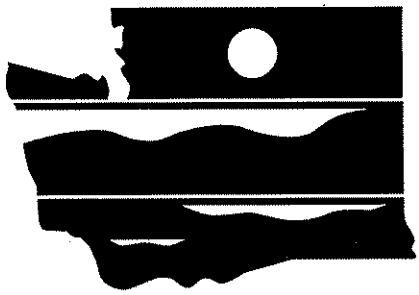

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

DDT in Osoyoos Lake Fish

December 1998
Publication No. 98-337

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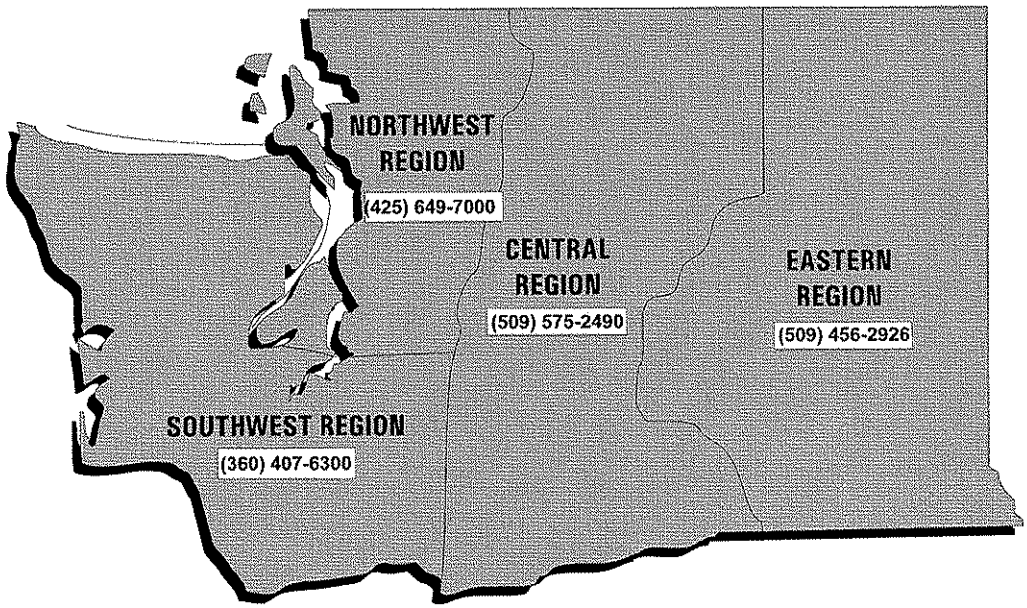

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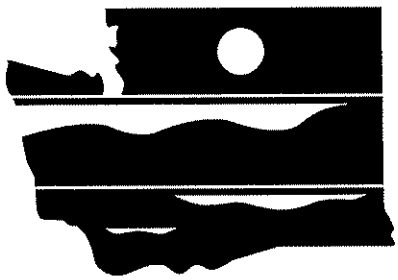

DDT in Osoyoos Lake Fish

by

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Water Body No. WA 49-9260

December 1998
Publication No. 98-337


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Recommendations

1. Ecology should retain Osoyoos Lake on the "water quality limited" 303(d) list for DDT in fish tissue. This recommendation is based on the finding that DDT concentrations in all species tested exceed the National Toxics Rule criteria.

2. The Washington State Department of Health (DOH) should consider using results of this study to conduct a site-specific health risk assessment for consumers of Osoyoos Lake fish. The DOH action level for the lower Yakima River was exceeded in four of the five species from Osoyoos Lake tested for DDT in edible tissue. In addition, DDT in Osoyoos Lake fish might result in excess lifetime cancer risks to humans beyond those considered acceptable due to fish tissue consumption.

3. This report should be distributed to local, state, federal, and tribal fish & wildlife officials concerned with predatory bird populations in the Okanogan basin. In general, wildlife managers and biologists should be aware of the widespread DDT contamination in the Okanogan River basin.

4. Source control recommendations detailed in the Ecology report *DDT Sources to the Okanogan River and Lake Osoyoos* should be implemented. Efforts to control DDT sources should be accompanied by periodic monitoring of DDT levels in fish from Osoyoos Lake and the Okanogan River to determine the effectiveness of control efforts over time.

Acknowledgements

To the many people who contributed to the completion of this survey, we thank you. We would especially like to acknowledge the following people for their efforts:

- Pam Covey, Karin Feddersen, Dickey Huntamer, Stuart Magoon, Will White, and other staff of the Manchester Laboratory provided sample handling, tracking, and analysis, as well as data quality review.

- E.V. Jensen (B.C. Environment), and George Brady, Joe Foster, and Ken Williams (WDFW) furnished valuable information on wildlife and fisheries in the Okanogan River basin.

- Glen Patrick (DOH) and Stew Lombard (Ecology) reviewed the project proposal.

- Larry Goldstein, Jim Milton, and Dale Norton (Ecology) provided comments on the report, as did Glen Patrick and Koenraad Marien (DOH) and the Colville Confederated Tribes.

- Shirley Rollins (Ecology) proofread and formatted the final report.

Abstract

During 1995, the Washington State Department of Ecology conducted a survey to assess concentrations of the pesticide DDT and its breakdown products DDD and DDE in edible fish tissues (muscle fillets) from Osoyoos Lake in north-central Washington. Species analyzed were yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieui*), mountain whitefish (*Prosopium williamsoni*), carp (*Cyprinus carpio*), and lake whitefish (*Coregonus clupeaformis*). Two whole body samples of large scale sucker (*Catostomus macrocheilus*) and one smallmouth bass fillet were also analyzed for additional bioaccumulative pesticides and PCBs. Mean concentrations of total DDT (t-DDT; DDT+DDD+DDE) in muscle fillet ranged from 60 ng/g (parts per billion) in yellow perch to 1,110 ng/g in lake whitefish. Carp had the second highest t-DDT concentrations in muscle (437 ng/g), followed by mountain whitefish (105 ng/g), and smallmouth bass (73 ng/g). PCBs, hexachlorobenzene (HCB), and DDMU, a further breakdown product of DDT, were detected at low concentrations ($\leq$ 60 ng/g) in whole fish.

Results were compared to criteria for the protection of human health, wildlife, and aquatic life. t-DDT concentrations in all species exceed the level expected to result in a 10^{-6} excess cancer risk, by factors of 1.9 to 35. Levels of t-DDT in whole suckers exceed several criteria to protect piscivorous birds and mammals. Recommendations are as follows:

1. To retain Osoyoos Lake on the "water quality limited" 303(d) list for DDT;

2. Conduct a site-specific health risk assessment for consumers of Osoyoos Lake fish;

3. Distribute the report to fish & wildlife officials concerned with predatory bird populations in the Okanogan basin; and

4. Implement source control recommendations detailed in an earlier study on DDT sources to the Okanogan River and Osoyoos Lake.

Summary of Findings

Osoyoos Lake is a large (5,728 acres) lake straddling the U.S.-Canada border in north central Washington, approximately two-thirds of which is located above the border. It is the furthest downstream in a chain of six lakes connected by river flow in the Okanogan basin, a region largely characterized by extensive areas of commercial fruit orchards.

Concerns about DDT*-contaminated fish in Osoyoos Lake stem from a single sample obtained during a 1989 Washington State Department of Ecology (Ecology) screening survey of fish statewide. Although DDT was essentially banned by the U.S. Environmental Protection Agency (EPA) in 1972, its persistence in the environment and capacity to accumulate in fish and other aquatic organisms remain a concern. Due to results of Ecology's previous sampling and concerns about DDT's persistence, a survey of DDT in Osoyoos Lake fish was identified as a monitoring need in Ecology' *Needs Assessment of the Okanogan Watershed*. Ecology's Environmental Investigations and Laboratory Services (EILS) Program subsequently conducted the survey. The primary objective was to assess DDT levels in edible fish tissue (muscle fillets) from Osoyoos Lake. A secondary objective was to obtain pesticide data for EILS' Washington State Pesticide Monitoring Program.

Results showed that total DDT (t-DDT; DDT+DDD+DDE) concentrations were highest in lake whitefish; an order of magnitude higher than concentrations in mountain whitefish, smallmouth bass, and yellow perch. Carp had concentrations 60% lower than lake whitefish. Aside from one carp sample, DDT and its breakdown products were detected in all samples analyzed. DDE was the predominant homolog, comprising 61-84% of t-DDT, followed by DDD (14-37%) and DDT (<1-10%). At least some of the variability among species was due to lipid content.

DDT Concentrations in Muscle Fillets of Osoyoos Lake Fish (ng/g [ppb], wet weight basis; mean concentrations except mountain whitefish).

Species	Number of Samples[a]	Mean Length (mm)	Mean Weight (g)	Percent Lipid	4,4'-DDT	4,4'-DDD	4,4'-DDE	Total DDT
Yellow perch	8	215	118	0.93	4	13	43	60
Smallmouth bass	3	277	374	1.04	4	12	57	73
Mountain whitefish	1	313	306	4.06	6	31	68	105
Carp	4	488	1,636	2.14	1	84	352	437
Lake whitefish	2	532	1,376	6.52	31	405	678	1,114

[a] Each sample was a composite of three to eight fish each; lake whitefish fillets were analyzed individually

* Unless otherwise stated, DDT refers to DDT and its breakdown products DDE and DDD.

Aside from DDT compounds, few additional bioaccumulative pesticides and PCBs were detected in whole largescale suckers and smallmouth bass fillet. DDMU, a further breakdown product of DDT, was detected in all samples at concentrations proportionate to the parent compound (2-60 ng/g). PCBs were detected at concentrations of 24-66 ng/g (total PCBs) and hexachlorobenzene (HCB) was detected at very low concentrations (1-2 ng/g) in sucker samples only.

Concentrations of t-DDT in Osoyoos Lake carp and lake whitefish are on the same order as fish from the lower Yakima River and Lake Chelan, two of the most contaminated areas in Washington. DDE concentrations in these species are higher than national averages reported during the 1980s. In general, t-DDT levels in Osoyoos Lake fish are probably lower than other parts of the Okanogan River basin, including the five major lakes upstream in Canada.

To assess the implications of DDT in Osoyoos Lake fish, concentrations were compared to criteria developed to protect human health and wildlife. Lifetime cancer risks to humans – beyond those considered acceptable due to fish tissue consumption (one in a million) – may result from eating Osoyoos Lake fish. Excess lifetime cancer risks calculated from t-DDT concentrations found during this survey are species-dependent and range from double (1 in 530,000) to 35 times (1 in 29,000) the acceptable level. These calculations were based on DDT cancer potency factors, a national average fish consumption rate, and an average adult body size recommended by EPA as default values for estimating risks; they were not derived from any site-specific data other than the t-DDT concentrations in fish tissue.

Concentrations of t-DDT in whole suckers from Osoyoos Lake exceed several criteria developed to protect fish-eating wildlife. However, some of these criteria are based on eggshell-thinning in the brown pelican, a species not found in the Okanogan River basin. Nevertheless, predatory bird populations may be at some risk of reduced reproductive success if DDT contamination reported in other parts of the Okanogan River basin is considered. Levels of PCBs, HCB, or DDMU in whole Osoyoos Lake suckers would not likely result in deleterious effects to aquatic life or associated wildlife.

Introduction

Osoyoos Lake is a large (5,728 hectare) lake straddling the U.S.-Canada border in north-central Washington, approximately two-thirds of which is located above the border (Figure 1). It is the furthest downstream in a chain of six lakes connected by river flow in the Okanogan basin, a region largely characterized by extensive areas of commercial fruit orchards.

Concerns about DDT*-contaminated fish in Osoyoos Lake stem from a single sample obtained during a 1989 Washington State Department of Ecology (Ecology) screening survey of fish statewide (Johnson and Norton, 1990)(Table 1). Fish collected during previous surveys of the Okanogan River downstream of Osoyoos Lake have also shown high levels of total DDT (t-DDT; DDT+DDD+DDE)(Hopkins *et al.*, 1985; Davis and Serdar, 1996). As a result, both Osoyoos Lake and the Okanogan River are on the "water quality limited" list – a listing of waterbodies not meeting water quality standards as required under section 303(d) of the federal Clean Water Act – due to exceedance of the DDT criterion for edible fish tissue.

In the Ecology report *DDT Sources to the Okanogan River and Lake Osoyoos*, Johnson *et al.* (1997) documented DDT in streams tributary to the Okanogan River. DDT has also been detected in sludge from the Okanogan Wastewater Treatment Plant (Reif, 1990), signifying potential widespread contamination in the Okanogan River basin.

Table 1. Ecology Historical Data on DDT in Osoyoos Lake and Okanogan River Fish.

Sample Location	Year	Species	Sample Type	n	t-DDT (ng/g, wet)
Osoyoos Lake	1989[a]	Largemouth bass	Fillet	1	210
Okanogan R. near Malott	1984[b]	Largescale sucker	"	1	1,800
" "	"	Bridgelip sucker	"	1	3,200
Okanogan R. above Brewster	1994[c]	Carp	"	1	2,900
" "	"	Largescale sucker	Whole	2	1,100[d]

[a] Johnson and Norton, 1990

[b] Hopkins *et al.*, 1985

[c] Davis and Serdar, 1996

[d] mean concentration

*Unless otherwise stated, DDT refers to DDT and its breakdown products DDE and DDD.
Although DDT was essentially banned by the U.S. Environmental Protection Agency (EPA) in 1972, its persistence in the environment and capacity to accumulate in fish tissues remain a concern. Due to results of Ecology's previous sampling and concerns about DDT's persistence, a survey of DDT in Osoyoos Lake fish was identified as a monitoring need in Ecology' *Needs Assessment of the Okanogan Watershed* (Milton, 1995). Ecology's Environmental Investigations and Laboratory Services (EILS) Program subsequently conducted the survey during 1995.

Objectives

The primary objective of this survey was to assess DDT levels in edible fish tissue (muscle fillets) from Osoyoos Lake. A secondary objective was to obtain pesticide data for EILS' Washington State Pesticide Monitoring Program (WSPMP).

Methods

Fish Collection

Table 2 summarizes the species, number, and size range of fish collected for the survey. Sampling data for individual fish are shown in the Appendix, Table A-1.

Yellow perch and smallmouth bass are the most popular species among anglers at Osoyoos Lake (Ken Williams, Washington State Department of Fish & Wildlife, personal communication). Largemouth bass (*Micropterus salmoides*) were targeted because they too are popular among Osoyoos Lake anglers, but samples of this species were unobtainable. Carp were collected because they are caught in Osoyoos Lake on a limited basis by bow and arrow fisherman and they tend to accumulate high concentrations of environmental contaminants (EPA, 1993). Mountain and lake whitefish were not targeted but were taken incidentally and saved for analysis because they tend to accumulate relatively high concentrations of DDT and other organochlorine compounds (Hopkins *et al.*, 1985; Johnson *et al.*, 1988 & 1991). Largescale suckers were selected because their wide-ranging distribution in a variety of habitats, tendency to bioaccumulate organic toxicants, and ease of capture has made them the species of choice for statewide comparisons of contaminant concentrations (Davis and Serdar, 1996).

Fish were collected by gillnet or electroshocking during August 28-31, 1995. Locations are shown in Figure 2. Most of the perch and both of the lake whitefish were collected by gillnet; most other specimens were obtained by electroshocking. Once captured, fish were assigned a sample number, measured for total length, weighed, double wrapped in aluminum foil, placed in zip-lock polyethylene bags, and put on ice until their delivery to the Ecology Headquarters building where they were stored frozen.

Table 2. Osoyoos Lake Fish Analyzed for DDT and WSPMP Pesticides.

Species	No. of Individuals	Mean [Range] Length (mm)	Mean [Range]	Weight (g)
Yellow perch (*Perca flavescens*)	64	215 [174-265]	118	[59-220]
Smallmouth bass (*Micropterus dolomieui*)	12	277 [200-383]	374	[109-871]
Mountain whitefish (*Prosopium williamsoni*)	3	313 [295-335]	306	[259-365]
Carp (*Cyprinus carpio*)	32	488 [400-570]	1,636	[1,035-3,176]
Lake whitefish (*Coregonus clupeaformis*)	2	532 [510-555]	1,376	[1,245-1,508]
Largescale sucker (*Catostomus macrocheilus*)	10	486 [435-525]	1,211	[870-1,567]

Preparation of Composite Tissue Samples

Fillet composite samples of three to eight individual fish were prepared for all species except largescale sucker (whole body composites) and lake whitefish (individual fillets). Fillet composites were grouped by size class in order to assess the relationship between size and DDT concentrations. For perch, eight composites were prepared of eight fish each; for smallmouth bass, three composites of four fish; for mountain whitefish, one composite of three fish; for carp, four composites of eight fish; and for sucker, two composites of five fish each.

Fillets were prepared by separating the foil from the frozen specimens, removing the scales while leaving the skin (skin-off for carp), and extracting the entire fillets on both sides (left side only for carp) from the gill arch to the caudal peduncle. For suckers, the entire fish was cut into rounds several centimeters thick and then chopped into small cubes for grinding.

Tissues were homogenized with three passes through a Kitchen-Aid® food processor or Hobart® commercial meat grinder. Ground tissue was thoroughly mixed following each pass through the grinder. All equipment used for tissue preparation was thoroughly washed with Liquinox® detergent, rinsed in hot water, deionized water, pesticide-grade acetone, and finally, pesticide-grade hexane. This decontamination procedure was repeated between processing of each composite sample. Fully homogenized tissues were stored frozen in 8 oz. glass jars with Teflon lid liners certified for trace organics analysis.

The preparation of composite tissue samples was consistent with EPA recommendations for conducting intensive (tier 2) chemical contaminant surveys (EPA, 1993) with the following exception: EPA recommends homogenizing fillets individually, then compositing equal weights of the homogenized fillet. For this survey, entire fillets were composited during homogenization, and therefore equal portions were not contributed from each fish. This was chosen as the best method for exposure assessment since it retains the bias that is probably inherent in normal consumption patterns, *i.e.*, humans and wildlife will probably consume more of a larger specimen than a smaller specimen and therefore the composite sample should reflect this. It is also the method adopted by the WSPMP.

Analytical Procedures

All tissue samples were analyzed at the Manchester Environmental Laboratory for, 4,4'-DDT, its derivatives 4,4'-DDD and 4,4'-DDE, and percent lipids. DDT was analyzed by gas chromatography/electron capture detection (GC/ECD; EPA Method 8080) with dual column confirmation. Percent lipids were determined gravimetrically after being extracted with hexane (EPA Region X Method RX1-608.5).

The analysis was limited to 4,4' isomers because the GC/ECD method does not include detection of 2,4'-DDT compounds. Data on DDT compounds in fish statewide (Hopkins *et al.*, 1985; Hopkins, 1991; Davis and Johnson, 1994; Serdar *et al.*, 1994; Davis and Serdar, 1996) and nationwide (Schmitt *et al.*, 1990) indicate that 2,4'-DDT compounds contribute relatively little to total DDT concentrations.

Suckers and one smallmouth bass fillet composite were analyzed at Manchester for pesticides on the WSPMP list. This list of 50 target compounds was originally developed by the California Department of Fish & Game Water Pollution Control Laboratory and is currently being used for WSPMP biota analysis (Rasmussen and Blethrow, 1991).

Quality of the Data

DDT Data

Data were reviewed by Karin Feddersen of the Manchester Lab for holding times, method blanks, initial and continuing calibration, and surrogate and matrix spike recovery. Narrative reviews are included in the Appendix. Quality of the data is generally good with few excursions from Method 8080 criteria. Several results were qualified as estimates (J) due to surrogates outside of the acceptable recovery window (sample no. 438249) or sample concentrations above the calibration curve (nos. 438231 and 438254).

Matrix spike recoveries for DDD and DDE were not calculated due to the high native concentrations of these compounds. However, recoveries for DDT and several other chlorinated pesticides were within control limits.

Analytical precision was estimated from four samples split after homogenization and submitted blind (Table 3). In most cases, precision was high with relative percent differences (RPDs) of 35% or less. The DDT results for sample nos. 438252/53 were in poor agreement, the reason for which is unknown. Precision of two matrix spikes analyzed in duplicate was good (RPDs ≤ 20%).

Table 3. Precision of Split Sample Analyses.

Sample Nos.	4,4'-DDT (ng/g)	RPD	4,4'-DDD (ng/g)	RPD	4,4'-DDE (ng/g)	RPD	Percent Lipid	RPD
438245/46	3/4	29%	7/10	35%	28/33	16%	0.57/0.64	12%
438234/35	1/1	0%	56/63	12%	250/270	8%	1.62/1.53	6%
438252/53	4/45	170%	440/480	9%	710/800	12%	5.34/5.72	7%
438230/54	23/30	26%	150/180	18%	720/720	0%	5.28/4.36	19%

RPD=Relative Percent Difference ((difference ÷ mean) × 100%)

WSPMP Pesticide Data

WSPMP pesticide data were reviewed by Karin Feddersen for the same QA/QC elements as DDT analysis (Appendix). Since these samples are a subset of the samples analyzed for the WSPMP, a detailed description of their analysis and data quality are included in *Washington State Pesticide Monitoring Program 1995 Fish Tissue Sampling Report* (Davis *et al.*, 1998).

Overall, the WSPMP data are of good quality and useable as qualified. Some sample results are qualified as estimates (J) due to low (<50%) surrogate recoveries.

Matrix spike recoveries were within acceptable limits (50-150%) for all detected compounds except for 152% DDE recovery in one spiked sample. Bias was also assessed through duplicate analysis of a non-certified reference material, frozen lake trout from Lake Michigan, which has been analyzed numerous times by U.S. Fish & Wildlife Service since 1985. Differences between the Manchester Lab's results and expected values range from 0 to 78 percent.

Analytical precision was assessed from five pair of blind split samples, and duplicate analyses of matrix spikes and the reference material. RPDs ranged from 0% to 78%, but were generally less than 20% suggesting a high degree of analytical precision.

To assess the variability of pesticide concentrations within a species at a given site, sampling was duplicated at three sites and triplicated at one site. Percent differences for the field replicates were approximately double those obtained from split sample analysis and duplicate analyses by the laboratory. These results indicate that environmental variability is a larger factor than sampling or laboratory precision in explaining overall variability in DDT concentrations within species.

Results and Discussion

DDT Concentrations in Osoyoos Lake Fish

DDT, DDD, and DDE concentrations in muscle fillets of Osoyoos Lake fish are shown in Table 4. Mean total DDT (t-DDT) concentrations were highest in lake whitefish; an order of magnitude higher than concentrations in mountain whitefish, smallmouth bass, and yellow perch (Figure 3). Carp had concentrations 60% lower than lake whitefish.

Aside from one carp sample, DDT and its breakdown products were detected in all samples analyzed. DDE was the predominant homolog, comprising 61-84% of t-DDT, followed by DDD (14-37%) and DDT (<1-10%). Concentrations of these compounds relative to t-DDT varied among several species, but were fairly consistent within species. For instance, the average DDT:DDD:DDE ratio was approximately 1:4:12 for perch, bass, and mountain whitefish, greater for lake whitefish (1:13:22), and greater still for carp (1:84:352). The high ratio for carp was most likely due to this species' ability to metabolize DDT to DDE (Schmitt *et al.*, 1990).

Due to their lipophilic nature, concentrations of DDT compounds are largely a function of lipid content in muscle tissue. Lipid-normalized DDT concentrations (Table 4) suggest that at least some of the variability among species is due to lipid content. Figures 4a and 4b show DDT concentrations as a function of lipid in perch and other species, respectively. For carp, lipid content probably accounts for DDT variability within this species, especially considering there is no apparent relationship between size – either length or weight – and DDT levels. The relationship between both length and weight versus DDT concentrations in perch (Figures 5a and 5b) is much weaker than the relationship between lipid and DDT. For smallmouth bass, however, size (not shown in regression) appears to be a much stronger determinant of DDT concentrations than lipid.

Differences in DDT, DDD, and DDE concentrations among species reflect a pattern normally seen for bioaccumulative organochlorines, such as chlorinated pesticides, dioxin, and PCBs. Percids (*i.e.* perch) and centrarchids (*i.e.* bass and sunfish) are generally predatory species with little fat and therefore have little tendency to accumulate high concentrations of these compounds. Perch and bass are usually facultative if not obligatory piscivores, depending on the food source, yet there is little evidence that DDT or its breakdown products biomagnify in fish species. Carp, on the other hand, tend to have fattier muscle tissue and are closely associated with bottom sediments where DDT compounds are sequestered in the aquatic environment. As mentioned previously, whitefish tend to have higher levels of bioaccumulative organochlorines compared to other species, probably due to the high lipid content of their muscle tissue.

Table 4. Concentrations of DDT, DDD, and DDE in Muscle Fillet of Osoyoos Lake Fish (ng/g [ppb], wet weight basis).

Sample No.	Species	Length[a] (mm)	Weight[a] (g)	Percent Lipid	4,4'-DDT	4,4'-DDD	4,4'-DDE	t-DDT	Lipid-Normalized t-DDT (ng/g lipid)
438241	Yellow perch	185	71	0.85	4	12	37	53	6,200
438243	"	199	91	1.10	4	12	35	51	4,600
438244	"	206	104	0.97	4	14	43	61	6,300
438242	"	212	113	1.12	5	15	48	68	6,100
438245/46	"	220	122	0.60	4	8	30	42	7,000
438239	"	223	131	0.96	5	16	55	76	7,900
438238	"	228	133	0.99	4	16	50	70	7,100
438240	"	245	175	0.87	4	13	47	64	7,400
	mean ± s.d. =	215 ± 19	118 ± 31	0.93 ± 0.16	4 ± 0.5	13 ± 3	43 ± 8	60 ± 11	6,600 ± 1,000
438247	Smallmouth bass	222	164	1.04	2	6	35	43	4,100
438248	"	252	234	1.11	5	13	65	83	7,500
438232	"	358	724	0.97	5	16	72	93	9,600
	mean ± s.d. =	277 ± 71	374 ± 305	1.04 ± 0.07	4 ± 1.7	12 ± 5	57 ± 20	73 ± 26	7,100 ± 2,800
438249	Mountain whitefish	313	306	4.06	6 J	31 J	68 J	105 J	2,600
438236	Carp	438	1,170	1.41	1	42	180	223	16,000
438237	"	478	1,515	2.78	U(8)	103	550	653	23,000
438233	"	495	1,638	2.80	2	130	420	552	20,000
438234/35	"	539	2,219	1.58	1	60	260	321	20,000
	mean ± s.d. =	488 ± 42	1,636 ± 437	2.14 ± 0.75	1 ± 0.8	84 ± 40	352 ± 165	437 ± 199	20,000 ± 3,000
438251	Lake whitefish	510	1,245	7.51	37	350	600	987	13,000
438252/53	"	555	1,508	5.53	25	460	755	1,240	22,000
	mean ± s.d. =	532 ± 32	1,376 ± 186	6.52 ± 1.40	31 ± 8	405 ± 78	678 ± 110	1,114 ± 179	18,000 ± 6,000

[a] mean of each composite sample; lake whitefish are individual samples

J = estimated concentration

U = Undetected at or above concentration in parentheses

Note: Carp filleted with skin off; perch, bass and whitefish scaled and filleted with skin on

Additional Pesticides and PCBs in Osoyoos Lake Fish

Table 5 shows pesticides detected in two whole sucker composites and one smallmouth bass fillet composite analyzed for the Washington State Pesticide Monitoring Program (WSPMP) target pesticide list. Results of the complete analysis are shown in the Appendix.

Aside from DDT compounds, few analytes were detected. Low concentrations of 2,4'-DDD in suckers was the only 2,4'-DDT isomer detected. DDMU, a further breakdown product of DDT, was proportionate to the parent compound at concentrations of 2-60 ng/g. PCBs were detected at concentrations of 24-66 ng/g (total PCBs) and hexachlorobenzene (HCB) was detected at very low concentrations (1-2 ng/g) in sucker samples only.

Comparison to Other Studies

Okanogan River Basin, Lower Yakima River, and Lake Chelan

Figures 6 and 7 show mean DDT concentrations in the present survey compared to other data from Osoyoos Lake, the Okanogan River, the lower Yakima River, and Lake Chelan. The Osoyoos Lake data in Figure 6 include a single largemouth bass fillet sample analyzed by Ecology during 1989 (Johnson and Norton, 1990), as well as results of 17 fillet samples analyzed in 1971 by the British Columbia Department of Recreation and Conservation. The B.C. data are from a large-scale study of DDT in fish from the six major Okanogan basin Lakes in Canada (Northcote *et al.*, 1972).

The lower Yakima River and Lake Chelan are included for comparison because they represent the most heavily DDT-contaminated areas of the state and have therefore received the most intensive investigation. DDT contamination of the Yakima River basin has been especially well documented over the past decade. In-depth investigations by Ecology during 1985 (Johnson *et al.*, 1986) and USGS during 1989-90 (Rinella *et al.*, 1992) constitute the bulk of data on DDT in Yakima River fish. Levels of DDT in fish from the lower Yakima River (below Yakima) are among the highest in the state, and in some cases the U.S., due primarily to extensive agricultural runoff the river receives during irrigation season (Schmitt *et al.*, 1990). Based on the results of the USGS survey, the Washington State Department of Health (DOH) has recommended that consumers eat fewer bottom fish from the lower Yakima River. This is the only area in the state where DOH has a current consumption advisory due to DDT contamination.

Lake Chelan is also contaminated with DDT, mainly a result of historical application to orchard lands in the lower basin. The most thorough investigation of DDT in Lake Chelan fish was included in a 1987 water quality assessment of the lake (Patmont *et al.*, 1989). Although the data are not as numerous as for the Yakima River, DDT concentrations in samples from two species (chinook salmon and squawfish) are among the highest in the state.

Table 5. Concentrations of WSPMP Pesticides Detected in Whole Largescale Suckers and Smallmouth Bass Muscle Fillet from Osoyoos Lake (ng/g [ppb], wet weight basis).

Sample No.	Species	Mean Length (mm)	Mean Weight (g)	Pct. Lipid	4,4'-DDT	4,4'-DDD	4,4'-DDE	2,4'-DDD	t-DDT	DDMU	PCB-1254	PCB-1260	HCB
378251	Ls.sucker	478	1,214	5.82	17	120	440	2.3 J	580	38	24	U(36)	1.2 J
378252	Ls.sucker	493	1,209	5.08	40	190	810	3.5	1,040	60	48	18	2.2
378253	Sm. bass	358	724	0.61	5.0 J	8.4	42	U(4.0)	55	2.1 J	U(40)	U(40)	U(2.0)

U=Undetected at or above concentration in parentheses
J = estimated concentration

Figures 6 and 7 also contain data from screening-level surveys of the Okanogan River near Malott (57 river miles below Osoyoos Lake; Hopkins *et al.*, 1985) and near the mouth above Brewster (74 river miles below Osoyoos Lake; Davis and Serdar, 1996). These data were included to provide a comparison between Osoyoos fish and Okanogan River fish. To avoid presenting excessive data, screening-level data from the Yakima River and Lake Chelan were not included in these figures.

Variables such as species, sample size, investigators, and years make comparisons awkward. However, the results suggest that DDT concentrations in Osoyoos Lake fish muscle are generally similar to the range of concentrations found in the lower Yakima River. It may also be reasonable to assume that Osoyoos and Chelan fish have similar DDT levels, excepting the extremely high DDT concentrations found in Lake Chelan chinook salmon and squawfish.

Fish from the Okanogan River also appear to have much higher DDT concentrations than Osoyoos Lake, although this is more evident in muscle fillet than whole fish. In general, DDT levels in Osoyoos Lake fish are probably lower than from other parts of the river, including the five major lakes upstream. In their 1971 study of upstream lakes, Northcote *et al.* (1972) analyzed DDT compounds in 107 composite samples of fish muscle, comprising 671 individual fish. Fifteen of these composite samples from three lakes had wet weight t-DDT concentrations exceeding 5,000 ng/g, and two samples from one lake had concentrations above 50,000 ng/g. t-DDT concentrations in Osoyoos Lake fish from the Northcote *et al.* study ranged from less than 10 ng/g to 2,600 ng/g (Figure 6).

More recent data from Okanagan Lake in B.C., the largest in the six-lake chain, suggest a downward trend in fish muscle DDT concentrations from 1970 through 1990 (E.V. Jensen, B.C. Ministry of Environment, written communication). These data were based on DDT concentrations in rainbow trout muscle collected during fishing tournaments, and therefore represent larger than average fish. The most recent (1990) data are from fish ranging from 2.7 kg to 6.0 kg, with t-DDT concentrations from 430 ng/g to 3,000 ng/g. The DDT concentrations in these fish are probably relatively high since they are positively correlated to fish weight (E.V. Jensen, written communication). Regardless of fish size, the B.C. data indicate a high degree of DDT contamination in the Okanogan River basin above the Canada border.

Statewide Screening Levels

Figures 8a and 8b show DDT concentrations compared to combined results from statewide surveys conducted by Ecology from 1984 until 1995. These screening-level data are from 58 waterbodies sampled during Ecology's Basic Water Monitoring Program (Hopkins *et al.*, 1985; Hopkins, 1991), Washington State Lakes and Reservoir Quality Assessment Program (Johnson and Norton, 1990; Serdar *et al.*, 1994), and WSPMP (Davis and Johnson, 1994; Davis *et al.*, 1995; Davis and Serdar, 1996; Davis *et al.*, 1998). Most of these surveys were conducted to assess ambient

conditions in a variety of rivers and lakes, although waterbodies with a high potential for pesticide contamination were also included in some cases. Figures 8a and 8b do not include data from the more intensive investigations of pesticide-contaminated waterbodies.

Mean concentrations of DDT in Osoyoos Lake fish muscle fall between the 50th and 90th percentile of fish analyzed statewide. Whole body DDT concentrations in Osoyoos Lake suckers and smallmouth bass are in the 77th and 22nd percentile of statewide samples, respectively. Although not identified in these figures, it is noteworthy that samples from the Okanogan River, lower Yakima River, and Lake Chelan together account for a majority of the top quintile in both Figure 8a (12 of 17 samples) and Figure 8b (6 of 9 samples). Osoyoos Lake data would therefore occupy much higher percentiles if data from these heavily contaminated waterbodies were excluded.

DDT Concentrations Nationwide

Nationwide screening-level surveys of bioaccumulative contaminants in fish were conducted by the EPA and U.S. Fish & Wildlife Service (USFWS) during the 1980s. A summary of 4,4'-DDE results is shown in Table 6.

EPA analyzed 4,4'-DDE, but no other DDT compounds, in whole fish and muscle fillets collected from 362 sites during 1987 (EPA, 1992). Targeted sites included locations near pulp and paper mills, refineries, wood preservers, other industrial sites, municipal treatment works, Superfund sites, USGS National Stream Quality Accounting Network (NASQAN) sites, and from agricultural and urban areas. Twenty background sites were also included. Samples were composites (3-5 fish) analyzed as fillets for predatory species, and whole for bottom feeders.

USFWS analyzed DDT compounds and other organochlorines in 321 samples collected from 112 sites during 1984-1985 as part of their National Contaminant Biomonitoring Program (Schmitt *et al.*, 1990). All of the USFWS samples were composites (3-5 fish) analyzed whole.

DDE concentrations from Osoyoos Lake fish bracketed mean concentrations nationally. Perch, bass, and mountain whitefish fillets had concentrations similar to the EPA median (58 ng/g). Fillet of carp and lake whitefish, and whole sucker samples from Osoyoos Lake were higher than either the mean or median concentrations from either of the national surveys, but were still much lower than the mean concentration from EPA agricultural sites.

Data from the nation-wide surveys demonstrate the pervasiveness of DDT compounds in the aquatic environment. DDE was detected in fish by both the EPA and USFWS at between 98% and 99% of their survey sites. Frequency of DDE detection in the Washington State data sets graphed in Figures 8a and 8b was 94% for fillet data and 96% for whole body data.

Table 6. Concentrations of 4,4'-DDE in Osoyoos Lake Fish Compared to EPA and USFWS National Surveys (ng/g [ppb], wet weight basis).

	No. of Sites	Mean	Median	Maximum
EPA[a] (1987; fillet and whole samples)				
Total	362	300	58	14,000
Agriculture only	15	1,500	200	8,700
Background only	20	56	12	380
USFWS[b] (1984-85; whole samples only)	112	190[c]	nr	4,700
Present Survey:				
Yellow perch fillet (n=8)	Osoyoos Lk.	43	45	55
Smallmouth bass fillet (n=3)	"	57	65	72
Mountain whitefish fillet (n=1)	"	--	--	68
Carp fillet (n=4)	"	350	340	550
Lake whitefish fillet (n=2)	"	680	--	760
Whole sucker (n=2)	"	630	--	810

[a] EPA, 1992
[b] Schmitt *et al.*, 1990
[c] Geometric mean
nr = not reported

Comparison to Environmental Criteria

Human Health

In 1992, the EPA promulgated the National Toxics Rule (NTR; 40 CFR Part 131) which established numeric, chemical-specific water quality criteria for all priority pollutants in order to bring states into compliance with the Clean Water Act. The NTR criterion for 4,4'-DDT and 4,4'-DDE is 0.59 ng/L; for 4,4'-DDD, the criterion is 0.84 ng/L. These standards were derived from edible fish tissue concentrations since fish consumption is considered the major exposure pathway for humans (exposure through water ingestion is considered negligible). The NTR fish tissue criteria for DDT compounds, based on a bioconcentration factor of 53,600 (EPA, 1980), are 32 ng/g (wet) for 4,4'-DDT and 4,4'-DDE, and 45 ng/g for 4,4'-DDD.

These NTR criteria are based on acceptable levels of cancer risk since DDT, DDD, and DDE are all considered probable (class B2) human carcinogens. For the purpose of assessing compliance with the NTR, Ecology has adopted an acceptable upper-bound cancer risk of one in a million (10^{-6}), that is, no more than one excess case of cancer per million people for a lifetime exposure.

To calculate cancer risks associated with known fish tissue concentrations, several components of risk evaluation must be established, including cancer potency factors or slope factors, and exposure assessment. EPA has developed slope factors for carcinogenic effects of DDT compounds; $[(0.34 \text{ mg/kg body weight})\text{day}]^{-1}$ for DDT and DDE, and $[(0.24 \text{ mg/kg body weight})\text{day}]^{-1}$ for DDD. However, EPA (1994) recommends using a slope factor of $[(0.34 \text{ mg/kg body weight})\text{day}]^{-1}$ for the sum of DDT compounds. They have also calculated national average values for purposes of exposure assessment, such as a fish consumption rate of 6.5 g/day and an average consumer body weight of 70 kg for adults.

Excess lifetime cancer risks associated with concentrations of DDT in Osoyoos Lake fish are shown in Table 7. They were calculated using the national average default values mentioned above, and substituted into the following equation:

$$RL = (FTC \times SF \times CR)/BW$$

Where:

RL = risk level for one excess case of cancer over a lifetime (dimensionless)
FTC = fish tissue concentration (mg/kg)
SF = slope factor $[(\text{mg/kg body weight})\text{day}]^{-1}$
CR = consumption rate (kg/day)
BW = body weight (kg)

This formula can be modified to reflect local conditions and conduct site-specific risk assessments or determine acceptable consumption limits for fish tissue. For instance, a fish consumption rate four times the default value (*i.e.* 26 grams or about 1 ounce/day) would quadruple the excess lifetime risk level for cancer, assuming all other variables remained the same. Average consumption rates of Osoyoos Lake fish are not known.

Table 7. Excess Lifetime Cancer Risks Associated with t-DDT in Osoyoos Lake Fish.

Species	t-DDT[a] (ng/g)	Excess Lifetime Cancer Risk[b]
Yellow perch	60	1.9×10^{-6}
Smallmouth bass	73	2.3×10^{-6}
Mountain whitefish	105	3.3×10^{-6}
Carp	437	1.4×10^{-5}
Lake whitefish	1,114	3.5×10^{-5}

[a] Mean concentrations except mountain whitefish (n=1)

[b] Calculated using a slope factor of 0.34 $[(\text{mg/kg body weight})\text{day}]^{-1}$, consumer body weight of 70 kg, and consumption rate of 6.5 g/day.

In establishing a fish consumption advisory for the lower Yakima River, the Washington State Department of Health (DOH) conducted a site-specific risk assessment using available data on local fish consumption rates rather than the default parameters discussed previously. DOH also used neurodevelopmental rather than carcinogenic effects of DDT in rodents to develop a tolerable daily intake (TDI) for DDT (Marien and Laflamme, 1995).

DOH's fish tissue action level (61 ng DDT+DDE/g) is based on a TDI of 0.005 (mg DDT+DDE/kg body weight)/day for consumers of 200 g fish tissue/day fish from the lower Yakima. This action level was exceeded in four of the five species from Osoyoos Lake tested for DDT concentrations in edible tissue. Perch had mean concentrations slightly below the action level.

The Food and Drug Administration (FDA) has also set action levels for pesticides, including DDT, in food (FDA, 1989). Action levels are enforceable regulatory limits for unavoidable pesticide residues in food items, which permit the agency to remove them from the market. The FDA action level is 5,000 ng/g for DDT, DDE, and DDD, individually or taken in combination, and is identical to allowable consumption limits set by Canada Food and Drug Directorate.

Aquatic Life and Associated Wildlife

Several criteria have been proposed to protect aquatic life and associated wildlife from the deleterious effects of DDT (Table 8). The EPA ambient water quality criterion to protect aquatic life from chronic exposure to DDT compounds is 1 ng/L (EPA, 1980). This value was derived to prevent eggshell-thinning and poor reproductive success in piscivorous birds, and has since been adopted as the (chronic) water quality standard in Washington State (WAC, Ch. 173-201A) and by Canada for their federal criterion. Toxic effects to most aquatic organisms occur at much higher concentrations (EPA, 1980).

The 1 ng/L criterion is based on observed effects to brown pelicans consuming northern anchovies with as little as 150 ng/g DDT in their tissues (EPA, 1980). The criterion was calculated by dividing this concentration by the percent lipid value of anchovies (8), then translated to a water concentration using an aquatic species' geometric mean lipid-normalized bioconcentration factor (BCF) of 17,870. However, the BCF used to establish this criterion may be underprotective since several fish species have demonstrated the capacity to concentrate DDT one-to-five million times the level in water (EPA, 1980).

Newell *et al.* (1987) have also proposed DDT criteria to protect fish-eating wildlife of the Niagara River vicinity. Their criterion of 200 ng/g in whole fish, intended to protect fish-eating birds, is based on the effects to brown pelicans. They have also proposed a criterion to protect piscivorous mammals (*e.g.* mink) from the possible carcinogenic effects of DDT compounds. This criterion, 266 ng DDT/g in whole fish, is based on the animals' excess lifetime cancer risk of one in a hundred (10^{-2}), a risk level judged to be acceptable to maintain viable populations.

Other criterion to protect wildlife include a maximum concentration of 1,000 ng/g DDT for whole fish to protect fish-eating wildlife recommended by the National Academies of Sciences and Engineering (NAS/NAE, 1972). This recommendation was also derived to prevent eggshell-thinning in fish-eating birds.

Exhaustive reviews on the subject indicate the brown pelican is by far the most DDT-sensitive wildlife species observed to date (EPA, 1980; Blus, 1996), though this species is not found in the Okanogan River basin (George Brady, Washington State Department of Fish & Wildlife, personal communication). The next most sensitive species may be the peregrine falcon which has been shown to suffer decreased reproductive success while consuming a diet of 1,000 ng DDT/g (Enderson *et al.*, 1982). Peregrines are probably less reliant on fish as a food source than the brown pelican, and therefore less at risk from contaminated fish. However, extremely high DDT concentrations have been found in some bird species which serve as peregrine falcon prey, and which utilize Okanogan basin orchard habitats in Canada (Elliott, 1993). DDT concentrations in robins and swallows were so high as to advise against any efforts to re-introduce peregrine falcons to that area.

Mean concentrations of DDT in whole fish from the present survey (800 ng DDT/g) would not likely result in eggshell-thinning of most piscivorous bird species. In a review of DDT-related risks to wildlife consuming fish of the lower Yakima River, Johnson *et al.* (1986) concluded that "... it appears likely that predatory birds which are sensitive to DDE, and feed on fish exclusively from the Yakima River [max. conc. = 3,000 ng DDE /g] would be expected to produce eggs with shell thickness somewhat below normal. The reduction in shell thickness should not be sufficient, however, to prevent maintenance of a stable population." This conclusion was based on data showing a 10% thinning of eggs in American kestrels fed a diet containing 2,800 ng DDE/g. Although this is higher than concentrations found in Osoyoos Lake, DDT concentrations in fish and other prey items from other areas of the Okanogan River basin might pose a threat to predatory bird populations.

Review of applicable criteria indicates that concentrations of other pesticides and PCBs in Osoyoos Lake whole fish should not be a threat to aquatic organisms or associated wildlife. The Niagara River criteria for total PCBs are 100 ng/g for non-carcinogenic effects and 110 ng/g for carcinogenic effects (Newell *et al.*, 1987), compared to a maximum concentration of 66 ng total PCBs/g in Osoyoos Lake fish. The National Academies of Sciences and Engineering (NAS/NAE, 1972) recommend a concentration in whole fish not to exceed 500 ng/g to protect aquatic life. The EPA ambient water quality criterion of 14 ng/L was derived to protect mink, a species sensitive to PCBs, from adverse effects at a dietary concentration of 640 ng PCBs/g.

For HCB, the maximum concentration detected in Osoyoos Lake fish (2.2 ng/g) fall two orders of magnitude below the Niagara River criteria of 330 ng/g for non-carcinogenic effects, 200 ng/g for carcinogenic effects, and the NAS/NAE recommendation of 100 ng/g to protect aquatic life. EPA has not established ambient water quality criteria for HCB. No applicable criteria could be found for DDMU.

Table 8. Summary of Applicable Fish Tissue Criteria to Protect Human Health, Aquatic Life, and Associated Wildlife (ng/g).

	DDT	PCBs	HCB
Human Health (Muscle Fillet)			
National Toxics Rule	32 [PE,SB,MW,CA,LW]	na	na
Wa. St. DOH Action Level for the Lower Yakima River	61[a] [SB,MW,CA,LW]	na	na
FDA Action Level	5,000	na	na
Aquatic Life & Wildlife (Whole Fish)			
EPA/Wa. St. Chronic Water Quality	150[b] [LS]	640[b]	ne
Niagara River:			
Non-Carcinogenic Effects	200 [LS]	100	330
Carcinogenic Effects	266 [LS]	110	200
NAS/NAE Recommendation	1,000	500	100

[ ] = species in the present survey exceeding the criteria:
PE = perch
SB = smallmouth bass
MW = mountain whitefish
CA = carp
LW = lake whitefish
LS = largescale sucker
Na = not applicable
[a] DDT+DDE only
[b] Basis for water criterion
ne = not established

Conclusions

- Moderate to high DDT concentrations are present in muscle fillet of at least five species of Osoyoos Lake fish. Lake whitefish have the highest concentrations, followed in decreasing order by carp, mountain whitefish, smallmouth bass, and yellow perch.

- DDT concentrations in muscle tissues among species are positively correlated with lipid content. Within-species differences also appear to be largely a function of lipid. Size appears to be directly related to DDT concentrations, yet aside from smallmouth bass, this relationship is rather weak. In general, it appears that DDT accumulation among species reflects a pattern normally seen for bioaccumulative organochlorines.

- Whole body DDT concentrations are high in largescale suckers. PCBs, hexachlorobenzene, DDMU, and other chlorinated pesticides are undetectable or present at low levels in whole largescale suckers and smallmouth bass muscle fillets.

- DDT concentrations in carp, lake whitefish, and suckers from Osoyoos Lake and the Okanogan River basin are on the same order as the lower Yakima River and Lake Chelan, two of the most contaminated areas in Washington. DDE concentrations in these species are higher than national averages reported during the 1980s.

- Excess lifetime cancer risks to humans beyond those considered acceptable due to fish tissue consumption (one in a million) might result from eating Osoyoos Lake fish. Excess lifetime cancer risks calculated from DDT concentrations reported here are species-dependent and range from double (1 in 530,000) to 35 times (1 in 29,000) the acceptable level. These calculations were based on a DDT cancer potency factor, national average fish consumption rate, and average adult body size recommended by EPA as default values for estimating risks; they were not derived from any site-specific data other than DDT concentrations in fish tissue.

- Concentrations of DDT in whole suckers from Osoyoos Lake exceed several criteria developed to protect fish-eating wildlife. Some of these criteria are based on eggshell-thinning in the brown pelican, a species not found in the Okanogan River basin. Nevertheless, predatory bird populations may be at some risk of reduced reproductive success if DDT contamination reported in other parts of the Okanogan River basin is considered. Levels of PCBs, HCB, or DDMU detected in whole Osoyoos Lake suckers would not result in deleterious effects to aquatic life or associated wildlife.

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Figures

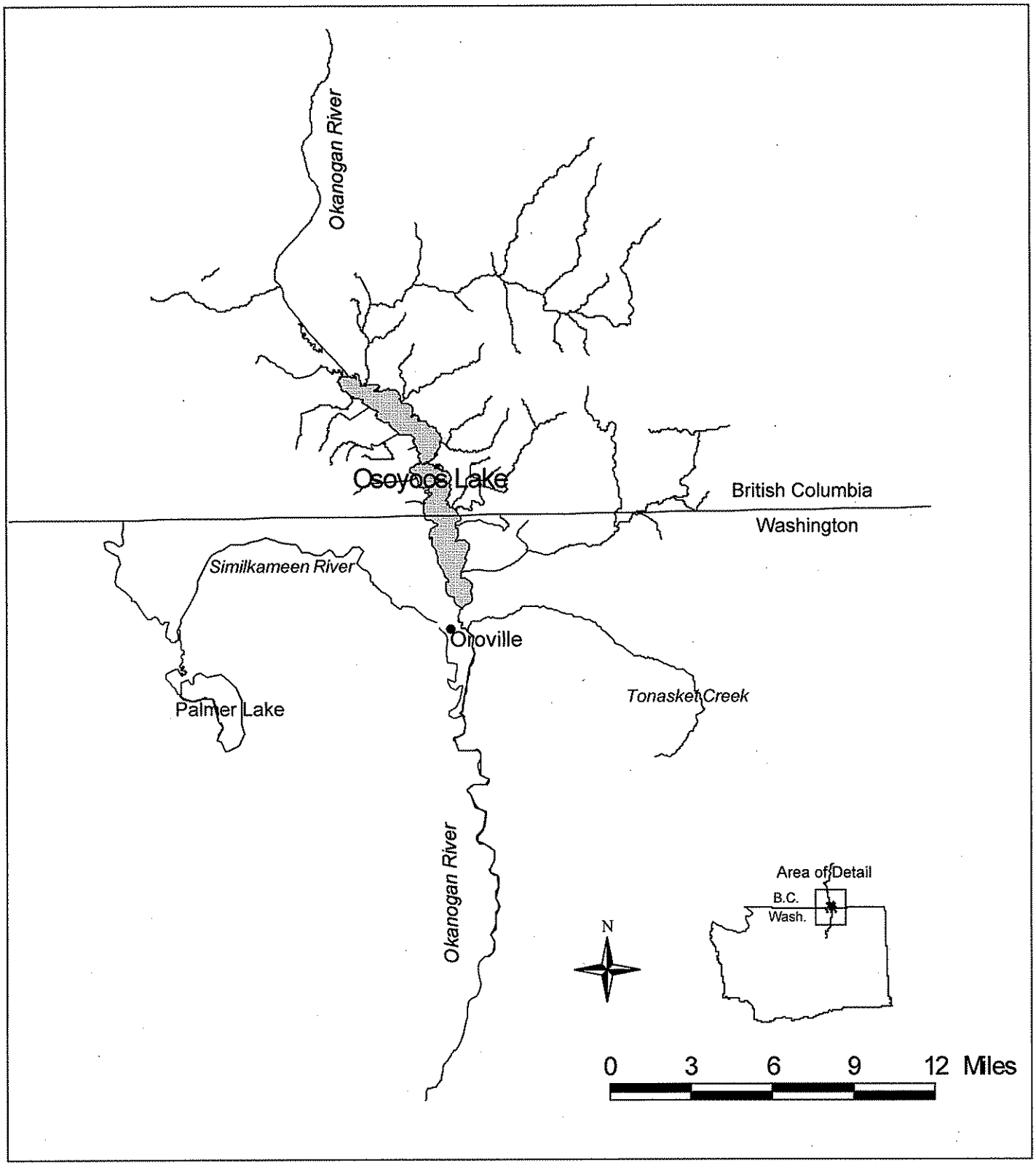

Figure 1. Osoyoos Lake and Vicinity

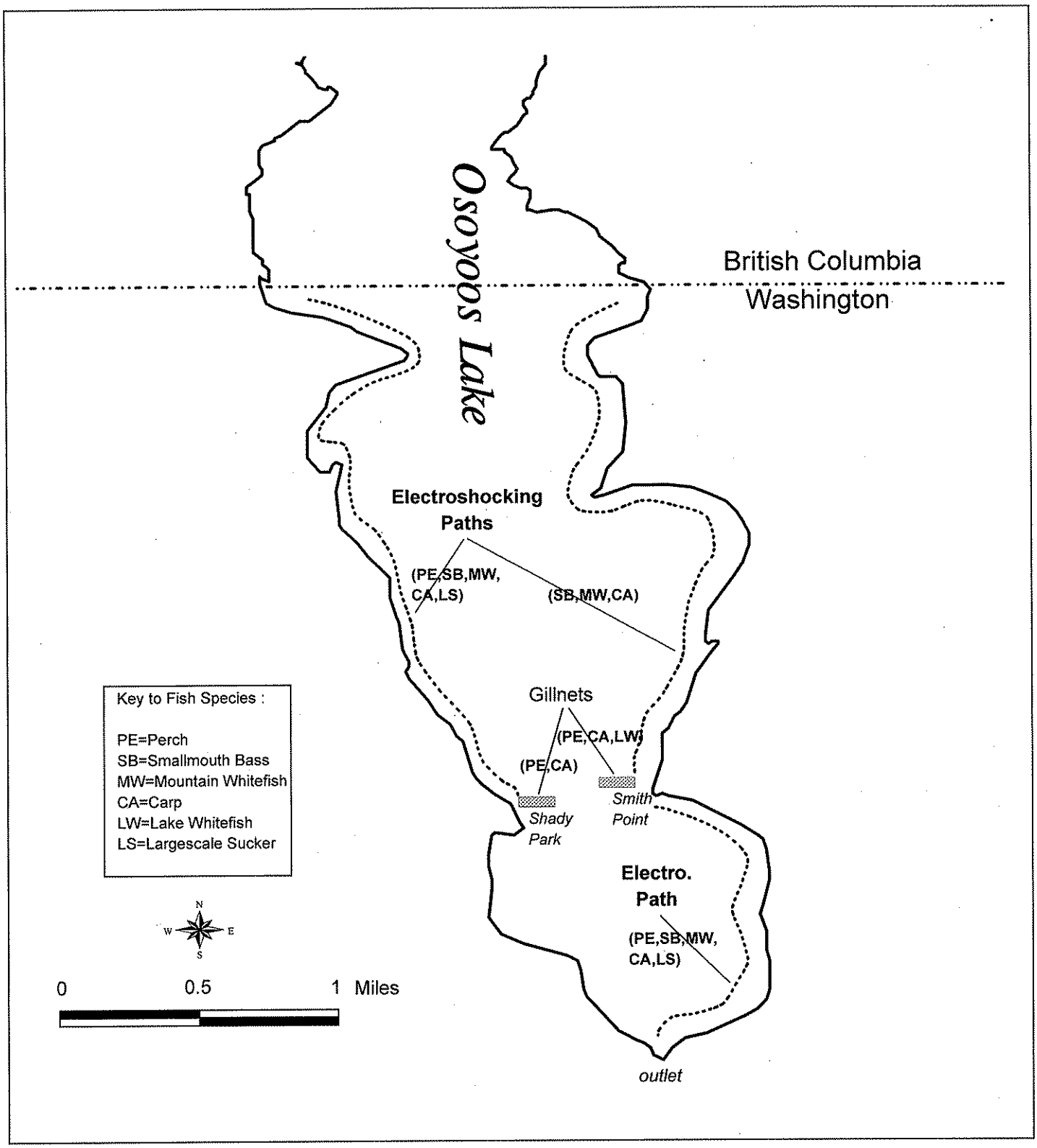

Figure 2. Locations for Fish Collection in Osoyoos Lake

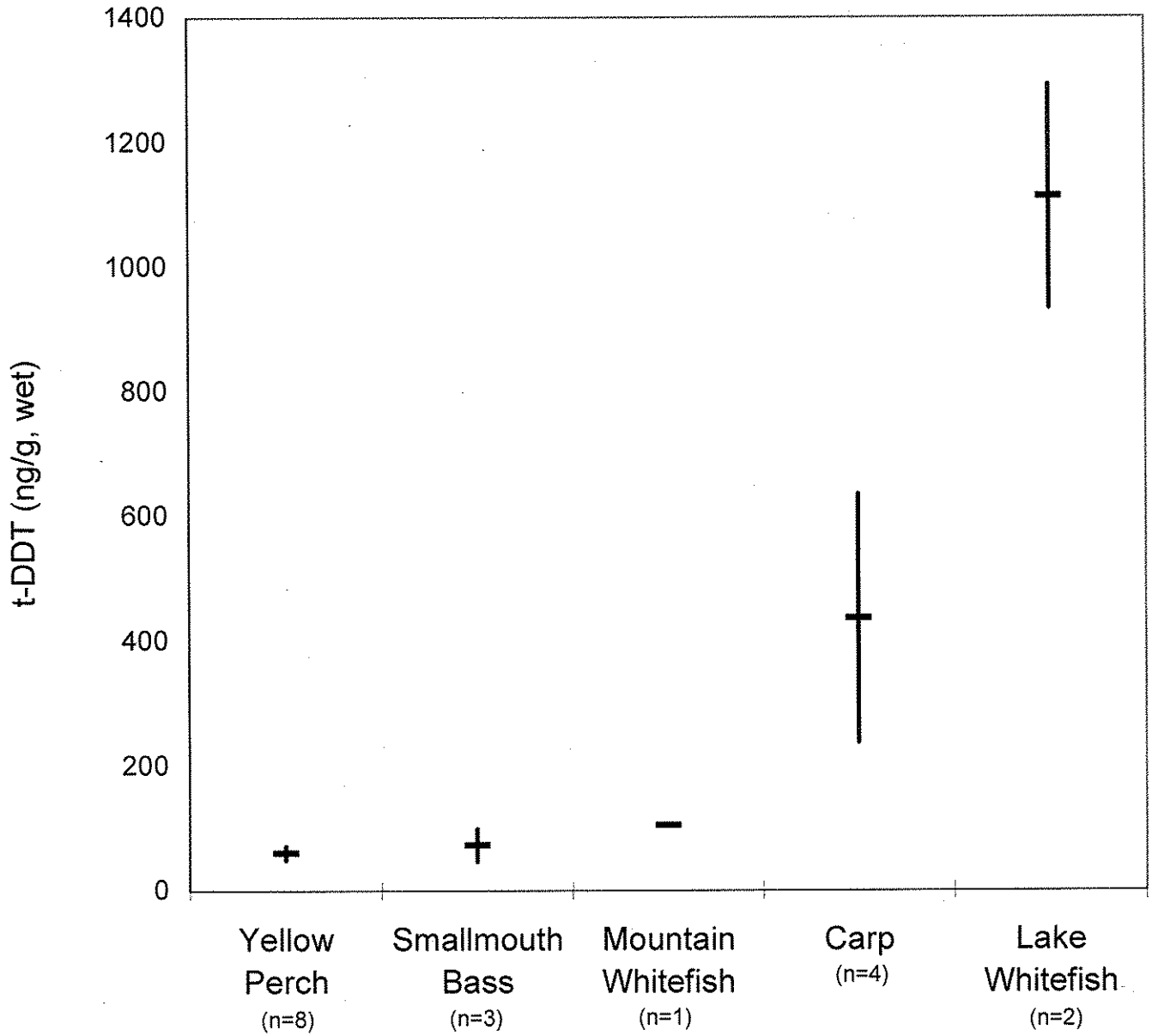

Figure 3. t-DDT Concentrations in Osoyoos Lake Fish Muscle (mean ± standard deviation)

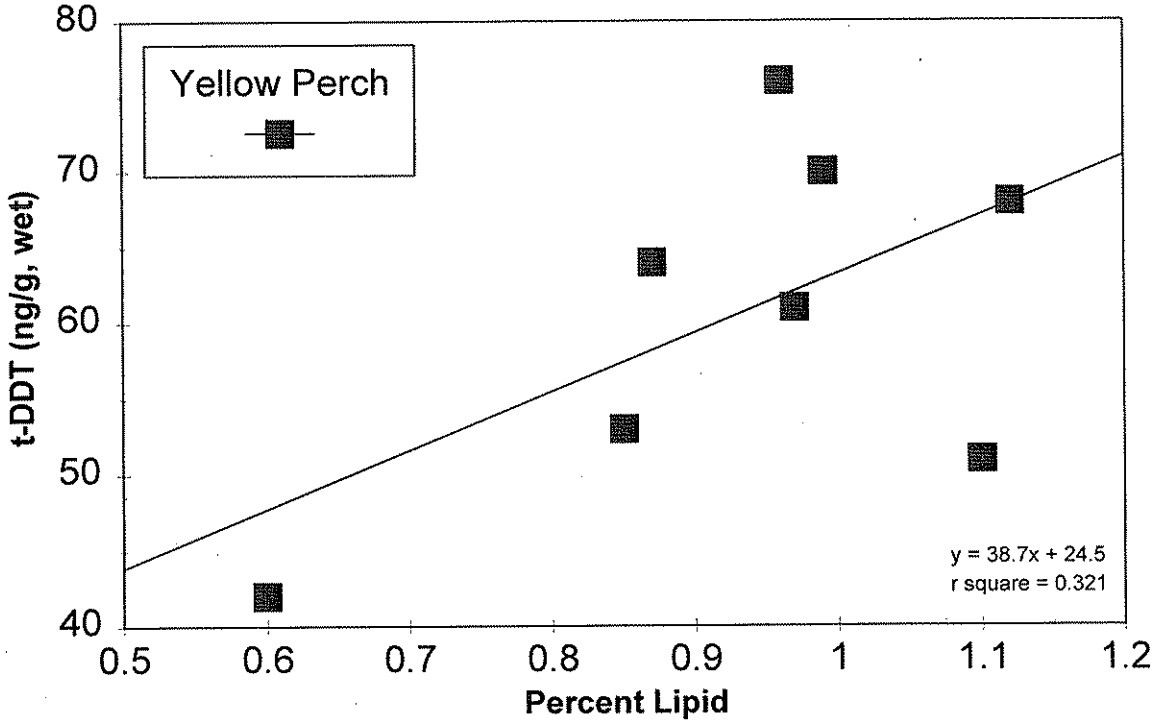

Figure 4a. t-DDT as a Function of Percent Lipid in Muscle of Yellow Perch.

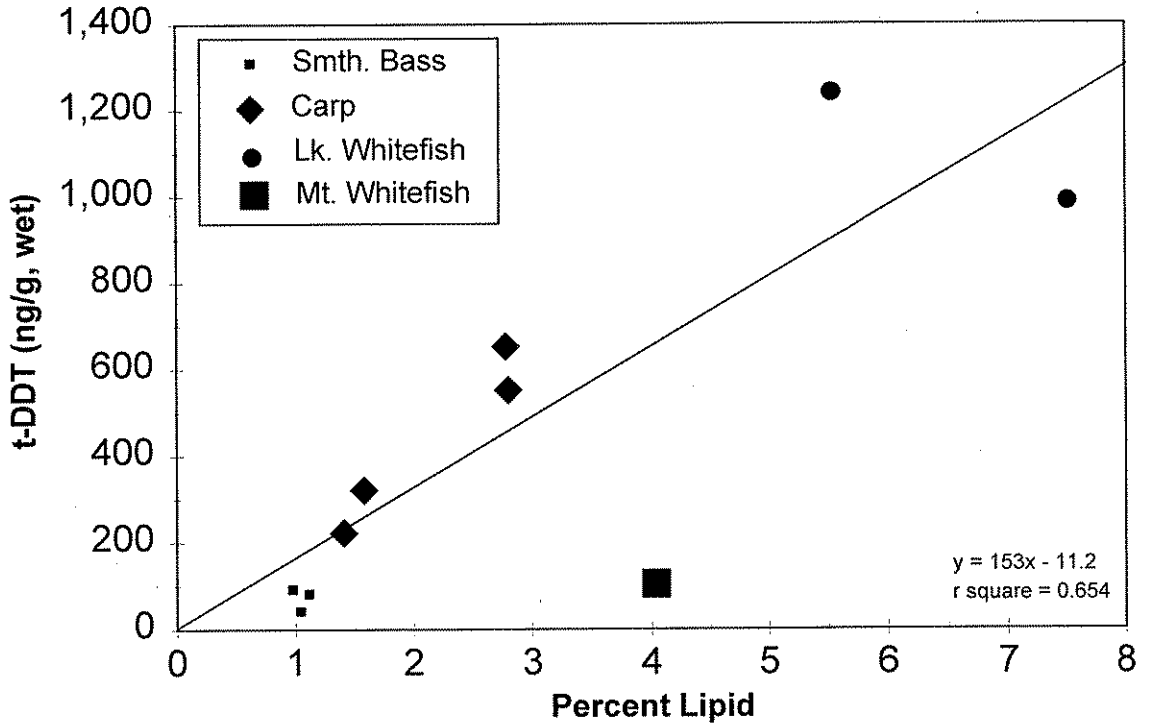

Figure 4b. t-DDT as a Function of Percent Lipid in Muscle of Smallmouth Bass, Carp, Lake Whitefish, and Mountain Whitefish.

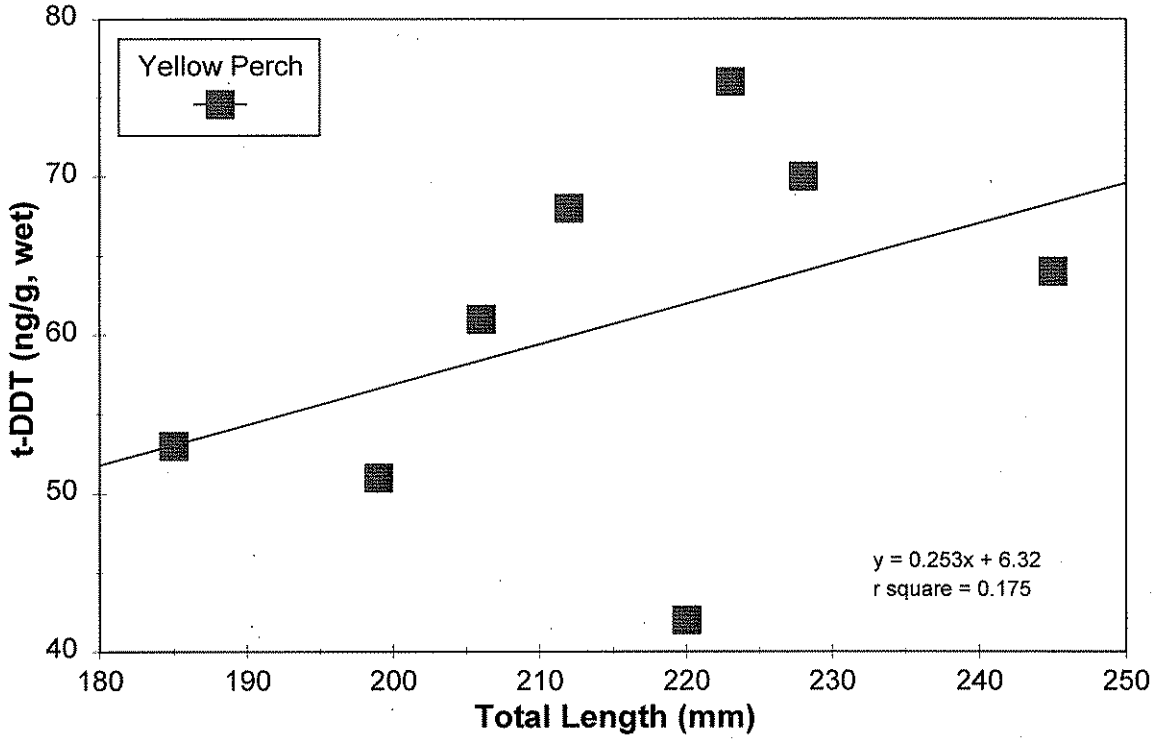

Figure 5a. t-DDT as a Function of Total Length in Yellow Perch.

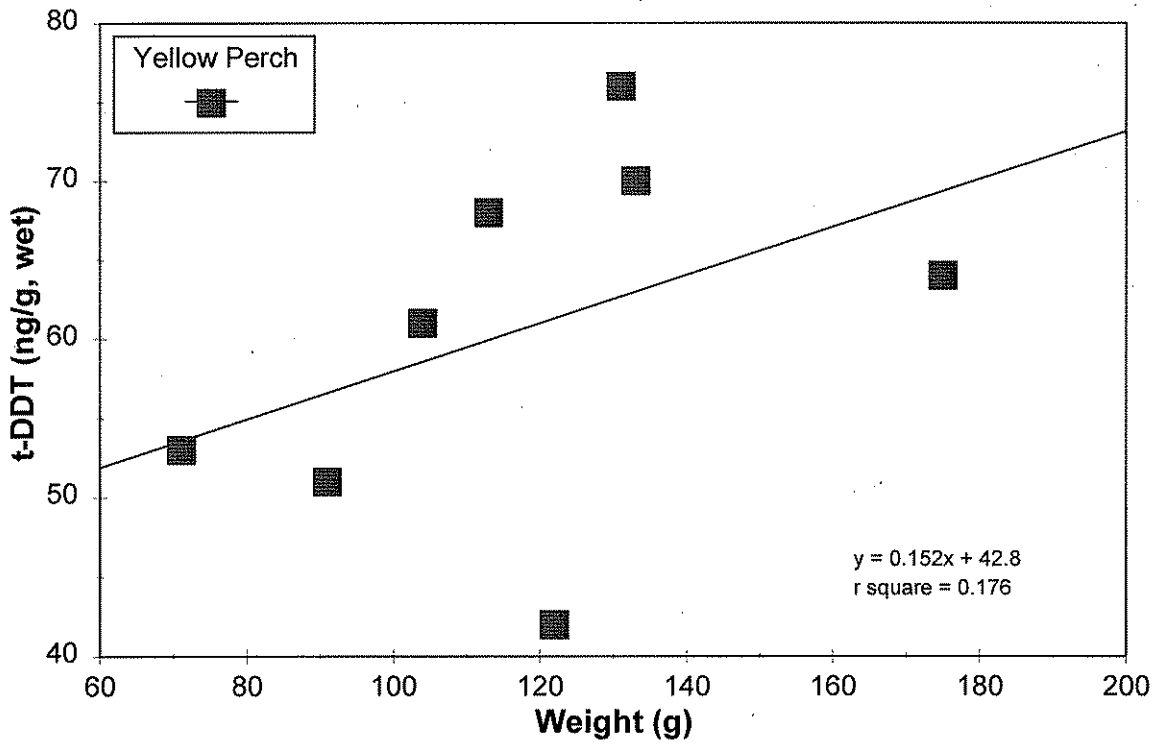

Figure 5b. t-DDT as a Function of Weight in Yellow Perch.

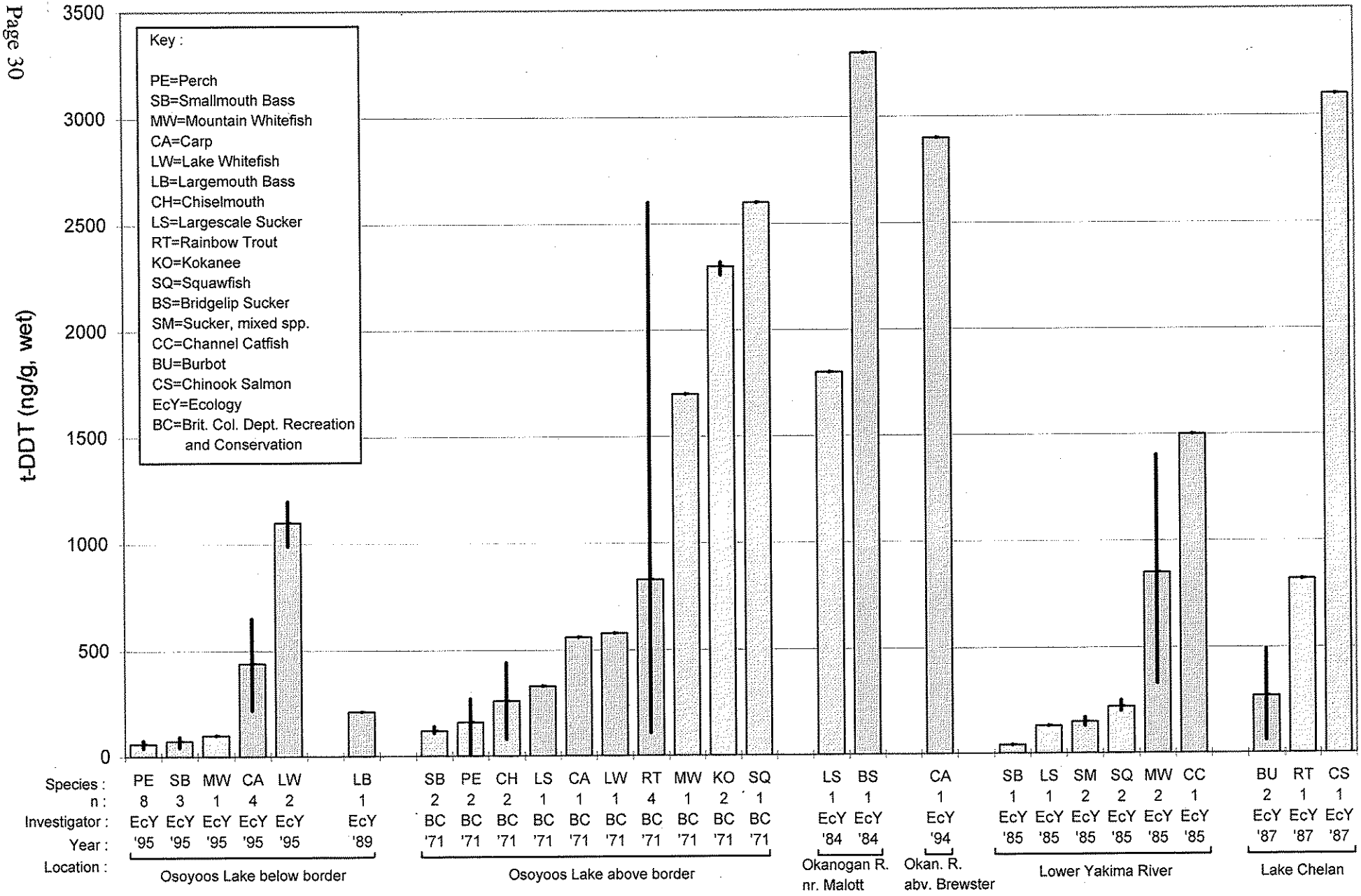

Figure 6. t-DDT Concentrations in Fish Muscle Analyzed During Present and Past Surveys of Osoyoos Lake, Okanogan River, Lower Yakima River, and Lake Chelan (mean concentrations where n>1, lines through bars represent range).

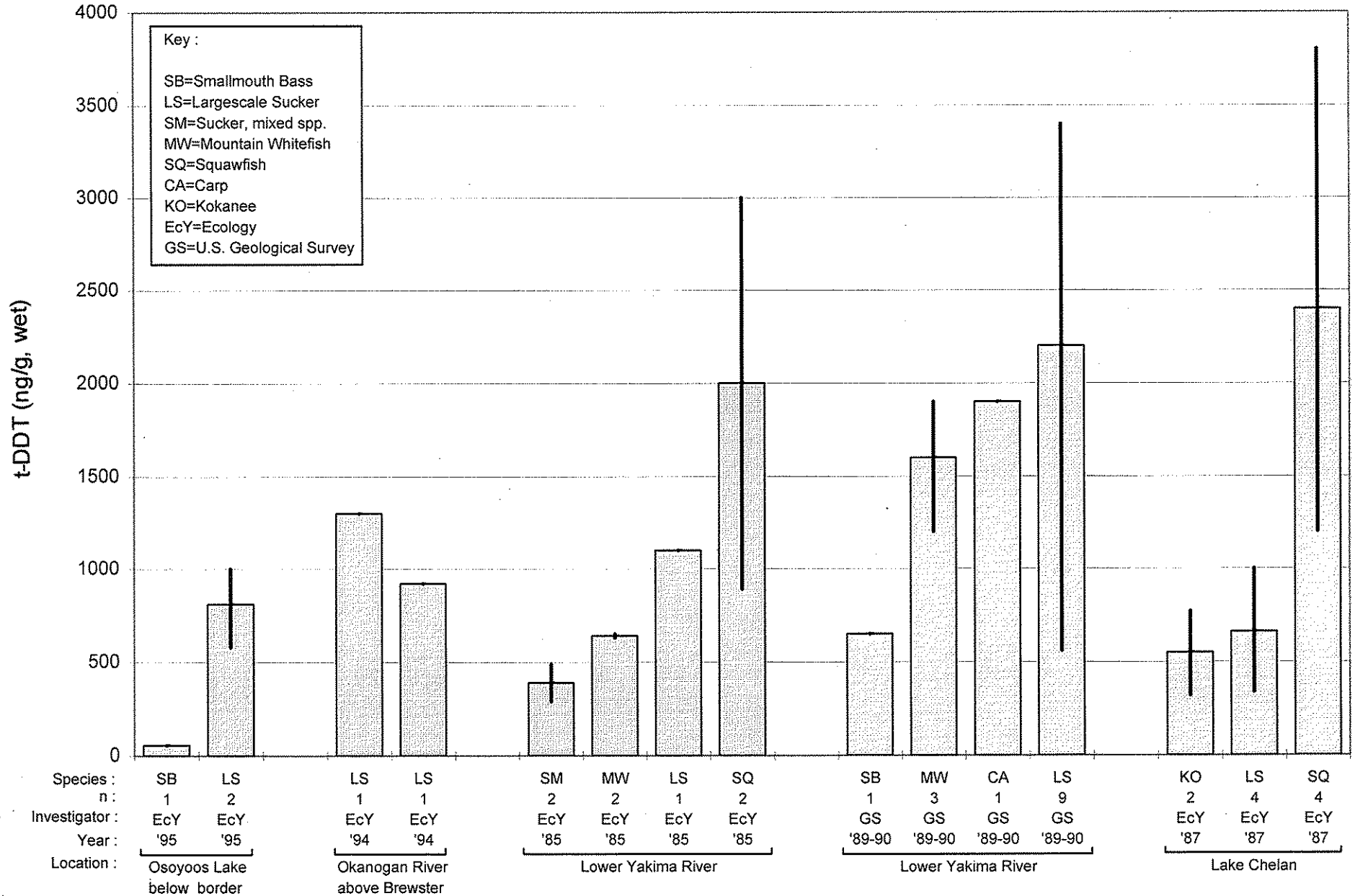

Figure 7. t-DDT Concentrations in Whole Fish Analyzed During Present and Past Surveys of Osoyoos Lake, Okanogan River, Lower Yakima River, and Lake Chelan (mean concentrations where n>1, lines through bars represent range).

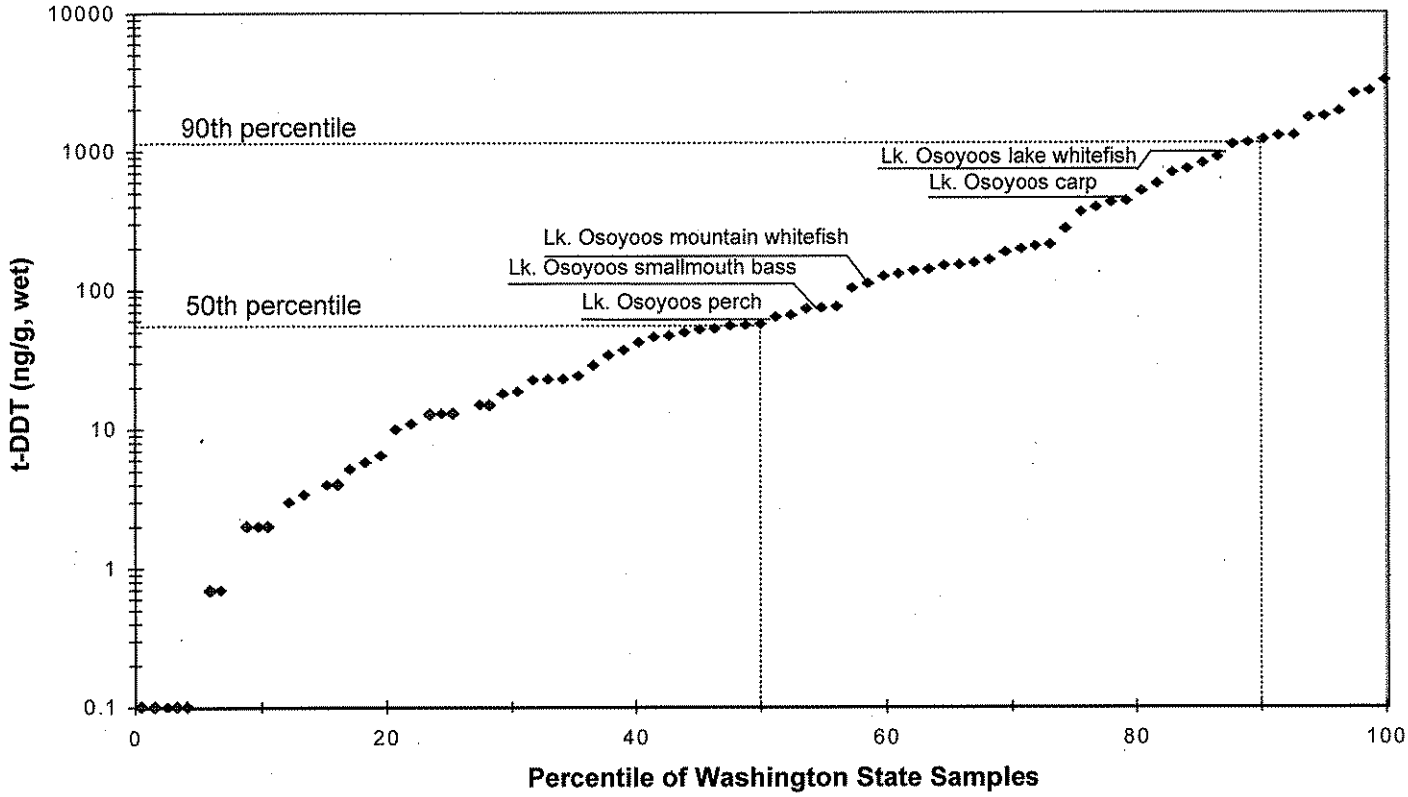

Figure 8a. Mean t-DDT Concentrations in Osoyoos Lake Fish Muscle Compared to Results of Washington State Screening-Level Surveys (n=83).

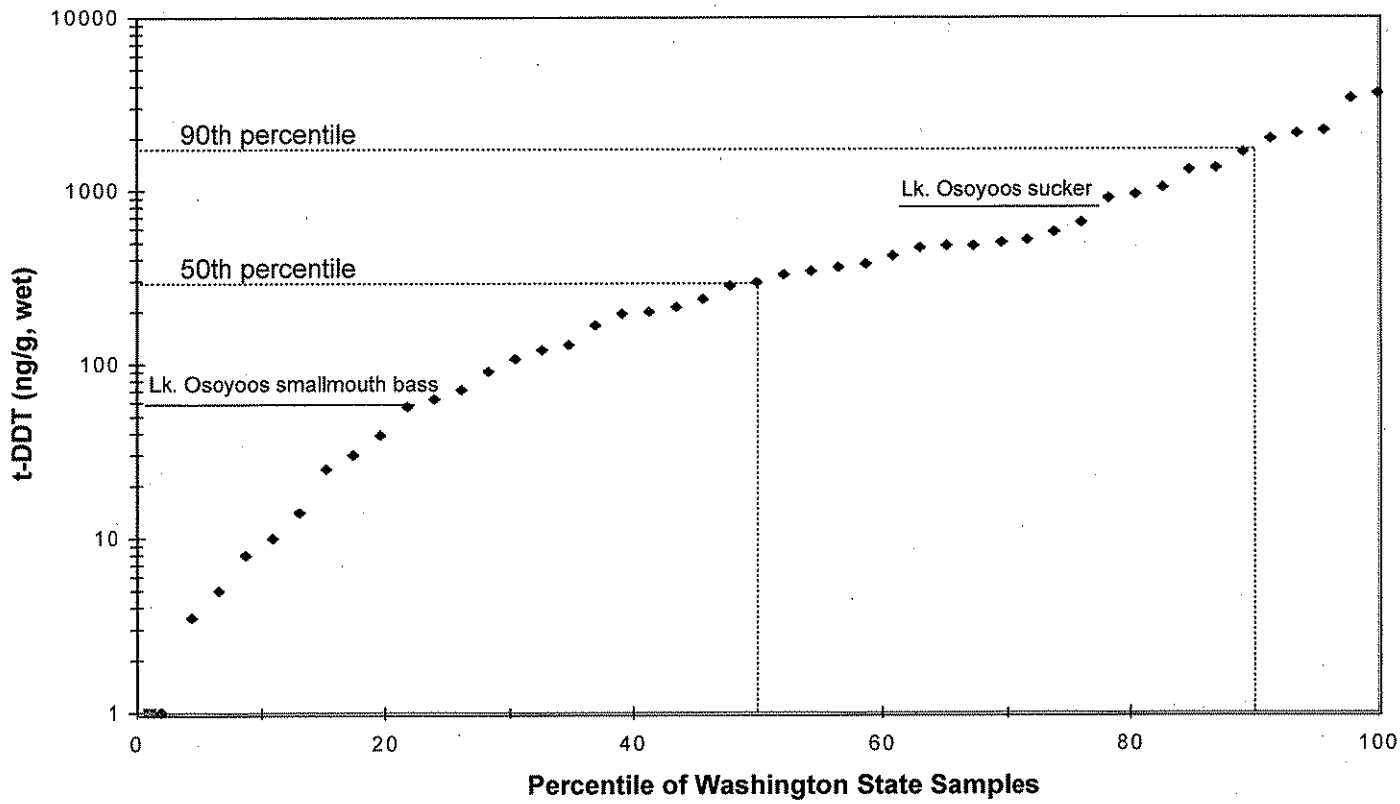

Figure 8b. Mean t-DDT Concentrations in Osoyoos Lake Whole Fish Compared to Results of Washington State Screening-Level Surveys (n=47).

Appendix

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438230/438254	Largescale Sucker	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	435	870	whole	-
(WSPMP 378251)	Largescale Sucker	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	450	1005	whole	-
	Largescale Sucker	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	480	1062	whole	-
	Largescale Sucker	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	505	1565	whole	-
	Largescale Sucker	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	520	1567	whole	-
				mean=	**478**	**1214**		
				SD=	**36**	**329**		
438231	Largescale Sucker	Along western shore from Shady Park to border	electroshocking	28th	435	1015	whole	-
(WSPMP 378252)	Largescale Sucker	Along western shore from Shady Park to border	electroshocking	28th	500	990	whole	-
	Largescale Sucker	Along western shore from Shady Park to border	electroshocking	28th	500	1405	whole	-
	Largescale Sucker	Along western shore from Shady Park to border	electroshocking	28th	505	1165	whole	-
	Largescale Sucker	Along western shore from Shady Park to border	electroshocking	28th	525	1470	whole	-
				mean=	**493**	**1209**		
				SD=	**34**	**220**		
438232	Smallmouth Bass	Along west. and east. shores from Shady Pk./Smith Pt.to border	electroshocking	30th	330	575	fillet	203
(WSPMP 378253)	Smallmouth Bass	Along western shore from Shady Park to border	electroshocking	28th	335	605	fillet	239
	Smallmouth Bass	Along western shore from Shady Park to border	electroshocking	28th	383	845	fillet	297
	Smallmouth Bass	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	383	871	fillet	332
				mean=	**358**	**724**		**268**
				SD=	**29**	**156**		**58**
438233	Carp	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	485	1775	fillet	217
	Carp	Along western shore from Shady Park to border	electroshocking	28th	490	1435	fillet	138
	Carp	Along west. and east. shores from Shady Pk./Smith Pt.to border	electroshocking	30th	490	1513	fillet	106
	Carp	Along western shore from Shady Park to border	electroshocking	28th	490	1680	fillet	232
	Carp	Along west. and east. shores from Shady Pk./Smith Pt.to border	electroshocking	30th	495	1569	fillet	231
	Carp	Along west. and east. shores from Shady Pk./Smith Pt.to border	electroshocking	30th	500	1679	fillet	206
	Carp	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	505	1706	fillet	123
	Carp	Along western shore from Shady Park to border	electroshocking	28th	505	1745	fillet	148
				mean=	**495**	**1638**		**175**
				SD=	**8**	**119**		**52**

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438234/438235	Carp	Along western shore from Shady Park to border	electroshocking	28th	515	1760	fillet	154
	Carp	Along western shore from Shady Park to border	electroshocking	28th	515	1825	fillet	203
	Carp	Along west. and east. shores from Shady Pk./Smith Pt.to border	electroshocking	30th	530	2105	fillet	181
	Carp	Along western shore from Shady Park to border	electroshocking	28th	531	3176	fillet	185
	Carp	Off Shady Park	gillnet	30th-31st	545	1965	fillet	158
	Carp	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	545	2399	fillet	302
	Carp	Along western shore from Shady Park to border	electroshocking	28th	560	2190	fillet	233
	Carp	Along western shore from Shady Park to border	electroshocking	28th	570	2328	fillet	195
				mean=	**539**	**2219**		**201**
				SD=	**20**	**448**		**48**
438236	Carp	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	400	1328	fillet	121
	Carp	Off Smith Point	gillnet	29th-30th	415	1085	fillet	140
	Carp	Along western shore from Shady Park to border	electroshocking	28th	435	1135	fillet	162
	Carp	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	445	1150	fillet	163
	Carp	Along western shore from Shady Park to border	electroshocking	28th	445	1205	fillet	175
	Carp	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	450	1202	fillet	164
	Carp	Off Smith Point	gillnet	29th-30th	455	1035	fillet	116
	Carp	Along western shore from Shady Park to border	electroshocking	28th	460	1220	fillet	107
				mean=	**438**	**1170**		**144**
				SD=	**21**	**90**		**26**
438237	Carp	Along western shore from Shady Park to border	electroshocking	28th	465	1390	fillet	180
	Carp	Along western shore from Shady Park to border	electroshocking	28th	475	1225	fillet	148
	Carp	Along western shore from Shady Park to border	electroshocking	28th	476	2589	fillet	143
	Carp	Along western shore from Shady Park to border	electroshocking	28th	480	1350	fillet	160
	Carp	Off Smith Point	gillnet	29th-30th	480	1376	fillet	195
	Carp	Along western shore from Shady Park to border	electroshocking	28th	480	1485	fillet	202
	Carp	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	485	1322	fillet	141
	Carp	Off Smith Point	gillnet	29th-30th	485	1385	fillet	190
				mean=	**478**	**1515**		**170**
				SD=	**6**	**440**		**25**

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438238	Yellow Perch	Off Smith Point	gillnet	29th-30th	225	119	fillet	43
	Yellow Perch	Off Smith Point	gillnet	29th-30th	225	128	fillet	47
	Yellow Perch	Off Smith Point	gillnet	29th-30th	225	156	fillet	68
	Yellow Perch	Off Smith Point	gillnet	28th-29th	226	91	fillet	33
	Yellow Perch	Off Smith Point	gillnet	29th-30th	230	130	fillet	53
	Yellow Perch	Along western shore from Shady Park to border	electroshocking	28th	230	138	fillet	48
	Yellow Perch	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	230	164	fillet	57
	Yellow Perch	Off Smith Point	gillnet	28th-29th	235	141	fillet	57
				mean=	**228**	**133**		**51**
				SD=	**4**	**23**		**11**
438239	Yellow Perch	Off Shady Park	gillnet	30th-31st	220	139	fillet	56
	Yellow Perch	Off Smith Point	gillnet	29th-30th	220	140	fillet	61
	Yellow Perch	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	222	134	fillet	49
	Yellow Perch	Off Smith Point	gillnet	28th-29th	223	95	fillet	42
	Yellow Perch	Off Smith Point	gillnet	29th-30th	225	131	fillet	55
	Yellow Perch	Off Shady Park	gillnet	30th-31st	225	138	fillet	57
	Yellow Perch	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	225	141	fillet	56
	Yellow Perch	Off Smith Point	gillnet	29th-30th	225	145	fillet	62
				mean=	**223**	**131**		**54**
				SD=	**2**	**16**		**6**
438240	Yellow Perch	Off Smith Point	gillnet	29th-30th	235	153	fillet	57
	Yellow Perch	Off Smith Point	gillnet	29th-30th	235	154	fillet	63
	Yellow Perch	Off Shady Park	gillnet	30th-31st	240	159	fillet	59
	Yellow Perch	Off Shady Park	gillnet	30th-31st	240	163	fillet	65
	Yellow Perch	Off Smith Point	gillnet	29th-30th	240	180	fillet	71
	Yellow Perch	Along western shore from Shady Park to border	electroshocking	28th	250	175	fillet	72
	Yellow Perch	Off Smith Point	gillnet	29th-30th	255	195	fillet	75
	Yellow Perch	Off Smith Point	gillnet	29th-30th	265	220	fillet	87
				mean=	**245**	**175**		**69**
				SD=	**11**	**23**		**10**

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438241	Yellow Perch	Off Smith Point	gillnet	28th-29th	174	59	fillet	23
	Yellow Perch	Off Smith Point	gillnet	28th-29th	175	62	fillet	27
	Yellow Perch	Off Smith Point	gillnet	28th-29th	180	69	fillet	30
	Yellow Perch	Off Smith Point	gillnet	28th-29th	185	71	fillet	25
	Yellow Perch	Off Smith Point	gillnet	29th-30th	190	81	fillet	28
	Yellow Perch	Off Smith Point	gillnet	29th-30th	190	78	fillet	35
	Yellow Perch	Off Smith Point	gillnet	29th-30th	190	78	fillet	31
	Yellow Perch	Off Smith Point	gillnet	28th-29th	195	72	fillet	31
				mean=	**185**	**71**		**29**
				SD=	**8**	**8**		**4**
438242	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	98	fillet	44
	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	102	fillet	37
	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	125	fillet	41
	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	125	fillet	43
	Yellow Perch	Off Smith Point	gillnet	28th-29th	212	110	fillet	46
	Yellow Perch	Along western shore from Shady Park to border	electroshocking	28th	212	110	fillet	47
	Yellow Perch	Off Smith Point	gillnet	28th-29th	215	109	fillet	44
	Yellow Perch	Off Smith Point	gillnet	28th-29th	215	124	fillet	57
				mean=	**212**	**113**		**45**
				SD=	**2**	**11**		**6**
438243	Yellow Perch	Off Smith Point	gillnet	29th-30th	195	84	fillet	35
	Yellow Perch	Off Smith Point	gillnet	28th-29th	195	84	fillet	38
	Yellow Perch	Off Smith Point	gillnet	29th-30th	195	95	fillet	37
	Yellow Perch	Off Smith Point	gillnet	29th-30th	195	106	fillet	45
	Yellow Perch	Off Smith Point	gillnet	28th-29th	200	79	fillet	29
	Yellow Perch	Off Smith Point	gillnet	29th-30th	200	95	fillet	40
	Yellow Perch	Off Smith Point	gillnet	28th-29th	204	95	fillet	37
	Yellow Perch	Off Smith Point	gillnet	29th-30th	205	92	fillet	40
				mean=	**199**	**91**		**38**
				SD=	**4**	**9**		**5**

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438244	Yellow Perch	Off Smith Point	gillnet	28th-29th	205	98	fillet	42
	Yellow Perch	Off Smith Point	gillnet	29th-30th	205	99	fillet	35
	Yellow Perch	Off Smith Point	gillnet	28th-29th	205	99	fillet	39
	Yellow Perch	Off Smith Point	gillnet	28th-29th	205	101	fillet	42
	Yellow Perch	Off Smith Point	gillnet	29th-30th	205	109	fillet	40
	Yellow Perch	Off Smith Point	gillnet	29th-30th	205	110	fillet	46
	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	105	fillet	42
	Yellow Perch	Off Smith Point	gillnet	29th-30th	210	110	fillet	43
				mean=	**206**	**104**		**41**
				SD=	**2**	**5**		**3**
438245/438246	Yellow Perch	Off Smith Point	gillnet	29th-30th	220	105	fillet	43
	Yellow Perch	Along western shore from Shady Park to border	electroshocking	28th	220	115	fillet	44
	Yellow Perch	Off Smith Point	gillnet	28th-29th	220	117	fillet	44
	Yellow Perch	Off Smith Point	gillnet	29th-30th	220	124	fillet	46
	Yellow Perch	Along western shore from Shady Park to border	electroshocking	28th	220	125	fillet	48
	Yellow Perch	Off Smith Point	gillnet	28th-29th	220	129	fillet	49
	Yellow Perch	Off Smith Point	gillnet	29th-30th	220	130	fillet	52
	Yellow Perch	Off Smith Point	gillnet	29th-30th	220	133	fillet	59
				mean=	**220**	**122**		**48**
				SD=	**0**	**9**		**5**
438247	Smallmouth Bass	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	200	109	fillet	36
	Smallmouth Bass	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	215	139	fillet	39
	Smallmouth Bass	Along western shore from Shady Park to border	electroshocking	28th	235	205	fillet	70
	Smallmouth Bass	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	236	201	fillet	61
				mean=	**222**	**164**		**52**
				SD=	**17**	**47**		**17**
438248	Smallmouth Bass	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	247	243	fillet	75
	Smallmouth Bass	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	250	206	fillet	68
	Smallmouth Bass	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	250	223	fillet	71
	Smallmouth Bass	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	260	264	fillet	87
				mean=	**252**	**234**		**75**
				SD=	**6**	**25**		**8**

Table A-1. Fish Sampling Data.

Sample No.	Species	Location	Method	Date (Aug95)	Total Length (mm)	Weight (g)	Sample Type	Fillet Size (g)
438249 (fillet)	Mountain Whitefish	Along eastern shore from lake outlet to Smith Point	electroshocking	29th	295	259	fillet/eggs	98
438250 (eggs)	Mountain Whitefish	Along west. and east. shores from Shady Pk./Smith Pt. to border	electroshocking	30th	310	295	fillet	88
	Mountain Whitefish	Along western shore from Shady Park to border	electroshocking	28th	335	365	fillet	122
				mean=	**313**	**306**		**103**
				SD=	**20**	**54**		**17**
438251	Lake Whitefish	Off Smith Point	gillnet	29th-30th	510	1245	fillet	459
438252/438253	Lake Whitefish	Off Smith Point	gillnet	29th-30th	555	1508	fillet	584

Note: Carp filleted with skin off
perch, bass, and whitefish scaled and filleted with skin on
one side of carp used for sample
both sides of perch, bass, and whitefish used for sample

Manchester Environmental Laboratory

7411 Beach Dr E
Port Orchard Washington 98366
December 12, 1995

Project: **Lake Osoyoos Fish**

Samples: 95438230 through 95438254

By: Karin Feddersen KF

These samples were analyzed by EPA Method 8080 for DDT analogs employing the dual column confirmation technique.

Holding Times:

These samples were kept frozen until extraction. No holding times have beeen established for frozen fish tissue. The samples were analyzed within forty days from extraction.

Method Blanks:

No analytes of interest were detected in the method blanks.

Initial Calibration:

The % Relative Standard Deviations were within the maximum of 30% for all target analytes.

Continuing Calibration:

The Percent Differences between the initial and continuing calibrations were within the maximum of 25% for all target analytes.

Surrogates:

Three surrogates are reported for each sample. The recommended range for surrogate recovery is between 50% and 150%. Recoveries were acceptable in all samples except 95438249 and its dilution analysis. All results for this sample have been qualified with a "J".

Matrix Spikes (MS/MSD):

MS and MSD analyses were performed on samples 95438231 and 95438233. The high native concentrations of DDT analogs prevented accurate quantitation of most of the spike recoveries for these compounds, since they exceeded the calibration curve. Where this occurred, the results were qualified "NC". No qualification of the data is warranted for this condition.

All other matrix spike analyte recoveries were between 57% and 144%. These recoveries are reasonable and acceptable.

Sample Results:

The results for most samples exceeded the calibration curve. Therefore, dilutions were required for most of the samples. 4,4'-DDT in sample 95438231 was still above the calibration curve when diluted. The result for this analyte was calculated from an extrapolation of the curve and has thus been qualified with a "J".

The results are reported on either the original analysis printout or on the dilution analysis printout. There is only one result reported for each analyte.

This data is acceptable for use with the qualifications mentioned.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an estimate.

NC - Not calculated.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

December 21, 1995

Subject: Lake Osoyoos Fish (DDT)

Samples: 95 - 438230 to -438254

Case No. 2264-95

Officer: Dave Serdar

By: Dickey D. Huntamer
Organics Analysis Unit

LIPIDS

ANALYTICAL METHODS:

The tissue samples were extracted with hexane by EPA Region X Method RX1-608.5. The percent lipids were determined gravimetrically.

HOLDING TIMES:

The tissue samples were stored frozen until extraction.

BLANKS:

No lipids were detected in the laboratory blanks.

ANALYTICAL COMMENTS:

No analytical problems were encountered in the analysis. The data is acceptable for use as qualified.

1995 Fish Tissue

Manchester Environmental Laboratory

7411 Beach Dr E
Port Orchard Washington 98366
July 31, 1996

Project: **WSPMP Fish Tissue**

Samples: 95378230 through 95378254, 95388030 through 95388036

By: Karin Feddersen KF

These samples were analyzed for Pesticides and PCB's, employing the dual column confirmation technique, and for % Lipids and % Solids.

Holding Times:

These samples were extracted and analyzed within the method-specified holding times.

Method Blanks:

No analytes of interest were detected in the method blanks.

Initial Calibration:

The % Relative Standard Deviations were within the maximum of 20%, or the coefficient was greater than 0.995, for all target analytes with several exceptions which did not affect the results.

Continuing Calibrations:

The percent difference between the initial and continuing calibration standards were within the maximum of 25%, with several exceptions which did not affect the results.

Matrix Spikes (MS and MSD):

Sample 95388230 was analyzed as MS and MSD. Matrix spike recoveries are within QC limits of 50% to 150% with two exceptions. Kelthane recovery was 0% in both spikes. It apparently degraded completely to 4'4-Dichlorobenzophenone (DCBP). DCBP recoveries were 210% and 280%. Subtraction of the calculated Kelthane contribution yields recoveries of 79% and 147%.

Positive results for DCBP have been qualified with "NJ" to indicate that some or all of the DCBP present in the samples may be due to the degradation of Kelthane. Positive results for Kelthane have been qualified "J". Also, since there is little information available regarding other possible breakdown products, all non-detects for these compounds have been qualified "UJ".

The MS/MSD recoveries for Captan and Captafol are relatively low. This was expected since the stability these compounds is somewhat less then the other targets. They both have the tendency to degrade the dicarboximide base structure, losing the chlorinated portions of their respective structures. However, because the precision between recovery results is good, no qualifiers were applied.

P'p-DDE recoveries are high due to the high native concentration. The concentration of p'p- native to the sample was much higher than the amount spiked. Thus accurate quantitation of this analyte in the MS and MSD is not possible. No qualification of the results is necessary.

Duplicate:

Sample 95378254 was analyzed in duplicate. Precision data between the two analyses is acceptable for all analytes except Heptachlor Epoxide. There was an unclear baseline in the original analysis. The duplicate result is likely to be more accurate.

Sample 95378230 was also analyzed in duplicate. All target compounds in the duplicate analysis are approximately 15 to 20% below the values reported for the original analysis. Since the surrogate recoveries are similarly low, the differences are most likely due to sample loss during preparation.

Surrogates:

Four surrogates are reported for each sample. The recommended range for surrogate recovery in tissue is between 50% and 150%.

Dibromooctafluorobiphenyl (DBOB) recoveries are slightly below 50% in samples 953. However, recoveries for Decachlorobiphenyl (DCB) and Tetrachloro-m-xylene (TCMX) were acceptable. DCB and TCMX are better indicators of analyte recovery. No qualification of the data is warranted in these instances.

Dibutyl Chlorendate (DBC) recoveries were slightly below 50% in samples 95378246, 95378253 and the duplicate analysis of 95378254. DBC is recovered in the 15% florisil fraction. Results for all analytes typically found in this fraction have been qualified for these samples: Detected analytes have been qualified with "J"; non-detects with "UJ".

Surrogate recoveries were acceptable in all other samples and in the blanks.

Sample Results:

All fish tissue results are reported on an "as received" (wet weight) basis.
The Mass Spectrometer was used to confirm compounds in some instances.

All positive Trifluralin results are estimated from a single concentration standard and are qualified with "J". Non-detects are qualified "UJ".

Toxaphene was confirmed present by GC/MS. Toxaphene patterns in samples 95378232, 95378233, and 95378234 were inconsistent, most likely due to weathering. This makes accurate

quantitation difficult. All positive results ion these samples have therefore been qualified with "J".

Evidence for the presence of Toxaphene in samples 95378242, 953782354, and 953782354 duplicate is less conclusive, and it was not confirmed present by GC/MS. Toxaphene results for these samples have been therefore qualified "NJ".

This data is acceptable for use with the qualifications mentioned.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated reported value is an estimate.

UJ - The analyte was not detected at or above the reported value. The reported value is an estimate.

NJ - There is evidence that the analyte is present. The associated reported value is an estimate.

Appendix F-1. Analytical Methods - QA/QC - Data Review

Analytical Methods

Fish tissue samples were analyzed by Ecology's Manchester Environmental Laboratory (extraction SOP 7300722, version1.0 and 730073, version 1.0; cleanup SOP 730018, version 1.0) incorporating the acetonitrile back-extraction clean-up portion of a method developed by the California Department of Fish and Game, Water Pollution Control Laboratory. A detailed explanation of the analytical procedure can be found in Rasmussen and Blethrow (1991). Briefly, the tissue is extracted with acetonitrile and the extract is partitioned with petroleum ether and water. The petroleum ether extract is then eluted through a Florisil column in four fractions; fraction one is eluted with petroleum ether, fraction two is eluted with 6% ethyl ether, fraction three is eluted with 15% ethyl ether, and the fourth fraction is eluted with 50% ethyl ether.

Each fraction was analyzed separately with a gas chromatograph using an electron capture detector (USEPA Method 8080). A five meter J&W DB5 fused silica pre-column was connected to the injector, and the effluent from the pre-column was split into 60 meter J&W DB5 and 60 meter J&W DB17 columns. Pesticide detections in the sample extracts were confirmed with a gas chromatograph/mass spectrometer (GC/MS) using an ion trap detector.

Percent lipid in tissue samples is determined using the method described in the USEPA document "Manual of Analytical Methods for the Analyses of Pesticides in Humans and Environmental Samples", EPA-600 18-80-038, June 1980 (Manchester Laboratory SOP 730009, version 1.0).

Quality Assurance/Quality Control

Field Quality Control Procedures

Field replicate samples were taken to estimate overall precision and to assess environmental variability. Replicate largescale sucker samples were collected from the Cowlitz and Yakima Rivers, and replicate carp samples were collected from Scooteney Reservoir.

Duplicate tissue samples (splits) were submitted to evaluate analytical precision. Duplicate samples were analyzed from Redrock and Royal Lakes, Scooteney Reservoir, and the Yakima River. Fish tissue quality control check material was submitted in duplicate to estimate analytical accuracy and precision.

Laboratory Quality Control Procedures

A portion of the largescale sucker sample collected from the Cowlitz River was used for matrix spike and matrix spike duplicate analyses to detect bias due to interferences from the sample matrix. Surrogate standards were added to each sample prior to extraction to evaluate the efficiency of the extractions. Matrix and surrogate spikes performed by the laboratory also provide estimates of accuracy and precision.

Data Review

Fish tissue analysis data packages and quality control results were reviewed and assessed by Karin Feddersen of Ecology's Manchester Environmental Laboratory. No significant problems were encountered. Minor difficulties are discussed in the attached data validation report.

Detection Limits

The values in Appendix B are quantitation limits, which are often different for each sample. Detection limits were not calculated separately, but were generally substantially lower than quantitation limits. A quantitation limit is the smallest concentration of a compound that the laboratory can quantify with a specified degree of confidence. When compounds are detected below the quantitation limit, these chemicals can often be positively identified, but the degree of confidence for the concentration of these compounds is lower than for those above the quantitation limit, and reported concentrations are qualified as estimates. In most instances, the level of detection was sufficiently low to compare with even the lowest criteria. However, comparison of qualified results to criteria should be made with caution.

While there is some uncertainty associated with the concentration of compounds detected below the quantitation limit, the probability of a false positive is still low in most cases. In a screening survey, such as the WSPMP, the consequences of a false positive are generally not serious. Detected compounds of interest would simply require additional sampling to verify their presence. False negatives would be more serious, indicating that there is no problem when one may be present.

Quality Control Samples

No accuracy or precision criteria have been established for any of the analytical methods used, but duplicate samples 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 between duplicate analyses. Evaluation of matrix and surrogate spike results is included in the attached data validation report. The laboratory has set the range for recommended matrix and surrogate spike recoveries in tissue samples at 50% to 150%. Data associated with recoveries above or below this range are "J" qualified. RPDs below 75% are considered acceptable.

Fish tissue quality control check material samples were submitted to the laboratory in duplicate. The check 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 F-1 (cont.). Analytical Methods - QA/QC - Data Review

Appendix F-2 compares check material results to expected values. RPD values between the means of the duplicate analyses and the expected values were 50 or lower for all compounds except oxychlordane and heptachlor epoxide, which were 78 and 57 respectively. The average RPD was 30. These results suggest good analytical accuracy.

Results from duplicate analyses (splits) are presented in Appendix F-3. Five sets of duplicate samples were analyzed, in addition to the quality control check sample that was analyzed in duplicate. RPDs ranged from 0-78 with an overall average of 17. These results indicate good precision.

Replicate samples were collected to evaluate environmental variability between samples from the same site. Differences between replicate samples were generally small (Appendix F-4), and with an average RPD of 32 for the Scooteney Reservoir and Cowlitz River samples, were about double the differences between duplicate analyses. Coefficients of variation for the Yakima River samples were also low, averaging only 16%. Since some of the disparity between replicates can be attributed to analytical variability, differences between replicates due to environmental variability is probably low.

Appendix F-2. 1995 Fish Tissue Quality Control Check Material Results (µg/kg (ppb) wet weight)

Analyte	Mean Concentration (± ½ duplicate range)		Expected Value	RPD[1]
4,4'-DDD	60	± 21	65	9
4,4'-DDE	550	± 30	495	11
4,4'-DDT	52	± 4	31	50
cis-chlordane	92	± 3	82	11
trans-chlordane	45	± 1	45	0
cis-nonachlor	54	± 0	45	18
trans-nonachlor	125	± 5	94	28
oxychlordane	12	± 5	28	78
dieldrin	93	± 8	152	49
heptachlor epoxide	21	± 7	37	57
total PCBs	1675	± 75	1333	23

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

Appendix F-3. 1995 Fish Tissue Duplicate Analysis Results (µg/kg (ppb) wet weight)

Analyte	Sample 1	Sample 2	RPD[1]
Redrock Lake largemouth bass (large)			
2,4'-DDD	1.3	1.8	32
2,4'-DDE	0.7	0.6	15
2,4'-DDT	0.7	0.6	15
4,4'-DDD	15	15	0
4,4'-DDE	130	130	0
4,4'-DDT	6.3	6.4	2
DDMU	5.3	5.3	0
chlorpyrifos	3.8	4	5
DCPA (dacthal)	4.9	4.7	4
dieldrin	8.5	8.7	2
hexachlorobenzene	0.7	0.6	15
trans-nonachlor	0.7	0.7	0
trifluralin	1.2	1.2	0
Royal Lake smallmouth bass			
4,4'-DDD	4.5	3.8	17
4,4'-DDE	68	67	1
4,4'-DDT	3.8	3.8	0
DDMU	7.9 U[2]	1.2	NC[3]
chlorpyrifos	3.9	3.7	5
DCPA (dacthal)	5.4	4.5	18
dieldrin	8.3	8.0	4
hexachlorobenzene	1.2	0.9	29
trifluralin	1.4	1.3	7
Scooteney Reservoir largemouth bass			
4,4'-DDD	7.5	5.9	24
4,4'-DDE	57	68	18
4,4'-DDT	5.7	3.2	56
chlorpyrifos	3.3	4.3	26
DCPA (dacthal)	7.8	8.7	11
dieldrin	8.7	11	23
hexachlorobenzene	1.2	1.3	8
trans-nonachlor	3.9 U	0.7	NC
trifluralin	1.2	1.4	15

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

[2] - U = Undetected at or above the reported value.

[3] - NC = Not Calculated.

Appendix F-3 (cont.). 1995 Fish Tissue Duplicate Analysis Results (µg/kg (ppb) wet weight)

Analyte	Sample 1	Sample 2	RPD[1]
Yakima River carp			
2,4'-DDD	7.0	5.7	20
2,4'-DDE	5.4	4.7	14
2,4'-DDT	5.2	4.1	24
4,4'-DDD	51	41	22
4,4'-DDE	940	750	22
4,4'-DDT	12	8.4	35
DDMU	19	15	24
cis-chlordane	5.1	4.8	6
trans-chlordane	1.1	0.89	21
cis-nonachlor	2.9	2.4	19
trans-nonachlor	6.6	5.6	16
oxychlordane	0.42	0.27	43
dieldrin	9.6	8.0	18
heptachlor epoxide	0.68	0.54	23
hexachlorobenzene	0.53	0.45	16
trifluralin	3.8	3.3	14
PCB-1254	30	28	7
PCB-1260	120	91	27
Yakima River largescale sucker (Rep-1)			
2,4'-DDD	32	31	3
2,4'-DDE	20	20	0
2,4'-DDT	37	46	22
4,4'-DDD	210	190	10
4,4'-DDE	2900	3400	16
4,4'-DDT	250	320	25
DDMU	56	57	2
4,4'-dichlorobenzophenone	8.7	10	14
cis-chlordane	8.8	9.3	6
trans-chlordane	2.7	3.1	14
cis-nonachlor	4.0	4.6	14
trans-nonachlor	17	18	6
oxychlordane	1.9	2.1	10
dieldrin	42	45	7
heptachlor epoxide	0.92	1.1	18
hexachlorobenzene	1.6	1.8	12
kelthane	44	58	27
pentachloroanisole	0.96	1.0	4
toxaphene	250	230	8
trifluralin	12	15	22
PCB-1254	81	97	18
PCB-1260	220	230	4

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

Appendix F-3 (cont.). 1995 Fish Tissue Duplicate Analysis Results (µg/kg (ppb) wet weight)

Analyte	Sample 1	Sample 2	RPD[1]
QC Check Material			
2,4'-DDD	4.8	11	78
4,4'-DDD	39	80	69
4,4'-DDE	580	520	11
4,4'-DDT	55	48	14
BHC-alpha	12	11	9
cis-chlordane	95	89	7
trans-chlordane	44	46	4
cis-nonachlor	54	54	0
trans-nonachlor	130	120	8
oxychlordane	7.5	17	78
DCPA (dacthal)	6.7	12	57
dieldrin	85	100	16
endrin	6	7.1	17
heptachlor epoxide	14	27	63
hexachlorobenzene	12	11	9
toxaphene	300	500	50
PCB-1254	1100	1000	10
PCB-1260	650	600	8

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

Appendix F-4. 1995 WSPMP Fish Tissue Replicate Analysis Results (µg/kg (ppb) wet weight)

Analyte	Replicate 1	Replicate 2	RPD[1]
Scooteney Reservoir carp			
aldrin	0.7	0.6	15
trans-chlordane	1.5	0.8	61
dieldrin	28	19	38
4,4'-DDE	370	250	39
4,4'-DDD	46	28	49
4,4'-DDT	4.1	3.4	19
oxychlordane	0.9	3.9 U[2]	NC[3]
DDMU	10	7.1	34
cis-chlordane	2.4	1.4	53
cis-nonachlor	2.1	1.5	33
2,4'-DDE	1.9	1.3	38
trans-nonachlor	4.6	3.1	39
2,4'-DDD	4.6	3.2	36
2,4'-DDT	1.8	1.7	6
toxaphene	120	140	15
hexachlorobenzene	5.7	3.3	53
DCPA (dacthal)	32	26	21
chlorpyrifos	20	18	11
trifluralin	9.3	7.1	27
Cowlitz River largescale sucker			
4,4'-DDE	73	59	21
4,4'-DDD	10	7.6	27
4,4'-DDT	7.6	4.5	51
trans-nonachlor	3.7 U	2.4	NC
hexachlorobenzene	1.1	1.2	9
pentachloroanisole	1.9 U	0.6	NC
PCB-1254	37	66	56
PCB-1260	47	42	11

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

Appendix F-4. 1995 WSPMP Fish Tissue Replicate Analysis Results (µg/kg (ppb) wet weight)

Analyte	Replicate 1[1]	Replicate 2	Replicate 3	COV[2]
Yakima River largescale sucker				
2,4'-DDD	32	26	21	21
2,4'-DDE	20	15	11	29
2,4'-DDT	42	36	24	27
4,4'-DDD	200	150	140	20
4,4'-DDE	3150	3000	1900	25
4,4'-DDT	285	250	180	22
DDMU	57	51	42	15
4,4'-dichlorobenzophenone	9.4	6.4	7.1	21
cis-chlordane	9.1	7.6	9.4	11
trans-chlordane	2.9	2.2	1.5	32
cis-nonachlor	4.3	4.0	5.0	12
trans-nonachlor	18	14	12	21
dieldrin	44	38	35	12
heptachlor epoxide	1.0	0.84	0.71	17
hexachlorobenzene	1.7	1.5	1.4	10
kelthane	51	51	55	4
oxychlordane	2.0	2.1	2.0	3
pentachloroanisole	1.0	1.0	1.0	0
toxaphene	240	230	200	9
trifluralin	14	11	9.8	19
PCB-1254	89	77	77	9
PCB-1260	225	220	150	21

[1] - Values are means of duplicate analyses

[2] - COV = Coefficient of Variation (%), (standard deviation/mean)x100

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Chlorinated Pesticides (GC/AED)

Project Name: WSPMP - Fish LS Sucker WF Rep-1 **LIMS Project ID:** 2249-95

Sample: 95378251 **Date Received:** 10/16/95 **Method:** SW8080
Field ID: LAKE OSOYOOS **Date Prepared:** 05/02/96 **Matrix:** Tissue
Project Officer: Dale Davis **Date Analyzed:** 06/05/96 **Units:** ug/Kg

Analyte	Result	Qualifier	Analyte	Result	Qualifier
Alpha-BHC	3.6	U	PCB - 1242	36	U
Beta-BHC	3.6	U	PCB - 1248	36	U
Gamma-BHC (Lindane)	3.6	U	**PCB - 1254**	**24**	**J**
Delta-BHC	3.6	U	PCB - 1260	36	U
Heptachlor	3.6	U	Dacthal (DCPA)	3.6	U
Aldrin	3.6	U	PCB - 1232	36	U
Heptachlor Epoxide	3.6	U	Parathion	7.3	U
Trans-Chlordane (Gamma)	3.6	U	Methyl Parathion	7.3	U
Endosulfan I	3.6	U	Diazinon	36	U
Dieldrin	3.6	U	Chlorpyriphos	7.3	U
4,4'-DDE	**440**		Ethion	15	U
Endrin	3.6	U	Treflan (Trifluralin)	3.6	UJ
Endosulfan II	3.6	U			
4,4'-DDD	**120**		**Surrogate Recoveries**		
Endrin Aldehyde	3.6	U			
Endosulfan Sulfate	3.6	U	**4,4-Dibromooctafluorobiphenyl**	**62**	**%**
4,4'-DDT	**17**		**Dibutylchlorendate**	**54**	**%**
Endrin Ketone	3.6	U	**Tetrachloro-m-xylene**	**61**	**%**
Methoxychlor	3.6	U	**Decachlorobiphenyl**	**66**	**%**
Alpha-Chlordene	3.6	U			
Gamma-Chlordene	3.6	U			
Oxychlordane	3.6	U			
DDMU	**38**				
Cis-Chlordane (Alpha-Chlordane	3.6	U			
Cis-Nonachlor	3.6	U			
Kelthane	15	UJ			
Captan	11	U			
2,4'-DDE	3.6	U			
Trans-Nonachlor	3.6	U			
2,4'-DDD	**2.3**	**J**			
2,4'-DDT	3.6	U			
Captafol	18	U			
Mirex	3.6	U			
Toxaphene	110	U			
4,4'-Dichlorobenzophenone	15	UJ			
Hexachlorobenzene	**1.2**	**J**			
Pentachloroanisole	1.8	U			
Tetradifon (Tedion)	15	U			

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Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Chlorinated Pesticides (GC/AED)

Project Name: WSPMP - Fish LS Sucker WF Rep-2 **LIMS Project ID:** 2249-95

Sample: 95378252 **Date Received:** 10/16/95 **Method:** SW8080
Field ID: LAKE OSOYOOS **Date Prepared:** 05/02/96 **Matrix:** Tissue
Project Officer: Dale Davis **Date Analyzed:** 06/05/96 **Units:** ug/Kg

Analyte	Result	Qualifier	Analyte	Result	Qualifier
Alpha-BHC	3.7	U	PCB - 1242	37	U
Beta-BHC	3.7	U	PCB - 1248	37	U
Gamma-BHC (Lindane)	3.7	U	**PCB - 1254**	**48**	**J**
Delta-BHC	3.7	U	**PCB - 1260**	**18**	**J**
Heptachlor	3.7	U	Dacthal (DCPA)	3.7	U
Aldrin	3.7	U	PCB - 1232	37	U
Heptachlor Epoxide	3.7	U	Parathion	7.4	U
Trans-Chlordane (Gamma)	3.7	U	Methyl Parathion	7.4	U
Endosulfan I	3.7	U	Diazinon	37	U
Dieldrin	3.7	U	Chlorpyriphos	7.4	U
4,4'-DDE	**810**		Ethion	15	U
Endrin	3.7	U	Treflan (Trifluralin)	3.7	UJ
Endosulfan II	3.7	U			
4,4'-DDD	**190**		**Surrogate Recoveries**		
Endrin Aldehyde	5.5	U			
Endosulfan Sulfate	3.7	U	**4,4-Dibromooctafluorobiphenyl**	**88**	**%**
4,4'-DDT	**40**		**Dibutylchlorendate**	**68**	**%**
Endrin Ketone	7.4	U	**Tetrachloro-m-xylene**	**84**	**%**
Methoxychlor	3.7	U	**Decachlorobiphenyl**	**90**	**%**
Alpha-Chlordene	3.7	U			
Gamma-Chlordene	3.7	U			
Oxychlordane	3.7	U			
DDMU	**60**				
Cis-Chlordane (Alpha-Chlordane	3.7	U			
Cis-Nonachlor	3.7	U			
Kelthane	29	UJ			
Captan	11	U			
2,4'-DDE	3.7	U			
Trans-Nonachlor	3.7	U			
2,4'-DDD	**3.5**				
2,4'-DDT	3.7	U			
Captafol	18	U			
Mirex	3.7	U			
Toxaphene	110	U			
4,4'-Dichlorobenzophenone	15	UJ			
Hexachlorobenzene	**2.2**				
Pentachloroanisole	1.8	U			
Tetradifon (Tedion)	15	U			

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Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Chlorinated Pesticides (GC/AED)

Project Name: WSPMP - Fish SM Bass Fillet **LIMS Project ID:** 2249-95

Sample: 95378253 **Date Received:** 10/16/95 **Method:** SW8080
Field ID: LAKE OSOYOOS **Date Prepared:** 05/02/96 **Matrix:** Tissue
Project Officer: Dale Davis **Date Analyzed:** 06/05/96 **Units:** ug/Kg

Analyte	Result	Qualifier	Analyte	Result	Qualifier
Alpha-BHC	4.0	U	PCB - 1242	40	U
Beta-BHC	4.0	U	PCB - 1248	40	U
Gamma-BHC (Lindane)	4.0	U	PCB - 1254	40	U
Delta-BHC	4.0	U	PCB - 1260	40	U
Heptachlor	4.0	U	Dacthal (DCPA)	4.0	UJ
Aldrin	4.0	U	PCB - 1232	40	U
Heptachlor Epoxide	4.0	U	Parathion	7.9	UJ
Trans-Chlordane (Gamma)	4.0	U	Methyl Parathion	7.9	UJ
Endosulfan I	4.0	U	Chlorpyriphos	7.9	U
Dieldrin	4.0	U	Diazinon	40	UJ
4,4'-DDE	**42**		Ethion	16	U
Endrin	4.0	UJ	Treflan (Trifluralin)	4.0	UJ
Endosulfan II	4.0	UJ			
4,4'-DDD	**8.4**		**Surrogate Recoveries**		
Endrin Aldehyde	4.0	UJ			
Endosulfan Sulfate	4.0	UJ	**4,4-Dibromooctafluorobiphenyl**	**48**	**%**
4,4'-DDT	**5.0**	**J**	**Dibutylchlorendate**	**42**	**%**
Endrin Ketone	4.0	U	**Tetrachloro-m-xylene**	**48**	**%**
Methoxychlor	4.0	U	**Decachlorobiphenyl**	**54**	**%**
Alpha-Chlordene	4.0	U			
Gamma-Chlordene	4.0	U			
Oxychlordane	4.0	U			
DDMU	**2.1**	**J**			
Cis-Chlordane (Alpha-Chlordane	4.0	U			
Cis-Nonachlor	4.0	U			
Kelthane	16	UJ			
Captan	12	U			
2,4'-DDE	4.0	U			
Trans-Nonachlor	4.0	U			
2,4'-DDD	4.0	U			
2,4'-DDT	4.0	U			
Captafol	20	U			
Mirex	4.0	U			
Toxaphene	120	U			
4,4'-Dichlorobenzophenone	16	UJ			
Hexachlorobenzene	2.0	U			
Pentachloroanisole	2.0	U			
Tetradifon (Tedion)	16	UJ			

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