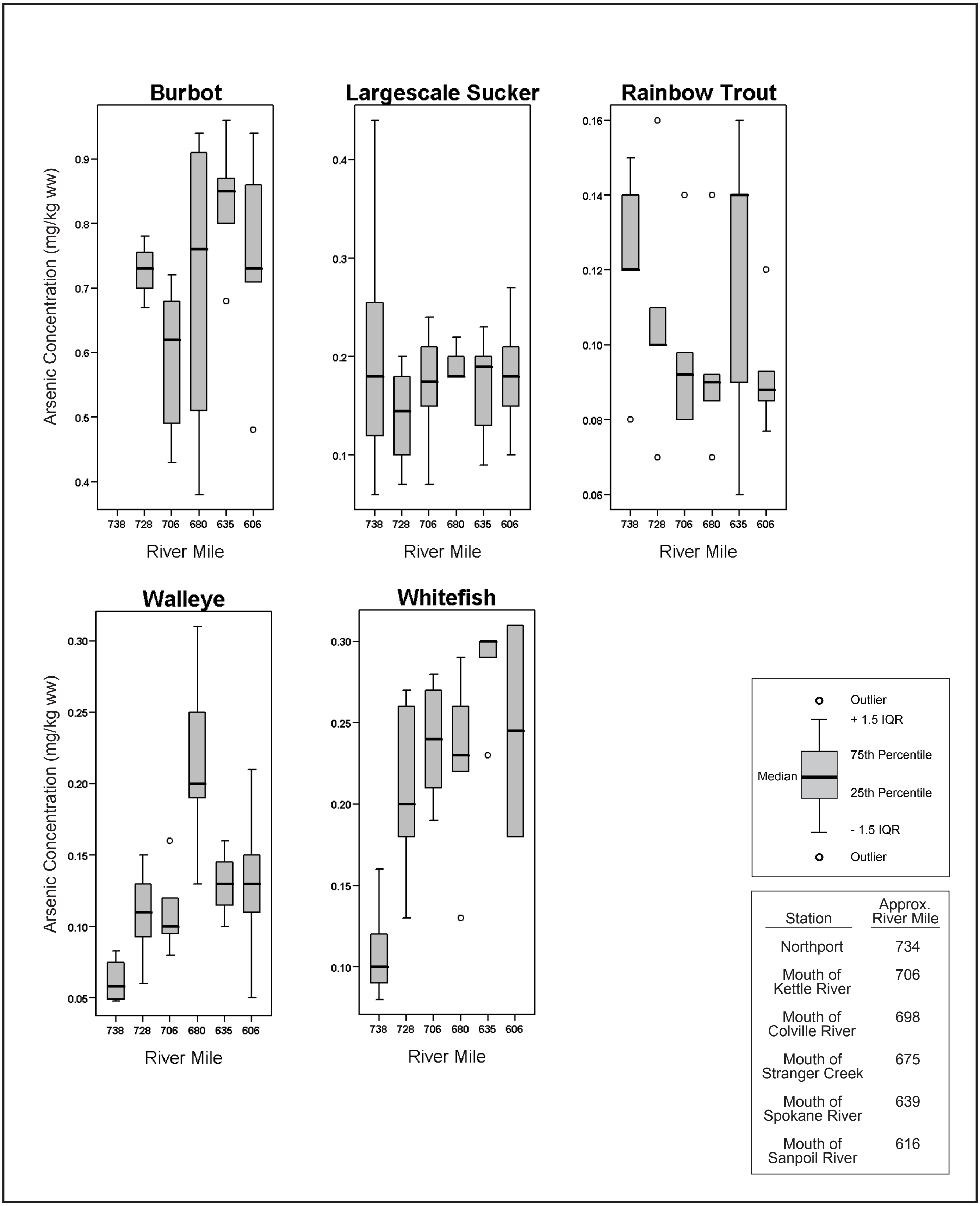
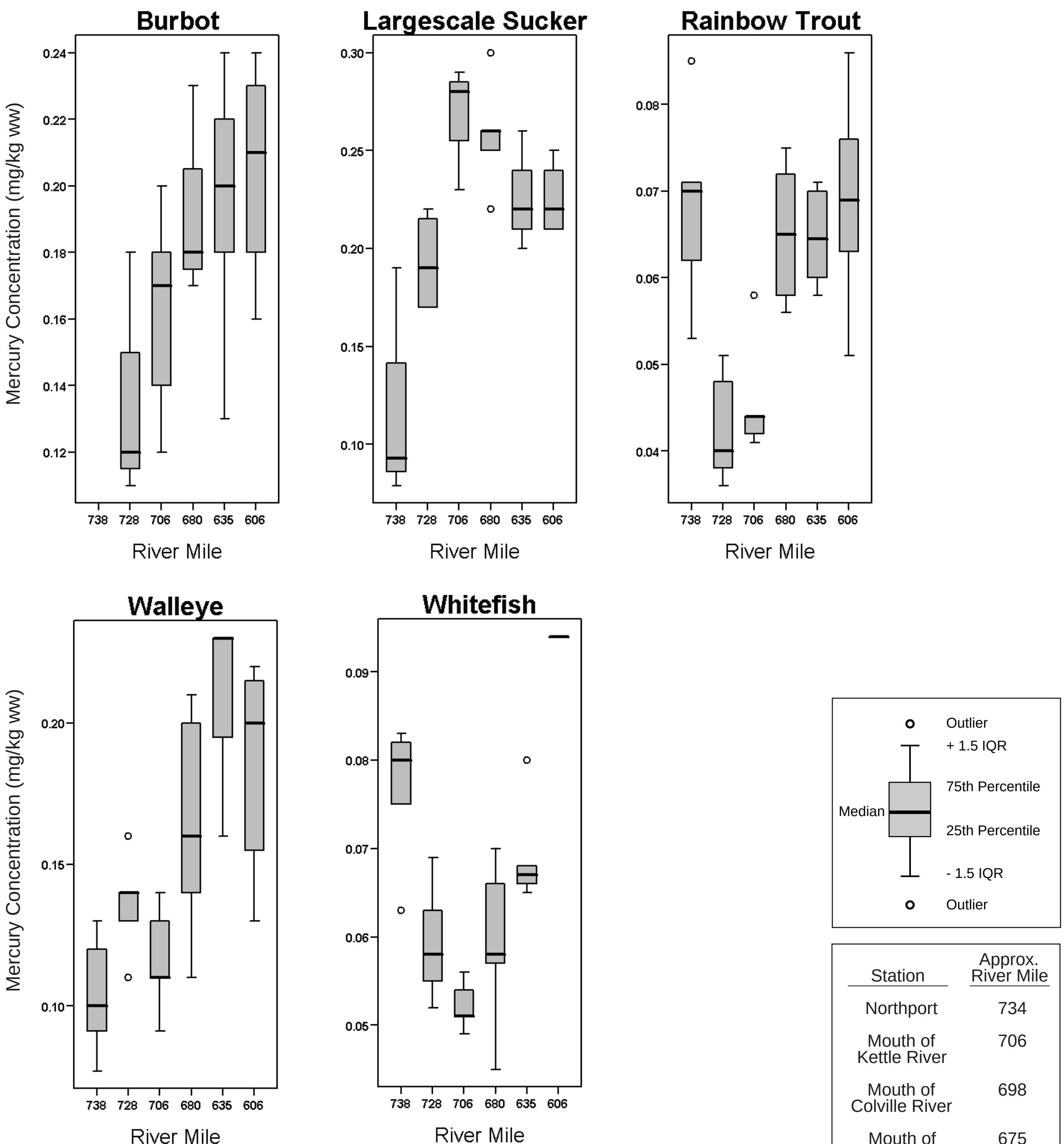


Figure B16. Arsenic Concentrations in Composite Samples of Whole Burbot, Largescale Sucker, Rainbow Trout, Walleye, and Whitefish by River Mile (USEPA 2007a).
Note: IQR - Interquartile Range.
Only Mountain Whitefish Were Collected from FSCA1, and Only Lake Whitefish Were Collected from All Other FSCAs.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

Figure B17. Mercury Concentrations in Composite Samples of Whole Burbot, Largescale Sucker, Rainbow Trout, Walleye, and Whitefish by River Mile (USEPA 2007a).
Note: IQR - Interquartile Range.
Only Mountain Whitefish Were Collected from FSCA1,
and Only Lake Whitefish Were Collected from All Other FSCAs.

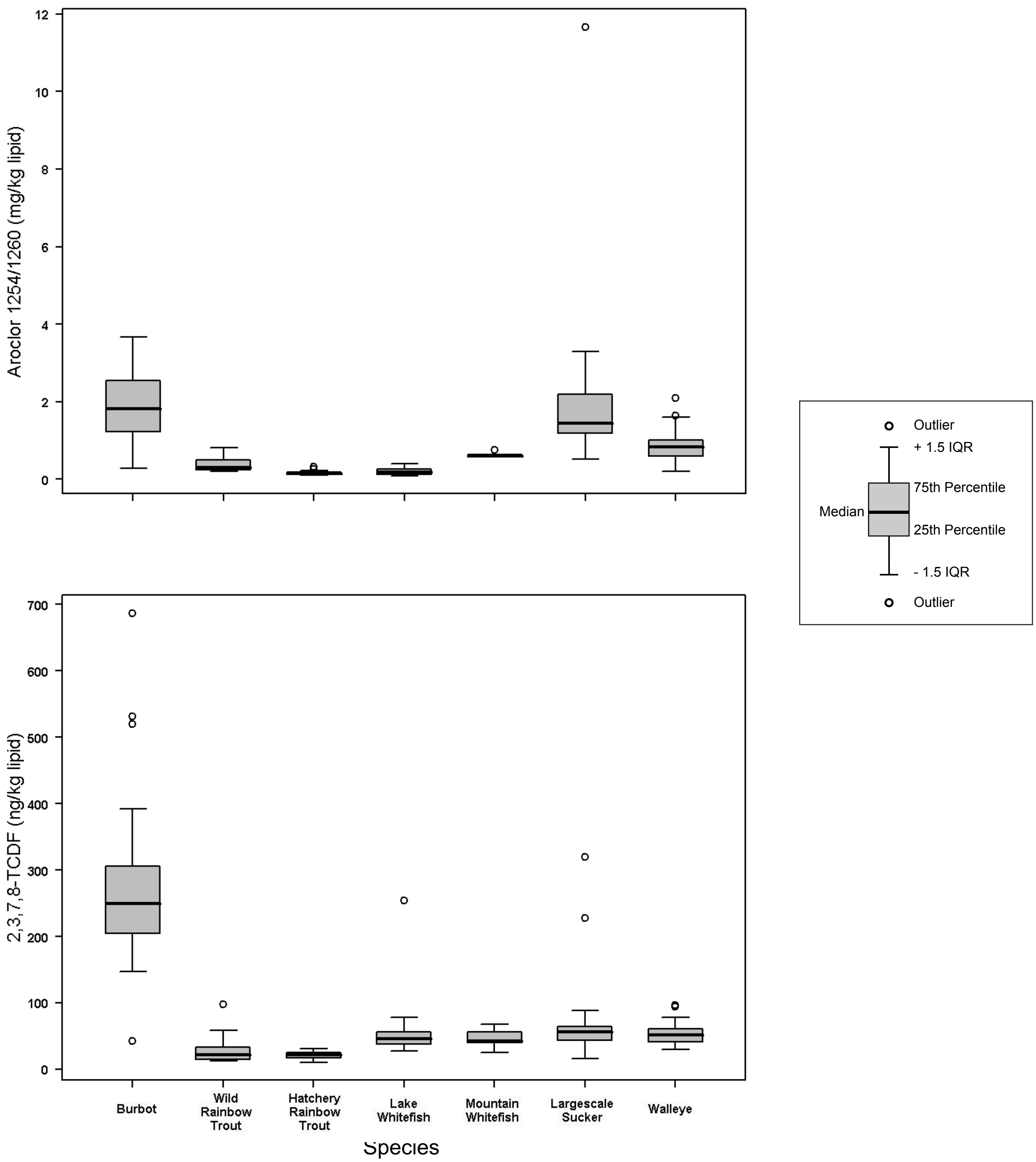


Figure B18. Lipid-Normalized Concentrations of Aroclor 1254/1260 and 2,3,7,8-TCDF in Whole Bodies of All Fish Collected for USEPA (2007a).

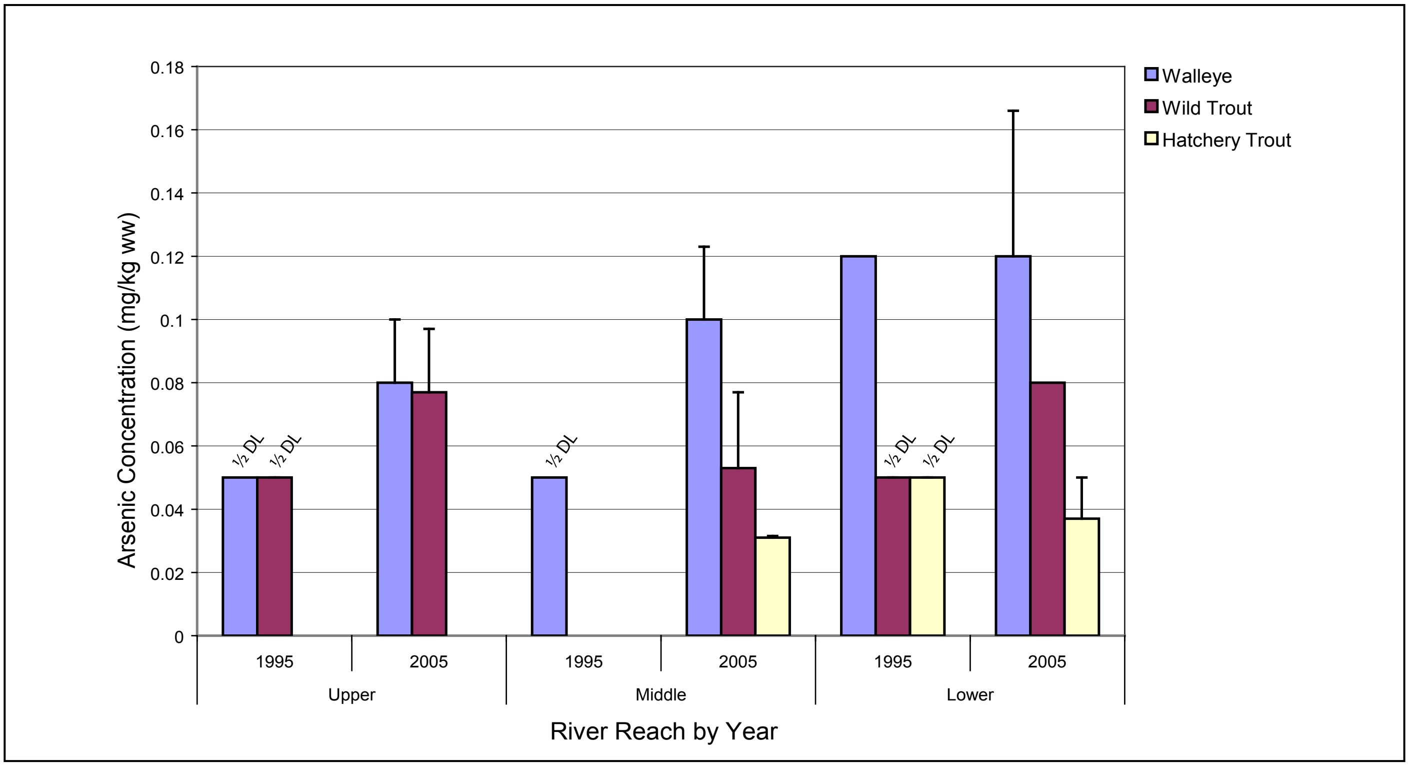


Figure B19. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Arsenic Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available.
DL - Detection Limit.

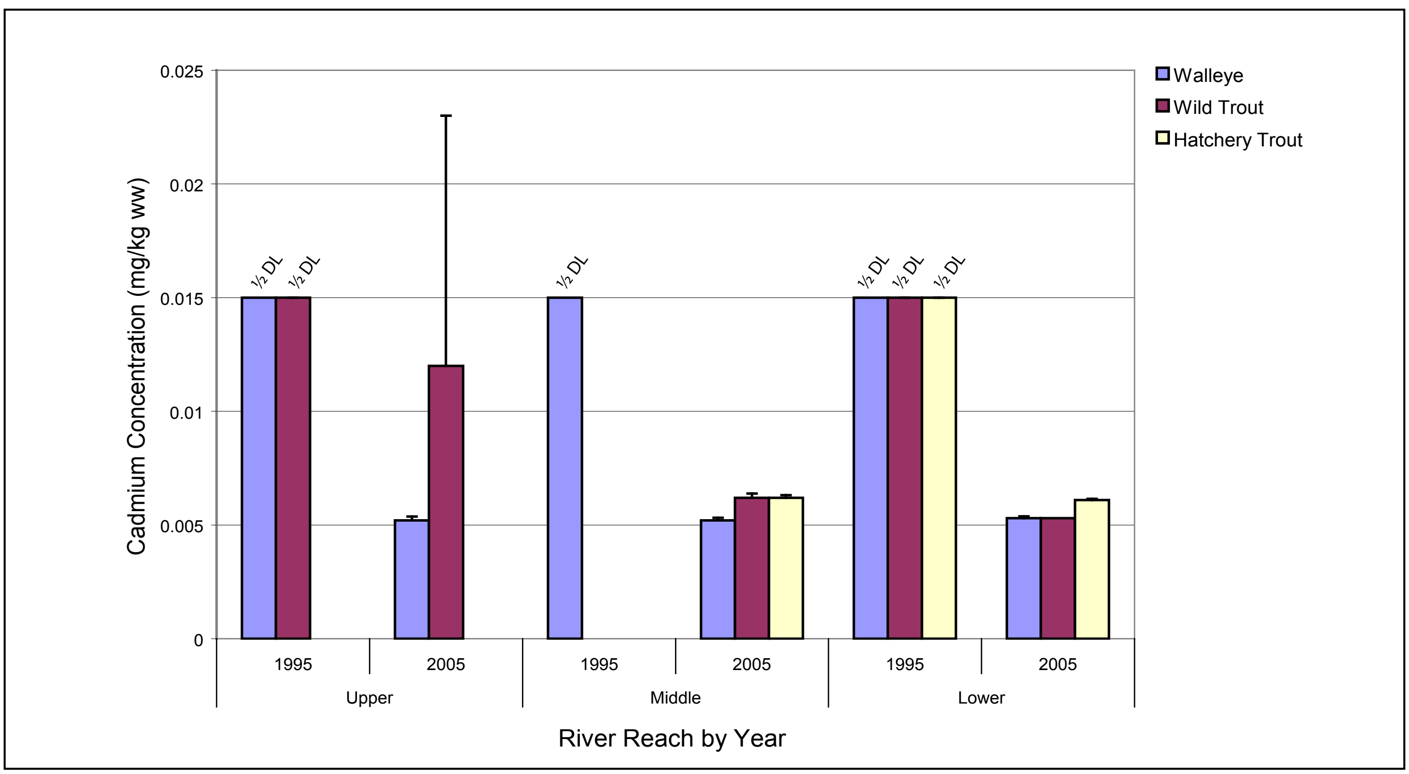


Figure B20. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Cadmium Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available.
DL - Detection Limit.

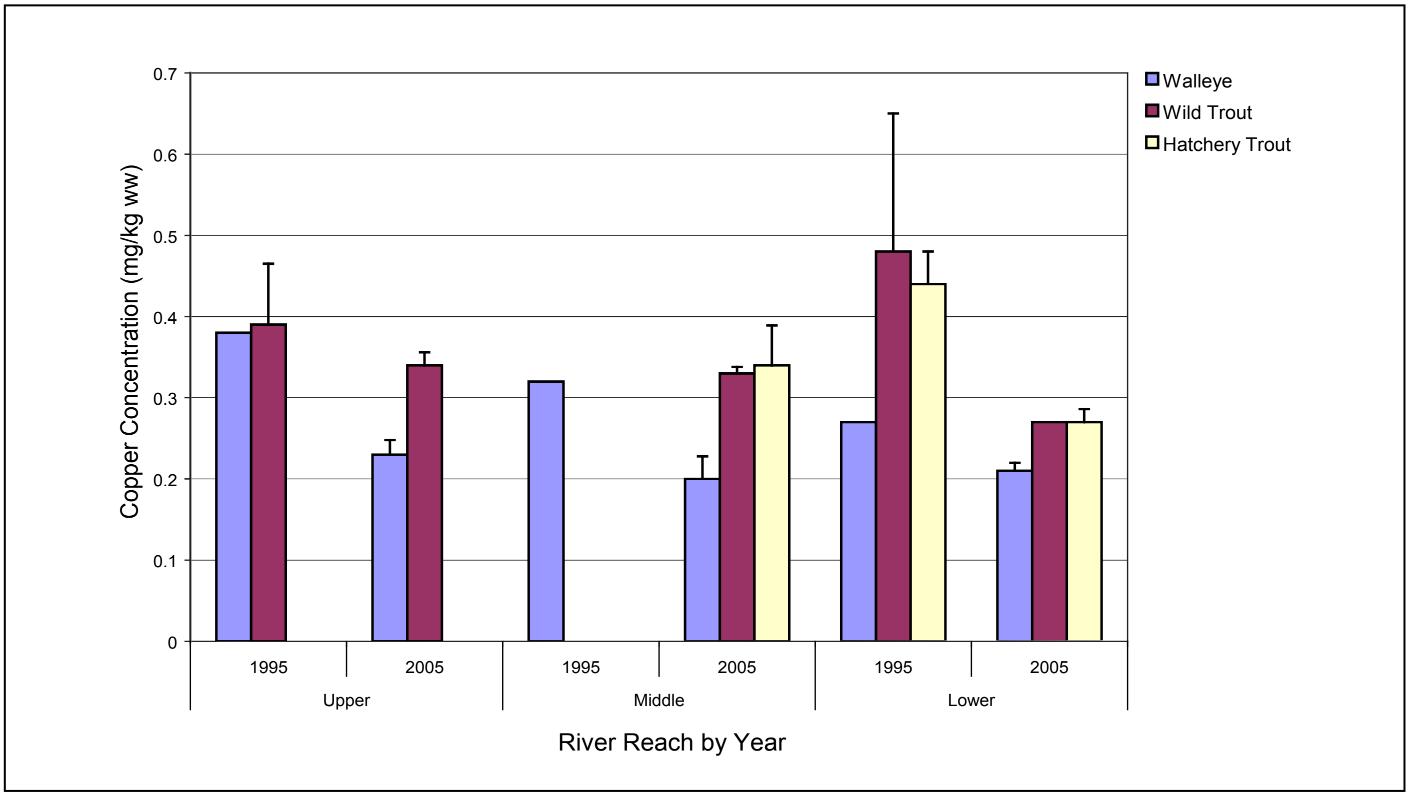


Figure B21. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Copper Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available.

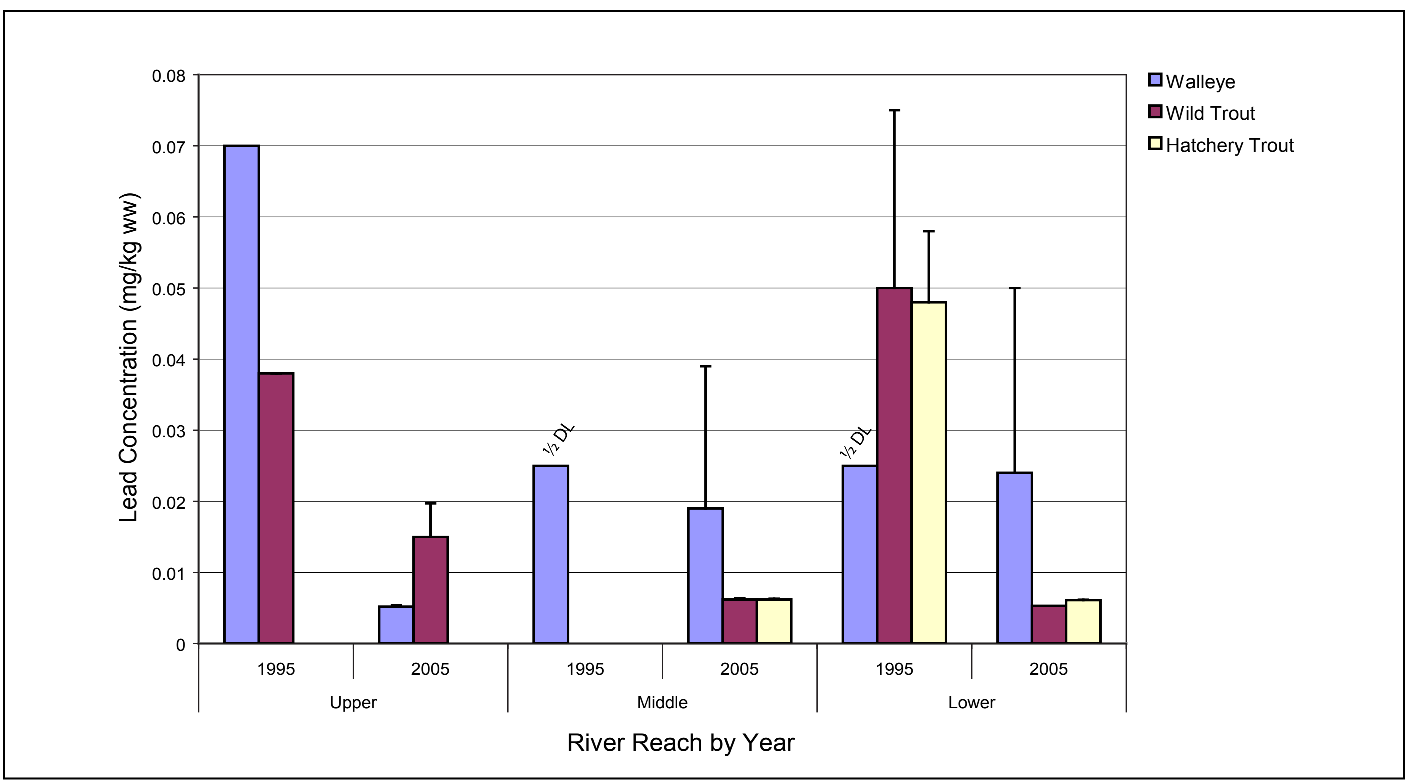


Figure B22. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Lead Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available. DL - Detection Limit.

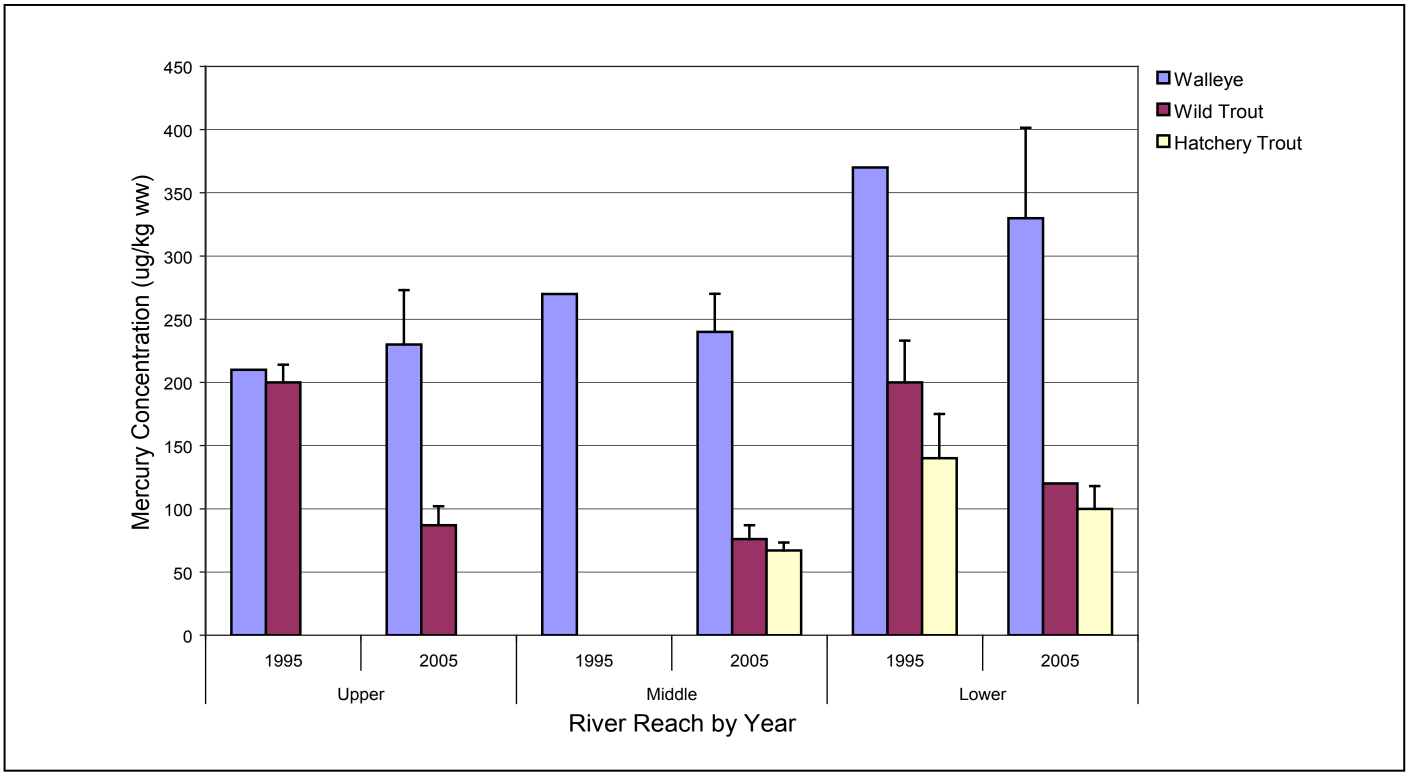


Figure B23. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Mercury Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available.

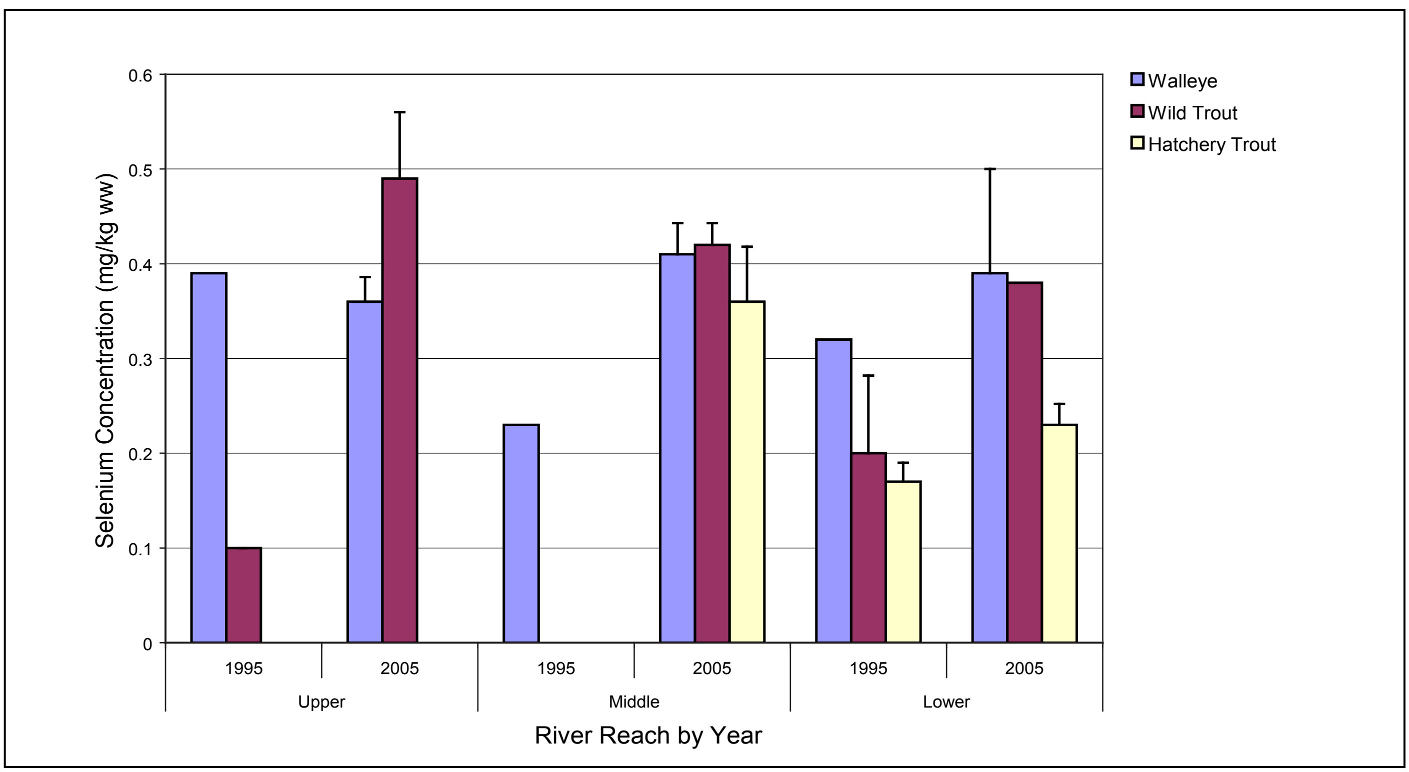


Figure B24. Historical (USGS 1995) and 2005 (USEPA 2007a) Mean Selenium Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Notes: Error Bars Represent +1SD, where available.

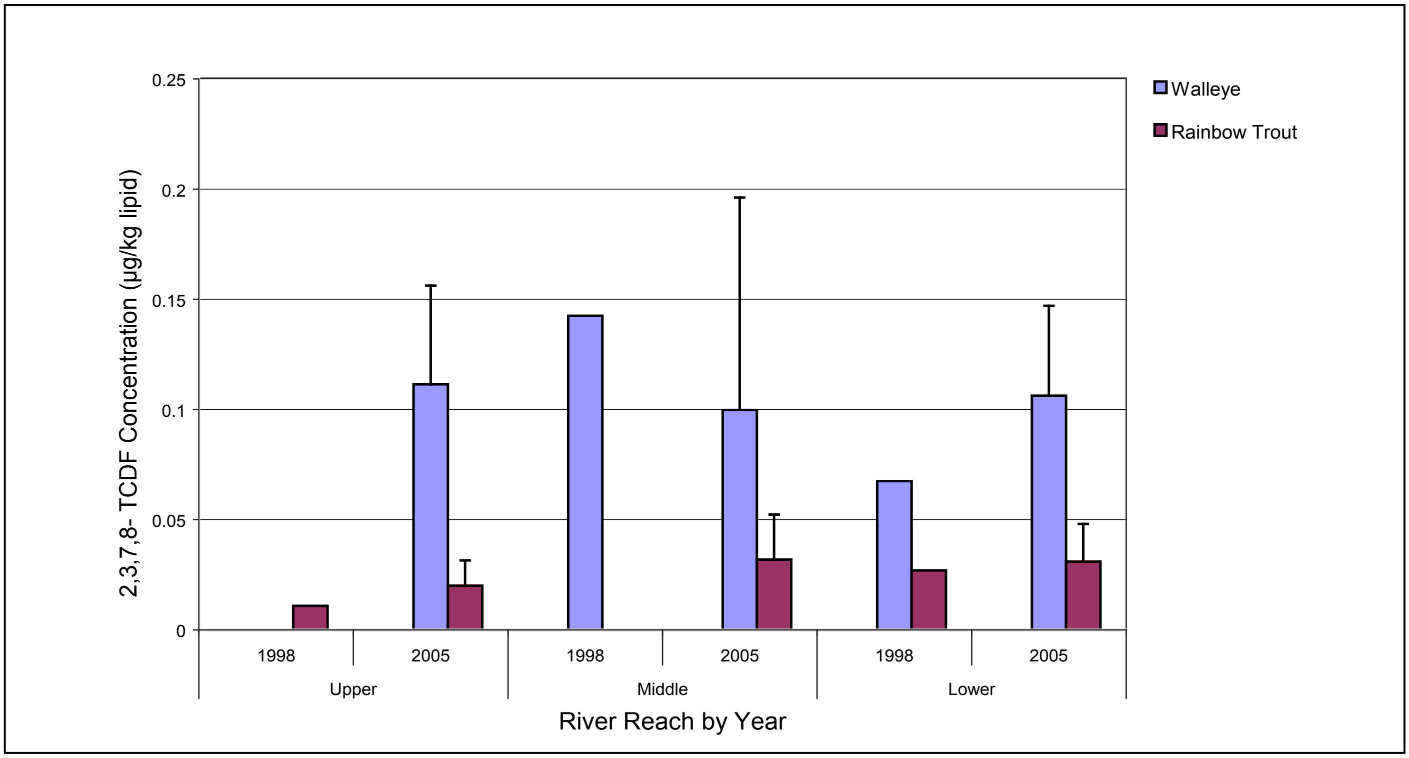


Figure B25. Historical (EVS 1998) and 2005 (USEPA 2007a) Mean Lipid-Normalized 2,3,7,8-TCDF Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Note: Error Bars Represent +1SD, where available.

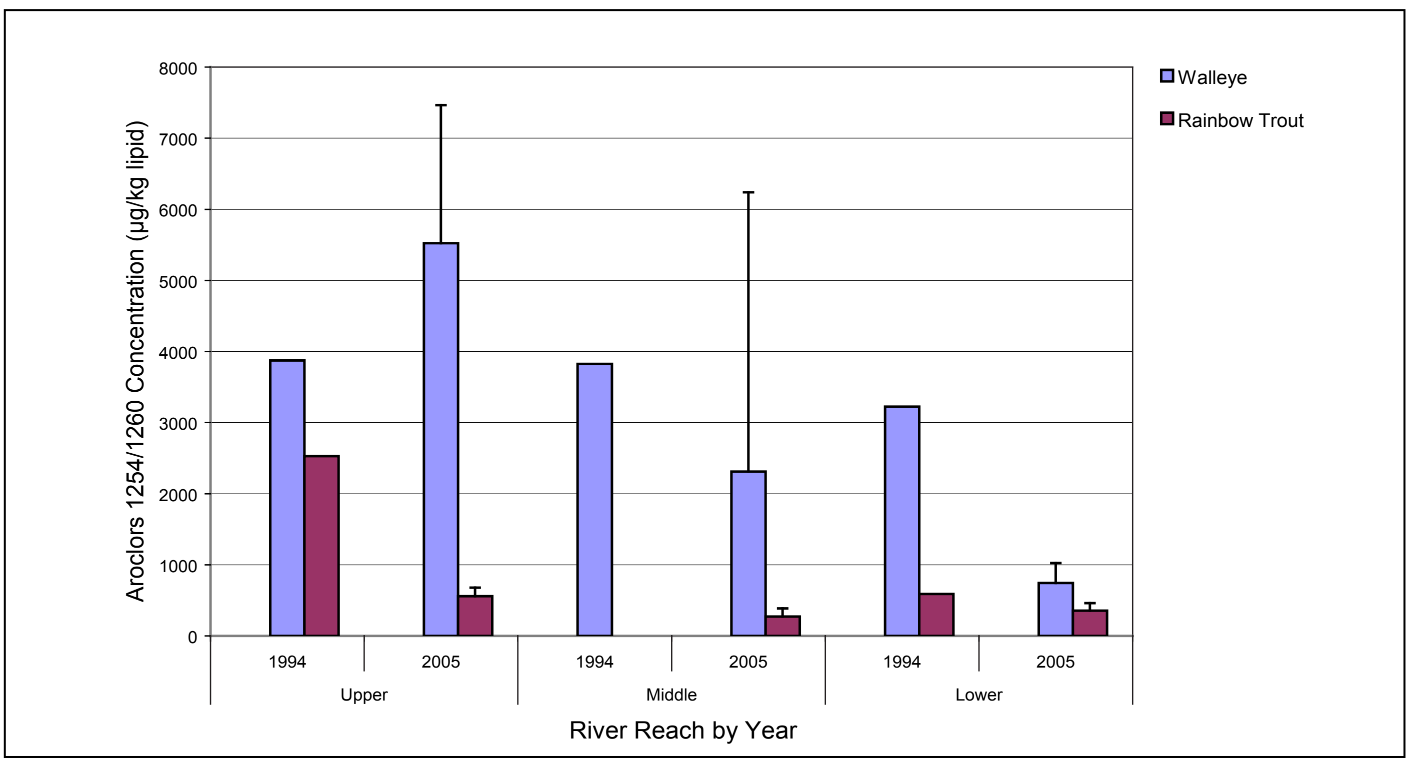


Figure B26. Historical (EVS 1998) and 2005 (USEPA 2007a) Mean Lipid-Normalized Total PCB Concentrations in Fillet of Wild and Hatchery Rainbow Trout and Walleye in Three Reaches of the UCR.
Note: Error Bars Represent +1SD, where available.
Aroclor 1256/1260 = Total PCBs as the Sum of Aroclors 1256 and 1260.

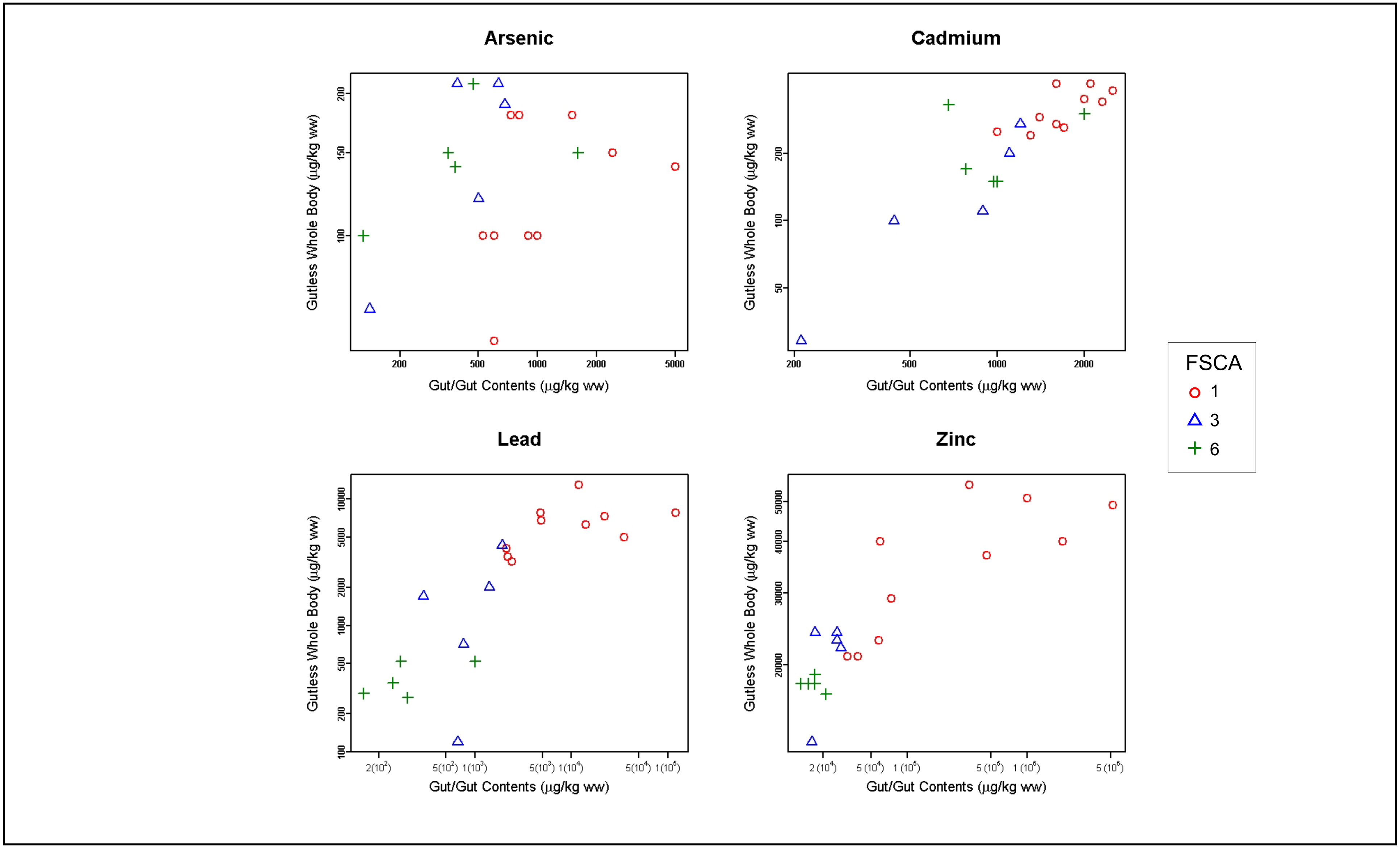


Figure B27. Illustration of the Three Types of Relationships between Gut/Gut Contents and Gutless Whole Body Concentrations of Metals in Largescale Sucker.
Notes: Gut/Gut Contents - A Sample That Included Both Stomach Contents and Portions of the Fish Digestive Tract. FSCA - Fish Sample Collection Area.

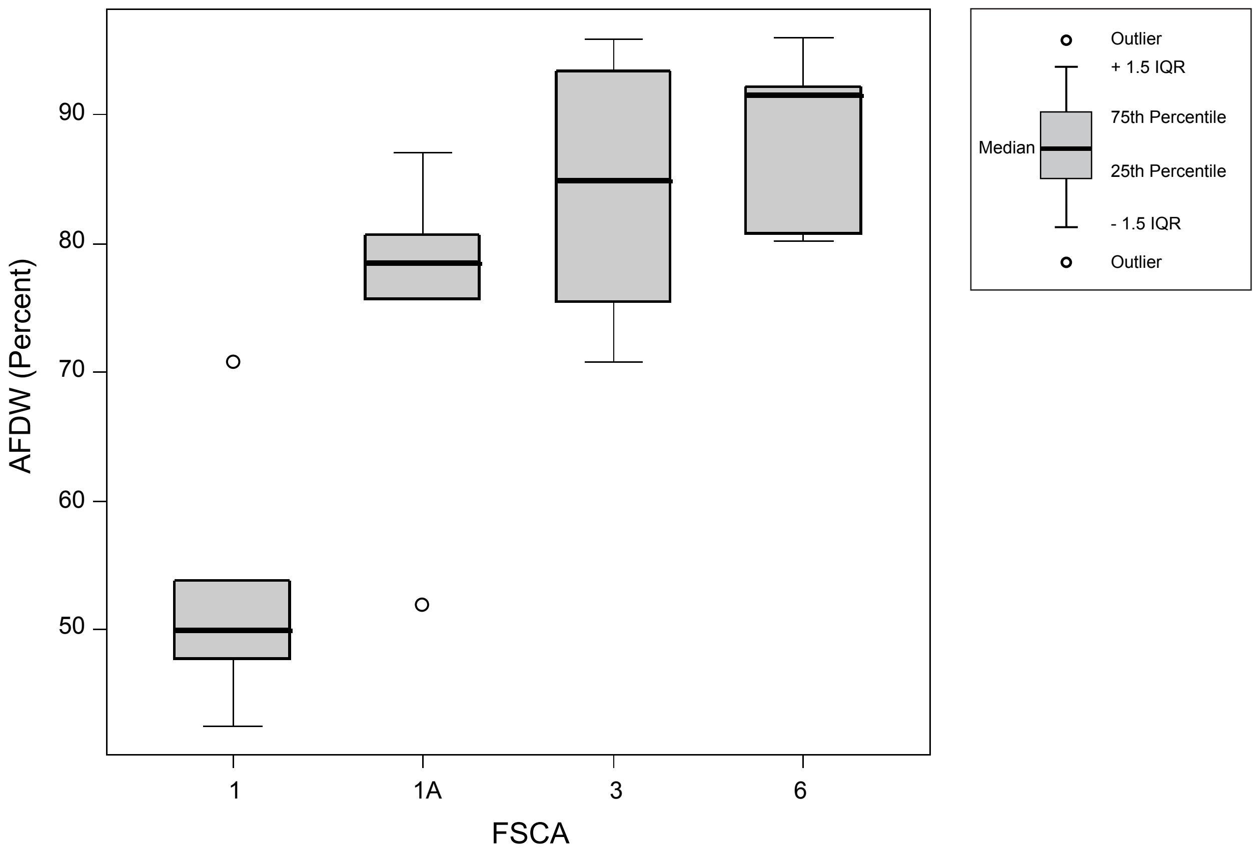


Figure B28. Ash-Free Dry Weight of Largescale Sucker Gut/Gut Contents Samples.

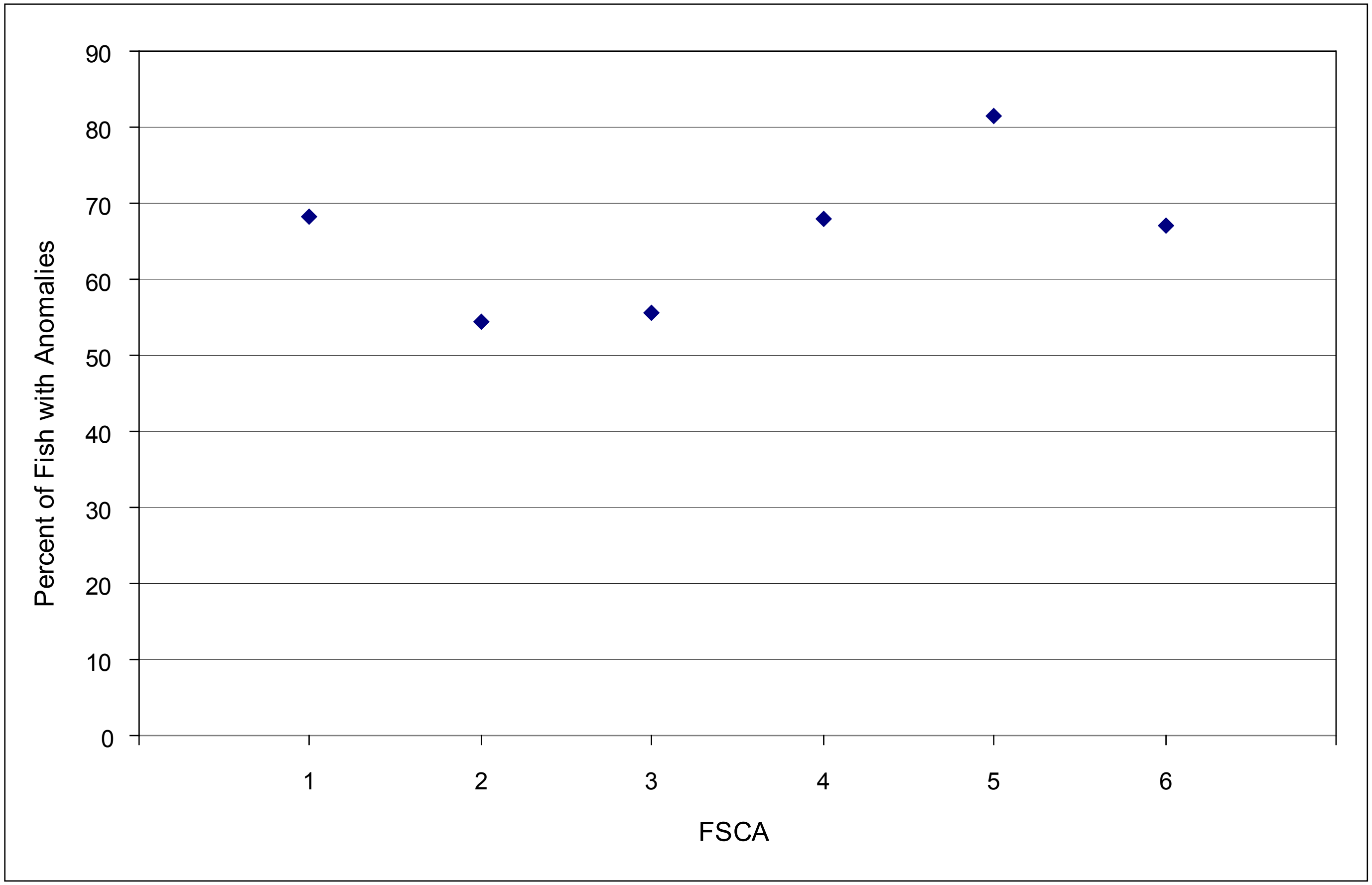


Figure B29. Percent of all Fish with External Anomalies in Each FSCA in 2005.

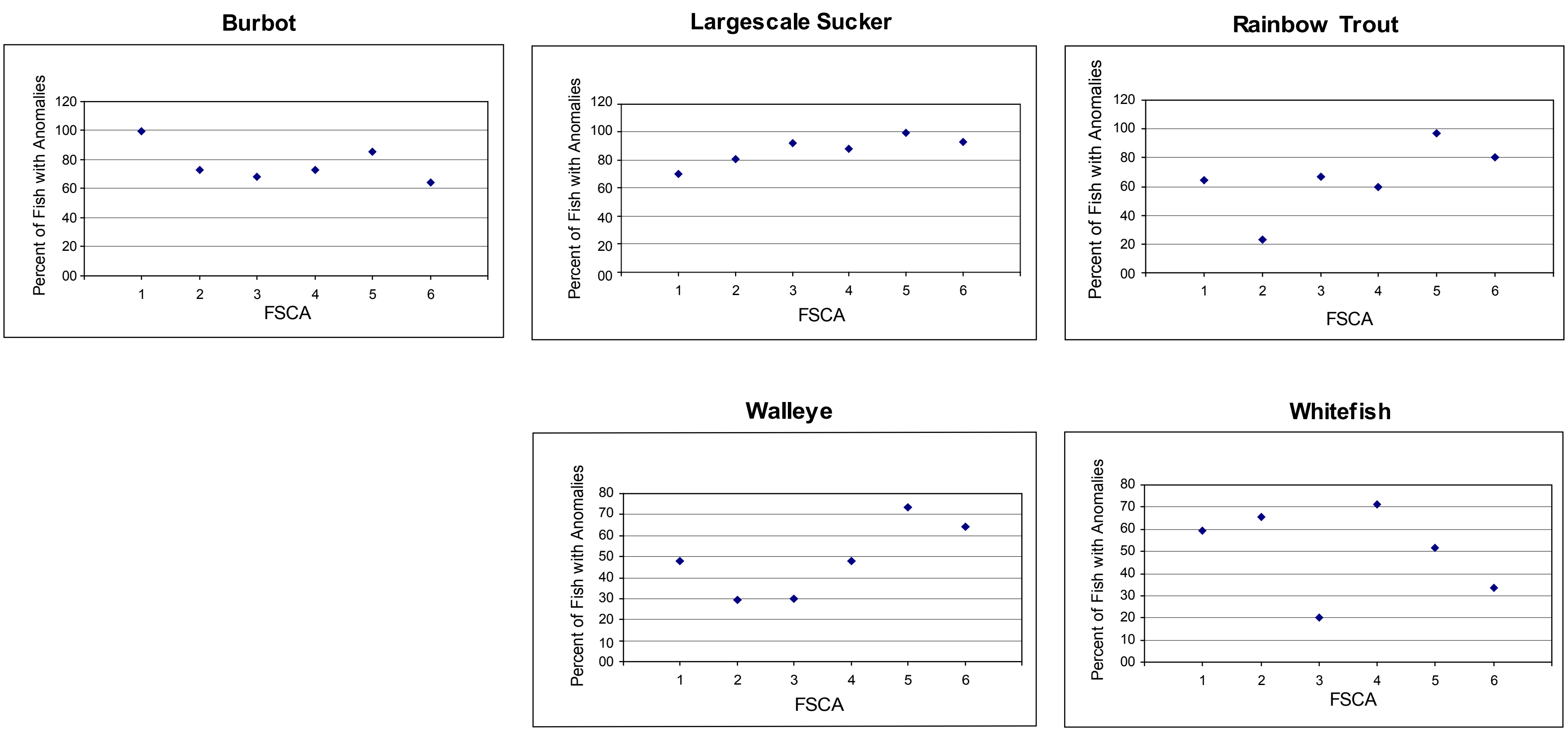


Figure B30. Percent of Fish by Species with External Anomalies in 2005.
Note: Only Mountain Whitefish were Examined in FSCA1, and Only Lake Whitefish were Examined in All Other FSCAs.

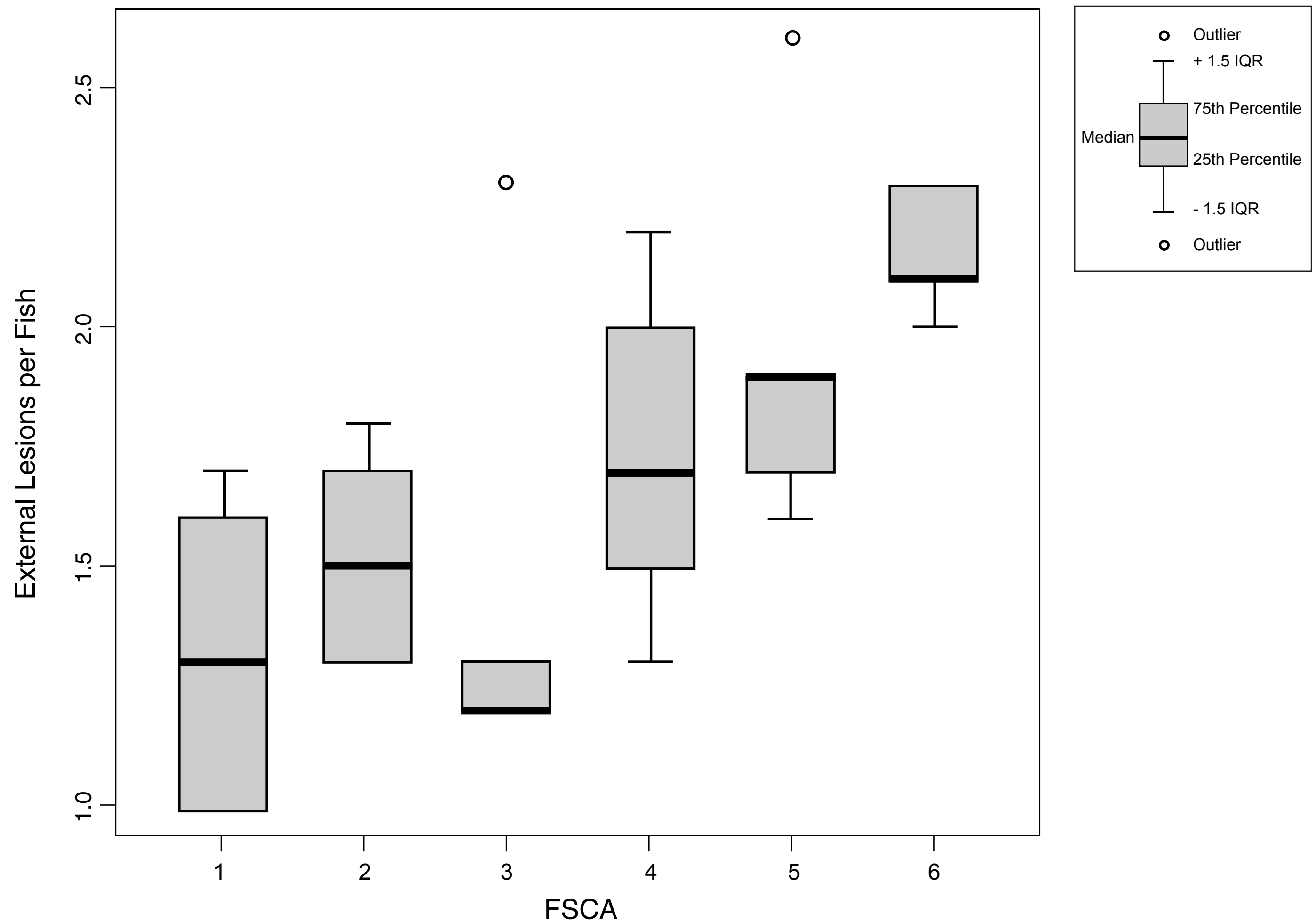


Figure B31. Number of External Anomalies per Fish (by Species) Examined in 2005 in each FSCA.

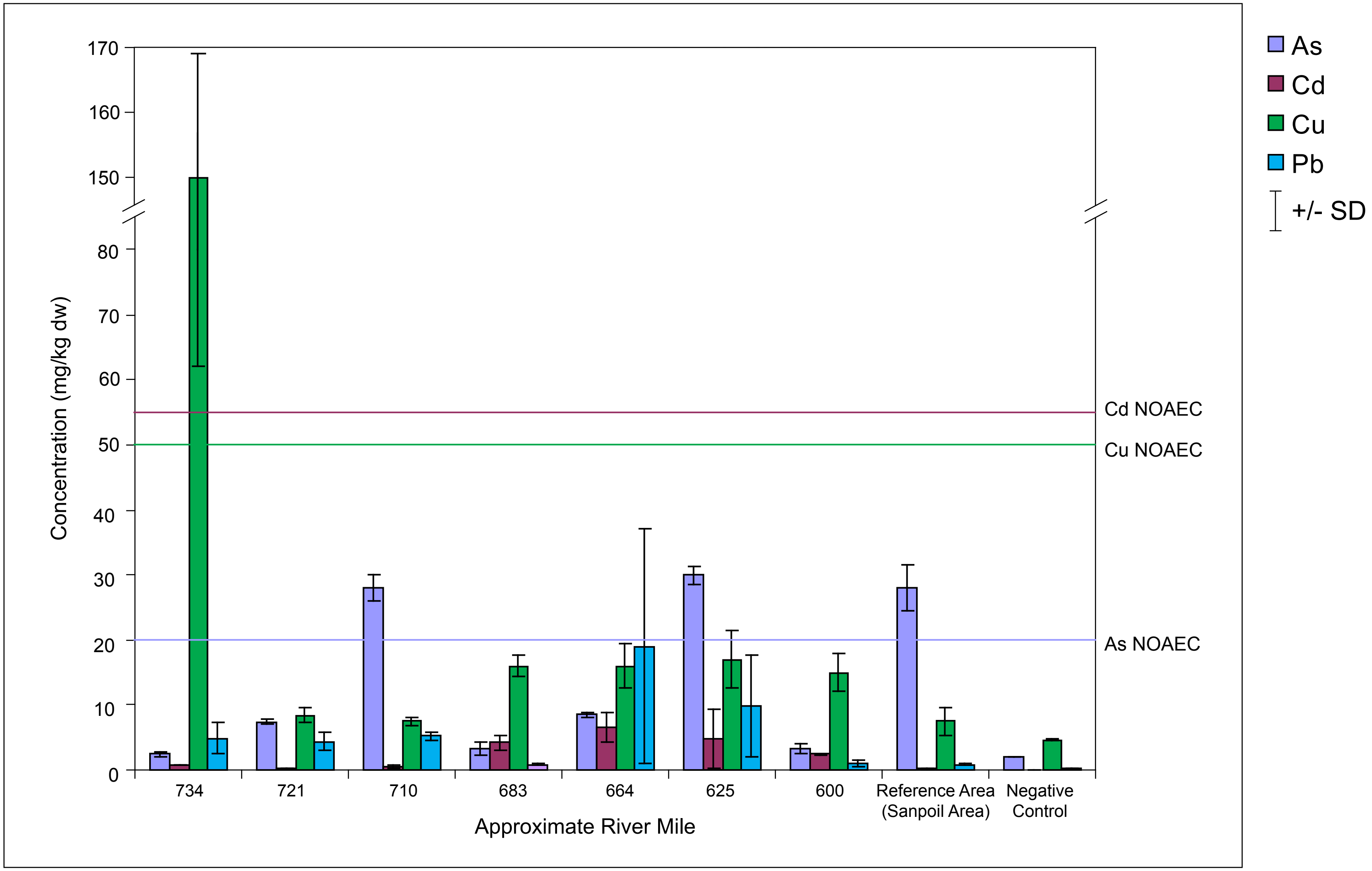


Figure B32. Mean Concentrations of Arsenic, Cadmium, Copper, and Lead in Depurated Oligochaetes Following Exposure to UCR Sediments Relative to NOAECs for Prey.
Notes: NOAEC - No Observed Adverse Effects Concentration.
NOAEC for Lead (7,040 mg/kg dw) not shown.
Source: (Oligochaetes Data) Besser et al. (2008).

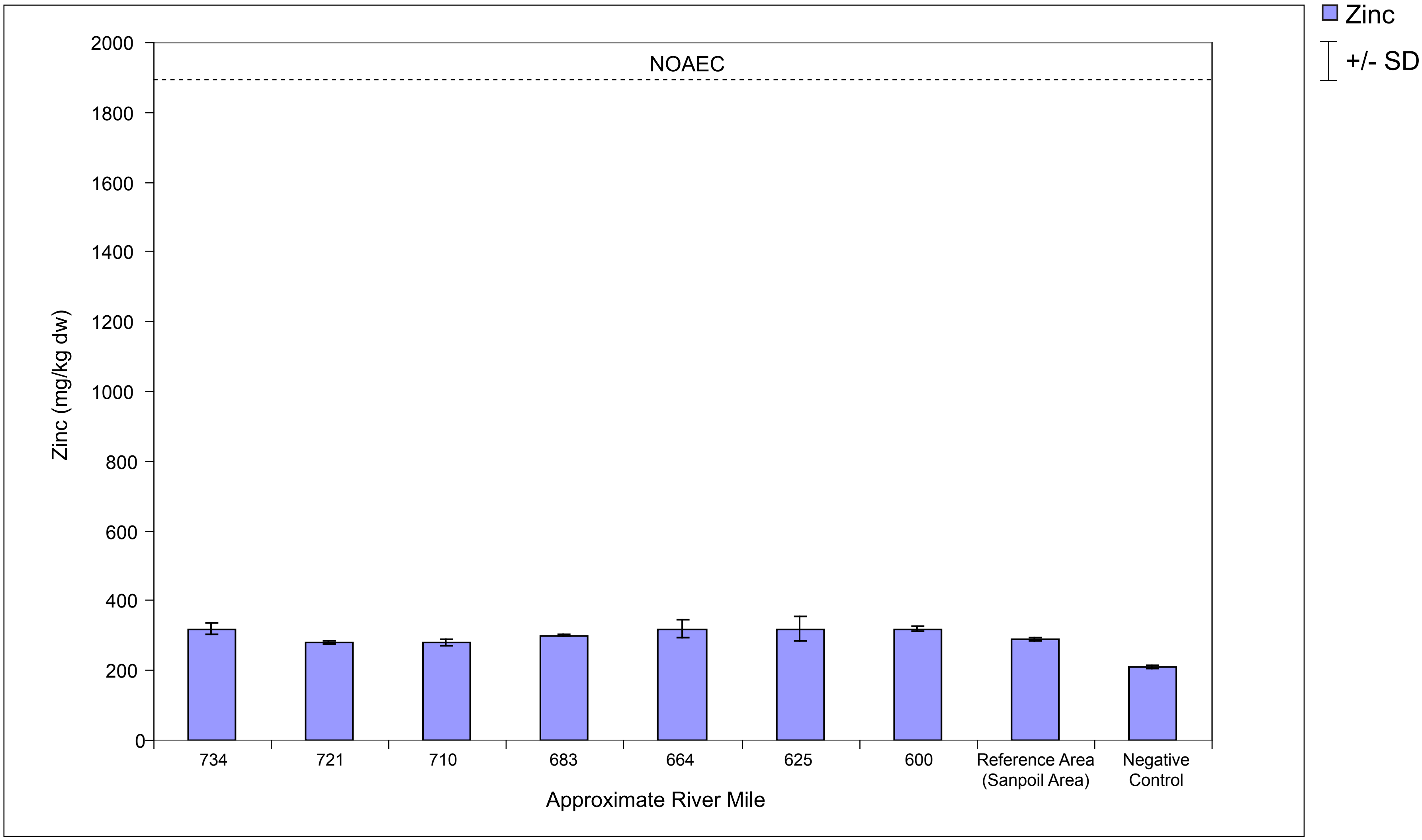


Figure B33. Concentrations of Zinc in Depurated Oligochaetes Following Exposure to Site Sediments Relative to the NOAEC for Zinc in Fish Prey.
Note: NOAEC - No Observed Adverse Effects Concentration.
Source: (Oligochaete Data): Besser et al. (2008).

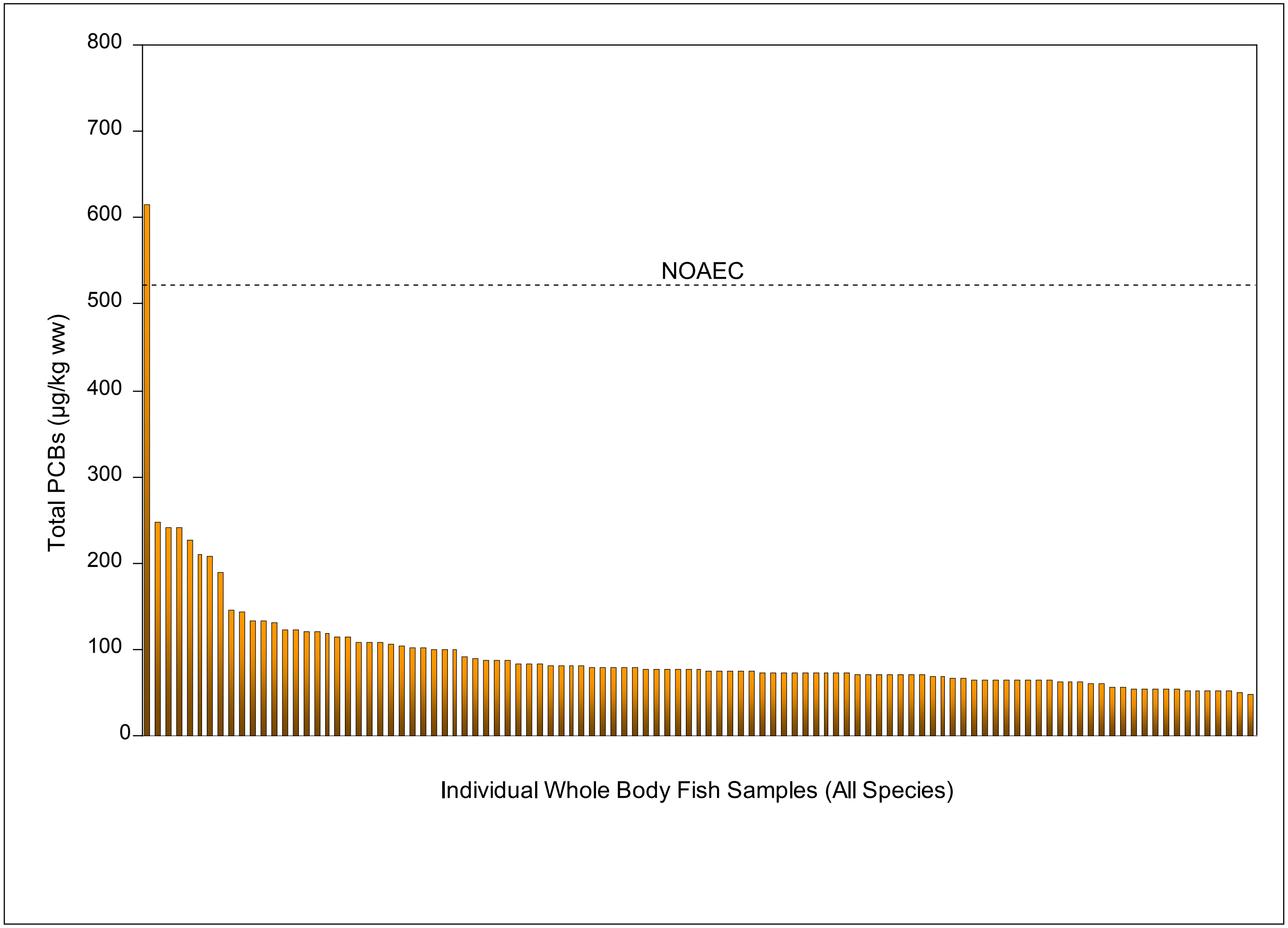


Figure B34. Concentrations of Total PCBs in Individual Samples of Whole Fish from the UCR in 2005 (USEPA 2007a) Relative to the Lowest Published NOAEC.
Notes: NOAEC - No Observed Adverse Effects Concentration.
Total PCBs Calculated as Sum of Aroclors with Non-Detects Set to 1/2 Detection Limit.

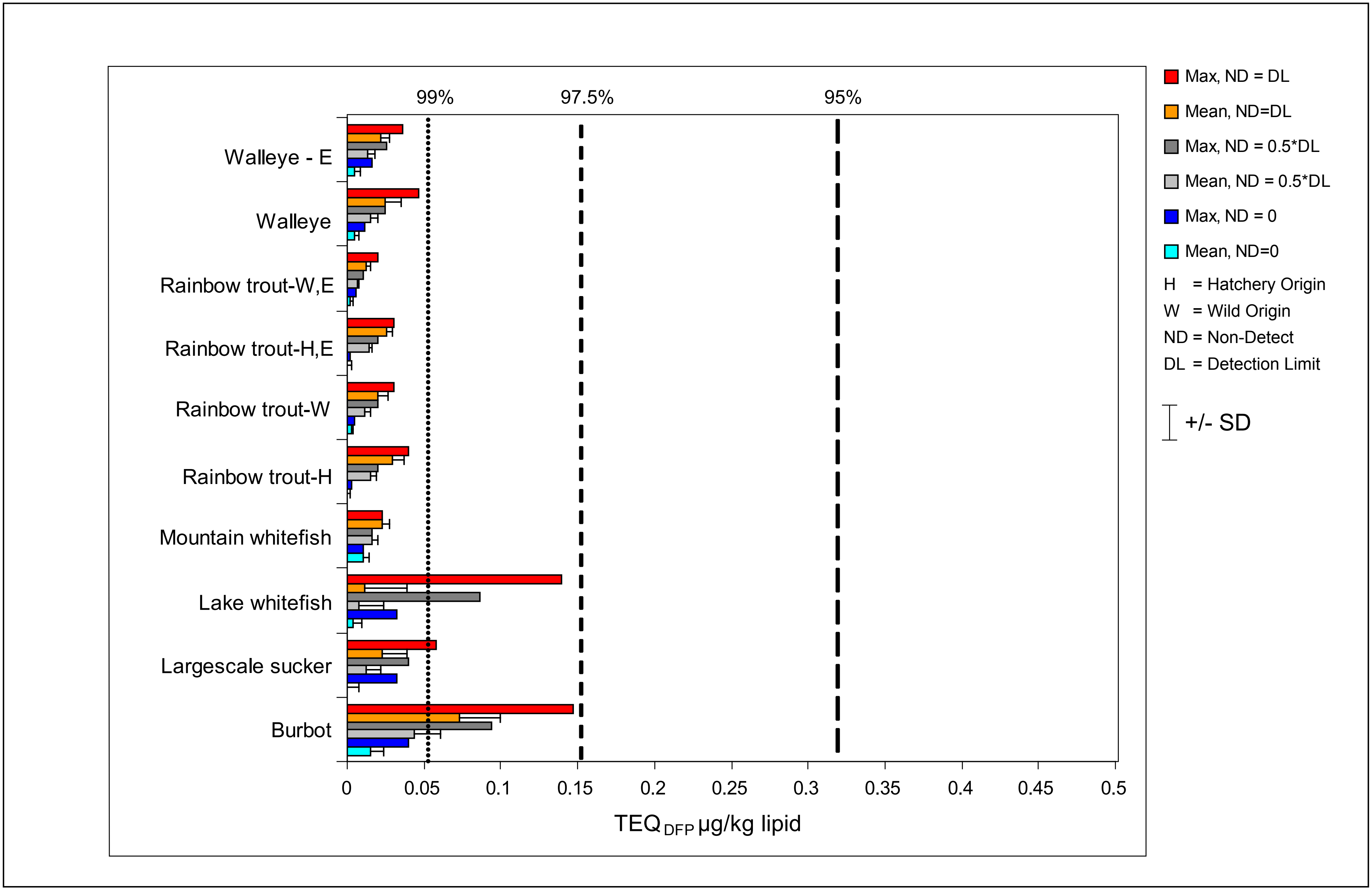


Figure B35. Concentrations of TEQ_{DFP} in Whole Body Fish Tissue Relative to Benchmarks Protective of 95, 97.5, and 99 Percent of Fish Species.
Note: Whole Body Concentration Estimated from Concentrations in Gutless Whole Body and Gut Tissue (Sucker), or Fillet and Offal.

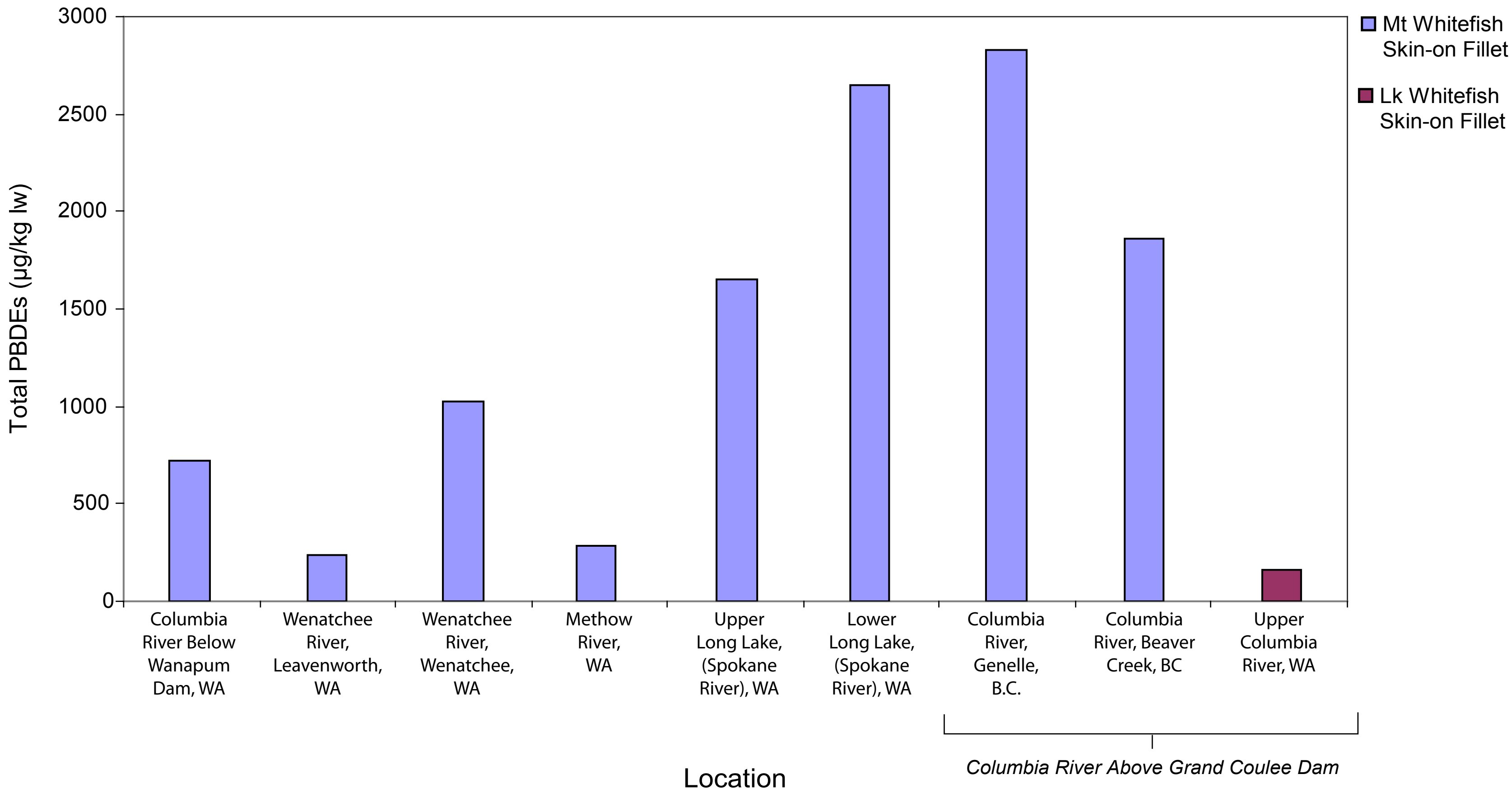


Figure B36. Lipid-Normalized PBDE Concentrations (µg/kg lw) in Lake Whitefish Fillet from the UCR and Mountain Whitefish Fillets from Other Waterbodies in Eastern Washington and British Columbia.

TABLES

Table B1. Summary of Fish Tissue Residue Studies Conducted in the UCR

Collection Dates	Organization/Reference	UCR Collection Areas (River Mile)	Species	Sample Types	Chemical Analyses: Metals (including Hg)	Chemical Analyses: Pesticides	Chemical Analyses: Dioxins/ Furans	Chemical Analyses: PCBs
1969–1986	USGS (2006)	Grand Coulee	largescale sucker, bridgelip sucker, carp, channel catfish, black crappie, longnose sucker, chiselmouth, largemouth bass, smallmouth bass, mountain whitefish, peamouth, northern pikeminnow, walleye, white crappie, yellow perch	whole body composites (5 per composite)	X	X		X
September 5, 1984	Ecology (Hopkins et al. 1985)	Northport	bridgelip sucker	fillet composites (number per composite unspecified)	X	X		X
September 23–26,1986	Ecology (Johnson et al. 1988)	Northport (732) Gifford (680) Seven Bays (635)	largescale sucker	whole body individuals	X			
			walleye, lake whitefish, rainbow trout, yellow perch, white sturgeon	muscle tissue from individuals				
May 27–July 18, 1989	Ecology (Johnson et al. 1989)	Marcus Island Colville River	white sturgeon, walleye	muscle tissue (individuals)	X (Hg only)		X	
June 26–28, 1990	Ecology (Johnson et al. 1991a)	Northport (733) China Bend (722) Marcus Island (709) French Pt. Rocks (697) Hunters (661) Grand Coulee (600)	largescale sucker	whole body composites (5 per composite)		X	X	X
May–October 1990	Ecology (Johnson et al. 1991b)	Northport to Kettle Falls (700–735) Seven Bays to Spring Canyon (600–673)	walleye, rainbow trout, white sturgeon, lake whitefish, kokanee, burbot	muscle tissue composites (4–5 per composite) liver and egg samples (individuals)			X	
October 6, 1993	Ecology (Serdar et al. 1994)	Kettle Falls	lake whitefish	muscle tissue composites (4–5 per composite) egg samples (individuals)	X		X	
		Kettle Falls Northport	largescale suckers	whole body (individuals)				
May–June 1994	USGS (Munn et al. 1995)	Northport to Kettle Falls Spokane River to Grand Coulee	walleye, rainbow trout, smallmouth bass	fillet (individuals) fillet composites (2–8 per composite)	X			

Table B1. Summary of Fish Tissue Residue Studies Conducted in the UCR (continued)

Collection Dates	Organization/Reference	UCR Collection Areas (River Mile)	Species	Sample Types	Chemical Analyses: Metals (including Hg)	Chemical Analyses: Pesticides	Chemical Analyses: Dioxins/ Furans	Chemical Analyses: PCBs
July 11–August 7, 1994	EVS (1998)	Northport Kettle Falls Seven Bays Spring Canyon	kokanee, lake whitefish, rainbow trout, smallmouth bass, walleye, white sturgeon	fillet with skin fillet without skin dorsal muscle without skin scaled with skin composites (4–8 per composite) and individuals			X	X
November 1997	USGS (Hinck et al. 2004)	Northport Grand Coulee	largescale sucker, walleye, rainbow trout	whole body composites (2–10 per composite)	X	X		X[a]
Summer and Fall 1998	USGS (Munn 2000)	Northport to Kettle Falls Spokane River to Grand Coulee	walleye, rainbow trout, mountain whitefish	fillet (individuals)	X (Hg only)		X	X[a]
September–October 2005	USEPA (2005d, 2006, 2007a)	Above Northport (735–741) Below Northport (720–734) Above Kettle Falls (702–707) Inchelium (673–689) Seven Bays (633–637) Above Spring Canyon (601–610)	burbot, largescale sucker, lake whitefish, mountain whitefish, walleye, rainbow trout	whole body composites (3–5 per composite) fillet and offal composites (3–5 per composite) whole body composites without GI tract (3–5 per composite) GI tract composites (3–5 per composite)	X		X	X[a]

Source: TCAI (2007)

Notes:
Hg = mercury
PCB = polychlorinated biphenyl
[a] Includes PCB Congeners.

Table B2. Summary of Concentrations of Metals and Organic Compounds in UCR Fish Tissues Reported by Historical Studies

Species	Sample Type[a]	Reference	Collection Year(s)	Inorganics (mg/kg-ww) Arsenic	Cadmium	Copper	Mercury	Lead	Selenium	Zinc	Dioxins/Furans (ng/kg-ww) 2,3,7,8-TCDD	2,3,7,8-TCDF	PCB Aroclors (µg/kg-ww) Aroclor 1254	Aroclor 1260
Black Crappie	WB-C	USGS (2006)	1969-1986	6 (<0.05-0.5)[b]	6 (<0.01-0.14)	3 (0.27-0.54)	7 (0.05-0.27)	6 (<0.01-0.19)	3 (0.4-0.56)	3 (26.9-33.0)	—	—	7 (<50-900)	4 (<50-100)
Bridgelip Sucker	WB-C	USGS (2006)	1969-1986	3 (0.18-0.27)	3 (0.07-0.28)	—	5 (0.02-0.12)	3 (0.53-1.0)	3 (0.2-0.26)	—	—	—	7 (<100-700)	4 (<100-4800)
	F-C	Hopkins et al. (1985)	1984	2 (<0.03)	2 (0.1-0.71)	2 (1.8-2.1)	2 (0.05-0.07)	2 (4.3-8.1)	—	2 (29.0-30.5)	—	—	—	2 (90-97)
Burbot	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	2 (<0.1-<0.1)	2 (2.7-2.9)	—	—
Carp	WB-C	USGS (2006)	1969-1986	17 (<0.05 -0.35)	17 (<0.05-1.8)	4 (1.11-1.42)	20 (<0.01-0.24)	17 (<0.1-0.4)	9 (0.22-0.99)	4 (75.4-112.4)	—	—	24 (<100-1900)	13 (<100-300)
Channel Catfish	WB-C	USGS (2006)	1969-1986	5 (<0.05-0.61)	5 (<0.05-0.13)	—	7 (0.08-0.9)	5 (<0.1-0.21)	2 (0.07-0.18)	—	—	—	8 (<100-1400)	3 (<100-500)
Chiselmouth	WB-C	USGS (2006)	1969-1986	2 (0.11 - 0.14)	2 (0.04-0.11)	2 (1.17-1.33)	2 (0.02-0.03)	2 (0.15-0.19)	2 (0.37-0.51)	2 (33.5-35.1)	—	—	2 (100-200)	2 (<100-200)
Kokanee	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	2 (0.7-0.9)	2 (42.1-63.3)	—	—
	F-I	EVS (1998)	1994	—	—	—	—	—	—	—	8 (<0.08-<0.16)	8 (1.78-6.74)	8 (26.6-85.4)	8 (9.9-19.3)
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	4 (<0.1-<0.13)	4 (2.76-3.13)	4 (27.8-37.7)	4 (9.7-13.9)
Lake Whitefish	M-I	Johnson et al. (1988)	1986	3 (<0.02-0.28)	3 (<0.01-0.01)	3 (0.44-0.6)	3 (0.07-0.12)	3 (0.03-0.04)	—	3 (3.4-4.5)	—	—	—	—
	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	12 (0.5-2.7)	12 (41.6-205)	—	—
	M-C	Serdar et al. (1994)	1990-1993	—	—	—	—	—	—	—	18 (0.18-2.3)	18 (2.6-157)	—	—
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	3 (<0.06-<0.14)	3 (3.78-15.6)	3 (35.2-50.6)	3 (16.1-40)
	F-I	EVS (1998)	1994	—	—	—	—	—	—	—	8 (<0.07-<1.41)	8 (1.6-125.9)	8 (13-156)	8 (5.3-38.8)
	M-I	EVS (1998)	1994	—	—	—	—	—	—	—	5 (<0.13-<1.37)	5 (3.25-6.77)	—	—
	M-C	EVS (1998)	1994	—	—	—	—	—	—	—	5 (<0.12-0.67)	5 (0.3-64)	5 (18.8-81.8)	5 (6.5-28.3)
Largemouth Bass	WB-C	USGS (2006)	1969-1986	1 (<0.05)	1 (<0.05)	—	1 (0.18)	1 (<0.1)	1 (0.1)	—	—	—	1 (<100)	1 (<100)
Largescale Sucker	WB-C	USGS (2006)	1969-1986	45 (<0.05-0.61)	45 (<0.003-0.6)	23 (<0.43-3.57)	49 (<0.01-0.3)	45 (0.3-2.57)	33 (0.06-0.55)	23 (14.1-60.1)	—	—	55 (<50-3000)	38 (<50-300)
	WB-I	Johnson et al. (1988)	1986	12 (<0.02-0.3)	12 (0.22-0.43)	12 (0.62-6.4)	12 (0.08-0.25)	12 (0.24-7.34)	—	12 (20.9-86.7)	—	—	—	—
	WB-C	Johnson et al. (1991a)	1990	—	—	—	—	—	—	—	6 (0.92-2.6)	6 (16.8-48.1)	—	—
	WB-I	Serdar et al. (1994)	1993	—	30 (0.23-1.0)	30 (0.74-20.1)	30 (0.07-0.35)	30 (1.7-23.3)	—	30 (15.5-136)	—	—	—	—
	WB-C	Hinck et al. (2004)	1997	4 (<0.21-0.52)	4 (0.31-0.46)	4 (1.24-3.46)	4 (0.08-0.15)	4 (0.68-9.29)	4 (<0.26-0.31)	4 (34.8-50.9)	—	—	—	—
Longnose Sucker	WB-C	USGS (2006)	1969-1986	2 (0.07-0.09)	2 (0.05-0.06)	2 (1.1-2.2)	2 (0.03-0.04)	2 (0.14-0.24)	2 (0.22-0.25)	2 (17.5-19.5)	—	—	2 (<50)	2 (<50)
Mountain Whitefish	WB-C	USGS (2006)	1969-1986	1 (0.12)	1 (0.07)	1 (0.59)	2 (0.06-0.19)	1 (0.1)	1 (0.47)	1 (18.8)	—	—	2 (100-800)	1 (100)
	F-I	Munn (2000)	1998	—	—	—	—	—	—	—	5 (0.04-0.12)	5 (0.87-6.26)	—	—
Northern Pikeminnow	WB-C	USGS (2006)	1969-1986	14 (<0.05-0.31)	14 (0.01-1.7)	2 (0.6)	16 (<0.01-1.2)	14 (<0.1-0.3)	11 (0.11-0.4)	2 (24-30)	—	—	19 (<100-4600)	8 (<100-1200)
Peamouth	WB-C	USGS (2006)	1969-1986	2 (0.07-0.08)	2 (0.03)	2 (0.75-1.08)	2 (0.02-0.03)	2 (0.05-0.09)	2 (0.45-0.47)	2 (19.7-24.6)	—	—	2 (100)	2 (<100-100)
Rainbow Trout (wild)	M-I	Johnson et al. (1988)	1986	2 (<0.02-0.12)	2 (0.01-0.04)	2 (0.4-0.44)	2 (0.04)	2 (0.05-0.07)	—	2 (4.6-5.5)	—	—	—	—
	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	12 (<0.1-1.6)	12 (3.7-53.2)	—	—
	F-C	Munn et al. (1995)	1994	6 (<0.1)	6 (<0.03)	6 (0.28-0.68)	6 (0.16-0.24)	6 (<0.05-0.1)	6 (<0.2-0.37)	6 (4.1-15.8)	—	—	—	—
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	7 (<0.04-<0.23)	7 (0.09-1.89)	7 (15.2-49.1)	7 (6.3-71.8)
	F-I	EVS (1998)	1994	—	—	—	—	—	—	—	24 (<0.07-<0.24)	24 (0.22-7.1)	16 (9.2-68.7)	16 (4.7-164)
	WB-C	Hinck et al. (2004)	1997	2 (<0.31)	2 (<0.06)	2 (1.1-1.11)	2 (<0.06)	2 (0.22-0.29)	2 (0.42-0.43)	2 (19.5-22.9)	—	—	—	—
	F-I	Munn (2000)	1998	—	—	—	—	—	—	—	16 (<0.01-0.1)	16 (0.2-2.03)	16 (8.8-49)	16 (2.4-39)
Smallmouth Bass	WB-C	USGS (2006)	1969-1986	—	—	—	2 (0.14-0.27)	—	—	—	—	—	3 (<100-600)	1 (200)
	F-C	Munn et al. (1995)	1994	5 (0.14)	5 (<0.03)	5 (0.36-0.41)	5 (0.17-0.62)	5 (<0.05-0.06)	5 (0.25-0.31)	5 (5.3-6.1)	—	—	—	—
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	9 (<0.09-<0.17)	9 (<0.15-4.1)	9 (4.7-7.9)	9 (2.6-7.2)
Walleye	WB-C	USGS (2006)	1969-1986	9 (<0.03-0.22)	9 (0.03-0.16)	3 (0.3-0.37)	11 (0.08-0.15)	9 (0.03-0.22)	7 (0.21-0.34)	3 (12.7-13.4)	—	—	13 (<100-3600)	7 (<100-400)
	M-I	Johnson et al. (1988)	1986	11 (<0.02-0.16)	11 (<0.01-0.02)	11 (0.08-0.48)	11 (0.07-0.36)	11 (0.01-0.11)	—	11 (3.5-4.5)	—	—	—	—
	M-I	Johnson (1989)	1989	—	—	—	24 (0.05-0.24)	—	—	—	—	—	—	—
	M-I	Johnson (1990)	1989	—	—	—	—	—	—	—	2 (0.21-4.0)	2 (8.9-326)	—	—
	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	12 (<0.1-0.32)	12 (0.9-6.0)	—	—
	F-C	Munn et al. (1995)	1994	3 (<0.1-0.12)	3 (<0.03)	3 (0.27-0.38)	34 (0.11-0.44)	3 (<0.05-0.07)	3 (0.23-0.39)	3 (4.6-5.2)	—	—	—	—
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	11 (<0.08-0.55)	11 (0.08-1.57)	11 (3.3-88.8)	11 (3.8-31.5)
	F-I	EVS (1998)	1994	—	—	—	—	—	—	—	8 (<0.05-<0.11)	8 (0.08-0.61)	8 (7.4-29.4)	8 (3.8-27.3)
	WB-C	Hinck et al. (2004)	1997	1 (<0.25)	1 (<0.05)	1 (0.53)	1 (0.15)	1 (<0.1)	1 (0.32)	1 (14.3)	—	—	—	—
	F-I	Munn (2000)	1998	—	—	—	16 (0.1-0.22)	—	—	—	—	—	—	—

Table B2. Summary of Concentrations of Metals and Organic Compounds in UCR Fish Tissues Reported by Historical Studies

				Inorganics (mg/kg-ww)							Dioxins/Furans (ng/kg-ww)		PCB Aroclors (µg/kg-ww)	
Species	Sample Type [a]	Reference	Collection Year(s)	Arsenic	Cadmium	Copper	Mercury	Lead	Selenium	Zinc	2,3,7,8-TCDD	2,3,7,8-TCDF	Aroclor 1254	Aroclor 1260
White Crappie	WB-C	USGS (2006)	1969-1986	2 (0.12-0.22)	2 (0.01)	2 (0.52-0.57)	2 (0.06-0.07)	2 (0.04-1.37)	2 (0.22-0.73)	2 (15.6-28.8)	—	—	3 (<100-4600)	1 (2900)
White Sturgeon	M-I	Johnson et al. (1988)	1986	1 (0.24)	1 (0.01)	—	1 (0.12)	1 (0.04)	—	1 (3.4)	—	—	—	—
	M-I	Johnson (1989)	1989	—	—	—	10 (0.02-0.1)	—	—	—	—	—	—	—
	M-I	Johnson (1990)	1989	—	—	—	—	—	—	—	2 (<0.1-2.2)	2 (3.9-221)	—	—
	M-C	Johnson et al. (1991b)	1990	—	—	—	—	—	—	—	4 (0.8-4.4)	4 (72.5-222)	—	—
	F-C	EVS (1998)	1994	—	—	—	—	—	—	—	2 (<0.15-<0.18)	2 (16.1-24.5)	2 (15-77)	2 (12.6-103)
Yellow Perch	WB-C	USGS (2006)	1969-1986	7 (<0.03-0.25)	7 (0.01-0.07)	6 (0.34-0.56)	7 (0.03-0.05)	7 (0.02-0.16)	6 (0.34-1.16)	6 (19.1-28.5)	—	—	7 (<100-300)	7 (<50-200)
	M-I	Johnson et al. (1988)	1986	1 (<0.02)	1 (0.01)	1 (1.32)	1 (0.4)	1 (0.11)	—	1 (9.4)	—	—	—	—

Source: TCAI (2007)

Notes:
— = No data available.
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*- dioxin
2,3,7,8-TCDF = 2,3,7,8-tetrachlorodibenzofuran

[a] Sample Type coding:
- F-I = Fillet tissue of individual fish
- F-C = Fillet tissue of multiple fish (composite)
- M-I = Muscle tissue of individual fish
- M-C = Muscle tissue of multiple fish (composite)
- WB-I = Whole body of individual fish
- WB-C = Whole body of multiple fish (composite)

[b] Data are reported as the sample size (minimum - maximum measured concentration)

Table B3. Summary of 2005 Fish Tissue Samples Collected by EPA from the UCR

FSCA	Walleye	Wild Rainbow Trout	Hatchery Rainbow Trout	Lake Whitefish	Mountain Whitefish	Largescale Sucker	Largescale Sucker Gut	Burbot
1	5F/5O	5F/5O	0	0	5WB	3WB	10G	0
2	5WB	5WB	0	5WB	0	4WB	0	3WB
3	5F/5O	2F/2O	3F/3O	5WB	0	4WB	5G	5WB
4	5WB	0	5WB	5WB	0	5WB	0	4WB
5	3WB	1WB	5WB	5WB	0	5WB	0	5WB
6	5F/5O+2WB	1F/1O	4F/4O	5WB	0	4WB	5G	5WB

Source: USEPA (2007a)

Notes:
F = fillet
FSCA = fish sample collection area
G = gut/gut contents
O = offal
WB = whole body

Table B4. Probabilities (*p*-values) for Spatial Comparisons of Each Metal among Sampling Areas for Burbot, Walleye, and Largescale Sucker in the UCR in 2005

	Burbot	Walleye			Largescale Sucker			
Metal	Whole Body	Whole Body	Fillet	Offal	Whole Body	Gut	Gutless	Reconstructed Whole Body
Arsenic	0.033	<0.001	0.024	0.009[a]	<0.001	0.007	--	--
Cadmium	--	--[a]	--[a]	--	--	0.002	0.002	<0.001
Chromium	--	--	--	--	0.007	0.014	0.015	0.027
Copper	--	0.002	--	--	<0.001	0.023	0.004	0.001
Mercury	--	0.001	0.013	0.002	0.011	--	--	--
Nickel	--	--	--	--	--	0.017	--	0.002
Lead	--	0.01[a]	--[a]	0.019	0.001	0.001	<0.001	<0.001
Selenium	0.005	0.001	--	--	0.004	0.037	--	--
Uranium	--	0.036[a]	NA	--	--	0.001	--	0.005
Zinc	--	0.015	0.003	--	0.005	0.001	<0.001	0.002

Note: Only significant values ($p \leq 0.05$) are shown
[a] Non-detects are present in the data set
-- = $p > 0.05$

Table B5. Correlations between Concentrations of Metals in Paired Whole Body and Fillet Samples of Rainbow Trout

Metal	Spearman's ρ	*p* value	Significance of linear test (*p* value)	Form of the Relationship
Aluminum	-0.40	0.138		n/r
Antimony	0.85	**0.000**	0.02	Non-Linear
Arsenic	0.76	**0.001**	0.09	Linear
Barium	0.25	0.361		n/r
Beryllium	0.76	**0.001**	0.45	Linear
Cadmium	-0.43	0.113		n/r
Calcium	-0.10	0.721		n/r
Chromium	0.76	**0.001**	0.05	Linear
Cobalt	0.43	0.113		n/r
Copper	0.62	0.014	0.49	Linear
Iron	0.34	0.213		n/r
Lead	0.52	0.045	0.59	Linear
Magnesium	0.15	0.597		n/r
Manganese	0.36	0.193		n/r
Mercury	0.89	**0.000**	0.17	Linear
Nickel	0.22	0.425		n/r
Potassium	-0.44	0.101		n/r
Selenium	0.93	**0.000**	0.29	Linear
Silver	0.81	**0.000**	0.39	Linear
Uranium	0.39	0.146		n/r
Vanadium	0.10	0.733		n/r
Zinc	0.26	0.348		n/r

Notes:
Bold = experimentwise $p < 0.05$
n/r = no relationship

Table B6. Correlations between Concentrations of Metals in Paired Whole Body and Fillet Samples of Walleye

Metal	Spearmans ρ	*p* value	Significance of linear test (*p* value)	Form of the Relationship
Aluminum	0.58	0.023	0.52	n/r
Antimony	0.65	0.009	0.24	n/r
Arsenic	0.76	**0.001**	0.44	Linear
Barium	-0.13	0.640	0.92	n/r
Beryllium	0.78	**0.001**	0.04	Non-Linear
Cadmium	0.33	0.228	0.54	n/r
Calcium	0.31	0.253	0.72	n/r
Chromium	0.25	0.373	0.43	n/r
Cobalt	-0.14	0.629	0.01	n/r
Copper	0.24	0.390	0.22	n/r
Iron	0.03	0.909	0.21	n/r
Lead	-0.19	0.495	0.91	n/r
Magnesium	-0.03	0.918	0.64	n/r
Manganese	-0.22	0.423	0.58	n/r
Mercury	0.96	**0.000**	0.33	Linear
Nickel	0.31	0.255	0.20	n/r
Potassium	0.23	0.400	0.34	n/r
Selenium	0.63	0.012	0.05	n/r
Silver	0.67	0.006	1.00	n/r
Uranium	-0.12	0.657	0.82	n/r
Vanadium	0.65	0.009	0.24	n/r
Zinc	0.68	0.005	0.82	n/r

Notes:
Bold = experimentwise $p < 0.05$
n/r = no relationship

Table B7. Relationships between Metals Concentrations in Paired Samples of Gutless Whole Body and Gut/Gut Contents of Largescale Sucker

Analyte	Correlation P Value	Spearman's ρ	Significance of Linear Test	Nature of Correlation
Aluminum	**< 0.001**	0.72	0.406	Linear
Antimony	0.268	0.26		n/r
Arsenic	0.513	0.16		n/r
Barium	0.521	0.15		n/r
Beryllium	0.299	0.24		n/r
Cadmium	**< 0.001**	0.80	0.621	Linear
Calcium	0.334	-0.23	0.829	n/r
Chromium	0.467	0.17	0.438	n/r
Cobalt	0.044	0.46	0.294	Linear
Copper	**0.001**	0.67	**< 0.001**	Non-linear
Iron	**< 0.001**	0.84	**< 0.001**	Non-linear
Lead	**< 0.001**	0.89	**< 0.001**	Non-linear
Magnesium	0.944	0.02		n/r
Manganese	**< 0.001**	0.76	**< 0.001**	Non-linear
Nickel	0.132	0.35		n/r
Potassium	0.037	0.47		n/r
Selenium	0.329	0.23		n/r
Silver	0.182	0.31		n/r
Zinc	**< 0.001**	0.85	**< 0.001**	Non-linear

Notes:
Bold = experimentwise *p* < 0.05
n/r = no relationship

Table B8. Mean Metal Concentrations in All Sediment Collected from within Each FSCA (mg/kg dw)

FSCA	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Uranium	Vanadium	Zinc
1	10000	16	780	1.6	59	26	920	89000	200	1600	0.18	12	6.9	27	32	6600
2	11000	16	730	2.0	54	24	880	82000	330	1600	0.18	13	5.0	40	29	7000
3	12000	10	340	1.5	34	12	280	51000	210	960	0.14	19	6.1	29	36	3600
4	12000	6.7	190	2.5	29	9.8	60	22000	130	440	0.60	23	5.7	30	35	330
5	13000	7.8	130	2.2	22	9.4	29	23000	68	510	0.29	19	4.0	32	29	270
6	13000	6.8	130	2.3	18	8.4	29	21000	68	590	0.34	15	3.9	36	28	280

Table B9. Mean Metal Concentrations in Sediment (without Thalweg Data) Collected from within Each FSCA (mg/kg dw)

FSCA	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Uranium	Vanadium	Zinc
1	10000	16	780	1.6	59	26	920	89000	200	1600	0.18	12	6.9	27	32	6600
2	7700	13	400	2.2	31	13	390	45000	300	800	0.21	13	4.1	27	25	4000
3	11000	7.0	210	1.5	30	9.6	49	23000	72	400	0.18	23	5.2	24	36	350
4	10000	5.7	130	1.5	24	8.6	34	19000	69	400	0.39	21	4.7	25	31	190
5	11000	7.7	120	2.2	20	8.5	24	21000	63	450	0.27	17	3.6	30	26	250
6	12000	6.5	110	1.6	16	7.5	23	20000	51	500	0.27	13	3.8	32	25	220

Notes:
Tabled concentrations are arithmetic means
FSCA = Fish Sample Collection Area

Table B10. Correlations (Spearman's ρ) between the Mean Concentration of Metals in All Sediment Samples Collected from within an FSCA and the Individual Whole Fish Concentrations

	Burbot		Largescale Sucker		Lake Whitefish		Hatchery Rainbow Trout		Wild Rainbow Trout		All Rainbow Trout		Walleye	
COI	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value
Aluminum	0.61	**0.003**	-0.23	0.065	--	--	-0.32	0.214	0.36	0.202	0.256	0.164	0.23	0.218
Arsenic	-0.20	0.364	-0.10	0.418	-0.19	0.396	0.22	0.395	-0.05	0.869	0.241	0.192	-0.60	**<0.001**
Barium	-0.58	**0.005**	0.04	0.765	-0.23	0.293	0.22	0.401	0.40	0.158	0.501	0.004	-0.17	0.383
Cadmium	0.39	0.073	0.06	0.622	0.41	0.057	-0.17	0.515	0.24	0.418	0.106	0.572	0.26	0.166
Chromium	0.17	0.440	-0.08	0.523	-0.61	**0.003**	0.60	0.011	0.69	**0.006**	0.813	**<0.001**	-0.24	0.206
Cobalt	-0.04	0.849	0.20	0.103	-0.36	0.105	0.01	0.963	0.40	0.157	-0.036	0.849	-0.27	0.147
Copper	0.28	0.210	0.53	**<0.001**	0.05	0.819	0.57	0.018	0.41	0.147	0.750	**<0.001**	-0.45	0.012
Iron	-0.32	0.142	0.30	0.015	-0.32	0.144	0.57	0.017	0.38	0.179	0.571	0.001	-0.17	0.359
Lead	-0.22	0.322	0.47	**<0.001**	0.54	0.010	0.52	0.033	0.13	0.650	0.749	**<0.001**	0.15	0.424
Manganese	-0.41	0.058	0.39	**0.001**	-0.82	**<0.001**	0.50	0.040	0.15	0.611	0.242	0.189	-0.66	**<0.001**
Mercury	0.39	0.077	0.19	0.352	0.48	0.023	0.49	0.047	-0.17	0.554	0.447	0.012	0.61	**<0.001**
Nickel	-0.13	0.555	-0.22	0.296	0.27	0.225	-0.19	0.476	-0.27	0.346	-0.273	0.138	-0.10	0.600
Selenium	0.80	**<0.001**	0.30	0.151	0.43	0.046	0.81	**<0.001**	0.87	**<0.001**	0.748	**<0.001**	-0.24	0.201
Uranium	-0.04	0.866	-0.48	0.016	0.05	0.812	-0.44	0.074	-0.10	0.739	-0.261	0.156	-0.22	0.239
Vanadium	0.16	0.478	0.29	0.152	--	--	--	--	--	--	--	--	--	--
Zinc	-0.21	0.347	0.73	**<0.001**	-0.13	0.568	-0.47	0.059	-0.297	0.303	-0.253	0.170	0.08	0.685

Table B11. Correlations (Spearman's ρ) between the Mean Concentration of Metals in Sediment (without Thalweg Data) Collected from within an FSCA and Individual Whole Fish Concentrations

	Burbot		Largescale Sucker		Lake Whitefish		Hatchery Rainbow Trout		Wild Rainbow Trout		All Rainbow Trout		Walleye	
COI	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value
Aluminum	0.61	**0.003**	-0.29	0.017	0.00	0.989	-0.32	0.214	0.22	0.441	0.147	0.430	0.00	0.994
Arsenic	0.08	0.725	-0.05	0.680	0.00	0.987	0.37	0.148	0.20	0.489	0.353	0.052	-0.68	**<0.001**
Barium	-0.58	**0.005**	0.04	0.765	-0.23	0.293	0.22	0.401	0.40	0.158	0.501	0.004	-0.17	0.383
Cadmium	-0.14	0.523	0.36	**0.004**	-0.58	**0.005**	-0.46	0.066	-0.08	0.778	-0.445	0.012	-0.32	0.081
Chromium	0.17	0.440	-0.08	0.523	-0.61	**0.003**	0.60	0.011	0.69	**0.006**	0.813	**<0.001**	-0.24	0.206
Cobalt	-0.04	0.849	0.20	0.103	-0.36	0.105	0.01	0.963	0.40	0.157	-0.036	0.849	-0.27	0.147
Copper	0.21	0.344	0.51	**<0.001**	0.13	0.552	0.87	**<0.001**	0.41	0.142	0.835	**<0.001**	-0.44	0.015
Iron	-0.18	0.410	0.23	0.069	-0.39	0.075	0.56	0.020	0.38	0.179	0.577	**0.001**	-0.29	0.126
Lead	-0.20	0.362	0.84	**<0.001**	0.49	0.020	0.28	0.268	0.48	0.080	0.708	**<0.001**	0.22	0.247
Manganese	0.11	0.639	0.47	**<0.001**	-0.20	0.371	-0.10	0.692	0.08	0.788	0.071	0.703	-0.21	0.276
Mercury	0.36	0.104	0.20	0.342	0.42	0.053	0.38	0.129	-0.17	0.570	0.416	0.020	0.65	**<0.001**
Nickel	-0.14	0.538	-0.31	0.127	0.27	0.230	0.19	0.463	-0.27	0.346	-0.108	0.565	-0.20	0.295
Selenium	0.70	**<0.001**	0.42	0.038	0.34	0.123	0.54	0.024	0.86	**<0.001**	0.693	**<0.001**	-0.31	0.096
Uranium	0.18	0.425	-0.25	0.232	-0.05	0.824	-0.44	0.074	-0.13	0.646	-0.354	0.050	-0.11	0.576
Vanadium	0.13	0.559	0.30	0.146	--	--	--	--	--	--	--	--	--	--
Zinc	-0.02	0.939	0.49	0.013	0.19	0.388	-0.07	0.799	0.43	0.127	-0.002	0.993	-0.22	0.247

Notes:
-- = Non detects in fish tissue exceeded 50 percent
Bold = experimentwise $p < 0.05$

Table B12. Correlations (Spearman's ρ) between the Mean Concentration of Metals in All Sediment Samples Collected from within an FSCA and the Individual Fillet Concentrations

	Hatchery Rainbow Trout		Wild Rainbow Trout		All Rainbow Trout		Walleye	
COI	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value
Aluminum	--	--	--	--	--	--	--	--
Arsenic	--	--	0.18	0.670	0.506	0.054	-0.52	0.046
Barium	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	--
Chromium	-0.294	0.522	0.78	0.021	0.692	**0.004**	0.05	0.867
Cobalt	--	--	0.10	0.821	-0.511	0.051	0.28	0.321
Copper	0.882	**0.009**	0.49	0.221	0.763	**0.001**	0.21	0.449
Iron	0.073	0.877	0.40	0.331	0.493	0.062	0.45	0.096
Lead	--	--	--	--	--	--	--	--
Manganese	0.000	1	-0.39	0.337	-0.267	0.335	0.60	0.017
Mercury	0.874	0.010	0.63	0.095	0.759	**0.001**	0.50	0.056
Nickel	--	--	--	--	--	--	-0.36	0.187
Selenium	0.874	0.010	0.77	0.024	0.881	**<0.001**	-0.13	0.636
Uranium	-0.091	0.846	-0.87	**0.005**	-0.781	**0.001**	-0.03	0.904
Vanadium	--	--	--	--	--	--	--	--
Zinc	0.364	0.422	0.85	**0.007**	0.711	**0.003**	0.62	0.014

Table B13. Correlations (Spearman's ρ) between the Mean Concentration of Metals in Sediment (without Thalweg Data) within an FSCA and Individual Fillet Concentrations

	Hatchery Rainbow Trout		Wild Rainbow Trout		All Rainbow Trout		Walleye	
COI	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value	Spearman's ρ	P-Value
Aluminum	--	--	--	--	--	--	--	--
Arsenic	--	--	0.180	0.670	0.506	0.054	-0.521	0.046
Barium	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	--
Chromium	-0.294	0.522	0.784	0.021	0.692	**0.004**	0.047	0.867
Cobalt	--	--	0.096	0.821	-0.511	0.051	0.275	0.321
Copper	0.882	**0.009**	0.487	0.221	0.763	**0.001**	0.211	0.449
Iron	0.073	0.877	0.397	0.331	0.493	0.062	0.446	0.096
Lead	--	--	--	--	--	--	--	--
Manganese	0.000	1	-0.168	0.691	-0.134	0.635	0.430	0.109
Mercury	0.874	0.010	0.629	0.095	0.759	**0.001**	0.504	0.056
Nickel	--	--	--	--	--	--	-0.360	0.187
Selenium	0.874	0.010	0.774	0.024	0.881	**<0.001**	-0.133	0.636
Uranium	-0.091	0.846	0.097	0.820	-0.116	0.681	0	1
Vanadium	--	--	--	--	--	--	--	--
Zinc	0.364	0.422	0.850	**0.007**	0.711	**0.003**	0.618	0.014

Notes:
-- = Non detects in fish tissue exceeded 50 percent
Bold = experimentwise p < 0.05

Table B14. Types of Lesions Recorded by the Smith et al. (2002) External Examination Protocol

Head	Gill and Opercula	Body	Eye	Fin	Barbels
Normal head	Normal	Normal	Normal	Normal	Normal
Deformed head	Slight shortening	Raised growth(s)	Exophthalmic	Mild erosion	Missing
Upper lip growth	Severe shortening	Reddened lesion(s)	Opaque	Severe erosion	Stubbed
Lower lip growth	Frayed	Spinal deformities	Missing	Frayed	Deformed
Swollen nare	Marginate	Hemorrhagic body	Hemorrhagic	Hemorrhagic	
	Pale	Focal discoloration	Emboli	Emboli	
		Body fungus			
		White spot(s)			
		Leech(es)			
		Black spot(s)			
		Anchor worm(s)			

Table B15. Incidence of Anomalies[a] Observed in External Examinations of Fish Collected by EPA in 2005 (USEPA 2007a)

Species	FSCA	Number of Fish Examined	Number of Fish with Anomalies	Percent of Fish with Anomalies	Average Anomalies/Fish	Average Anomalies/ Affected Fish
Largescale Sucker	1	27	19	70	1.1	1.6
	2	21	17	81	1.4	1.8
	3	27	25	93	2.1	2.3
	4	25	22	88	1.9	2.2
	5	18	18	100	2.6	2.6
	6	30	28	93	2.1	2.3
Burbot	1	1	1	100	1.0	1.0
	2	11	8	73	0.9	1.3
	3	25	17	68	0.8	1.2
	4	22	16	73	1.5	2.0
	5	27	23	85	1.4	1.7
	6	25	16	64	1.5	2.3
Walleye	1	25	12	48	0.5	1.0
	2	44	13	30	0.5	1.7
	3	30	9	30	0.4	1.3
	4	25	12	48	0.8	1.7
	5	15	11	73	1.4	1.9
	6	45	29	64	1.3	2.1
Rainbow Trout	1	25	16	64	0.80	1.3
	1	26	6	23	0.35	1.5
	2	27	18	67	0.81	1.2
	4	30	18	60	0.77	1.3
	5	32	31	97	1.81	1.9
	6	25	20	80	1.64	2.1
Mountain Whitefish	1	32	19	59	1.00	1.7
Lake Whitefish	2	32	21	66	0.84	1.3
	3	30	6	20	0.23	1.2
	4	35	25	71	1.09	1.5
	5	27	14	52	0.85	1.6
	6	6	2	33	0.67	2.0

Notes:
[a] Counts of anomalies reported in this table do not include anomalies that were recorded in the "notes" sections of the field forms.

Table B16. List of Water Bodies, Species, and Analytes in the Fish Tissue Reference Area Database

Water Body	Species	Chemical Analytes
Bonaparte Lake	Black Crappie	Arsenic
Banks Lake	Bridgelip Sucker	Cadmium
Bead Lake	Burbot	Cobalt
Buffalo Lake	Channel Catfish	Copper
Columbia River, downstream of Grand Coulee Dam	Common Carp	Lead
Curlew Lake	Lake Whitefish	Mercury
Deer Lake	Largemouth Bass	Selenium
Entiat River	Largescale Sucker	Zinc
Frenchman Hills Lake	Mountain Whitefish	Total PCBs
Lake Chelan	Northern Pikeminnow	Dioxins
Lake Wallula	Peamouth	Furans
Liberty Lake	Rainbow Trout	PBDEs
Long Lake	Smallmouth Bass	*alpha*-Chlordane
Loon Lake	Walleye	*gamma*-Chlordane
Methow River	Yellow Perch	Dachtal
Newman Lake		DDD
Okanogan River		DDE
Palmer Lake		DDT
Palouse River		Dieldrin
Patterson Lake		Endrin
Pend Oreille River		Heptachlor epoxide
Potholes Reservoir		Hexachlorobenzene
Rock Lake		*gamma*-Lindane
Roses Lake		*alpha*-Lindane
Scootney Reservoir		*cis*-Nonachlor
Snake River		*trans*-Nonchlor
Sprague Lake		Toxaphene
Stan Coffin Lake		
Walla Walla River		
Wenatchee River		

Table B17. Summary Statistics for Chemical Concentrations in Fish from Reference Areas and the UCR

Walleye		Reference Areas				UCR			
		Fillet				Fillet			
Chemical	Units	N	Min	Max	Mean	N	Min	Max	Mean
Mercury	µg/kg ww	6	51	640	210	15	180	420	270
Total PCBs	µg/kg ww	5	2.2[a]	46	12[b]	15			36

Largescale Sucker		Reference Areas				UCR			
		Whole body				Whole body			
Chemical	Units	N	Min	Max	Mean	N	Min	Max	Mean
Mercury	µg/kg ww	6	46.8	295	184	29	77	300	190

Rainbow Trout		Reference Areas				UCR				UCR			
		Fillet				Fillet				Hatchery Trout Fillet			
Chemical	Units	N	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean
Mercury	µg/kg ww	5	5.8	295	102	9	65	120	88	8	63	122	86
Total PCBs	µg/kg ww	4	2.4[a]	8.7	5.2[b]	9			63	8			44

Notes:
nc = not calculated
na = not analyzed
ww = wet weight

[a] Minimum was non-detect = 1/2 detection limit
[b] Calculated using non-detects = 1/2 detection limit

Table B18. Summary of Available TRVs Expressed as Concentrations in Fish Prey

Metal	TRV (mg/kg dry weight)
Arsenic	20
Cadmium	55
Chromium	9.42
Copper	50
Lead	7,040
Silver	3,000
Vanadium	2.04
Zinc	1,900

Notes:
TRVs are no observed adverse effect concentrations (NOAECs)

Table B19. Summary of Available CBRs for Whole Bodies of Fish

Chemical	CBR
Total PCBs	520 mg/kg wet weight
TEQ_{DFP}	0.321 ng/kg lipid weight

Notes:
The CBR for PCBs is no observed adverse effect concentration (NOAEC)
The CBR for TEQ is a concentration at or below which no adverse effect is expected in 95 percent of fish species

Table B20. Concentrations of Metals in Depurated Oligochaetes Following a 28-Day Exposure to UCR Sediment

		Arsenic		Cadmium		Copper		Lead		Zinc	
Station	River Mile[a]	Conc.	SD	Conc.	SD	Conc.	SD	Conc.	SD	Conc.	SD
LR-7	734	2.4	0.5	0.7	0.05	150	18	4.9	2.4	320	18
LR-6	721	7.4	0.3	0.24	0.03	8.4	1.2	4.4	1.3	280	6
LR-5	710	28	2.1	0.48	0.19	7.5	0.6	5.2	0.6	280	8
LR-4	683	3.2	1	4.2	1.2	16	1.6	0.84	0.2	300	3
LR-3	664	8.5	0.4	6.6	2.2	16	3.4	19	18	320	25
LR-2	625	30	1.4	4.8	4.6	17	4.5	9.8	7.8	320	36
LR-1	600	3.2	0.8	2.4	0.1	15	2.8	1.1	0.5	320	8
Reference Site		28	3.5	0.14	0.02	7.5	2.1	0.87	0.16	290	6
Negative Control		2	0.1	0.05	0.01	4.6	0.16	0.25	0.07	210	5

Source: data are from Besser et al. (2008); Table 6

Notes:
Concentrations are mg/kg dry weight
LR = Lake Roosevelt
SA = Sanpoil Arm
SD = standard deviation

[a] UCR river mile locations were approximated from the map provided by Besser et al. (2008)

Table B21. Number of Largescale Sucker Gut/Gut Contents Samples (N=20) with Metals Concentrations that Exceeded TRVs

	TRV (mg/kg dry weight)	Number of Samples Exceeding TRVs
Arsenic	20	0
Cadmium	55	0
Chromium	9.42	17
Copper	50	7
Lead	7,040	0
Silver	3,000	0
Vanadium	2.04	14
Zinc	1,900	3

Notes:
TRV = toxicity reference value (Table B18)

Table B22. Maximum Concentrations (mg/kg dw) of Selected Metals among all (N=125) Whole Body Fish Samples and TRVs for Fish Prey

Metal	TRV mg/kg dw	Max mg/kg dw	Species
Arsenic	20	4.9	Burbot
Cadmium	55	1.8	Largescale Sucker
Chromium	9.42	10.9	Largescale Sucker
Copper	50	40.6	Largescale Sucker
Lead	7,040	51.1	Largescale Sucker
Silver	3,000	0.26	Largescale Sucker
Vanadium	2.04	1.77	Largescale Sucker
Zinc	1,900	378	Largescale Sucker

Source of fish tissue data used: USEPA (2007a)

Table B23. Summary of Comments on USEPA (2007a) Provided by the Participating Parties and Responses to Those Comments

Comment No.	Summary of Comment	Response
TF1	A new study that analyzes the concentrations of chemicals in the contents of largescale sucker stomachs without the gut tissue is needed. [See also comment TF22]	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF2	PCB and dioxin/furan data should be lipid normalized. Additional analyses of the phase I fish tissue data should be performed.	Interspecific comparisons and spatial patterns of TCDF and Aroclors were evaluated using lipid-normalized concentrations in the UCR RI/FS work plan, and are summarized in this technical memorandum. In addition, it is recommended in this technical memorandum that future analyses of organic compounds in fish tissue should be based wholly or in part on lipid-normalized concentrations.
TF3	Explore effects of size, age and sex on each species body burdens using composite samples. Evaluate patterns of variance within FSCA for each analyte and species. Report in tables and with graphics.	Analysis of fish age and size was performed in the RI/FS work plan. Length, weight and age were found to covary, and length was more strongly correlated with age, so length differences were evaluated. Lengths of all fish species except rainbow trout were found to differ between FSCAs, and this is illustrated graphically. It is concluded that differences in length might affect interpretation of tissue chemistry data for largescale sucker, which vary widely in age within a given size category.
TF4	Estimate sizes of populations of USEPA's (2007) target fish species.	In this technical memorandum, it is recommended that the fish population data in the LRFEP annual reports be evaluated for potential use in assessment the status of the populations in the UCR, and summarized in the BERA work plan if appropriate.
TF5	Plot fillet concentrations relative to sediment concentrations by species and FSCA.	Correlations between sediment metals and fillet tissue are discussed in Section 3.2 of this technical memorandum.
TF6	Future risk assessments should not be limited by the limited list of chemicals identified and discussed in detail by the USEPA (2007a) report. Full screening level analyses resulting in selection of contaminants of interest are expected.	The list of COIs is presented in the SLERA, and will be refined in the BERA work plan.
TF7	Antimony, manganese, thallium, vanadium, PCB congeners and Dioxin/Furan congeners should be considered in screening level risk assessments	The list of COIs is presented in the SLERA and will be refined in the BERA work plan.

Table B23. Summary of Comments on USEPA (2007a) Provided by the Participating Parties and Responses to Those Comments

Comment No.	Summary of Comment	Response
TF8	Future tissue collection efforts should include analysis of pesticides, PAHs, specialty metals, fire retardants, PCB congeners, speciated arsenic. Future tissue studies should also include analysis of target analytes (particularly speciated arsenic) in burbot fillet.	The list of COIs is presented in the SLERA and will be refined in the BERA work plan.
TF9	Provide a more detailed evaluation of the sediment-tissue relationships for largescale sucker by conducting more sampling and analysis of sediment and LSS tissue.	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF10	Several additional analyses of the existing fish tissue data are needed, including comparisons of chemical concentrations: 1) by analyte, among species; 2) by analyte and FSCA among species; 3) by analyte and species, among FSCAs; 4) by analyte and species, among FSCAs within reaches.	Analyses of spatial and interspecific patterns were conducted in the RI/FS work plan and by USEPA (2007a) and are summarized in this technical memorandum.
TF11	Evaluate PCB congener distribution by species in fillet and WB tissue. Evaluate PCB congener distribution by location for each species. Evaluate exposures and risks using TEQs.	In this technical memorandum, potential risks to fish were evaluated by comparing tissue concentrations of total PCBs and TEQs to conservative literature-based critical body residues (CBRs). Analyses of PCB congener patterns in the RI/FS work plan did not identify trends. Additional kinds of analyses may be considered in the BERA work plan.
TF12	A site-specific study of the bioavailability of metals from sediment and water to suckers should be conducted.	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF13	Evaluate historical and long term trends in fish tissue concentrations.	Temporal trends are evaluated in this technical memorandum.
TF14	Tissue of smaller fish should be collected and analyzed.	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF15	Future fish sampling should include analysis of individual fish.	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF16	An analysis of lesions and hemorrhagic abnormalities [recorded during 2005 sampling] relative to concentrations of chemicals in tissue should be performed.	A summary of observed lesions and abnormalities is provided in Section 3.2.1.4.
TF17	A thorough selection process for ecological screening criteria shall be conducted for the SLERA and BERA.	The list of COIs is presented in the SLERA and will be refined in the BERA work plan.

Table B23. Summary of Comments on USEPA (2007a) Provided by the Participating Parties and Responses to Those Comments

Comment No.	Summary of Comment	Response
TF18	The following should be considered: studies of chemical concentrations in tissue of white sturgeon of various sizes; toxicological studies with white sturgeon to determine the relative toxicity of different chemicals to different life stages of the white sturgeon; collection and analysis of forage fish (e.g., dace and sculpin) for chemical contaminants; studies of other trophic guilds to determine chemical concentrations in their tissue.	In this technical memorandum, these kinds of future evaluations are recommended for consideration in the BERA work plan, with the exception of evaluations related to the white sturgeon which will be addressed as a separate component of the RI/FS.
TF19	The following studies are recommended: collection of recreationally important species from areas known to receive heavy recreational fishing pressure; fish collection from areas with good foraging habitat for piscivorous wildlife; collection of large scale sucker and co-located sediment for the purposes of defining relationships between the two media; collection of media to evaluate relationships between concentrations of mercury and TCDF in fish and in media (surface water, susp. particulates, sediment and food sources); a study to evaluate sources of PCBs.	In this technical memorandum, the kinds of future evaluations related to risks to fish are recommended for consideration in the BERA work plan. Other ecological evaluations will also be considered in the BERA work plan, whereas the evaluations related to human health will be addressed by USEPA.
TF20	Results of external examination of fish have been summarized, but the data were not interpreted. These should be interpreted and discussed.	USEPA (2007a) cites the Phase I Fish Tissue Sampling Field Summary Report as housing information on abnormalities. The document and appendices were thoroughly searched for the notes on abnormalities but only one note mentioning two abnormalities was found.
TF21	Further analysis of how results (of USEPA 2007) will support refinement of exposure calculations for the ERA and development of further fish collection for the ERA should be conducted. Technical meetings on the following topics will be helpful: percent metals with gut/gut contents of LSS; comparisons of COI concentrations by area for each species; site-wide comparisons by species for each COI; comparisons between species (using whole body and fillet) within a FSCA; comparison by species within reaches; comparisons of concentrations in LSS with those in sediment.	The topics identified in the comment were discussed at the March 2008 Technical Workshop or will be discussed at a subsequent workshop.

Table B23. Summary of Comments on USEPA (2007a) Provided by the Participating Parties and Responses to Those Comments

Comment No.	Summary of Comment	Response
TF22	This comment provides a detailed recommendation for a study design to evaluate bioavailability of metals in sediment to the LSS. Their focus is whether the presence of sediment in the gut of LSS increases whole body concentrations of COIs above those if the sediment were not present in the gut.	In this technical memorandum, this kind of future evaluation is recommended for consideration in the BERA work plan.
TF 23	USEPA recommends that the full suite of analytical results be discussed, especially as they relate to DQOs developed by TCAI.	The DQOs for risks to fish are being developed and were discussed at the March 2008 Technical Workshop. The list of COIs is presented in the SLERA and will be refined in the BERA work plan. The focus of all future evaluations will be based on the refined list of COIs.
TF24	Same as TF8	Same as TF8
TF25	Same as TF10	Same as TF10
TF26	Fish tissue studies should be designed to account for the effects of size and age on fish contamination levels.	In this technical memorandum, this kind of future consideration is recommended for consideration in the BERA work plan.
TF27	Same as TF12	Same as TF12
TF28	Gaps in the fish tissue dataset shall be filled	In this technical memorandum, this kind of future consideration is recommended for consideration in the BERA work plan.

Table B24. Concentrations (µg/kg ww) of Total PBDEs[a] in Fillets of Fish in the UCR Region

Species		Year	N	Mean	Min	Max
UCR						
Largescale Sucker	UCR	2005	1	9.8	--	--
Rainbow Trout	UCR	2005	1	0.92	--	--
Walleye	UCR	2005	1	1.5	--	--
Lake Whitefish	UCR	2005	1	18	--	--
Reference Areas in Washington						
Common Carp	Reference Areas	2005	2	16	2.8	30
Common Carp	Reference Areas	2006	1	0.09	--	--
Lake Whitefish	Reference Areas	2005	1	1.9	--	--
Largemouth Bass	Reference Areas	2004	1	0.47	--	--
Largemouth Bass	Reference Areas	2005	3	2.8	0.58	6.2
Largemouth Bass	Reference Areas	2006	3	0.37	0.29	0.46
Largescale Sucker	Reference Areas	2005	4	8.7	0.48	29
Mountain Whitefish	Reference Areas	2004	3	32	7.2	50
Mountain Whitefish	Reference Areas	2005	1	11.0	--	--
Northern Pikeminnow	Reference Areas	2004	1	11	--	--
Northern Pikeminnow	Reference Areas	2005	5	14	4.1	42
Peamouth	Reference Areas	2004	1	2.1	--	--
Peamouth	Reference Areas	2005	3	4.9	0.29	12
Rainbow Trout	Reference Areas	2004	1	0.99	--	--
Smallmouth Bass	Reference Areas	2005	4	4.1	0.62	8.6
Walleye	Reference Areas	2005	3	0.72	0.3	1.4
Yellow Perch	Reference Areas	2004	1	6.2	--	--
Yellow Perch	Reference Areas	2005	2	0.52	0.44	0.6
Yellow Perch	Reference Areas	2006	2	1	0.28	1.8
Spokane River						
Rainbow Trout	Plante Ferry	2005	3	90	65	107
Rainbow Trout	Misson Park	2005	3	30	27	32
Mountain Whitefish	Misson Park	2005	3	368	355	391
Rainbow Trout	Ninemile	2005	3	418	292	564
Mountain Whitefish	Ninemile	2005	3	1059	905	1222
Mountain Whitefish	Upper Long Lake	2005	3	175	161	198
Brown Trout	Upper Long Lake	2005	1	159	--	--
Smallmouth Bass	Upper Long Lake	2005	1	42	--	--
Mountain Whitefish	Lower Long Lake	2005	6	122	56	228
Smallmouth Bass	Lower Long Lake	2005	3	57	34	92
Upper Columbia River in British Columbia						
Mountain Whitefish	Genelle	1992	2	6.1	4.6	--
Mountain Whitefish	Genelle	1995	5	19.1	5.3	--
Mountain Whitefish	Genelle	2000	12	71.8	19.0	--
Mountain Whitefish	Genelle	2002	5	107	69.5	142.0
Mountain Whitefish	Genelle	2004	12	130	60.1	279.0
Rainbow Trout	Genelle	2003	10	18.4	10.5	33.9
Mountain Whitefish	Beaver Creek	1992	4	4.5	1.8	--
Mountain Whitefish	Beaver Creek	2000	9	29.2	15.4	--
Mountain Whitefish	Beaver Creek	2002	5	90.8	67.9	117

Table B24. Concentrations (µg/kg ww) of Total PBDEs[a] in Fillets of Fish in the UCR Region

Species		Year	N	Mean	Min	Max
Mountain Whitefish	Beaver Creek	2004	12	85.5	15.9	351
Rainbow Trout	Beaver Creek	2003	10	17.3	14.4	22.6
Mountain Whitefish	Kootenay Lake	1998	5	14.3	10.4	--
Mountain Whitefish	Slocan Lake	1996	3	0.9	0.2	--
Largescale Sucker	Kootenay River	2000	6	5.0	1.9	--

Notes:
[a] Total PBDE concentration calculated as the sum of detected congeners

ATTACHMENT B1

SUMMARY OF ANALYTICAL DATA FOR EPA 2005 FISH COMPOSITE SAMPLES

CONTENTS

Table B1-1. Summary of Analytical Data for Burbot

Burbot	Collection Area	2		3		4		5		6	
	River Mile	723		706		678		635		605	
	Fish per composite	3		5		5		5		5	
	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Aluminum											
	1	5.0		4.7		5.5		5.3		11	
	2	5.5		8.1		5.0		20		6.0	
	3	3.7		14		4.9		7.5		8.6	
	4			3.8		6.2		8.5		8.6	
	5			4.8				11.1		6.8	
	median	*5.0*		*4.8*		*5.2*		*8.5*		*8.6*	
	mean	*4.7*		*7.0*		*5.4*		10		*8.3*	
	se	*0.5*		*2.2*		*0.3*		*3.2*		*1.1*	
Arsenic											
	1	0.78		0.62		0.88		0.80		0.71	
	2	0.67		0.68		0.64		0.68		0.94	
	3	0.73		0.65		0.76		0.96		0.73	
	4			0.72		0.94		0.85		0.96	
	5			0.52				0.87		0.86	
	median	0.70		0.66		0.76		0.86		0.90	
	mean	0.70		0.64		0.78		0.84		0.87	
	se	*0.03*		*0.03*		*0.07*		*0.05*		*0.05*	
Barium											
	1	5.4		5.3		6.6		5.1		6.2	
	2	3.9		6.1		5.9		5.9		7.3	
	3	5.6		6.0		5.0		8.1		6.3	
	4			5.2		6.2		5.6		5.8	
	5			3.2				8.5		7.1	
	median	*5.4*		*5.3*		*6.1*		*5.9*		*6.3*	
	mean	*5.0*		*5.2*		*5.9*		*6.6*		*6.5*	
	se	*1.3*		*1.1*		*1.2*		*1.3*		*1.3*	
Cadmium											
	1	0.030		0.021		0.032		0.088		0.037	
	2	0.025		0.048		0.046		0.023		0.038	
	3	0.020		0.039		0.043		0.047		0.065	
	4			0.024		0.043		0.042		0.044	
	5			0.032				0.040		0.053	
	median	*0.025*		*0.032*		*0.043*		*0.042*		*0.044*	
	mean	*0.025*		*0.033*		*0.041*		*0.048*		*0.047*	
	se	*0.003*		*0.006*		*0.003*		*0.014*		*0.006*	
Calcium											
	1	8390	J	9120	J	9700	J	7080	J	10100	
	2	7710	J	7990	J	7260	J	10300	J	10400	
	3	9240	J	8610	J	6690	J	10300	J	7780	
	4			7840	J	8180	J	8350		7390	
	5			4900	J			11600		8830	
	median	*8390*		*7990*		*7720*		*10300*		*8830*	
	mean	*8450*		*7690*		*7958*		*9530*		*8900*	
	se	*443*		*295*		*657*		*790*		*776*	

Table B1-1. Summary of Analytical Data for Burbot

Burbot	Collection Area	2		3		4		5		6	
	River Mile	723		706		678		635		605	
	Fish per composite	3		5		5		5		5	
	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Chromium											
	1	0.39		0.30		0.44		0.29		0.45	
	2	0.50		0.37		0.26		1.49		0.34	
	3	0.41		0.42		0.31		0.27		0.26	
	4			0.33		0.29		0.40		0.48	
	5			0.34				0.34		0.27	
	median	0.41		0.34		0.30		0.34		0.34	
	mean	0.43		0.35		0.33		0.56		0.36	
	se	*0.03*		*0.03*		*0.04*		*0.29*		*0.05*	
Cobalt											
	1	0.041		0.028		0.038		0.035		0.029	
	2	0.027		0.042		0.038		0.037		0.030	
	3	0.028		0.044		0.037		0.039		0.040	
	4			0.033		0.035		0.032		0.035	
	5			0.029				0.036		0.033	
	median	*0.028*		*0.033*		*0.037*		*0.036*		*0.033*	
	mean	*0.032*		*0.035*		*0.037*		*0.036*		*0.033*	
	se	*0.004*		*0.004*		*0.001*		*0.002*		*0.003*	
Copper											
	1	1.2		0.9		1.2		1.3		1.0	
	2	1.1		1.4		1.4		0.8		0.9	
	3	1.0		1.4		1.0		1.2		1.5	
	4			1.0		1.0		1.0		1.0	
	5			1.3				0.9		1.1	
	median	*1.1*		*1.3*		*1.1*		*1.0*		*1.0*	
	mean	*1.1*		*1.2*		*1.1*		*1.0*		*1.1*	
	se	*0.0*		*0.1*		*0.1*		*0.1*		*0.1*	
Iron											
	1	22		18		21		30		26	
	2	18		34		24		36		24	
	3	17		37		23		28		28	
	4			22		23		26		32	
	5			21				29		26	
	median	*18*		*22*		*23*		*29*		*26*	
	mean	*19*		*27*		*23*		*30*		*27*	
	se	*1*		*5*		*1*		*2*		*2*	
Lead											
	1	0.073		0.066		0.082		0.092		0.078	
	2	0.064		0.13		0.084		0.056		0.089	
	3	0.065		0.17		0.10		0.12		0.091	
	4			0.087		0.11		0.062		0.083	
	5			0.070				0.11		0.084	
	median	*0.065*		*0.087*		*0.094*		*0.092*		*0.084*	
	mean	*0.067*		*0.10*		*0.095*		*0.088*		*0.085*	
	se	*0.003*		*0.023*		*0.007*		*0.015*		*0.003*	

Table B1-1. Summary of Analytical Data for Burbot

Burbot	Collection Area	2		3		4		5		6	
	River Mile	723		706		678		635		605	
	Fish per composite	3		5		5		5		5	
	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Magnesium											
	1	350	J	350	J	365	J	341	J	332	
	2	347	J	335	J	322	J	364	J	354	
	3	358	J	348	J	310	J	363	J	305	
	4			353	J	334	J	320		300	
	5			294	J			370		324	
	median	*350*		*348*		*328*		*363*		*324*	
	mean	*352*		*336*		*333*		*352*		*323*	
	se	*3.3*		*4.0*		*12*		*10*		*13*	
Manganese											
	1	2.1		1.9		3.2		2.1		2.4	
	2	2.2		2.1		2.4		2.8		2.8	
	3	2.1		2.9		2.1		3.0		1.9	
	4			1.9		2.5		1.8		2.5	
	5			1.3				2.8		2.6	
	median	*2.1*		*1.9*		*2.4*		*2.8*		*2.5*	
	mean	*2.1*		*2.0*		*2.6*		*2.5*		*2.4*	
	se	*0.0*		*0.2*		*0.2*		*0.3*		*0.2*	
Mercury											
	1	0.18		0.14		0.17		0.24		0.21	
	2	0.11		0.20		0.23		0.13		0.15	
	3	0.12		0.18		0.18		0.18		0.23	
	4			0.12		0.18		0.18		0.18	
	5			0.16				0.22		0.24	
	median	*0.12*		*0.16*		*0.18*		*0.18*		*0.21*	
	mean	*0.14*		*0.16*		*0.19*		*0.19*		*0.20*	
	se	*0.02*		*0.02*		*0.01*		*0.02*		*0.02*	
Nickel											
	1	0.30		0.32		0.38		0.27		0.35	
	2	0.32		0.31		0.26		0.42		0.32	
	3	0.30		0.33		0.25		0.37		0.26	
	4			0.24		0.29		0.28		0.25	
	5			0.18				0.36		0.31	
	median	*0.30*		*0.31*		*0.27*		*0.36*		*0.31*	
	mean	*0.31*		*0.28*		*0.29*		*0.34*		*0.30*	
	se	*0.01*		*0.02*		*0.03*		*0.04*		*0.02*	
Potassium											
	1	3140		2900		2960		3160		2640	
	2	3120		2950		3060		2700		2600	
	3	2990		2950		2990		2720		2870	
	4			3170		3170		2880		2860	
	5			3160				2810		2710	
	median	*3120*		*2950*		*3025*		*2810*		*2710*	
	mean	*3080*		*3030*		*3045*		*2850*		*2740*	
	se	*47*		*60*		*47*		*106*		*71*	

Table B1-1. Summary of Analytical Data for Burbot

Burbot	Collection Area	2		3		4		5		6	
	River Mile	723		706		678		635		605	
	Fish per composite	3		5		5		5		5	
	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Selenium											
	1	0.58		0.59		0.59		0.52		0.41	
	2	0.71		0.58		0.56		0.42		0.49	
	3	0.77		0.83		0.63		0.43		0.42	
	4			0.71		0.58		0.51		0.46	
	5			0.57				0.52		0.39	
	median	0.71		0.59		0.59		0.51		0.42	
	mean	0.68		0.66		0.59		0.48		0.43	
	se	*0.06*		*0.06*		*0.02*		*0.03*		*0.02*	
Sodium											
	1	1360		1360		1340		1640		1300	
	2	1330		1360		1330		1400		1460	
	3	1540		1550		1300		1560		1490	
	4			1420		1470		1460		1490	
	5			1220				1510		1370	
	median	*1360*		*1360*		*1335*		*1510*		*1460*	
	mean	*1410*		*1380*		*1360*		*1510*		*1420*	
	se	*66*		*45*		*38*		*53*		*46*	
Uranium											
	1	0.0046		0.0042		0.0054		0.0052		0.0051	
	2	0.0045		0.0053		0.0038		0.0045		0.0070	
	3	0.0031		0.011		0.0039		0.0063		0.0045	
	4			0.0044		0.0048		0.0043		0.0037	
	5			0.0030				0.0051		0.0051	
	median	*0.0045*		*0.0044*		*0.0043*		*0.0051*		*0.0051*	
	mean	*0.0041*		*0.0057*		*0.0045*		*0.0051*		*0.0051*	
	se	*0.0005*		*0.0017*		*0.0004*		*0.0005*		*0.0007*	
Vanadium											
	1	0.084	U	0.085		0.099		0.086		0.08	U
	2	0.11		0.11		0.076	U	0.079	U	0.097	
	3	0.13		0.17		0.080		0.10		0.091	
	4			0.093		0.080	U	0.10		0.089	U
	5			0.09	U			0.10		0.084	U
	median	*0.11*		*0.09*		*0.08*		*0.10*		*0.09*	
	mean	*0.11*		*0.11*		*0.08*		*0.09*		*0.09*	
	se	*0.01*		*0.02*		*0.01*		*0.01*		*0.00*	
Zinc											
	1	12		12		13		14		12	J
	2	12		13		13		11		12	J
	3	12		14		11		13		13	J
	4			13		12		13	J	12	J
	5			11				13	J	14	J
	median	*12*		*13*		*12*		*13*		*12*	
	mean	*12*		*12*		*12*		*13*		*12*	
	se	*0.2*		*0.4*		*0.4*		*0.5*		*0.3*	

Table B1-1. Summary of Analytical Data for Burbot

Burbot	Collection Area	2		3		4		5		6	
	River Mile	723		706		678		635		605	
	Fish per composite	3		5		5		5		5	
	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Moisture %	1	79		79		79		80		80	
	2	77		79		80		79		79	
	3	78		79		81		80		80	
	4			78		79		79		79	
	5			77				79		80	
	median	*78*		*79*		*80*		*79*		*80*	
	mean	*78*		*79*		*80*		*79*		*79*	
	se	*0.4*		*0.3*		*0.3*		*0.3*		*0.2*	
Lipids %	1	1.3		6.3		1.1		0.8		1.6	
	2	2.4		1.3		0.6		1.4		2.0	
	3	2.2		1.2		0.9		0.9		1.3	
	4			2.3		1.3		1.9		1.6	
	5			2.5				1.4		1.0	
	median	*2.2*		*2.3*		*1.0*		*1.4*		*1.6*	
	mean	*2.0*		*2.7*		*1.0*		*1.3*		*1.5*	
	se	*0.3*		*1.2*		*0.1*		*0.3*		*0.1*	
Age years	1	3.7		4.0		3.8		8.0		4.6	
	2	3.3		7.2		5.2		3.8		5.4	
	3	3.7		6.6		5.0		7.0		6.8	
	4			4.2		5.2		8.2		5.2	
	5			4.8				7.2		7.2	
	median	*3.7*		*4.8*		*5.1*		*7.2*		*5.4*	
	mean	*3.6*		*5.4*		*4.8*		*6.8*		*5.8*	
	se	*0.1*		*0.8*		*0.3*		*1.0*		*0.5*	
Length mm	1	597		734		490		872		621	
	2	781		650		492		758		593	
	3	602		714		584		781		637	
	4			735		619		796		659	
	5			1042				706		616	
	median	602		734		538		781		621	
	mean	660		775		546		783		625	
	se	*60*		*20*		*33*		*25*		*14*	
Weight g	1	484		515		471		573		496	
	2	536		523		493		527		495	
	3	490		541		498		569		507	
	4			513		540		557		510	
	5			553				550		503	
	median	*490*		*523*		*495*		*557*		*503*	
	mean	*503*		*529*		*501*		*556*		*502*	
	se	*16*		*6.2*		*14*		*10*		*3.7*	

Notes: Q = Laboratory qualifier
U = reported value is at or below the limit of detection

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Aluminum	whole body composite														
	1	138	J	64	J	12	J	51	J	46	J	22	J	40	J
	2	81	J			24	J	48	J	79	J	79	J	88	J
	3					19	J	13	J	86	J	23	J	50	J
	4					42	J	20	J	86	J	13	J	47	J
	5									89	J	9	J		
	median	109		64		21		34		86		22		49	
	mean	109		64		24		33		77		29		56	
	se	29				6		10		8		13		11	
	gutless individual														
	1	20	J	3.7	U			4.3	J					4.8	U
	2	7.1	J	5.1				3.6	J					3.7	U
	3	113	J	4.5				15	J					14	
	4	6.8	J	5.2				5.8	J					3.9	U
	5	8.2	J	3.8				4.5	J					4.0	U
	median	8.2		4.5				4.5						4.0	
	mean	31		4.5				6.7						6.0	
	se	21		0.3				2.2						2.0	
	gut														
	1	2860		213				609						56	
	2	1870		450				346						29	
	3	744		246				183						1180	
	4	1410		424				324						117	
	5	6490		297				65						150	
	median	1870		297				324						117	
	mean	2670		326				305						307	
	se	1000		47				91						220	
	reconstructed whole body														
	1	232		20				38						8	
	2	150		39				23						5	
	3	138		27				27						107	
	4	94.5		32				31						13	
	5	401		32				8.3						11	
	median	150		32				27						11	
	mean	203		30				26						29	
	se	54		3				5						20	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale	Collection Area	1		1(A)		2		3		4		5		6	
Sucker	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Arsenic	whole body composite														
	1	0.33		0.16		0.16		0.16		0.18		0.17		0.18	
	2	0.28				0.15		0.19		0.19		0.23		0.22	
	3					0.14		0.16		0.18		0.20		0.18	
	4					0.20		0.13		0.22		0.19		0.21	
	5									0.20		0.13			
	median	0.31		0.16		0.16		0.16		0.19		0.19		0.20	
	mean	0.31		0.16		0.16		0.16		0.19		0.18		0.20	
	se	0.03				0.01		0.01		0.01		0.02		0.01	
	gutless individual														
	1	0.15		0.10				0.19						0.21	
	2	0.20		0.18				0.21						0.20	
	3	0.12		0.18				0.21						0.15	
	4	0.18		0.10				0.12						0.14	
	5	0.15		0.19				0.14						0.15	
	median	0.15		0.18				0.19						0.15	
	mean	0.16		0.15				0.18						0.17	
	se	0.01		0.02				0.02						0.02	
	gut														
	1	2.4		0.61				0.67						0.47	
	2	1.7		0.73				0.39						0.25	
	3	1.1		0.81				0.63						1.6	
	4	1.5		1.0				0.50						0.38	
	5	5.0		0.083				0.26						0.35	
	median	1.7		0.73				0.50						0.38	
	mean	2.3		0.65				0.49						0.62	
	se	0.7		0.16				0.08						0.26	
	reconstructed whole body														
	1	0.31		0.14				0.22						0.23	
	2	0.31		0.22				0.22						0.20	
	3	0.16		0.24				0.24						0.27	
	4	0.26		0.16				0.15						0.16	
	5	0.44		0.25				0.15						0.16	
	median	0.31		0.22				0.22						0.20	
	mean	0.30		0.20				0.20						0.20	
	se	0.04		0.02				0.02						0.02	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Barium	whole body composite														
	1	12		5.1	J	2.0		2.6		4.0	J	3.3	J	2.8	J
	2	7.7				2.8		3.1		4.3	J	4.1	J	3.7	J
	3					2.5		1.6		2.6	J	3.7	J	3.8	J
	4					3.5		1.9		3.4	J	2.3	J	3.5	J
	5									4.2	J	3.3	J		
	median	9.7		5.1		2.7		2.2		4.0		3.3		3.6	
	mean	9.7		5.1		2.7		2.3		3.7		3.3		3.5	
	se	1.9				0.3		0.3		0.3		0.3		0.2	
	gutless individual														
	1	2.6		1.1				4.1						2.0	
	2	1.7		2.3				2.2						1.7	
	3	3.2		1.2				1.5						2.5	
	4	3.0		1.8				0.97						3.3	
	5	2.2		1.9				2.3						2.6	
	median	2.6		1.8				2.2						2.5	
	mean	2.6		1.7				2.2						2.4	
	se	0.3		0.2				0.5						0.3	
	gut														
	1	2.4		0.61				0.67						0.47	
	2	1.7		0.73				0.39						0.25	
	3	1.1		0.81				0.63						1.6	
	4	1.5		1.0				0.50						0.38	
	5	5.0		0.83				0.26						0.35	
	median	1.7		0.81				0.50						0.38	
	mean	2.3		0.80				0.49						0.62	
	se	0.7		0.068				0.075						0.26	
	reconstructed whole body														
	1	21		2.1				4.4						2.0	
	2	11		3.4				2.9						1.6	
	3	4.9		2.0				1.8						3.7	
	4	7.0		3.2				1.2						3.3	
	5	39		3.5				2.2						2.7	
	median	11		3.2				2.2						2.7	
	mean	16		2.9				2.5						2.7	
	se	6		0.3				0.6						0.4	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Cadmium	whole body composite														
	1	0.20		0.31		0.29		0.29		0.28		0.28		0.29	
	2	0.27				0.45		0.30		0.30		0.29		0.30	
	3					0.37		0.31		0.37		0.29		0.26	
	4					0.34		0.39		0.27		0.28		0.26	
	5									0.33		0.26			
	median	0.24		0.31		0.35		0.31		0.30		0.28		0.275	
	mean	0.24		0.31		0.36		0.32		0.31		0.28		0.277	
	se	0.04				0.03		0.02		0.02		0.01		0.01	
	gutless individual														
	1	0.27		0.29				0.20						0.30	
	2	0.41		0.26				0.27						0.15	
	3	0.34		0.25				0.11						0.33	
	4	0.41		0.35				0.03						0.17	
	5	0.038		0.24				0.10						0.15	
	median	0.34		0.26				0.11						0.17	
	mean	0.30		0.28				0.14						0.22	
	se	0.07		0.02				0.04						0.04	
	gut														
	1	1.6		1.4				1.1						2.0	
	2	2.1		1.7				1.2						0.97	
	3	2.3		1.0				0.89						0.69	
	4	1.6		2.0				0.21						0.78	
	5	2.5		1.3				0.44						1.0	
	median	2.1		1.4				0.89						0.97	
	mean	2.0		1.5				0.77						1.1	
	se	0.2		0.2				0.19						0.23	
	reconstructed whole body														
	1	0.37		0.37				0.25						0.41	
	2	0.54		0.36				0.32						0.19	
	3	0.42		0.33				0.17						0.36	
	4	0.49		0.45				0.043						0.22	
	5	0.51		0.35				0.13						0.19	
	median	0.49		0.36				0.17						0.22	
	mean	0.47		0.37				0.18						0.27	
	se	0.03		0.02				0.05						0.05	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Calcium	whole body composite														
	1	8650		13200	J	9810		10600		15700	J	11700	J	6830	J
	2	8120				11300		12800		13000	J	13600	J	9890	J
	3					11400		9810		8010	J	10900	J	10700	J
	4					10300		8830		8200	J	9300	J	12700	J
	5									12000	J	14100	J		
	median	8390		13200		10800		10200		12000		11700		10300	
	mean	8390		13200		10700		10500		11400		11900		10000	
	se	270				390		840		1500		880		1200	
	gutless individual														
	1	9660		7730				11100						7840	
	2	8910		8110				10600						11700	
	3	14000		10500				12400						7730	
	4	10600		9410				9520						12600	
	5	8240		9890				10600						10300	
	median	9660		9410				10600						10300	
	mean	10300		9130				10800						10000	
	se	1000		530				470						990	
	gut														
	1	7740		17800				3070						2560	
	2	6350		8930				8320						167	
	3	8990		18800				10900						2250	
	4	5360		27800				407						1700	
	5	21100		14100				514						735	
	median	7740		17800				3070						1700	
	mean	9910		17500				4640						1480	
	se	2900		3100				2100						450	
	reconstructed whole body														
	1	9510		8490				10500						7510	
	2	8710		8170				10500						11100	
	3	13800		11200				12300						7290	
	4	10300		10600				8810						11700	
	5	9020		10300				10000						9840	
	median	9510		10300				10500						9840	
	mean	10300		9750				10400						9490	
	se	920		600				560						900	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Chromium	whole body composite														
	1	3.1	J	1.3		0.67	J	1.0	J	0.71		1.1		1.8	
	2	1.7	J			1.6	J	0.86	J	1.2		1.5		1.8	
	3					1.1	J	0.65	J	1.3		0.95		1.3	
	4					1.0	J	0.60	J	1.6		0.51		1.7	
	5									2.1		0.47			
	median	2.4		1.3		1.1		0.76		1.3		0.95		1.8	
	mean	2.4		1.3		1.1		0.79		1.4		0.89		1.7	
	se	0.7				0.2		0.10		0.2		0.18		0.1	
	gutless individual														
	1	0.64	J	0.47				0.50	J					0.81	
	2	0.66	J	0.68				0.43	J					0.76	
	3	0.75	J	0.59				0.36						1.5	
	4	0.63	J	0.33				0.50						0.46	
	5	0.55	J	0.61				0.37						0.95	
	median	0.64		0.59				0.43						0.81	
	mean	0.64		0.53				0.44						0.89	
	se	0.03		0.06				0.03						0.16	
	gut														
	1	54		3.2				46						1.3	
	2	99		8.6				4.7						2.0	
	3	54		3.5				3.5						21	
	4	38		4.6				24						6.8	
	5	102		3.3				1.9						5.6	
	median	54		3.5				4.7						5.6	
	mean	69		4.6				16						7.3	
	se	13		1.0				8.4						3.5	
	reconstructed whole body														
	1	4.6		0.68				3.0						0.84	
	2	8.2		1.3				0.68						0.82	
	3	2.9		0.86				0.58						3.0	
	4	3.0		0.60				2.3						0.99	
	5	6.7		0.87				0.47						1.2	
	median	4.6		0.86				0.68						0.99	
	mean	5.1		0.86				1.4						1.4	
	se	1.1		0.12				0.52						0.41	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Cobalt	whole body composite														
	1	0.36		0.12		0.040		0.065		0.063		0.054		0.061	
	2	0.18				0.056		0.067		0.081		0.099		0.080	
	3					0.045		0.034		0.086		0.061		0.058	
	4					0.064		0.039		0.11		0.036		0.063	
	5									0.11		0.050			
	median	0.27		0.12		0.050		0.052		0.086		0.054		0.062	
	mean	0.27		0.12		0.051		0.051		0.091		0.060		0.065	
	se	0.09				0.006		0.009		0.009		0.011		0.005	
	gutless individual														
	1	0.052		0.03				0.050						0.035	
	2	0.036		0.03				0.027						0.023	
	3	0.058		0.05				0.029						0.069	
	4	0.041		0.04				0.016						0.046	
	5	0.035		0.04				0.034						0.027	
	median	0.041		0.037				0.029						0.035	
	mean	0.044		0.038				0.031						0.040	
	se	0.005		0.005				0.006						0.008	
	gut														
	1	8.7		0.44				0.86						0.10	
	2	5.0		0.45				0.24						0.06	
	3	1.9		0.36				0.17						0.80	
	4	2.5		0.58				0.39						0.15	
	5	18.8		0.33				0.06						0.16	
	median	5.000		0.440				0.240						0.150	
	mean	7.380		0.432				0.344						0.255	
	se	3.096		0.044				0.140						0.137	
	reconstructed whole body														
	1	0.70		0.057				0.096						0.039	
	2	0.42		0.065				0.039						0.025	
	3	0.13		0.083				0.039						0.128	
	4	0.19		0.074				0.045						0.055	
	5	1.18		0.066				0.036						0.033	
	median	0.416		0.066				0.039						0.039	
	mean	0.524		0.069				0.051						0.056	
	se	0.191		0.004				0.011						0.019	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Copper	whole body composite														
	1	13	J	3.1		0.91	J	0.95	J	0.71		0.77		1.2	
	2	8.1	J			1.4	J	0.91	J	0.83		0.81		1.0	
	3					1.2	J	0.72	J	0.86		0.67		0.79	
	4					1.5	J	0.79	J	0.83		0.60		0.96	
	5									0.82		0.71			
	median	10		3.1		1.3		0.85		0.83		0.71		1.0	
	mean	10		3.1		1.3		0.84		0.81		0.72		0.99	
	se	2.3				0.1		0.05		0.03		0.04		0.08	
	gutless individual														
	1	1.9	J	0.61				0.50	J					0.61	
	2	0.92	J	0.59				0.65	J					0.37	
	3	1.2	J	0.81				0.49						0.94	
	4	0.77	J	0.74				0.40						0.54	
	5	1.0	J	0.70				0.45						0.35	
	median	1.0		0.70				0.49						0.54	
	mean	1.2		0.69				0.50						0.56	
	se	0.2		0.04				0.04						0.11	
	gut														
	1	307		25				13						3.9	
	2	164		14				7.5						7.4	
	3	71		14				6.9						4.2	
	4	83		26				6.0						2.7	
	5	785		7.4				5.7						5.9	
	median	164		14				6.9						4.2	
	mean	282		17				7.8						4.8	
	se	130		4				1.3						0.8	
	reconstructed whole body														
	1	25		2.4				1.2						0.81	
	2	13		1.6				1.0						0.72	
	3	3.9		2.0				0.95						1.2	
	4	5.9		2.3				0.83						0.72	
	5	49		1.4				0.78						0.62	
	median	13		2.0				0.95						0.72	
	mean	19		2.0				0.96						0.81	
	se	8		0.2				0.07						0.10	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Iron	whole body composite														
	1	1060		301		44		89		67		38		86	
	2	585				69		93		93		120		151	
	3					56		29		122		46		91	
	4					92		46		130		25		90	
	5									131		19			
	median	823		301		63		67		122		38		90	
	mean	823		301		65		64		109		49		104	
	se	240				10		16		12		18		16	
	gutless individual														
	1	139		14	J			11						11	J
	2	30		23	J			26						10	J
	3	70		22	J			11						28	J
	4	34		44	J			9.7						11	J
	5	62		15	J			16						12	J
	median	62		22				11						11	
	mean	67		24				15						15	
	se	20		5				3						4	
	gut														
	1	25000		833				1080						96	
	2	14100		1210				677						102	
	3	4980		728				304						2030	
	4	7770		1390				617						259	
	5	66700		665				146						352	
	median	14100		833				617						259	
	mean	23700		965				565						568	
	se	11000		140				160						370	
	reconstructed whole body														
	1	1990		76				71						16	
	2	1100		113				63						15	
	3	265		88				32						188	
	4	517		129				57						32	
	5	4100		79				24						28	
	median	1100		88				57						28	
	mean	1590		97				49						56	
	se	690		10				9						33	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Lead	whole body composite														
	1	6.4	J	6.5	J	3.6	J	3.3	J	2.1	J	0.72	J	0.43	J
	2	3.2	J			4.1	J	3.0	J	1.4	J	0.74	J	0.55	J
	3					4.3	J	2.0	J	1.1	J	0.72	J	0.81	0
	4					3.7	J	3.5	J	1.1	0	0.45	J	0.95	J
	5									1.5	J	0.63	J		
	median	4.8		6.5		3.9		3.2		1.4		0.72		0.68	
	mean	4.8		6.5		3.9		3.0		1.5		0.65		0.69	
	se	1.6				0.2		0.3		0.2		0.05		0.12	
	gutless individual														
	1	5.0	J	3.2				0.71	J					0.35	
	2	7.3	J	6.8				4.3	J					0.29	
	3	14	J	4.1				2.0	J					0.52	
	4	6.3	J	7.8				0.12	J					0.52	
	5	7.8	J	3.5				1.7	J					0.27	
	median	7.3		4.1				1.7						0.35	
	mean	8.0		5.1				1.8						0.39	
	se	1.5		0.93				0.72						0.05	
	gut														
	1	35		2.4				0.80						0.14	
	2	22		5.0				1.9						0.070	
	3	12		2.1				1.4						1.0	
	4	14		4.8				0.66						0.17	
	5	116		2.2				0.29						0.20	
	median	22		2.4				0.80						0.17	
	mean	40		3.3				1.0						0.32	
	se	19		0.66				0.29						0.18	
	reconstructed whole body														
	1	7.3		3.1				0.72						0.34	
	2	8.4		6.6				4.2						0.28	
	3	13		3.9				2.0						0.56	
	4	6.8		7.6				0.16						0.49	
	5	14		3.4				1.7						0.27	
	median	8.4		3.9				1.7						0.34	
	mean	10		4.9				1.7						0.39	
	se	1.6		0.9				0.7						0.06	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Magnesium	whole body composite														
	1	367		383		337		370		394		339		305	
	2	353				356		398		382		397		364	
	3					356		337		346		327		351	
	4					338		324		343		289		369	
	5									398		369			
	median	360		383		347		354		382		339		358	
	mean	360		383		347		357		373		344		347	
	se	7				5		17		12		18		15	
	gutless individual														
	1	357		305				334						289	
	2	332		319				362						307	
	3	412		347				385						291	
	4	369		319				389						318	
	5	328		321				374						340	
	median	357		319				374						307	
	mean	359		322				369						309	
	se	15		7				10						9	
	gut														
	1	1200		363				505						173	
	2	885		536				348						129	
	3	498		417				295						887	
	4	854		595				262						174	
	5	2020		422				146						214	
	median	885		422				295						174	
	mean	1090		467				311						316	
	se	260		43				59						140	
	reconstructed whole body														
	1	420		310				343						282	
	2	374		335				361						299	
	3	415		353				378						339	
	4	399		336				379						306	
	5	430		331				360						334	
	median	415		335				361						306	
	mean	408		333				364						312	
	se	9.8		7				7						11	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker														
Collection Area	1		1(A)		2		3		4		5		6	
River Mile	741		735		723		706		678		635		605	
Fish per composite	5		5		5		5		5		5		5	
	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Manganese whole body composite														
1	28		14	J	6.7		7.6		8.9	J	6.3	J	4.4	J
2	23				7.5		8.3		9.3	J	9.3	J	6.5	J
3					6.9		4.3		6.6	J	7.7	J	6.3	J
4					7.5		5.3		7.3	J	4.3	J	8.2	J
5									9.1	J	6.1	J		
median	25		14		7.2		6.5		8.9		6.3		6.4	
mean	25		14		7.1		6.4		8.2		6.7		6.3	
se	2				0.2		0.9		0.5		0.8		0.8	
gutless individual														
1	8.7		4.5	J			4.5						2.4	J
2	12		11	J			5.8						2.6	J
3	15		5.4	J			6.8	J					7.5	J
4	12		9.9	J			2.0	J					4.6	J
5	10		5.1	J			5.9	J					2.4	J
median	12		5.4				5.8						2.6	
mean	12		7.1				5.0						3.9	
se	1.1		1.3				0.8						1.0	
gut														
1	504	J	26	J			47	J					11	J
2	284	J	28	J			22	J					1.7	J
3	100	J	22	J			19	J					47	
4	166	J	43	J			13						12	J
5	1250	J	17	J			3.1	J					8.8	J
median	284		26				19						10.6	
mean	461		27				21						16.0	
se	210		5				7						7.9	
reconstructed whole body														
1	46		6.1				6.9						2.9	
2	33		12				6.7						2.6	
3	19		6.9				7.6						11	
4	22		12				2.9						5.2	
5	85		6.2				5.7						2.8	
median	33		6.9				6.8						2.9	
mean	41		8.7				6.0						4.8	
se	12		1.4				0.8						1.5	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale	Collection Area	1		1(A)		2		3		4		5		6	
Sucker	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Mercury	whole body composite														
	1	0.077		0.19		0.22		0.28		0.30		0.24		0.21	
	2	0.093				0.21		0.23		0.26		0.23		0.25	
	3					0.17		0.28		0.25		0.21		0.23	
	4					0.17		0.29		0.22		0.20		0.21	
	5									0.26		0.26			
	median	0.085		0.19		0.19		0.28		0.26		0.23		0.22	
	mean	0.085		0.19		0.19		0.27		0.26		0.23		0.23	
	se	0.008				0.01		0.01		0.01		0.01		0.01	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Nickel	whole body composite														
	1	0.89		0.60		0.35		0.57		0.58		0.54		0.61	
	2	0.40				0.84		0.54		0.54		0.73		0.58	
	3					0.63		0.39		0.49		0.50		0.57	
	4					0.53		0.37		0.58		0.30		0.60	
	5									0.89		0.41			
	median	0.65		0.60		0.58		0.46		0.58		0.50		0.59	
	mean	0.65		0.60		0.59		0.47		0.62		0.50		0.59	
	se	0.24				0.10		0.05		0.07		0.07		0.01	
	gutless individual														
	1	0.29		0.24				0.38						0.21	
	2	0.30		0.31				0.36						0.25	
	3	0.42		0.34				0.34						0.63	
	4	0.35		0.29				0.34						0.30	
	5	0.09		0.11				0.09						0.12	
	median	0.30		0.29				0.34						0.25	
	mean	0.29		0.26				0.30						0.30	
	se	0.06		0.04				0.05						0.09	
	gut														
	1	20	J	1.8	J			30	J					0.47	J
	2	64	J	4.7	J			2.6	J					0.70	J
	3	33	J	2.0	J			2.1	J					10	J
	4	20	J	2.3	J			17	J					3.8	J
	5	39	J	1.8	J			0.70	J					3.1	J
	median	33		2.0				2.7						3.1	
	mean	35		2.5				11						3.7	
	se	8		0.6				5.8						1.8	
	reconstructed whole body														
	1	1.7		0.36				2.0						0.23	
	2	5.2		0.64				0.49						0.27	
	3	1.7		0.49				0.46						1.4	
	4	1.6		0.41				1.7						0.59	
	5	2.6		0.47				0.34						0.36	
	median	1.7		0.47				0.49						0.36	
	mean	2.6		0.48				1.0						0.57	
	se	0.7		0.05				0.36						0.22	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Potassium	whole body composite														
	1	3280		2700		3210		3420		2910		2880		3110	
	2	3420				3160		3070		3040		2890		3180	
	3					3250		3180		3310		2880		2800	
	4					3240		3150		3210		2810		2730	
	5									3200		2670			
	median	3350		2700		3230		3170		3200		2880		2960	
	mean	3350		2700		3220		3210		3130		2830		2960	
	se	70				20		75		71		42		110	
	gutless individual														
	1	3480		3367				3389						2922	
	2	3206		3596				3736						3207	
	3	3353		2961				3458						3020	
	4	3440		3418				3551						2712	
	5	3767		2932				3498						3400	
	median	3440		3370				3500						3020	
	mean	3450		3250				3530						3050	
	se	92		130				59						120	
	gut														
	1	20	J	1.8	J			30	J					0.47	J
	2	64	J	4.7	J			2.6	J					0.70	J
	3	33	J	2.0	J			2.1	J					10	J
	4	20	J	2.3	J			17	J					3.8	J
	5	39	J	1.8	J			0.70	J					3.1	J
	median	33		2.0				2.7						3.1	
	mean	35		2.5				11						3.7	
	se	8		0.6				5.8						1.8	
	reconstructed whole body														
	1	3424		3272				3348						2868	
	2	3154		3501				3673						3162	
	3	3331		2863				3370						2919	
	4	3399		3357				3397						2641	
	5	3716		2850				3422						3339	
	median	3400		3270				3400						2920	
	mean	3400		3170				3440						2990	
	se	91		130				59						120	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Selenium	whole body composite														
	1	0.36		0.57		0.58		0.73		0.45		0.44		0.49	
	2	0.60				0.61		0.68		0.57		0.50		0.52	
	3					0.58		0.73		0.46		0.47		0.54	
	4					0.64		0.59		0.55		0.48		0.63	
	5									0.62		0.36			
	median	0.48		0.57		0.60		0.70		0.55		0.47		0.53	
	mean	0.48		0.57		0.60		0.68		0.53		0.45		0.54	
	se	0.12				0.01		0.03		0.03		0.03		0.03	
	gutless individual														
	1	0.55		0.50				0.58						0.61	
	2	0.52		0.59				0.77						0.48	
	3	0.68		0.68				0.49						0.44	
	4	0.66		0.47				0.42						0.54	
	5	0.52		0.70				0.56						0.30	
	median	0.55		0.59				0.56						0.48	
	mean	0.59		0.59				0.56						0.47	
	se	0.04		0.05				0.06						0.05	
	gut														
	1	1.1		1.2				1.06						0.93	
	2	0.81		1.5				0.94						0.95	
	3	1.0		1.2				0.83						0.93	
	4	0.84		1.0				0.82						0.87	
	5	1.5		1.5				0.94						1.2	
	median	1.1		1.2				0.94						0.93	
	mean	1.1		1.3				0.92						0.97	
	se	0.1		0.1				0.04						0.05	
	reconstructed whole body														
	1	0.59		0.55				0.60						0.63	
	2	0.54		0.65				0.78						0.50	
	3	0.70		0.73				0.52						0.48	
	4	0.67		0.51				0.45						0.57	
	5	0.58		0.78				0.58						0.34	
	median	0.59		0.65				0.58						0.50	
	mean	0.62		0.64				0.59						0.50	
	se	0.03		0.05				0.06						0.05	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Sodium	whole body composite														
	1	1020		1300		1050		1360		1290		1340		1180	
	2	1050				1360		1350		1270		1290		1300	
	3					1380		1410		1170		1240		1310	
	4					1320		1380		1150		1210		1290	
	5									1300		1430			
	median	1040		1300		1340		1370		1270		1290		1300	
	mean	1040		1300		1280		1380		1240		1300		1270	
	se	15				77		13		32		39		30	
	gutless individual														
	1	1020		987				1230						1070	
	2	1120		1060				1370						1180	
	3	1390		122				1080						985	
	4	1230		1280				836						1490	
	5	1200		1230				1040						1290	
	median	1200		1060				1080						1180	
	mean	1190		936				1110						1200	
	se	61		210				90						88	
	gut														
	1	1310		1610				1380						1650	
	2	1500		1420				1750						1680	
	3	1450		1560				1390						943	
	4	1590		1750				961						1680	
	5	1860		1650				1250						1450	
	median	1500		1610				1380						1650	
	mean	1540		1600				1350						1480	
	se	92		54				130						140	
	reconstructed whole body														
	1	1040		1030				1240						1110	
	2	1150		1090				1390						1200	
	3	1400		1250				1110						982	
	4	1340		1300				846						1500	
	5	1240		1270				1050						1300	
	median	1240		1250				1110						1200	
	mean	1230		1190				1130						1220	
	se	65		54				91						88	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Uranium	whole body composite														
	1	0.033		0.028		0.018		0.018		0.018		0.016		0.013	
	2	0.024				0.018		0.026		0.021		0.019		0.018	
	3					0.014		0.016		0.015		0.014		0.014	
	4					0.016		0.015		0.014		0.015		0.017	
	5									0.020		0.0092			
	median	0.028		0.028		0.017		0.017		0.018		0.015		0.015	
	mean	0.028		0.028		0.017		0.019		0.017		0.015		0.015	
	se	0.004				0.001		0.002		0.001		0.002		0.001	
	gutless individual														
	1	0.015		0.0078				0.019						0.011	
	2	0.027		0.010				0.019						0.0068	
	3	0.030		0.011				0.024						0.015	
	4	0.018		0.024				0.0028						0.010	
	5	0.011		0.011				0.022						0.0066	
	median	0.018		0.011				0.019						0.010	
	mean	0.020		0.013				0.018						0.010	
	se	0.004		0.003				0.004						0.002	
	gut														
	1	0.66		0.10				0.058						0.010	
	2	0.39		0.11				0.12						0.0059	
	3	0.20		0.14				0.050						0.096	
	4	0.31		0.16				0.024						0.016	
	5	1.4		0.11				0.0097						0.019	
	median	0.39		0.12				0.050						0.016	
	mean	0.60		0.13				0.053						0.030	
	se	0.22		0.01				0.020						0.017	
	reconstructed whole body														
	1	0.063		0.015				0.021						0.011	
	2	0.055		0.018				0.025						0.007	
	3	0.036		0.023				0.026						0.022	
	4	0.036		0.033				0.004						0.011	
	5	0.098		0.021				0.022						0.007	
	median	0.055		0.021				0.022						0.011	
	mean	0.058		0.022				0.020						0.012	
	se	0.011		0.003				0.004						0.003	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Vanadium	whole body composite														
	1	0.33		0.18		0.10	U	0.21		0.17		0.12		0.16	
	2	0.27				0.13		0.21		0.20		0.25		0.33	
	3					0.12		0.14		0.29		0.11	U	0.15	J
	4					0.18		0.14		0.28		0.12	U	0.20	
	5									0.30		0.11	U		
	median	0.30		0.18		0.13		0.18		0.28		0.12		0.18	
	mean	0.30		0.18		0.14		0.18		0.25		0.14		0.21	
	se	0.03				0.02		0.02		0.03		0.03		0.04	
	gutless individual														
	1	0.11	U	0.10	U			0.12						0.12	U
	2	0.11	U	0.10	U			0.12						0.10	U
	3	0.11	U	0.11	U			0.10	U					0.17	U
	4	0.11	U	0.10				0.11	U					0.10	U
	5	0.11	U	0.10	U			0.10	U					0.11	U
	median	0.11		0.10				0.11						0.11	
	mean	0.11		0.10				0.11						0.12	
	se	0.00		0.00				0.00						0.01	
	gut														
	1	6.9		0.77				2.1						0.15	
	2	5.3		1.5				1.1						0.13	
	3	2.8		1.1				0.51						3.0	
	4	4.5		1.4				1.2						0.35	
	5	11.5		1.1				0.25						0.44	
	median	5.3		1.1				1.1						0.35	
	mean	6.2		1.2				1.0						0.81	
	se	1.5		0.1				0.3						0.54	
	reconstructed whole body														
	1	0.62		0.15				0.23						0.13	
	2	0.50		0.20				0.17						0.10	
	3	0.21		0.20				0.13						0.39	
	4	0.38		0.19				0.19						0.12	
	5	0.80		0.20				0.11						0.12	
	median	0.50		0.20				0.17						0.12	
	mean	0.50		0.19				0.17						0.17	
	se	0.10		0.01				0.02						0.06	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Zinc	whole body composite														
	1	126	J	45		23	J	21	J	24		18		19	
	2	68	J			28	J	21	J	22		22		20	
	3					27	J	18	J	21		21		17	
	4					25	J	21	J	23		18		19	
	5									21		18			
	median	97		45		26		21		22		18		19	
	mean	97		45		26		20		22		19		19	
	se	29				1.0		0.84		0.67		0.94		0.53	
	gutless individual														
	1	40	J	23				22	J					18	
	2	51	J	40				24	J					19	
	3	55	J	21				23						17	
	4	37	J	29				13						18	
	5	49	J	21				24						18	
	median	49		23				23						18	
	mean	46		27				21						18	
	se	3		4				2						0	
	gut														
	1	1950		58				28						15	
	2	1040		60				26						17	
	3	331		39				26						21	
	4	460		74				16						13	
	5	5170		32				17						17	
	median	1040		58				26						17	
	mean	1790		53				23						17	
	se	890		8				3						1	
	reconstructed whole body														
	1	183		26				22						18	
	2	126		41				24						19	
	3	66		23				23						18	
	4	64		32				13						18	
	5	360		22				24						18	
	median	126		26				23						18	
	mean	160		29				21						18	
	se	55		4				2						0	

Table B1-2. Summary of Analytical Data for Largescale Sucker

Largescale Sucker	Collection Area	1		1(A)		2		3		4		5		6	
	River Mile	741		735		723		706		678		635		605	
	Fish per composite	5		5		5		5		5		5		5	
		mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Lipids	whole body composite														
%	1	5.8		4.0		3.5		5.7		4.1		4.6		8.3	
	2	2.7				2.8		11		5.1		7.7		6.4	
	3					3.6		4.3		7.5		8.1		6.6	
	4					5.3		3.1		6.4		11		8.3	
	5									5.2		6.7			
	median	4.3		4.0		3.6		5.0		5.2		7.7		7.5	
	mean	4.3		4.0		3.8		6.0		5.7		7.5		7.4	
	se	1.6				0.5		1.7		0.6		1.0		0.5	
Age	whole body composite														
years	1	12		30		24		28		26		27		32	
	2	14				27		31		30		29		30	
	3					25		23		24		31		23	
	4					29		30		26		27		29	
	5									28		31			
	median	13		30		26		29		26		29		29	
	mean	13		30		26		28		27		29		29	
	se	1				1		2		1		1		2	
Length	whole body composite														
mm	1	453		553		518		548		500		550		533	
	2	444				592		579		521		532		521	
	3					537		522		508		541		559	
	4					575		566		518		523		521	
	5									533		573			
	median	449		553		556		557		518		541		527	
	mean	449		553		556		554		516		544		534	
	se	5				17		12		6		9		9	
Weight	whole body composite														
g	1	1078		1854		1414		1684		1301		1732		1921	
	2	1088				1918		1893		1602		1603		1487	
	3					1664		1628		1324		1781		1745	
	4					2029		1674		1619		1566		1546	
	5									28		31			
	median	1083		1854		1666		1789		1451		1667		1704	
	mean	1083		1854		1666		1789		1451		1667		1704	
	se	5				252		105		151		65		217	

Notes: Q = Laboratory qualifier
U = reported value is at or below the limit of detection

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Aluminum															
	Wild	WB	1	4.7	2u	4.4	U	8.8	1u			5.1		5.7	1u
	Wild	WB	2	6.6	1u	4.8	U	6.5	1u						
	Wild	WB	3	5.7	2u	4.8	U								
	Wild	WB	4	4.4	2u	4.8									
	Wild	WB	5	5.5	1u	9.3									
			median	*5.5*		*4.8*		*7.7*				*5.1*		*5.7*	
			mean	*5.4*		*5.6*		*7.7*				*5.1*		*5.7*	
			se	*0.4*		*0.9*		*1.1*							
	Wild	F	1	4.2	U			3.6	U					3.1	U
	Wild	F	2	3.8	U			3.8	U						
	Wild	F	3	3.9	U										
	Wild	F	4	4.1	U										
	Wild	F	5	4	U										
			median	*4.0*				*3.7*						*3.1*	
			mean	*4.0*				*3.7*						*3.1*	
			se	*0.1*				*0.1*							
	Wild	O	1	5.2	U			*14*						8.2	
	Wild	O	2	9.3				8.9							
	Wild	O	3	7.5	U										
	Wild	O	4	4.8	U										
	Wild	O	5	7.2											
			median	*7.2*				*11*						*8.2*	
			mean	*6.8*				*11*						*8.2*	
			se	*0.8*				*2*							
	Hatchery	WB	1					29	1u	4.5		11		6.2	1u
	Hatchery	WB	2					13	1u	18		4.8		6.1	1u
	Hatchery	WB	3					34	1u	8.2		24		5.6	1u
	Hatchery	WB	4							5.4		4.7		5.5	1u
	Hatchery	WB	5							8.9		6.5			
			median					*29*		*8.2*		*6.5*		*5.9*	
			mean					*25*		*9.0*		*10*		*5.9*	
			se					*6.5*		*2.4*		*3.5*		*0.18*	
	Hatchery	F	1					3.8	U					3.7	U
	Hatchery	F	2					3.7	U					3.7	U
	Hatchery	F	3					3.7	U					3.7	U
	Hatchery	F	4											3.7	U
	Hatchery	F	5												
			median					*3.7*						*3.7*	
			mean					*3.7*						*3.7*	
			se					*0.0*						*0.0*	
	Hatchery	O	1					55						9.5	
	Hatchery	O	2					23						8.8	
	Hatchery	O	3					61						7.6	
	Hatchery	O	4											7.5	
	Hatchery	O	5												
			median					*55*						*8.2*	
			mean					*46*						*8.4*	
			se					12						*0.48*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Zinc															
	Wild	WB	1	24		20		22				21.8		28.1	
	Wild	WB	2	30		22		23							
	Wild	WB	3	26		21									
	Wild	WB	4	24		23									
	Wild	WB	5	24		22									
			median	*24*		*22*		*23*				*21.800*		*28.100*	
			mean	*26*		*22*		*23*				*21.800*		*28.100*	
			se	*1*		*0*		*0*							
	Wild	F	1	8.5				6.5						6.33	
	Wild	F	2	7.9				6.3							
	Wild	F	3	8.0											
	Wild	F	4	8.4											
	Wild	F	5	8.6											
			median	*8.4*				*6.4*						*6.330*	
			mean	*8.3*				*6.4*						*6.330*	
			se	*0.1*				*0.1*							
	Wild	O	1	40				37						49.7	
	Wild	O	2	51				37							
	Wild	O	3	45											
	Wild	O	4	41											
	Wild	O	5	41											
			median	*41*				*37*						*49.700*	
			mean	*44*				*37*						*49.700*	
			se	*2*				*0*							
	Hatchery	WB	1					25		21.2		24.5		21.7	
	Hatchery	WB	2					20		24.4		23.5		25.4	
	Hatchery	WB	3					23		24.5		26.2		25.5	
	Hatchery	WB	4							22.2		22.9		24.8	
	Hatchery	WB	5							22.8		22			
			median					*23*		*22.800*		*23.500*		*25.100*	
			mean					*23*		*23.000*		*23.800*		*24.400*	
			se					*1*		*0.637*		*0.721*		*0.897*	
	Hatchery	F	1					7.7						6.52	
	Hatchery	F	2					6.5						7.92	
	Hatchery	F	3					8.0						7.05	
	Hatchery	F	4											6.4	
	Hatchery	F	5												
			median					*7.7*						*6.790*	
			mean					*7.4*						*6.970*	
			se					*0*						*0.346*	
	Hatchery	O	1					41						41.6	
	Hatchery	O	2					36						44.2	
	Hatchery	O	3					37						44.5	
	Hatchery	O	4											45.7	
	Hatchery	O	5												
			median					*37*						*44.400*	
			mean					*38*						*44.000*	
			se					*2*						*0.863*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Vanadium															
	Wild	WB	1	0.12	2u	0.12	U	0.12	1u			0.12	U	0.12	1u
	Wild	WB	2	0.12	1u	0.13	U	0.11	1u						
	Wild	WB	3	0.12	2u	0.13	U								
	Wild	WB	4	0.12	2u	0.12	U								
	Wild	WB	5	0.12	2u	0.11	U								
			median	*0.12*		*0.12*		*0.11*				*0.12*		*0.12*	
			mean	*0.12*		*0.12*		*0.11*				*0.12*		*0.12*	
			se	*0.00*		*0.00*		*0.00*							
	Wild	F	1	0.11	U			0.10	U					0.08	U
	Wild	F	2	0.10	U			0.10	U						
	Wild	F	3	0.10	U										
	Wild	F	4	0.11	U										
	Wild	F	5	0.11	U										
			median	*0.11*				*0.10*						*0.08*	
			mean	*0.11*				*0.10*						*0.08*	
			se	*0.00*				*0.00*							
	Wild	O	1	0.14	U			0.14	0					0.15	0
	Wild	O	2	0.14				0.12	0						
	Wild	O	3	0.13	U										
	Wild	O	4	0.13	U										
	Wild	O	5	0.13	U										
			median	*0.13*				*0.13*						*0.15*	
			mean	*0.13*				*0.13*						*0.15*	
			se	*0.00*				*0.01*							
	Hatchery	WB	1					0.13	1u	0.11	U	0.11	U	0.11	2u
	Hatchery	WB	2					0.10	2u	0.12	U	0.11	U	0.11	2u
	Hatchery	WB	3					0.13	1u	0.11	U	0.11	U	0.11	2u
	Hatchery	WB	4							0.11	U	0.11	U	0.11	2u
	Hatchery	WB	5							0.11	U	0.12	U		
			median					*0.13*		*0.11*		*0.11*		*0.11*	
			mean					*0.12*		*0.11*		*0.11*		*0.11*	
			se					*0.01*		*0.00*		*0.00*		*0.00*	
	Hatchery	F	1					0.10	U					0.10	U
	Hatchery	F	2					0.10	U					0.10	U
	Hatchery	F	3					0.10	U					0.10	U
	Hatchery	F	4											0.10	U
	Hatchery	F	5												
			median					*0.10*						*0.10*	
			mean					*0.10*						*0.10*	
			se					*0.00*						*0.00*	
	Hatchery	O	1					0.16						0.12	U
	Hatchery	O	2					0.11	U					0.12	U
	Hatchery	O	3					0.16						0.11	U
	Hatchery	O	4											0.12	U
	Hatchery	O	5												
			median					*0.16*						*0.12*	
			mean					*0.15*						*0.12*	
			se					*0.02*						*0.00*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Uranium															
	Wild	WB	1	0.0028	1u	0.0015		0.0023	1u			0.0016	U	0.0019	1u
	Wild	WB	2	0.0039	1u	0.0032		0.0020	1u						
	Wild	WB	3	0.0030	1u	0.0018									
	Wild	WB	4	0.0022	1u	0.0035									
	Wild	WB	5	0.0027	1u	0.0042									
			median	*0.0028*		*0.0032*		*0.0022*				*0.0016*		*0.0019*	
			mean	*0.0030*		*0.0028*		*0.0022*				*0.0016*		*0.0019*	
			se	*0.0003*		*0.0005*		*0.0001*							
	Wild	F	1	0.0014	U			0.0012	U					0.0011	U
	Wild	F	2	0.0013	U			0.0013	U						
	Wild	F	3	0.0013	U										
	Wild	F	4	0.0014	U										
	Wild	F	5	0.0013	U										
			median	*0.0013*				*0.0012*						*0.0011*	
			mean	*0.0013*				*0.0012*						*0.0011*	
			se	*0.0000*				*0.0000*							
	Wild	O	1	0.0044				0.0033						0.0027	
	Wild	O	2	0.0064				0.0027							
	Wild	O	3	0.0049											
	Wild	O	4	0.0032											
	Wild	O	5	0.0042											
			median	*0.0044*				*0.0030*						*0.0027*	
			mean	*0.0046*				*0.0030*						*0.0027*	
			se	*0.0005*				*0.0003*							
	Hatchery	WB	1					0.0084	1u	0.0014	U	0.0014		0.0016	1u
	Hatchery	WB	2					0.0027	1u	0.0014	U	0.0014	U	0.0018	2u
	Hatchery	WB	3					0.0087	1u	0.0014	U	0.0020		0.0013	2u
	Hatchery	WB	4							0.0014	U	0.0014	U	0.0014	2u
	Hatchery	WB	5							0.0014	U	0.0016	U		
			median					*0.0084*		*0.0014*		*0.0014*		*0.0015*	
			mean					*0.0066*		*0.0014*		*0.0016*		*0.0015*	
			se					*0.0019*		*0.0000*		*0.0001*		*0.0001*	
	Hatchery	F	1					0.0013	U					0.0012	U
	Hatchery	F	2					0.0012	U					0.0012	U
	Hatchery	F	3					0.0012	U					0.0012	U
	Hatchery	F	4											0.0012	U
	Hatchery	F	5												
			median					*0.0012*						*0.0012*	
			mean					*0.0012*						*0.0012*	
			se					*0.0000*						*0.0000*	
	Hatchery	O	1					0.0155						0.0021	
	Hatchery	O	2					0.0044						0.0025	U
	Hatchery	O	3					0.0152						0.0014	U
	Hatchery	O	4											0.0015	U
	Hatchery	O	5												
			median					*0.0152*						*0.0018*	
			mean					*0.0117*						*0.0019*	
			se					*0.0036*						*0.0003*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Sodium															
	Wild	WB	1	807		811		877				808		1040	
	Wild	WB	2	920		819		921							
	Wild	WB	3	831		781									
	Wild	WB	4	840		786									
	Wild	WB	5	787		858									
			median	*831.000*		*811.000*		*899.000*				*808.000*		*1040.000*	
			mean	*837.000*		*811.000*		*899.000*				*808.000*		*1040.000*	
			se	*22.731*		*13.780*		*22.000*							
	Wild	F	1	382				407						497	
	Wild	F	2	434				431							
	Wild	F	3	390											
	Wild	F	4	424											
	Wild	F	5	397											
			median	*397.000*				*419.000*						*497.000*	
			mean	*405.000*				*419.000*						*497.000*	
			se	*10.048*				*12.000*							
	Wild	O	1	1260				1320						1570	
	Wild	O	2	1380				1330							
	Wild	O	3	1300											
	Wild	O	4	1280											
	Wild	O	5	1210											
			median	*1280.000*				*1330.000*						*1570.000*	
			mean	*1290.000*				*1330.000*						*1570.000*	
			se	*27.857*				*5.000*							
	Hatchery	WB	1					898		811		976		857	
	Hatchery	WB	2					763		841		868		1040	
	Hatchery	WB	3					879		837		924		934	
	Hatchery	WB	4							906		868		876	
	Hatchery	WB	5							917		844			
			median					*879.000*		*841.000*		*868.000*		*905.000*	
			mean					*847.000*		*862.000*		*896.000*		*927.000*	
			se					*42.191*		*20.769*		*23.933*		*41.149*	
	Hatchery	F	1					414						409	
	Hatchery	F	2					350						486	
	Hatchery	F	3					373						454	
	Hatchery	F	4											412	
	Hatchery	F	5												
			median					*373.000*						*433.000*	
			mean					*379.000*						*440.000*	
			se					*18.717*						*18.386*	
	Hatchery	O	1					1380	0					1440	
	Hatchery	O	2					1230	0					1630	
	Hatchery	O	3					1320						1430	
	Hatchery	O	4											1400	
	Hatchery	O	5												
			median					*1320.000*						*1440.000*	
			mean					*1310.000*						*1480.000*	
			se					*43.589*						*52.361*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Selenium															
	Wild	WB	1	0.82		0.62		0.71				0.53		0.54	
	Wild	WB	2	0.76		0.58		0.68							
	Wild	WB	3	0.75		0.64									
	Wild	WB	4	0.69		0.64									
	Wild	WB	5	0.75		0.60									
			median	*0.75*		*0.62*		*0.69*				*0.53*		*0.54*	
			mean	*0.75*		*0.61*		*0.69*				*0.53*		*0.54*	
			se	*0.02*		*0.01*		*0.02*							
	Wild	F	1	0.61				0.46						0.38	
	Wild	F	2	0.43				0.40							
	Wild	F	3	0.45											
	Wild	F	4	0.49											
	Wild	F	5	0.49											
			median	*0.49*				*0.43*						*0.38*	
			mean	*0.49*				*0.43*						*0.38*	
			se	*0.03*				*0.03*							
	Wild	O	1	1.0				0.95						0.70	
	Wild	O	2	1.1				0.91							
	Wild	O	3	1.1											
	Wild	O	4	0.91											
	Wild	O	5	1.0											
			median	*1.0*				*0.93*						*0.70*	
			mean	*1.0*				*0.93*						*0.70*	
			se	*0.03*				*0.02*							
	Hatchery	WB	1					0.56		0.41		0.40		0.32	
	Hatchery	WB	2					0.46		0.46		0.31		0.28	
	Hatchery	WB	3					0.50		0.50		0.39		0.31	
	Hatchery	WB	4							0.41		0.44		0.27	
	Hatchery	WB	5							0.54		0.37			
			median					*0.50*		*0.46*		*0.39*		*0.29*	
			mean					*0.51*		*0.46*		*0.38*		*0.29*	
			se					*0.03*		*0.03*		*0.02*		*0.01*	
	Hatchery	F	1					0.43						0.29	
	Hatchery	F	2					0.34						0.22	
	Hatchery	F	3					0.32						0.24	
	Hatchery	F	4											0.22	
	Hatchery	F	5												
			median					*0.34*						*0.23*	
			mean					*0.36*						*0.24*	
			se					*0.03*						*0.02*	
	Hatchery	O	1					0.68						0.36	
	Hatchery	O	2					0.60						0.36	
	Hatchery	O	3					0.66						0.37	
	Hatchery	O	4											0.33	
	Hatchery	O	5												
			median					*0.66*						*0.36*	
			mean					*0.65*						*0.35*	
			se					*0.02*						*0.01*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Potassium															
	Wild	WB	1	3410		3540		3730				3410	0	3540	
	Wild	WB	2	3320		3360		3570							
	Wild	WB	3	3420		3350									
	Wild	WB	4	3380		3390									
	Wild	WB	5	3290		3460									
			median	*3380*		*3390*		*3650*				*3410*		*3540*	
			mean	*3360*		*3420*		*3650*				*3410*		*3540*	
			se	*25*		*36*		*80*							
	Wild	F	1	4100				4570						4530	
	Wild	F	2	4170				4440							
	Wild	F	3	4300											
	Wild	F	4	4270											
	Wild	F	5	4160											
			median	*4170*				*4510*						*4530*	
			mean	*4200*				*4510*						*4530*	
			se	*37*				*65*							
	Wild	O	1	2680				2940						2560	
	Wild	O	2	2530				2840							
	Wild	O	3	2500											
	Wild	O	4	2450											
	Wild	O	5	2360											
			median	*2500*				*2890*						*2560*	
			mean	*2500*				*2890*						*2560*	
			se	*53*				*50*							
	Hatchery	WB	1					3830		3550		3780		3500	
	Hatchery	WB	2					3620		3820		3610		3480	
	Hatchery	WB	3					3690		3470		3660		3570	
	Hatchery	WB	4							3810		3740		3450	
	Hatchery	WB	5							3530		3530			
			median					*3690*		*3550*		*3660*		*3490*	
			mean					*3710*		*3640*		*3660*		*3500*	
			se					*62*		*74*		*45*		*25*	
	Hatchery	F	1					4870						4260	
	Hatchery	F	2					4330						4350	
	Hatchery	F	3					4590						4400	
	Hatchery	F	4											4300	
	Hatchery	F	5												
			median					*4590*						*4330*	
			mean					*4600*						*4330*	
			se					*156*						*30*	
	Hatchery	O	1					2780						2500	
	Hatchery	O	2					2820						2560	
	Hatchery	O	3					2900						2730	
	Hatchery	O	4											2490	
	Hatchery	O	5												
			median					*2820*						*2530*	
			mean					*2830*						*2570*	
			se					*35*						*56*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Nickel															
	Wild	WB	1	0.21	1u	0.16		0.19				0.14		0.24	
	Wild	WB	2	0.28		0.21		0.21	1u						
	Wild	WB	3	0.23	1u	0.17									
	Wild	WB	4	0.17	1u	0.21									
	Wild	WB	5	0.20	1u	0.37									
			median	*0.21*		*0.21*		*0.20*				*0.14*		*0.24*	
			mean	*0.22*		*0.22*		*0.20*				*0.14*		*0.24*	
			se	*0.02*		*0.04*		*0.01*							
	Wild	F	1	0.042	U			0.039						0.033	
	Wild	F	2	0.053				0.038	U						
	Wild	F	3	0.039	U										
	Wild	F	4	0.041	U										
	Wild	F	5	0.040	U										
			median	*0.041*				*0.038*						*0.033*	
			mean	*0.043*				*0.038*						*0.033*	
			se	*0.003*				*0.000*							
	Wild	O	1	0.38				0.34						0.44	
	Wild	O	2	0.49				0.35							
	Wild	O	3	0.43											
	Wild	O	4	0.31											
	Wild	O	5	0.37											
			median	*0.38*				*0.34*						*0.44*	
			mean	*0.40*				*0.34*						*0.44*	
			se	*0.03*				*0.00*							
	Hatchery	WB	1					0.37		0.15		0.18		0.16	1u
	Hatchery	WB	2					0.22		0.18		0.21		0.21	1u
	Hatchery	WB	3					0.39	1u	0.14		0.24		0.16	1u
	Hatchery	WB	4							0.12		0.15		0.19	1u
	Hatchery	WB	5							0.19		0.15			
			median					*0.37*		*0.15*		*0.18*		*0.17*	
			mean					*0.33*		*0.16*		*0.19*		*0.18*	
			se					*0.05*		*0.01*		*0.02*		*0.01*	
	Hatchery	F	1					0.13						0.037	U
	Hatchery	F	2					0.06						0.041	U
	Hatchery	F	3					0.04	U					0.037	U
	Hatchery	F	4											0.037	U
	Hatchery	F	5												
			median					*0.06*						*0.037*	
			mean					*0.08*						*0.038*	
			se					*0.03*						*0.001*	
	Hatchery	O	1					0.60						0.33	
	Hatchery	O	2					0.41						0.38	
	Hatchery	O	3					0.70						0.29	
	Hatchery	O	4											0.35	
	Hatchery	O	5												
			median					*0.60*						*0.34*	
			mean					*0.57*						*0.34*	
			se					*0.08*						*0.02*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Manganese															
	Wild	WB	1	1.4		1.2		1.3				1.3		2.4	
	Wild	WB	2	1.4		1.7		1.1							
	Wild	WB	3	1.7		1.2									
	Wild	WB	4	1.0		2.1									
	Wild	WB	5	1.2		2.2									
			median	*1.4*		*1.7*		*1.2*				*1.3*		*2.4*	
			mean	*1.3*		*1.7*		*1.2*				*1.3*		*2.4*	
			se	*0.1*		*0.2*		*0.1*							
	Wild	F	1	0.14				0.14						0.17	
	Wild	F	2	0.13				0.12							
	Wild	F	3	0.12											
	Wild	F	4	0.15											
	Wild	F	5	0.13											
			median	*0.13*				*0.13*						*0.17*	
			mean	*0.13*				*0.13*						*0.17*	
			se	*0.00*				*0.01*							
	Wild	O	1	2.6				2.3						4.5	
	Wild	O	2	2.6				1.9							
	Wild	O	3	3.3											
	Wild	O	4	1.8											
	Wild	O	5	2.3											
			median	*2.6*				*2.1*						*4.5*	
			mean	*2.5*				*2.1*						*4.5*	
			se	*0.2*				*0.2*							
	Hatchery	WB	1					2.4		1.0		1.8		1.2	
	Hatchery	WB	2					1.4		1.6		1.3		1.4	
	Hatchery	WB	3					2.9		1.0		1.8		1.1	
	Hatchery	WB	4							0.9		1.5		1.4	
	Hatchery	WB	5							1.1		1.6			
			median					*2.4*		*1.0*		*1.6*		*1.3*	
			mean					*2.2*		*1.1*		*1.6*		*1.3*	
			se					*0.5*		*0.1*		*0.1*		*0.1*	
	Hatchery	F	1					0.16						0.14	
	Hatchery	F	2					0.11						0.14	
	Hatchery	F	3					0.18						0.13	
	Hatchery	F	4											0.19	
	Hatchery	F	5												
			median					*0.16*						*0.14*	
			mean					*0.15*						*0.15*	
			se					*0.02*						*0.01*	
	Hatchery	O	1					4.7						2.7	
	Hatchery	O	2					2.8						2.7	
	Hatchery	O	3					5.3						2.1	
	Hatchery	O	4											2.9	
	Hatchery	O	5												
			median					*4.7*						*2.7*	
			mean					*4.3*						*2.6*	
			se					*0.8*						*0.2*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Magnesium															
	Wild	WB	1	303		289		303	1J			304	J	336	2J
	Wild	WB	2	296		309		308	1J						
	Wild	WB	3	312		296									
	Wild	WB	4	287		293									
	Wild	WB	5	270		310									
			median	*296*		*296*		*306*				*304*		*336*	
			mean	*294*		*299*		*306*				*304*		*336*	
			se	*7*		*4*		*3*							
	Wild	F	1	265				283	J					273	J
	Wild	F	2	262				267	J						
	Wild	F	3	272											
	Wild	F	4	275											
	Wild	F	5	258											
			median	*265*				*275*						*273*	
			mean	*266*				*275*						*273*	
			se	*3*				*8*							
	Wild	O	1	343				323	J					397	J
	Wild	O	2	328				342	J						
	Wild	O	3	353											
	Wild	O	4	299											
	Wild	O	5	283											
			median	*328*				*333*						*397*	
			mean	*321*				*333*						*397*	
			se	*13*				*10*							
	Hatchery	WB	1					355		303		307		287	
	Hatchery	WB	2					305		324		319		304	
	Hatchery	WB	3					332		302		303		290	
	Hatchery	WB	4							286		292		306	
	Hatchery	WB	5							307		291			
			median					*332*		*303*		*303*		*297*	
			mean					*331*		*304*		*302*		*297*	
			se					*14*		*6*		*5*		*5*	
	Hatchery	F	1					306						257	
	Hatchery	F	2					272						259	
	Hatchery	F	3					283						265	
	Hatchery	F	4											262	
	Hatchery	F	5												
			median					*283*						*261*	
			mean					*287*						*261*	
			se					*10*						*2*	
	Hatchery	O	1					404						326	
	Hatchery	O	2					343						353	
	Hatchery	O	3					375						316	
	Hatchery	O	4											357	
	Hatchery	O	5												
			median					*375*						*340*	
			mean					*374*						*338*	
			se					*18*						*10*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Lead															
	Wild	WB	1	0.12		0.06		0.032	1u			0.015	U	0.025	1u
	Wild	WB	2	0.16		0.12		0.034	1u						
	Wild	WB	3	0.18	1u	0.08									
	Wild	WB	4	0.11		0.11									
	Wild	WB	5	0.13		0.11									
			median	*0.13*		*0.11*		*0.033*				*0.015*		*0.025*	
			mean	*0.14*		*0.10*		*0.033*				*0.015*		*0.025*	
			se	*0.01*		*0.01*		*0.001*							
	Wild	F	1	0.018				0.012	U					0.011	U
	Wild	F	2	0.016				0.013	U						
	Wild	F	3	0.013	U										
	Wild	F	4	0.018											
	Wild	F	5	0.016											
			median	*0.016*				*0.012*						*0.011*	
			mean	*0.016*				*0.012*						*0.011*	
			se	*0.00*				*0.000*							
	Wild	O	1	0.22				0.051						0.039	
	Wild	O	2	0.30				0.052							
	Wild	O	3	0.37											
	Wild	O	4	0.20											
	Wild	O	5	0.26											
			median	*0.26*				*0.052*						*0.039*	
			mean	*0.27*				*0.052*						*0.039*	
			se	*0.03*				*0.001*							
	Hatchery	WB	1					0.21	1u	0.014	U	0.014	U	0.014	1u
	Hatchery	WB	2					0.07	1u	0.017		0.014	U	0.020	1u
	Hatchery	WB	3					0.21	1u	0.015		0.022		0.014	1u
	Hatchery	WB	4							0.014		0.014	U	0.016	1u
	Hatchery	WB	5							0.014	U	0.015	U		
			median					*0.21*		*0.014*		*0.014*		*0.015*	
			mean					*0.16*		*0.015*		*0.016*		*0.016*	
			se					*0.05*		*0.001*		*0.002*		*0.002*	
	Hatchery	F	1					0.013	U					0.012	U
	Hatchery	F	2					0.012	U					0.012	U
	Hatchery	F	3					0.012	U					0.012	U
	Hatchery	F	4											0.012	U
	Hatchery	F	5												
			median					*0.012*						*0.012*	
			mean					*0.012*						*0.012*	
			se					*0.000*						*0.000*	
	Hatchery	O	1					0.41						0.016	
	Hatchery	O	2					0.13						0.029	
	Hatchery	O	3					0.38						0.015	
	Hatchery	O	4											0.021	
	Hatchery	O	5												
			median					*0.38*						*0.018*	
			mean					*0.31*						*0.020*	
			se					*0.09*						*0.003*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Iron															
	Wild	WB	1	20		19		25				17		22	
	Wild	WB	2	29		19		20							
	Wild	WB	3	38		18									
	Wild	WB	4	21		24									
	Wild	WB	5	30		30									
			median	*29*		*19*		*22*				*17*		*22*	
			mean	*28*		*22*		*22*				*17*		*22*	
			se	*3*		*2*		*3*							
	Wild	F	1	4.1				3.8						5.2	
	Wild	F	2	6.3				4.1							
	Wild	F	3	5.2											
	Wild	F	4	5.5											
	Wild	F	5	4.9											
			median	*5.2*				*3.9*						*5.2*	
			mean	*5.2*				*3.9*						*5.2*	
			se	*0.4*				*0.1*							
	Wild	O	1	37				46						38	
	Wild	O	2	51				33							
	Wild	O	3	72											
	Wild	O	4	37											
	Wild	O	5	58											
			median	*51*				*39*						*38*	
			mean	*51*				*39*						*38*	
			se	*7*				*7*							
	Hatchery	WB	1					43		15		19		15	
	Hatchery	WB	2					21		28		15		18	
	Hatchery	WB	3					45		18		34		17	
	Hatchery	WB	4							15		16		15	
	Hatchery	WB	5							16		17			
			median					*43*		*16*		*17*		*16*	
			mean					*37*		*18*		*20*		*16*	
			se					*8*		*2*		*3*		*1*	
	Hatchery	F	1					5.0						3.3	
	Hatchery	F	2					3.4						4.5	
	Hatchery	F	3					4.0						3.9	
	Hatchery	F	4											3.6	
	Hatchery	F	5												
			median					*4.0*						*3.8*	
			mean					*4.1*						*3.8*	
			se					*0.5*						*0.3*	
	Hatchery	O	1					81						30	
	Hatchery	O	2					42						33	
	Hatchery	O	3					81						31	
	Hatchery	O	4											27	
	Hatchery	O	5												
			median					*81*						*30*	
			mean					*68*						*30*	
			se					*13*						*1*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Copper															
	Wild	WB	1	1.2		1.3		1.3				0.56		0.42	
	Wild	WB	2	1.9		1.3		1.0							
	Wild	WB	3	1.4		1.5									
	Wild	WB	4	1.1		1.8									
	Wild	WB	5	1.3		1.9									
			median	*1.3*		*1.5*		*1.2*				*0.56*		*0.42*	
			mean	*1.4*		*1.6*		*1.2*				*0.56*		*0.42*	
			se	*0.2*		*0.1*		*0.1*							
	Wild	F	1	0.36				0.34						0.27	
	Wild	F	2	0.33				0.33							
	Wild	F	3	0.34											
	Wild	F	4	0.35											
	Wild	F	5	0.32											
			median	*0.34*				*0.33*						*0.27*	
			mean	*0.34*				*0.33*						*0.27*	
			se	*0.01*				*0.01*							
	Wild	O	1	2.0				2.2						0.58	
	Wild	O	2	3.5				1.6							
	Wild	O	3	2.5											
	Wild	O	4	1.8											
	Wild	O	5	2.3											
			median	*2.3*				*1.9*						*0.58*	
			mean	*2.4*				*1.9*						*0.58*	
			se	*0.3*				*0.3*							
	Hatchery	WB	1					2.5		0.61		0.56		0.41	
	Hatchery	WB	2					1.6		0.90		0.45		0.39	
	Hatchery	WB	3					2.6		0.71		0.86		0.42	
	Hatchery	WB	4							0.54		0.55		0.42	
	Hatchery	WB	5							0.56		0.58			
			median					*2.5*		*0.61*		*0.56*		*0.42*	
			mean					*2.2*		*0.66*		*0.60*		*0.41*	
			se					*0.3*		*0.06*		*0.07*		*0.01*	
	Hatchery	F	1					0.40						0.27	
	Hatchery	F	2					0.32						0.27	
	Hatchery	F	3					0.32						0.27	
	Hatchery	F	4											0.27	
	Hatchery	F	5												
			median					*0.32*						*0.27*	
			mean					*0.35*						*0.27*	
			se					*0.03*						*0.00*	
	Hatchery	O	1					4.61						0.60	
	Hatchery	O	2					2.99						0.52	
	Hatchery	O	3					4.55						0.57	
	Hatchery	O	4											0.59	
	Hatchery	O	5												
			median					*4.55*						*0.58*	
			mean					*4.05*						*0.57*	
			se					*0.53*						*0.02*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Cobalt															
	Wild	WB	1	0.026	1u	0.015	U	0.019	1u			0.018		0.025	
	Wild	WB	2	0.032	1u	0.016	U	0.018	1u						
	Wild	WB	3	0.030	1u	0.011	U								
	Wild	WB	4	0.018	1u	0.017	U								
	Wild	WB	5	0.023	1u	0.022									
			median	*0.026*		*0.016*		*0.018*				*0.018*		*0.025*	
			mean	*0.026*		*0.016*		*0.018*				*0.018*		*0.025*	
			se	*0.002*		*0.002*		*0.001*							
	Wild	F	1	0.008	U			0.004	U					0.005	
	Wild	F	2	0.010	U			0.004	U						
	Wild	F	3	0.007	U										
	Wild	F	4	0.007	U										
	Wild	F	5	0.008	U										
			median	*0.008*				*0.004*						*0.005*	
			mean	*0.008*				*0.004*						*0.005*	
			se	*0.001*				*0.000*							
	Wild	O	1	0.045				0.034						0.044	
	Wild	O	2	0.052				0.029							
	Wild	O	3	0.053											
	Wild	O	4	0.030											
	Wild	O	5	0.040											
			median	*0.045*				*0.032*						*0.044*	
			mean	*0.044*				*0.032*						*0.044*	
			se	*0.004*				*0.003*							
	Hatchery	WB	1					0.034		0.017		0.025		0.022	
	Hatchery	WB	2					0.021		0.022		0.018		0.021	
	Hatchery	WB	3					0.034		0.018		0.033		0.018	
	Hatchery	WB	4							0.014		0.021		0.025	
	Hatchery	WB	5							0.017		0.021			
			median					*0.034*		*0.017*		*0.021*		*0.021*	
			mean					*0.030*		*0.018*		*0.023*		*0.022*	
			se					*0.004*		*0.001*		*0.003*		*0.001*	
	Hatchery	F	1					0.009						0.006	
	Hatchery	F	2					0.006						0.006	
	Hatchery	F	3					0.006						0.006	
	Hatchery	F	4											0.008	
	Hatchery	F	5												
			median					*0.006*						*0.006*	
			mean					*0.007*						*0.007*	
			se					*0.001*						*0.001*	
	Hatchery	O	1					0.060						0.042	
	Hatchery	O	2					0.038						0.037	
	Hatchery	O	3					0.058						0.031	
	Hatchery	O	4											0.044	
	Hatchery	O	5												
			median					*0.058*						*0.039*	
			mean					*0.052*						*0.039*	
			se					*0.007*						*0.003*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Chromium															
	Wild	WB	1	0.81		0.62		0.68				0.69		0.48	
	Wild	WB	2	0.81		0.58		0.62							
	Wild	WB	3	0.86		0.81									
	Wild	WB	4	0.73		0.73									
	Wild	WB	5	0.98		0.91									
			median	*0.81*		*0.73*		*0.65*				*0.69*		*0.48*	
			mean	*0.84*		*0.73*		*0.65*				*0.69*		*0.48*	
			se	*0.04*		*0.06*		*0.03*							
	Wild	F	1	0.53				0.41						0.44	
	Wild	F	2	0.51				0.40							
	Wild	F	3	0.58											
	Wild	F	4	0.54											
	Wild	F	5	0.72											
			median	*0.54*				*0.41*						*0.44*	
			mean	*0.57*				*0.41*						*0.44*	
			se	*0.04*				*0.00*							
	Wild	O	1	1.1				0.92						0.52	0
	Wild	O	2	1.1				0.80							
	Wild	O	3	1.2											
	Wild	O	4	0.9											
	Wild	O	5	1.3											
			median	*1.1*				*0.86*						*0.52*	
			mean	*1.1*				*0.86*						*0.52*	
			se	*0.05*				*0.06*							
	Hatchery	WB	1					0.77		0.50		0.40		0.38	
	Hatchery	WB	2					0.42		0.52		0.53		0.36	
	Hatchery	WB	3					0.72		0.53		0.63		0.35	
	Hatchery	WB	4							0.41		0.55		0.31	
	Hatchery	WB	5							0.51		0.57			
			median					*0.72*		*0.51*		*0.55*		*0.35*	
			mean					*0.64*		*0.49*		*0.54*		*0.35*	
			se					*0.11*		*0.02*		*0.04*		*0.01*	
	Hatchery	F	1					0.53						0.37	
	Hatchery	F	2					0.27						0.33	
	Hatchery	F	3					0.27						0.37	
	Hatchery	F	4											0.30	
	Hatchery	F	5												
			median					*0.27*						*0.35*	
			mean					*0.35*						*0.34*	
			se					*0.09*						*0.02*	
	Hatchery	O	1					1.0						0.39	
	Hatchery	O	2					0.6						0.38	
	Hatchery	O	3					1.1						0.34	
	Hatchery	O	4											0.33	
	Hatchery	O	5												
			median					*1.0*						*0.36*	
			mean					*0.9*						*0.36*	
			se					*0.16*						*0.02*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Calcium															
	Wild	WB	1	5310	2j	3810	J	4620				4190		6970	
	Wild	WB	2	6200	2j	5600	J	5540							
	Wild	WB	3	5910	2j	4340	J								
	Wild	WB	4	4630	2j	5050	J								
	Wild	WB	5	4630	2j	8610	J								
			median	*5310*		*5050*		*5080*				*4190*		*6970*	
			mean	*5340*		*5480*		*5080*				*4190*		*6970*	
			se	*322*		*839*		*460*							
	Wild	F	1	296	J			341						249	
	Wild	F	2	340	J			196							
	Wild	F	3	272	J										
	Wild	F	4	370	J										
	Wild	F	5	380	J										
			median	*340*				*269*						*249*	
			mean	*332*				*269*						*249*	
			se	*21*				*73*							
	Wild	O	1	10700	J			8630						13600	
	Wild	O	2	11800	J			10000							
	Wild	O	3	11800	J										
	Wild	O	4	9120	J										
	Wild	O	5	9220	J										
			median	*10700*				*9320*						*13600*	
			mean	*10500*				*9320*						*13600*	
			se	*590*				*685*							
	Hatchery	WB	1					7520	1j	3930	J	5250		4490	
	Hatchery	WB	2					4800	1j	4330	J	5850		5460	
	Hatchery	WB	3					6770	1j	3610	J	4950		4410	
	Hatchery	WB	4							3430		4010		5510	
	Hatchery	WB	5							5580		4340			
			median					*6770*		*3930*		*4950*		*4980*	
			mean					*6360*		*4180*		*4880*		*4970*	
			se					*811*		*383*		*326*		*299*	
	Hatchery	F	1					341	J					243	
	Hatchery	F	2					250	J					299	
	Hatchery	F	3					442	J					311	
	Hatchery	F	4											311	
	Hatchery	F	5												
			median					*341*						*305*	
			mean					*344*						*291*	
			se					*55*						*16*	
	Hatchery	O	1					14700	J					10000	
	Hatchery	O	2					9970	J					11000	
	Hatchery	O	3					12300	J					8610	
	Hatchery	O	4											11400	
	Hatchery	O	5												
			median					*12300*						*10500*	
			mean					*12300*						*10300*	
			se					*1365*						*622*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Cadmium															
	Wild	WB	1	0.023	1u	0.033		0.053	1u			0.066	0	0.048	1u
	Wild	WB	2	0.054	1u	0.035		0.045	1u						
	Wild	WB	3	0.024	1u	0.039									
	Wild	WB	4	0.020	1u	0.035									
	Wild	WB	5	0.022	1u	0.048									
			median	*0.023*		*0.035*		*0.049*				*0.066*		*0.048*	
			mean	*0.029*		*0.038*		*0.049*				*0.066*		*0.048*	
			se	*0.006*		*0.003*		*0.004*							
	Wild	F	1	0.014	U			0.012	U					0.011	U
	Wild	F	2	0.064	U			0.013	U						
	Wild	F	3	0.013	U										
	Wild	F	4	0.014	U										
	Wild	F	5	0.013	U										
			median	*0.014*				*0.012*						*0.011*	
			mean	*0.023*				*0.012*						*0.011*	
			se	*0.010*				*0.000*							
	Wild	O	1	0.034				0.091						0.086	
	Wild	O	2	0.046				0.073							
	Wild	O	3	0.035											
	Wild	O	4	0.028											
	Wild	O	5	0.032											
			median	*0.034*				*0.082*						*0.086*	
			mean	*0.035*				*0.082*						*0.086*	
			se	*0.003*				*0.009*							
	Hatchery	WB	1					0.068	1u	0.061		0.051		0.052	1u
	Hatchery	WB	2					0.063	1u	0.055		0.022		0.057	1u
	Hatchery	WB	3					0.060	1u	0.059		0.047		0.039	1u
	Hatchery	WB	4							0.038		0.041		0.043	1u
	Hatchery	WB	5							0.040		0.036			
			median					*0.063*		*0.055*		*0.041*		*0.047*	
			mean					*0.063*		*0.050*		*0.039*		*0.048*	
			se					*0.002*		*0.005*		*0.005*		*0.004*	
	Hatchery	F	1					0.013	U					0.012	U
	Hatchery	F	2					0.012	U					0.012	U
	Hatchery	F	3					0.012	U					0.012	U
	Hatchery	F	4											0.012	U
	Hatchery	F	5												
			median					*0.012*						*0.012*	
			mean					*0.012*						*0.012*	
			se					*0.000*						*0.000*	
	Hatchery	O	1					0.123						0.105	
	Hatchery	O	2					0.121						0.105	
	Hatchery	O	3					0.101						0.066	
	Hatchery	O	4											0.077	
	Hatchery	O	5												
			median					*0.121*						*0.091*	
			mean					*0.115*						*0.088*	
			se					*0.007*						*0.010*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Barium															
	Wild	WB	1	0.73	1u	0.61		0.57	1u			0.38	0	0.76	1u
	Wild	WB	2	0.97	1u	0.69		0.47	1u						
	Wild	WB	3	1.01	1u	0.50									
	Wild	WB	4	0.59	1u	1.20									
	Wild	WB	5	0.70	1u	1.74									
			median	*0.73*		*0.69*		*0.52*				*0.38*		*0.76*	
			mean	*0.80*		*0.95*		*0.52*				*0.38*		*0.76*	
			se	*0.08*		*0.23*		*0.05*							
	Wild	F	1	0.14	U			0.12	U					0.11	U
	Wild	F	2	0.13	U			0.13	U						
	Wild	F	3	0.13	U										
	Wild	F	4	0.14	U										
	Wild	F	5	0.13	U										
			median	*0.13*				*0.12*						*0.11*	
			mean	*0.13*				*0.12*						*0.11*	
			se	*0.00*				*0.00*							
	Wild	O	1	1.37	0			0.99						1.42	
	Wild	O	2	1.78	0			0.76							
	Wild	O	3	1.94	0										
	Wild	O	4	1.07	0										
	Wild	O	5	1.32	0										
			median	*1.37*				*0.87*						*1.42*	
			mean	*1.50*				*0.87*						*1.42*	
			se	*0.16*				*0.11*							
	Hatchery	WB	1					1.6	1u	0.35		0.69		0.46	1u
	Hatchery	WB	2					0.6	1u	0.62		0.40		0.52	1u
	Hatchery	WB	3					1.6	1u	0.34		0.88		0.41	1u
	Hatchery	WB	4							0.28		0.36		0.42	1u
	Hatchery	WB	5							0.47		0.43			
			median					*1.6*		*0.35*		*0.43*		*0.44*	
			mean					*1.3*		*0.41*		*0.55*		*0.45*	
			se					*0.3*		*0.06*		*0.10*		*0.02*	
	Hatchery	F	1					0.13	U					0.12	U
	Hatchery	F	2					0.12	U					0.12	U
	Hatchery	F	3					0.12	U					0.12	U
	Hatchery	F	4											0.12	U
	Hatchery	F	5												
			median					*0.12*						*0.12*	
			mean					*0.12*						*0.12*	
			se					*0.00*						*0.00*	
	Hatchery	O	1					3.0	0					0.91	0
	Hatchery	O	2					1.2	0					0.95	0
	Hatchery	O	3					2.9						0.70	0
	Hatchery	O	4											0.76	0
	Hatchery	O	5												
			median					*2.9*						*0.83*	
			mean					*2.4*						*0.83*	
			se					*0.6*						*0.06*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Arsenic															
	Wild	WB	1	0.15		0.10		0.16				0.18		0.14	
	Wild	WB	2	0.14		0.11		0.15							
	Wild	WB	3	0.14		0.13									
	Wild	WB	4	0.13		0.11									
	Wild	WB	5	0.15		0.16									
			median	*0.14*		*0.11*		*0.15*				*0.18*		*0.14*	
			mean	*0.14*		*0.12*		*0.15*				*0.18*		*0.14*	
			se	*0.01*		*0.01*		*0.00*							
	Wild	F	1	0.10				0.08						0.08	
	Wild	F	2	0.07				0.07							
	Wild	F	3	0.07											
	Wild	F	4	0.10											
	Wild	F	5	0.10											
			median	*0.10*				*0.07*						*0.08*	
			mean	*0.09*				*0.07*						*0.08*	
			se	*0.01*				*0.01*							
	Wild	O	1	0.22				0.23						0.20	
	Wild	O	2	0.21				0.22							
	Wild	O	3	0.20											
	Wild	O	4	0.16											
	Wild	O	5	0.21											
			median	*0.21*				*0.22*						*0.20*	
			mean	*0.20*				*0.22*						*0.20*	
			se	*0.01*				*0.01*							
	Hatchery	WB	1					0.10	1u	0.09		0.14		0.12	0
	Hatchery	WB	2					0.09	1u	0.09		0.11		0.09	1u
	Hatchery	WB	3					0.11	1u	0.13		0.14		0.08	1u
	Hatchery	WB	4							0.09		0.14		0.10	1u
	Hatchery	WB	5							0.13		0.16			
			median					*0.10*		*0.09*		*0.14*		*0.10*	
			mean					*0.10*		*0.10*		*0.14*		*0.10*	
			se					*0.00*		*0.01*		*0.01*		*0.01*	
	Hatchery	F	1					0.063	U					0.081	0
	Hatchery	F	2					0.061	U					0.061	U
	Hatchery	F	3					0.061	U					0.061	U
	Hatchery	F	4											0.062	U
	Hatchery	F	5												
			median					*0.061*						*0.061*	
			mean					*0.062*						*0.066*	
			se					*0.001*						*0.005*	
	Hatchery	O	1					0.15						0.16	
	Hatchery	O	2					0.13						0.13	
	Hatchery	O	3					0.15						0.11	
	Hatchery	O	4											0.15	
	Hatchery	O	5												
			median					*0.15*						*0.14*	
			mean					*0.14*						*0.14*	
			se					*0.00*						*0.01*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Mercury															
	Wild	WB	1	0.057		0.051		0.056				0.070		0.098	
	Wild	WB	2	0.086		0.041		0.070							
	Wild	WB	3	0.066		0.038									
	Wild	WB	4	0.073		0.048									
	Wild	WB	5	0.073		0.036									
			median	*0.073*		*0.041*		*0.063*				*0.070*		*0.098*	
			mean	*0.071*		*0.043*		*0.063*				*0.070*		*0.098*	
			se	*0.005*		*0.003*		*0.007*							
	Wild	F	1	0.065				0.068						0.120	
	Wild	F	2	0.108				0.084							
	Wild	F	3	0.080											
	Wild	F	4	0.087											
	Wild	F	5	0.089											
			median	*0.087*				*0.076*						*0.120*	
			mean	*0.086*				*0.076*						*0.120*	
			se	*0.007*				*0.008*							
	Wild	O	1	0.048				0.044						0.076	
	Wild	O	2	0.064				0.058							
	Wild	O	3	0.050											
	Wild	O	4	0.058											
	Wild	O	5	0.055											
			median	*0.055*				*0.051*						*0.076*	
			mean	*0.055*				*0.051*						*0.076*	
			se	*0.003*				*0.007*							
	Hatchery	WB	1					0.054		0.072		0.071		0.068	
	Hatchery	WB	2					0.061		0.075		0.067		0.103	
	Hatchery	WB	3					0.053		0.057		0.059		0.085	
	Hatchery	WB	4							0.058		0.060		0.069	
	Hatchery	WB	5							0.065		0.062			
			median					*0.054*		*0.065*		*0.062*		*0.077*	
			mean					*0.056*		*0.065*		*0.064*		*0.081*	
			se					*0.002*		*0.004*		*0.002*		*0.008*	
	Hatchery	F	1					0.063						0.080	
	Hatchery	F	2					0.074						0.122	
	Hatchery	F	3					0.063						0.104	
	Hatchery	F	4											0.081	
	Hatchery	F	5												
			median					*0.063*						*0.093*	
			mean					*0.067*						*0.097*	
			se					*0.004*						*0.010*	
	Hatchery	O	1					0.045						0.054	
	Hatchery	O	2					0.046						0.083	
	Hatchery	O	3					0.045						0.066	
	Hatchery	O	4											0.054	
	Hatchery	O	5												
			median					*0.045*						*0.060*	
			mean					*0.045*						*0.064*	
			se					*0.000*						*0.007*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Age															
	Wild	WB	1	2.2		1.2		2.0				2.8		5.0	
	Wild	WB	2	2.8		1.0		2.3							
	Wild	WB	3	3.2		1.4									
	Wild	WB	4	3.0		1.2									
	Wild	WB	5	3.0		1.0									
			median	*3.0*		*1.2*		*2.2*				*2.8*		*5.0*	
			mean	*2.8*		*1.2*		*2.2*				*2.8*		*5.0*	
			se	*0.2*		*0.1*		*0.2*							
	Wild	F	1	2.2				2.0						5.0	
	Wild	F	2	2.8				2.3							
	Wild	F	3	3.2											
	Wild	F	4	3.0											
	Wild	F	5	3.0											
			median	*3.0*				*2.2*						*5.0*	
			mean	*2.8*				*2.2*						*5.0*	
			se	*0.2*				*0.2*							
	Wild	O	1	2.2				2.0						5.0	
	Wild	O	2	2.8				2.3							
	Wild	O	3	3.2											
	Wild	O	4	3.0											
	Wild	O	5	3.0											
			median	*3.0*				*2.2*						*5.0*	
			mean	*2.8*				*2.2*						*5.0*	
			se	*0.2*				*0.2*							
	Hatchery	WB	1					1.2		1.4		1.2		1.3	
	Hatchery	WB	2					1.0		1.2		1.2		1.8	
	Hatchery	WB	3							1.0		1.4		1.6	
	Hatchery	WB	4							1.0		1.0		1.2	
	Hatchery	WB	5							1.0		1.3			
			median					*1.1*		*1.0*		*1.2*		*1.5*	
			mean					*1.1*		*1.1*		*1.2*		*1.5*	
			se					*0.1*		*0.1*		*0.1*		*0.1*	
	Hatchery	F	1					1.2						1.3	
	Hatchery	F	2					1.0						1.8	
	Hatchery	F	3											1.6	
	Hatchery	F	4											1.2	
	Hatchery	F	5												
			median					*1.1*						*1.5*	
			mean					*1.1*						*1.5*	
			se					*0.1*						*0.1*	
	Hatchery	O	1					1.2						1.3	
	Hatchery	O	2					1.0						1.8	
	Hatchery	O	3											1.6	
	Hatchery	O	4											1.2	
	Hatchery	O	5												
			median					*1.1*						*1.5*	
			mean					*1.1*						*1.5*	
			se					*0.1*						*0.1*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Length															
	Wild	WB	1	913		662		496				860		572	
	Wild	WB	2	1024		600		595							
	Wild	WB	3	907		689									
	Wild	WB	4	969		662									
	Wild	WB	5	1018		600									
			median	*969*		*662*		*546*				*860*		*572*	
			mean	*966*		*642*		*546*				*860*		*572*	
			se	*25*		*18*		*49*							
	Wild	F	1	913				496						572	
	Wild	F	2	1024				595							
	Wild	F	3	907											
	Wild	F	4	969											
	Wild	F	5	1018											
			median	*969*				*546*						*572*	
			mean	*966*				*546*						*572*	
			se	*25*				*49*							
	Wild	O	1	913				496						572	
	Wild	O	2	1024				595							
	Wild	O	3	907											
	Wild	O	4	969											
	Wild	O	5	1018											
			median	*969*				*546*						*572*	
			mean	*966*				*546*						*572*	
			se	*25*				*49*							
	Hatchery	WB	1					662		966		710		652	
	Hatchery	WB	2					600		867		748		772	
	Hatchery	WB	3							700		838		852	
	Hatchery	WB	4							658		598		607	
	Hatchery	WB	5							770		747			
			median					*631*		*770*		*747*		*712*	
			mean					*631*		*792*		*728*		*721*	
			se					*31*		*56*		*39*		*56*	
	Hatchery	F	1					662						652	
	Hatchery	F	2					600						772	
	Hatchery	F	3											852	
	Hatchery	F	4											607	
	Hatchery	F	5												
			median					*631*						*721*	
			mean					*631*						*721*	
			se					*31*						*56*	
	Hatchery	O	1					662						652	
	Hatchery	O	2					600						772	
	Hatchery	O	3											852	
	Hatchery	O	4											607	
	Hatchery	O	5												
			median					*631*						*721*	
			mean					*631*						*721*	
			se					*31*						*56*	

Table B1-3. Summary of Analytical Data for Rainbow Trout

Rainbow Trout			Collection	1		2		3		4		5		6	
			River Mile	741		723		706		678		635		605	
	Origin	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Weight															
	Wild	WB	1	440		380		462				410		370	
	Wild	WB	2	459		480		429							
	Wild	WB	3	438		394									
	Wild	WB	4	446		380									
	Wild	WB	5	458		480									
			median	*446*		*394*		*445*				*410*		*370*	
			mean	*448*		*422*		*445*				*410*		*370*	
			se	*4*		*23*		*17*							
	Wild	F	1	440				462						370	
	Wild	F	2	459				429							
	Wild	F	3	438											
	Wild	F	4	446											
	Wild	F	5	458											
			median	*446*				*445*						*370*	
			mean	*448*				*445*						*370*	
			se	*4*				*17*							
	Wild	O	1	440				462						370	
	Wild	O	2	459				429							
	Wild	O	3	438											
	Wild	O	4	446											
	Wild	O	5	458											
			median	*446*				*445*						*370*	
			mean	*448*				*445*						*370*	
			se	*4*				*17*							
	Hatchery	WB	1					380		412		391		378	
	Hatchery	WB	2					480		399		397		426	
	Hatchery	WB	3							384		410		423	
	Hatchery	WB	4							374		364		381	
	Hatchery	WB	5							397		390			
			median					*430*		*397*		*391*		*402*	
			mean					*430*		*393*		*390*		*402*	
			se					*50*		*7*		*8*		*13*	
	Hatchery	F	1					380						378	
	Hatchery	F	2					480						426	
	Hatchery	F	3											423	
	Hatchery	F	4											381	
	Hatchery	F	5												
			median					*430*						*402*	
			mean					*430*						*402*	
			se					*50*						*13*	
	Hatchery	O	1					380						378	
	Hatchery	O	2					480						426	
	Hatchery	O	3											423	
	Hatchery	O	4											381	
	Hatchery	O	5												
			median					*430*						*402*	
			mean					*430*						*402*	
			se					*50*						*13*	

Notes: Q = Laboratory qualifier
U = reported value is at or below the limit of detection

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Aluminum														
	WB	1	126	1u	5.1		3.2	2u	3.3	U	3.1	U	3.0	1u
	WB	2	3.1	2u	5.7		2.9	2u	6.5		25.9		5.5	1u
	WB	3	2.9	2u	3.1	U	4.1	1u	5.0		3.0	U	4.3	1u
	WB	4	3.2	2u	3.1	U	4.5	1u	6.8		3.0	U	4.5	1u
	WB	5	2.9	2u	3.1	U	3.8	1u	5.2		5.5		3.6	1u
	WB	6											7.5	
	WB	7											3.2	U
	WB	*median*	*3.1*		*3.1*		*3.8*		*5.2*		*3.1*		*4.3*	
	WB	*mean*	*27.6*		*4.0*		*3.7*		*5.4*		*8.1*		*4.5*	
	WB	*se*	*25*		*0.6*		*0.3*		*0.6*		*4.5*		*0.6*	
	F	1	280				2.6	U					2.5	U
	F	2	2.6	U			2.4	U					2.5	U
	F	3	2.5	U			2.5	U					2.5	U
	F	4	2.6	U			2.5	U					2.6	U
	F	5	2.4	U			2.5	U					2.5	U
	F	*median*	*2.6*				*2.5*						*2.5*	
	F	*mean*	*58.0*				*2.5*						*2.5*	
	F	*se*	*55.5*				*0.0*						*0.0*	
	O	1	3.6	U			3.6	U					3.5	
	O	2	3.6	U			3.4	U					8.3	
	O	3	3.3	U			5.6						5.7	
	O	4	3.7	U			6.0						6.0	
	O	5	3.3	U			4.9						4.5	
	O	*median*	*3.6*				*4.9*						*5.7*	
	O	*mean*	*3.5*				*4.7*						*5.6*	
	O	*se*	*0.1*				*0.5*						*0.8*	
Zinc														
	WB	1	13		14		11		14		12		12	
	WB	2	13		14		11		16		14		13	
	WB	3	13		12		12		14		12		12	
	WB	4	13		13		11		12		12		12	
	WB	5	13		13		13		12		13		11	
	WB	6											11	
	WB	7											12	
	WB	*median*	*13*		*13*		*11*		*14*		*12*		*12*	
	WB	*mean*	*13*		*13*		*12*		*14*		*13*		*12*	
	WB	*se*	*0.1*		*0.4*		*0.3*		*0.7*		*0.4*		*0.2*	
	F	1	7.7				6.3						6.4	
	F	2	7.7				5.7						6.6	
	F	3	6.7				6.4						6.4	
	F	4	7.3				5.2						6.2	
	F	5	7.0				6.7						6.5	
	F	*median*	*7.3*				*6.3*						*6.4*	
	F	*mean*	*7.3*				*6.1*						*6.4*	
	F	*se*	*0.2*				*0.3*						*0.1*	
	O	1	18				15						18	
	O	2	17				16						18	
	O	3	18				18						17	
	O	4	18				16						17	
	O	5	18				18						16	
	O	*median*	*18*				*16*						*17*	
	O	*mean*	*18*				*16*						*17*	
	O	*se*	*0.2*				*0.6*						*0.5*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Uranium														
	WB	1	0.0009	1u	0.0008		0.0008	1u	0.0010		0.0008		0.0008	1u
	WB	2	0.0008	1u	0.0007		0.0009	1u	0.0012		0.0012		0.0009	1u
	WB	3	0.0008	1u	0.0006	U	0.0010	1u	0.0009		0.0007		0.0008	1u
	WB	4	0.0008	1u	0.0006	U	0.0012	1u	0.0010		0.0008		0.0013	1u
	WB	5	0.0012	1u	0.0007	U	0.0015	1u	0.0007		0.0009		0.0009	1u
	WB	6											0.0020	
	WB	7											0.0013	
	WB	*median*	*0.0008*		*0.0007*		*0.0010*		*0.0010*		*0.0008*		*0.0009*	
	WB	*mean*	*0.0009*		*0.0007*		*0.0011*		*0.0010*		*0.0009*		*0.0011*	
	WB	*se*	*0.0001*		*0.0000*		*0.0001*		*0.0001*		*0.0001*		*0.0002*	
	F	1	0.0005	U			0.0005	U					0.0005	U
	F	2	0.0005	U			0.0005	U					0.0005	U
	F	3	0.0005	U			0.0005	U					0.0005	U
	F	4	0.0005	U			0.0005	U					0.0005	U
	F	5	0.0005	U			0.0005	U					0.0005	U
	F	*median*	*0.0005*				*0.0005*						*0.0005*	
	F	*mean*	*0.0005*				*0.0005*						*0.0005*	
	F	*se*	*0.0000*				*0.0000*						*0.0000*	
	O	1	0.0013				0.0010						0.0011	
	O	2	0.0010				0.0013						0.0012	
	O	3	0.0011				0.0014						0.0009	
	O	4	0.0010				0.0017						0.0019	
	O	5	0.0017				0.0023						0.0012	
	O	*median*	*0.0011*				*0.0014*						*0.0012*	
	O	*mean*	*0.0012*				*0.0015*						*0.0013*	
	O	*se*	*0.0001*				*0.0002*						*0.0002*	
Sodium														
	WB	1	968		1100		982		1010		1090		967	
	WB	2	917		1000		902		936		1020		945	
	WB	3	911		1040		944		913		937		983	
	WB	4	892		979		890		949		967		1030	
	WB	5	948		971		962		974		945		932	
	WB	6											919	
	WB	7											1010	
	WB	*median*	*917*		*1000*		*944*		*949*		*967*		*967*	
	WB	*mean*	*927*		*1020*		*936*		*956*		*992*		*969*	
	WB	*se*	*14*		*24*		*18*		*17*		*29*		*15*	
	F	1	411				430						460	
	F	2	392				434						428	
	F	3	377				479						500	
	F	4	388				375						529	
	F	5	390				485						477	
	F	*median*	*390*				*434*						*477*	
	F	*mean*	*392*				*441*						*479*	
	F	*se*	*5.5*				*20*						*17*	
	O	1	1410				1370						1400	
	O	2	1350				1360						1410	
	O	3	1360				1370						1370	
	O	4	1330				1280						1420	
	O	5	1400				1350						1310	
	O	*median*	*1360*				*1360*						*1400*	
	O	*mean*	*1370*				*1350*						*1380*	
	O	*se*	*15*				*17*						*20*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Selenium														
	WB	1	0.42		0.51		0.43		0.72		0.55		0.50	
	WB	2	0.39		0.47		0.41		0.75		0.37		0.50	
	WB	3	0.42		0.52		0.51		0.80		0.58		0.52	
	WB	4	0.42		0.44		0.66		0.54		0.50		0.40	
	WB	5	0.43		0.48		0.59		0.80		0.50		0.33	
	WB	6											0.62	
	WB	7											0.51	
	WB	*median*	*0.42*		*0.48*		*0.51*		*0.75*		*0.50*		*0.50*	
	WB	*mean*	*0.41*		*0.48*		*0.52*		*0.72*		*0.50*		*0.48*	
	WB	*se*	*0.01*		*0.01*		*0.05*		*0.05*		*0.04*		*0.04*	
	F	1	0.39				0.37						0.57	
	F	2	0.32				0.39						0.42	
	F	3	0.37				0.42						0.38	
	F	4	0.37				0.43						0.30	
	F	5	0.38				0.44						0.30	
	F	*median*	*0.37*				*0.42*						*0.38*	
	F	*mean*	*0.37*				*0.41*						*0.39*	
	F	*se*	*0.01*				*0.01*						*0.05*	
	O	1	0.45				0.48						0.44	
	O	2	0.45				0.43						0.56	
	O	3	0.47				0.59						0.63	
	O	4	0.46				0.82						0.48	
	O	5	0.46				0.70						0.36	
	O	*median*	*0.46*				*0.59*						*0.48*	
	O	*mean*	*0.46*				*0.60*						*0.49*	
	O	*se*	*0.00*				*0.07*						*0.05*	
Potassium														
	WB	1	3300		3690		3320		3300		3290		3370	
	WB	2	3290		3240		3360		3200		3180		3250	
	WB	3	3190		3370		3540		3220		3230		3340	
	WB	4	3350		3320		3290		3320		3370		3210	
	WB	5	3300		3330		3270		3250		3250		3200	
	WB	6											3320	
	WB	7											3310	
	WB	*median*	*3300*		*3330*		*3320*		*3250*		*3250*		*3310*	
	WB	*mean*	*3290*		*3390*		*3360*		*3260*		*3260*		*3290*	
	WB	*se*	*26*		*78*		*48*		*23*		*32*		*25*	
	F	1	4390				4360						4330	
	F	2	4390				4340						4240	
	F	3	4160				4430						4280	
	F	4	4470				4220						4300	
	F	5	4460				4300						4240	
	F	*median*	*4390*				*4340*						*4280*	
	F	*mean*	*4370*				*4330*						*4280*	
	F	*se*	*56*				*35*						*17*	
	O	1	2430				2590						2550	
	O	2	2380				2380						2350	
	O	3	2360				2710						2600	
	O	4	2370				2590						2370	
	O	5	2360				2420						2340	
	O	*median*	*2370*				*2590*						*2370*	
	O	*mean*	*2380*				*2540*						*2440*	
	O	*se*	*13*				*61*						*55*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Nickel														
	WB	1	0.46		0.41		0.38		0.36		0.34		0.36	
	WB	2	0.47		0.44		0.35		0.39		0.37		0.38	
	WB	3	0.44		0.34		0.31		0.42		0.35		0.48	
	WB	4	0.37		0.36		0.42		0.40		0.36		0.47	
	WB	5	0.42		0.33		0.45		0.44		0.38		0.43	
	WB	6											0.34	
	WB	7											0.35	
	WB	*median*	*0.44*		*0.36*		*0.38*		*0.40*		*0.36*		*0.38*	
	WB	*mean*	*0.43*		*0.38*		*0.38*		*0.40*		*0.36*		*0.40*	
	WB	*se*	*0.02*		*0.02*		*0.02*		*0.01*		*0.01*		*0.02*	
	F	1	0.17				0.16						0.06	
	F	2	0.10				0.07						0.06	
	F	3	0.15				0.08						0.13	
	F	4	0.10				0.14						0.10	
	F	5	0.16				0.10						0.13	
	F	*median*	*0.15*				*0.10*						*0.10*	
	F	*mean*	*0.14*				*0.11*						*0.10*	
	F	*se*	*0.01*				*0.02*						*0.02*	
	O	1	0.68				0.54						0.61	
	O	2	0.78				0.63						0.66	
	O	3	0.69				0.53						0.75	
	O	4	0.61				0.63						0.75	
	O	5	0.63				0.73						0.69	
	O	*median*	*0.68*				*0.63*						*0.69*	
	O	*mean*	*0.68*				*0.61*						*0.69*	
	O	*se*	*0.03*				*0.04*						*0.03*	
Manganese														
	WB	1	1.5		1.5		1.0		1.9		1.4		1.2	
	WB	2	1.3		1.1		1.2		2.3		1.4		1.3	
	WB	3	1.1		1.0		1.0		1.9		1.4		1.5	
	WB	4	0.9		1.2		1.3		1.6		1.2		1.7	
	WB	5	1.1		1.1		1.2		1.5		1.3		1.2	
	WB	6											1.1	
	WB	7											1.2	
	WB	*median*	*1.1*		*1.1*		*1.2*		*1.9*		*1.4*		*1.2*	
	WB	*mean*	*1.2*		*1.2*		*1.1*		*1.8*		*1.3*		*1.3*	
	WB	*se*	*0.1*		*0.1*		*0.1*		*0.1*		*0.0*		*0.1*	
	F	1	0.20				0.15						0.13	
	F	2	0.16				0.12						0.14	
	F	3	0.16				0.15						0.15	
	F	4	0.19				0.47						0.15	
	F	5	0.20				0.15						0.17	
	F	*median*	*0.19*				*0.15*						*0.15*	
	F	*mean*	*0.18*				*0.21*						*0.15*	
	F	*se*	*0.01*				*0.07*						*0.01*	
	O	1	2.5				1.6						2.1	
	O	2	2.2				2.2						2.4	
	O	3	1.9				1.8						2.5	
	O	4	1.6				1.9						2.8	
	O	5	1.8				2.0						2.0	
	O	*median*	*1.9*				*1.9*						*2.4*	
	O	*mean*	*2.0*				*1.9*						*2.4*	
	O	*se*	*0.2*				*0.1*						*0.1*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Magnesium														
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	
	WB	1	372		394		352		388		363		360	
	WB	2	368		383		371		356		368		342	
	WB	3	368		352		342		370		360		349	
	WB	4	350		373		344		364		360		375	
	WB	5	361		364		364		369		342		360	
	WB	6											344	
	WB	7											368	
	WB	*median*	*368*		*373*		*352*		*369*		*360*		*360*	
	WB	*mean*	*364*		*373*		*355*		*369*		*359*		*357*	
	WB	*se*	*3.9*		*7.3*		*5.6*		*5.3*		*4.4*		*4.7*	
	F	1	280				280						266	
	F	2	281				264						260	
	F	3	269				281						265	
	F	4	282				268						272	
	F	5	277				274						270	
	F	*median*	*280*				*274*						*266*	
	F	*mean*	*278*				*273*						*267*	
	F	*se*	*2.4*				*3.3*						*2.1*	
	O	1	446				402						441	
	O	2	440				478						416	
	O	3	452				398						416	
	O	4	409				402						454	
	O	5	429				436						435	
	O	*median*	*440*				*402*						*435*	
	O	*mean*	*435*				*423*						*432*	
	O	*se*	*7.6*				*15*						*7.4*	
Lead														
	WB	1	0.030	1u	0.033		0.032		0.072		0.16		0.051	
	WB	2	0.029	1u	0.023		0.045		0.107		0.013		0.024	1u
	WB	3	0.039	1u	0.036		0.038		0.085		0.048		0.036	
	WB	4	0.038	1u	0.047		0.053	1u	0.12		0.051		0.020	1u
	WB	5	0.041	1u	0.055		0.054	1u	0.22		0.024		0.016	1u
	WB	6											0.015	
	WB	7											0.015	
	WB	*median*	*0.038*		*0.036*		*0.045*		*0.11*		*0.048*		*0.020*	
	WB	*mean*	*0.035*		*0.039*		*0.044*		*0.12*		*0.060*		*0.025*	
	WB	*se*	*0.002*		*0.005*		*0.004*		*0.027*		*0.027*		*0.005*	
	F	1	0.011	U			0.022						0.062	
	F	2	0.011	U			0.053						0.011	U
	F	3	0.010	U			0.012						0.040	
	F	4	0.011	U			0.010	U					0.011	U
	F	5	0.010	U			0.011	U					0.011	U
	F	*median*	*0.011*				*0.012*						*0.011*	
	F	*mean*	*0.011*				*0.021*						*0.027*	
	F	*se*	*0.000*				*0.008*						*0.011*	
	O	1	0.045				0.039						0.041	
	O	2	0.045				0.037						0.036	
	O	3	0.063				0.062						0.033	
	O	4	0.061				0.085						0.028	
	O	5	0.066				0.089						0.021	
	O	*median*	*0.061*				*0.062*						*0.033*	
	O	*mean*	*0.056*				*0.062*						*0.032*	
	O	*se*	*0.005*				*0.011*						*0.003*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Iron														
	WB	1	11		9.2		9.2		9.7		8.6		12	
	WB	2	9.6		9.1		7.1		13		8.7		10	
	WB	3	9.4		12		11		10		7.1		9.8	
	WB	4	10		9.1		12		10		12		10	
	WB	5	11		8.2		10		9.4		10		8.4	
	WB	6											11.2	
	WB	7											9.1	
	WB	*median*	*10*		*9.1*		*10*		*10*		*8.7*		*10*	
	WB	*mean*	*10*		*9.4*		*9.8*		*11*		*9.3*		*10*	
	WB	*se*	*0.4*		*0.6*		*0.8*		*0.7*		*0.8*		*0.4*	
	F	1	4.7				3.4						2.3	
	F	2	2.3				2.6						2.1	
	F	3	3.3				2.5						2.9	
	F	4	3.7				5.6						3.0	
	F	5	3.4				2.5						3.0	
	F	*median*	*3.4*				*2.6*						*2.9*	
	F	*mean*	*3.5*				*3.3*						*2.7*	
	F	*se*	*0.4*				*0.6*						*0.2*	
	O	1	16				13						20	
	O	2	16				12						17	
	O	3	15				19						15	
	O	4	16				17						15	
	O	5	18				16						13	
	O	*median*	*16*				*16*						*15*	
	O	*mean*	*16*				*15*						*16*	
	O	*se*	*1*				*1*						*1*	
Copper														
	WB	1	0.34		0.38		0.32		0.36		0.34		0.35	
	WB	2	0.34		0.34		0.26		0.57		0.40		0.36	
	WB	3	0.30		0.29		0.35		0.45		0.30		0.39	
	WB	4	0.32		0.36		0.42		0.48		0.35		0.40	
	WB	5	0.33		0.29		0.38		0.44		0.36		0.36	
	WB	6											0.31	
	WB	7											0.37	
	WB	*median*	*0.33*		*0.34*		*0.35*		*0.45*		*0.35*		*0.36*	
	WB	*mean*	*0.33*		*0.33*		*0.35*		*0.46*		*0.35*		*0.36*	
	WB	*se*	*0.01*		*0.02*		*0.03*		*0.03*		*0.02*		*0.01*	
	F	1	0.24				0.18						0.20	
	F	2	0.21				0.18						0.21	
	F	3	0.20				0.19						0.23	
	F	4	0.24				0.25						0.21	
	F	5	0.24				0.20						0.21	
	F	*median*	*0.24*				*0.19*						*0.21*	
	F	*mean*	*0.23*				*0.20*						*0.21*	
	F	*se*	*0.01*				*0.01*						*0.00*	
	O	1	0.42				0.42						0.47	
	O	2	0.45				0.34						0.50	
	O	3	0.38				0.50						0.51	
	O	4	0.40				0.54						0.54	
	O	5	0.41				0.52						0.48	
	O	*median*	*0.41*				*0.50*						*0.50*	
	O	*mean*	*0.41*				*0.46*						*0.50*	
	O	*se*	*0.01*				*0.04*						*0.01*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Cobalt														
	WB	1	0.021		0.026		0.020		0.025		0.020		0.023	
	WB	2	0.020		0.023		0.021		0.039		0.020		0.021	
	WB	3	0.020		0.021		0.022		0.029		0.020		0.022	
	WB	4	0.020		0.023		0.029		0.028		0.023		0.024	
	WB	5	0.021		0.020		0.025		0.030		0.021		0.022	
	WB	6											0.020	
	WB	7											0.021	
	WB	*median*	*0.020*		*0.023*		*0.022*		*0.029*		*0.020*		*0.022*	
	WB	*mean*	*0.020*		*0.023*		*0.023*		*0.030*		*0.021*		*0.022*	
	WB	*se*	*0.000*		*0.001*		*0.002*		*0.002*		*0.001*		*0.000*	
	F	1	0.0060				0.0056						0.0044	
	F	2	0.0051				0.0037						0.0040	
	F	3	0.0051				0.0044						0.0052	
	F	4	0.0048				0.0074						0.0048	
	F	5	0.0060				0.0038						0.0057	
	F	*median*	*0.0051*				*0.0044*						*0.0048*	
	F	*mean*	*0.0054*				*0.0050*						*0.0048*	
	F	*se*	*0.0003*				*0.0007*						*0.0003*	
	O	1	0.033				0.030						0.038	
	O	2	0.033				0.037						0.036	
	O	3	0.033				0.038						0.036	
	O	4	0.034				0.045						0.039	
	O	5	0.033				0.043						0.036	
	O	*median*	*0.033*				*0.038*						*0.036*	
	O	*mean*	*0.033*				*0.039*						*0.037*	
	O	*se*	*0.000*				*0.003*						*0.001*	
Chromium														
	WB	1	0.56		0.41		0.53		0.53		0.47		0.84	
	WB	2	0.56		0.44		0.38		0.47		0.45		0.55	
	WB	3	0.49		0.97		0.47		0.53		0.48		0.68	
	WB	4	0.55		0.41		0.80		0.63		0.84		0.47	
	WB	5	0.49		0.38		0.55		0.63		0.55		0.42	
	WB	6											0.47	
	WB	7											0.40	
	WB	*median*	*0.55*		*0.41*		*0.53*		*0.53*		*0.48*		*0.47*	
	WB	*mean*	*0.53*		*0.52*		*0.55*		*0.56*		*0.56*		*0.55*	
	WB	*se*	*0.02*		*0.11*		*0.07*		*0.03*		*0.07*		*0.06*	
	F	1	0.51				0.57						0.46	
	F	2	0.26				0.39						0.42	
	F	3	0.45				0.40						0.54	
	F	4	0.52				0.90						0.39	
	F	5	0.52				0.40						0.46	
	F	*median*	*0.51*				*0.40*						*0.46*	
	F	*mean*	*0.45*				*0.53*						*0.45*	
	F	*se*	*0.05*				*0.10*						*0.02*	
	O	1	0.59				0.51						1.17	
	O	2	0.81				0.37						0.66	
	O	3	0.52				0.53						0.79	
	O	4	0.58				0.73						0.54	
	O	5	0.46				0.67						0.39	
	O	*median*	*0.58*				*0.53*						*0.66*	
	O	*mean*	*0.59*				*0.56*						*0.71*	
	O	*se*	*0.06*				*0.06*						*0.13*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Calcium														
	WB	1	11600		12400		10100		13600		12200		11200	
	WB	2	11200		13200		11500		11700		11900		10500	
	WB	3	11500		10800		8930		11800		12000		10600	
	WB	4	10100		12100		10100		11700		11200		12800	
	WB	5	11100		11400		11800		12400		10500		11800	
	WB	6											10500	
	WB	7											12200	
	WB	*median*	*11200*		*12100*		*10100*		*11800*		*11900*		*11200*	
	WB	*mean*	*11100*		*12000*		*10500*		*12200*		*11600*		*11400*	
	WB	*se*	*266*		*413*		*523*		*364*		*314*		*347*	
	F	1	847				516						468	
	F	2	547				264						397	
	F	3	502				559						393	
	F	4	393				424						540	
	F	5	456				551						874	
	F	*median*	*502*				*516*						*468*	
	F	*mean*	*549*				*463*						*534*	
	F	*se*	*79*				*55*						*89*	
	O	1	20100				16800						20300	
	O	2	20100				22600						19600	
	O	3	20900				16600						18700	
	O	4	18500				17400						22300	
	O	5	19800				21000						21000	
	O	*median*	*20100*				*17400*						*20300*	
	O	*mean*	*19900*				*18900*						*20400*	
	O	*se*	*390*				*1226*						*613*	
Cadmium														
	WB	1	0.026	1u	0.038		0.019	1u	0.022		0.022		0.021	1u
	WB	2	0.021	1u	0.017		0.018	1u	0.042		0.020		0.021	1u
	WB	3	0.019	1u	0.018		0.026	1u	0.032		0.014		0.025	1u
	WB	4	0.026	1u	0.026		0.036	1u	0.028		0.021		0.025	1u
	WB	5	0.024	1u	0.019		0.023	1u	0.026		0.021		0.024	1u
	WB	6											0.017	
	WB	7											0.017	
	WB	*median*	*0.024*		*0.019*		*0.023*		*0.028*		*0.021*		*0.021*	
	WB	*mean*	*0.023*		*0.024*		*0.024*		*0.030*		*0.019*		*0.021*	
	WB	*se*	*0.001*		*0.004*		*0.003*		*0.003*		*0.001*		*0.001*	
	F	1	0.011	U			0.011	U					0.010	U
	F	2	0.011	U			0.010	U					0.011	U
	F	3	0.010	U			0.011	U					0.011	U
	F	4	0.011	U			0.010	U					0.011	U
	F	5	0.010	U			0.011	U					0.011	U
	F	*median*	*0.011*				*0.011*						*0.011*	
	F	*mean*	*0.011*				*0.011*						*0.011*	
	F	*se*	*0.000*				*0.000*						*0.000*	
	O	1	0.039				0.024						0.029	
	O	2	0.030				0.025						0.031	
	O	3	0.026				0.041						0.036	
	O	4	0.040				0.054						0.036	
	O	5	0.036				0.034						0.036	
	O	*median*	*0.036*				*0.034*						*0.036*	
	O	*mean*	*0.034*				*0.036*						*0.034*	
	O	*se*	*0.003*				*0.006*						*0.001*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Barium														
	WB	1	0.91	1u	0.96		0.78	1u	1.06		1.02		0.80	1u
	WB	2	0.82	1u	0.88		0.81	1u	1.03		0.82		0.83	1u
	WB	3	0.85	1u	0.80		0.74	1u	0.97		0.79		0.83	1u
	WB	4	0.73	1u	0.88		0.86	1u	0.95		0.80		1.03	1u
	WB	5	0.86	1u	0.79		0.91	1u	0.88		0.83		0.85	1u
	WB	6											0.78	
	WB	7											0.90	
	WB	*median*	*0.85*		*0.88*		*0.81*		*0.97*		*0.82*		*0.83*	
	WB	*mean*	*0.83*		*0.86*		*0.82*		*0.98*		*0.85*		*0.86*	
	WB	*se*	*0.03*		*0.03*		*0.03*		*0.03*		*0.04*		*0.03*	
	F	1	0.086	U			0.086	U					0.083	U
	F	2	0.085	U			0.081	U					0.084	U
	F	3	0.082	U			0.084	U					0.084	U
	F	4	0.087	U			0.082	U					0.086	U
	F	5	0.080	U			0.084	U					0.084	U
	F	*median*	*0.085*				*0.084*						*0.084*	
	F	*mean*	*0.084*				*0.084*						*0.084*	
	F	*se*	*0.001*				*0.001*						*0.001*	
	O	1	1.6				1.3						1.4	
	O	2	1.4				1.5						1.5	
	O	3	1.5				1.4						1.4	
	O	4	1.3				1.5						1.8	
	O	5	1.5				1.6						1.5	
	O	*median*	*1.5*				*1.5*						*1.5*	
	O	*mean*	*1.5*				*1.4*						*1.5*	
	O	*se*	*0.0*				*0.1*						*0.1*	
Arsenic														
	WB	1	0.11		0.15		0.12		0.21		0.16		0.16	
	WB	2	0.10		0.09		0.14		0.31		0.12		0.16	
	WB	3	0.11		0.13		0.14		0.23		0.19		0.16	
	WB	4	0.07		0.11		0.19		0.20		0.16		0.12	
	WB	5	0.07		0.09		0.15		0.25		0.16		0.13	
	WB	6											0.20	
	WB	7											0.16	
	WB	*median*	*0.10*		*0.11*		*0.14*		*0.23*		*0.16*		*0.16*	
	WB	*mean*	*0.09*		*0.12*		*0.15*		*0.24*		*0.16*		*0.16*	
	WB	*se*	*0.01*		*0.01*		*0.01*		*0.02*		*0.01*		*0.01*	
	F	1	0.11				0.11						0.18	
	F	2	0.10				0.13						0.14	
	F	3	0.10				0.11						0.12	
	F	4	0.07				0.10						0.10	
	F	5	0.06				0.12						0.12	
	F	*median*	*0.10*				*0.11*						*0.12*	
	F	*mean*	*0.09*				*0.11*						*0.13*	
	F	*se*	*0.01*				*0.01*						*0.01*	
	O	1	0.12				0.12						0.14	
	O	2	0.10				0.15						0.19	
	O	3	0.12				0.18						0.19	
	O	4	0.08				0.25						0.14	
	O	5	0.07	U			0.18						0.13	
	O	*median*	*0.10*				*0.18*						*0.14*	
	O	*mean*	*0.10*				*0.18*						*0.16*	
	O	*se*	*0.01*				*0.02*						*0.01*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Age														
	WB	1	3.3		3		3.8		3.8		3.2		3.2	
	WB	2	3.6		3.4		2.5		4		2.5		3.5	
	WB	3	3.8		3.4		3.8		3.3		2.2		3.2	
	WB	4	4		2.6		3.4		4		3.2		3.6	
	WB	5	3.6		3.6		3.8		3.2		3.5		3.3	
	WB	6											3	
	WB	7											3.6	
	WB	*median*	*3.6*		*3.4*		*3.8*		*3.8*		*3.2*		*3.3*	
	WB	*mean*	*3.7*		*3.2*		*3.5*		*3.7*		*2.9*		*3.3*	
	WB	*se*	*0.1*		*0.2*		*0.3*		*0.2*		*0.2*		*0.1*	
	F	1	3.3				3.8						3.2	
	F	2	3.6				2.5						3.5	
	F	3	3.8				3.8						3.2	
	F	4	4				3.4						3.6	
	F	5	3.6				3.8						3.3	
	F	*median*	*3.6*				*3.8*						*3.3*	
	F	*mean*	*3.7*				*3.5*						*3.4*	
	F	*se*	*0.1*				*0.3*						*0.1*	
	O	1	3.3				3.8						3.2	
	O	2	3.6				2.5						3.5	
	O	3	3.8				3.8						3.2	
	O	4	4				3.4						3.6	
	O	5	3.6				3.8						3.3	
	O	*median*	*3.6*				*3.8*						*3.3*	
	O	*mean*	*3.7*				*3.5*						*3.4*	
	O	*se*	*0.1*				*0.3*						*0.1*	
Length														
	WB	1	499		435		538		555		508		547	
	WB	2	512		404		512		502		598		559	
	WB	3	431		409		514		536		430		558	
	WB	4	539		344		448		553		547		585	
	WB	5	394		477		482		510		559		566	
	WB	6											574	
	WB	7											623	
	WB	*median*	*499*		*409*		*512*		*536*		*547*		*566*	
	WB	*mean*	*475*		*414*		*499*		*531*		*528*		*573*	
	WB	*se*	*27*		*22*		*16*		*11*		*29*		*9.5*	
	F	1	499				538						547	
	F	2	512				512						559	
	F	3	431				514						558	
	F	4	539				448						585	
	F	5	394				482						566	
	F	*median*	*499*				*512*						*559*	
	F	*mean*	*475*				*499*						*563*	
	F	*se*	*27*				*16*						*6.3*	
	O	1	499				538						547	
	O	2	512				512						559	
	O	3	431				514						558	
	O	4	539				448						585	
	O	5	394				482						566	
	O	*median*	*499*				*512*						*559*	
	O	*mean*	*475*				*499*						*563*	
	O	*se*	*27*				*16*						*6.3*	

Table B1-4. Summary of Analytical Data for Walleye

Walleye		Collection Area	1		2		3		4		5		6	
		River Mile	741		723		706		678		635		605	
	Tissue	comp	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Weight														
	WB	1	382		384		405		405		392		412	
	WB	2	396		365		400		399		420		409	
	WB	3	376		367		391		399		373		409	
	WB	4	397		355		377		397		412		419	
	WB	5	362		388		391		392		409		411	
	WB	6											401	
	WB	7											418	
	WB	*median*	*382*		*367*		*391*		*399*		*409*		*411*	
	WB	*mean*	*382*		*372*		*393*		*398*		*401*		*411*	
	WB	*se*	*6.5*		*6.2*		*4.8*		*2.0*		*8.4*		*2.2*	
	F	1	382				405						412	
	F	2	396				400						409	
	F	3	376				391						409	
	F	4	397				377						419	
	F	5	362				391						411	
	F	*median*	*382*				*391*						*411*	
	F	*mean*	*382*				*393*						*412*	
	F	*se*	*6.5*				*4.8*						*1.8*	
	O	1	382				405						412	
	O	2	396				400						409	
	O	3	376				391						409	
	O	4	397				377						419	
	O	5	362				391						411	
	O	*median*	*382*				*391*						*411*	
	O	*mean*	*382*				*393*						*412*	
	O	*se*	*6.5*				*4.8*						*1.8*	

Notes:

U = result not detected, reported at detection limit converted from dry weight to wet weight using sample-specific moisture content

1U = one sample used to estimate value was below detection limit

2U = both samples used to estimate value were below detection limit

Table B1-5. Summary of Analytical Data for Whitefish Species

		Mountain		Lake		Lake		Lake		Lake		Lake	
Whitefish	Collection Area	1		2		3		4		5		6	
species	River Mile	741		723		706		678		635		605	
	composite	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Aluminum													
	1	19		4.8		3.8	U	7.1		5.2		3.9	U
	2	13		3.9	U	3.8	U	5.9		3.7	U	4.0	U
	3	4.9		3.8	U	3.9		4.8		6.0			
	4	20		4.1	U	3.5	U	5.2		4.5			
	5	17		3.9	U	5.8		7.8		4.2	U		
	median	*17*		*3.9*		*3.8*		*5.9*		*4.5*		*4.0*	
	mean	*15*		*4.1*		*4.2*		*6.2*		*4.7*		*4.0*	
	se	*2.6*		*0.18*		*0.42*		*0.56*		*0.40*		*0.1*	
Arsenic													
	1	*0.17*		*0.27*		*0.27*		*0.29*		*0.30*		*0.19*	
	2	*0.16*		*0.20*		*0.28*		*0.26*		*0.30*		*0.31*	
	3	*0.14*		*0.26*		*0.24*		*0.22*		0.23			
	4	*0.15*		*0.26*		*0.28*		*0.25*		*0.30*			
	5	0.12		*0.19*		*0.24*		*0.23*		*0.29*			
	median	*0.15*		*0.26*		*0.27*		*0.25*		*0.30*		*0.25*	
	mean	*0.15*		*0.24*		*0.26*		*0.25*		*0.28*		*0.25*	
	se	*0.01*		*0.02*		*0.01*		*0.01*		*0.01*		*0.06*	
Barium													
	1	1.0		*0.51*		*0.51*		*0.70*		*0.55*		*0.35*	
	2	1.8		*0.55*		*0.53*		*0.62*		*0.63*		*0.32*	
	3	0.46		*0.41*		*0.52*		*0.55*		*0.67*			
	4	1.3		*0.54*		*0.58*		*0.85*		*0.58*			
	5	2.8		*0.45*		*0.62*		0.7		*0.56*			
	median	*1.3*		*0.51*		*0.53*		*0.7*		*0.58*		*0.33*	
	mean	*1.5*		*0.49*		*0.55*		*0.68*		*0.60*		*0.33*	
	se	*0.39*		*0.03*		*0.02*		*0.05*		*0.02*		*0.01*	
Cadmium													
	1	0.13		0.024		0.019		0.02		0.018		0.017	
	2	0.11		0.016	U	0.018	J	0.029		0.016	U	0.024	
	3	0.092		0.016	U	0.020		0.022		0.017	U		
	4	0.13		0.017	U	0.016		0.024		0.015	U		
	5	0.092		0.020		0.017		0.032		0.017	U		
	median	*0.11*		*0.017*		*0.018*		*0.024*		*0.017*		*0.020*	
	mean	*0.11*		*0.019*		*0.018*		*0.025*		*0.017*		*0.020*	
	se	*0.01*		*0.002*		*0.001*		*0.002*		*0.000*		*0.003*	
Calcium													
	1	*6070*		*4550*	J	*5690*		*5070*		*5570*		*4860*	
	2	*4870*		*5150*	J	*5470*		*4760*		*7410*		*6000*	J
	3	*4120*		*4650*	J	*4840*		*4650*		*6280*			
	4	*6290*		*4610*	J	*4980*		*6490*		*4420*			
	5	*5490*		*4960*	J	*4600*		*4500*		*7500*			
	median	*5490*		*4650*		*4980*		*4760*		*6280*		*5430*	
	mean	*5370*		*4780*		*5120*		*5090*		*6240*		*5430*	
	se	*398*		*116*		*202*		*361*		*580*		*570*	
Chromium													
	1	1.2		0.72		0.66		0.88		0.92		0.91	
	2	0.95		0.52		0.69		0.84		0.82		0.64	
	3	1.0		0.66		0.65		0.86		0.80			
	4	1.1		0.64		0.70		0.82		0.90			
	5	1.1		0.55		0.94		0.75		0.92			
	median	*1.1*		*0.64*		*0.69*		*0.84*		*0.90*		*0.78*	
	mean	*1.1*		*0.62*		*0.73*		*0.83*		*0.87*		*0.78*	
	se	*0.0*		*0.04*		*0.05*		*0.02*		*0.02*		*0.14*	
Cobalt													
	1	0.059		0.029	JK	0.025	JK	0.025	JK	0.030	JK	0.020	JK
	2	0.062		0.025	JK	0.023	JK	0.029	JK	0.037	JK	0.026	JK
	3	0.028		0.024	JK	0.019	JK	0.024	JK	0.032	JK		
	4	0.072		0.022	JK	0.024	JK	0.028	JK	0.027	JK		
	5	0.067		0.023	JK	0.033	JK	0.029	JK	0.031	J		
	median	*0.062*		*0.024*		*0.024*		*0.028*		*0.031*		*0.023*	
	mean	*0.058*		*0.025*		*0.025*		*0.027*		*0.032*		*0.023*	
	se	*0.008*		*0.001*		*0.002*		*0.001*		*0.002*		*0.003*	

Table B1-5. Summary of Analytical Data for Whitefish Species

		Mountain		Lake		Lake		Lake		Lake		Lake	
Whitefish species	Collection Area	1		2		3		4		5		6	
	River Mile	741		723		706		678		635		605	
	composite	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Copper													
	1	1.2	J	0.82		0.44		0.68		0.73		0.45	
	2	1.5	J	0.65		0.53		0.72		0.54		0.57	
	3	0.56	J	0.54		0.65		0.72		0.67			
	4	2.0	J	0.64		0.51		0.65		0.67			
	5	1.3	J	0.75		0.85		0.65		0.56			
	median	*1.3*		*0.65*		*0.53*		*0.68*		*0.67*		*0.51*	
	mean	*1.3*		*0.68*		*0.60*		*0.68*		*0.63*		*0.51*	
	se	*0.23*		*0.05*		*0.07*		*0.02*		*0.04*		*0.06*	
Iron													
	1	112	J	17		11		18		17		11	
	2	113	J	12		12		17		13		18	
	3	30	J	11		15		15		16			
	4	147	J	15		12		17		19			
	5	109	J	15		22		19		11			
	median	*112*		*15*		*12*		*17*		*16*		*15*	
	mean	*102*		*14*		*15*		*17*		*15*		*15*	
	se	*19*		*1*		*2*		*1*		*2*		*4*	
Lead													
	1	0.45		0.075		0.089		0.068		0.048		0.071	
	2	0.40		0.058		0.057		0.049		0.047		0.040	
	3	0.18		0.06		0.049		0.041		0.053			
	4	0.34		0.081		0.067		0.062		0.038			
	5	0.30		0.062		0.12		0.11		0.053			
	median	*0.34*		*0.062*		*0.067*		*0.062*		*0.048*		*0.056*	
	mean	*0.34*		*0.067*		*0.077*		*0.067*		*0.048*		*0.056*	
	se	*0.047*		*0.0046*		*0.013*		*0.013*		*0.0027*		*0.016*	
Magnesium													
	1	314		277		297		286		279		258	
	2	344		284		276		289		282		268	
	3	296		269		278		267		280			
	4	336		274		276		296		265			
	5	322		271		271		270		297			
	median	*322*		*274*		*276*		*286*		*280*		*263*	
	mean	*322*		*275*		*280*		*282*		*281*		*263*	
	se	*8*		*3*		*5*		*6*		*5*		*5*	
Manganese													
	1	4		*1.1*		0.81	J	1.7	J	2.0	J	1.0	J
	2	*4.9*		0.68		0.90	J	2.0	J	1.7	J	*0.99*	
	3	*1.6*		0.63		0.87	J	1.2	J	1.7	J		
	4	*4.3*		0.85		0.67	J	3.8	J	2.4	J		
	5	*3.7*		0.81		1.6	J	2.1	J	1.3	J		
	median	*4.0*		*0.81*		*0.87*		*2.0*		*1.7*		*0.99*	
	mean	*3.7*		*0.81*		*0.97*		*2.2*		*1.8*		*0.99*	
	se	*0.6*		*0.08*		*0.17*		*0.4*		*0.2*		*0.01*	
Mercury													
	1	0.082		0.065		0.051		0.045		0.080		0.094	
	2	0.083		0.069		0.056		0.058		0.067		0.095	
	3	0.063		0.052		0.054		0.070		0.065			
	4	0.080		0.055		0.051		0.066		0.069			
	5	0.075		0.058		0.050		0.057		0.066			
	median	*0.080*		*0.058*		*0.051*		*0.058*		*0.067*		*0.094*	
	mean	*0.077*		*0.060*		*0.052*		*0.059*		*0.069*		*0.094*	
	se	*0.004*		*0.003*		*0.001*		*0.004*		*0.003*		*0.000*	
Nickel													
	1	0.27		0.17		0.24		0.23		0.21		0.24	
	2	0.21		0.18		0.21		0.19		0.27		0.21	
	3	0.17		0.17		0.16		0.19		0.26			
	4	0.29		0.16		0.17		0.25		0.18			
	5	0.27		0.17		0.30		0.17		0.25			
	median	*0.27*		*0.17*		*0.21*		*0.19*		*0.25*		*0.23*	
	mean	*0.24*		*0.17*		*0.22*		*0.20*		*0.23*		*0.23*	
	se	*0.02*		*0.00*		*0.03*		*0.01*		*0.02*		*0.01*	

Table B1-5. Summary of Analytical Data for Whitefish Species

		Mountain		Lake		Lake		Lake		Lake		Lake	
Whitefish species	Collection Area	1		2		3		4		5		6	
	River Mile	741		723		706		678		635		605	
	composite	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Potassium													
	1	3020		2980		3160		3000		3040		2970	
	2	3430		3170		2990		3110		2750		2790	
	3	3050		3110		3020		2900		2910			
	4	3040		3120		3070		3010		3010			
	5	3220		2990		3070		3000		2810			
	median	*3050*		*3110*		*3070*		*3000*		*2910*		*2880*	
	mean	*3150*		*3070*		*3060*		*3000*		*2900*		*2880*	
	se	*78*		*38*		*29*		*33*		*56*		*90*	
Selenium													
	1	1.0		0.86		0.78		0.87		0.59		0.49	
	2	1.1		0.71		0.65		0.78		0.64		0.44	
	3	1.0		0.70		0.59		0.75		0.67			
	4	1.2		0.75		0.80		0.86		0.84			
	5	0.85		0.62		0.88		0.78		0.70			
	median	*1.0*		*0.71*		*0.78*		*0.78*		*0.67*		*0.46*	
	mean	*1.0*		*0.73*		*0.74*		*0.81*		*0.69*		*0.46*	
	se	*0.1*		*0.04*		*0.05*		*0.02*		*0.04*		*0.03*	
Silver													
	1	0.052	U	0.092	U	0.076	U	0.081	U	0.080	U	0.081	U
	2	0.055	U	0.081	U	0.077	U	0.078	U	0.078	U	0.084	U
	3	0.053	U	0.079	U	0.079	U	0.086	U	0.084	U		
	4	0.052	U	0.085	U	0.073	U	0.082	U	0.077	U		
	5	0.053	U	0.081	U	0.079	U	0.081	U	0.085	U		
	median	*0.053*		*0.081*		*0.077*		*0.081*		*0.080*		*0.082*	
	mean	*0.053*		*0.084*		*0.077*		*0.081*		*0.080*		*0.082*	
	se	*0.001*		*0.002*		*0.001*		*0.001*		*0.002*		*0.001*	
Sodium													
	1	742	J	677		762	JK	665	JK	720		791	JK
	2	732	J	687		692	JK	688	JK	809		690	
	3	648	J	657		674		657	JK	698			
	4	751	J	658		729		737	JK	707			
	5	722	J	690		700		642	JK	753	JK		
	median	*732*		*677*		*700*		*665*		*720*		*741*	
	mean	*719*		*674*		*711*		*678*		*737*		*741*	
	se	*18*		*7*		*15*		*17*		*20*		*51*	
Thallium													
	1	0.086	U	0.092	U	0.076	U	0.081	U	0.080	U	0.081	U
	2	0.092	U	0.081	U	0.077	U	0.078	U	0.078	U	0.084	U
	3	0.088	U	0.079	U	0.079	U	0.086	U	0.084	U		0
	4	0.087	U	0.085	U	0.073	U	0.082	U	0.077	U		0
	5	0.088	U	0.081	U	0.079	U	0.081	U	0.085	U		0
	median	*0.088*		*0.081*		*0.077*		*0.081*		*0.080*		*0.082*	
	mean	*0.088*		*0.084*		*0.077*		*0.081*		*0.080*		*0.082*	
	se	*0.001*		*0.002*		*0.001*		*0.001*		*0.002*		*0.001*	
Uranium													
	1	0.0096	0	0.0025	0	0.0047	0	0.0019	0	0.0025	0	0.0016	U
	2	0.012	0	0.0024	0	0.0023	0	0.0016	U	0.0031	0	0.0017	U
	3	0.0046	0	0.0022	0	0.0017	0	0.0017	U	0.0025	0		0
	4	0.0104	0	0.0022	0	0.0014	U	0.0021	0	0.0021	0		0
	5	0.0075	0	0.0018	0	0.0038	0	0.0017	0	0.0018	U		0
	median	*0.0096*		*0.0022*		*0.00227*		*0.00172*		*0.0025*		*0.0017*	
	mean	*0.0089*		*0.0022*		*0.0028*		*0.0018*		*0.0024*		*0.0017*	
	se	*0.0013*		*0.0001*		*0.0006*		*0.0001*		*0.0002*		*0.0000*	
Vanadium													
	1	0.14	U	0.15	U	0.12	U	0.13	U	0.14		0.13	U
	2	0.15	U	0.13	U	0.12	U	0.13	U	0.16		0.13	U
	3	0.14	U	0.13	U	0.12	U	0.14	U	0.14			
	4	0.14	U	0.14	U	0.11	U	0.13	U	0.12	U		
	5	0.14	U	0.13	U	0.13	U	0.13	U	0.14	U		
	median	*0.14*		*0.13*		*0.12*		*0.13*		*0.14*		*0.13*	
	mean	*0.14*		*0.13*		*0.12*		*0.13*		*0.14*		*0.13*	
	se	*0.00*		*0.00*		*0.00*		*0.00*		*0.01*		*0.00*	

Table B1-5. Summary of Analytical Data for Whitefish Species

		Mountain		Lake		Lake		Lake		Lake		Lake	
Whitefish	Collection Area	1		2		3		4		5		6	
species	River Mile	741		723		706		678		635		605	
	composite	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q	mg/kg ww	Q
Zinc													
	1	29	J	14	0	14	0	14	0	14	0	13	0
	2	32	J	12	0	13	0	12	0	14	0	12	0
	3	20	J	12	0	13	0	11	0	13	0		0
	4	28	J	12	0	14	0	12	0	12	0		0
	5	40	J	13	0	14	0	11	0	13	0		0
	median	*29*		*12*		*14*		*12*		*13*		*12*	
	mean	*30*		*13*		*14*		*12*		*13*		*12*	
	se	*3*		*0*		*0*		*1*		*0*		*0*	
Lipids													
%	1	7.6	0	13	0	7.8	0	11	0	10	0	13	0
	2	8.3	0	12	0	11	0	12	0	13	0	14	0
	3	8.9	0	11	0	12	0	15	0	14	0		0
	4	7.8	0	14	0	11	0	13	0	12	0		0
	5	10	0	1.4	0	6	0	12	0	16	0		0
	median	*8.3*		*12*		*11*		*12*		*13*		*13*	
	mean	*8.6*		*10*		*9.6*		*12*		*13*		*13*	
	se	*0.5*		*2*		*1*		*1*		*1*		*1*	
Age													
years	1	6.5		2.8		1.6		1.4		2.6		2	
	2	6.3		2.4		2		1.4		2.6		3.7	
	3	ND		2.8		2		2		2			
	4	ND		2.2		1.6		1.2		1.8			
	5	ND		2.4		2		1.6		2.4			
	median	*6.4*		*2.4*		*2*		*1.4*		*2.4*		*2.9*	
	mean	*6.4*		*2.5*		*1.8*		*1.5*		*2.3*		*2.9*	
	se	*0.1*		*0.1*		*0.1*		*0.1*		*0.2*		*0.9*	
Length													
mm	1	928		499		427		401		469		462	
	2	923		473		438		406		487		505	
	3	834		492		464		448		468			
	4	978		483		435		423		431			
	5	978		484		448		410		484			
	median	*928*		*484*		*438*		*410*		*469*		*483*	
	mean	*928*		*486*		*442*		*418*		*468*		*483*	
	se	*26*		*4*		*6*		*8*		*10*		*22*	
Weight													
g	1	422		1500		892		772		1170		1139	
	2	416		1106		970		800		1194		1523	
	3	407		1232		1144		1032		1108			
	4	423		1234		957		897		921			
	5	417		1342		1044		804		1253			
	median	*417*		*1234*		*970*		*804*		*1170*		*1331*	
	mean	*417*		*1280*		*1000*		*861*		*1130*		*1330*	
	se	*2.9*		*66*		*43*		*48*		*57*		*192*	

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

	Collection Area =	1		2	3		4	5	6	
	River Mile =	738		728	706		680	635	606	
Analyte	Composite									
Burbot (whole body)										
Lipids (%)	1	-		1.30	6.30		1.10	0.80	1.60	
	2	-		2.40	1.30		0.60	1.40	2.00	
	3	-		2.20	1.20		1.30	0.90	1.30	
	4	-		-	2.30		0.90	1.90	1.60	
	5	-		-	2.50		-	1.40	1.00	
2,3,7,8-TCDF (ng/kg-ww)	1	-		3.97	2.71		5.71	1.59	4.93	
	2	-		5.11	3.65		4.12	3.90	3.96	
	3	-		5.48	3.03		4.78	2.19	3.26	
	4	-		-	4.03		3.14	3.89	4.67	
	5	-		-	3.67		-	3.41	3.92	
2,3,7,8-TCDF (ng/kg lipid)	1	-		305.38	43.02		519.09	198.75	308.13	
	2	-		212.92	280.77		686.67	278.57	198.00	
	3	-		249.09	252.50		531.11	243.33	250.77	
	4	-		-	175.22		241.54	204.74	291.88	
	5	-		-	146.80		-	243.57	392.00	
Aroclor 1254/1260 (ug/kg-ww)	1	-		20.00	18.00		28.00	20.00	20.00	
	2	-		43.00	32.00		21.00	26.00	19.00	
	3	-		27.00	35.33		11.00	20.00	21.00	
	4	-		-	21.00		33.00	58.00	27.00	
	5	-		-	28.00		-	28.00	27.00	
Aroclor 1254/1260 (ug/kg lipid)	1	-		1538.46	285.71		2545.45	2500.00	1250.00	
	2	-		1791.67	2461.54		3500.00	1857.14	950.00	
	3	-		1227.27	2944.44		846.15	2222.22	1615.38	
	4	-		-	913.04		3666.67	3052.63	1687.50	
	5	-		-	1120.00		-	2000.00	2700.00	
Total PCB Congeners (ug/kg-ww)	1	-		27.89	26.68		14.87	22.96	24.78	
	2	-		-	-		-	-	-	
Total PCB Congeners (ug/kg lipid)	1	-		1267.67	2223.07		2478.74	1640.14	2477.58	
	2	-		-	-		-	-	-	
Walleye (whole body)										
Lipids (%)	1	2.94	E	2.10	3.68	E	2.70	3.10	3.30	
	2	2.54	E	2.20	2.51	E	3.00	3.60	3.50	
	3	1.29	E	2.60	3.11	E	3.50	3.00	2.27	E
	4	2.94	E	2.10	2.36	E	5.10	-	5.37	E
	5	1.21	E	2.27	3.65	E	4.00	-	3.53	E
	6	-		-	-		-	-	3.94	E
	7	-		-	-		-	-	3.07	E
2,3,7,8-TCDF (ng/kg-ww)	1	1.15	E	1.13	1.38	E	2.62	1.57	2.05	
	2	1.31	E	0.89	1.12	E	2.35	1.56	2.06	
	3	0.92	E	1.36	1.13	E	1.59	1.98	1.39	E
	4	1.01	E	1.27	1.37	E	2.37	-	2.79	E
	5	0.67	E	1.14	1.10	E	1.29	-	2.37	E
	6	-		-	-		-	-	2.06	E
	7	-		-	-		-	-	1.49	E
2,3,7,8-TCDF (ng/kg lipid)	1	168.86	E	53.81	50.78	E	97.04	50.65	62.12	
	2	106.15	E	40.45	63.03	E	78.33	43.33	58.86	
	3	171.28	E	52.31	54.02	E	45.43	66.00	70.21	E
	4	72.58	E	60.48	88.52	E	46.47	-	79.15	E
	5	110.62	E	50.29	48.75	E	32.25	-	108.62	E
	6	-		-			-	-	74.24	E
	7	-		-			-	-	77.25	E
Aroclor 1254/1260 (ug/kg-ww)	1	34.79	E	33.00	13.55	E	18.30	21.00	22.00	
	2	24.80	E	22.00	8.89	E	20.90	33.00	33.00	
	3	18.81	E	26.00	6.46	E	16.40	28.00	20.13	E

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

	Collection Area =	1		2	3		4	5	6	
	River Mile =	738		728	706		680	635	606	
Analyte	Composite									
	4	27.42	E	27.00	10.63	E	20.80	-	54.81	E
	5	19.17	E	47.67	11.59	E	16.50	-	27.53	E
	6	-		-	-		-	-	35.32	E
	7	-		-	-		-	-	27.69	E
Aroclor 1254/1260	1	2058.93	E	1571.43	380.03	E	677.78	677.42	666.67	
(ug/kg lipid)	2	1615.66	E	1000.00	499.36	E	696.67	916.67	942.86	
	3	2887.51	E	1000.00	343.75	E	468.57	933.33	653.56	E
	4	1622.93	E	1285.71	2120.70	E	407.84	-	803.55	E
	5	2956.06	E	2102.94	446.76	E	412.50	-	891.86	E
	6	-		-	-		-	-	839.18	E
	7	-		-	-		-	-	869.01	E
Total PCB Congeners	1	246.05	E	38.39	37.46	E	37.03	35.65	37.82	E
(ug/kg-ww)	2	3.70	E	-	-		-	-	-	
Total PCB Congeners	1	6545.75	E	1693.89	1464.19	E	726.11	990.41	1248.49	E
(ug/kg lipid)	2	3366.36	E	-	-		-	-	-	
Walleye (fillet)										
Lipids (%)	1	0.10		-	0.50		-	-	0.60	
	2	0.20		-	0.40		-	-	0.70	
	3	0.11		-	0.50		-	-	0.40	
	4	0.23		-	0.30		-	-	0.60	
	5	0.11		-	0.40		-	-	0.40	
2,3,7,8-TCDF	1	0.34	U	-	0.36		-	-	0.51	
(ng/kg-ww)	2	0.36	U	-	0.34	U	-	-	0.80	
	3	0.33	U	-	0.39		-	-	0.67	
	4	0.28	U	-	0.40		-	-	0.65	
	5	0.20	U	-	0.30	U	-	-	0.47	U
2,3,7,8-TCDF	1	338.00		-	72.80		-	-	84.67	
(ng/kg lipid)	2	177.50		-	85.50		-	-	113.71	
	3	300.00		-	77.00		-	-	167.50	
	4	120.00		-	134.67		-	-	108.00	
	5	185.45		-	74.50		-	-	117.00	
Aroclor 1254/1260	1	3.20		-	2.00		-	-	1.70	
(ug/kg-ww)	2	4.90		-	2.70		-	-	3.70	
	3	5.20		-	2.60		-	-	4.20	
	4	5.70		-	14.00		-	-	4.50	
	5	5.30		-	2.50		-	-	3.30	
Aroclor 1254/1260	1	3200.00		-	400.00		-	-	283.33	
(ug/kg lipid)	2	2450.00		-	675.00		-	-	528.57	
	3	4727.27		-	520.00		-	-	1050.00	
	4	2478.26		-	4666.67		-	-	750.00	
	5	4818.18		-	625.00		-	-	825.00	
Total PCB Congeners	1	9.81		-	5.73		-	-	6.00	
(ug/kg-ww)	2	8.27		-	-		-	-	-	
Total PCB Congeners	1	4266.61		-	1433.13		-	-	1498.87	
(ug/kg lipid)	2	7522.04		-	-		-	-	-	
Walleye (offal)										
Lipids (%)	1	5.20		-	5.90		-	-	3.70	
	2	4.50		-	4.60		-	-	9.60	
	3	2.30		-	5.50		-	-	6.00	
	4	5.30		-	3.90		-	-	6.50	
	5	2.10		-	6.30		-	-	5.30	
2,3,7,8-TCDF	1	1.79		-	2.09		-	-	2.14	
(ng/kg-ww)	2	2.10		-	1.88		-	-	4.60	
	3	1.42		-	1.81		-	-	3.72	
	4	1.65		-	2.10		-	-	3.14	

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

	Collection Area =	1		2	3		4	5	6	
	River Mile =	738		728	706		680	635	606	
Analyte	Composite									
	5	1.05		-	1.75		-	-	2.34	
2,3,7,8-TCDF	1	34.42			35.42				57.84	
(ng/kg lipid)	2	46.67			40.87				47.92	
	3	61.74			32.91				62.00	
	4	31.13			53.85				48.31	
	5	50.00			27.78				44.15	
Aroclor 1254/1260	1	59.90			21.60				35.90	
(ug/kg-ww)	2	41.40			15.00				101.00	
	3	30.40			10.00				46.00	
	4	46.40			8.10				59.00	
	5	30.40			19.00				48.00	
Aroclor 1254/1260	1	1151.92			366.10				970.27	
(ug/kg lipid)	2	920.00			326.09				1052.08	
	3	1321.74			181.82				766.67	
	4	875.47			207.69				907.69	
	5	1447.62			301.59				905.66	
Total PCB Congeners	1	452.49		-	68.76		-	-	63.02	
(ug/kg-ww)	2	-		-	-		-	-	-	
Total PCB Congeners	1	8537.46		-	1494.82		-	-	1050.26	
(ug/kg lipid)	2	-		-	-		-	-	-	
Wild Rainbow Trout (whole body)										
Lipids (%)	1	8.86	E	7.60	4.16	E	-	8.20	3.86	E
	2	6.58	E	10.70	5.24	E	-	-	-	
	3	6.54	E	9.87	-		-	-	-	
	4	5.76	E	6.70	-		-	-	-	
	5	7.69	E	4.80	-		-	-	-	
2,3,7,8-TCDF	1	3.39	E	2.25	1.03	E	-	1.84	0.97	E
(ng/kg-ww)	2	1.01	E	1.54	1.17	E	-	-	-	
	3	1.02	E	3.28	-		-	-	-	
	4	0.93	E	3.95	-		-	-	-	
	5	1.15	E	4.67	-		-	-	-	
2,3,7,8-TCDF	1	38.79	E	29.61	27.27	E	-	22.44	30.79	E
(ng/kg lipid)	2	16.10	E	14.39	24.55	E	-	-	-	
	3	15.72	E	33.21	-		-	-	-	
	4	15.34	E	58.96	-		-	-	-	
	5	14.73	E	97.29	-		-	-	-	
Aroclor 1254/1260	1	59.27	E	25.50	12.22	E	-	16.00	10.37	E
(ug/kg-ww)	2	35.15	E	27.90	12.17	E	-	-	-	
	3	25.82	E	30.37	-		-	-	-	
	4	22.56	E	34.30	-		-	-	-	
	5	27.39	E	24.00	-		-	-	-	
Aroclor 1254/1260	1	654.00	E	335.53	324.37	E	-	195.12	322.22	E
(ug/kg lipid)	2	603.45	E	260.75	255.23	E	-	-	-	
	3	425.92	E	307.77	-		-	-	-	
	4	406.87	E	511.94	-		-	-	-	
	5	387.75	E	500.00	-		-	-	-	
Total PCB Congeners	1	39.21	E	63.80	8.94	E	-	13.14	-	
(ug/kg-ww)	2	-		-	-		-	-	-	
Total PCB Congeners	1	646.12	E	952.24	227.05	E	-	160.25	-	
(ug/kg lipid)	2	-		-	-		-	-	-	
Wild Rainbow Trout (fillet)										
Lipids (%)	1	6.00		-	2.10		-	-	1.40	
	2	3.10		-	2.80		-	-	-	
	3	4.10		-	-		-	-	-	
	4	4.50		-	-		-	-	-	

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte	Collection Area = River Mile = Composite	1 738	2 728	3 706	4 680	5 635	6 606
	5	4.45	-	-	-	-	-
2,3,7,8-TCDF	1	2.42	-	0.68	-	-	0.56
(ng/kg-ww)	2	0.54	-	0.84	-	-	-
	3	0.66	-	-	-	-	-
	4	0.53	-	-	-	-	-
	5	0.63	-	-	-	-	-
2,3,7,8-TCDF	1	40.33	-	32.57	-	-	39.93
(ng/kg lipid)	2	17.52	-	30.11	-	-	-
	3	16.15	-	-	-	-	-
	4	11.87	-	-	-	-	-
	5	14.19	-	-	-	-	-
Aroclor 1254/1260	1	36.60	-	8.20	-	-	5.70
(ug/kg-ww)	2	23.00	-	8.80	-	-	-
	3	20.70	-	-	-	-	-
	4	21.30	-	-	-	-	-
	5	20.35	-	-	-	-	-
Aroclor 1254/1260	1	610.00	-	390.48	-	-	407.14
(ug/kg lipid)	2	741.94	-	314.29	-	-	-
	3	504.88	-	-	-	-	-
	4	473.33	-	-	-	-	-
	5	457.30	-	-	-	-	-
Total PCB Congeners	1	23.15	-	5.32	-	-	-
(ug/kg-ww)	2	-	-	-	-	-	-
Total PCB Congeners	1	746.63	-	253.51	-	-	-
(ug/kg lipid)	2	-	-	-	-	-	-
Wild Rainbow Trout (offal)							
Lipids (%)	1	11.90	-	6.10	-	-	6.30
	2	9.90	-	7.30	-	-	-
	3	9.10	-	-	-	-	-
	4	7.10	-	-	-	-	-
	5	11.20	-	-	-	-	-
2,3,7,8-TCDF	1	4.42	-	1.36	-	-	1.37
(ng/kg-ww)	2	1.46	-	1.45	-	-	-
	3	1.39	-	-	-	-	-
	4	1.35	-	-	-	-	-
	5	1.72	-	-	-	-	-
2,3,7,8-TCDF	1	37.14	-	22.30	-	-	21.75
(ng/kg lipid)	2	14.75	-	19.86	-	-	-
	3	15.27	-	-	-	-	-
	4	19.01	-	-	-	-	-
	5	15.31	-	-	-	-	-
Aroclor 1254/1260	1	83.40	-	16.00	-	-	15.00
(ug/kg-ww)	2	46.70	-	15.00	-	-	-
	3	31.20	-	-	-	-	-
	4	23.90	-	-	-	-	-
	5	35.00	-	-	-	-	-
Aroclor 1254/1260	1	700.84	-	262.30	-	-	238.10
(ug/kg lipid)	2	471.72	-	205.48	-	-	-
	3	342.86	-	-	-	-	-
	4	336.62	-	-	-	-	-
	5	312.50	-	-	-	-	-
Total PCB Congeners	1	54.50	-	12.33	-	-	-
(ug/kg-ww)	2	-	-	-	-	-	-
Total PCB Congeners	1	550.51	-	202.20	-	-	-
(ug/kg lipid)	2	-	-	-	-	-	-

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte	Collection Area = / River Mile = / Composite	1 / 738	2 / 728	3 / 706		4 / 680		5 / 635	6 / 606	
Hatchery Rainbow Trout (whole body)										
Lipids (%)	1	-	-	7.70	E	5.20		6.30	5.57	E
	2	-	-	3.40	E	5.20		6.50	5.45	E
	3	-	-	3.66	E	5.20		5.30	5.17	E
	4	-	-	-		4.90		5.20	5.34	E
	5	-	-	-		6.20		9.37	-	
2,3,7,8-TCDF (ng/kg-ww)	1	-	-	1.16	E	1.24	U	1.55	1.52	E
	2	-	-	0.97	E	1.41		1.40	1.36	E
	3	-	-	1.71	E	0.91		1.54	1.82	E
	4	-	-	-		1.25		0.97	0.97	E
	5	-	-	-		1.25		1.50	-	
2,3,7,8-TCDF (ng/kg lipid)	1	-	-	21.38	E	23.85		24.60	29.90	E
	2	-	-	29.91	E	27.12		21.54	26.04	E
	3	-	-	51.07	E	17.42		29.06	42.18	E
	4	-	-	-		25.51		18.65	17.67	E
	5	-	-	-		20.16		15.98	-	
Aroclor 1254/1260 (ug/kg-ww)	1	-	-	10.50	E	12.00		7.30	9.36	E
	2	-	-	7.20	E	7.60		9.20	13.51	E
	3	-	-	7.70	E	6.70		17.10	15.84	E
	4	-	-	-		7.40		6.30	10.66	E
	5	-	-	-		7.50		10.30	-	
Aroclor 1254/1260 (ug/kg lipid)	1	-	-	170.47	E	230.77		115.87	197.43	E
	2	-	-	223.79	E	146.15		141.54	294.89	E
	3	-	-	243.30	E	128.85		322.64	374.79	E
	4	-	-	-		151.02		121.15	223.52	E
	5	-	-	-		120.97		109.96	-	
Total PCB Congeners (ug/kg-ww)	1	-	-	15.60	E	11.26		9.10	17.29	E
	2	-	-	-		-		-	-	
Total PCB Congeners (ug/kg lipid)	1	-	-	429.29	E	229.89		97.18	354.45	E
	2	-	-	-		-		-	-	
Hatchery Rainbow Trout (fillet)										
Lipids (%)	1	-	-	11.00		-		-	2.75	
	2	-	-	2.00		-		-	2.50	
	3	-	-	1.90		-		-	2.20	
	4	-	-	-		-		-	2.20	
	5	-	-	-		-		-	-	
2,3,7,8-TCDF (ng/kg-ww)	1	-	-	0.73	U	-		-	0.93	U
	2	-	-	0.65		-		-	0.70	
	3	-	-	1.16		-		-	1.19	
	4	-	-	-		-		-	0.37	U
	5	-	-	-		-		-	-	
2,3,7,8-TCDF (ng/kg lipid)	1	-	-	6.61		-		-	33.96	
	2	-	-	32.65		-		-	27.88	
	3	-	-	61.05		-		-	54.09	
	4	-	-	-		-		-	16.91	
	5	-	-	-		-		-	-	
Aroclor 1254/1260 (ug/kg-ww)	1	-	-	10.00		-		-	6.65	
	2	-	-	5.00		-		-	9.40	
	3	-	-	6.10		-		-	10.80	
	4	-	-	-		-		-	5.70	
	5	-	-	-		-		-	-	
Aroclor 1254/1260 (ug/kg lipid)	1	-	-	90.91		-		-	241.82	
	2	-	-	250.00		-		-	376.00	
	3	-	-	321.05		-		-	490.91	
	4	-	-	-		-		-	259.09	

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte	Collection Area = River Mile = Composite	1 738		2 728	3 706		4 680	5 635	6 606
	5	-		-	-		-	-	-
Total PCB Congeners	1	-		-	8.28		-	-	8.54
(ug/kg-ww)	2	-		-	-		-	-	-
Total PCB Congeners	1	-		-	435.55		-	-	388.28
(ug/kg lipid)	2	-		-	-		-	-	-
Hatchery Rainbow Trout (offal)									
Lipids (%)	1	-		-	4.40		-	-	9.25
	2	-		-	5.00		-	-	8.60
	3	-		-	5.20		-	-	8.20
	4	-		-	-		-	-	8.90
	5	-		-	-		-	-	-
2,3,7,8-TCDF	1	-		-	1.59	U	-	-	2.28
(ng/kg-ww)	2	-		-	1.34		-	-	2.07
	3	-		-	2.20	U	-	-	2.46
	4	-		-	-		-	-	1.65
	5	-		-	-		-	-	-
2,3,7,8-TCDF	1	-		-	36.14		-	-	24.59
(ng/kg lipid)	2	-		-	26.80		-	-	24.07
	3	-		-	42.31		-	-	30.00
	4	-		-	-		-	-	18.54
	5	-		-	-		-	-	-
Aroclor 1254/1260	1	-		-	4.40		-	-	9.25
(ug/kg-ww)	2	-		-	5.00		-	-	8.60
	3	-		-	5.20		-	-	8.20
	4	-		-	-		-	-	8.90
	5	-		-	-		-	-	-
Aroclor 1254/1260	1	-		-	11.00		-	-	12.90
(ug/kg lipid)	2	-		-	9.70		-	-	17.90
	3	-		-	9.10		-	-	21.00
	4	-		-	-		-	-	16.30
	5	-		-	-		-	-	-
Total PCB Congeners	1	-		-	22.04		-	-	26.23
(ug/kg-ww)	2	-		-	-		-	-	-
Total PCB Congeners	1	-		-	423.79		-	-	319.87
(ug/kg lipid)	2	-		-	-		-	-	-
Whitefish (whole body)									
Lipids (%)	1	7.60		13.00	7.80		11.30	13.00	12.80
	2	8.30		12.00	11.33		11.70	13.50	14.00
	3	8.90		11.00	12.00		14.70	11.50	-
	4	7.83		14.00	10.90		12.80	15.80	-
	5	10.20		1.40	6.00		11.60	-	-
2,3,7,8-TCDF	1	4.28		4.93	2.12		5.26	7.76	7.35
(ng/kg-ww)	2	3.32		4.92	3.40		6.79	8.19	8.35
	3	6.00		4.55	3.46		7.45	7.02	-
	4	3.48		4.67	4.15		4.80	5.30	-
	5	2.58		3.56	3.04		6.87	6.96	-
2,3,7,8-TCDF	1	56.32		37.92	27.18		46.55	77.60	57.42
(ng/kg lipid)	2	40.00		41.00	29.97		58.03	63.00	59.64
	3	67.42		41.36	28.83		50.68	52.00	-
	4	44.43		33.36	38.07		37.50	46.09	-
	5	25.29		254.29	50.67		59.22	44.05	-
Aroclor 1254/1260	1	57.30		31.00	15.00		20.60	26.90	30.50
(ug/kg-ww)	2	49.00		14.90	20.95		13.70	48.00	38.00
	3	55.70		15.00	13.40		17.30	28.40	-
	4	45.35		15.00	9.50		11.00	21.80	-

Table B1-6. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

	Collection Area =	1	2	3	4	5	6
	River Mile =	738	728	706	680	635	606
Analyte	Composite						
	5	58.20	5.50	21.30	18.90	28.10	-
Aroclor 1254/1260	1	753.95	238.46	192.31	182.30	269.00	238.28
(ug/kg lipid)	2	590.36	124.17	184.85	117.09	369.23	271.43
	3	625.84	136.36	111.67	117.69	210.37	-
	4	578.94	107.14	87.16	85.94	189.57	-
	5	570.59	392.86	355.00	162.93	177.85	-
Total PCB Congeners	1	97.35	25.97	24.80	22.24	37.07	47.28
(ug/kg-ww)	2	-	-	-	-	-	-
Total PCB Congeners	1	1280.97	1854.83	218.82	190.12	322.38	369.34
(ug/kg lipid)	2	-	-	-	-	-	-
Largescale Sucker (whole body)							
Lipids (%)	1	5.80	3.50	5.70	4.10	4.60	8.30
	2	2.70	2.83	11.00	5.10	7.70	6.40
	3	4.00	3.60	4.30	7.50	8.10	6.60
	4	-	5.30	3.10	6.40	10.50	8.30
	5	-	-	-	5.20	6.70	-
2,3,7,8-TCDF	1	0.92	1.60	1.90	2.57	3.83	6.52
(ng/kg-ww)	2	1.53	6.39	3.12	3.73	3.72	5.63
	3	1.22	11.50	1.57	4.28	3.45	3.71
	4	-	2.33	1.93	3.92	5.44	4.70
	5	-	-	-	3.35	3.54	-
2,3,7,8-TCDF	1	15.79	45.71	33.33	62.68	83.26	78.55
(ng/kg lipid)	2	56.67	225.41	28.36	73.14	48.31	87.97
	3	30.50	319.44	36.51	57.07	42.59	56.21
	4	-	43.96	62.26	61.25	51.81	56.63
	5	-	-	-	64.42	52.84	-
Aroclor 1254/1260	1	55.00	40.00	31.00	126.00	102.00	103.00
(ug/kg-ww)	2	89.00	80.00	56.00	73.00	123.00	146.00
	3	58.00	419.00	61.00	142.00	154.00	79.33
	4	-	74.00	68.00	76.00	164.00	87.00
	5	-	-	-	154.00	93.00	-
Aroclor 1254/1260	1	948.28	1142.86	543.86	3073.17	2217.39	1240.96
(ug/kg lipid)	2	3296.30	2823.53	509.09	1431.37	1597.40	2281.25
	3	1450.00	11638.89	1418.60	1893.33	1901.23	1202.02
	4	-	1396.23	2193.55	1187.50	1561.90	1048.19
	5	-	-	-	2961.54	1388.06	-
Total PCB Congeners	1	104.96	126.86	108.81	152.31	133.85	172.39
(ug/kg-ww)	2	-	-	-	-	-	-
Total PCB Congeners	1	3887.52	2393.65	989.16	2929.10	1738.31	2693.54
(ug/kg lipid)	2	-	-	-	-	-	-

" - " = No data collected
E = Estimated from fillet and offal tissues.
U = Not-detected