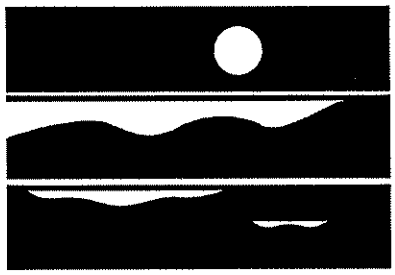

WASHINGTON STATE PESTICIDE MONITORING PROGRAM RECONNAISSANCE SAMPLING OF FISH TISSUE AND SEDIMENTS (1992)

December 1994

Water Body Nos. (See Page iv for Numbers)
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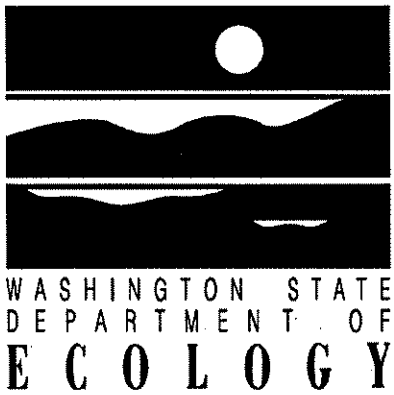

Washington State Pesticide Monitoring Program Reconnaissance Sampling of Fish Tissue and Sediments (1992)

by
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Abstract

A reconnaissance survey was conducted to refine the target analyte list, analytical methods, and field sampling techniques for the biota and sediment sampling portion of the Washington State Pesticide Monitoring Program. Fish and/or sediment samples were collected from seven freshwater sites in September and October of 1992. Fish tissue samples were analyzed for 42 pesticides and breakdown products, including chlorinated pesticides and organophosphates; sediment samples were analyzed for 98 target analytes, to include chlorinated pesticides, organophosphates, urea pesticides, nitrogen-containing pesticides, and chlorophenoxy herbicides.

Twenty-four pesticides and breakdown products were detected in fish tissue samples, and nine compounds were detected in sediment. One organophosphate pesticide (chlorpyrifos) was detected in fish; the remaining compounds detected were chlorinated pesticides. Of the nine target analytes detected in sediment, one was a nitrogen-containing pesticide (dichlobenil), one was a chlorophenoxy herbicide (pentachlorophenol), and the rest were chlorinated pesticides. PCBs, which are not classified as pesticides, also were detected in fish. Results are compared to available criteria and historical data. Findings from this survey will be used to design the final monitoring plan for pesticides in state surface waters.

Water Body Numbers	Segment Numbers
WA-01-1115	01-01-04
WA-08-2100	04-08-02
WA-23-1100	10-23-15
WA-28-1020	13-28-03
WA-49-2100	21-45-01
WA-50-1030	19-50-06
WA-32-1010	15-32-02
WA-37-1048	18-37-02
WA-41-1010	19-41-01

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- Dave Serdar assisted with sample collection.

- Larry Goldstein and Glen Patrick provided valuable review comments for the draft report.

- Scott Breidenbach for preparation of the GIS map for Figure 1.

- Joan LeTourneau for preparation and proofing of the final report.

Summary

A total of 24 pesticides and breakdown products were detected in fish tissue, and nine compounds were detected in sediment samples collected from seven freshwater sites in September and October of 1992. A minimum of ten target analytes were detected in fish tissue per sample site, with a maximum of 23 and an average of 18 per site. Three pesticides were detected in two or more sediment samples.

Pesticides detected in high concentrations include 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, dieldrin, and heptachlor epoxide. DDT and metabolites, chlordane, and two PCBs were detected at all sample sites.

High concentrations of 4,4'-DDE were found in whole largescale suckers from the Yakima River and kokanee fillets and eggs from Lake Chelan. Lipid normalized values indicate that the bioavailability of DDT and metabolites to fish in the Walla Walla River is higher than the other sites.

EPA human health screening values, used only to prioritize problem areas, were exceeded for total DDT in fillet samples from Lake Chelan, Crab Creek, and the Yakima River. The screening value for total PCBs was exceeded in samples from Lake Chelan, Crab Creek, the Yakima River, and Mercer Slough. Dieldrin in fillet samples from the Yakima River and heptachlor epoxide from the Walla Walla River were also above screening values.

Sites with fillet samples exceeding National Toxics Rule (NTR) criteria were recommended for addition to the 303(d) water quality limited list. Samples from Lake Chelan, Crab Creek, Mercer Slough, and the Yakima and Walla Walla Rivers all had one or more compounds exceeding NTR criteria.

Whole largescale sucker samples from all sites except Lake Chelan exceeded proposed wildlife criteria developed for the Niagara River (Newell, *et al.*, 1987). Concentrations of pesticides in sediments were well below severe effects guidelines developed by the Ontario Ministry of the Environment (Persaud, *et al.*, 1991). Wildlife and sediment criteria are available for only a small portion of the target pesticides for this survey.

Comparisons with historical data indicate that pesticide concentrations in fish tissue have changed little. DDE in samples from the Yakima and Walla Walla Rivers continues to be above proposed wildlife criteria. Concentrations of DDE in fish from the Walla Walla and Yakima Rivers, and chlordane in the Yakima River and Mercer Slough, are high as compared to national averages. Pesticide levels in sediment from the Yakima River appear to be decreasing as compared to samples collected since 1984.

Detection limits for the Washington State Pesticide Monitoring Program (WSPMP) are substantially lower than those in other reports of fish and sediment data from Washington, and the target analyte list is larger. These analytical improvements are probably responsible for the higher number of pesticide detections for the WSPMP as compared to historical surveys.

Comparisons between total and non-polar lipid normalized data indicate that there is little difference between the two methods or non-polar lipid normalized data are more variable. This suggests that data would be more comparable when normalized to total lipids.

Concentrations of pesticides detected in fish tissue by the WSPMP probably do not impair egg production. However, the level of total DDT in kokanee eggs from Lake Chelan was above the concentration likely to cause increased mortality of eggs and fry, and may be high enough to cause significant mortality.

Recommendations

1) Adopt sampling methodology and sample processing procedures as outlined.

2) Drop sediment analyses, except at selected sites that may indicate significant contamination of sediments or at sites where fish cannot be collected.

3) Drop analysis of eggs for largescale suckers. If funds permit, evaluate eggs of other high lipid species and include analysis of eggs from all sport fish sampled.

4) Continue analysis of fish tissue for total and non-polar lipids. Discontinue analysis for non-polar lipids if high variability persists.

5) Lake Chelan, Crab Creek, the Walla Walla and Yakima Rivers, and Mercer Slough should be added to the water quality limited list, based on concentrations of pesticides or PCBs in fish fillet composites from these sites that exceed National Toxics Rule criteria.

6) Additional sampling is recommended for the following sites, which are listed in order of priority (intensive surveys are not an objective of the WSPMP and would require separate funding and implementation):

Lake Chelan

Available data, including Lake Toxics Screening Survey results from Roses Lake, indicate that this site has the highest potential for adverse human health and fisheries effects.

- Perform an intensive survey of sport fish to evaluate potential human health risks and the impact on fisheries.
- Consider as possible trend site.

Walla Walla River

Lipid normalized data indicate that the bioavailability of some pesticides may be higher than the Yakima River.

- Collect additional whole fish largescale sucker samples to confirm existing data.
- Collect fillet samples from a species with high lipid content to assess human health risks.
- Consider as possible trend site.

Yakima River

WSPMP and historical data show consistently high levels of several pesticides. The Washington State Department of Health has issued bottom fish consumption recommendations for the Yakima River.

- Consider sampling as a trend site until pesticide concentrations fall below criteria. Use largescale suckers for all tissue samples to give a worst case evaluation of fish contamination.
- Consider performing an intensive survey of sport fish to evaluate potential human health risks.

Lake River

Whole fish samples indicate elevated levels of some pesticides, but no fillet samples have been assessed.

- Collect fillet samples to assess human health risks.

Mercer Slough

Largescale sucker samples indicate high levels of some pesticides, but rainbow trout fillets do not.

- Collect fillet samples from a species with high lipid content to assess human health risks. Use largescale sucker fillets if necessary.

Potholes Reservoir

Data from the Lake Toxics Screening Survey show high concentrations of dieldrin in lake whitefish.

- Collect additional lake whitefish and fillet samples from other sport fish to assess dieldrin contamination.

Introduction

Fish tissue and/or sediment samples for the Washington State Pesticide Monitoring Program (WSPMP) were collected at seven sites in September and October of 1992 (Figure 1). Fish tissue samples were analyzed for 42 pesticides and breakdown products; sediment samples were analyzed for 98. Polychlorinated biphenyls (PCBs) were included as target analytes, but are not pesticides.

This survey was designed as a reconnaissance to aid in the development of the final surface water monitoring plan. Results were used to refine the target analyte list, analytical methods, and field sampling techniques. Objectives for the reconnaissance were as follows:

- Evaluate and finalize logistics and mechanics of sampling methods and sample handling.
- Evaluate analytical methods and detection limits achieved.
- Quantify target pesticide concentrations in fish tissues and sediments.
- Evaluate value of analyzing fish eggs.
- Evaluate value of non-polar lipid measurement.
- Identify trend monitoring and other sampling sites.
- Use results from above steps to design a final monitoring plan.

Field work for a surface water reconnaissance survey was completed in May and June of 1992. A final report for the surface water reconnaissance was completed in March of 1993 (Davis, 1993).

Historical Information

In 1985, the Department of Social and Health Services reported that the pesticide ethylene dibromide (EDB) had been detected in drinking water wells in Skagit, Thurston, and Whatcom Counties. This prompted the Washington State Legislature to direct the Department of Ecology to determine the extent of pesticide contamination in ground waters of the state. This project became known as the Washington State Agricultural Chemicals Pilot Study.

The ground water studies revealed numerous incidents of pesticide contamination in drinking water (Erickson and Norton, 1990; Erickson, 1992; and Larson and Erickson, 1992). As these studies were limited to ground water, it was recognized that a more comprehensive monitoring program was needed. The WSPMP was initiated by Ecology's Environmental Investigations and Laboratory Services (EILS) Program in 1991 to monitor both ground water and surface water, including associated biota such as fish, shellfish, and waterfowl and bed sediments.

Washington State Pesticide Monitoring Program

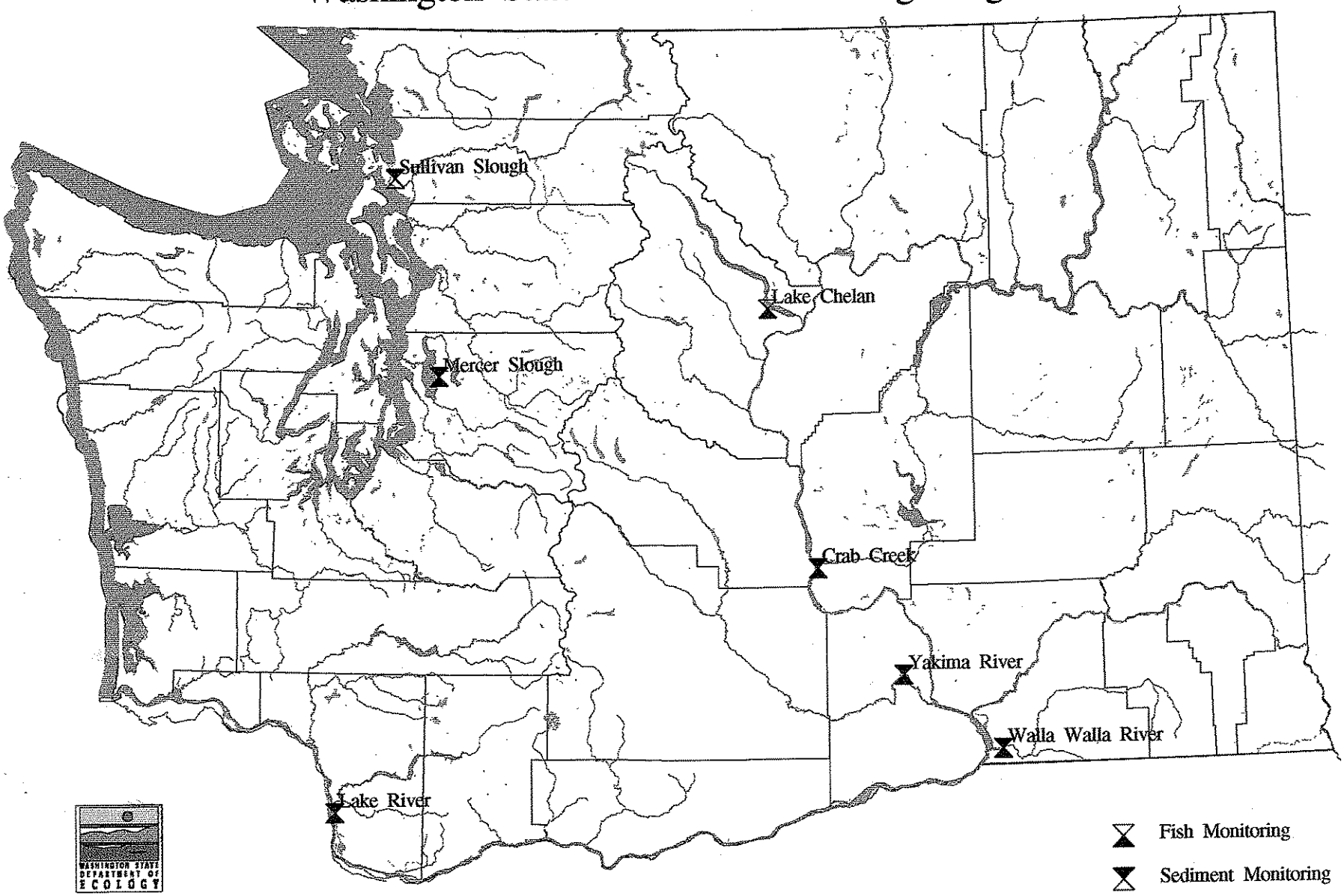

Figure 1. 1992 Fish Tissue and Sediment Reconnaissance Sampling Sites

The program was developed to provide a coherent overview of pesticide residues in surface and ground water throughout Washington State. Several years of data will be necessary to fulfill the goal of this program. The goal and objectives of the WSPMP are as follows:

Goal

To characterize pesticide residues geographically and over time in ground water and surface water (including sediments and biota) throughout Washington.

Objectives

- Identify and prioritize aquifers, lakes, and streams with known or potential pesticide contamination.
- Quantify pesticide concentrations in high priority areas.
- Document temporal trends in pesticide concentrations at selected sites.
- Provide data to the State Department of Health for assessment of potential adverse effects on human health.
- Assess the potential for adverse effects of pesticides on aquatic biota.
- Construct and maintain a pesticide database for ground water and surface water in Washington.
- Provide information for the improvement of pesticide management in Washington State.

The final surface water monitoring plan will be an implementation/quality assurance plan to guide sampling and analysis of surface water, biota, and sediments to fulfill the above stated goal and objectives. Ground water sampling and analysis is being implemented as a separate, but parallel, task.

In a guidance document for assessing chemical contaminants in fish tissue, the EPA (USEPA, 1993) describes two types of surveys. Initially, screening surveys are designed to identify potential problem areas by collecting one or two composite samples from a number of water bodies. These data are used to determine where more intensive surveys should be implemented to thoroughly investigate the extent and severity of the problem. The surface water portion of the WSPMP is essentially an ongoing screening survey.

Samples of fish tissue were collected from five Washington lakes in August and September of 1992 as a part of the Lake Toxics Screening Survey (LTSS), also performed by the EILS Program (Serdar, *et al.*, 1994). These fish were collected, processed, and analyzed using the same methods and equipment used for the WSPMP. Pesticides were analyzed for the LTSS as a part of a larger target list of toxic chemicals. Essentially, the LTSS pesticides results can be

considered an extension of the WSPMP data set, and are included in this report for comparisons to the WSPMP results and to assess these sites for future sampling.

For this report, total DDT consists of the sum of 4,4'- and 2,4'- isomers of DDT, DDD, and DDE. Total chlordane is the sum of cis- and trans-chlordane, cis- and trans-nonachlor, and oxychlordane. Total PCBs is the sum of all aroclors. These compounds were used in this report for various comparisons because these were the most frequently detected compounds, they comprise a majority of the compounds detected, and in their summed form they simplify comparisons.

Methods

Sampling Design

Sampling began on September 14 and ended on October 13, 1992. The timing for sample collection was intended to allow spring spawners to rebuild lipid reserves (which tend to be a sink for bioaccumulative pesticides), and take place before fall spawning occurred. Late summer to early fall is also the best time for sediment collection due to low stream flows, which allow particulates to settle out.

For a screening survey, the EPA recommends collecting one composite for each of two species at each sample site. One species should be a bottom feeder and the other a sport fish.

The EPA document was written for use in developing advisories regarding human consumption of fish fillets. The WSPMP is designed as a screening survey, but also to provide data to evaluate the effects of pesticides in the environment. Thus, whole samples of bottom feeding fish were collected to assess wildlife impacts, and sport fish were collected to evaluate potential risk to human health.

Target species were selected based on the following criteria:

- geographic distribution (statewide when possible),
- potential to bioaccumulate high concentrations of pesticides (have a high lipid content),
- be commonly consumed in the study area (sport fish only),
- easily identified,
- and abundant, easy to capture, and large enough to provide an adequate sample size.

Largescale suckers were chosen as the bottom feeding target species because they possess all of the desired attributes of a target species. No single species of sport fish is widely distributed throughout Washington, so the species of opportunity was collected.

When possible, all fish collected within a composite were similar in size. In addition, larger (older) individuals were selected when there was a choice, because they have had more time to accumulate contaminants and generally represent a "worst-case" sample.

Composite samples were collected rather than individual samples because composites are the most cost-effective method of estimating average contaminant concentrations (USEPA, 1993). For assessment of sites to be added to the water quality limited list (section 303(d) of the federal Clean Water Act), fish composites must be composed of at least five individuals. Composite samples for the WSPMP included material from five fish or sediment grabs. Replicate composites were collected at two sites to evaluate variability between composites.

Fish egg samples were analyzed to determine their value in results interpretation and to determine if this tissue should be included in future WSPMP sampling events. Eggs were chosen over other tissues because they indicate potential impacts on fisheries at a sensitive life stage, they are lipid-rich, and because metabolites may be more readily detected than in other tissues (Johnson, *et al.*, 1986).

Sampling Sites

Sample Site Locations and Selection

Sampling locations are shown in Figure 1. Table 1 lists sample sites, their location, and the number and type of samples collected. Latitude, longitude, and state plane coordinates are listed in Appendix A. Fish tissue and sediment sampling locations were primarily based on 1992 surface water sampling sites; for a full discussion, see Davis (1993). Samples were collected where pesticide contamination was found in surface water reconnaissance samples, had been reported historically, or was suspected from land use.

Sampling Site Descriptions

Lake Chelan

Lake Chelan lies along the northeastern border of Chelan County. The lake's fish and sediments have been sampled for pesticides as a part of Ecology's (discontinued) Basic Water Monitoring Program (BWMP) (Hopkins, *et al.*, 1985) and the Lake Chelan Water Quality Assessment (Patmont, *et al.*, 1989). DDT and its metabolites DDD and DDE were detected in most sediment and fish samples in both studies.

Table 1. List of Sampling Sites, Locations, and Number and Type of Samples

Sample Site	Location	Number of Composite Samples			
		WF[1]	Fillet	Egg	Sediment
Lake Chelan	Near Wapato Pt.	1	2	1	0
Crab Creek	Above bridge on hwy 243	2	1	0	1
Walla Walla River	Near mouth	1	1	1	1
Yakima River	At Horn Rapids Dam	2	2	2	2
Mercer Slough	Below mouth of creek	1	1	0	1
Lake River	Below Ridgefield	1	0	0	1
Sullivan Slough	Near LaConner	0	0	0	1
Totals		8	7	4	7

[1] WF = Whole Fish

WSPMP samples were taken from Lake Chelan near Wapato Point, where the highest pesticide levels have been detected. One whole fish sample, eggs and fillets from kokanee, and fillets from rainbow trout were collected.

Crab Creek

Crab Creek originates in the northeast portion of Lincoln County and flows into Moses Lake. Lower Crab Creek begins below Potholes Reservoir and flows into the Columbia River at Beverly, Washington. Lower Crab Creek receives irrigation return water from about 85 percent of the Columbia Basin Irrigation Project area (USGS, *et al.*, 1991 - draft). Eight pesticides were detected in water samples taken for the 1992 WSPMP water sampling task (Davis, 1993). No organochlorine pesticides were detected in sediment samples taken for the BWMP (Hopkins, 1991). BWMP personnel were unable to collect fish from Crab Creek.

Fish and sediment samples for this project were from the mouth of Crab Creek. One mountain whitefish fillet composite, one sediment sample, and two whole fish replicates were collected.

Walla Walla River

The Walla Walla River starts in Oregon, but several creeks and the Touchet River drain into the Walla Walla from heavily used agricultural land in Washington. Water from the Walla Walla River is used for irrigation throughout the Walla Walla Valley and much of this water eventually returns to the river.

Seven pesticides were detected in water samples from the Walla Walla River collected in June as a part of the 1992 WSPMP. Most were detected at low levels, but concentrations of DCPA (dacthal) were the highest of those recorded from surface water reconnaissance sites at 12.1 µg/L.

One composite each of whole fish, white crappie fillets, and largescale sucker eggs were sampled from the lower Walla Walla River. A sediment sample was also collected.

Yakima River

The Yakima River runs from Keechelus Lake in northwestern Kittitas County to the Columbia River near Richland in Benton County. As the river proceeds through Kittitas, Yakima, and Benton Counties, it receives numerous irrigation return flows from some of the most productive and intensively farmed agricultural land in the state. Water from many of these return flows has been analyzed for pesticides by the U.S. Geological Survey (USGS), most recently in 1987-91 (Rinella, *et al.*, 1992); and by Ecology in 1985 (Johnson, *et al.*, 1986), 1987 (Kendra, 1988), and 1992 (Davis, 1993; Seiders, 1993).

Fish tissue samples have been collected from the main stem of the Yakima and analyzed for bioaccumulative pesticides by the EPA (USEPA, 1992), the USGS (Rinella, *et al.*, 1992), the U.S. Fish and Wildlife Service (USFWS) (Schmitt, *et al.*, 1981, 1990), and by Ecology (Hopkins, *et al.*, 1985; Johnson, *et al.*, 1986; Johnson and Serdar, 1991). The lists of target compounds for these studies vary considerably, but DDT and its metabolites DDD and DDE were detected in all the studies. Several other bioaccumulative pesticides have been detected in one or more of these studies.

Fish and sediment samples were collected from the Yakima River just above the Horn Rapids Dam at river mile 18. Two samples each (replicates) of whole fish, largemouth bass fillets, largescale sucker eggs, and sediment were collected.

Mercer Slough

Mercer Slough is a channelized wetland that receives urban run-off from much of south Bellevue. Most of this water comes from Mercer Creek, which receives water from Richards Creek, Sunset Creek, and Kelsey Creek. Seven pesticides were detected in water samples collected for the 1992 WSPMP. Nine pesticides were identified in water and sediment samples from Mercer Creek and Slough collected for the 1990 Puget Sound Pesticide Reconnaissance Survey (PTI, 1991).

Fish and sediment samples were taken from the area where Mercer Creek runs into Mercer Slough. One sample each of whole fish, rainbow trout fillets, and sediment were collected from the Slough.

Lake River

Lake River receives most of the urban and agricultural run-off from the city of Vancouver through Vancouver Lake in Clark County. In addition, several other streams draining agricultural areas flow into Lake River. Pacific Pole operates a wood treating plant near the mouth of Lake River in the town of Ridgefield. Only one pesticide (dacthal) was identified in water samples collected for the 1992 WSPMP. One sample each of whole fish and sediment was taken near the area where water samples were collected. Only one species of fish (largescale sucker) was encountered.

Sullivan Slough

Sullivan Slough has been channelized to drain agricultural run-off from much of the central Skagit Valley. Six pesticides were detected in water samples taken for the 1992 WSPMP. Five pesticides were detected in sediment samples collected for the 1990 Puget Sound Pesticide Reconnaissance Survey (PTI, 1991). One sediment sample was collected for the WSPMP at the same site as the water samples. No fish were collected because there is no boat access.

Sample Collection and Processing Procedures

See Appendix B for a detailed discussion of sample collection and processing procedures.

Target Pesticides

Fish Tissue

An initial list of target compounds for fish tissue analysis was compiled from other studies or guidelines on analyzing tissue samples for bioaccumulative pesticides (USEPA, 1989; Schmitt, *et al.*, 1990; Tetra Tech, Inc., 1988; Rasmussen and Blethrow, 1991; Crawford and Luoma, 1993). Pesticides recommended for monitoring in tissues in the Puget Sound Basin (Tetra Tech, Inc.,1988) were also included on the list. Endrin aldehyde and endrin ketone were added to the list because they were detected in fish samples from the Yakima River (Johnson, *et al.*, 1986). Appendix C-1 lists the fish tissue target pesticides analyzed for the WSPMP.

Sediments

The target analyte list for sediments (Appendix C-2) is a reduced version of the list for water (Davis, 1993; Table 1). The primary criteria for inclusion of a compound on the sediments list was its designation by Tetra Tech, Inc. (1988) as being of primary or secondary level of concern in sediments. All chlorinated pesticides from the surface water target list were included on the sediment target list. Additional compounds that were added to the sediment list are pesticides that have been detected in Washington sediments and breakdown products of any pesticides in the above categories. The list of sediment target pesticides is organized by analytical method in Appendix C-2.

Analytical Methods - QA/QC - Data Review

See Appendix D for a detailed discussion of analytical methods, field and laboratory quality control procedures, and data review.

Results and Discussion

Pesticides Detected

A total of 24 pesticides and breakdown products were detected in fish tissue samples (Table 2) and nine compounds were detected in sediment samples (Table 3). In addition, three PCBs

Table 2. Concentrations of Pesticides Detected in Fish Tissue (µg/Kg (ppb) wet weight)

Sample Site	Lake Chelan				Crab Creek			Walla Walla River		
					Rep1	Rep2				
Fish Species	LSS	RBT	KOK	KOK	LSS	LSS	MWF	LSS	LSS	WCR
Tissue Type	WF	FIL	FIL	EGG	WF	WF	FIL	WF	EGG	FIL
% Total Lipid	1.79	0.13	0.54	2.59	2.54	2.19	2.47	1.94	0.89	0.15
% Non-Polar Lipid	0.43	0.06	0.27	2.53	1.38	1.60	1.78	1.65	0.58	0.10
Analyte										
4,4'-DDE	133	53	398	1370	218	162	105	425	57	17
4,4'-DDD	29	2.2 J	17	59	63	26	20	51	7.2 J	1.7 J
4,4'-DDT	5.1 J	1.8 J	19	82	14	7 J	5.2 J	26	3.6 J	
2,4'-DDE	1.7 J		2 J	11				2.9 J		
2,4'-DDD	3 J		2.1 J	12 J	6.5 J	2 J	1.3 J	7.0		
2,4'-DDT			5.1 J	24						
total DDT	172	57	443	1558	302	197	132	512	68	19
DDMU	17 J	6.9 J	14 J	41	18 J	10 J	11 J	16 J	1.9 J	
alpha-BHC	0.5 J			1.5 J				0.5 J		
gamma-BHC (lindane)				0.5 J				7.9	2.3 J	1.3 J
heptachlor epoxide								8.3	2.1 J	3.7 J
dieldrin						3 NJ		5 J		
endrin			2.8 J	13 J						
kelthane			9 NJ	50 NJ						
methoxychlor					1.7 NJ	1.0 NJ				
alpha-chlordene				0.3 NJ						
gamma-chlordene				0.5 NJ						
cis-chlordane (alpha)	1.3 J		0.5 J	2.1 J		0.8 J		4.6 J	0.8 J	0.7 J
trans-chlordane (gamma)	1.3 J		0.6 J	0.8 J				4.9 J	0.7 J	0.7 J
cis-nonachlor			0.1 J	3.8 J				1.9 J		
trans-nonachlor			1.5 J	7.3 J				10 J		
oxychlordane	0.4 J		1.0 J	4.0 J				2.0 J		
total chlordane	3.0		3.7	18.0		0.8		23	1.5	1.4
hexachlorobenzene				2.1 J				6.9 J	2.7 J	2.1 J
pentachloroanisole				0.3 J						
PCB-1242				10 NJ						
PCB-1254	17 J	15 J	12 J	14 J	26 J	19 J	14 J	48 J	10 J	
PCB-1260				16 J	25 J	24 J	16 J	90	22 J	
total PCBs	17	15	12	40	51	43	30	138	32	

Fish species key: LSS=Largescale Sucker; RBT=Rainbow Trout; KOK=Kokanee (land-locked Sockeye Salmon); MWF=Mountain Whitefish; WCR=White Crappie

Tissue type key: WF=Whole Fish; FIL=Fillet (muscle only); EGG=Eggs

Data qualifier codes: J = The analyte was positively identified, but the value is an estimate.

NJ = There is evidence that the analyte is present. The value is an estimate.

Table 2 (cont.). Concentrations of Pesticides Detected in Fish Tissue (µg/Kg (ppb) wet weight)

	Yakima River						Mercer Slough		Lake River
	Rep1	Rep2	Rep1	Rep2	Rep1	Rep2			
Fish Species	LSS	LSS	LSS	LSS	SMB	SMB	LSS	RBT	LSS
Tissue Type	WF	WF	EGG	EGG	FIL	FIL	WF	FIL	WF
% Total Lipid	5.90	4.47	1.25	1.11	0.06	0.05	3.66	0.05	4.47
% Non-Polar Lipid	5.08	3.32	0.88	0.85	0.00	0.00	3.36	NAF[1]	3.66
Analyte									
4,4'-DDE	1420	532	107	252	45	43	144	15	157
4,4'-DDD	151 J	76	15	21	3.2 J	2.0 J	75	4.4 J	39
4,4'-DDT	94	45	8.6 J	15	1.3 J	1.0 J	18	3.5 J	17
2,4'-DDE	13	7.1	0.8 J	1.7 J					
2,4'-DDD	26	11	1.6 J	2.4 J			12		5.1 J
2,4'-DDT	13	6.4							2.2 J
total DDT	1717	678	133	292	50	46	249	23	220
DDMU	55	23	6.0 J	13	2.6 J	1.3 J	26 NJ	3 J	13 J
alpha-BHC									0.3 NJ
gamma-BHC (lindane)							1.1 J		0.4 NJ
dieldrin	42	31	11	12	3.3 J	3.3 J			
kelthane								1.4 NJ	
alpha-chlordene	1.7 J	0.7 J					1.7 J		
gamma-chlordene	5.6 J	2.0 J					2.7 J		
cis-chlordane (alpha)	21	7.4 J	1.4 J	2.0 J	0.4 NJ	0.3 NJ	24	2.1 J	3.0 J
trans-chlordane (gamma)	15	6.0 J	0.9 J	1.3 J	0.4 NJ	0.3 NJ	10 J	1.3 J	2.4 J
cis-nonachlor	8.1	3.6 J		0.4 J		0.5 J	17	0.7 J	1.2 J
trans-nonachlor	32	15	2.2 J	4.6 J	0.7 J	0.4 J	43	3.8 J	6.1 J
oxychlordane	7.5	2.9 J	0.8 J	1.5 J	0.5 J	0.5 J	2.3 J	0.4 J	1.0 J
total chlordane	84	35	5.3	9.8	2.0	2.0	96	8.3	13.7
hexachlorobenzene	1.7 J						2.9 J		1.7 J
pentachloroanisole	1.1 NJ	0.5 J		0.2 J			6.2 J	0.6 J	6.1 J
chlorpyrifos	3.37 J								
PCB-1242									21 NJ
PCB-1254	68 J	27 J	6 J	13 J	7 J		104 J	20 J	95
PCB-1260	164	49 J	13 J	27 J	9 J	8 J	275	31 J	83
total PCBs	232	76	19	40	16	8	379	51	199

[1] NAF = Not Analyzed For (insufficient sample volume for analysis)

Fish species key: LSS=Largescale Sucker; RBT=Rainbow Trout; SMB=Smallmouth Bass

Tissue type key: WF=Whole Fish; FIL=Fillet (muscle only); EGG=Eggs

Data qualifier codes: J = The analyte was positively identified, but the value is an estimate.

NJ = There is evidence that the analyte is present. The value is an estimate.

Table 3. Concentrations of Pesticides Detected in Sediments (µg/Kg (ppb) dry weight)

Sample Site	Mercer Slough	OPSG[1]	Walla Walla River	OPSG	Yakima River Rep1	Rep2	OPSG	Crab Creek	Sullivan Slough
% Fines	77		100		42	44		34	83
% TOC	8.2		2.3		1.2	1.2		1.7	2.9
Analyte									
4,4'-DDE	7 J	1558	8 J	437	15 J	16 J	228		
4,4'-DDD	16 J	492			3 J	3 J	72		
4,4'-DDT	8 J								
chlordane (cis+trans)	26 J	492							
gamma-BHC (lindane)			8 J	23					
trans-nonachlor	10 J								
dichlobenil	42 J								
pentachlorophenol	32 NJ		14 NJ		23 NJ	16 NJ		22 NJ	19 NJ

[1] OPSG = Ontario Provincial Sediment Guidelines (see page 20)

Data qualifier codes J=The analyte was positively identified, but the value is an estimate.
NJ=There is evidence that the analyte is present. The value is an estimate.

were detected in fish tissue and one non-target compound (pentachloroaniline) was tentatively identified in sediment. A minimum of ten target analytes were detected in fish tissue per sample site, with a maximum of 23 and an average of 18 per site. Pentachlorophenol, 4,4'-DDE, and 4,4'-DDD were detected in two or more sediment samples.

Figure 2 shows the frequency of detection for target analytes in fish tissue. DDT and metabolites, chlordane, and two PCBs were detected at all sample sites. Over 75% of the compounds detected were found at three or more sites.

The highest concentration detected (1420 μg/Kg) was for 4,4'-DDE in whole fish samples from the Yakima River. The highest level for fillet samples (398 μg/Kg) was also for 4,4'-DDE, detected in kokanee from Lake Chelan. The high level of 4,4'-DDE found in kokanee fillets was substantiated by an even higher concentration in kokanee eggs (1370 μg/Kg), which was the highest detected in egg samples. Other pesticides that were detected in high concentrations were 4,4'-DDD, 4,4'-DDT, and dieldrin (Yakima River), and heptachlor epoxide (Walla Walla River).

Lake Toxics Screening Survey

Detected compounds from the Lake Toxics Screening Survey (LTSS) are presented in Table 4. In general, far fewer pesticides were detected in the LTSS fish samples as compared to WSPMP samples. The most compounds detected at one site was 11 at Lake Sammamish, the least was four at Roses Lake, and the average was seven. Roses Lake is located above Manson, Washington and drains into Lake Chelan. The concentrations of 4,4'-DDE in fillet and whole fish samples from Roses Lake are similar to the levels found in WSPMP fish tissue samples from Lake Chelan. Lake Chelan samples contained many compounds, including PCBs, that were not detected in samples from Roses Lake. Few pesticides were detected in fish from Long Lake (Spokane County), but PCB concentrations were very high. Subsequently, Ecology has performed a study to assess PCB contamination in the Spokane River (Johnson, *et al.*, 1994).

Comparisons of Lipid Normalized Results

Lipid determinations are routinely performed because the accumulation of pesticide residues in fish is thought to be proportional to their extractable lipid contents. Lipid normalized results are thus an indication of bioavailability of the pesticides to the fish. Wet weight based pesticide concentrations in fish samples are often compared by first normalizing the data to percent lipid.

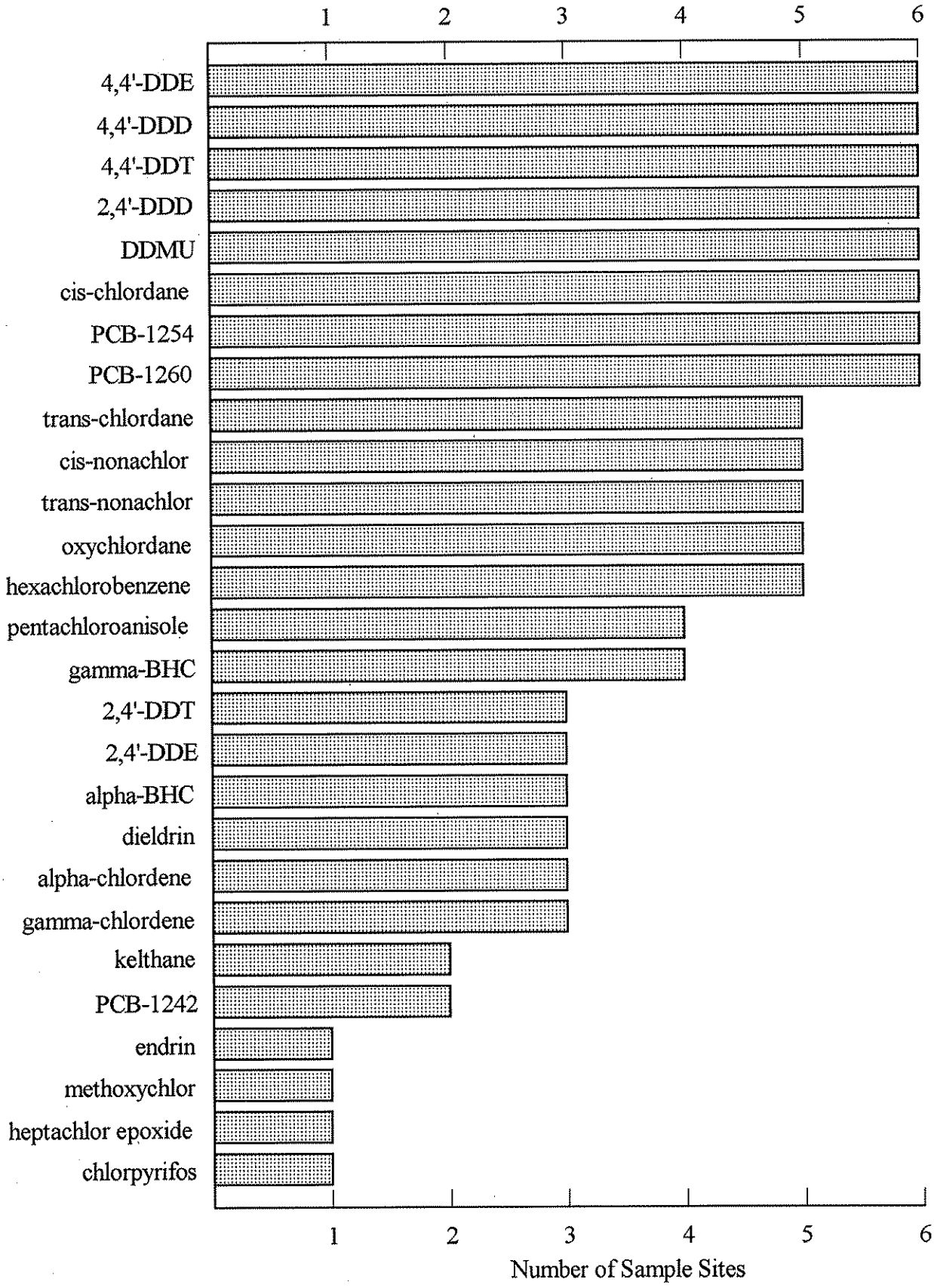

Figure 2. Detection Frequency of Pesticides and PCBs in Fish Tissue

Table 4. Results from the Lake Toxics Screening Survey (Serdar, 1994) (μg/Kg (ppb) wet weight)

Sample Site	Potholes Reservoir			Long Lake			Roses Lake			Lake Sammamish			Ward Lake	
Fish Species	LSS	LWF	LMB	LSS	YP	LMB	BBH	BBH	RBT	LSS	BBH	LMB	LMB	RBT
Tissue Type	WF	FIL	FIL	WF	FIL	FIL	WF[1]	FIL	FIL	WF	FIL	FIL	FIL	FIL
% Total Lipid	8.63	7.26	0.34	NAF[2]	0.18	2.12	1.53	0.72	0.88	4.52	0.52	0.40	0.13	0.97
Analyte														
4,4'-DDE	82	28	4 J	91 J	2 J	2 J	388	165	75	35	2 J	3 J	4 J	7
4,4'-DDD	18	8		9 J			86	19	26	19				3 J
4,4'-DDT	10	6 J		7 J			6 J	2 NJ	2 J	3 J				3 J
2,4'-DDE	3 J													
2,4'-DDD	2 J													
total DDT	115	42	4	107	2	2	480	186	103	57	2	3	4	13
DDMU							24 J	5 J	15 J					
dieldrin	37	32	5 J							8				
methoxychlor	7 J													
alpha-chlordene										10 J				
gamma-chlordene										4 J				
hexachlorobenzene	2 J	2 J								4 J		0.4 J		2 J
pentachloroanisole										2 J				
dacthal	19 J	62 J	5 J											
PCB-1248				287						21 J				
PCB-1254				208 J						86 J				
PCB-1260				229						62 J				8 J
total PCBs				724						169				8

[1] Mean of duplicate analyses

[2] NAF = Not Analyzed For

Fish species key: LSS=Largescale Sucker; LWF=Lake Whitefish; RBT=Rainbow Trout; YP=Yellow Perch; LMB=Largemouth Bass; BBH=Brown Bullhead

Tissue type key: WF=Whole Fish; FIL=Fillet (muscle only)

Data qualifier codes: J = The analyte was positively identified, but the value is an estimate.

NJ = There is evidence that the analyte is present. The value is an estimate.

Figure 3 compares total DDT, chlordane, and PCBs detected in whole largescale suckers on a wet weight and a lipid weight basis and includes data from the LTSS. Results from largescale suckers were used in Figure 3 because this was the only tissue common to all the sites compared.

On a wet weight basis, the concentration of total DDT from the Yakima River was over twice as high as any other site. Normalized values of total DDT from the Walla Walla River are substantially higher than those from the Yakima River or any other site. This suggests that the bioavailability of DDT and metabolites is higher in the Walla Walla than in the Yakima. The apparent bioavailability of total chlordane and PCBs from the Walla Walla River is also higher in relation to the other sites.

Results from Lake Chelan are similar. Total DDT calculated on a wet weight basis was the lowest for WSPMP sites. Lipid normalized total DDT values from Lake Chelan were elevated above Mercer Creek and Lake River, and were similar to Crab Creek values. Clearly, the bioavailability of DDT and metabolites in Lake Chelan is higher than indicated by wet weight results. This agrees well with results from other fish tissue analyzed from Lake Chelan (fillets and eggs) that indicate high levels of total DDT (Patmont, *et al.*, 1989).

Comparisons with Applicable Criteria

Human Health

As discussed earlier, the WSPMP should be interpreted as a screening survey. Standing alone, data from screening surveys are not adequate for making decisions regarding fish consumption, but the EPA recommends evaluating detected chemical contaminants with screening values to prioritize problem areas. Data from intensive surveys are then evaluated to determine if consumption recommendations or advisories are warranted.

Screening values for carcinogenic compounds are calculated using a risk level. A risk level is a value that predicts the increased number of cancer cases caused by a specific or multiple contaminant(s); a risk factor of $1x10^{-6}$ suggests that one person in a million will contract cancer as a result of long term exposure to the contaminant(s) through consumption of fish tissue. Washington State has adopted $1x10^{-6}$ as its risk level under the State Water Quality Standards (173-201A-040 WAC).

Screening values for non-carcinogenic analytes are calculated using a reference dose that is derived from no observed adverse effects levels (NOAELs) or lowest observed adverse effects levels (LOAELS).

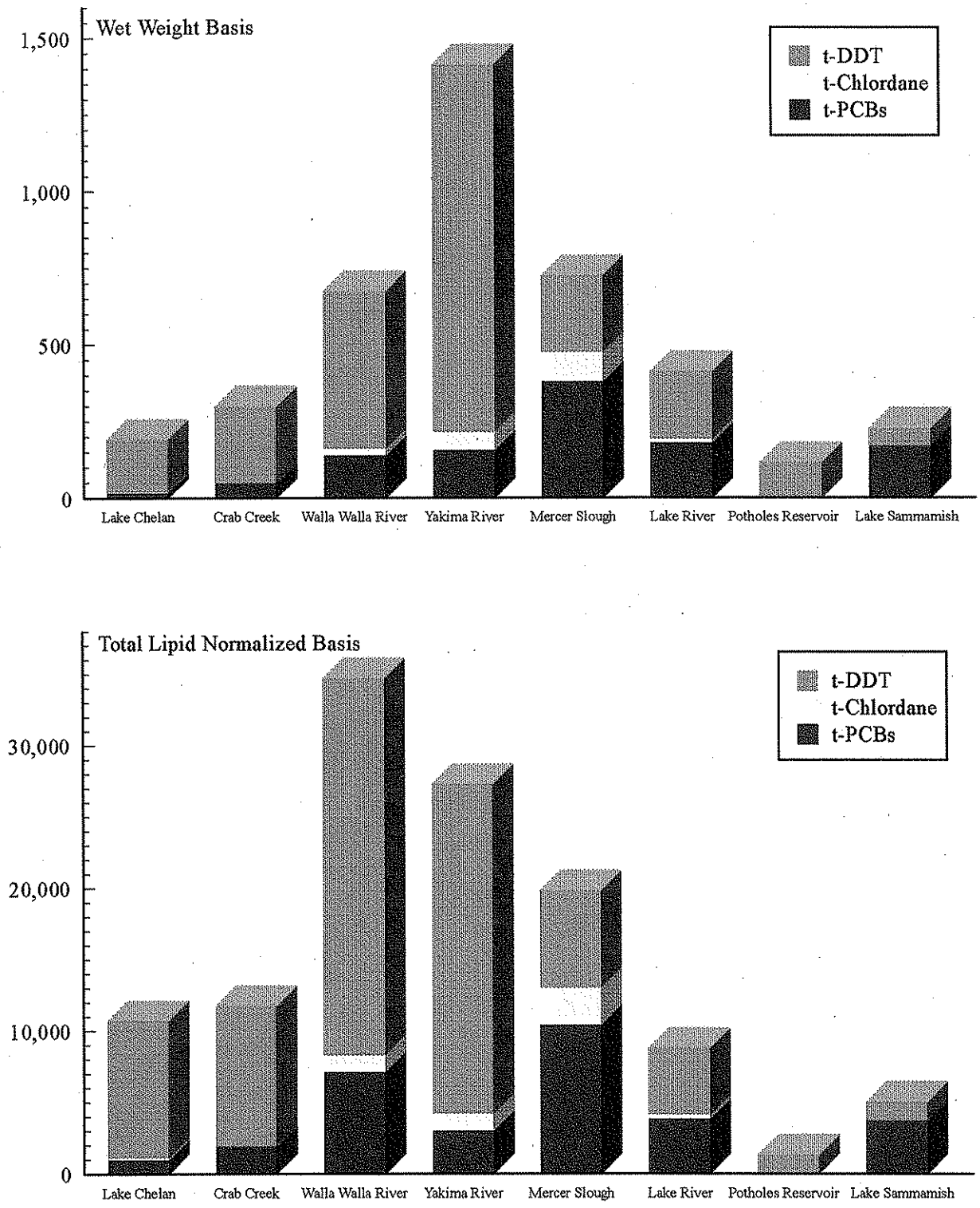

Figure 3. Wet Weight vs Lipid Normalized Concentrations of Compounds Detected in Whole Largescale Suckers (ug/Kg)

Potholes Reservoir and Lake Sammamish were sampled for the Lake Toxics Screening Survey (Serdar, et al., 1994)

Other variables used in screening value equations are a body weight of 70 kg and a consumption rate of 6.5 grams per day. These values represent the mean body weight for all adults and the average consumption rate for the general U.S. population (USEPA, 1993).

Pesticides detected in the WSPMP are compared to screening values in Table 5. Screening values were exceeded for one or more compounds at all of the sites sampled. Notable exceedances include DDT for Lake Chelan, Crab Creek, and the Yakima River and dieldrin for the Yakima River.

303(d) List

As calculated, the screening values listed in Table 5 are the same as National Toxics Rule (NTR) criteria (40 CFR part 131) that are used to assess sites for possible addition to the water quality limited list (section 303(d) of the federal Clean Water Act). However, chlordane and kelthane are not included in NTR criteria. The 303(d) list contains state waterbodies that do not meet water quality standards, and is used to help set priorities for controlling water pollution from a variety of sources. WSPMP sites will be added to the list if there is one or more NTR criterion exceeded for a five fish composite of edible tissue (State Water Quality Policy 1-11, 1993).

Fillet samples from Lake Chelan, Crab Creek, and the Yakima River all contained 4,4'-DDE in concentrations above the NTR criterion. Samples from Lake Chelan were collected from rainbow trout and kokanee; both contained concentrations of 4,4'-DDE above the criterion. PCB-1254 and -1260 were above NTR criteria in samples from Crab Creek, the Yakima River, and Mercer Slough; and PCB-1254 exceeded the criterion in samples from Lake Chelan. NTR criteria were also exceeded for heptachlor epoxide in samples from the Walla Walla River and for dieldrin in the Yakima River. All of these sites qualify for addition to the water quality limited list.

Wildlife Criteria

There are no pesticide criteria that have been adopted for protection of wildlife. Proposed fish flesh criteria were developed by Newell, *et al.* (1987) for contaminants found in Niagara River fish to protect piscivorous wildlife. Criteria were calculated from NOELs to prevent non-carcinogenic effects in fish-eating wildlife. Criteria for carcinogenic compounds were also developed, using a 1 in 100 ($1x10^{-2}$) cancer risk to provide a level of protection for wildlife "to ensure that there will be virtually no reduction in a population from toxic-induced cancer". Additional guidelines have been recommended by the National Academy of Sciences (NAS, 1973) for the protection of aquatic wildlife and fish predators. The WSPMP results are compared to these criteria in Table 6.

Table 5. Comparison of Pesticides Detected in Fish Fillets to Human Health Screening Levels (μg/Kg (ppb) wet weight)

Sample Site	Lake Chelan		Crab Creek	Walla Walla River	YakimaRiver		Mercer Slough	Screening Levels EPA, 1993
Fish Species	RBT	KOK	MWF	WCR	Rep1 SMB	Rep2 SMB	RBT	
Carcinogenic Analytes								
total DDT	**57**	**443**	**132**	19	**50**	**46**	23	32
total chlordane		3.7		1.4	2.0	2.0	8.3	8.3
gamma-BHC (lindane)				1.3 J				8.3
dieldrin					**3.3 J**	**3.3 J**		0.7
heptachlor epoxide				**3.7 J**				1.2
hexachlorobenzene				2.1 J			0.6 J	6.7
total PCBs	**15**	**12**	**30**		**16**	**8**	**51**	1.4
Non-Carcinogenic Analytes								
endrin		2.8 J						3200
kelthane (dicofol)		9 NJ					1.4 NJ	11000

Values in bold exceed screening levels

Fish species key

RBT=Rainbow Trout
KOK=Kokanee (land-locked sockeye salmon)
MWF=Mountain Whitefish
WCR=White Crappie
SMB=Smallmouth Bass

Data qualifier codes

J=The analyte was positively identified, but the value is an estimate.
NJ=There is evidence that the analyte is present. The value is an estimate.

Table 6. Comparison of Pesticides Detected in Whole Fish Samples to Wildlife Criteria (μg/Kg (ppb) wet weight)

Sample Site	Lake Chelan	Crab Creek		Walla Walla River	Yakima River		Mercer Slough	Lake River	Criteria Newell,et al., 1987		NAS, 1973
		Rep1	Rep2		Rep1	Rep2			Non-Carinogenic	Carcinogenic	
Analyte											
4,4'-DDE	133	**218**	162	**425**	**1420**	**532**	144	157	200	270	1000
4,4'-DDD	29	63	26	51	151 J	76	75	39	200	270	1000
4,4'-DDT	5.1 J	14	7 J	26	94	45	18	17	200	270	1000
total DDT	172	**302**	197	**512**	**1717**	**678**	**249**	**220**	200	270	1000
total chlordane*	3.0		0.8	23	84	35	96	8.3	500	370	100
gamma-BHC (lindane)*				7.9			1.1 J	0.4 NJ			100
dieldrin*			3 NJ	5 J	**42**	**31**			120	22	100
heptachlor epoxide*				8.3					200	210	100
* - sum of marked compounds	3		3.8	44	**126**	66	97	8.7			100
hexachlorobenzene				6.9 J	1.7 J		2.9 J	1.7 J	330	200	
total PCBs	17	51	43	**138**	**232**	76	**379**	**178**	110	110	500

Values in bold exceed criteria

All data are from largescale suckers

Data qualifier codes

J=The analyte was positively identified, but the value is an estimate.

NJ=There is evidence that the analyte is present. The value is an estimate.

One or more analyte concentration exceeded wildlife criteria at all of the sample sites, except Lake Chelan. These results indicate that aquatic life and/or piscivorous wildlife may be at risk at these sites.

Sediment Criteria

Adopted criteria for freshwater sediments are also lacking in Washington State. Table 3 compares sediment results to provincial sediment quality guidelines developed by the Ontario Ministry of the Environment (Persaud, *et al.*, 1991). The guidelines in Table 3 reflect levels of sediment contaminants that would be expected to produce severe effects[1] on sediment dwelling organisms that are chronically exposed. These values have been organic carbon normalized. Of the compounds detected in sediment samples, guidelines are available for DDE, DDD, chlordane, and lindane. Concentrations of these pesticides in this study were well below guidelines.

Comparisons with Historical Data

Results of the WSPMP were compared to historical data from other surveys to further assess the reliability and usefulness of the WSPMP data, and to identify pesticides that may be a chronic problem in affected waterways. Historical data with the same species and tissues analyzed as in the WSPMP were only available for four of the WSPMP sites and then for one or two samples only. Because methods used to analyze lipids have not been consistent between surveys, only wet weight based data could be compared.

Differences between sample processing and analytical methods are likely to result in some variability between surveys. Results from the present study indicate that differences between replicates can be expected to be 100% or more. For these reasons and due to small sample sizes, little significance can be attributed to differences observed between surveys.

Many of the pesticides that bioaccumulate have been banned by the EPA, and presumably are no longer being used. Concentrations of these pesticides in fish or sediment are not likely to increase. Comparisons with historical data may show trends of decreasing concentrations and can indicate when problem pesticides fall below criteria. Presently, the only instance where a clear decreasing trend has been established is for the Yakima River as discussed below.

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[1] Severe effects level - Pronounced disturbance of sediment-dwelling organisms can be expected. Contaminant concentration would be detrimental to the majority of benthic species.

Fish Tissue

Yakima River

Data from fish tissue collected by the USFWS (Schmitt, *et al.*, 1981; 1990) at Granger, Washington show a significant decrease in the concentration of total DDT and trans-chlordane from 1970 to 1980. Similar, but not significant, trends are apparent for other chlorinated pesticides detected in the fish. However, in 1980 concentrations of DDT in fish remained above EPA criteria (40 CFR Part 131).

Based on USGS data (Rinella, *et al.*, 1992), the Washington State Department of Health (DOH) issued a consumption recommendation for bottom fish from the Yakima River in July of 1993. The pamphlet distributed by the DOH recommends limiting the consumption of bottom fish, such as largescale suckers, from the Yakima River due to high concentrations of DDT and metabolites in the fish tissue. There are not enough data points for trend analysis in the information used to prepare Figure 4A, but the data illustrates that concentrations of DDT in the Yakima River continue to be elevated.

Lake Chelan, Walla Walla River, and Crab Creek

Total DDT concentrations in WSPMP fish tissue from Lake Chelan, the Walla Walla River, and Crab Creek are compared to historical data in Figure 4B. All data presented are for whole fish samples. DDE in Walla Walla River samples continues to be above the proposed wildlife criterion. DDE in samples from Lake Chelan appear to be slightly lower than samples taken in 1987 and the WSPMP concentration was below the wildlife criterion. Additional sampling at Lake Chelan will be necessary to confirm the lower value.

National Studies

Figure 5 compares results from whole fish analyses, for each site sampled for the WSPMP, with mean concentrations from national fish tissue surveys. Data from the USFWS (Schmitt, *et al.*, 1990) includes national averages for data collected in 1984. National averages of contaminants in fish tissue samples collected in 1987 and reported by the EPA (USEPA, 1992) are broken down by chemical use categories (industry and urban, and agriculture) and include background levels.

Many of the WSPMP concentrations are above national background levels, but most are near or below other national averages. Notable exceptions include DDE in the Walla Walla and Yakima rivers, and chlordane in the Yakima River and Mercer Slough, which are higher than most other national averages. For pesticides detected in the WSPMP but not included in

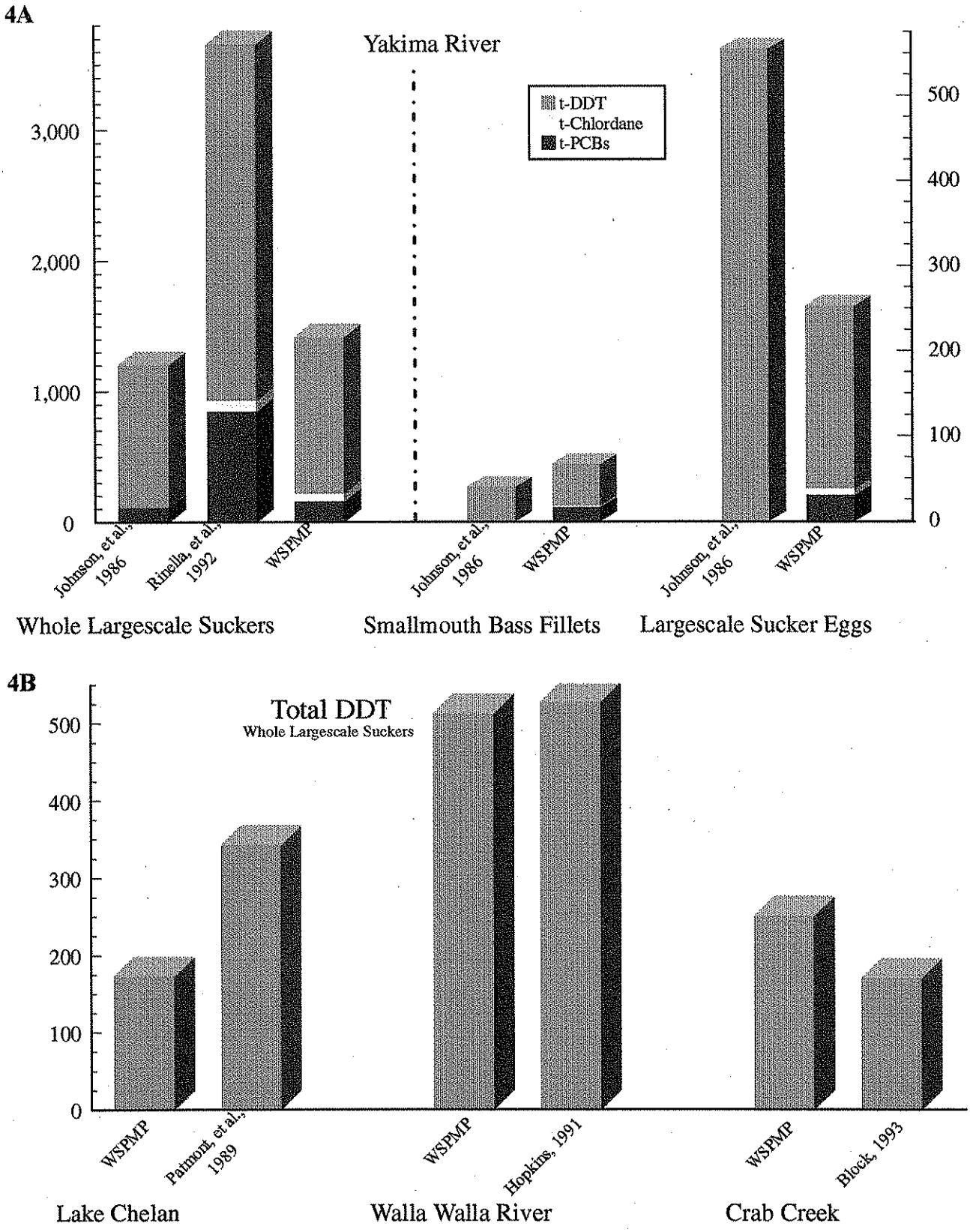

Figure 4 A&B. Comparison of WSPMP Fish Tissue Results with Historical Data (µg/Kg, (ppb) wet weight)

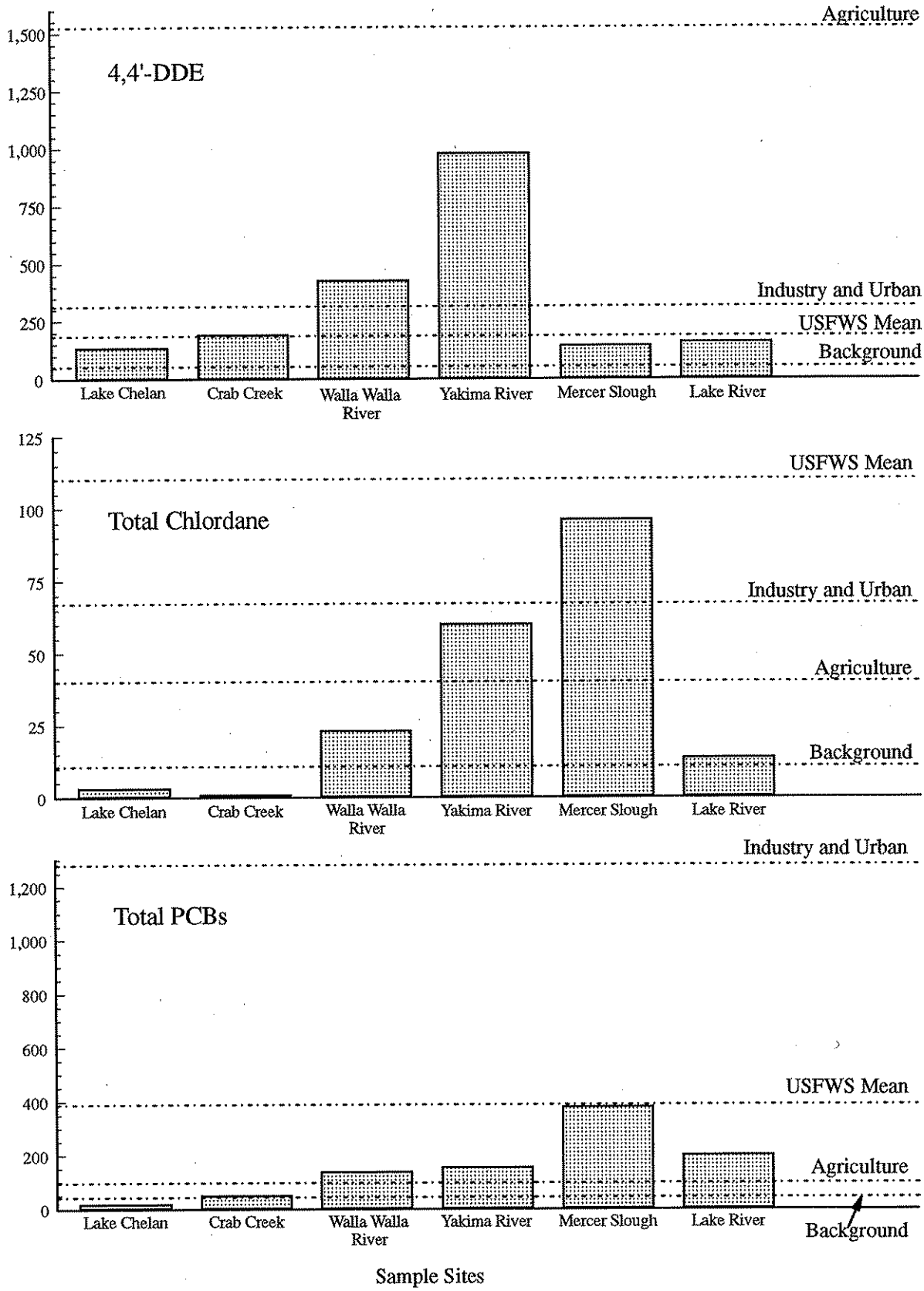

Figure 5. Comparison of Whole Fish Results with Concentrations from National Studies (µg/Kg (ppb) wet weight)

Figure 5, concentrations of heptachlor epoxide and gamma-BHC from the Walla Walla, dieldrin from the Yakima, and pentachloroanisole (a metabolite of pentachlorophenol) from Mercer Slough and Lake River were high as compared to national averages.

Sediments

For the few pesticides detected in sediment samples from the Yakima River, concentrations appear to decrease from the earliest Ecology data collected in 1984 (Hopkins, *et al.*, 1985) to the data collected in 1992 for the WSPMP (Table 7). There are only two sets of data each for the Walla Walla River and Mercer Slough, which is not enough information to assess trends. Concentrations do not appear to be substantially different.

Conventional Parameters

Length and weight data for each fish composite and complete sediment grain size data are presented in Appendix H. Lipid data have been included in Table 2 and percent total organic carbon (TOC) and percent fines have been included in Table 3 to facilitate comparisons with pesticide detections.

Evaluation of Non-Polar Lipid Analysis

Recent literature (Schneider, 1982; Schmitt, *et al.*, 1990) suggests that chlorinated pesticides and PCBs are partitioned into the non-polar or "fat" portion of lipids and only this should be the basis for normalizing data as opposed to total lipid.

Total and non-polar lipid normalized data were compared to determine which is more useful. In Figure 6, comparisons are made between replicate samples and between sample sites for largescale suckers. Different tissues from the same species are compared in Figure 7. In all cases, either there is little difference between the two approaches or non-polar lipid normalized data are substantially more variable. From these data, it appears that data are more comparable when they are total lipid normalized.

Evaluation of Fish Egg Analysis

Fish egg samples were analyzed to determine their value in results interpretation and to determine if this tissue should be included in future WSPMP sampling events. For all three largescale sucker egg samples analyzed, the concentrations of detected pesticides were lower than those for whole fish samples (Table 2). Lipid concentrations were lower, and fewer metabolites were detected in sucker eggs than in whole fish. The opposite is true for kokanee

Table 7. Comparison of Sediment Results to Available Historical Data (μg/Kg (ppb) dry weight)

Sample Site	Yakima River				Walla Walla River		Mercer Slough	
Agency	Ecology	Ecology	USGS	Ecology	Ecology	Ecology	USEPA	Ecology
Year(s) of Collection	1984	1985	1989-90	1992	1984	1990	1990	1992
Reference	Hopkins, et al., 1985	Johnson, et al., 1986	Rinella, et al., 1992	WSPMP	Hopkins, et al. 1985	WSPMP	PTI, 1991	WSPMP
Analyte								
4,4'-DDE	51	30.1	7	16 J	1 u	8 J	3.8	7 J
4,4'-DDD	23	5.3	2	3 J	1 u	36 u	7.4	16 J
4,4'-DDT	35	3.4	0.3	36 u	1 u	36 u	9.7	8 J
2,4'-DDT	NAF[1]	0.71	NAF	36 u	NAF	36 u	NAF	36 u
total DDT	109	39.5	9	19 J	1 u	8 J	20.9	31 J
total chlordane	1.0 u	0.1 u	5	36 u	1.0 u	36 u	16 u	36 J
dichlobenil	NAF	NAF	NAF	72 u	NAF	72 u	22	42 J
dieldrin	1.0 u	1.7	0.8	36 u	1.0 u	36 u	NAF	36 u
endosulfan I	NAF	0.1 u	<0.1	36 u	NAF	36 u	11.3	36 u
endosulfan II	NAF	0.1 u	NAF	36 u	NAF	36 u	8.0 J	36 u
pentachlorophenol	20 u	NAF	NAF	20 NJ	20 u	14 NJ	13.0 J	32 NJ

[1] NAF = Not Analyzed For

Data qualifier codes

u = The analyte was not detected at or above the reported value.

J = The analyte was positively identified, but the value is an estimate.

NJ = There is evidence that the analyte is present. The value is an estimate.

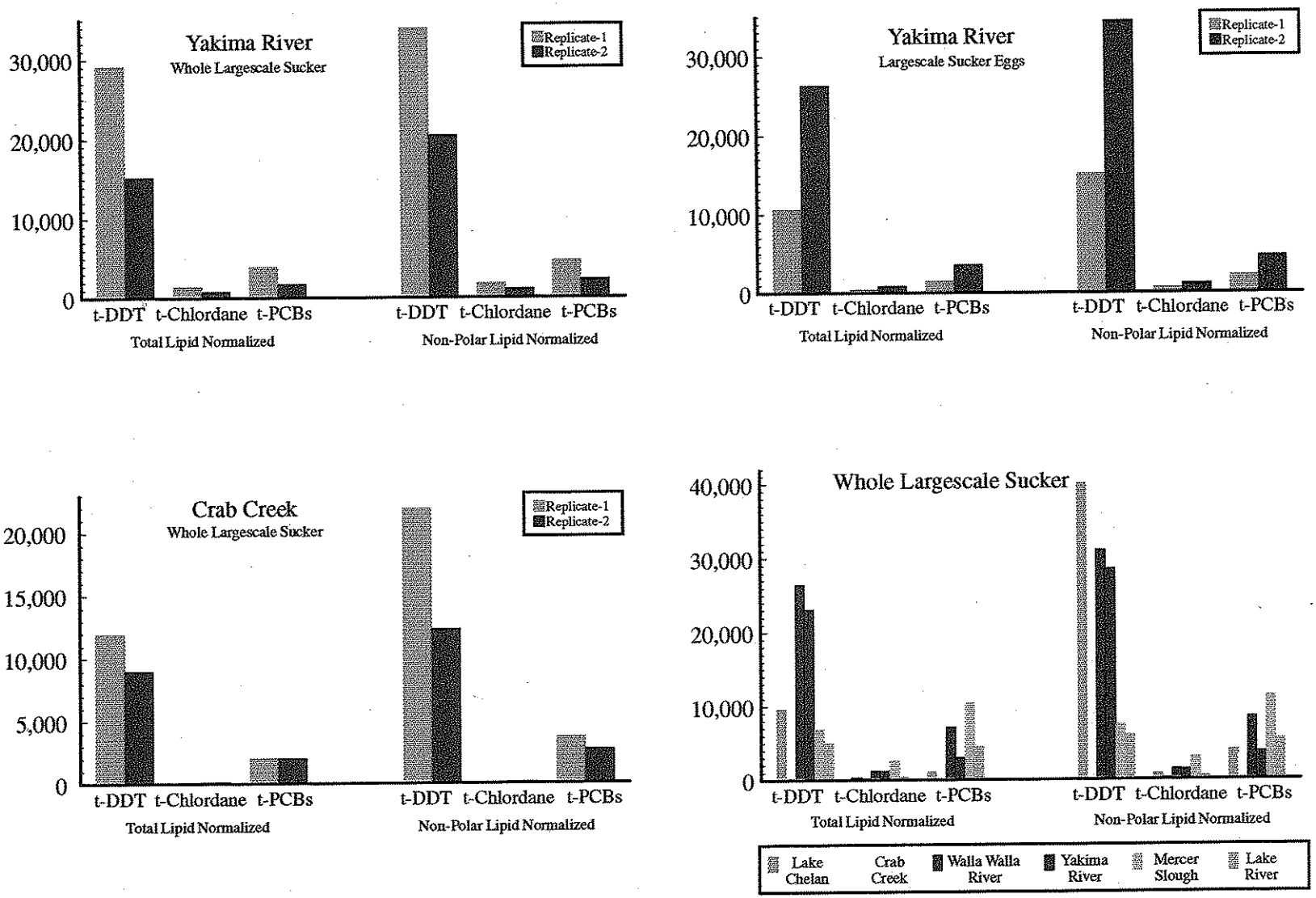

Figure 6. Lipid Normalized Comparisons Between Replicate Samples and Between Sample Sites (µg/Kg lipid)

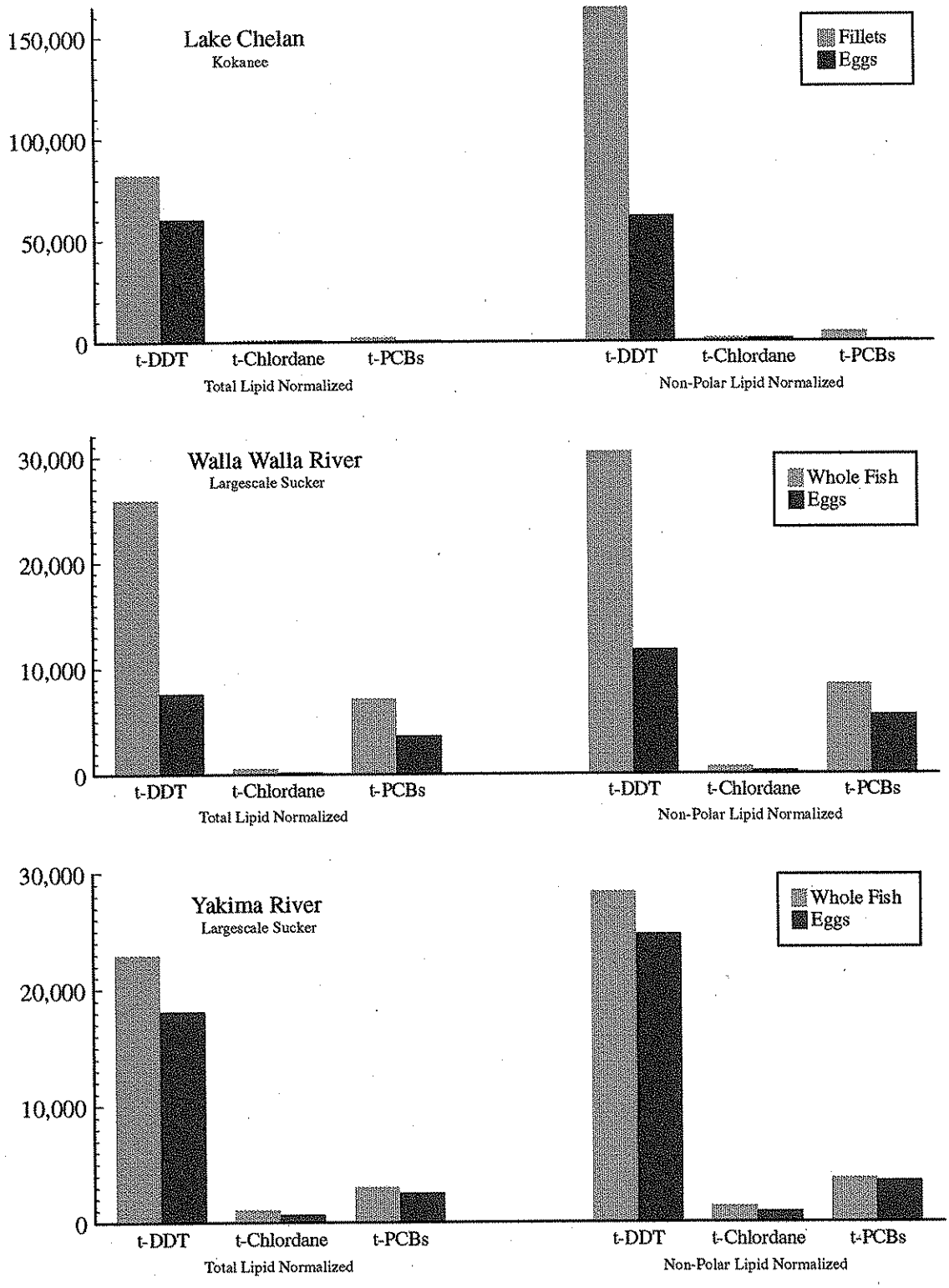

Figure 7. Lipid Normalized Comparisons Between Different Tissues from the Same Species (µg/Kg lipid)

egg and fillet samples. The eggs of largescale suckers do not appear to be a particularly useful addition to the monitoring program. For sport fish, such as kokanee, the lipid content of eggs is likely to be higher than for other tissues and results from egg analyses should be more valuable.

Eggs were also analyzed to assess potential impacts on fisheries at a sensitive life stage. Egg production is probably not impaired by pesticide concentrations equal to those detected by the WSPMP (Allison, *et al.*, 1964; Macek, 1968; Chadwick and Shumway, 1970). In fact, DDT and chlordane are reported to increase egg production and the number of ova at concentrations similar to the highest WSPMP detections (Macek, 1968; Malone and Blaylock, 1970).

The effects of organochlorine pesticides on fish eggs and fry were summarized by Johnson, *et al.* (1986). Data from total DDT exposure experiments are variable, due to the use of different methods (e.g., chronic or acute exposures). However, it appears that increased egg or fry mortality will be observed when accumulated concentrations are over 1000 μg/Kg, with up to 40% mortality at concentrations as low as 1200 μg/Kg, depending on the species affected. Results are also variable for dieldrin studies. In one study, dieldrin concentrations as low as 500 μg/Kg in steelhead trout alevins caused over 90% mortality (Chadwick and Shumway, 1970). In another study, walleye fry were not significantly affected until dieldrin concentrations reached 12,000 μg/Kg (Hair, 1972).

Based on the literature, it appears the concentrations of pesticides detected in largescale sucker eggs by the WSPMP probably do not pose a threat to the reproductivity of these fish. Total DDT and dieldrin concentrations in egg samples from the Yakima River were above human health screening levels, but were well below concentrations that are likely to significantly increase egg or fry mortality. However, the level of total DDT in kokanee eggs from Lake Chelan was well above the concentration likely to cause increased mortality of eggs and fry, and may be high enough to cause significant mortality. In addition, there is evidence to suggest that the action of pesticide combinations may be additive, resulting in increased toxicity (Macek, 1975). If the effect of the 20 pesticides detected in kokanee eggs is additive, mortality of eggs and fry may be quite high.

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Appendices

Appendix A. Sample Site Positions

Site Name	Latitude			Longitude			State Plane	
	deg	min	sec	deg	min	sec	X	Y
Lake Chelan near Wapato Pt.	47	52	34	120	11	43	2074827	927528
Crab Creek near hwy 243	46	49	3.6	119	54	57.6	2146211	541826
Walla Walla River near mouth	46	04	18.6	118	50	51.6	2419350	273695
Yakima River 46 at Horn Rapids Dam	22	48.0	119	25	12.0	2272569	383544	
Sullivan Slough near LaConner	48	24	7.2	122	27	54.6	1522444	1125214
Mercer Slough below mouth of creek	47	36	1.8	122	11	5.4	1584311	831258
Lake River below Ridgefield	45	49	33.0	122	45	30.0	1424320	187839

All positions except Lake Chelan are for sediment collection. Fish were collected near the listed sites, but were generally from a number of positions that may have been separated by as much as 4 to 5 miles.

Appendix B. Sample Collection and Processing Procedures

Fish Collection

Electroshocking equipment and/or gill nets were used to collect fish. When possible, each fish for a composite was taken from a different location within the specified sampling area (space-bulking). This should result in a sample that is more representative of a water body than a sample of fish all taken from the same location. The position of each sampling site was recorded using a Magellan® global positioning system (GPS). When possible, whole fish samples were a mixture of males and females. As fish were collected, they were placed in clean stainless steel buckets until they could be processed.

Field Processing of Fish Tissue Samples

After collection, all fish samples were rinsed with native water, measured for total length, and weighed. A portable battery powered scale was used to weigh the fish to the nearest gram. Scale samples were taken from each fish for age determinations, but these samples have not been analyzed.

Whole Fish - Fish samples for whole fish and fillet analyses were preserved on ice and transported to the laboratory whole. Each fish was wrapped in aluminum foil with the dull side in contact with the specimen. All specimens forming a composite were placed in a separate polyethylene bag.

Egg Samples - Resections were performed in the field to remove egg samples. Resections were done in the field rather than the laboratory to ensure collection of an adequate sample size. The following procedure was used:

- Clean fish with a cloth to remove mucus and other debris.
- Place fish on clean aluminum foil.
- Open body cavity with precleaned instruments.
- Excise eggs with a second set of precleaned instruments.
- Place tissue sample in a precleaned glass container with a teflon-lined cap.
- Repeat procedure until composite is complete.
- Seal container and place in a polyethylene bag.

Sediment Collection

Sediment samples were taken with a stainless steel $0.05m^2$ Ponar grab sampler. Sampling positions were located in depositional areas as close as possible to the positions where fish samples were taken and were recorded using GPS. After collection, samples were judged for acceptability using the following criteria:

Appendix B (cont.). Sample Collection and Processing Procedures

- Partial samples - grabs filling only a portion of the sampler were discarded.
- Washed samples - grabs that were washed excessively from a door staying open or from sloshing were discarded.
- Under- or over-filled sampler - sampler penetration of less than 5cm or a sample touching the top of the sampler was unacceptable.
- Leaves, sticks, and rocks - samples that consisted primarily of leaves, sticks, rocks, or other unrepresentative debris were discarded.

Overlying water was removed by siphoning with a short piece of tubing, being careful not to disturb the surface of the sediment. The top 2cm of sediment was removed with a precleaned stainless steel spatula and placed in a precleaned stainless steel bowl. Only sediment that did not touch the edge of the sampler was removed. The completed composite sample was homogenized to a uniform color and consistency. Enough of the sample was transferred to fill two 8 oz. jars 3/4 full. In addition, aliquots of sediment were taken for total organic carbon, percent solids, and grain size analysis.

Sample Preservation and Storage

Whole fish samples were held on ice for transportation to the laboratory. Egg and sediment samples, except those for grain size analysis, were frozen on dry-ice in the field. Samples for whole body analysis were transferred to freezers at the laboratory and stored at -20° C until further processing. Fish collected for fillet analyses were processed fresh.

Laboratory Processing of Fish Tissue Samples

Fish collected for whole body analysis were cut into chunks small enough to be put through a Hobart® commercial meat grinder. The sex of each fish was recorded during processing. Subsamples of the homogenized whole fish samples were transferred to appropriate containers and refrozen. Egg samples were thawed, homogenized with a grinding attachment for a Kitchen-Aid® food mixer, and refrozen.

Fish collected for muscle tissue (fillets) were processed in the laboratory using the following procedure:

- Clean area of fish to be resected with a cloth.
- Cut a patch through the skin larger than the section of muscle to be taken as the sample.
- Remove skin from the patch.
- Remove a section of muscle from within the skinned area smaller than the original cut.
- Place tissue in an appropriate container.
- Open body cavity to determine sex.
- Repeat process for all specimens to be included in the composite.
- Homogenize tissue and refreeze to -20° C.

Appendix B (cont.). Sample Collection and Processing Procedures

Decontamination Procedures

Fish tissue and sediment samples destined for pesticide analysis were contained in glass jars with teflon-lined lids. These containers were precleaned by Eagle-Picher Environmental Services Miami, Oklahoma using the following process:

- washed in laboratory grade detergent,
- rinsed three times with distilled water,
- rinsed with 1:1 nitric acid,
- rinsed three times with organic-free water,
- oven-dried for one hour,
- rinsed with hexane,
- and oven-dried again for one hour.

Sampling equipment, homogenization equipment and utensils, and resection instruments were stainless steel or glass and were precleaned using the following procedure:

- washed with laboratory grade detergent (Alconox®),
- rinsed with tap water,
- rinsed with deionized water,
- rinsed with pesticide grade acetone, and
- allowed to air dry.

A similar decontamination procedure was used in the field for sampling equipment after each fish or sediment composite and for resection instruments between each tissue composite. Sampling equipment was rinsed with site water before use.

Appendix C-1. Target Pesticides for Fish Tissue

EPA METHOD 1618

Chlorinated Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb wet)	Analyte	Quantitation Limit (μg/Kg, ppb wet)
4,4'-DDT	8	endosulfan sulfate	8
4,4'-DDE	8	endrin	8
4,4'-DDD	8	endrin aldehyde	8
2,4'-DDT	8	endrin ketone	8
2,4'-DDE	8	heptachlor	8
2,4'-DDD	8	heptachlor epoxide	8
DDMU	8	hexachlorobenzene	8
aldrin	8	methoxychlor	8
BHC-alpha	8	mirex	8
BHC-beta	8	nonachlor-cis	8
BHC-delta	8	nonachlor-trans	8
BHC-gamma (lindane)	8	oxychlordane	8
chlorbenside	REJ*	pentachloroanisole	8
chlordane-cis (alpha)	8	tetradifon	40
chlordane-trans (gamma)	8	toxaphene	400
chlordene-alpha	8	PCB-1016	80
chlordene-gamma	8	PCB-1221	80
4,4'-dichlorobenzophenone	40	PCB-1232	160
dicofol (kelthane)	40	PCB-1242	80
dieldrin	8	PCB-1248	80
endosulfan I	8	PCB-1254	80
endosulfan II	8	PCB-1260	80

* - chlorbenside was not recovered from matrix spike samples, all results were rejected.

Appendix C-1 (cont.). Target Pesticides for Fish Tissue

EPA METHOD 1618

Organophosphorus Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb wet)	Analyte	Quantitation Limit (μg/Kg, ppb wet)
chlorpyrifos	140	paraoxon-methyl	160
diazinon	160	parathion	140
ethion	140		

Appendix C-2. Target Pesticides for Sediment

EPA METHOD 1618

Chlorinated Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb dry)	Analyte	Quantitation Limit (μg/Kg, ppb dry)
4,4'-DDT	36	endrin aldehyde	36
4,4'-DDE	36	endrin ketone	18
4,4'-DDD	36	endosulfan I	36
2,4'-DDT	36	endosulfan II	36
2,4'-DDE	36	endosulfan sulfate	36
2,4'-DDD	36	heptachlor	36
DDMU	36	heptachlor epoxide	36
aldrin	36	hexachlorobenzene	36
BHC-alpha	36	methoxychlor	36
BHC-beta	36	mirex	36
BHC-delta	36	nonachlor-trans	36
BHC-gamma (lindane)	36	oxychlordane	36
chlordane-cis (alpha)	36	pentachloroanisole	36
chlordane-trans (gamma)	36	toxaphene	720
chlordene-alpha	36	PCB-1242	120
chlordene-gamma	36	PCB-1248	120
dicofol (kelthane)	140	PCB-1254	120
dieldrin	36	PCB-1260	120
endrin	36		

METHOD NPS-4

Urea Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb dry)	Analyte	Quantitation Limit (μg/Kg, ppb dry)
cyanazine	90	diuron	480

Appendix C-2 (cont.). Target Pesticides for Sediment

EPA METHOD 1618

Nitrogen-Containing Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb dry)	Analyte	Quantitation Limit (μg/Kg, ppb dry)
alachlor	140	molinate	160
ametryn	60	metolachlor	180
atraton	180	metribuzin	60
atrazine	60	napropamide	180
benefin	90	norflurazon	90
bromacil	360	oxyflurazon	160
butachlor	210	pebulate	140
butylate	90	pendimethalin	90
carboxin	660	prometon	60
chlorothalonil	140	prometryn	60
chlorpropham	300	pronamide	180
cycloate	90	propachlor	120
dichlobenil	72	propazine	60
diphenamid	180	simazine	60
eptam	90	terbacil	300
ethalfluralin	90	terbutryn	60
fenarimol	180	trifluralin	90
fluridone	480	triadimefon	160
hexazinone	90	triallate	160
MGK264	420	vernolate	90

Appendix C-2 (cont.). Target Pesticides for Sediment

EPA METHOD 1618

Organophosphorus Pesticides

Analyte	Quantitation Limit (μg/Kg, ppb dry)	Analyte	Quantitation Limit (μg/Kg, ppb dry)
azinphos-ethyl	96	ethoprop	48
azinphos-methyl	110	fensulfothion	60
chlorpyrifos	42	fonofos	36
chlorpyrifos-methyl	42	malathion	48
diazinon	48	parathion	48
dimethoate	48	parathion-methyl	42
disulfoton	36	phorate	42
ethion	42		

EPA METHOD 8150

Chlorophenoxy Herbicides

Analyte	Quantitation Limit (μg/Kg, ppb dry)	Analyte	Quantitation Limit (μg/Kg, ppb dry)
2,4-D	150	dicamba	140
2,4-DB	170	diclofop-methyl	220
2,4,5-TP (silvex)	110	MCPA	290
Bentazon	220	pentachlorophenol	85

Appendix D. Analytical Methods - QA/QC - Data Review

Analytical Methods

Fish Tissue and Sediment - Fish tissue and sediment samples were analyzed by Ecology's Manchester Environmental Laboratory. Chlorinated, organophosphorus, and nitrogen-containing pesticides were analyzed using EPA Method 1618, modified to include non-standard target compounds (modifications are summarized in Huntamer, *et al.*, 1992). This method allows the use of alternate detectors. The Atomic Emission Detector (AED) was selected because it has a high degree of specificity for the elements of interest (Cl, P, N) and non-target compounds can be identified and quantified. Chlorinated herbicides were analyzed using EPA Method 8150. Urea pesticides were analyzed using the NPS-4 method. These methods were developed for the surface water analyses and have been extended for analysis of fish tissue and sediments. Extracts from fish tissue required multiple clean-up steps to achieve the quantitation limits shown in Table 2.

Conventional Parameters - Lipid analyses were performed by Manchester Environmental Laboratory using a portion of the fish tissue samples collected for pesticides analysis. Total lipids were determined using a petroleum ether extraction method (USEPA, 1980). Non-polar lipids were analyzed using a method by Schneider (1982).

Conventional parameters that were measured for sediment samples include total organic carbon, total solids, and grain size. Separate samples were taken for these parameters and analyzed by Laucks Testing Laboratories, Inc. Seattle, Washington.

Quality Assurance/Quality Control

Field Quality Control Procedures

Field replicate samples were taken to estimate overall precision. Two replicate samples were collected from the Yakima River for whole fish, eggs, fillets, and sediment. Two replicate samples of whole fish were also collected from Crab Creek.

Laboratory Quality Control Procedures

Samples were collected for matrix spike and matrix spike duplicate analyses to detect bias due to interferences from the sample matrix. Fish tissue matrix spikes were analyzed with aliquots of samples taken from Crab Creek (chlorinated pesticides analysis) and Lake Chelan (organophosphorus pesticides analysis). Sediment samples for matrix spikes were collected from Lake River.

Appendix D (cont.). Analytical Methods - QA/QC - Data Review

In addition to routine quality control practices followed by Manchester Laboratory (Kirchmer, 1988), fish tissue reference material was submitted to the laboratory in duplicate to estimate analytical precision and accuracy. Matrix and surrogate spikes performed by the laboratory also provide estimates of accuracy and precision.

Data Review

Fish tissue and sediment pesticide analysis data packages and quality control results were reviewed and assessed by Dickey Huntamer of Ecology's Manchester Environmental Laboratory. Results from conventional sediment analyses performed by Laucks Testing Laboratories were reviewed and assessed by David Thompson of Manchester Laboratory.

No significant problems were encountered for the fish tissue or sediment analyses. Numerous minor difficulties required qualification of affected data. Tissue extracts for chlorinated pesticides analysis were held up to 26 days beyond the recommended holding time of 40 days. This was not expected to have any significant effect on the results, because of the persistence of these compounds. A trace amount of hexachlorobenzene (HCB) was detected in one laboratory blank. Applying the EPA five times rule, compounds detected in a sample are considered real and not the result of contamination if the concentration is greater than or equal to five times the amount in the blank. HCB was detected in two samples affected by the contaminated blank, but the concentration in both samples was over five times the amount detected in the blank. For another laboratory blank and the corresponding blank duplicate, no surrogates were spiked for either the chlorinated or the organophosphorus pesticides, so all associated blank results were "J"[2] qualified. Chlorbenside was not recovered from the matrix spikes, so all chlorbenside results were rejected.

Fewer problems were associated with sediment analyses. A trace of pentachlorophenol (PCP) was detected in one laboratory blank using the gas chromatograph and an electron

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[2] Data Qualifier Codes
U - The analyte was not detected at or above the reported value.
J - The analyte was positively identified. The value is an estimate.
UJ - The analyte was not detected at or above the reported estimated result.
REJ - The data are unusable for all purposes.
NAF - Not analyzed for.
NJ - There is evidence that the analyte is present. The value is an estimate.

capture detector (GC/ECD). The same sample was reanalyzed by AED, but the contaminant was not detected. Due to conflicting results, along with questionable matrix spike results, PCP data were reported with an "NJ" data qualifier. Bentazon also had questionable matrix spike results, so affected data was "J" qualified. All compounds detected in the chlorinated pesticides analysis were "J" qualified because their levels were below quantitation limits. HCB and pentachloroanisole (a metabolite of PCP) results were "UJ" qualified because their quantitation limits were calculated from the calibration mixture. Dicofol was "J" qualified because it showed some instability during calibration.

Sediment for grain size analysis was not pre-treated with hydrogen peroxide. This could have resulted in a bias of the grain size distribution and there was potential for the final cumulative percentage to be different than 100%. This was observed with two of the samples, which were slightly over 100%.

All data were considered acceptable as qualified.

Detection Limits - The detection limits achieved for fish tissue analyses were a significant improvement over past studies. The values in Appendix C are quantitation limits, which are often different for each sample. Detection limits were not calculated separately, but were generally substantially lower than quantitation limits. In this study, many pesticides were detected below quantitation limits. In most instances, the level of detection was sufficiently low to compare with even the lowest criteria.

Quantitation and detection limits for sediment analyses were rather disappointing. Detection limits for other published sediment surveys (Johnson, *et al.*, 1986; PTI, 1991; Rinella, *et al.*, 1992) are one to two orders of magnitude lower than those obtained for the WSPMP sediment samples. This may explain the low number of pesticides detected in sediment, although the number of detections were low for the historical surveys as well.

Quality Control Samples - No accuracy or precision criteria have been established for any of the analytical methods used, but duplicate reference material and matrix and surrogate spike analyses provide estimates of accuracy and precision. Recoveries near 100% indicate good accuracy and low relative percent difference (RPD) values indicate high precision.

Fish tissue reference material samples were submitted to the laboratory in duplicate. The reference material was composed of frozen lake trout from Lake Michigan, obtained from the U.S. Fish and Wildlife Service in Ann Arbor, Michigan. This is not certified reference material, but the USFWS has been analyzing it since 1985 for their studies and have compiled considerable data to establish the expected values.

Appendix D (cont.). Analytical Methods - QA/QC - Data Review

Appendix E compares reference material results to expected values. RPDs range from 4 to 62% with an average of 28%. Recoveries ranged from 49 to 190% with an average of 99%. Most of these results indicate good accuracy. Results for heptachlor epoxide, total PCBs, and 4,4'-DDT had high RPDs, but all were within an order of magnitude of the expected values. RPDs for the duplicate recoveries (not included on Table 3) range from 0 to 42% with an average of 20%. For the three compounds listed above, their recovery RPDs are 15, 0, and 12% respectively. These data suggest good precision.

Matrix spike and duplicate recoveries and corresponding RPDs are presented in Appendix F. Recoveries averaged 80% for fish tissue and 93% for sediment spikes indicating good accuracy. RPD values for fish tissue and sediment averaged 9% and 12% respectively, suggesting that precision was also good.

Surrogate spike recoveries are presented in Appendix G. For chlorinated pesticides in tissue, most recoveries were between 60 and 80%. Recoveries for the organophosphorus (OP) pesticides tissue surrogate were variable, with about half being between 50 and 60% and the other half being between 20 and 40 %. As discussed earlier, surrogates were not added to one laboratory blank. Surrogate recoveries for sediment analyses were generally higher. Most were from 80 to 100%. Recoveries for the chlorophenoxy herbicides surrogate ranged from 31 to 87%, with most near 60%. No surrogate was available for the urea pesticides analysis. Most surrogate recoveries indicate good accuracy. Accuracy for many of the OP pesticides tissue analysis results may have been poor. Since the surrogate recoveries for all OP pesticides tissue analyses were low, the values reported for detected analytes may be underestimates.

Replicate samples were collected to evaluate environmental variability between samples from the same site. Results for most samples were very similar between replicates, indicating little environmental variability. However, concentrations of all compounds detected in whole-fish samples from the Yakima River were substantially different between replicates. Surrogate recoveries for the second replicate of these samples were all nearly half that of the first replicate, indicating that the differences were primarily due to analytical anomalies and not environmental variability. Surrogate recoveries for the first replicate of the Yakima whole-fish ranged from 69% to 82%, suggesting that these results are probably more reliable than those from the second replicate.

Appendix E. Comparison of Fish Tissue Reference Material Results to Expected Values (μg/Kg (ppb) wet weight)

Analyte	Mean Concentration (± 1/2 duplicate range)	Expected Value	RPD[1]
4,4'-DDE	517 ±59	495	4
4,4'-DDD	83 ±9	65	24
4,4'-DDT	56 ±4	31	57
dieldrin	110 ±23	152	33
heptachlor epoxide	20 ±2	37	62
alpha-chlordane	71 ±3	82	15
gamma-chlordane	36 ±3	45	22
cis-nonachlor	40 ±7	45	13
trans-nonachlor	136 ±5	94	36
oxychlordane	27 ±6	28	6
total chlordane	308 ±17	294	5
total PCBs	880 ±2	1333	41

[1] RPD = Relative Percent Difference, (difference/mean) x 100.

Appendix F. Matrix Spike Recoveries (%)

Analyte	Sediment MS[1]	Sediment MSD[2]	Sediment RPD[3]	Fish Tissue MS	Fish Tissue MSD	Fish Tissue RPD
Chlorinated Pesticides						
4,4'-DDT	114	84	30	89	93	4
2,4'-DDE				80	83	4
4,4'-dichlorobenzophenone				85	100	16
aldrin				86	86	0
gamma-BHC (lindane)	84	92	9	84	87	4
chlorbenside				0	0	0
trans-chlordane	105	102	3	88	88	0
DDMU				108	113	5
endosulfan I	110	106	4	101	97	4
endrin	93	94	1	102	109	7
heptachlor	63	74	16	90	75	18
hexachlorobenzene				55	68	21
kelthane				62	64	3
methoxychlor	120	87	32	88	91	3
mirex				81	93	3
pentachloroanisole				61	67	9
tetradifon				94	102	8
Organophosphorus Pesticides						
chlorpyrifos	124	110	12	73	60	20
diazinon	99	90	10			
ethion	110	104	6	25	26	4
ethoprop	108	105	3			
ethyl azinphos	116	114	2			
fonofos	122	110	10			
malathion	112	106	6			
methyl parathion	133	120	10	59	42	34
phorate	94	92	2			
Nitrogen-Containing Pesticides						
alachlor	76	102	29			
bromacil	96	101	5			
dichlobenil	110	99	11			
hexazinone	55	102	60			
metribuzin	39	57	38			
pronamide	91	93	2			
simazine	95	97	2			
trifluralin	104	98	6			
Chlorophenoxy Herbicides						
2,4-D	89	85	5			
2,4-DB	85	81	5			
2,4,5-TP (silvex)	89	85	5			
dicamba	59	61	3			
diclofop-methyl	82	77	6			
MCPA	90	86	5			
Urea Pesticides						
cyanazine	45	67	39			
diuron	68	72	6			

[1] MS = Matrix Spike [2] MSD = Matrix Spike Duplicate [3] RPD = Relative Percent Difference, (difference/mean) x 100

Appendix G. Surrogate Spike Recoveries for Fish Tissue Samples (%)

Sample Site	Sample Type	Chlorinated Pesticides DBC	DCBP	DBOFBP	Organophosphorus Pesticides TPP
Lake Chelan	WF LSS	76	76	67	52
	RBT Fillet	90	76	71	50
	KOK Fillet	73	69	59	34
	KOK Eggs	63	76	71	33
Crab Creek	WF LSS Rep-1	76	71	63	55
	WF LSS Rep-2	77	68	66	61
	MWF Fillet	66	79	67	52
Walla Walla River	WF LSS	81	77	74	65
	WCR Fillet	87	78	73	55
	LSS Eggs	65	73	70	47
Yakima River	WF LSS Rep-1	82	74	69	21
	WF LSS Rep-2	39	47	41	25
	LSS Eggs Rep-1	81	73	69	44
	LSS Eggs Rep-2	92	82	76	48
	SMB Fillet Rep-1	71	64	58	39
	SMB Fillet Rep-2	70	65	59	33
Mercer Slough	WF LSS	77	81	74	41
	RBT Fillet	84	77	71	42
Lake River	WF LSS	69	76	68	45
Reference Material	Replicate-1	53	64	63	29
	Replicate-2	63	67	60	39
Matrix Spike		90	76	71	52
Matrix Spike Duplicate		97	82	66	44
Lab Blanks	38-8080	0	0	0	0
	Duplicate	0	0	0	0
	38-8081	64	68	2	31
	Duplicate	66	69	7	21
	38-8100	55	63	57	31
	Duplicate	62	72	52	30

Sample type key
WF = Whole Fish
LSS = Largescale Sucker
RBT = Rainbow Trout
KOK = Kokanee
MWF = Mountain Whitefish
WCR = White Crappie
SMB = Smallmouth Bass

Surrogate key
DBC = Dibutylchlorendate
DCBP = Decachlorobiphenyl
DBOFBP = 4,4-Dibromooctafluorobiphenyl
TPP = Triphenyl Phosphate

Appendix G (cont.). Surrogate Spike Recoveries for Sediment Samples (%)

Sample Site	Chlorinated Pesticides DBC	DCBP	DBOFBP	OP[1] Pesticides TPP	N-C[2] Pesticides DMNB	Chl[3] Herbicides TBP
Crab Creek	80	89	100	103	103	68
Walla Walla River	85	86	86	93	97	56
Yakima River Rep-1	100	91	97	94	119	63
Yakima River Rep-2	92	90	97	96	97	40
Mercer Slough	43	30	89	53	106	33
Lake River	103	98	99	106	89	31
Sullivan Slough	66	65	100	94	97	54
Matrix Spike	114	106	103	101	107	80
Matrix Spike Duplicate	106	100	95	101	93	76
Lab Blank	106	100	80	91	87	76
Lab Blank Duplicate	74	71	74	79	97	87

[1] - OP = Organophosphate
[2] - N-C = Nitrogen-Containing
[3] - Chl = Chlorophenoxy

Surrogate key
DBC = Dibutylchlorendate
DCBP = Decachlorobiphenyl
DBOFBP = 4,4-Dibromooctafluorobiphenyl
TPP = Triphenyl Phosphate
DMNB = Dimethylnitrobenzene
TBP = 2,4,6-Tribromophenol

Appendix H. Length and Weight Data

Location and Species	Collection Date (1992)	Mean Length (mm)	Length Range (mm)	Mean Weight (grams)	Weight Range (grams)	Tissue Type
Lake Chelan	9/15					
largescale sucker		255	230-300	173	117-295	WF[1]
rainbow trout		269	245-305	193	140-295	Fillet
kokanee		345	325-375	427	371-531	Fillet/Egg
Crab Creek	9/15					
mountain whitefish		314	295-330	299	200-435	Fillet
largescale sucker (rep-1)		494	454-520	900	592-1125	WF
largescale sucker (rep-2)		489	443-534	977	635-1188	WF
Walla Walla River	9/16					
white crappie		191	175-224	76	45-141	Fillet
largescale sucker		446	353-526	924	445-1479	WF
largescale sucker		482	430-522	DNC[2]	DNC	Egg
Yakima River	9/16					
smallmouth bass (rep-1)		262	238-293	225	156-315	Fillet
smallmouth bass (rep-2)		249	217-310	201	133-374	Fillet
largescale sucker (rep-1)		448	420-488	1108	963-1324	WF
largescale sucker (rep-2)		440	405-475	1138	794-1309	WF
largescale sucker (rep-1)		481	452-519	1213	1050-1560	Egg
largescale sucker (rep-2)		525	481-565	1345	990-1707	Egg
Mercer Slough	10/13					
rainbow trout		206	178-253	72	45-110	Fillet
largescale sucker		474	443-495	1291	1150-1410	WF
Lake River	9/25					
largescale sucker		424	332-475	753	422-996	WF

[1] WF = Whole Fish [2] DNC = Data Not Collected

Appendix H (cont.). Sediment Conventionals

Sample Location	Collection Date (1992)	% Total Solids	% Total Organic Carbon	Grain Size (% of Total Weight) Gravel (>2mm)	Sand (2mm-62μm)	Silt (62μm-4μm)	Clay (<4μm)
Crab Creek	9/15	51.4	1.7	0	66	23	11
Walla Walla River	9/16	46.1	2.3	0	5	57	51
Yakima River (rep-1)	9/16	52.3	1.2	0	74	37	5
Yakima River (rep-2)	9/16	50.9	1.2	0	56	32	12
Sullivan Slough	10/1	36.3	2.9	1	16	70	13
Mercer Slough	10/13	21.6	8.2	0	23	65	12
Lake River	9/25	57.4	0.9	0	61	24	15
Lake River (dup.)	9/25	NAF[1]	NAF	0	60	26	14

[1] NAF = Not Analyzed For