DEPARTMENT OF ECOLOGY
State of Washington

Addendum 1
Quality Assurance Project Plan

Freshwater Fish Contaminant Monitoring Program, 2019

August 2021

Publication 21-03-114

Publication Information

This Quality Assurance Project Plan Addendum is on the Department of Ecology's website at https://apps.ecology.wa.gov/publications/SummaryPages/2103114.html. This is an addition to an original Quality Assurance Project Plan. It is not a correction (errata) to the original plan.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at EIM Database. Search Study ID FFCMP19.

Activity Tracker code
Ecology's Activity Tracker code for this addendum is 02-500.

Original Publication
Seiders, K. and P. Sandvik, 2020. Quality Assurance Project Plan: Freshwater Fish Contaminant Monitoring Program. Publication 20-03-106.
https://apps.ecology.wa.gov/publications/SummaryPages/2003106.html.

Contact Information

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: 360-407-6764

Washington State Department of Ecology – ecology.wa.gov

Headquarters, Olympia	360-407-6000
Northwest Regional Office, Bellevue	425-649-7000
Southwest Regional Office, Olympia	360-407-6300
Central Regional Office, Union Gap	509-575-2490
Eastern Regional Office, Spokane	509-329-3400

Addendum 1 to
Quality Assurance Project Plan

Freshwater Fish Contaminant Monitoring Program, 2019

by Keith Seiders

August 2021

Approved by:

Signature:	Date:
Jessica Archer, Client and Author's Section Manager, EAP	
Signature:	Date:
Keith Seiders, Author / Project Manager, TSU, EAP	
Signature:	Date:
Jim Medlen, Author's Supervisor (acting), TSU, EAP	
Signature:	Date:
Adriane Borgias, Supervisor, ERO, WQP	
Signature:	Date:
Chad Atkins, Supervisor, ERO, Watershed Unit, WQP	
Signature:	Date:
George Onwumere, Supervisor, Eastern Operations Section, EAP	
Signature	Date:
Alan Rue, Director, Manchester Environmental Laboratory	
Signature:	Date:
Arati Kaza, Ecology Quality Assurance Officer	

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
ERO: Eastern Regional Office
TSU: Toxics Studies Unit, EAP
WQP: Water Quality Program

1.0 Table of Contents

The numbered headings in this document correspond to the headings used in the original QAPP. Only relevant sections are included; therefore, some numbered headings are missing.

List of Figures

List of Tables

2.0 Abstract

Fish tissue sampling efforts in the Snake River basin from the 1980s into the 2000s were part of national and statewide screening-level studies for various contaminants. Target analytes included: chlorinated pesticides (CPs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs), mercury, and polybrominated diphenyl ethers (PBDEs) flame retardants.

Results from previous studies showed that concentrations of ten chemicals in fish tissue did not meet Washington State's water quality standards. During Ecology's 2014 Water Quality Assessment, these findings resulted in 37 Clean Water Act Section 303(d) listings (Ecology Category 5 listings) across eight segments of the river. The elevated levels of contaminants in fish tissue present risks to humans and wildlife that consume Snake River fish.

The goal of this 2019 sampling is to characterize the extent and magnitude of contaminants in fish within the mainstem Snake River. Results will be used to evaluate temporal trends in fish contaminant levels and inform resource managers about potential risks to human health from eating contaminated fish.

This document is an addendum to the most recent Quality Assurance Project Plan (Seiders and Sandvik, 2020) and focuses on the 2019 sampling work for the Snake River.

3.0 Background

This document is an addendum to the most recent programmatic QAPP (Seiders and Sandvik, 2020) for Washington State Department of Ecology's (Ecology) Freshwater Fish Contaminant Monitoring Program (FFCMP). This document gives specific details about the 2019 sampling in the Snake River and addresses only those sections in Ecology's current QAPP format where such detail is needed.

3.1 Introduction and problem statement

Fish tissue sampling studies in the Snake River basin from the 1980s into the 2000s were part of national and statewide screening-level studies for various contaminants. During Ecology's 2016 Water Quality Assessment, these findings resulted in 37 Clean Water Act Section 303(d) listings across eight segments of the river. Elevated levels of contaminants in fish tissue present risks to humans and wildlife that consume Snake River fish. The Washington Department of Health has issued advisories for mercury in several species from Lower Granite Dam to Clarkston as well as for mercury in bass and northern pikeminnow in the Snake River and all other state waters (Health, 2018).

The 303(d) listings are also known as Category 5 listings in Ecology's periodic statewide Water Quality Assessment: https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d.

3.2 Study area and surroundings

The Snake River drainage basin encompasses 92,960 square miles, or about 36 percent of the area of the Columbia River Basin. Flowing for nearly 1,100 miles, the Snake River is the largest tributary of the Columbia River and accounts for about 19 percent of the Columbia's annual discharge into the ocean.

The mainstem Snake River has 22 hydropower facilities, 15 in Idaho, three on the Idaho/Oregon border, and four in Washington (NPCC, 2019). These dams provide water for irrigation and for agricultural use, municipal, industrial, and domestic uses, recreation, and habitat for fish and wildlife.

These uses have led to various problems affecting water quality, such as: hydrologic modifications, high water temperatures, nutrient pollution, and contamination by various toxic chemicals such as pesticides, PCBs, mercury, and dioxins/furans.

3.2.2 Summary of previous studies and existing data

Six fish tissue monitoring studies have been conducted since the 1980s. When viewed collectively, these historical efforts reveal a patchwork of sites, species, tissue types, collection seasons, target analytes, and analytical methods. The earliest studies (Beak Consultants, 1989; EPA, 1992) focused on environmental contamination by dioxins/furans which were inadvertently produced during pulp and paper manufacturing processes. Studies conducted in the 1990s (Davis and Serdar, 1996; EPA, 2002) analyzed fish tissue for broader suites of contaminants, especially chlorinated pesticides and PCBs.

Sampling in the 2000s was increased in order to address concerns about the extent and magnitude of toxic contaminants in fish tissue across the state. Snake River sampling in 2004 and 2005 (Seiders, et al., 2007) expanded on Ecology's 1994 (Davis and Serdar, 1996) sampling by adding more sites, species, and contaminants such as dioxin/furans and PBDE flame retardants.

In 2009, the Snake River basin was chosen to be included in a long-term monitoring program to track temporal trends of contaminants in fish. Sampling in 2009 obtained multiple composite samples of various species at different sites in order to create a baseline data set for future reference (Seiders et al., 2011).

Table 1 summarizes these sampling efforts by showing sampling years, locations, and species for studies conducted in the Snake River. Fish species codes used in tables and figures are given in Appendix A, with the exception of LSSf (largescale sucker analyzed as fillets) and LSSw (largescale sucker analyzed as whole fish).

Figures B1-B10 in Appendix B show results from historical studies for parameters of greatest concern. Most of the results are from fillet samples, with the exception of whole largescale suckers (LSSw) used in some studies. The vertical axis (concentration) in Figures B1-B10 are plotted using log scale. The x-axis identifies each sample by providing a code with the following information:

- The river mile (RM) and name of the sample collection area. Two graphs are used for some parameters, showing results for the lower and upper river segments within Washington.
- A fish species code and year of sample collection (e.g. 'CAT-2009' = channel catfish collected in 2009).

Figures B1-B10 also display thresholds for the protection of human health using horizontal lines. Thresholds include TECc and TECn which stand for Tissue Exposure Concentration: the "c" and "n" denoting whether the health effects are carcinogenic or non-carcinogenic. The TECs are part of Ecology's Water Quality Program Policy 1-11 which is used to implement Washington's water quality standards (Chapter 173-201A WAC). Also shown are Washington Department of Health's Fish Consumption Advisory Screening Levels (FCASL) for low and high consumption rates ("LoFCR" and "HiFCR", respectively).

Examination of the figures show two important characteristics that were used in designing the 2019 sampling plan:

- There is high variability across species, sites, and years. Closer examination of past results also reveal high sampling variability for field replicates of the same species and same site in the 2009 study.
- Many samples did not meet Washington's water quality standards for the protection of human health: these samples contributed to multiple 303(d) listings during Washington's past Water Quality Assessments.

Table 1. Number of tissue composite samples from the Snake River by study, site, and species.

Location Description	Species	Number of composite samples by study and year					
		NSCRF 1987 [1]	Beak 1987 [2]	WSPMP 1994 [3]	CRITFC 1997-98 [4]	WSTMP 2004/5 [5]	WSTMP 2009 [6]
above Clarkston	LSSw	1					
	SMB	1					
below Clarkston (to Steptoe Creek)	BG						3
	CCP						1
	LMB					1	3
	LSSw				3		
	MWF					1	
	PEA					1	
	PMP						1
	SMB						3
	WST				3i		
below Steptoe Creek	LSSf				3		
below Lower Granite Dam	CAT						3
	CCP						2
	MWF						2
	NPM						3
Central Ferry	BG						1
	CAT					1	3
	CCP						3
	LMB					1	
	PEA					1	1
	PMP						1
	SMB						3
	YP					1	
below Lyon's Ferry	CAT						2
	CCP						3
below Lower Monumental Dam	CAT					1	3
	NPM						1
	PEA						3
	SMB						2
above Ice Harbor Dam	CAT			1			3
	CCP					1	
	LMB						1
	LSSw			1			
	NPM						1
	PEA					1	3
	SMB						3
	YP					1	2
below Ice Harbor Dam	CCP		n				
	WST		n				

Notes: All samples were fillet tissue except some largescale suckers which are designated as “LSSw”. The “LSSf” indicates that these largescale sucker samples were from fillet tissue. The “3i” indicates that these were samples of individual fish, rather than composites of multiple fish each. The “n” indicates that the number of samples is unknown.

Study codes: NSCRF: National Study of Chemical Residues in Fish; Beak: Beak Consultants; WSPMP - Washington State Pesticide Monitoring Program; CRITIFC - Columbia River Inter-Tribal Fish Contaminant Survey; WSTMP - Washington State Toxics Monitoring Program.

References: 1 - EPA, 1992; 2 - Beak Consultants, 1989; 3 - Davis and Serdar, 1996;
4 - EPA, 2002; 5 - Seiders et al., 2007; 6 - Seiders et al., 2011.

3.2.3 Parameters of interest and potential sources

The primary target analytes for long term trend assessment are DDT and its metabolites DDD and DDE, PCBs, mercury, and polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs). Contaminants of interest also include other chlorinated pesticides and polybrominated diphenyl ethers (PBDEs). Chlorinated pesticides are of particular interest because of associated 303(d) listings, which include: chlordanes, dieldrin, hexachlorobenzene, and toxaphene. Potential sources for parameters of interest are given in Table 2.

Table 2. Pollutants and their potential sources in the Snake River basin.

Pollutant	Potential Source
Dioxins/Furans	Pulp and paper mills (historically), incinerators, fires
PCBs	Electrical transformers, hydraulic fluids, caulks
DDT and metabolites	Agriculture, soil erosion
Dieldrin	Agriculture, soil erosion
Chlordanes	Agriculture, soil erosion
Toxaphene	Agriculture, soil erosion
Mercury	Gold mining, coal-fired power plants and other fossil fuels
Flame retardants	Furniture, plastics in consumer products

3.2.4 Regulatory criteria or standards

Water quality standards and the Water Quality Assessment process are described in the programmatic QAPP for the FFCMP (Seiders and Sandvik, 2020). The most recent statewide Water Quality Assessment was approved by EPA in 2016 (https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d/EPA-approved-assessment) and resulted in 47 Category 5, 4A, or 2 listings for ten toxic pollutants in the Snake River mainstem (Table 3).

There has been no TMDL (Water Cleanup Plan) in Washington's part of the Snake River basin for toxic contaminants, with one exception. In 1991, EPA established a TMDL for 2,3,7,8-TCDD (EPA, 1991) because water quality standards were not being met in the Columbia, Snake, and Willamette Rivers. The states of Washington, Oregon, and Idaho requested that EPA establish this TMDL as a federal action to help address multi-state consistency concerns.

The human health water quality standard for mercury is based on methylmercury, the toxic and bioaccumulative form of mercury in fish tissue. More than 95% of the total mercury in fish fillet tissue is methylmercury where it is associated with muscle proteins (Bloom, 1995; Driscoll et al., 1994). Ecology continues to use results from total mercury analyses for comparison to water quality standards because nearly all of the total mercury in fish is methylmercury and it is easier and less costly to analyze total mercury as compared to methylmercury. Total mercury was the target analyte used in other fish tissue studies in Washington and in past water quality assessments.

Table 3. Category 5, 4A, and 2 listings for fish tissue from the Snake River.

Location Description	RM start	RM end	Total RMs	Assessment Unit ID	Listing ID	WQA Category 2014	Parameter	Species contributing to WQA listing								
								CAT	CCP	LMB	LSS	MWF	NPM	PEA	SMB	WST
above Clarkston	139.2	150.3	11.1	170601030307_01_01	8839	4A	Dioxin				x				x	
below Clarkston (to Steptoe Creek)	128.2	139.2	11.0	170601070201_01_01	51580	5*	2,3,7,8-TCDD (Dioxin)		x							
					51634	2	2,3,7,8-TCDD TEQ		x			x				
					19018	5	4,4'-DDE				x					
					19052	2	Chlordane				x					x
					52064	5	Dieldrin		x					x		
					34871	4A	Dioxin									x
					19121	5	PCBs				x					
					52819	5	Toxaphene		x							
below Steptoe Creek	115.8	128.2	12.4	170601070203_01_01	19017	5	4,4'-DDE				x					
					34942	5*	Dioxin				x					
					19120	5	PCBs				x					
below Lower Granite Dam	91.7	107.3	15.6	170601070802_01_01	78510	5*	2,3,7,8-TCDD (Dioxin)	x	x							
					78613	2	2,3,7,8-TCDD TEQ	x	x			x	x			
					72217	5	4,4'-DDE	x	x			x	x			
					76267	5	Dieldrin	x	x			x				
					79521	5	Mercury						x			
					78963	5	PCBs	x	x			x	x			
					76525	5	Toxaphene	x	x			x	x			
Central Ferry	77.9	91.7	13.8	170601070804_01_01	51582	5*	2,3,7,8-TCDD (Dioxin)	x	x							
					51635	2	2,3,7,8-TCDD TEQ	x	x							
					51761	5	4,4'-DDE	x	x							
					52760	5	Chlordane	x								
					52065	5	Dieldrin	x	x							
					52697	5	PCBs	x	x	x				x		
					52820	5	Toxaphene	x	x							

Table 3 continued on next page

Location Description	RM start	RM end	Total RMs	Assessment Unit ID	Listing ID	WQA Category 2014	Parameter	Species contributing to WQA listing								
								CAT	CCP	LMB	LSS	MWF	NPM	PEA	SMB	WST
below Lyon's Ferry	51.8	59.5	7.7	1706011001 02_01_01	78620	5*	2,3,7,8-TCDD (Dioxin)	x	x							
					78572	2	2,3,7,8-TCDD TEQ	x	x							
					72219	5	4,4'-DDE	x	x							
					76319	5	Dieldrin	x	x							
					75612	5	Hexachlorobenzene		x							
					78962	5	PCBs	x	x							
					76531	5	Toxaphene	x	x							
below Lower Monumental Dam	29.0	41.6	12.6	1706011001 06_01_01	51581	5*	2,3,7,8-TCDD (Dioxin)	x								
					51633	2	2,3,7,8-TCDD TEQ	x					x			
					51698	5	4,4'-DDD	x								
					51759	5	4,4'-DDE	x								
					52759	5	Chlordane	x								
					52063	5	Dieldrin	x								
					52695	5	PCBs	x					x*	x*	x*	
					52821	5	Toxaphene	x					x*			
above Ice Harbor Dam	9.8	21.2	11.4	1706011004 03_01_01	51583	5*	2,3,7,8-TCDD (Dioxin)	x	x							
					51636	2	2,3,7,8-TCDD TEQ	x	x				x			
					8753	5	4,4'-DDE	x	x				x	x		
					8752	5	Dieldrin	x					x			
					8755	5	PCBs	x								
below Ice Harbor Dam	0.3	9.8	9.5	1706011004 04_01_01	8814	4A	Dioxin		x							x
Sum of species in listings:								32	27	1	7	6	9	3	1	3

5* = May qualify for a Cat 4A listing because of EPA's Dioxin TMDL: as is the case for other Cat 4A listings for Dioxin (n=3).

x* = Species whose 2009 sampling results suggest water quality standards for the parameter were not met: the Basis Statement in the associated listings refer to the results from 2004 only: the listings exclude results from 2009 for unknown reasons.

4.0 Project Description

4.1 Project goals

The goal of the 2019 monitoring in the Snake River is to develop a data set of contaminant concentrations in fish in order to meet the objectives described below.

4.2 Project objectives

- Characterize temporal trends by comparisons to historical and future data.
- Characterize spatial trends by comparisons among different sections of the river.
- Compare results to water quality standards.
- Support fish consumption risk assessments conducted by health jurisdictions.
- Inform current and future water quality improvement studies.

These objectives will be met by collecting various fish species from different sites and in adequate numbers and sizes. The Study Design section below describes sampling strategies and target numbers of fish that will allow us to meet multiple objectives.

4.3 Information needed and sources

Historical data and information are needed for this 2019 focus on the Snake River. Previous studies (described above) and associated data were obtained from Ecology project files, Ecology's EIM database, and reports from other entities. All information was reviewed to guide development of project objectives and the sampling plan. Contaminants assessed in fish from previous studies focused mainly on CPs and PCBs. Limited sampling has been done for other contaminants, such as PCDD/Fs and PBDEs. This project will use data collected through past monitoring studies conducted by Ecology and others to characterize temporal trends.

5.0 Organization and Schedule

5.3 Organization chart

Table 4 lists organizations that may be involved with this study.

Table 4. List of organizations that may be involved with sampling, FFCMP 2019.

Organization	Role	Persons
Ecology WQP HQ	Water Quality Program: Watershed Management Section	Melissa Gildersleeve, Chad Brown, Benjamin Rau
Ecology WQP ERO	Regional WQ Program staff: watershed and TMDL leads,	Adriane Borgias (ERO)
Ecology EAP Region	Regional EAP staff: liaison with regional staff, field support	George Onwumere (CRO)
Ecology HQ	Agency Liaison to Tribes: awareness of monitoring activities	Tyson, Oreiro
WDFW HQ	Fish Age Lab: fish age determination	Andrew Claiborne
WDFW HQ	Scientific Collection Permits	Bruce Baker, others at ScientificCollection.Permits @dfw.wa.gov
WDFW District 3	Fish Program Biologists: local knowledge, sampling permissions, possible collaboration	Jeremy Trump
NOAA	Scientific Collection Permits	Claire McGrath, Mitch Dennis
USFWS	Scientific Collection Permits, local biologist liaison, possible collaboration	Jeffery Chan, Erin Britton-Kuttel
NPS	Scientific Collection Permits, local biologist liaison, possible collaboration	Matthew Dubeau
WDOH	Uses FFCMP data to conducts risk assessments for Fish Consumption Advisories	Dave McBride
WCC and CDs	WCC and CD staff: possible collaboration	Not specified
Tribes	Tribal Leadership Councils: permission to sample as needed, possible collaboration	Not specified
Local Government	Local governments: counties, cities, PUDs, special districts: permissions to sample as needed	Not specified
Private Citizens	Private citizens and businesses: permissions to sample as needed	Not specified
USACOE, BOR, PUDs, Private Corporations	Operators of dams: need notify them of our field activities near dams and related structures	multiple
Law Enforcement	Law Enforcement: notifications of field work	multiple

5.4 Proposed project schedule

Table 5 lists the schedule for completing this study.

Table 5. Schedule for completing field, laboratory, and report tasks, FFCMP 2019.

Field and laboratory work	Due date	Lead staff
Field work completed	December 2019	Patti Sandvik
Sample processing completed	February 2020	Patti Sandvik
Ecology lab results delivered	December 2020	Alan Rue, MEL
Contract lab results delivered	October 2020	Alan Rue, MEL
Environmental Information System (EIM) database		
EIM user study ID	FFCMP19	
Product	Due date	Lead staff
EIM data loaded [1]	February 2021	Patti Sandvik
EIM data verification [2]	March 2021	To be determined
EIM complete [3]	April 2021	Patti Sandvik
Final report		
Author lead / Support staff	Keith Seiders / Patti Sandvik	
Schedule		
Draft due to supervisor	April 2021	
Draft due to client/peer reviewer	May 2021	
Draft due to external reviewer(s)	May 2021	
Final due to publications team	June 2021	
Final report due on web	July 2021	

[1] All data entered into EIM by the lead person for this task.

[2] Data verified to be entered correctly by a different person; any data entry issues identified. Allow one month.

[3] All data entry issues identified in the previous step are fixed (usually by the original entry person); EIM Data Entry Review Form signed off and submitted to EIM coordinator (Melissa Petersen, who then enters the *EIM Completed* date into Activity Tracker; allow one month for this step). The final EIM completion date is usually targeted to be no later than the final report publication date.

5.5 Budget and funding

This project is funded by the Environmental Assessment Program. About 1.5 FTE are assigned to the project. Laboratory analytical costs are estimated at approximately $83,000. Section 7.2.1 below details the laboratory costs for sample analyses.

7.0 Study Design

7.1 Study boundaries

The study boundaries are within the mainstem of the Snake River between Ice Harbor Dam and the town of Asotin, WA. Figure 1 shows the target locations in the Snake River for the 2019 sampling.

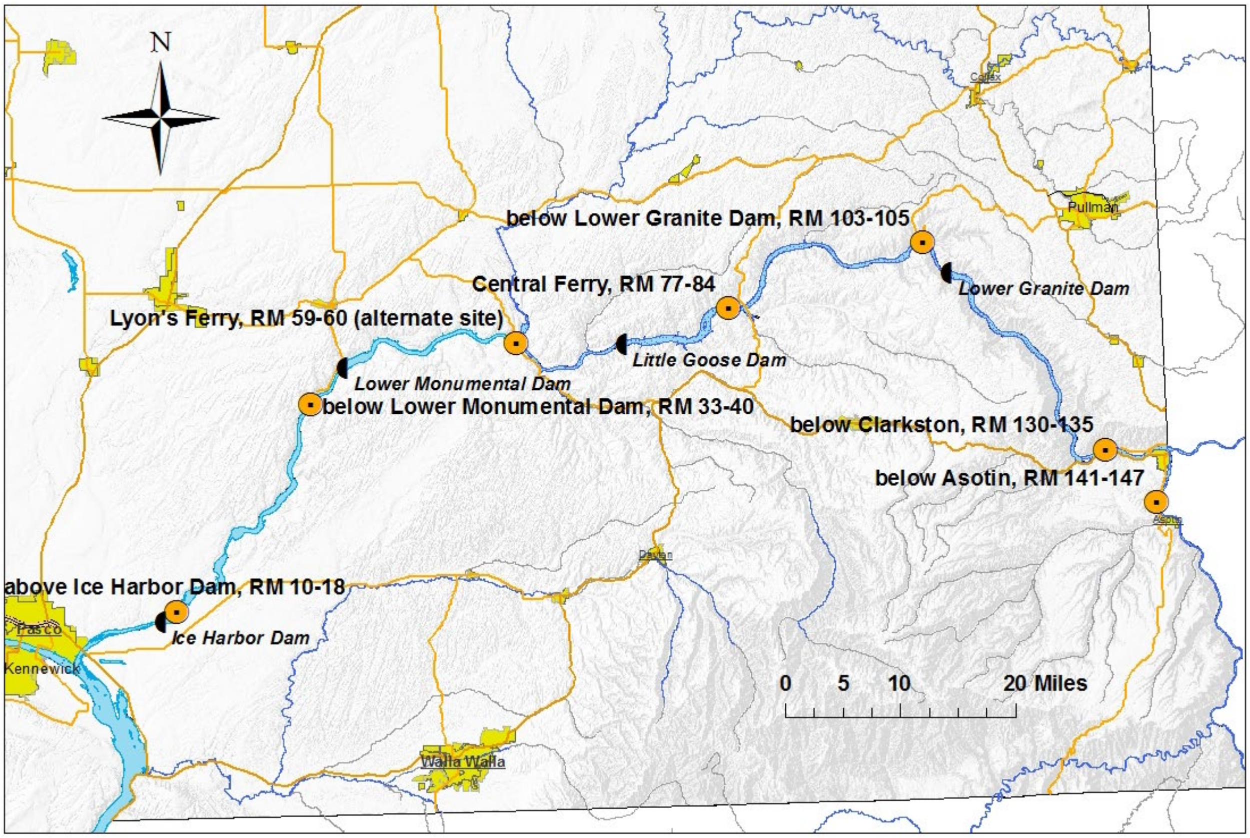

Figure 1. Fish collection sites in the Snake River for FFCMP 2019.

7.2 Field data collection

7.2.1 Sampling strategy, frequency, and locations

Strategy

The sampling strategy used a subjective best-professional-judgement approach to select the locations, season, species, tissue type (i.e. fillet or whole), fish size, and sample sizes to best meet the objectives for long term trends, water quality standards comparisons, and health risk assessments.

The selection of sites, species, fish size, and tissue type for the 2019 sampling was largely determined by historical sampling, particularly the 2009 (Seiders, et al., 2011) work; this was the broadest study in terms of spatial coverage and variety of species and target analytes. Species that were most often collected in previous studies and had fillet tissue analyzed are targeted for this study. These species include common carp, channel catfish, smallmouth bass, largemouth bass, peamouth, mountain whitefish, and northern pikeminnow. Largescale suckers will also be collected in order to create a baseline for future sampling and for comparisons to data from other statewide studies; these fish will be analyzed as whole fish. The target size range for each species at each site was determined by considering the size ranges used in past studies as well as the legal size limits for recreational fishers.

Sample Size

Generally, the sample size needed to detect a given change is dependent upon the sample variance and the statistical parameters of the test (Fabrizio, et al., 1995; Zar, 1984). The number of samples that are needed to see the Minimum Detectable Change (MDC) between two data sets using a two-sample test (e.g. student's t-test) were estimated using power analyses as described in Zar (1984). Two analytes, DDE and PCBs, were the focus of these analyses because they are of greatest interest for temporal trends and had some of the highest variabilities of target analytes.

Sample size estimates were conducted for DDE and PCBs in two species (channel catfish and common carp) from several sites sampled in 2009. For these cases, we set the significance level (alpha) to 0.05 and power (B-1) to 0.8. A series of calculations were made using historical sample variance and different MDCs: the results from these were plotted to show the sample sizes needed for given MDCs. These plots were then used to help determine the sampling strategy for 2019.

Figure 2 is an example of one of these estimates for DDE in catfish from the Ice harbor Dam site (Lake Sacajawea). The curve in Figure 2 shows that a sample size of 7 should be adequate to detect a difference of about 170 ppb of DDE. With the 2009 average concentration of 289 ppb, 7 samples may allow us to detect a difference from a mean of 289 ppb to a mean of 119 ppb.

The 2019 sampling aims to collect fish of the same species and size ranges that were collected in the past, especially in 2009. Actual numbers of samples to be analyzed may be adjusted depending on success of fish collection efforts; past FFCMP studies have met about 60-80% of the target number of fish. If target species are not found in desired numbers or size ranges, the size ranges for each site and species may be adjusted in order to obtain sufficient numbers of fish to improve site representativeness and comparability.

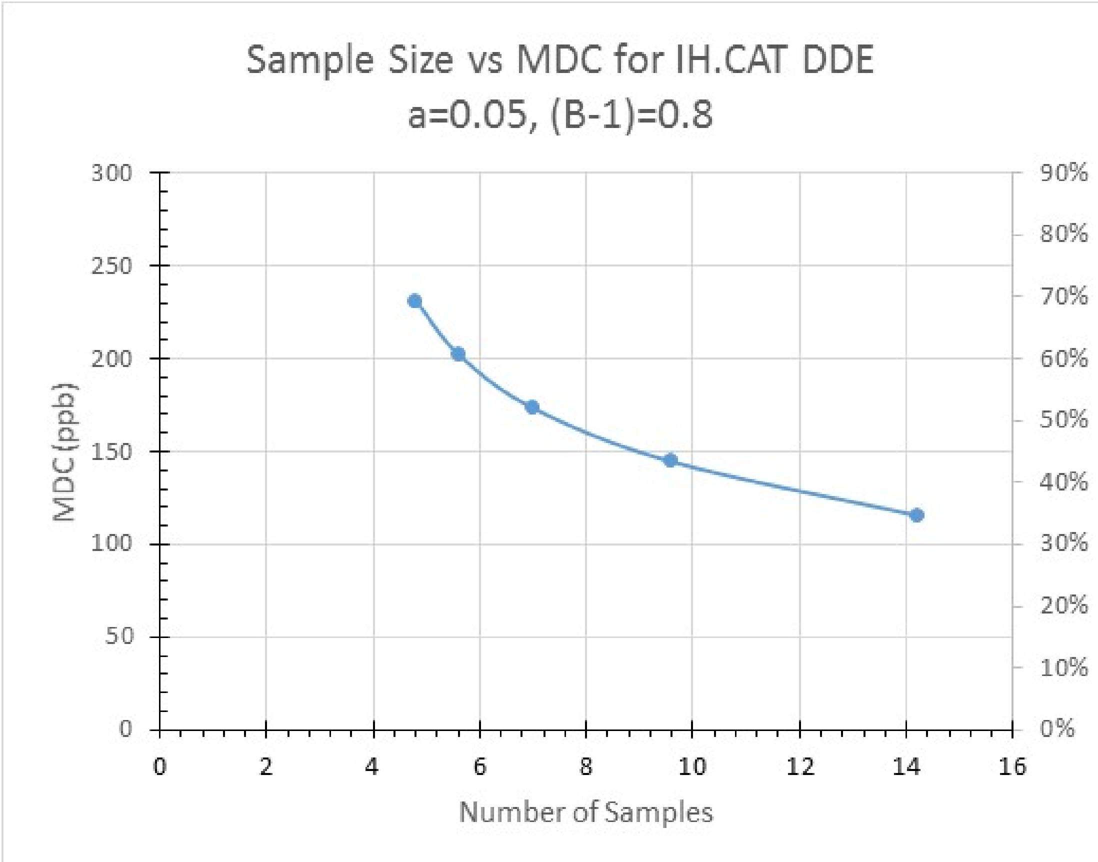

Figure 2. Sample size estimates and MDCs for DDE in catfish from Ice Harbor Dam site.

Table 6 shows the sampling plan with sites, target species, target number of analyses of composite samples for each suite of analyses, and estimated laboratory costs.

Table 6. Sampling plan and estimated laboratory costs, FFCMP 2019.

Sample Location	Site Code	Target Species	Target # Samples	Number of Analyses			
				Hg	3DDx, 3PCB, Lipid	Pest, PCB, PBDE, Lipid	PCDD/Fs
Asotin to Clarkston	AS	LSSw	5	3	2	3	3
		PEA	3	3		3	
		SMB	3	3		3	
Clarkston (below city)	CT	LMB	3	3	3		
		LSSw	5	3	2	3	3
		PEA	3	3	3		
		SMB	3	3	3		
Lower Granite (below dam)	LG	CAT	7	3	4	3	5
		CCP	7	3	4	3	3
		LSSw	5	3	2	3	
		MWF	3	3		3	
		NPM	3	3		3	
Central Ferry	CF	CAT	7	3	4	3	5
		CCP	7	3	4	3	3
		LSSw	5	3	2	3	
		PEA	3	3		3	
		SMB	3	3	3		
Lower Monumental (below dam)	LM	CAT	7	3	4	3	5
		LSSw	5	3	2	3	
		PEA	3	3	3		
		SMB	3	3	3		
Ice Harbor (above dam)	IH	CAT	7	3	4	3	5
		LSSw	5	3	2	3	
		PEA	3	3		3	
		SMB	3	3	3		
Total # field sample analyses			111	75	57	54	32
Total # lab QC analyses			23	8	6	6	3
Total # analyses			241	83	63	60	35
Cost per analysis				$50	$300	$620	$650
Subtotal costs				$4,150	$18,900	$37,200	$22,750
Total analytical cost			**$83,000**				

Table 7 shows the historical and target fish size range for each species at each site. The target number of individual fish per species at each site is based on using 5 individual fish per composite sample. If desired numbers of fish are low, 3 fish per composite sample could be acceptable.

Table 7. Target numbers and size ranges for Snake River fish, FFCMP 2019.

Sample Location	Site Code	Target Species	Target # Samples	# Fish Needed	Target Total Length (mm)	Historical Total Length (mm)
Asotin to Clarkston	AS	LSSw	5	25	400-500	-
		PEA	3	15	280-310	-
		SMB	3	15	230-310	-
Clarkston (below city)	CT	LMB	3	15	270-360	291-353
		LSSw	5	25	400-500	-
		PEA	3	15	280-310	-
		SMB	3	15	260-340	295-314
Lower Granite (below dam)	LG	CAT	7	35	480-590	515-547
		CCP	7	35	600-700	631-645
		LSSw	5	25	400-500	-
		MWF	3	15	230-300	260-280
		NPM	3	15	300-400	354-369
Central Ferry	CF	CAT	7	35	480-590	547-569
		CCP	7	35	600-700	611-696
		LSSw	5	25	400-500	-
		PEA	3	15	280-310	298
		SMB	3	15	230-310	237-346
Lower Monumental (below dam)	LM	CAT	7	35	450-570	468-513
		LSSw	5	25	400-500	-
		PEA	3	15	280-310	288-308
		SMB	3	15	205-270	216-218
Ice Harbor (below dam)	IH	CAT	7	35	450-570	495-549
		LSSw	5	25	400-500	-
		PEA	3	15	280-310	283-298
		SMB	3	15	205-270	205-271
		Totals	**111**	**555**		

Frequency

With a 12-14-year frequency of sampling fish tissue for long-term trends and other objectives, the next sampling study under the FFCMP would be around 2031-2033.

Locations

The 2019 sampling will target most of the same areas of the Snake River in October and November, as was done in the 2009 study. The reach between Asotin and Clarkston will also be sampled in order to provide results that can be used in the next Water Quality Assessment: this reach was last sampled in 1987. The reach that includes Lyon's Ferry is reserved as an alternate site in 2019. While this site was sampled in 2009, we chose to focus resources at other sites to best meet objectives for 2019. Table 8 shows location information for the 2019 target sampling sites.

Table 8. Location information for sampling, FFCMP 2019.

Site Description	Field Abbr. for Site	River Mile	Coordinates used in EIM*		EIM Location ID	Assessment Unit
			Latitude	Longitude		
Snake River, between Asotin and Clarkston**	AS	141-147	46.3602	-117.0625	not in EIM	170601030307_01_01
Snake River, near Clarkston and Chief Timothy Park (upper Lower Granite Lake)	CT	130-135	46.4294	-117.1521	SNAKERDSCLARK-F	170601070201_01_01
Snake River, below Lower Granite Dam near Almota (upper Lake Bryan)	LG	103-105	46.7000	-117.4700	SNAKERBLWLGD-F	170601070802_01_01
Snake River, Central Ferry (lower to middle Lake Bryan)	CF	77-84	46.6257	-117.8295	SNAKERNRCFRY-F	170601070804_01_01
Snake River, Lyon's Ferry, near Palouse River confluence (Lake Herbert G. West) ***	LF	59-60	46.5902	-118.2187	SNAKERNRLF-F	170601100102_01_01
Snake River, below Lower Monumental Dam, Windust Park area (upper Lake Sacajawea)	LM	33-40	46.5197	-118.5971	SNAKERBLWMD-F	170601100106_01_01
Snake River, above Ice Harbor Dam, Charbonneau Park area (lower Lake Sacajawea)	IH	10-18	46.2627	-118.8490	SNAKERABVIH-F	170601100403_01_01

* datum is NAD83 HARN
** coordinates for this site were estimated from an older study which was not entered into EIM
*** alternate site

8.0 Field Procedures

8.1 Invasive species evaluation

Invasive or unwanted aquatic species may be encountered during fish collections for this project. The Snake River is classified as an area of Extreme Concern due to the presence of the New Zealand mud snail.

Environmental ethics and Washington law prohibit the transportation of all aquatic plants, animals, and many noxious weeds. Sample collection for this project will follow the Ecology Environmental Assessment Program's SOP to Minimize the Spread of Invasive Species (Parsons et al., 2018). The Ecology SOP supersedes the Washington Invasive Species Council SOP "Reducing Accidental Introductions of Invasive Species". It covers all points considered in that protocol and is more stringent in some areas.

9.0 Laboratory Procedures

9.3 Special method requirements

MEL is proposing a new extraction and/or cleanup for fish tissue samples analyzed by method 8081/8082. MEL will evaluate the QuEChERS extraction (MEL Method AOAC2007) and compare it to the current extraction/cleanup method (3541/3620C-with acetonitrile back-extraction (ACN)). QuEChERS is a solid phase extraction and cleanup method for detection of pesticide residues. The term was coined using characteristics of this method: "quick, easy, cheap, effective, rugged, and safe". The comparison study will focus on the following six analytes: 4,4-DDT, 4,4-DDD, 4,4-DDE, and PCB Aroclors 1248, 1254, and 1260.

The development and use of new sample preparation and analytical methods for long term monitoring programs such as the FFCMP will follow EAP Procedure 01-10: EAP Procedure on Method Implementation. The agency Quality Assurance Officer will review the proposal and determine the scope of the method comparison study and statistical evaluation that is needed (formal or informal). The Project Manager will review results from the comparison studies and take part in the method approval process prior to MEL implementing it for FFCMP samples.

The draft approach for developing the new sample preparation method and comparing it to the long-used preparation method is:

1. MEL will first conduct a pilot method study in the summer-fall 2020 timeframe using the QuEChERS extraction and cleanup on a fish tissue Standard Reference Material.
2. If that study yields good results, MEL will conduct a more formal method comparison study. The method comparison study plan will be developed and describe the number of samples, source of samples, extraction and analysis procedures, and statistical analysis of the results to evaluate the comparability of the two extraction/cleanup methods (QuEChERS versus 3541/ACN).
3. If the QuEChERS study fails, MEL will evaluate the GPC cleanup option for a better lipid cleanup than the current method of acetonitrile back-extractions if time permits.

4. |If both studies fail or cannot be completed in time, MEL will use the current analytical methods as written (preparation with 3541/3620C-ACN and analysis with GCECD 8081/8082).

If the proposed method is approved for use, an addendum to this document will be needed to describe the changes. Table 9 summarizes the steps and methods for comparison.

Table 9. Summary of methods proposed for comparison studies.

Step	Current Methods	Proposed Method (QuEChERS)	Proposed Alternate Method (GPC)
Extraction	EPA 3541	AOAC 2007 (includes a lipid cleanup)	EPA 3541
Cleanup	EPA 3620C/CAN (4 extracts/sample)	EPA 3620C (2 extracts/sample)	EPA 3640A/EPA 3620C (2 extracts/sample)
Analysis	EPA 8081/8082	EPA 8081/8082	EPA 8081/8082

15.0 References

Beak Consultants, 1989. Columbia River fish study. fish collection, fish tissue sampling and age of fish sampled. Prepared for Northwest Pulp & Paper Association, Bellevue, WA. 30 pp. *(FROM abstract in: Lower Columbia River Bi-State Program: Reconnaissance Survey of the Lower Columbia River: Task 1 - Summary of Existing Data and Prelim ID of problem Area and Data Gaps May 13, 1992).*

Bloom, N. 1995. Considerations in the analysis of water and fish for mercury. In National Forum on Mercury in Fish: Proceedings. EPA Office of Water, Washington D.C. EPA publication 823-R-95-002.

Davis, D. and D. Serdar. 1996. Washington State Pesticide Monitoring Program: 1994 Fish Tissue and Sediment Sampling Report. Washington State Department of Ecology, Olympia, WA. Publication 96-352. https://apps.ecology.wa.gov/publications/summarypages/96352.html

Driscoll, C., C. Yan, C. Schofield, R. Munson, and J. Holsapple. 1994. *The Mercury Cycle and Fish in the Adirondack Lakes*. Environment Science and Technology, Volume 28, No. 3. American Chemical Society.

EPA, 1991. Total Maximum Daily Load (TMDL) to Limit Discharges of 2,3,7,8-TCDD (Dioxin) to the Columbia River Basin. Originally published on February 25, 1991 by the U.S. Environmental Protection Agency Region 10, Seattle, WA. Republished in July 2009 by Washington State Department of Ecology, Olympia, WA. Publication 09-10-058. https://apps.ecology.wa.gov/publications/SummaryPages/0910058.html

EPA, 1992. National Study of Chemical Residues in Fish, Volumes 1 and II. USEPA, Office of Science and Technology (WH-551), Washington D.C. EPA 823-R-92-008a & -008b.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. U.S. Environmental Protection Agency, Region 10, Office of Water, Seattle, WA. Publication EPA-910/R-02-006. https://www.epa.gov/sites/production/files/documents/columbia_fish_contaminant_survey_1996-1998.pdf

Fabrizio, M.C., A.M. Frank, and J.F. Savino. 1995. Procedures for formation of composite samples from segmented populations. Environmental Science and Technology, Vol. 29(5): 1137-1144.

Health, 2018. Fish Consumption Advisories web page. Washington State Department of Health, Olympia, WA. https://www.doh.wa.gov/CommunityandEnvironment/Food/Fish/Advisories

NPCC (Northwest Power and Conservation Council), 2019. Website access 9/12/19: https://www.nwcouncil.org/reports/columbia-river-history/snakeriver

Parsons, J., D. Hallock, K. Seiders, B. Ward, C. Coffin, E. Newell, C. Deligeannis, and K. Welch. 2018. Standard Operating Procedure EAP070, Version 2.2: Minimize the Spread of Invasive Species. Washington State Department of Ecology, Olympia, WA. https://apps.ecology.wa.gov/publications/SummaryPages/1803201.html

Seiders, K., C. Deligeannis, and P. Sandvik. 2007. Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005. Washington State Department of Ecology, Olympia, WA. Publication 07-03-024. https://apps.ecology.wa.gov/publications/summarypages/0703024.html

Seiders, K., C. Deligeannis, and M. Friese. 2011. Focus on Fish Testing: Snake River Fish Tested for Chemicals. Washington State Department of Ecology, Olympia, WA. Publication 11-03-067. https://apps.ecology.wa.gov/publications/summarypages/1103067.html

Seiders, K. and P. Sandvik. 2020. Quality Assurance Project Plan: Freshwater Fish Contaminant Monitoring Program. Washington State Department of Ecology, Olympia, WA. Publication 20-03-106. https://apps.ecology.wa.gov/publications/summarypages/2003106.html

Zar, J. H. 1984. Biostatistical Analysis, 2nd Edition. Prentice Hall, Inc. Englewood Cliffs, NJ.

16.0 Appendices

Appendix A. Target Fish Species

Table A-1. Characteristics of fish species that may be collected for the FFCMP.

Common name	Ecology Species Code	Scientific name	Habitat	Feeding	Water temp	Tolerance	Family name	Possible Hatchery or Transplant
Black crappie	BC	*Pomoxis nigromaculatus*	water column	invert/piscivore	warm	T	Centrarchidae	Y
Bluegill	BG	*Lepomis macrochirus*	water column	invert/piscivore	warm	T	Centrarchidae	Y
Bridgelip sucker	BLS	*Catostomus columbianus*	benthic	herbivore	cool	T	Catostomidae	
Brook trout	BKT	*Salvelinus fontinalis*	hider	invert/piscivore	cold	I	Salmonidae	Y
Brown bullhead	BBH	*Ameiurus nebulosus*	hider	invert/piscivore	warm	T	Ictaluridae	
Brown trout	BNT	*Salmo trutta*	hider	invert/piscivore	cold	I	Salmonidae	Y
Burbot	BUR	*Lota lota*	benthic	piscivore	cold	I	Gadidae	
Channel catfish	CAT	*Ictalurus punctatus*	benthic	invert/piscivore	warm	T	Ictaluridae	Y
Chiselmouth	CLM	*Arocheilus alutaceus*	benthic	herbivore	cool	I	Cyprinidae	
Common carp	CCP	*Cyprinus carpio*	benthic	omnivore	warm	T	Cyprinidae	
Cutthroat trout (Coastal) [1]	CTTC	*Oncorhynchus clarki clarki*	water column	invert/piscivore	cold	S	Salmonidae	Y
Cutthroat Trout (Lahontan) [1]	CTTL	*Oncorhynchus clarki henshawi*	water column	invert/piscivore	cold	S	Salmonidae	Y
Cutthroat Trout (Western) [1]	CTTW	*Oncorhynchus clarki lewisi*	water column	invert/piscivore	cold	S	Salmonidae	Y
Grass carp	GCP	*Ctenopharyngodon idella*	benthic	herbivore	warm	T	Ictaluridae	Y
Green sturgeon	GST	*Acipenser medirostris*	benthic	piscivore	cold	S	Acipenseridae	
Green sunfish	GS	*Lepomis cyanellus*	water column	invert/piscivore	warm	T	Centrarchidae	
Kokanee salmon	KOK	*Oncorhynchus nerka*	water column	invertivore	cold	S	Salmonidae	Y
Lake trout	LKT	*Salvelinus namaycush*	benthic	piscivore	cold	S	Salmonidae	
Lake whitefish	LWF	*Coregonus clupeaformis*	water column	invertivore	cold	I	Salmonidae	
Largemouth bass	LMB	*Micropterus salmoides*	water column	piscivore	warm	T	Centrarchidae	Y
Largescale sucker	LSS	*Catostomus macrocheilus*	benthic	omnivore	cool	T	Catostomidae	
Longnose sucker [2]	LNS	*Catostomus catostomus*	benthic	invertivore	cold	I	Catostomidae	

Common name	Ecology Species Code	Scientific name	Habitat	Feeding	Water temp	Tolerance	Family name	Possible Hatchery or Transplant
Mountain sucker	MS	*Catostomus platyrhynchus*	benthic	herbivore	cool	I	Catostomidae	
Mountain whitefish	MWF	*Prosopium williamsoni*	benthic	invertivore	cold	I	Salmonidae	
Northern Pike	NOP	*Esox lucius*	water column	piscivore	cold	S	Esocidae	
Northern pikeminnow	NPM	*Ptychocheilus oregonensis*	water column	invert/piscivore	cool	T	Cyprinidae	
Peamouth	PEA	*Mylocheilus caurinus*	water column	invertivore	cool	I	Cyprinidae	
Pumpkinseed	PMP	*Lepomis gibbosus*	water column	invert/piscivore	cool	T	Centrarchidae	
Rainbow trout [3]	RBT	*Oncorhynchus mykiss*	hider	invert/piscivore	cold	S	Salmonidae	Y
Rock bass	RKB	*Ambloplites rupestris*	water column	invert/piscivore	warm	I	Centrarchidae	
Salish Sucker [2]	SS	*Catostomus catostomus*	benthic	omnivore	cool	S	Catostomidae	
Sculpins	COT	*Cottus sp.*	benthic	invertivore	cool	T	Cottidae	
Smallmouth bass	SMB	*Micropterus dolomieui*	water column	piscivore	cool	I	Centrarchidae	Y
Starry flounder	STF	*Platicthys stellatus*	benthic	invertivore	cold	S	Pleuronectidae	
Tench	TCH	*Tinca tinca*	water column	invertivore	warm	T	Cyprinidae	
Tiger Trout	TT	*Salmo trutta X Salvelinus fontinalis*	hider	invert/piscivore	cold	I	Salmonidae	Y
Walleye	WAL	*Sander vitreus*	water column	piscivore	cool	I	Percidae	Y
Warmouth	WM	*Lepomis gulosus*	water column	invert/piscivore	warm	T	Centrarchidae	
White crappie	WC	*Pomoxis annularis*	water column	invert/piscivore	warm	T	Centrarchidae	Y
White sturgeon	WST	*Acipenser transmontanus*	benthic	invert/piscivore	cold	I	Acipenseridae	
Yellow bullhead	YBH	*Ameiurus natalis*	hider	invert/piscivore	warm	T	Ictaluridae	
Yellow perch	YP	*Perca flavescens*	water column	invert/piscivore	cool	I	Percidae	

1 - Cutthroat trout: if uncertain of subspecies, just call it CTT (Oncorhynchus clarki). Subspecies usually haven't been distinguished in past work. EIM doesn't distinguish fish subspecies yet. (2008)

2 - Same species, Salish Sucker appears to be dwarf form of Longnose. Salish is found west of Cascade crest. The Longnose is found east of the Cascade crest. EIM doesn't distinguish different forms.

3 - Some RBT hybridize with CTT so that fish have some characteristics of both species. Note in field book if hybrids suspected.

Tolerance field describes overall pollution tolerance: S = sensitive, I = intolerant, T = tolerant

Appendix B. Summary of Historical Results for Selected Parameters

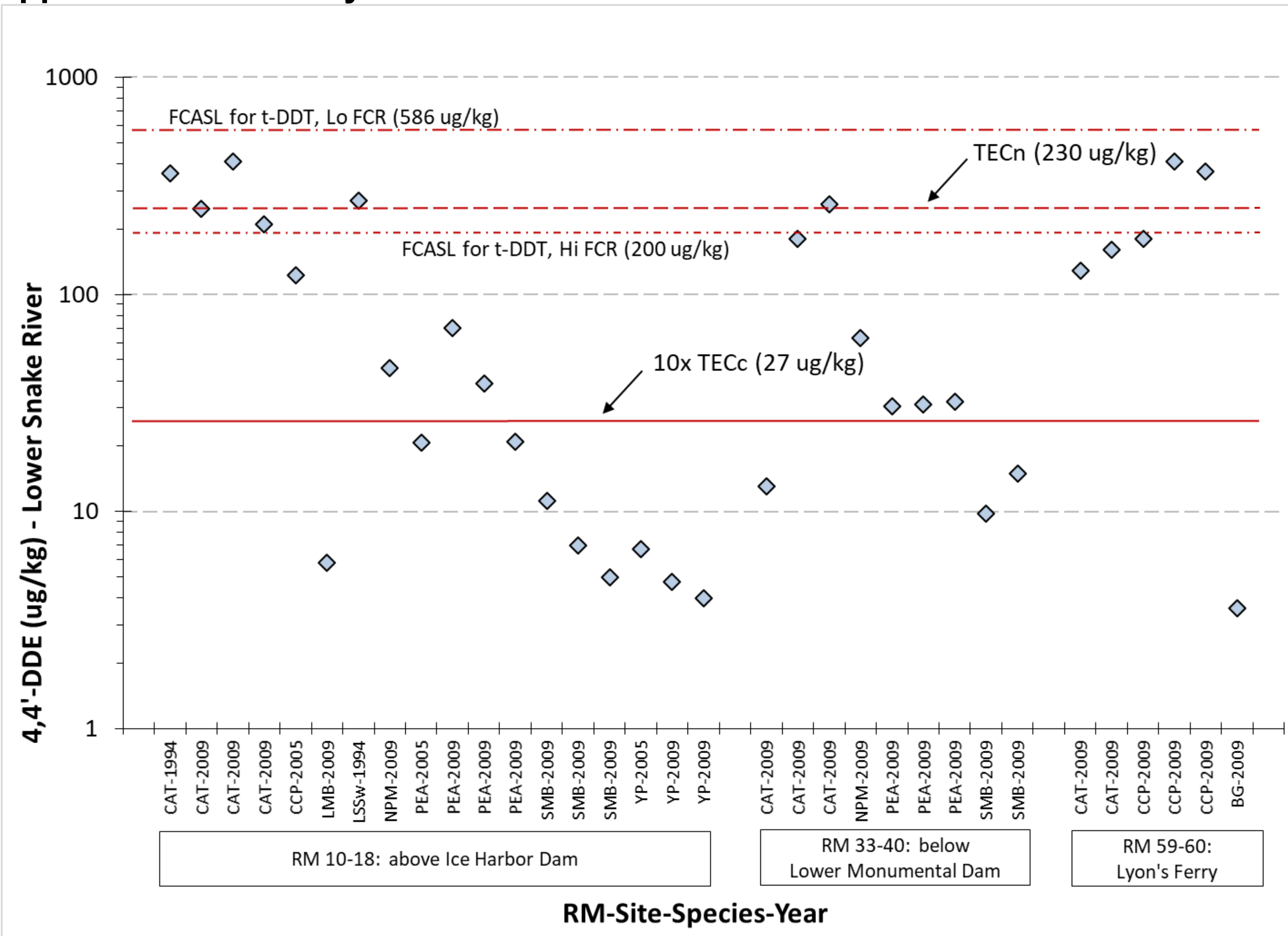

Figure B 1. Results for 4,4'-DDE in fish from the Lower Snake River.

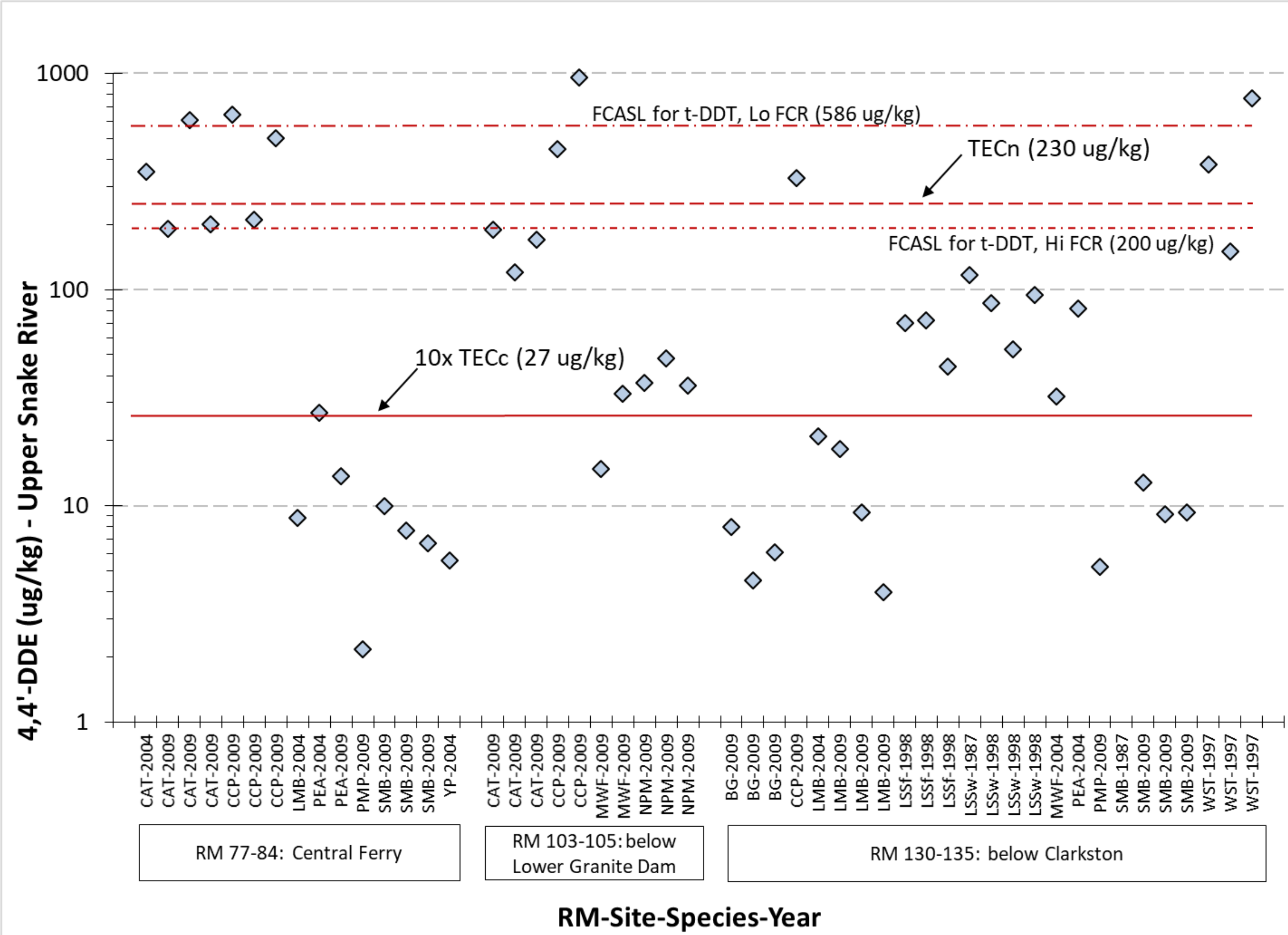

Figure B 2. Results for 4,4'-DDE in fish from the Upper Snake River.

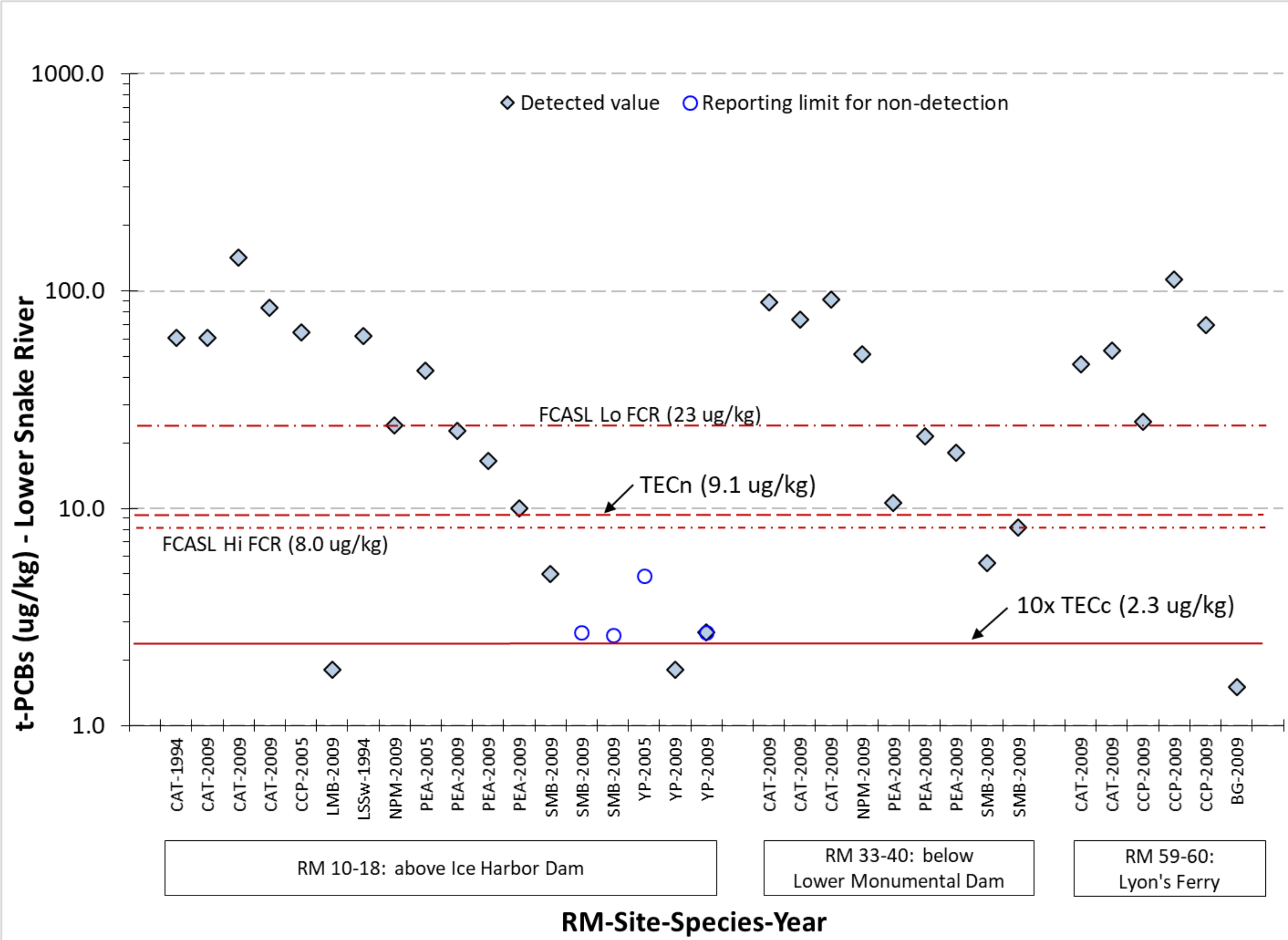

Figure B 3. Results for PCBs in fish from the Lower Snake River.

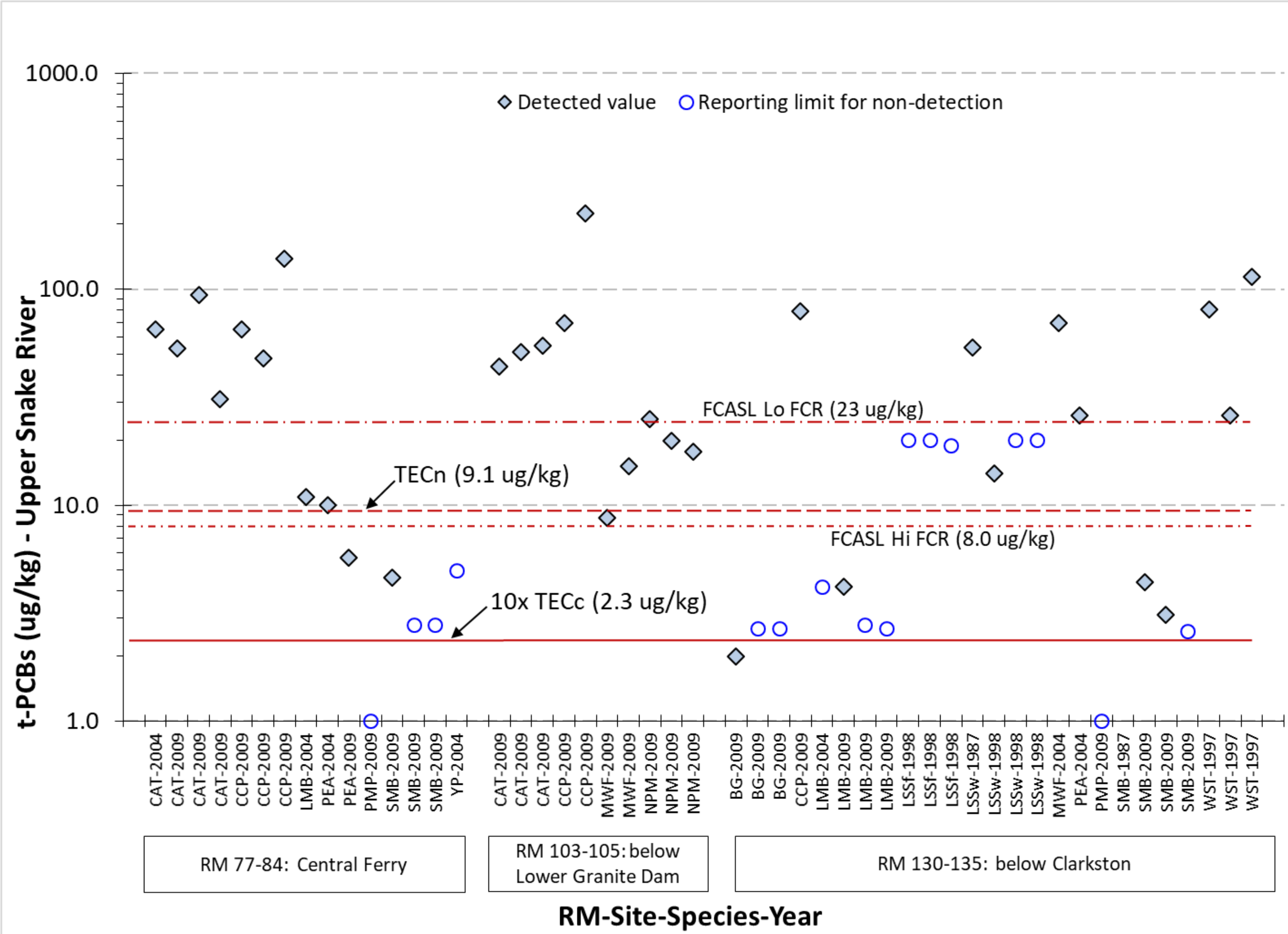

Figure B 4. Results for PCBs in fish from the Upper Snake River.

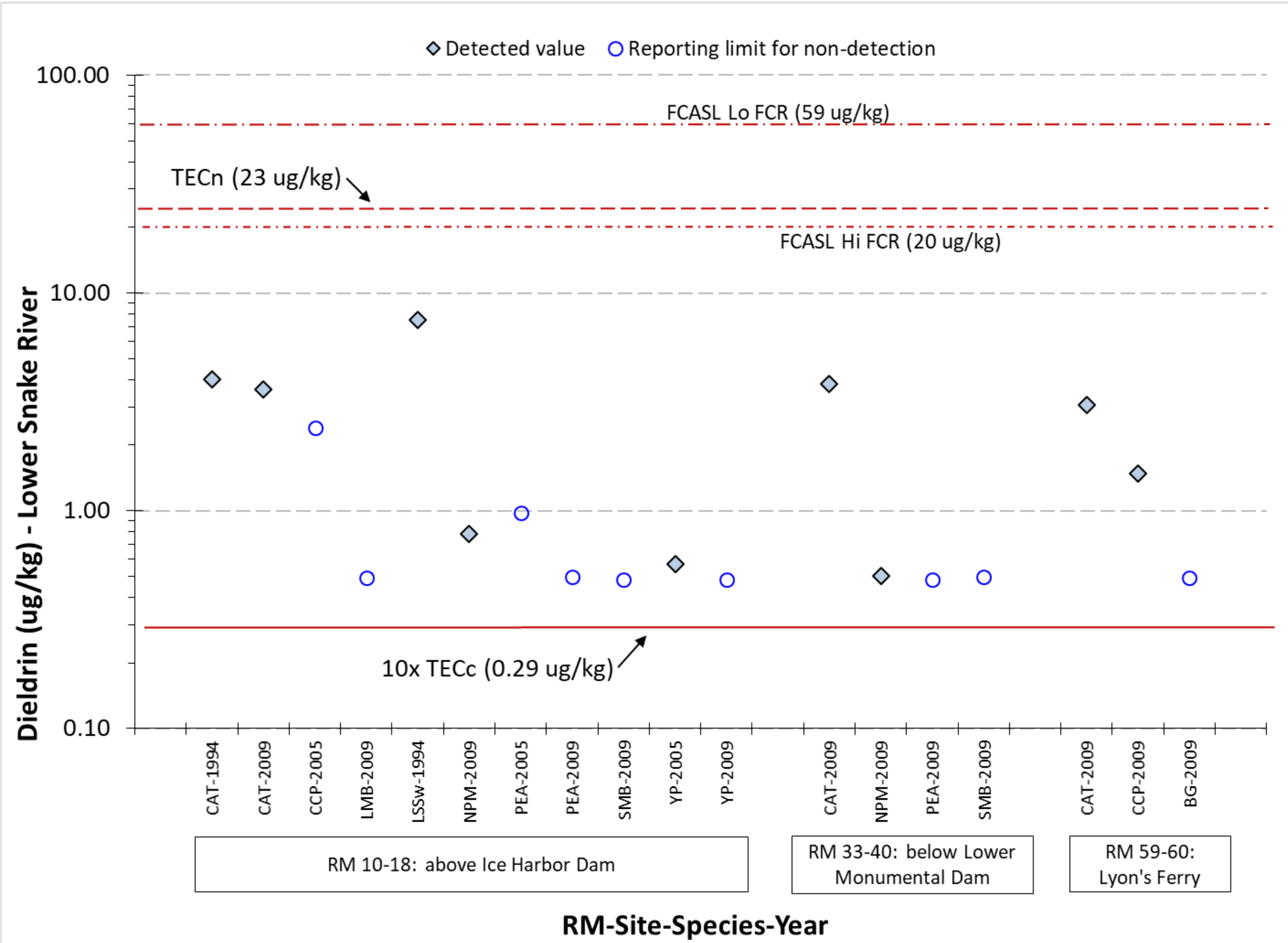

Figure B 5. Results for dieldrin in fish from the Lower Snake River.

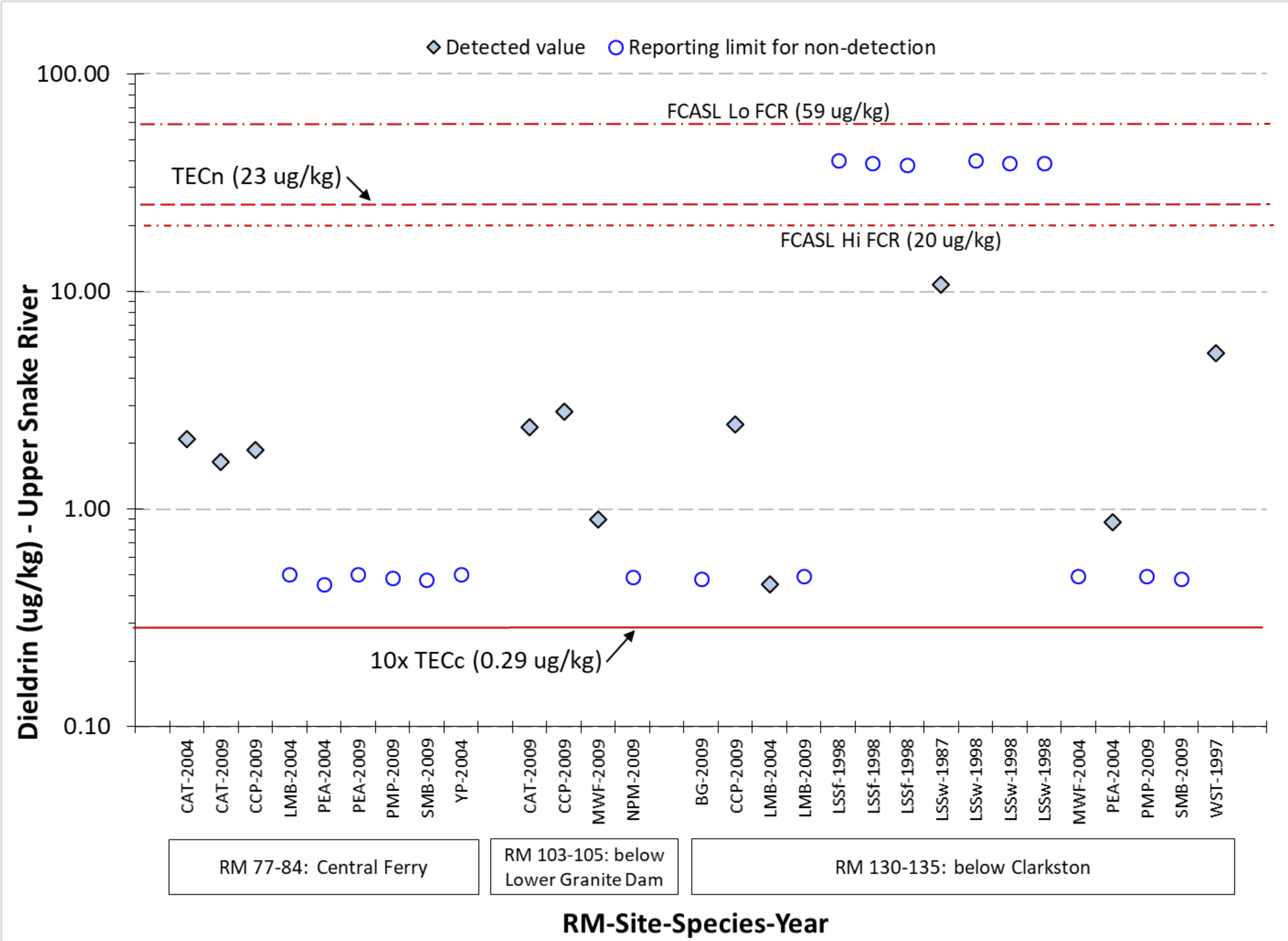

Figure B 6. Results for dieldrin in fish from the Upper Snake River.

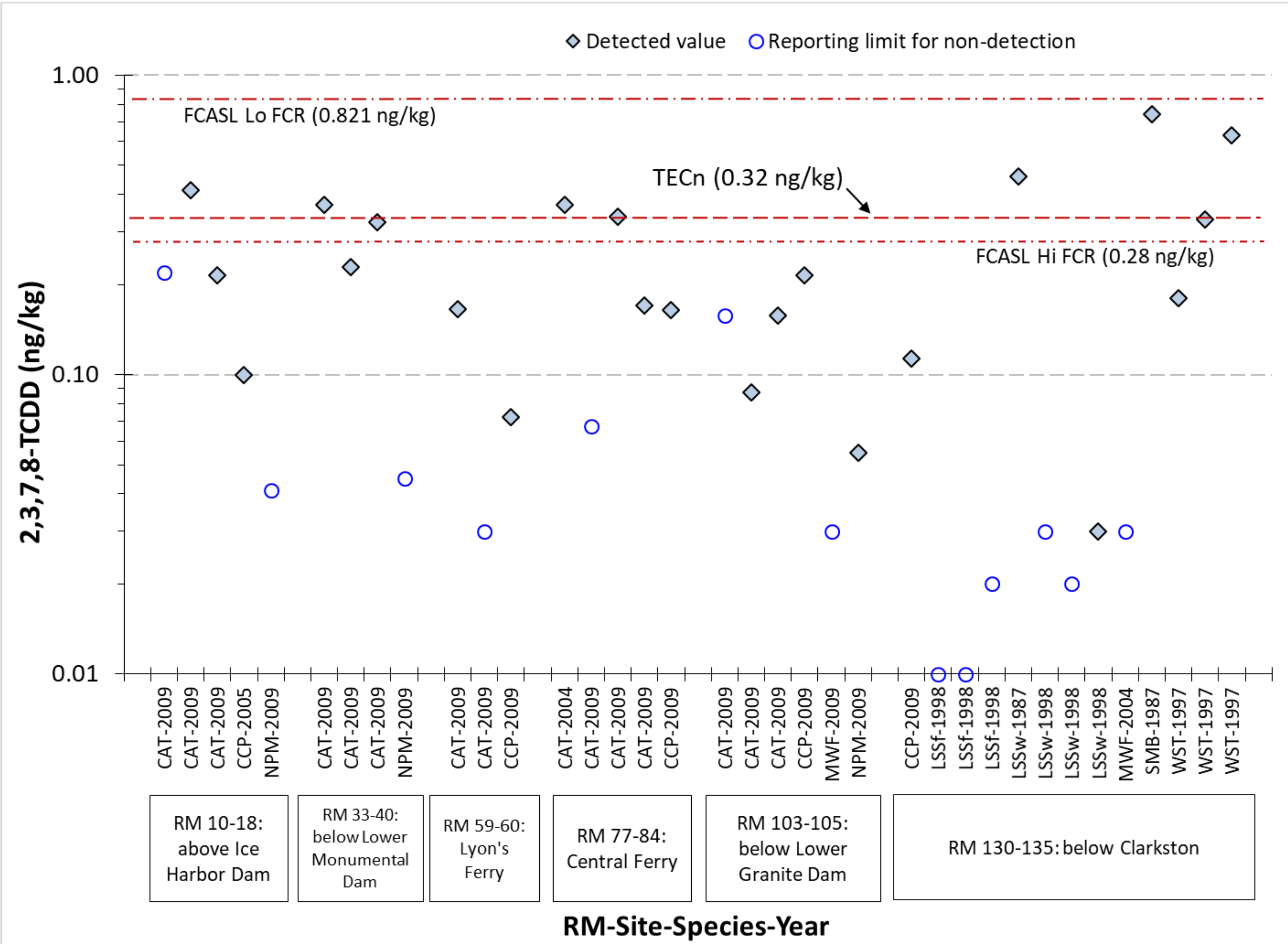

Figure B 7. Results for 2,3,7,8-TCDD in fish from the Snake River.

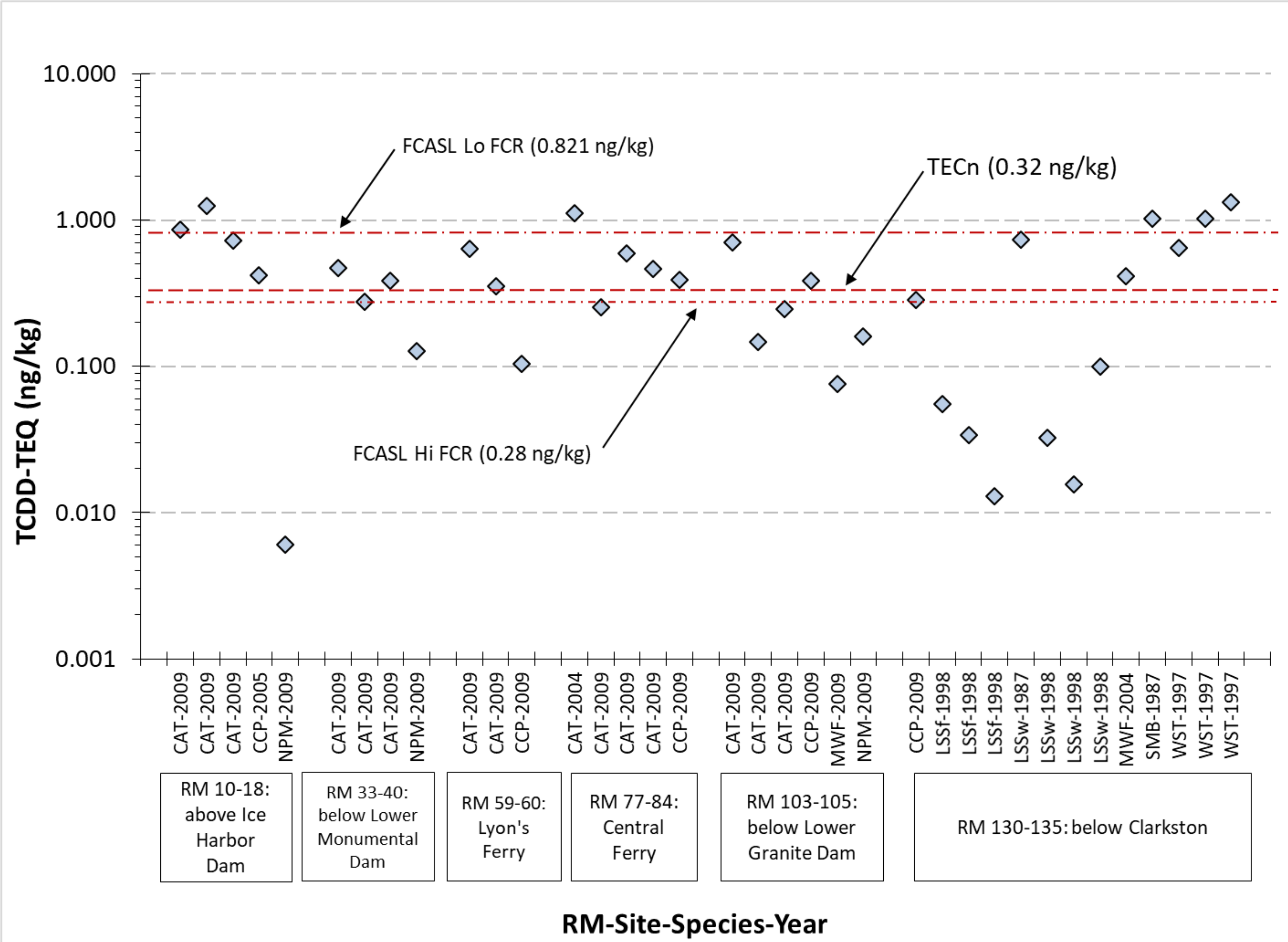

Figure B 8. Results for TCDD-TEQ in fish from the Snake River.

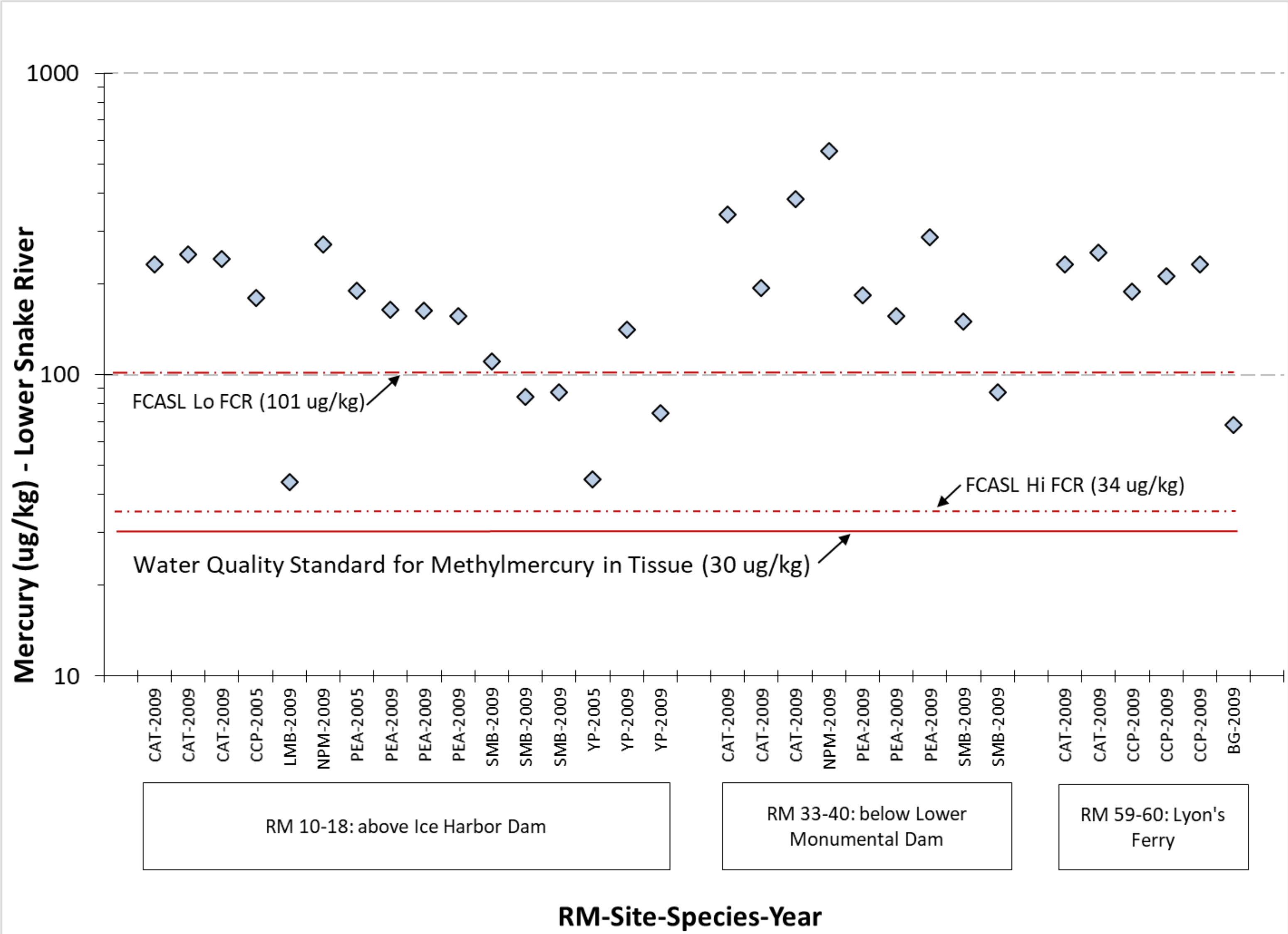

Figure B 9. Results for mercury in fish from the Lower Snake River

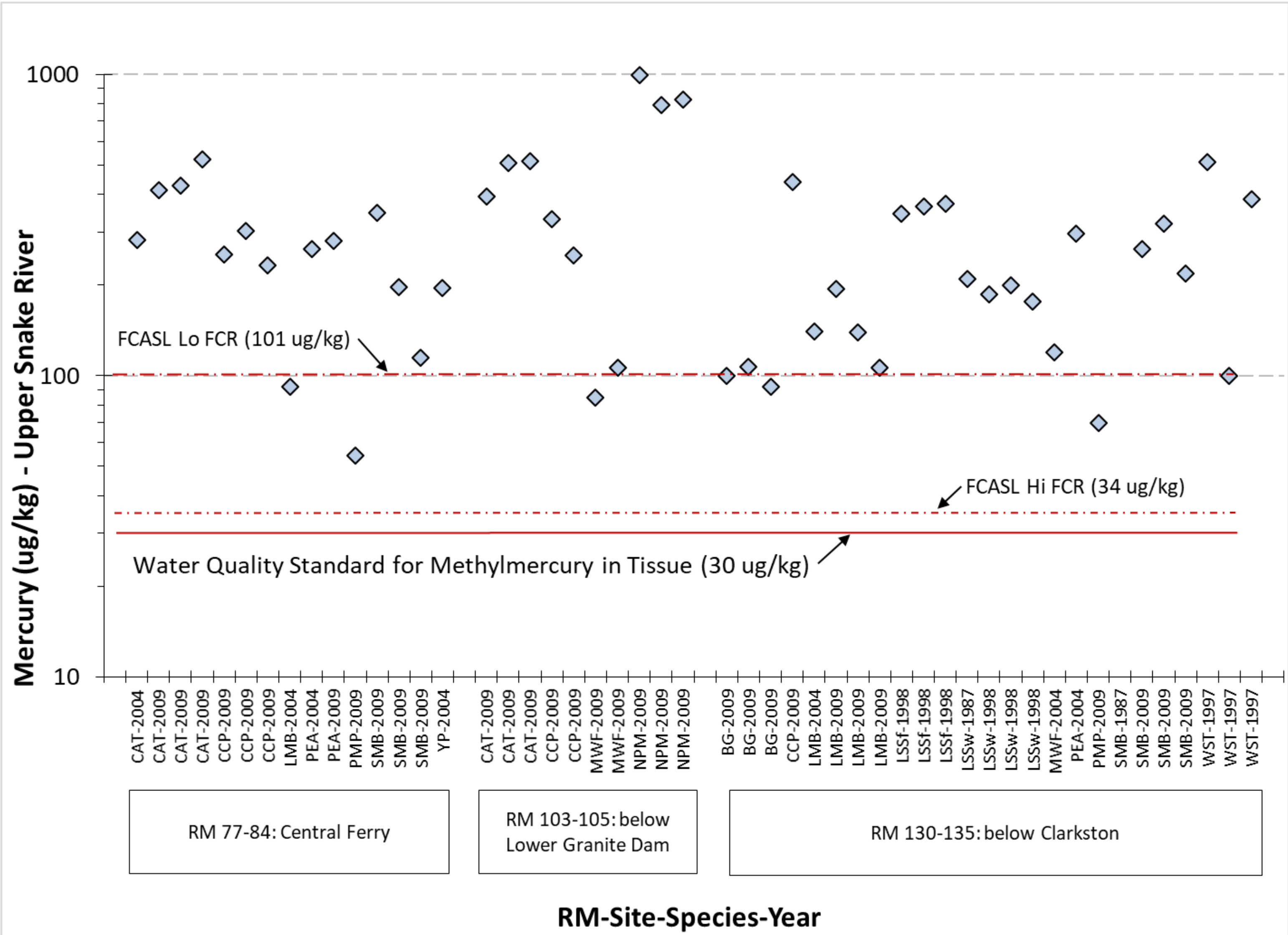

Figure B 10. Results for mercury in fish from the Upper Snake River.

Appendix C. Glossary, Acronyms, and Abbreviations

Glossary

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

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Effectiveness Monitoring: An effectiveness monitoring evaluation is an essential component of TMDLs and Water Cleanup Plans because it determines to what extent the actions to control pollution have attained the goals of watershed restoration. Formal effectiveness monitoring evaluation addresses four fundamental questions with respect to restoration or implementation activity: (1) Is the restoration or implementation work achieving the desired objectives or goals? (2) How can restoration or implementation techniques be improved? (3) Is the improvement sustainable? (4) How can the cost-effectiveness of the work be improved?

Fish Consumption Advisory Screening Level (FCASL): The FCASL is a tissue contaminant concentration used by Washington Department of Health to help determine whether a risk assessment should be done for the site and species concerned. A risk assessment may result in a Fish Consumption Advisory.

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

QuEChERS: A solid phase extraction method for detection of pesticide residues. The term was coined using characteristics of this method: "quick, easy, cheap, effective, rugged, and safe".

TEC: Tissue Exposure Concentration. Concentration of a toxic chemical in edible fish and/or shellfish tissue which, when exceeded, indicates that adverse human health effects could potentially occur if such tissues were consumed regularly over of time. The TEC is a tissue concentration threshold used by Ecology to help determine whether the designated use of harvest of fish and shellfish is supported in a waterbody. When the concentration of a pollutant in fish and/or shellfish tissue is greater than the TEC, this indicates that the designated use of harvest could potentially be impaired, and thus the waterbody can be assessed as not meeting water quality standards for the State of Washington, and be placed on the Clean Water Act 303(d) list. The TECs of pollutants are rooted in the human health criteria equations and are expressed as stand-alone tissue concentrations that relate to exposure of a pollutant through the consumption of fish and/or shellfish. The TECs for carcinogenic (TECc) and non-carcinogenic (TECn) effects differ because the underlying assumptions associated with exposure, toxicity, and risk/hazard with the two types of health effects differ. For example, the TECc assumes a daily exposure over a 70 year period while the TECn can assume a daily exposure over a 7-70 year period, depending on the pollutant. Some carcinogens also have non-cancer health effects above certain concentrations so these chemicals will have both TECc and TECn values. Calculation of TECs:

- TECc = (Risk level) x (Body weight) ÷ (Cancer slope factor) x (Fish consumption rate).
- TECn = (Reference dose) x (Body weight) ÷ Fish consumption rate.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Trend: A meaningful change or difference that can be measured and differentiated from measurement error. Often used in the context of time (temporal trend) or space (spatial trend).

Water Quality Assessment (WQA): Washington's Water Quality Assessment lists the water quality status for water bodies in the state. This assessment meets the federal requirements for an integrated report under Sections 303(d) and 305(b) of the Clean Water Act. The assessed waters are grouped into categories that describe the status of water quality. The 303(d) list comprises those waters that are in the polluted water category, for which beneficial uses– such as drinking, recreation, aquatic habitat, and industrial use – are impaired by pollution.

Water Quality Standards: Water quality standards consist of designated uses, numeric and narrative criteria, and anti-degradation components. These components work together to protect the health of surface waters in Washington.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

CCP	Common carp (*Cyprinus carpio*)
CP	Chlorinated pesticide
DDE	Dichloro-diphenyl-dichloroethylene
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
FCASL	Fish Consumption Advisory Screening Level
FFCMP	Freshwater Fish Contaminant Monitoring Program
Health	Washington State Department of Health
LSS	Largescale sucker (*Catostomus macrocheilus*)
MDC	Minimum Detectable Change
MEL	Manchester Environmental Laboratory
NPM	Northern pikeminnow (*Ptychocheilus oregonensis*)
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyl
PCDD/F	Polychlorinated dibenzo-p-dioxin and -furan
SMB	Smallmouth bass (*Micropterus salmoides*)
t-PCB	Total PCBs
t-PBDE	Total PBDEs
TCDD	2,3,7,8-tetra-chlorinated dibenzo-p-dioxin
TEC	Tissue Exposure Concentration
TECc	Tissue Exposure Concentration for carcinogenic effects
TECn	Tissue Exposure Concentration for non-carcinogenic effects
TEQ	Toxicity equivalent
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WQA	Water Quality Assessment

Units of Measurement

g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
mg	milligram
ng/kg	nanograms per kilogram (parts per trillion)
ug/kg	micrograms per kilogram (parts per billion)
pg/g	pictograms per gram (parts per trillion)