A Department of Ecology Report

WASHINGTON STATE DEPARTMENT OF ECOLOGY

PCB Concentrations in Fish from Ward Lake (Thurston County) and the Lower Elwha River

Abstract

Polychlorinated biphenyl (PCB) concentrations were sampled in edible fish tissue from Ward Lake (Thurston County) and the lower Elwha River below Lake Aldwell. The objective was to assess PCB concentrations to determine if one or both of these waterbodies should retain "water quality limited" [i.e., 303(d) list] status due to PCBs. PCB Aroclors 1254 and 1260 were detected in all samples at concentrations from 3 to 12 µg/kg, above the National Toxics Rule criterion of 1.4 µg/kg. Therefore it is recommended that both Ward Lake and the lower Elwha River be included on the 303(d) list for both PCB-1254 and PCB-1260. In neither waterbody is the source(s) of PCBs known.

Introduction

Ward Lake is a 65-acre lake bordering Olympia in a residential area of Thurston County. It is currently on the 303(d) list based on results from a 1992 Ecology survey which found PCB-1260 at 8 µg/kg (parts per billion) in a composite sample of rainbow trout fillet (Serdar *et al.*, 1994). The National Toxics Rule (NTR, 40 CFR Part 131) criterion for PCBs in edible fish tissue is 1.4 µg/kg. The source of PCBs in Ward Lake fish is not known.

The Washington State Department of Fish and Wildlife (WDFW) annually plants kokanee and rainbow trout in Ward Lake to maintain a popular sport fishery. According to WDFW area fish biologists Steve Jackson and Chuck Baranski, Ward Lake receives approximately 15,000 kokanee fry and 3,000 rainbow trout fry each May. An additional 5,000 "catchable" rainbow trout (approximately 1/4 lb. each) are released during April. Three hundred broodstock cutthroat trout have also been planted (date unknown). Largemouth bass, brown bullhead (catfish), and yellow perch also inhabit the lake and propagate naturally.

by Dave Serdar

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Waterbody Numbers: Ward Lake -1228740460088 (formerly WA-13-9200)
Lower Elwha River - 1235577481507 (formerly WA-18-2010)

The lower Elwha River (downstream of Lake Mills in Clallam County) is currently on the 303(d) list due to two water samples collected between Lake Mills and Lake Aldwell by the U.S. Geological Survey (USGS) during 1980. PCB-1254 concentrations in the USGS samples were 0.07 and 0.90 µg/L, several orders of magnitude above the criterion to protect human health (0.000044 µg/L, WAC 173-201A). The source of PCBs in the Elwha River is not known, but it is conceivable that the electric generating station at Glines Canyon (Lake Mills) Dam may be the origin.

Methods

Fish Collection

Biological data on fish, as well as dates and locations for fish collection, are in the appendix. Fish from Ward Lake were captured on different occasions using a variety of methods including electroshocking, fyke net, and hook-and-line. Four species were obtained for analysis: rainbow trout (*Oncorhynchus mykiss*), kokanee (*O. nerka*), cutthroat trout (*O. clarki*), and largemouth bass (*Micropterus salmoides*). There are no legal size restrictions for bass or trout in lakes. Rainbow trout from the lower Elwha River were captured by electroshocking with the assistance of Cathy Lear of the lower Elwha Klallam Tribe. Fish were 6"-9", smaller than the preferred legal size of 14". Table 1 shows the number and species composition of each composite sample.

Table 1. Number and Species of Fish in Composite Samples.

	No. composite samples	No. fish per composite
Ward Lake		
Largemouth bass	1	8
Rainbow trout	1	4
Cutthroat trout	1	2
Kokanee	1	5
Elwha River		
Rainbow trout	3	6

Once captured, fish were placed in polyethylene bags on ice then transported to the Ecology Headquarters building the same day. Each fish was assigned a sample number, measured for total length, weighed, double wrapped in aluminum foil, double bagged in zip-lock polyethylene bags, and frozen at –20°C.

Fillets were prepared by separating the foil from frozen specimens, removing the scales, and extracting the entire skin-on fillets on both sides from the gill arch to the caudal peduncle. Fillets generally included dark muscle along the lateral line and belly flap fat. Care was taken to avoid rupturing or including contents of the gut cavity.

Compositing procedures were consistent with EPA recommendations for chemical contaminants in fish (EPA, 1993). Fillets were homogenized individually, then equal weight aliquots of the homogenized fillets were combined to form the composite sample. Tissues were homogenized with three passes through a Kitchen-Aid® food processor. 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 (–20°C) in 8-oz. glass jars with Teflon lid liners certified for trace organics analysis. All tissues were analyzed within the one-year maximum holding time recommended by EPA for PCB analysis in tissue samples stored frozen (EPA, 1993).

Laboratory Analysis

All tissue samples were analyzed at the EPA/Ecology Manchester Environmental Laboratory for PCB Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, and lipid content. Aroclors are PCB mixtures distinguished primarily on chlorine content and are the chemicals for which NTR criteria have been established. PCBs were extracted with methylene chloride and GPC/Florisil clean-up, then analyzed by gas chromatography/electron capture detection with dual dissimilar column confirmation (GC/ECD, modified EPA Method 8082). Percent lipids were determined gravimetrically after being extracted with 50/50 hexane/methylene chloride.

Data Quality

Data quality was good. Surrogate and spike recoveries were within method control limits (see case narrative in the appendix), although matrix spike recoveries were slightly lower than those specified in the Quality Assurance Project Plan (64%-69% vs. 75%-125%)(Serdar, 1999). Duplicate samples submitted blind had relative percent differences (RPDs, the difference as a percent of the mean) of 18% for PCB-1254 and 27% for PCB-1260. Laboratory duplicates had RPDs of 10% and 22% for PCB-1254 and PCB-1260, respectively. The RPD between samples spiked with PCB-1260 was 6%. No PCBs were found in laboratory blanks.

Results

PCB concentrations in Ward Lake and Elwha River fish are shown in Tables 2 and 3, respectively. PCB-1254 and PCB-1260 were detected at low concentrations in all samples: total PCBs were <20 µg/kg. Concentrations were similar between waterbodies and among species. All results exceeded NTR criteria for PCBs (1.4 µg/kg).

Table 2. PCB Concentrations in Ward Lake Fish Muscle (µg/kg, wet).

	Largemouth bass	Rainbow trout	Cutthroat trout	Kokanee
Sample no.(99-)	*178105*	*178106*	*178107*	*238112*
Total length (mm, mean ± SD)	344 ± 77	219 ± 34	291 ± 42	260 ± 11
Weight (g, mean ± SD)	715 ± 507	129 ± 79	238 ± 102	162 ± 23
Lipid content	<0.1%	2.3%	2.2%	9.4%
PCB-1016	2.5 U	2.5 U	2.5 U	2.4 U
PCB-1221	2.5 U	2.5 U	2.5 U	2.4 U
PCB-1232	2.5 U	2.5 U	2.5 U	2.4 U
PCB-1242	2.5 U	2.5 U	2.5 U	2.4 U
PCB-1248	2.5 U	2.5 U	2.5 U	2.4 U
PCB-1254	**12**	**7.9**	**8.2**	**12** J
PCB-1260	**7.1** J	**5.7** J	**5.1** J	**4.4** J

U=not detected at concentration shown
J=estimated concentration
Detected analytes in **bold**

Table 3. PCB Concentrations in Elwha River Fish Muscle (µg/kg, wet).

	Rainbow trout	Rainbow trout	Rainbow trout
Sample no.(99-)	*178108/11*	*178109*	*178110*
Total length (mm, mean ± SD)	221 ± 14	189 ± 11	165 ± 7
Weight (g, mean ± SD)	102 ± 25	58 ± 10	44 ± 6
Lipid content	1.4%	0.5%	1.1%
PCB-1016	2.6 U	2.7 U	2.3 U
PCB-1221	2.6 U	2.7 U	2.3 U
PCB-1232	2.6 U	2.7 U	2.3 U
PCB-1242	2.6 U	2.7 U	2.3 U
PCB-1248	2.6 U	2.7 U	2.3 U
PCB-1254	**12** J	**5.8** J	**8.7**
PCB-1260	**5.6**	**3.0** J	**4.3**

U=not detected at concentration shown
J=estimated concentration
Detected analytes in **bold**

Discussion

Comparison to Criteria

The National Toxics Rule (NTR) establishes numeric, chemical-specific criteria for all priority pollutants in order to bring states into compliance with the Clean Water Act. The criterion for each PCB Aroclor in edible fish tissue is 1.4 µg/kg, derived to protect humans from excess cancer risk. This concentration is expected to cause no more than one excess cancer per million people (i.e., an acceptable upper-bound cancer risk of 10^{-6}) for a lifetime exposure, a risk level adopted by Ecology and codified in WAC 173-201A. These risk levels are partially based on default exposure values set out in the NTR, e.g., an average consumption rate of 6.5 g/day, and therefore do not necessarily reflect consumer habits of the local population.

Although samples analyzed for the present survey exceed the NTR criteria for both PCB-1254 and PCB-1260, they are present at very low concentrations by almost any standard and probably reflect background levels of these ubiquitous chemicals. For instance, in their national study EPA found total PCB concentrations averaging 47 µg/kg in 20 whole fish collected from background sites (EPA, 1992). PCBs, especially Aroclors 1254 and 1260, are routinely detected in fish tissue throughout Washington, with a state average of 67 µg/kg total PCBs for fillets (Davis and Serdar, 1996).

In contrast, PCB concentrations are reported to be much higher for sites with known PCB sources or in heavily urbanized/industrialized areas. Nineteen finfish fillets from the Spokane River in the vicinity of a large aluminum mill and other industrial facilities near Spokane were found to have total PCB concentrations averaging 390 µg/kg (Ecology, 1995). The median total PCB concentration in 36 sport fish fillets from urban/industrial sites nationwide was 290 µg/kg (EPA, 1992), and concentrations were as high as 5,100 µg/kg, three orders of magnitude higher than the present study.

EPA has proposed revisions to the human health water quality standards for PCBs due to a re-evaluation of the cancer potency factor for PCBs (Federal Register: April 2, 1998). Changes in the PCB standards would result in an increase of the NTR criteria from 1.4 µg/kg to 5.4 µg/kg and would apply to total Aroclors rather than individual Aroclors. Adoption of these revisions would not change the status of water quality violations for Ward Lake and the Elwha River.

Possible Sources

As mentioned previously, there are no known sources of PCBs to Ward Lake. PCBs, like other persistent organic compounds (e.g., dioxins) are ubiquitous in the environment and are distributed globally through atmospheric transport and deposition (Erickson, 1993). Therefore, it seems likely that the bulk of PCBs in Ward Lake fish is from atmospheric inputs to the basin. Local atmospheric sources, runoff from historical land applications (e.g., PCBs in pesticides, oils to control road dust), or

small-scale spills may have also contributed to the low levels resulting from global atmospheric distribution.

Another possible scenario to explain PCBs in Ward Lake is that hatchery fish contain PCBs prior to planting by WDFW. This concern was expressed by the Thurston County Health Department following the initial finding of PCBs in Ward Lake fish in 1992. In response, WDFW analyzed feed and broodstock from the Eells Spring hatchery, the source of Ward Lake rainbow trout (Michael, 1997). No PCBs were found in either the feed (detct. lim. 15-16 µg/kg) or various tissues of one- to two-year-old rainbow trout and three-year-old cutthroat trout (detct. lim. 3-71 µg/kg). No information was provided on the types of PCBs analyzed or the quality of these data.

Although PCBs were not found in samples from the Eells Spring hatchery, contaminated feed has been documented at other hatcheries or rearing facilities in Washington (Michael, 1997; Tracy Collier, National Marine Fisheries Service, personal communication). Therefore, the only practical approach to further investigate the source of PCBs in Ward Lake is a more rigorous study of hatchery feed and hatchery fish. Such a study should (1) employ low detection levels and adequate quality assurance/ quality control measures, and (2) sample a number of hatcheries to assess whether any findings of contamination represent a potential widespread problem. A survey comparing PCB concentrations in wild fish from Ward Lake to fish from a nearby unstocked lake would help determine whether hatchery fish are a significant PCB source to waterbodies like Ward Lake.

The source of PCBs in Elwha River fish is also unclear, although contamination from upstream hydroelectric generating facilities is a possibility. Soil and sediments from the vicinity of the powerplants have recently been analyzed for PCBs as part of a larger dam removal study, but those data are not yet available. Like Ward Lake, however, atmospheric deposition in the Elwha basin must be considered a possible source. The similarities between PCB concentrations and Aroclor ratios in Ward Lake and Elwha fish seem to support an atmospheric deposition scenario. A recent survey of Lake Whatcom near Bellingham also found similar concentrations of PCB-1254 and PCB-1260 in kokanee and bass fillets although there is no documented or suspected local source of PCBs in the Lake Whatcom basin (Serdar *et al.*, 1999).

At least six of the 18 rainbow trout from the Elwha River were hatchery fish; the aforementioned concerns about PCB-contaminated feed and fish are therefore relevant. Of the three composite samples analyzed from the Elwha, one contained 33% adipose fin-clipped fish (sample number 99-178108/11), one contained 66% fin-clipped fish (99-178109), and the third had no fin-clipped fish (99-178110). The number of fin-clipped fish in these composite samples did not appear to be correlated with the PCB concentrations. Lipid content among these samples probably accounted for some of the small differences in PCBs.

Recommendations

Based on these data, the following is recommended:

- Retain Ward Lake on the 303(d) list for PCB-1260 based on the present data and add it to the list for PCB-1254.

- Retain the lower Elwha River on the 303(d) list for PCB-1254 based on the present data and add it to the list for PCB-1260.

- Consider an assessment of PCBs in hatchery feed and hatchery fish. A survey comparing PCB concentrations in wild fish from Ward Lake to fish from a nearby unstocked lake would help determine whether hatchery fish are a significant PCB source to waterbodies like Ward Lake.

- Analyze PCBs in fish upstream from all potential local sources (i.e., hydroelectric generating stations and related facilities/equipment) in the Elwha River. Fish should be collected from areas isolated by barriers from potential contaminant sources.

Acknowledgements

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Contacts

Dave Serdar Washington State Department of Ecology
Environmental Assessment Program
(360) 407-6772

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Appendix

Manchester Environmental Laboratory

7411 Beach DR E, Port Orchard Washington 98366

CASE NARRATIVE

July 23, 1999

Subject: Ward Lake / Elwha River PCBs

Samples: 99178105 - 99178112

Case No. 1384-99

Officer: Dave Serdar

By: M. Mandjikov

PCB Results for the Sediment Ward Lake / Elwha River Fish Tissue Study

SUMMARY:

Samples 99178105 – 99178112 were analyzed for the presence of polychlorinated biphenyls (PCBs). Arochlors 1254 and 1260 were found in all samples.

The reported concentrations are calculated from averages of several congener compounds that form each arochlor. The relative standard deviations (RSD) between these congeners ranged from 5% - 36% for this project. Congener averages with RSDs greater than 20% are qualified as estimates, "J".

The data is usable as reported.

METHODS:

The samples were stored frozen prior to extraction. They were thawed and then extracted into methylene chloride using a Soxhlet apparatus. After extraction, the extracts were treated with concentrated sulfuric acid and eluted through a Florisil® column with 100% hexane. Prior to GC-ECD analysis each extract was solvent exchanged to iso-octane and concentrated to 1mL. These methods are modifications of EPA SW- 846 methods 3540, 3620, 3665, and 8082.

BLANKS:

No analytes of interest were detected in the blanks above the reporting limits.

SURROGATES:

All samples and blanks were spiked with tetrachloro-m-xylene (TMX) and 2,2',4,4',5,5' hexabromobiphenyl. All surrogate spike recoveries are within 60% - 85%. Acceptable surrogate recoveries for this method range from 50% - 150% of the spiked value.

DUPLICATE SAMPLES:

Sample 99178107 was analyzed in duplicate to provide information on the precision of this method. The relative percent difference (RPD) between the duplicates is 17% for Arochlor 1260 and 4% for Arochlor 1254.

SPIKED AND SPIKED DUPLICATE SAMPLES:

Sample 99178105 was prepared in triplicate. Two of the replicates were spiked with PCB arochlor 1260. The samples were then extracted, treated and analyzed identically. The spike recoveries were within the control limits of 50% - 150% of the reference value. The RPD between the spiked duplicate samples is 6%.

HOLDING TIMES:

The samples were analyzed within the recommended holding times.

COMMENTS:

P,p' DDE was found in all samples. The following table lists the concentrations found in the respective samples:

Sample	p,p' DDE ug/Kg wet weight
99178105	6.2 J
99178106	4.0 J
99178107	5.6 J
99178107d	5.2 J
99178108	8.4 J
99178109	3.4 J
99178110	5.5 J
99178111	7.4 J
99178112	8.1 J

DATA QUALIFIERS:

Code	Definition
E	Reported result is an estimate because it exceeds the calibration.
J	The analyte was positively identified. The associated numerical result is an estimate.
N	There is evidence the analyte is present in this sample.
NJ	There is evidence that the analyte is present. The associated numerical result is an estimate.
NAF	Not analyzed for.
REJ	The data are unusable for all purposes.
U	The analyte was not detected at or above the reported result.
UJ	The analyte was not detected at or above the reported estimated result.
Bold Type	The analyte was present in the sample. Used as a visual aid to locate detected compounds on the report sheet.

Table A-1. Fish Collected for 1999 Ward Lake/Elwha River PCB Survey.

Field Sample No.	Lab Sample No.	Species	Date	Collection Method	Total Length (mm)	Weight (g)	Observations
Ward Lake							
WL-8	99178105	Largemouth bass	31-Mar-99	electroshocking	485	1793	
WL-10	"	"	31-Mar-99	"	384	923	
WL-9	"	"	31-Mar-99	"	360	730	
WL-1	"	"	29-Mar-99	"	356	723	
WL-7	"	"	31-Mar-99	"	339	625	
WL-2	"	"	29-Mar-99	"	335	546	
WL-3	"	"	29-Mar-99	"	249	208	
WL-4	"	"	29-Mar-99	"	241	169	
WL-11	99178106	Rainbow trout	31-Mar-99	electroshocking	267	244	
WL-13	"	"	2-Apr-99	fyke net	221	118	
WL-14	"	"	2-Apr-99	fyke net	199	80	
WL-12	"	"	31-Mar-99	electroshocking	190	73	
WL-5	99178107	Cutthroat trout	29-Mar-99	electroshocking	320	310	
WL-6	"	"	"	"	261	166	
1	99238112	Kokanee	5-Jun-99	hook and line	270	174	
2	"	"	"	"	245	128	
3	"	"	"	"	267	178	
4	"	"	"	"	259	166	
5	"	"	"	"	nm	nm	
Lower Elwha River (between one lane bridge and state fish hatchery)							
ER-1	99178108/11	Rainbow trout	5-Apr-99	electroshocking	239	117	
ER-2	"	"	"	"	231	134	
ER-4	"	"	"	"	230	121	
ER-7	"	"	"	"	211	89	adipose fin clipped
ER-5	"	"	"	"	209	77	adipose fin clipped
ER-3	"	"	"	"	206	76	
ER-6	99178109	Rainbow trout	5-Apr-99	electroshocking	202	69	adipose fin clipped
ER-8	"	"	"	"	200	70	adipose fin clipped
ER-11	"	"	"	"	191	53	adipose fin clipped
ER-10	"	"	"	"	186	59	
ER-9	"	"	"	"	178	53	adipose fin clipped
ER-15	"	"	"	"	174	44	
ER-12	99178110	Rainbow trout	5-Apr-99	electroshocking	171	50	
ER-14	"	"	"	"	170	44	
ER-13	"	"	"	"	168	50	
ER-16	"	"	"	"	167	45	
ER-18	"	"	"	"	164	39	
ER-17	"	"	"	"	151	36	

nm=not measured